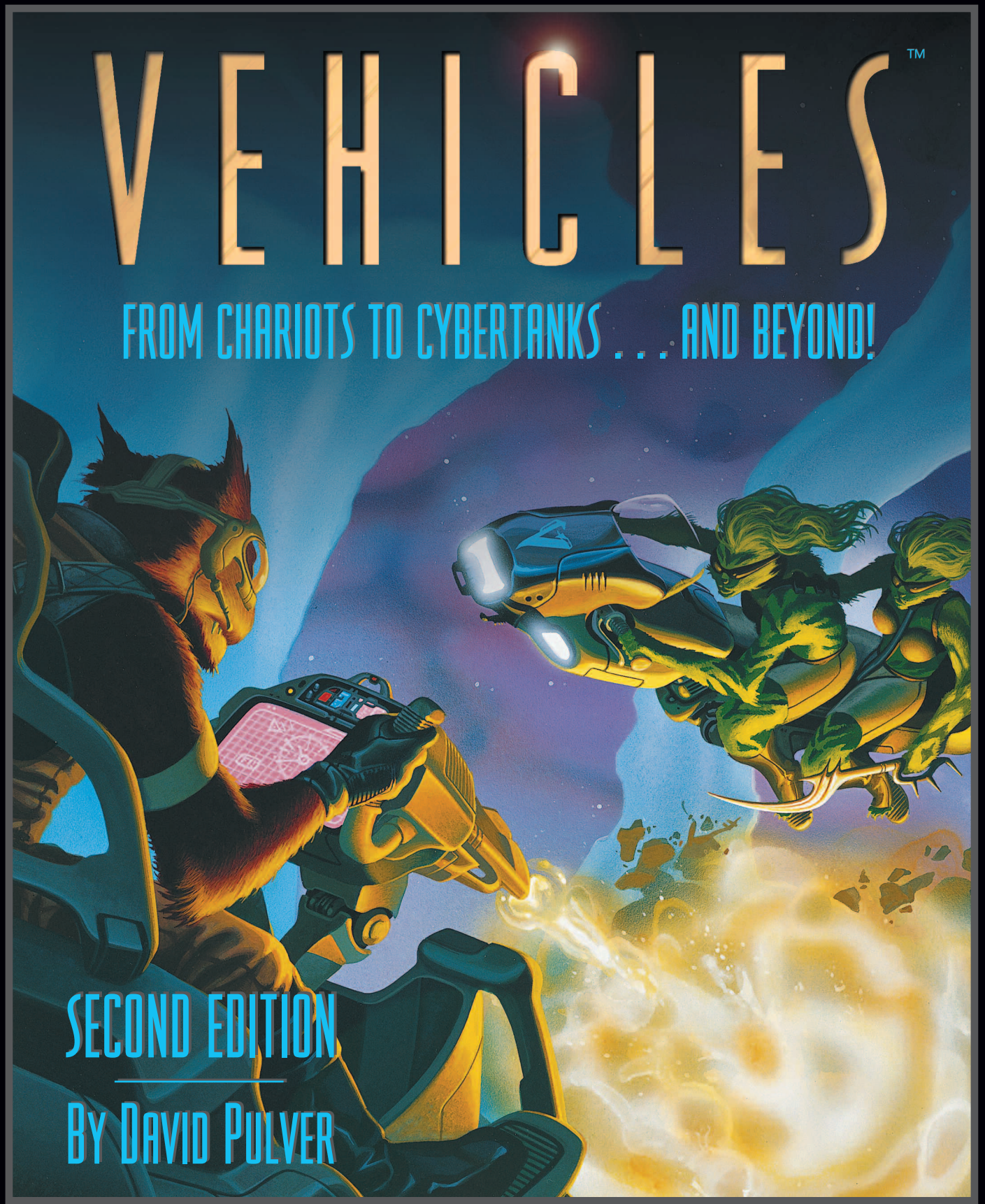
G U R P S®

VEHICLES™

FROM CHARIOTS TO CYBERTANKS . . . AND BEYOND!



SECOND EDITION

By David Pulver

STEVE JACKSON GAMES

GURPS

VEHICLES

Second Edition

By David L. Pulver



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STEVE JACKSON GAMES

INTRODUCTION

About GURPS

Steve Jackson Games is committed to full support of the ***GURPS*** line. Our address is SJ Games, Box 18957, Austin, TX 78760. Please include a self-addressed, stamped envelope (SASE) any time you write us! Resources now available include:

Pyramid. Our online magazine includes new rules and articles for ***GURPS***. It also covers all the hobby's top games – ***AD&D, Traveller, World of Darkness, Call of Cthulhu, Shadowrun*** and many more – and other SJ Games releases like ***In Nomine, INWO, Car Wars, Toon, Ogre Miniatures*** and more. And *Pyramid* subscribers also have access to playtest files online, to see (and comment on) new books before they're released.

New supplements and adventures. ***GURPS*** continues to grow, and we'll be happy to let you know what's new. A current catalog is available for an SASE. Or check out our Web site (below).

Errata. Everyone makes mistakes, including us – but we do our best to fix our errors. Up-to-date errata sheets for all ***GURPS*** releases, including this book, are always available from SJ Games; be sure to include an SASE with your request. Or download them from the Web – see below.

Q&A. We do our best to answer any game question accompanied by an SASE.

Gamer input. We value your comments. We will consider them, not only for new products, but also when we update this book on later printings!

Internet. Visit us on the World Wide Web at www.sjgames.com for an online catalog, errata and updates, and hundreds of pages of information. We also have conferences on Compuserve and America Online. ***GURPS*** has its own Usenet group, too: rec.games.frp.gurps.

GURPSnet. Much of the online discussion of ***GURPS*** happens on this e-mail list. To join, send mail to majordomo@io.com with "subscribe GURPSnet-L" in the body, or point your World Wide Web browser to www.io.com/~ftp/GURPSnet/www/.

Page References

References to the ***GURPS Basic Set,*** *Third Edition Revised* begin with a B – e.g., p. B121 is page 121 of that edition.

Similarly, CI refers to ***GURPS Compendium I: Character Creation;*** HT means ***GURPS High-Tech,*** *Second Ed.;* S means ***GURPS Space,*** *Second Ed.;* SU means ***GURPS Supers,*** *Second Ed.;* UT means ***GURPS Ultra-Tech,*** *Second Ed.;* M refers to ***GURPS Magic,*** *Second Ed.;* RO points to ***GURPS Robots;*** P signals ***GURPS Psionics*** and TT to ***GURPS Time Travel.***

GURPS Vehicles is a generic construction kit for designing almost any type of conveyance, from rowboats to antimatter-powered grav tanks. This second edition of ***GURPS Vehicles*** offers an easier-to-use design sequence and many new options, including detailed rules for building spacecraft and locomotives, as well as a comprehensive weapon design system.

GURPS Vehicles is designed to build a vehicle from the ground up, allowing maximum versatility by not restricting designers to specific hull or vehicle types. While ***GURPS Vehicles*** will let you design cars and airplanes, it will also let you create very exotic craft: Want a combination submarine-helicopter? You can build it . . .

Conventions

The following conventions are used throughout this book:

Abbreviations for Units

The following abbreviations are not standard, but are used to save space:

"cf" (instead of "cu. ft.") for "cubic foot"
"cy" (instead of "cu. yd. ") for "cubic yard"
"sf" (instead of "sq. ft.") for "square foot"



Metric and Other Conversions

1 cubic yard = 27 cubic feet
1 cubic foot = 7.481 US gallons = 28.317 liters
1 litre = 0.264 US gallons
1 displacement ton = 35 cubic feet
1 ton = 2,000 pounds
1 pound = 0.4536 kilograms
1 Astronomical Unit (AU) = 93 million miles
2 mph = (approx.) Speed or Move of 1
1 kph = 0.621 mph
1 knot = 1.15 mph
1 gravity (g) = 10.7 yd/s/s = 21.9 mph/s
1 horsepower = 0.746 kilowatts (kW)
1 kilowatt-hour = 3,600 kilowatt-seconds (kWs) (kilojoules)

Constants and Equivalents

The following equalities are assumed:
Speed of light in vacuum = 328,000,000 yd/s
1 inch of unsloped hard steel armor = DR 70
An "E" power cell holds 360,000 kilowatt-seconds at TL8

Calculations

There are lot of calculations in the vehicle design rules; a calculator is recommended! Two points of order:

Fractions and Rounding: Fractional hit points, DR, PD, DF, SR and crew requirements are rounded up to the next whole number (e.g., DR 7.5 becomes DR 8); values less than 0.5 are dropped to 0. In all other cases, retain fractions – but you can round them off to two decimal places (e.g., 20.1234 becomes 20.12) if desired. Any exceptions to these rounding conventions are noted in the text.

Cube Roots: A few of the formulas used for watercraft performance require cube roots to be calculated. In the event your calculator or spreadsheet lacks a cube root function, we've included a simplified cube root table in the appendix to the *Performance* chapter (p. 138).

About the Author

David L. Pulver is a writer and game designer based in Kingston, Ontario. He is the author of ***GURPS Ultra-Tech, Psionics*** and ***Robots,*** and the "Phoenix Sector" in ***Space Atlas 4,*** as well as many ***GURPS*** adventures. He has also written game supplements for other companies, including ***Glory of Rome*** and ***The Complete Druid*** (TSR) and ***Indiana Jones and the Rising Sun*** (West End Games). Besides gaming, David's interests include science fiction, military history and Japanese animation.

VEHICLE DESIGN 1

"So there I was," Morgan told Cassidy. "We had just landed the Huey outside the Lost City when six Harrier jump jets, well, jumped us."

The 60-year-old mechanic looked down his nose at the intense young woman in combat fatigues standing in front of him.

"I thought you were a good pilot."

"In a helicopter? Against a VTOL fighter?" The former 1st Special Operations Wing captain gave him a good-natured sneer. "Get real. We sucked up a couple of 25mm shells, lost the engine and had to autorotate down into the jungle and hotfoot it back. It's a good thing we ran into that lost tribe of Amazons, or we'd still be in the rain forest."

"I wondered about that scar."

Morgan absently brushed back a lock of red hair. "Got it when I defeated their queen in hand-to-hand combat. But after I spared her life, their shaman was grateful enough to help me get back to Panama, especially after I told them what I was doing."

Both of them turned to gaze at the artifact. The man-size obsidian statue was resting against the workbench. Even in the dim light of the hangar, the thing seemed ***wrong,*** *its proportions alien. It wasn't hard to believe there was a Demon Lord locked inside.*

"Chthon, one of the Twin Demons," Morgan said. "Locked out of time. We found it in the Temple of the Seven Seals."

Cassidy said. "Is it . . ."

"Don't worry," Morgan said, as if reading his mind. "It's not awake. The shaman put a ward on it for me. It's safe for the moment, but until this is over, it doesn't leave my sight."

Cassidy tore his gaze away. "The Twin Demons. What about its mate?"

Morgan looked away. "Bobby was wounded. We couldn't carry both him and the other statue. We left it buried a mile from the Huey's wreckage. If the Sons of the Outer Dark haven't found it. They only need one to complete the First Ritual, and then there'll be hell to pay."

"Literally," Cassidy said. Even in the warm New Mexico sun, he shivered. "So you want to go back?"

"We've ***got*** *to go back," Morgan said. "The damned Sons know that one of the statues is still in the Amazon, and they'll be combing the jungle looking for She of the Seven Eyes." Morgan rubbed her scar, and her eyes glinted dangerously. "But if I'm going back, damned if I'll do it in a Huey! That helicopter's been obsolete for 20 years!"*

Cassidy stared at her. "So?"

Morgan's anger vanished. She cocked her head and smiled sweetly at the old mechanic. "So that's where you come in, sugar." She handed him a disk. "The CAD/CAM instructions are in here. But I need to help you install the special systems."

"So that's why you came," Cassidy said slowly. He walked a few paces forward, looked out of the hanger at the semi-trailer parked right outside, the two armed guards standing next to it. The trailer was resting low on its wheels. Something big was sitting inside. "You finally got the parts."

"Langley finally gave me access to Warehouse 23," Morgan replied quietly.

"The UFO components, you mean?"

"Sure. No one was using them." She shrugged. "They'll pay for the rest. Black account out of Zurich. After I showed them tapes of the Moondark ritual, they paid. For any incidental expenses, I've got my gold card."

Cassidy wasn't listening; he was staring at the truck. "The Kitty Hawk," he said slowly. "So you're finally going to build it?"

Morgan plunked herself down on a workbench and booted up Cassidy's micro-Cray. The computer hummed into life. She inserted the disk. "Wrong. ***You're*** *going to build it. I've finished all the design work, baby."*

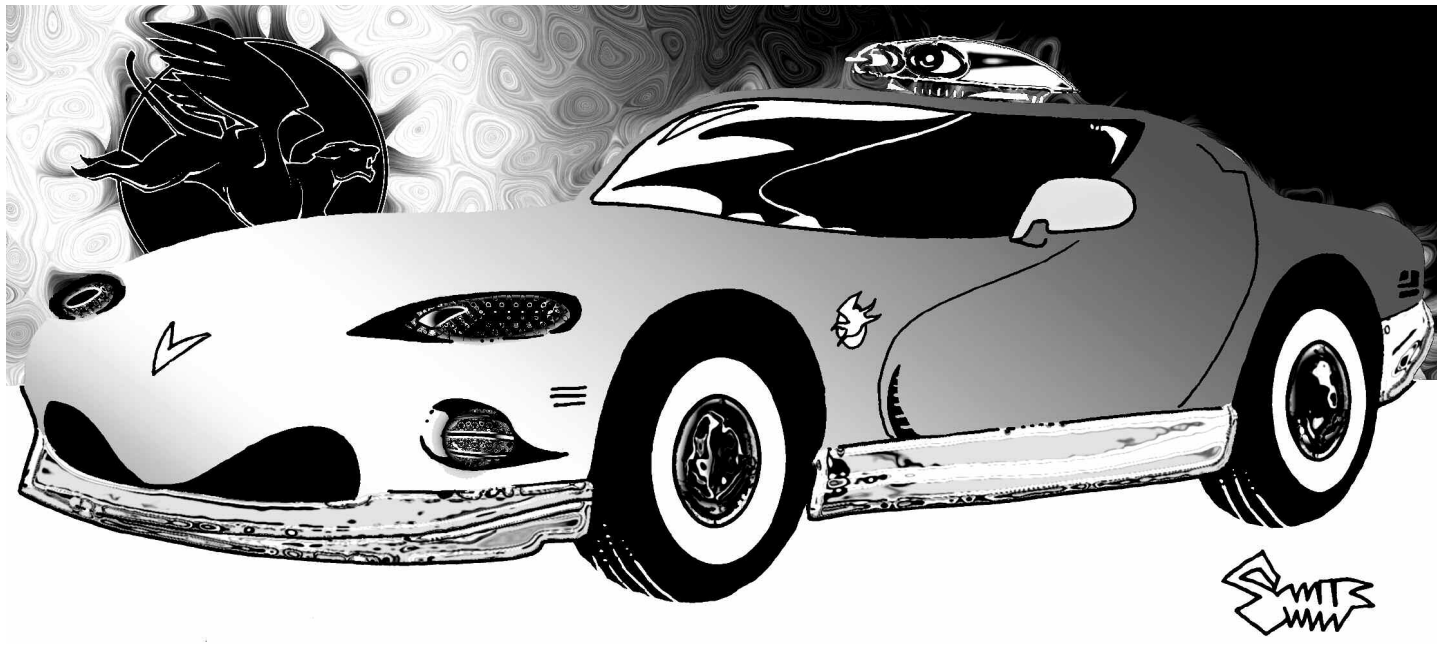
She stood up, took off her sunglasses, and stared deep into Cassidy's eyes, her own blue meeting his.

"Do it for me, Cassidy. For old time's sake."

Cassidy felt himself melting. He made one last protest. "It'll take months!"

"You've got 72 hours to assemble the prototype, soldier."

"Right."





This book provides a comprehensive metasystem for creating nearly any type of vehicle. A vehicle is designed by choosing the major *subassemblies* (like wheels or wings or turrets) it will have, along with any *body features* like streamlining. Next, components that go into it such as propulsion systems, weapons, seats and power systems are selected and placed within the body or subassemblies. Then the volume of the body and each subassembly is determined, and the size, weight and cost of the structure needed to contain and support these components is calculated. Surface features like armor are layered over the vehicle. Last of all, the vehicle's statistics are determined.

Create vehicles by following the steps outlined in this chapter, and referring to other chapters as directed, recording all the design features as they are chosen.

EXAMPLE

To demonstrate how the system works, we'll build Captain Morgan's Kitty Hawk, an "omnimobile" intended for a modern-day super agent campaign.

Tech Level

First, decide what tech level the vehicle will be built at – this may be anything from TL 0 (Stone Age) to TL16 (super science).

The various components and technologies that can be used in a vehicle are rated for the TL at which they first appear.

Occasionally, a historical tech level may be prefixed with "early," referring to the first half of the period covered in the tech level, or "late" indicating that availability limited to the latter half of that tech level. If no tech level is listed for a component, it is assumed to be available at any TL. A vehicle can normally only be built with technologies and components from its own or a lower TL, unless some source of higher-TL parts is available, or the designer has the Gadgeteer advantage.

The Kitty Hawk is built at late TL7, but has a few TL13 components salvaged from a wrecked UFO.

EXAMPLE

Concept

Next, come up with a general concept of the vehicle. What's it for? What should it look like? The most basic concepts are:

Ground Vehicle (TL0): A vehicle designed to move in contact with the ground or another solid surface, such as a car, locomotive or tank.

Water Vehicle (TL0): A watercraft; a vehicle designed to float on water or another liquid, such as a boat or ship.

Underwater Vehicle (TL5): A watercraft that can swim while totally submerged in liquid – a submarine.

Air Vehicle (TL5): An aircraft; a vehicle designed to fly in an atmosphere, such as a balloon or airplane.

Space Vehicle (TL7): A spacecraft; a vehicle designed to fly beyond an atmosphere.

Hovercraft (TL7): A vehicle that uses hover fans to maintain an air cushion and achieve lift, and as such is capable of skimming over ground or water at altitudes of a few feet. Also called an air cushion vehicle (ACV) or ground-effect vehicle (GEV).

A vehicle can combine one or more of these concepts. For instance, most airplanes are a combination of aircraft and ground vehicles (taxiing on a runway), and seaplanes are combination watercraft and air vehicles.

The Kitty Hawk is a combination aircraft, water vehicle, ground vehicle and submarine: an "omnimobile." It's supposed to resemble an ordinary automobile, but with special features that enable it to fly and swim in or under water.

EXAMPLE

Part I: Subassemblies

Every vehicle has a main *body.* But many vehicles have subassemblies attached to their bodies, such as wheels, wings or turrets. At this stage, choose which subassemblies, if any, the vehicle has.

Subassemblies are broken down into three broad categories: motive subassemblies (like wheels or legs), flight subassemblies (like wings or rotors) and structures (like turrets or arms).

A. Motive Subassemblies

If the vehicle will have skids, wheels, tracks, halftracks, skitracks or legs for moving on the ground, pick one or more of these subassemblies and refer to the appropriate section below; otherwise skip ahead to *B. Flight Subassemblies,* on p. 7. A ground vehicle will normally have a motive subassembly; the only way a vehicle can travel in contact with the ground without one is to install a flexibody drivetrain (covered later, in the *Propulsion and Lift Systems* chapter) and slither like a snake.

If a motive subassembly is desired, refer to each one's description below for its available TLs, capabilities and any other design decisions that need to be made (e.g., if a wheeled subassembly is chosen, there are several subtypes available).

The Kitty Hawk will have wheels.

EXAMPLE

Skids

Skids are the oldest form of motive system, dating back to prehistory. They can represent sled, ski or sleigh-style runners, or aircraft landing skids. Any vehicle can use skids to slide along on the ground, although it will need some form of external propulsion system – like harnessed animals, sails, propellers or a jet engine – to move under its own power. Skids are slower than wheels on normal terrain, but are very effective on ice or snow. A single skid subassembly represents *all* skids on the vehicle; decide exactly how many skids this represents.

At TL6 and up, skids can be built to retract into the vehicle, which is useful for reducing drag in flight. The only disadvantage is that this will take up space in the vehicle. If a vehicle with retractable skids will also have wings, decide whether the skids retract into the body or into the body and wings.

Wheels

Wheels allow a vehicle to roll along on the ground. If a vehicle has wheels, decide which of these sub-types it has:

Standard Wheels (TL1) are used by most ground vehicles. They are designed for use on a road, but have limited cross-country capability. Those built before TL5 lack suspensions and tires, so the ride is very rough! Starting at late TL5, wheels are assumed to have a sprung suspension and tires.

Small Wheels (TL1) are similar to standard wheels, but are smaller in proportion to body size. They are mainly used as landing gear for aircraft. They have poor off-road capability, especially if the vehicle is very heavily loaded.

Heavy Wheels (TL5) are larger and heavier versions of the standard wheels. They beef up a vehicle's suspension for transporting heavier loads. They are common on trucks.

Railway Wheels (TL5) are heavy wheels built solely for use on railway tracks. A vehicle with railway wheels can carry great loads and move more quickly – as long as it stays on the railroad.

Off-Road Wheels (TL6) are heavy wheels with high-clearance suspensions and large tires for cross-country use.

Retractable Wheels (TL6) are small wheels that can retract into the vehicle. This is useful for reducing drag if the vehicle flies. If a vehicle with retractable wheels will also have wings (p. 8), the wheels can retract into either the body alone or the body and wings – decide which.

The entire set of wheels along with its suspension system is a single subassembly. But the exact *number* of wheel positions a wheeled subassembly has must be chosen. This may be one, two, three or any even number past three. Fewer wheels generally makes the vehicle less stable but more maneuverable.

Vehicles with wheels that retract into the body *and* wings generally have three wheels or a multiple of three wheels.

EXAMPLE

The Kitty Hawk will have standard wheels. We decide it has four wheels.

Tracked Motive Subassemblies

There are three types of tracked motive subassemblies:

Tracks (TL6) are caterpillar tracks like those of a tank or bulldozer. They were first used in the early 20th century, on American earth-moving tractors, and were added to British armored vehicles in the middle of World War I to create the first tanks. Tracks are slower than wheels when on roads, but have far superior cross-country performance, which is what endears them to the military. The entire tracked motive system, including the right and left sets of tracks plus the running gear and suspension they are attached to, is a single subassembly; decide whether this represents two or four sets of tracks.

Halftracks (TL6) use caterpillar tracks for propulsion and wheels for steering. Halftracks were developed during World War II for light armored vehicles. They are a hybrid of fully tracked and wheeled vehicles – somewhat faster than tracks on a road, but not as good cross-country. The entire halftrack motive system (rear tracks and front wheels) is a single subassembly; decide whether this represents two or four sets of tracks.

Skitracks (TL6): These are halftracks with the front wheels replaced with skis. They are most popular on light, motorcycle-sized snowmobiles but are usable on larger vehicles. Skitracks are excellent at moving over packed snow or ice, but inefficient on normal terrain. The entire skitrack motive system (including both the tracks and the front skis) is a single subassembly; decide whether this represents two or four sets of tracks.

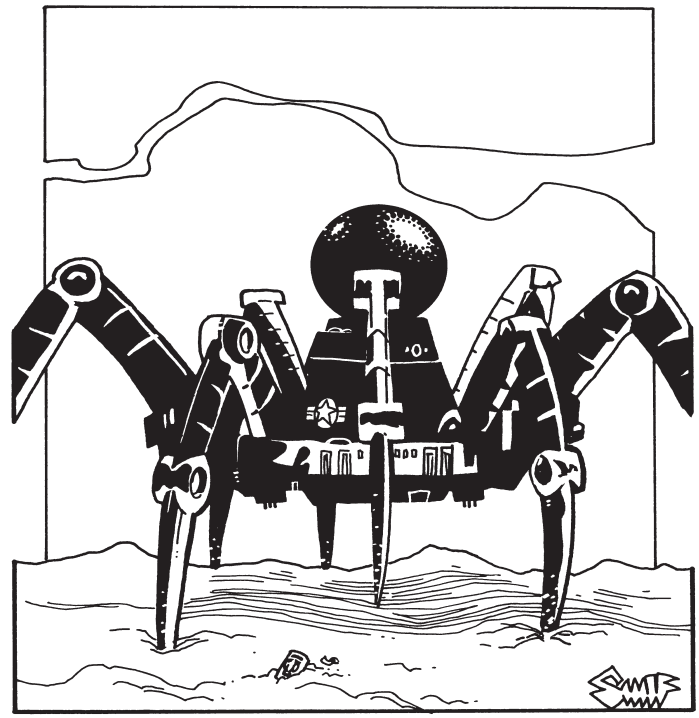
Legs

These are robotic limbs used for walking and running.

Legs are even more mobile in rough terrain than tracks. Their disadvantages lie in low speed, poor stability and the greater expense of the leg motors that operate them.

Historically, legged vehicles are not available until TL7, and even then they are only experimental. Optionally, GMs may allow anachronistic vehicles to have legs at earlier TLs.

If a vehicle has legs, decide how many it has. Unlike other motive subassemblies, each leg is an *individual* subassembly. More legs generally make the vehicle faster and more stable but less maneuverable. Vehicles built at or before TL7 should have at least three legs, but by TL8, improved stabilization systems make two-legged vehicles more practical.



B. Flight Subassemblies

If the vehicle will have airplane-style *wings,* helicopter-type *rotors,* or be a *hydrofoil* or a *hovercraft,* consult the appropriate section below; otherwise, skip ahead to *C. Structural Subassemblies,* on p. 9.

Air vehicles intended to fly partly or wholly via aerodynamic lift require either wings or rotors; a vehicle may have both.

Watercraft intended to skim along at high speeds may be given hydrofoil subassemblies.

Hovercraft should have hovercraft subassemblies – either a GEV (Ground Effect Vehicle) skirt or SEV (Surface Effect Vehicle) sidewalls.

If any of these subassemblies are desired, refer to the sections below for descriptions and further design options.

There are other means of flying besides aerodynamic lift or hovercraft; these are dealt with later!

EXAMPLE

The Kitty Hawk will have no flight subassemblies – while we want it to fly, we aren't going to use wings or rotors to do it.

Wings

Wings are a means by which a heavier-than-air vehicle can achieve flight. A vehicle with wings must be given *two* of these subassemblies; a pair includes a tail used for stability and steering. A vehicle that has wings is called an airplane if it can propel itself once in flight, or a glider if it cannot.

Wings are used by aircraft to generate lift aerodynamically, through the motion of the wings through the air. A wing is curved so that the flow of air going over the wing travels faster than that passing under it. The faster air travels, the lower its pressure. Because the air under the wing is moving slower and is at a higher pressure than the air immediately above it, the air tries to rise upward – and this results in lift. The faster the wing travels through the air, the greater this pressure difference and so the more lift it can produce. If a winged vehicle on the ground is moving fast enough, its wings' motion through the air will result in enough lift to counter the weight of the airplane, and the aircraft will lift into the air and enter aerodynamic flight. However, to stay in the air, it must continue to move at or faster than this speed.

The minimum speed needed for an aircraft's wing to provide enough lift for flight is referred to in ***GURPS Vehicles*** as the aircraft's *stall speed.* The greater the aircraft's wing area compared to its loaded weight, the lower its stall speed.

Ideally, an aircraft wants a low stall speed, since this means it can take off or land without requiring a long runway, and can also maneuver at fairly low speeds. However, a low stall speed requires either a light aircraft or a big wing. The bigger the wing, the more drag the wing produces and the slower the aircraft will be. This can be countered by streamlining the aircraft (using a thin wing and a sleek body). Also, the shape of wing is quite important: some wing designs affect stall speed.

The exact *size* of the wing will be determined later in the design process, when we have a better idea how big and heavy the vehicle will really be. However, the wing's *shape* is selected now. Pick one of these wing types:

Standard Wings (TL6) are conventional wing and tail structures curved to generate lift. Whether they are straight or swept back will depend on the degree of streamlining the vehicle will be given (covered on p. 11).

STOL (Short Takeoff and Landing) Wings (TL6) are built with additional lift-enhancing devices such as large flaps. They are shaped to generate more lift at the expense of a lower top speed. On aircraft without much streamlining, STOL wings tend to be large and mounted high atop the body. Highly streamlined STOL designs often use canards (small winglets) on the front of the fuselage.

Biplane Wings (TL6) are two pairs of wings stacked atop one another to increase the wing area. They have even higher lift than STOL wings, but the top speed is even lower.

Triplane Wings (TL6) are three sets of wings stacked atop each other. They are similar to biplane wings, but the reduction in stall speed and increase in drag are greater still.

High Agility Wings (late TL6) are wing and tail configurations with flaps and lift devices that are optimized for superior maneuverability at the cost of some extra weight and some loss of speed.

Flarecraft Wings (late TL7) are a recent "ram wing" design that manipulates airflow to create an enhanced ground effect that greatly boosts lift while limiting the vehicle to altitudes of only a few feet off the ground. These small, downward-swept wings allow a vehicle to achieve high-speed "flight" over water or smooth surfaces like ice without the dangers and difficulties of operating a true aircraft.

Wings are also useful because their large area allows various pylons to be attached under them. Flying vehicles that do not rely on wings for lift are sometimes fitted with a special kind of wing for just this purpose:

Stub Wings (TL7) are small wings designed primarily to provide extra surfaces to which one can attach hardpoints for bombs, missiles, drop tanks and the like. They also provide a bit of extra lift.

Rotors

These are rotating blades, mounted atop the vehicle, whose rapid rotation functions like a wing, allowing the vehicle to fly as a helicopter or autogyro.

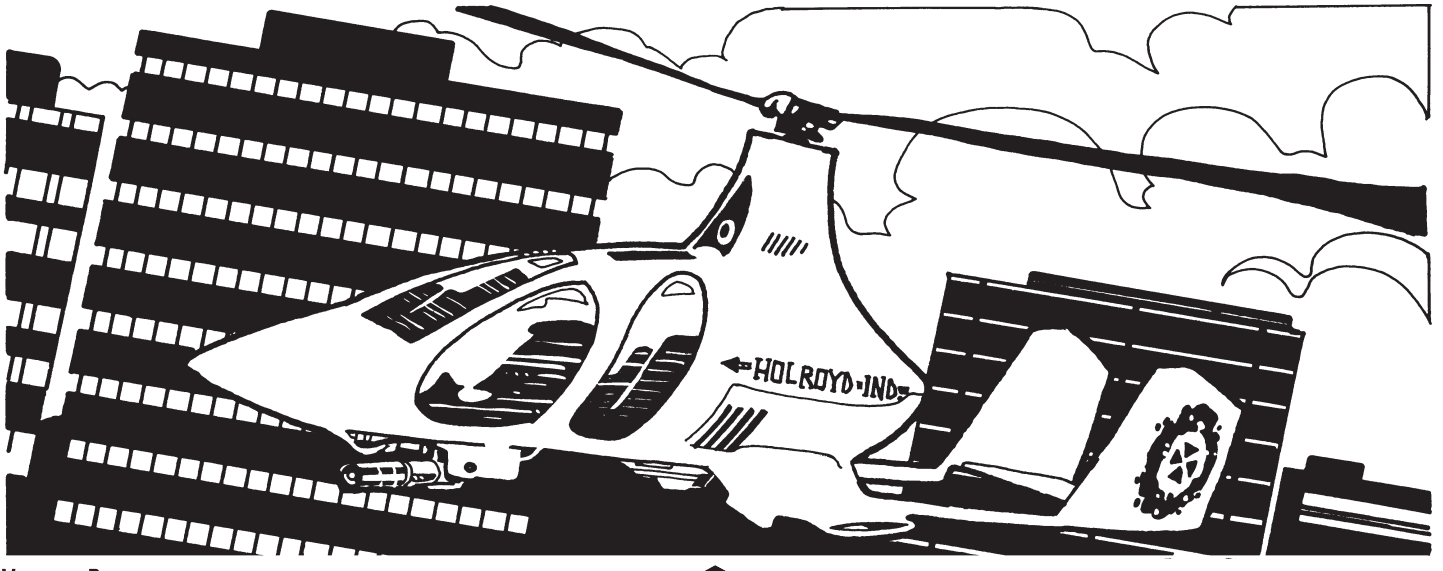
An autogyro is a rotary-wing vehicle whose rotors are unpowered: like an airplane, it has a stall speed and can only fly if the vehicle is moving forward fast enough to create lift. Its advantages over conventional wings are that the rotor is lighter and cheaper, and the stall speed is usually lower. The disadvantages are that the autogyro is generally slower and cannot perform the same kind of high-G maneuvers a winged airplane can.

A helicopter is a vehicle whose rotors are driven via a motor (a helicopter drivetrain). Because the rotor motion is independent of the vehicle's, it can achieve lift while stationary.

Select an autogyro rotor (TL6) or one of these helicopter rotors:

Top-and-Tail Rotor (TTR, late TL6) using a large main rotor for lift. A rotor turning in a single direction produces torque, causing the vehicle to spin. To prevent this, a small, side-mounted tail rotor or fan is geared to it, and this tail rotor produces a lateral thrust that counteracts this torque.

Multiple Main Rotor (MMR, TL6) using two or more big rotors turning in opposite directions to cancel torque, giving added speed and lift (compared to TTR) at the expense of agility and weight. Decide how many rotors – at least two – it has.



Coaxial Rotors (CAR, TL7) using a single rotor shaft with twin sets of blades rotating in opposite directions around it. CAR systems are somewhat heavier than TTR systems but offer some performance advantages over them in terms of safety.

Hydrofoil Subassemblies

Hydrofoils are underwater "airfoils" that enable a water vehicle to skim along over water at higher speeds than usual. Hydrofoils were experimented with in the early 20th century by numerous inventors and are considered TL6. However, they did not enter commercial or military service until the TL7 period.

A single hydrofoil subassembly represents all the vehicle's foils (normally two in front and one in back).

Hovercraft Subassemblies

Hovercraft, or more technically, air cushion vehicles, were invented in the 1950s. They are capable of very low, level flight over ground or water on a cushion of air formed by the thrust of downward-directed fans. A hovercraft does not *require* a hovercraft subassembly – it can hover with just hoverfans, which are added later in the design process – but an efficient hovercraft will use some form of skirt or sidewalls to contain the air cushion, and should be given one of these two subassemblies:

GEV Skirt (TL7): This is a semi-rigid skirt attached under the body of a hovercraft to efficiently make use of the air cushion generated by its fans. A GEV (Ground Effect Vehicle) skirt will more than double the effectiveness of the vehicle's hoverfans and is usable when the hovercraft is moving over land and water. A vehicle can only have one GEV skirt assembly.

SEV Sidewalls (TL7): These Surface Effect Vehicle sidewalls (surface meaning "water surface") are an alternative to GEV skirts. They are intended for hovercraft built solely for over-water travel. The air cushion is contained by light, semi-rigid walls on either side of the body that dip into the water while the vehicle is hovering. This provides greater maneuverability in water since the walls can be used to steer with at the expense of some drag and slightly reduced lift. A vehicle can only have one SEV sidewall subassembly (representing a pair of sidewalls).

C. Structural Subassemblies

If the vehicle is to have superstructures, open mounts, masts, pods, turrets, a gasbag envelope or arms, consult the appropriate section below; otherwise, skip ahead to *Part II: Body Features,* on p. 10.

These are subassemblies attached to a vehicle which are not used for movement or lift, such as turrets or arms. When a structure is installed, decide where it is located. Structures may be attached to a vehicle body, or to other structures. If one structure is attached to another, like two turrets stacked one atop the other, or a turret on a superstructure, the subassembly nearer to the body is described as "supporting" the outer subassembly.

Superstructures (TL0): These are fixed towers or housings, like the superstructure, conning tower or castle on a ship. A vehicle can have several superstructures, but most ships have only one or two.

Open Mount (TL0): These are brackets, pedestals or masts used to mount equipment – usually sensors or weapons – outside the vehicle's structure. Examples of open mounts include the machine gun mount atop a tank's turret, an anti-aircraft gun mounted on the deck of a warship, or a large radar mast. Open mounts must be bought as either fixed, limited (180° pivot) or full (360° pivot) rotation. Aside from the ability of some open mounts to rotate, they are useful because components placed in them do not take up space inside the vehicle (reducing the vehicle's size and thus weight and cost). The disadvantages of an open mount are that it is not protected by the vehicle's structure and armor, and it is not compatible with any better than Fair streamlining.

Military ground vehicles from jeeps to tanks usually have one or two limited- or full-rotation open mounts for attaching external machine guns or searchlights. Small bombers and torpedo bombers, if they lack real turrets, often use open mounts for the rear gunner's weapon. Warships often have many open mounts.



Masts (TL1): These are poles used to hang sails on. If a vehicle is to use sails for propulsion, it must be given masts. Decide how many masts the vehicle will have, and how high each mast will be. The more masts, and the taller they are, the greater the area of sail the vehicle will be able to use and hence the faster it will move. Maximum mast height is 150' at TL1-4 with wooden masts, or 200' at TL5+ with metal masts. Average mast heights are about 20'-40' for small sailboats and small TL1-3 ships; small TL4+ ships often have one or two 40-80' masts, while large TL4+ ships have multiple masts 80-200' tall. The maximum number of masts a vehicle may have is six or its TL, whichever is less.

Masts impose a certain minimum size on the vehicle: if it has masts, its final body volume will have to be at least (tallest mast height in feet/4) cubed. Record this minimum vehicle volume – when calculating vehicle volume late in the design process, check to see if the vehicle is big enough for its masts. If not, simply add extra cargo or empty space to increase its size.

A mast can only be attached atop a superstructure or body. The only structural subassembly that can be attached atop it is a single open mount, and that open mount may not house components whose combined volume in cf is greater than half the mast's height. At TL5+, short masts are sometimes built without sails as attachment points for open mount sensors or lookout positions.

Pods (TL1): These are housings attached to pylons, like outriggers or aircraft engine pods. Pods can be attached to the body or to wings: decide where each pod is placed. If pods are attached to wings, each wing must have the same number of pods, and corresponding pods on either wing must match in volume and weight. The main use of pods is in the design of a vehicle intended to resemble a modern, multi-engine aircraft whose engines are attached to pods on the wings or body – in this case, give the vehicle as many pods as the number of engines you intend to later install. The advantage of using pods is that damage to a pod is much less likely to affect the rest of the vehicle.

Turrets (TL5): These are rotating superstructures, like tank or warship turrets, or radar domes. Their main purpose is to allow guns or sensors to cover a wider arc. For each turret, decide if it has limited (180°) or full (360°) rotation. This is the maximum degree the turret can rotate. A vehicle can have multiple turrets, if desired. Decide how each turret is placed. Full-rotation turrets can go atop or below the body; limited-rotation turrets can also go on the left, right, back and front sides of the vehicle's body. Also, turrets can be stacked atop other turrets or superstructures that are above the body, or they can be

attached to the underside of turrets or superstructures that are underneath the body. Turrets are mostly carried by tanks, naval vessels and some combat aircraft.

Superstructures, open mounts, masts or other turrets mounted on the same plane as a turret may partially restrict each other's field of fire or vision – imagine two gun turrets both atop a vehicle's body, for example. The GM will have to judge exactly what structures block which turrets from which angles. This problem is often reduced in warships by stacking turrets atop one another or atop superstructures. Note that the restrictions on turret placement do not apply to space vehicles.

Pop Turrets (TL5): These are identical to normal turrets except they can retract into the vehicle, concealing themselves when not in use. A pop turret is useful for surprising an opponent, and has reduced aerodynamic drag compared to a normal turret. Pop turrets use up extra space in the body or subassembly they are attached to.

Gasbag Envelopes (TL5): A balloon or a nonrigid airship such as a blimp usually stores lifting gas in a large structure attached to the body, rather than in the body itself. A gasbag envelope is such a structure. If a vehicle is intended to resemble a blimp or a balloon, it should have a gasbag envelope. Normally a vehicle has only one, but multiples are possible.

Arms (TL7): These are limbs that are not used for walking – instead they manipulate objects or act as flexible weapon or equipment mounts. A vehicle can have any number of arms. As with legs, each is a *separate* subassembly. Decide where each arm is attached to the body. On humanoid vehicles such as giant robots, arms are normally attached to the right or left side; arms can also be attached to the back, like tails, or directly forward, like trunks, or attached to structures.

EXAMPLE

The Kitty Hawk has a single pop turret with full rotation atop the body. This gives the vehicle a good arc of fire for any weapons we mount in it without being too obvious!

Part II: Body Features

After subassemblies have been chosen, decide if the vehicle has any *features*. These fall into several categories: water vehicle features, streamlining and slope.

Any vehicle intended as a watercraft or submarine should have water vehicle features. Streamlining and slope are optional.

A. Water Vehicle Features

These features are required if the vehicle is intended to be a watercraft or submarine. Otherwise, jump ahead to *B. Streamlining,* on p. 11.

EXAMPLE

The Kitty Hawk has water vehicle features.

Flotation Hulls

This feature is required for all watercraft. In order to float in water, the vehicle's volume must be sufficient to support its weight. It will have a flotation rating in pounds. This is the maximum the vehicle can weigh and still float. Actual flotation rating is based on the vehicle's body volume, which will not be determined until a much later stage of the design process. For now, simply record the flotation as "62.5 lbs. per cf." Aside from this weight limit, a vehicle that will float will be somewhat more expensive, since it must be waterproofed. Again, actual costs will be determined later in the design process.

EXAMPLE

The Kitty Hawk will have a flotation hull.

Submersible Hulls (TL5)

This feature is required for underwater vehicles. Making a vehicle submersible equips it to dive and swim underwater. The body has control planes for steering underwater, a strong inner pressure hull and an outer shell containing ballast tanks and pumps to control buoyancy. While surfaced, the vehicle is under the influence of positive buoyancy, and floats. When moving submerged, buoyancy becomes neutral by taking in water to allow the vehicle to stay at the desired depth. To dive or to rest on the bottom, negative buoyancy is achieved by adding water or diminishing air.

Making a vehicle submersible will increase the vehicle's final body volume by 25% (since room must be made for ballast tanks and the like) and double structural weight and cost. These effects occur later in the design sequence.

EXAMPLE

The Kitty Hawk will be submersible.

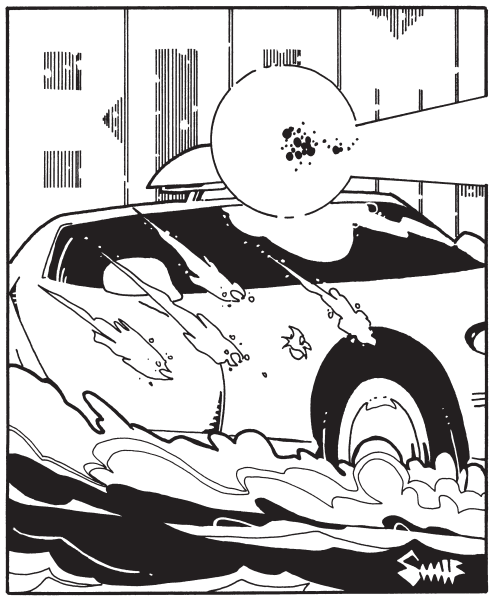
Hydrodynamic Hulls

A craft moving through water encounters strong resistance, which increases as its speed increases, slowing it down. A vehicle with the flotation hull feature can be given a boat-shaped *hydrodynamic hull* shaped to reduce water resistance and allow it to achieve higher aquatic speeds.

Most watercraft and submersibles are built with hydrodynamic hulls; exceptions include barges and many amphibious vehicles, such as swimming tanks and landing craft. A vehicle with GEV skirts may not have a hydrodynamic hull.

A hydrodynamic hull is rated for its sleekness, classed as either Mediocre, Average, Fine or Very Fine lines.

A vessel with finer lines will move more swiftly, at the expense of less usable volume, lower stability and a deeper draft. Draft refers to the minimum depth of water a vehicle requires to avoid running aground.



Craft with Mediocre lines generally have boat-shaped hulls with a length-to-beam (width) ratio of 3 to 5:1. This is typical of most sailing ships, river boats and modern bulk cargo ships.

Craft with Average lines have somewhat longer, sleeker hulls with length-to-beam ratios of 5 to 7:1. This is typical of power boats, clipper sailing ships, modern fast cargo ships and ocean liners.

Craft with Fine lines have very sleek hulls with length-to-beam ratios of 8:1 or more; this is typical of ancient oared war galleys, modern warships and sea planes.

Craft with Very Fine lines are similar in length-to-beam ratio to those with Fine lines, but more care is taken to ensure an optimum hydrodynamic shape.

Submarine Lines (TL7): Instead of the above hull types, a submersible vehicle with a hydrodynamic hull may be built with submarine lines. This is a hull with a shape optimized for underwater travel at the expense of surface speed, a type introduced on many nuclear submarines beginning in the 1960s. Earlier submarines were generally built with boat-shaped hulls – which was appropriate, since non-nuclear submarines spent most of the time cruising on the surface anyway!

Catamaran or Trimaran Hull: This is a double or triple hydrodynamic hull. It can be added as an option to a hull with any degree of hydrodynamic lines. It increases stability at the expense of greater waste volume.

Hydrodynamic Hull Effects on Flotation: A vehicle with a hydrodynamic hull (unless the vehicle is submersible) has a slightly reduced flotation rating. Flotation is 57 lbs. per cf if it has Mediocre lines, 52 lbs. per cf if its lines are Average, 48 lbs. per cf if Fine or 45 lbs. per cf if Very Fine. If a vehicle has a submersible hull, flotation is automatically 62.5 lbs. per cf, regardless of the type of hydrodynamic hull.

EXAMPLE

Since most cars don't have hydrodynamic hulls, we won't give the Kitty Hawk one. Its flotation is 62.5 lbs. per cf due to its submersible hull.

B. Streamlining

Is the vehicle to be streamlined? If so, read this section; otherwise, skip ahead to *C. Slope,* below.

Streamlining a vehicle shapes it so as to reduce the drag it experiences when moving through an atmosphere, increasing its top speed. This can be thought of as the atmospheric equivalent of hydrodynamic lines. A vehicle doesn't have to have streamlining. If it does, select one of these levels of streamlining:

Fair (TL1), typical of sports cars, some speed boats and many light propeller aircraft and helicopters.

Good (TL5), typical of race cars and fast propeller aircraft. A ground vehicle with good or better streamlining is normally shaped like a racing car, with airdams and spoilers.

Very Good (TL6), typical of subsonic jet aircraft and slow but highly-streamlined craft like airships.

Superior (TL6) is typical of slow supersonic jet aircraft.

Excellent (TL6) is typical of fast supersonic jet aircraft.

Radical (TL6) is typical of missiles and hypersonic aircraft.

Streamlining does not confer a particular speed, but merely reduces the effects of drag: a car could have Good streamlining but still be capable of only 20 mph, if its engine were underpowered. It would certainly *look* fast, though!

Vehicles with some types of subassemblies cannot have certain levels of streamlining:

A vehicle with masts cannot have better than Fair streamlining. A vehicle with skids or wheels (unless retractable), tracks, halftracks, skitracks, biplane or triplane wings, GEV skirts, SEV sidewalls, open mounts, gasbags, rotors, arms or legs cannot have better than Good streamlining. A vehicle with superstructures or turrets (except pop turrets) cannot have better than Very Good streamlining. Vehicles with wings cannot have Superior, Excellent or Radical streamlining before TL7.

Streamlining affects the shape of wings. While this is factored into the performance rules, vehicle designers should be aware that vehicles with no, Fair or Good streamlining have relatively straight wings, while



those vehicles with Very Good, Superior, Excellent or Radical streamlining almost always have swept-back, cranked-arrow or delta-wing shapes with less lift and hence higher stall speeds, but greatly reduced drag.

Lifting Body (late TL6): A flying vehicle with Very Good or better streamlining can be built as a lifting body, like the Space Shuttle or some "flying wing" designs. A lifting body's flat belly is specially designed to provide extra lift in flight, especially at high speeds. This enables an aircraft to get by with far smaller wings than usual (or no wings), reducing drag at the expense of stall speed and maneuverability. If normal-size wings are used, this option reduces stall speed via body lift.

EXAMPLE

The Kitty Hawk will have Fair streamlining.

C. Slope

Will the vehicle's turrets or body have sloped armor like a tank's hull or a battleship's turrets? If so, read this section; otherwise skip ahead to *Part III: Components,* on p. 12.

A body, turret or superstructure can be *sloped,* so that when armor is added it will be better able to deflect attacks. In game terms, this means its armor will have a higher PD and better DR. Slope is available at TL5 and up.

The right, left, front or back faces of the body, superstructures and turrets can be given either no slope, a 30° slope or a 60° slope.

Decide at this point what faces on which subassemblies will be sloped, and how much, if any, slope they will have. The body, turret and superstructure can have different degrees of slope, e.g., a vehicle's body might have 60° front and 30° back slope while its turret has 30° slope on its front side, but no slope anywhere else.

Most tanks and other armored vehicles designed late in World War II (mid TL6) and afterward have slope on their front bodies and turrets (and sometimes other sides). The turrets on many warships from TL5 on are also sloped.

The disadvantage of slope is it takes up space that might otherwise be used for components, which effectively means a body or subassembly with slope will be somewhat larger, and hence heavier and more expensive. However, if a vehicle is to be heavily armored, slope is usually worth the trade-off, since it is the only way to get very high Passive Defense values.

Part III: Components

With the subassemblies and body features selected, we know roughly what the vehicle looks like. Now we decide what's inside it, which means choosing the components. These are the parts built *into* the vehicle. They include things like propulsion systems, sensors, weapons, seats and power plants. Most of the design process consists of selecting the vehicle's components, determining their characteristics and deciding where to put them.

Each component has several statistics. The first is its basic description, e.g., "TL9 gasoline engine, 200 kW output" or "TL6 75mm gun." The other statistics are location, weight, volume, cost and power requirement.

Location must be chosen when a component is selected. Decide in what part of the vehicle it will be housed – either in the vehicle's body or in a particular subassembly. In general, only the body and the turret, superstructure, open mount, pod, leg, wing or arm subassemblies can house components. Many components have specific restrictions as to where they can be placed.

Weight (wt.) is measured in pounds (lbs.).

Volume (vol.) is measured in cubic feet (cf).

Cost is in dollars.

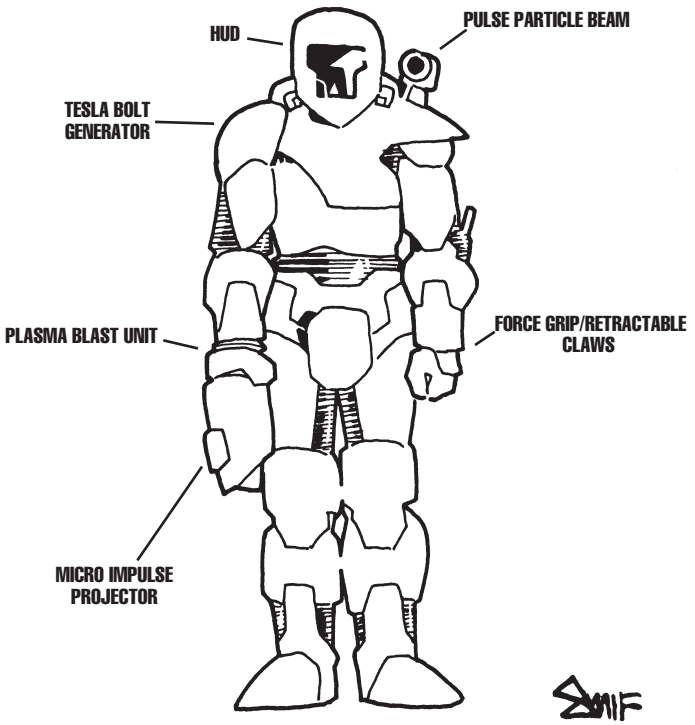
Power is measured in kilowatts. Some components require negligible (abbreviated "neg.") amounts of power. This means they function as long as the vehicle has any kind of working power system. At the GM's option, a negligible power component can be considered to actually require 0.01 kW power.

Some components may lack weight, volume, cost or power.

The various components that a vehicle may need have been broken down by category, with each category described in a different chapter. Go through the design sequence below, starting with *A. Propulsion,* to find what components the vehicle needs, referring to the chapters they are described in as necessary. When a component is chosen, record its description and work out its statistics. A suggested format is: "description (location, weight, volume, cost, power consumption)." For instance:

"*Propulsion:* 1,000 kW motive power wheeled drivetrain (body, 2,040 lbs., 40.8 cf, $40,400, 1,000 kW)."

Ruggedized Components: Any vehicle component that has cost, weight and volume can be "ruggedized" to make it more resistant to damage by adding multiple, redundant subsystems. See *Ruggedized Components,* p. 27.



A. Propulsion

Almost every vehicle should have a propulsion system; the exceptions are vehicles that are intended only to be towed by other vehicles, or to be released as gliders, as well as such things as balloons and rafts.

If a vehicle is to be self-propelled, refer to the *Propulsion and Lift Systems* chapter (p. 28) and decide what propulsion systems, if any, the vehicle will use.

EXAMPLE

The Kitty Hawk needs to be able to propel itself on land, in and under water, and in the air. We end up installing a wheeled drivetrain, hydrojets and a jet engine – see the *Propulsion* chapter for details!

B. Aerostatic Lift

Aerostatic lift systems allow a vehicle to fly without wings or rotors.

Aerostatic lift is needed to create an air vehicle that lacks wing or rotor subassemblies. They can also assist a wing- or rotor-equipped aircraft's maneuverability and reduce its stall speed, sometimes down to zero. For example, the Harrier jump jets that shot down Captain Morgan's Huey were winged aircraft with additional aerostatic lift using vectored thrust lift engines. To design an aircraft that will use aerostatic lift, refer to Chapter 2 and install either levitation (p. 41), lifting gas (TL5, p. 40), lift engines (TL3, p. 40), lift fans (TL7, p. 40), or contragravity generators (TL12, p. 41).

Aerostatic lift is needed for vehicles with GEV skirt or SEV sidewall subassemblies: refer to *Aerostatic Lift* in Chapter 2 and install hovercraft fans (p. 41).

Vehicles with mag-lev propulsion are automatically capable of a form of aerostatic lift: they don't need any more . . . but then again, they don't really fly, they just float above a track.

EXAMPLE

The Kitty Hawk needs an aerostatic lift system, since it doesn't have wings or rotors and we want it to be an air vehicle. We refer to the *Aerostatic Lift* section (p. 40), and, thanks to that salvaged alien technology Morgan mentioned, end up installing contragravity generators. See Chapter 2 for details.

C. Built-In Weaponry

Vehicles can be armed with a wide variety of built-in ranged weapons, such as guns, launchers and beam weapons.

Only permanent or semi-permanent weapon installations built into the body or subassemblies are chosen at this point in the design process. External pylons (hardpoints) like those carried by combat aircraft are not installed at this point, nor are bombs, missiles or other weapons on hardpoints.

If the vehicle is to be armed with built-in weapons, refer to the *Armaments* chapter (p. 42) and select the vehicle's weapons from those available. For more choice, weapons can be designed from scratch using the *Weaponry* chapter (p. 97). Once the weapons have been chosen, follow the guidelines below for their installation:

Location: Ranged weapons can be located in the body, or in turret, superstructure, open mount, wing, arm, leg or pod subassemblies.

Weight: Each ranged weapon has an empty weight (Ewt.) in pounds. Use this weight when installing the weapon.

Volume: A ranged weapon takes up its weight/50 cf in most cases.

However, any weapon can also be concealed within the vehicle, without its tube or muzzle protruding, taking up empty weight/20 cf. All muzzleloaders on gun carriages *must* be mounted in this fashion, as must all ranged weapons on a vehicle with Very Good or better streamlining or located in pop turrets.

Cost: Use the weapon's listed cost.

Facing: Weapons in arms and legs are mounted so as to fire where the limb is pointed. For a weapon located in the body or any other subassembly, specify whether it points forward, backward, right, left, up or down; this determines the direction it can fire. Of course, a weapon in a limited or full rotation turret or open mount can fire in different directions as the turret or mount itself rotates.

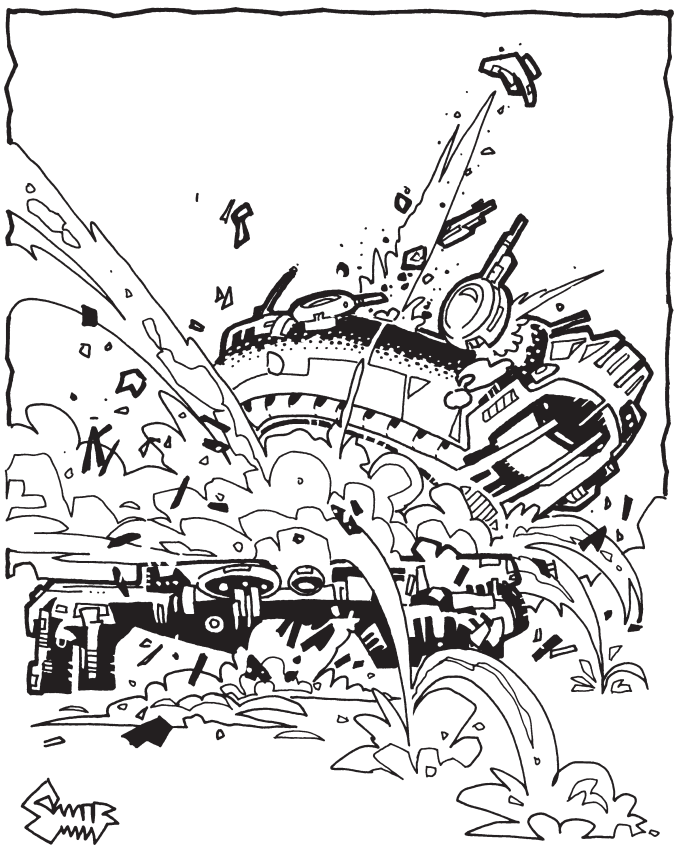
Weapons facing up are generally only useful for indirect or anti-aircraft fire, while those facing down are mostly good for attacking submerged vessels or targets the vehicle flies over. A weapon can't be mounted to face in the direction that the subassembly is attached to the vehicle – a gun in a turret on top of a vehicle can't be mounted to face down, for instance.

EXAMPLE

The Kitty Hawk is to be armed. We go to the *Armaments* chapter and read through the weapons available. We decide a 40mm grenade launcher (p. 43) is just what Captain Morgan is looking for, but she also wants the vehicle to have a rapid-fire Gatling gun, like the 20mm cannon on the fighters she flew. The 20mm Gatling looks too big and heavy for a car-sized craft – what she really needs is a Gatling gun in smaller caliber, firing rifle bullets rather than shells. There isn't one in the weapon table, so we go to the *Weaponry* chapter and build one! See the gun design rules there for how the Kitty Hawk's "minigun" was built.

After we built the minigun, we decide that it and the grenade launcher both go in the pop turret. We record each weapon's weight, decide each is concealed (which they must be, since they are going in a pop turret), and calculate their volumes as weight/20 cf. Then we record the costs, and decide that both weapons face forward out of the turret. The Kitty Hawk's weaponry is:

***Weaponry:* 7.62mm minigun, concealed (turret front, 33 lbs., 1.65 cf, $3,700, 0.55 kW). 40mm grenade launcher (turret front, 72 lbs., 3.6 cf, $5,400).**



Ammunition

Mechanical artillery, guns and launchers all require ammunition. Each weapon's statistics include a weight per shot (WPS), volume per shot (VPS) and cost per shot (CPS) – the weight, volume and cost of a single round of ammunition. For each weapon, decide how many shots it has ready to fire, and if several types of ammunition are available, what type or mixture of types it normally has. Weapons in vehicles often carry a number of shots whose weight is about equal to the empty weapon's weight, but any amount of ammunition can be carried!

Location: Ready-to-fire ammunition must normally be located in the same location as the weapon that fires it. If the weapon is in a turret, open mount, superstructure, arm or leg, the ammunition can also be located in the part of the vehicle that subassembly is supported by.

Weight, Volume and Cost: Calculate the weight, volume and cost of each weapon's ammunition by multiplying the number of shots by its WPS, VPS and CPS.

Ammunition can also be stored in cargo spaces. This ammunition cannot be used immediately, but can replace fired "ready" shots if several minutes are spent to unpack and replenish ammo. Ammunition can be stowed in body, superstructure, pods, turrets, open mounts, arms or legs.

We decide the Kitty Hawk has 400 shots of 7.62mm solid ammunition for the minigun and 50 shots HEDP for the grenade launcher. The ammunition will be in the turret with the weapon, ready to fire. We multiply each weapon's WPS, VPS and CPS by the number of shots and then record:

***Ammunition:* 400 shots 7.62mm solid (turret, 22 lbs., 0.148 cf, $44). 50 shots 40mm HEDP (turret, 60 lbs., 0.6 cf, $550).**

EXAMPLE

Weapon Accessories

Weapons can be fitted with additional accessories to improve their performance. These include *links* allowing several weapons to be fired simultaneously by the same gunner, *special mountings* to increase the weapon's arc of fire or allow fire at high angles and *stabilizers* so the weapon can fire more accurately on the move. If any of these options are desired, refer to *Weapon Accessories* on p. 45 of the *Armaments* chapter for details.

We look through the *Weapon Accessories* section and give the Kitty Hawk's weaponry full stabilization (p. 45). We record:

***Weapon Accessories:* Full stabilization for minigun (turret, 3.3 lbs., 0.165 cf, $330). Full stabilization for grenade launcher (turret, 7.2 lbs., 0.36 cf, $720).**

EXAMPLE

D. Instruments and Electronics

Vehicles may be equipped with a variety of gadgets, instruments and electronic systems, including:

Communication Systems (p. 47) such as carrier pigeons or radios for communicating over a distance.

Sensors (p. 49) for detecting things.

Audio/Visual Systems (p. 56) for making recordings.

Navigation Instruments (p. 56) for setting accurate courses and avoiding collisions.

Targeting Systems (p. 58) for aiming weapons.

Electronic Countermeasures (ECM, p. 59) for detecting and jamming radars, radios and the like.

Computers (p. 60) for running programs that control vehicle systems and manipulating and storing information.

Neural Interfaces (p. 64) for directly interfacing between man and machine.

If the vehicle is to have equipment in these categories, refer to the referenced page in the *Instruments and Electronics* chapter and select the components to be installed.

EXAMPLE

Since money is no object, Morgan installs a plethora of specialized equipment from every category except *Neural Interfaces!* See Chapter 4 for details.

E. Arm Motors

If the vehicle was given arm subassemblies, it will need arm motors, one per arm. Refer to *Arm Motors* on p. 65 of the *Miscellaneous Equipment* chapter to design the vehicle's arm motors.

F. Miscellaneous Components

Vehicles may be fitted with a wide variety of optional equipment to tailor them for their exact roles. If the vehicle is to use any of these fittings, refer to the appropriate section for its characteristics:

Fire Extinguishers and *Bilge Pumps,* on pp. 65-66.

Heavy Equipment such as winches, extendable ladders, cranes, forklifts and tractor beams, on p. 66.

Emergency and Sick Bay Equipment such as sirens, stretchers, operating rooms and freeze capsules, on p. 68.

Entertainment Facilities such as conference rooms, swimming pools, movie projectors or holographic recreation rooms, on p. 68.

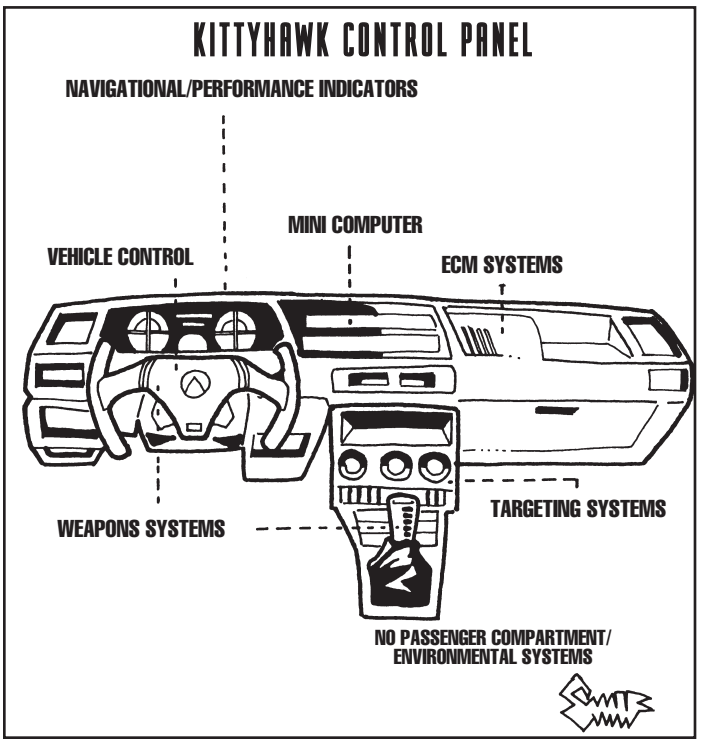
Laboratories and Workshops for conducting research or making repairs, on p. 66.

Security Systems and Dirty Tricks like burglar alarms, smoke screens, oil jets or switchable license plates, on p. 70.

Vehicle Access such as airlocks, cargo ramps and teleport projectors, on p. 69.

EXAMPLE

The Kitty Hawk has fewer miscellaneous systems than it has electronics. Morgan decides to check out what's available in *Fire Extinguishers* and *Security and Dirty Tricks* – see those sections in Chapter 5 for what was added.



G. Manned and Unmanned Vehicles

A *manned* vehicle is one with crew, passengers, or both. An *unmanned* vehicle is one that carries no crew or passengers. If the vehicle is to maneuver or use weapons or other systems it must either be manned or have a computer equipped with the *robotic* option or appropriate programs.

An unmanned vehicle that doesn't do anything on its own won't need a computer: trailers and freight cars are examples.

If the vehicle is to be manned refer to the *Crew and Passengers* chapter on p. 73 and install *vehicle controls* and assign *control stations,* determine the vehicle's *occupancy* and *crew requirement,* and add any necessary *accommodations* and *facilities.* Then consider *environmental systems* and *safety systems.*

EXAMPLE

We decide the Kitty Hawk is a manned vehicle. We refer to the *Crew and Passengers* chapter (p. 73) and determine these statistics; see Chapter 6 for details on what was installed.

H. Power Systems

Any vehicle with components that need power requires a power system to provide energy. If no components use power, skip this section. Otherwise, refer to the *Power and Fuel* chapter on p. 81 and install power plants, energy banks or both and decide which systems they power.

EXAMPLE

The Kitty Hawk has several components which require power. We end up installing a standard gas turbine and advanced batteries to handle it. See the examples in the *Power and Fuel* chapter for details.

I. Fuel

Vehicles with any propulsion system or power plant that consumes fuel must be provided with fuel.

Refer to *Fuel Bunkers* on p. 88 of Chapter 7 if the vehicle uses coal or wood fuel.

Refer to *Fuel Tanks* on pp. 88-89 of Chapter 7 if the vehicle uses any other type of fuel.

The fuel tank rules can also be used to install additional water tankage for non-fuel purposes (e.g., drinking, water cannons) or to design storage tanks for shipping chemicals.

Fuel Accessories: Vehicles may be equipped with devices for transferring fuel to other vehicles or collecting or processing raw materials for use as fuel. See *Fuel Transfer and Processing Equipment* on p. 71.

EXAMPLE

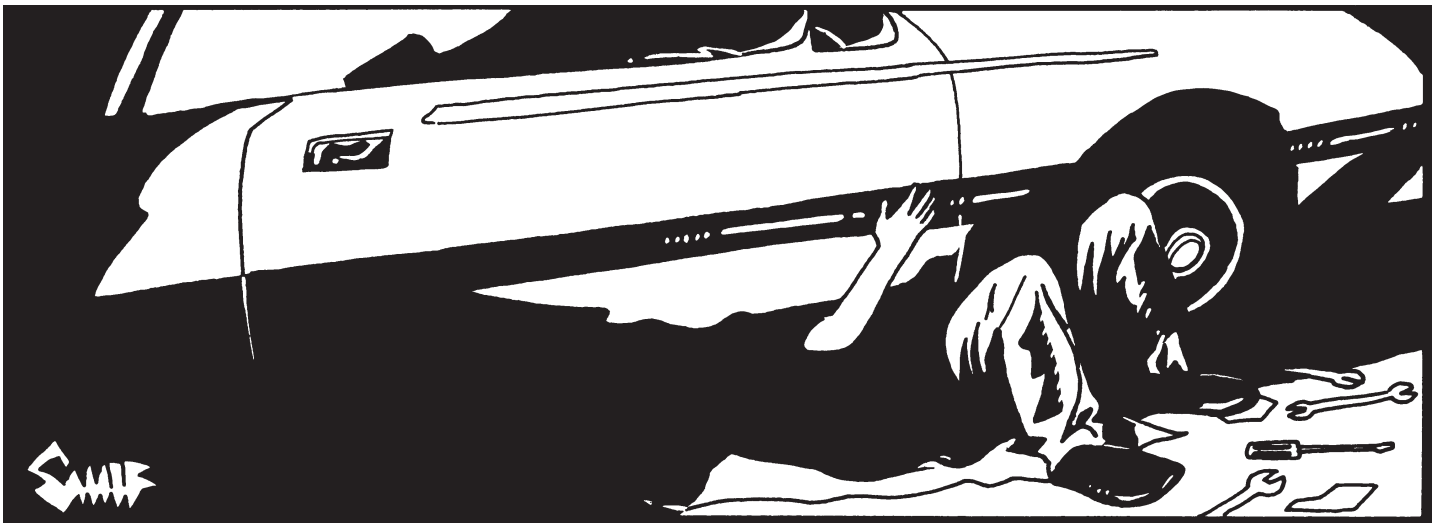
The Kitty Hawk's jet and its gas turbine both use fuel. We install a 60-gallon, light, self-sealing tank. See the *Fuel* section (p. 88) in Chapter 7 for details.

J. Access, Cargo and Empty Space

These are spaces in a vehicle that do not contain other components.

Access Space

Access space is the space needed to allow maintenance to be performed, either from within or without the vehicle. Access space is *optional* for vehicles that are unmanned or which have *only* battlesuit, cycle or harness crew stations (see p. 74).



When powered propulsion systems or power plants are located anywhere but in a pod, access space must be added to that same location. Access space has no weight or cost, but has volume equal to the power or propulsion system's volume. *Exception:* if the vehicle is designed for long occupancy, access space volume is *doubled.*

EXAMPLE

The Kitty Hawk's wheeled drivetrain, hydrojet, jet engine and gas turbine all require access space. Their total volume adds up to 26.64 cf, so we add access space equal to that in the same location, listed as "Access space (body, 26.64 cf)."

Cargo Space

This is storage space inside the vehicle. It may range from a trunk or glove compartment to a giant cargo hold. A vehicle may have several different cargo spaces. Each cargo space is rated for its location in the vehicle and its volume in cubic feet. Cargo space can also be pressed into service to carry standing passengers, at 20 cf per person.

Cargo spaces can be located in the body, pods, superstructures, turrets, arms, legs, open mounts or wings.

Hidden Cargo (TL1): If a vehicle has cargo space, some or all of it may be divided into one or more concealed secret compartments. If someone searches the vehicle, the secret compartment can be found on a roll vs. Holdout skill. Subtract 10; add +1 per 2% of a vehicle's total volume that is hidden. Hidden cargo costs $20 per cf of hidden cargo space.

Open Cargo: Some or all of a vehicle's cargo (except for hidden cargo) can be designated as "open." This is a cargo bed whose upper half is open to the elements (or covered with a soft fabric). Each cubic foot of open cargo effectively takes up only one-half cf of space in the vehicle because of this.

EXAMPLE

Morgan gives the Kitty Hawk a 6-cf cargo space – the trunk. We record: "6 cf cargo (body, 6 cf)."

Empty Space

Empty space is volume left unused in the vehicle and not set up for cargo stowage. Empty space can be located in the body, pods, arms, legs, open mounts, wings, superstructures or turrets. It has no weight or cost, only a location and a volume in cf.

Leaving empty space in a vehicle can also provide a vehicle with "growth potential" – that is, room for future modifications as new equipment becomes available.

Cubic feet of empty space may also be added to the body or a subassembly while working out its volume (see *Volume of Body and Subassemblies,* below). This is done to even out the size of a particular body or subassembly, or simply to make it larger.

Morgan won't add any empty space yet; we'll wait until the Kitty Hawk's volume is determined.

EXAMPLE

Part IV: Volume and Structure

With all the components selected, we can now determine how large the body and each subassembly actually is, and what kind of structure the vehicle will require.

Volume of Body and Subassemblies

Find the volume of the body and each subassembly, in the order listed; skip any subassemblies the vehicle doesn't have.

A. Open Mounts

For each open mount the vehicle has, add up the volume of all components located in it. Extra cubic feet of empty space can also be added. Every open mount must contain at least some volume, even if it is only empty space! Add up the total volume of components (including any cargo and empty space) in the mount.

Volume of rotating open mounts is increased: multiply volume by 1.1 if limited rotation or 1.2 if full rotation. The result is the *volume* of that particular open mount subassembly.

B. Turret Volume

If a vehicle has multiple turrets stacked one on top of another, calculate their individual volumes beginning with the outermost turrets and working inwards. For each individual turret, add up the volume of all components located in it, along with any additional empty space to find the total component volume.

If a turret has *slope* its volume will be increased. Add up the total degrees of slope that turret's different faces have, and then multiply the turret's total component volume (including empty space) as follows: ×1 if no slope, ×1.1 if 30°, ×1.25 if 60°, ×1.4 if 90°, ×1.6 if 120°, ×2 if 150°, ×2.5 if 180°, ×3.3 if 210° or ×5 if a total of 240°.



The sum of component volume (including empty space) multiplied by slope, if any, is the turret's real volume. A turret must have a real volume at least equal to the combined volume of all open mounts or other turrets or superstructures it is supporting. If it doesn't, add more empty space to increase its volume.

Every turret has a rotation space. This is effectively a component which takes up volume in whatever body or subassembly the turret is supported by. This rotation space is 0.1 times a limited rotation turret's volume, 1.1 times a limited pop turret's volume, 0.2 times a full rotation turret's volume, or 1.2 times a full rotation pop turret's volume.

EXAMPLE

We add up the volume of everything in the Kitty Hawk's pop turret: that's the minigun, grenade launcher, stabilization gear, ammunition, thermograph and periscope. It works out to 7.063 cf, which isn't aesthetically pleasing, so we add some cf of empty space (turret, 0.9370 cf) and get it up to an even 8 cf. The turret doesn't have slope, but as it is a full rotation pop turret its rotation space is 1.2 × 8 = 9.6 cf. Since it's attached to the body, it will take up this space in the body as if it were a component. We record:

Volumes: **Turret (8 cf) takes up 9.6 cf in body.**

C. Arm, Superstructure and Pod Volume

The volume of arms, superstructures and pods is calculated in much the same way as turrets, except they do not take up rotation space. Total the volumes of all components placed in that particular subassembly, including cargo space, and then decide if any extra empty space is to be added. If a superstructure directly supports a turret, add the turret's rotation space to its volume. If a superstructure has slope, its volume is multiplied as for turrets, above. Pods and arms do not have slope. The sum of component volume (including empty space) multiplied by slope, if any, is the subassembly's real volume.

A superstructure must have a minimum volume at least equal to the combined volume of all open mounts, turrets or superstructures it is supporting. If its volume is less, add more empty space!

D. Body Volume

To find body volume, add up the sum of the volume of all components located in the body, including cargo space. As with turrets, cubic feet of empty space can also be added. If the body is directly supporting any turrets, add that turret's rotation space. This gives the body's total component volume. If the vehicle has masts, the body's total component volume must also be at least (tallest mast height/4) cubed. If it isn't, add empty space to further increase volume. If trying to duplicate a real-life ship whose size is known, a good rule of thumb is to make the body's volume equal to about 35 cf per displacement ton, adding empty space as necessary to meet this. So, a 1,000-ton ship's body should be approximately 35,000 cf.

This volume will be increased if the body has certain features:

Catamaran or Trimaran Hull ×1.3.

Submersible Hull: ×1.25.

Streamlining: ×1.1 if Fair, by ×1.2 if Good, ×1.25 if Very Good, ×1.3 if Superior, ×1.35 if Excellent, or ×1.4 if Radical.

Hydrodynamic Hull: ×1.1 if Mediocre lines, ×1.2 if Average or Submarine or ×1.3 if Fine or Very Fine.

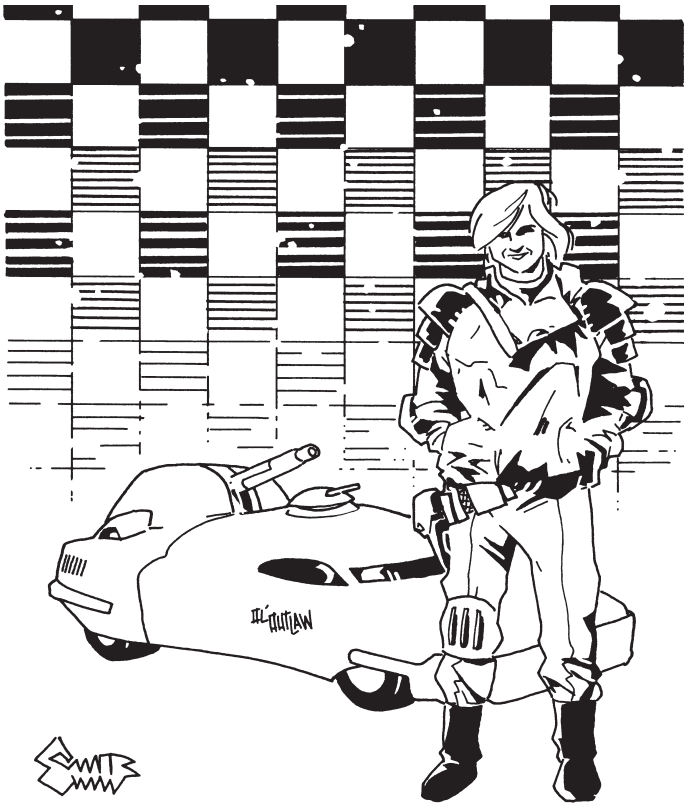
Slope on Body: Add together the total degrees of slope on the body's different faces. Multiply by an amount based on that total: ×1.1 if 30°, ×1.25 if 60°, ×1.4 if 90°, ×1.6 if 120°, ×2 if 150°, ×2.5 if 180°, ×3.3 if 210° or ×5 if 240°.

Retractable Wheels/Skids: Multiply by ×1.075 if the vehicle has skids or retractable wheels that retract only into the body. Multiply by ×1.025 if it has skids or retractable wheels that retract into both the body and the wings.

The sum of component volume (including empty space) multiplied as shown above is the body's real volume. All multipliers are cumulative, e.g., a body with 40 cf of components and empty space, a submersible hull and Average lines would be 40 × 1.25 × 1.2 = 60 cf.

The real body volume must exceed the combined volume of all turrets, arms, open mounts, superstructures and pods directly attached to the body. If it doesn't, go back and add more empty space.

Flotation Rating: If the vehicle has the flotation hull feature, multiply the "flotation per cf" by the final body volume to get the actual flotation rating in pounds. This is the amount of weight that the hull can support without sinking. Exception: for submersible vehicles, multiply flotation by the sum of body, superstructure and turret volumes.



At this stage in the design, the flotation rating should ideally be about twice the weight of the vehicle's components and cargo weight. This will leave weight for the structure, armor, and so on. If an estimate of their weight indicates the vehicle is heavier than this, add more empty space to the body to increase its volume so that it will have a greater flotation rating!

EXAMPLE

First we add up the volume of everything in the body. In the Kitty Hawk, that's everything that didn't go in the turret and it adds up to 179.315 cf, including the turret's 9.6 cf rotation space. We decide that isn't neat enough, so we add some empty space (body, 0.685 cf) to raise it to a total component volume of 180 cf and leave room for later options. Next, we multiply by 1.25 for the submersible hull and 1.1 for Fair streamlining to get a real body volume of 247.5 cf. This gives it a flotation of 247.5 × 62.5 = 15,468.75 lbs.

At this point we do a quick weight check to make sure that the contragrav generators can lift the vehicle – remembering it will get heavier as we add the hull – and that the flotation hull can support it: yes, the weight looks fine so far.

E. Wing Volume

To determine a wing's volume, first add up the volumes of all components located in that wing, including cargo space.

Then, if the vehicle has wheels or skids that retract into both wing and body, they count as components. Add 0.025 × *body* volume to each wing for retractable skids or wheels.

Cubic feet of empty space can also be added to a wing. A typical wing's volume should be about 0.1 × of the body volume. (A larger wing will increase maneuverability and allow shorter takeoffs and landings, at the expense of reduced top speed; a smaller wing has the opposite effect.) Many wings contain mostly empty space to make up this volume. *Exception:* Stub wings, which don't need to provide lift, are normally about 0.02 × body volume. A vehicle with a lifting body can also get by with a wing this small, although it can have a full size one if desired.

Add up the sum of the volume of all components and empty space in each wing: this is that wing's real volume. Each wing must have the same volume; if one wing works out larger, add empty space to the other so they match.

F. Leg Volume

For each leg the vehicle has, add up the volume of all components located in it. Empty space can also be added to the leg. Each leg requires a minimum volume to support the vehicle: 0.4 × body volume divided by the number of legs. Thus, in a vehicle with two legs, each leg must be 0.2 × body volume, while on one with four legs, each must be 0.1 × body volume. Each leg must also be the same volume. If the legs don't have the required minimum volume or match up, add additional cubic feet of empty space to them.

G. Gasbag Volume

A gasbag envelope's volume is equal to the volume of the lifting gas located within it.

H. Masts

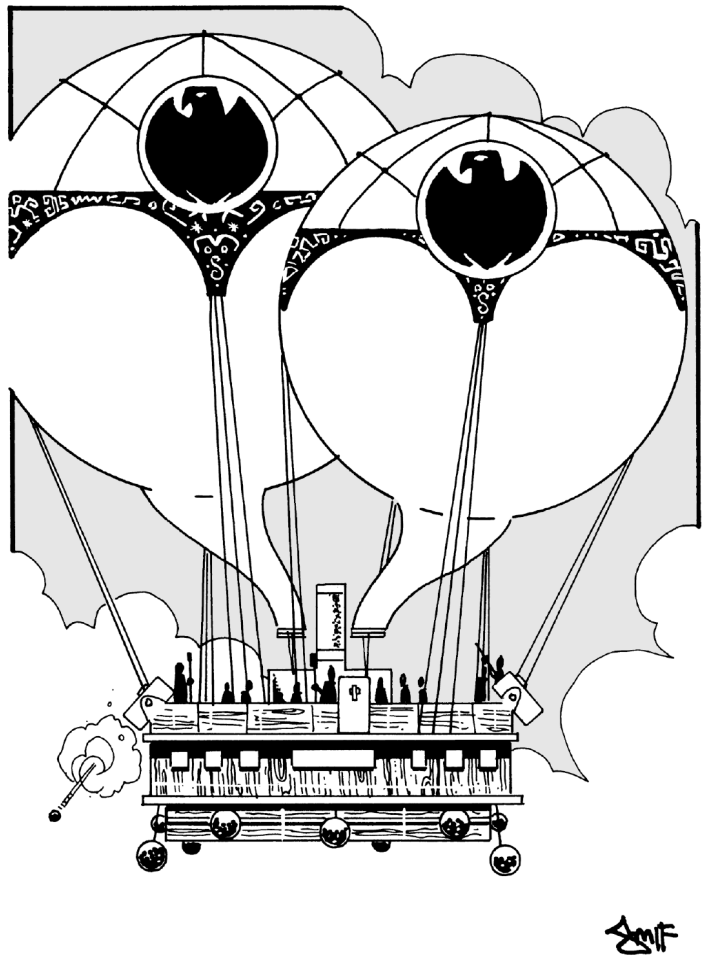
A mast's volume in cf is (height in feet cubed)/10,000.

I. Volume of Other Subassemblies

The other subassemblies don't contain components, but do have volume, which is entirely taken up by their internal structures and, in some cases, by steering and suspension systems.

Skids volume is 0.05 × body volume. Note that this is the combined volume of all of the skids together, not each individual skid.

Wheels volume depends on the type of wheels. It is 0.05 × body volume for small or retractable wheels, 0.1 × body volume for standard wheels, or 0.2 × body volume for heavy, off-road or railway wheels. As



with skids this volume is not per wheel, but includes all the subassembly's wheels as well as the suspension systems and, at late TL5 and up, the tires.

Tracks volume is 0.6 × body volume. This is the volume of all tracks together, rather than per track, and also includes suspension and running gear.

Halftrack or Skitrack volume is 0.4 × body volume. Note that this is the volume of all tracks together, not per track. It includes both the tracks and the wheels or skis.

Ground-Effect Skirt volume is 0.6 × body volume.

SEV Sidewalls volume is 0.4 × body volume.

Hydrofoils volume is 0.15 × body volume, for all foils.

Rotor volume is 0.02 × body volume for autogyro, TTR or CAR rotors, 0.02 × body volume *per* main rotor for MMR.

EXAMPLE

The Kitty Hawk's only other subassembly is its standard wheels. They take up 0.1 cf × body volume; since body volume is 247.5 cf, the wheels require 24.75 cf.

Surface Area

Each body or subassembly is rated for its surface area ("area"). Area is an approximation of the body or subassembly's area in square feet, and is also a convenient number used to help calculate the vehicle's structural weight, cost, hit points and other attributes.

Calculate the surface area individually for the body and then for each subassembly. To do so, look up that body or subassembly's volume in the Volume column, and then read the surface area from the Area column directly to the right of the volume. If a value falls between two numbers, use the lower.

Area Table

Volume (cf)	Area (sf)	Volume (cf)	Area (sf)	Volume (cf)	Area (sf)	Volume (cf)	Area (sf)
under 0.03	0.5	3.3-3.5	14	25-31	60	3,376-6080	2,000
0.03-0.06	1	3.6-3.9	15	32-44	75	6,081-8,495	2,500
0.07-0.12	1.5	4.0-4.3	16	45-68	100	8,496-11,180	3,000
0.13-0.19	2	4.4-4.7	17	69-95	125	11,181-17,185	4,000
0.2-0.26	2.5	4.8-5.1	18	96-125	150	17,186-24,110	5,000
0.27-0.3	3	5.2-5.6	19	126-157	175	24,111-35,650	6,500
0.4-0.5	4	5.7-6.0	20	158-188	200	35,651-48,650	8,000
0.6-0.75	5	6.1-6.5	21	189-268	250	48,651-68,025	10,000
0.8-1.0	6	6.6-7.0	22	269-353	300	68,026-89,440	12,000
1.1-1.25	7	7.1-7.4	23	354-543	400	89,441-125,000	15,000
1.3-1.5	8	7.5-8.0	24	544-759	500	125,001-192,420	20,000
1.6-1.8	9	8.1-8.4	25	760-1000	600	192,421-268,960	25,000
1.9-2.2	10	8.5-9.5	27	1,001-1,540	800	268,961-353,450	30,000
2.3-2.5	11	9.6-11	30	1,541-2,150	1,000	353,451-544,335	40,000
2.6-2.8	12	12-17	40	2,151-2,830	1,200	544,336-760,610	50,000
2.9-3.2	13	18-24	50	2,831-3,375	1,500	760,611-1,000,000	60,000

EXAMPLE

The Kitty Hawk's 247.5 cf body has a surface area of 250 sf. Its 8 cf pop turret has a surface area of 24 sf. Its 24.75 cf wheels have a surface area of 50 sf.

For larger surface areas use this formula:

Surface area = [(cube root of volume) squared] × 6.

Round to nearest 10,000 sf.

(If desired, the formula can be used instead for *all* volumes, replacing the rounded-off surface areas given above.)

The surface area of wing and rotor subassemblies is greater than that shown on the table. Multiply the surface area of each wing or rotor as follows: standard or flarecraft wings (x1.5), high agility or STOL wings (x2), biplane wings (x3), rotors (x3), triplane wings (x4).

Total and Structural Surface Area: Once the surface area of the body and all mounts and subassemblies are known, find the *Total Area* by adding together the sum of all their surface areas. Then, subtract the surface area of masts, open mounts and gasbag subassemblies; record the remaining surface area as the *Structural Area.* If a vehicle has neither open mounts, masts nor gasbags, simply record the Total Area.

Arms and Area: Arms will have a Reach (p. B102) in yards of 0.5 × the square root of their area, rounded to the nearest whole number.

EXAMPLE

The Kitty Hawk's total surface area is 324 sf. Its structural surface area is the same.

Structures

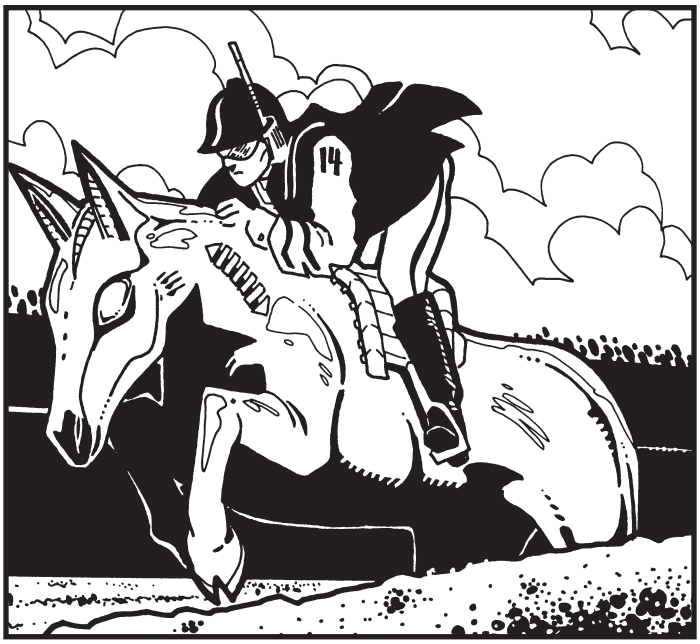
After structural surface area is calculated, the vehicle's internal skeleton and frame – its structure – can be designed. A vehicle's structure can be modified with various structural options, which affect the structure's weight and cost.

Choose the vehicle's frame strength and material quality. A vehicle can also be given a *special structure.*

Frame Strength: Select one of the following frame strengths for the vehicle. The heavier the frame strength, the stronger the vehicle, but the more its structure will weigh and cost:

Super-light, typical of balloons, airships and early spacecraft.

Extra-light, typical of chariots, wagons, early biplanes and simple boats.



Light, typical of galleys, sail boats and speedboats, most cars, light planes and civilian starships.

Medium, typical of transport aircraft and Age-of-Sail warships.

Heavy, typical of modern steamships, motorcycles, heavy trucks, many modern-day commercial ships and most armored vehicles, late WWII fighter aircraft and modern jet bombers.

Extra-heavy, typical of locomotives, modern jet fighters and most metal-hulled warships.

Materials: Decide what quality of construction materials were used in the vehicle's structure. Vehicles are normally built using standard quality materials. Instead, they can use very cheap or cheap materials which make the vehicle's structure less costly but heavier. Or they can use costlier expensive, very expensive or advanced materials that make the structure lighter without sacrificing any strength. Very expensive materials are unavailable before TL5, and advanced materials are not available before TL6.

Special Structures: These are options for any vehicle that meets certain conditions. Unless specifically noted, a vehicle can combine these options.

Robotic Structure (TL7) – This is *required* if the vehicle has a computer with the robot brain option, and is unavailable otherwise. It provides the necessary systems and internal data highways to enable the vehicle to be controlled entirely by the robot brain.

Responsive Structure (TL8) – This option gives the vehicle a body that automatically alters its structural shape to best adjust to different speeds, maneuvering regimes or G-forces. At TL8, this option can only be added if the vehicle uses advanced or very expensive materials; at TL9, the vehicle may not use cheap or very cheap materials, and at TL10+, any materials are compatible with it.

Biomechanical Structure (TL9) – This is a different kind of vehicle body, built of a mix of organic and mechanical parts. A vehicle with a biomechanical structure can feel pain and become infected with a disease, but can also heal itself. A biomechanical structure heals 1 hit point per day for its body and each subassembly on a successful HT roll.

Living Metal Structure (TL13) – This gives the vehicle a structure built of living metal, a nanotechnological material that is capable of self-regeneration. The tiny "nanobots" contained within the living metal structure will repair damage to the vehicle at 1 hit point per hour (as long as the vehicle isn't utterly destroyed). They also perform routine maintenance. If the vehicle has damaged or ablated armor, this also regenerates at the same rate. A living-metal structure also enables the vehicle to dispense with regular internal and external doors – the vehicle just "opens" a hole in the wall to allow access, then seals it afterward. A living-metal structure cannot be combined with a biomechanical structure.

Some previous body features or design choices will also affect the weight and cost of the structure:

Submersible Hull: A vehicle given a submersible hull will have a structure that is heavier and more costly due to the need to add a double hull design, add diving planes, and strengthen the hull and external structures (turrets, mounts, etc.) to resist the stress of diving and surfacing.

Wings/Rotors: A vehicle with wings or rotors must be very carefully designed to enable it to fly. Even things like turrets and pods will influence the vehicle's aerodynamics, thus the cost increase is based on the total surface area. However, if the vehicle has both wings *and* rotors, the cost increase is applied only *once,* not once for each feature.

Streamlining: This also increases the overall cost of the vehicle, for similar reasons to wings and rotors above.

Flexibody Drivetrain: If the vehicle has a flexibody drivetrain, the structure will be heavier and more expensive due to its unique construction.

Refer to the table below to find the structural weight and cost of the vehicle:

Vehicle Structure Table

Feature	*Basic Design Weight*	*Basic Design Cost*
TL0-1 structure	20	$5
TL2-4 structure	18	$5
TL5 structure	12	$5
TL6 structure	8	$10
TL7 structure	6	$50
TL8 structure	4	$50
TL9 structure	3	$50
TL10 structure	2	$50
TL11 structure	1.5	$50
TL12+ structure	1	$50
Frame Strength	***Weight Multiplier***	***Cost Multiplier***
Super-Light	×0.1	×0.1
Extra-Light	×0.25	×0.25
Light	×0.5	×.5
Medium	×1	×1
Heavy	×1.5	×2
Extra-Heavy	×2	×5
Materials		
Very Cheap	×2	×0.2
Cheap	×1.5	×.5
Standard	×1	×1
Expensive	×0.75	×2
Very Expensive	×0.5	×5
Advanced	×0.375	×10
Special Structure		
Responsive	×1	×1.5
Robotic	×1	×2
Biomechanical	×1	×1.5
Living Metal	×1	×2
Other Modifiers		
if Submersible	×2	×2
if Wings or Rotors	×1	×10
if Fair streamlining	×1	×1.2
if Good streamlining	×1	×1.5
if Very Good streamlining	×1	×2
if Superior streamlining	×1	×3
if Excellent streamlining	×1	×5
if Radical streamlining	×1	×10
if Lifting Body	×1	×1.2
if Flexibody Drivetrain	×2	×2

Weight: Determine the structural weight as follows: Multiply the vehicle's structural surface area (that is, the total surface area minus masts, open mounts and gasbags) by the basic design weight shown for the vehicle's TL and then by every applicable multiplier in the *weight* column.

Cost: Determine the structural cost as follows: Multiply the structural surface area by the basic design cost shown for the vehicle's TL and then by every applicable multiplier in the *cost* column.

Wooden Structures: Since wood is flammable, it's important to know what vehicle structures use it. At TL4- all structures are wooden. At TL5, super-light, extra-light, light and medium structures and very cheap heavy structures are wooden. At TL6, very cheap super-light, extra-light and light structures are wooden. At TL7+, no structures are normally wooden. If desired, any vehicle can use a lower TL structure – this can be used to build a less expensive wooden boat at TL7+.

EXAMPLE

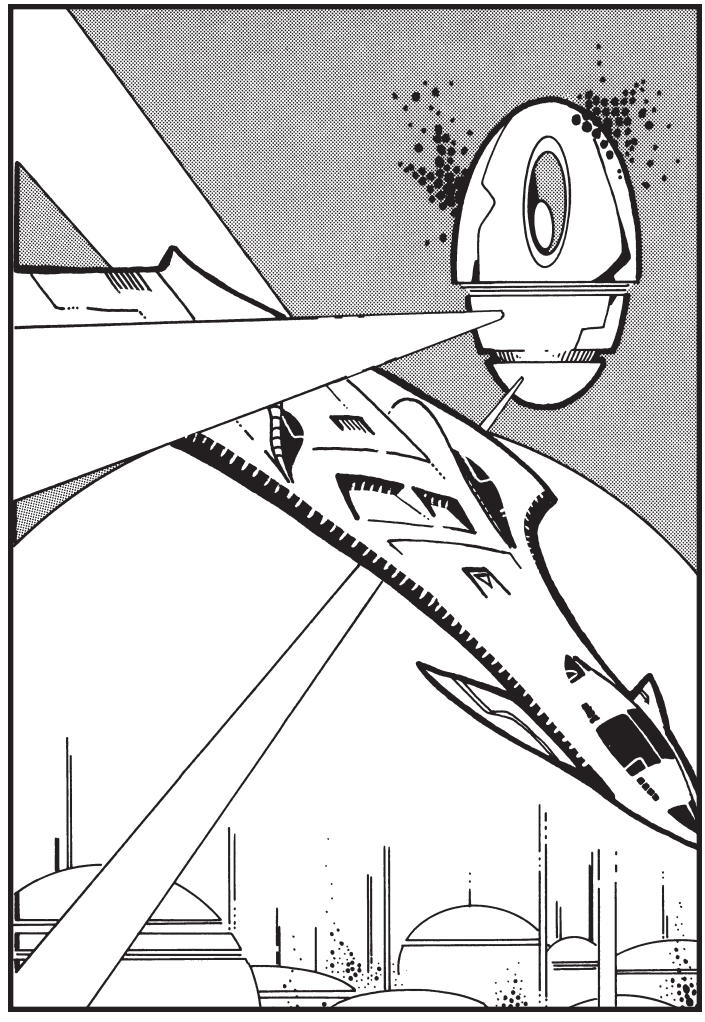
We decide the Kitty Hawk has a light frame built with very expensive materials. The fact that it is submersible and streamlined will also affect its structural weight and cost. Weight is 6 lbs. (TL7 structure) × 0.5 (light frame) × 0.5 (very expensive materials) × 2 (submersible) × 1 (Fair streamlining) × 324 (structural area) = 972 lbs. Its cost is $50 × 0.5 (light frame) × 5 (very expensive materials) × 2 (submersible) × 1.2 (Fair streamlining) × 324 = $97,200. We record: *Structure:* Light frame, very expensive materials modified by streamlining and submersible (972 lbs., $97,200).

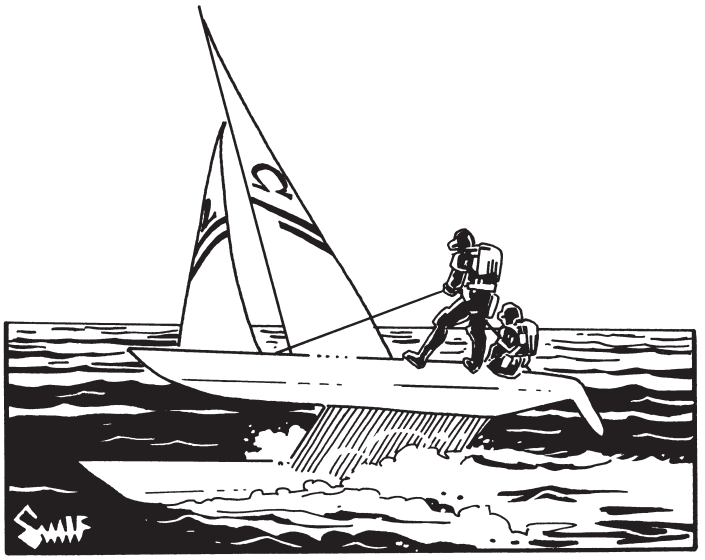
Option: Different Structures for Subassemblies

Subassemblies may optionally be given different structural strengths, materials and special structures than the body. The exception is Responsive Structure, which must be applied to all subassemblies if it is applied to any.

For example, a spaceship might have expensive, medium-strength materials for the vehicle itself, but standard, extra-light material for pods that house nothing but fuel or cargo.

If so, instead of calculating structural weight and cost based on total surface area, calculate it based on the individual body or subassembly's area using only those structural options it has. The multiples for features like streamlining, wings/rotors or submersible apply to all subassemblies, however.





Weight and Cost of Masts, Open Mounts and Gasbags

Gasbags, masts and open mounts do not count against the structural weight and cost of the vehicle. However, they do have their own weights and costs which must be determined.

For each open mount or mast, multiply its surface area as shown below to find its weight and cost:

Mast and Open Mount Weight and Cost Table

TL	*Weight*	*Cost*	*TL*	*Weight*	*Cost*
5-	12	$10	9	3	$10
6	8	$10	10	2	$10
7	6	$10	11	1.5	$10
8	4	$10	12+	1	$10

For each gasbag subassembly, multiply its surface area as shown below to find its weight and cost. This covers the bag and the cables, ropes or keel needed to attach it to the vehicle.

Gasbag Weight and Cost Table

TL	*Weight*	*Cost*	*TL*	*Weight*	*Cost*
5-	0.012	$0.003	9	0.003	$0.01
6	0.008	$0.005	10	0.002	$0.01
7	0.006	$0.01	11	0.015	$0.01
8	0.004	$0.01	12+	0.001	$0.01

Hit Points

Once the vehicle's structure has been determined, find the hit points for the vehicle's body and for each subassembly:

Body . . . . . .the body's area × 1.5.
Each Arm . . . . . .the arm's area × 3.
Each Superstructure, Turret or Pod . . . . . its area × 1.5.
Each Leg . . . . . the leg's area × 1.5.
Each Wing . . . . . its area × 1.5.
Each Rotor . . . . . .its area × 3.
Ground-effect skirt or SEV sidewalls . . . . . its area × 1.5.
Each Skid . . . . . .skid subassembly area × 1.5 / number of skids.
Each Track (for Tracks, Skitracks, or Halftracks) . . . . . subassembly area × 1.5 / number of tracks.
Each Gasbag . . . . . its area × 0.01.
Each Mast or Open Mount . . . . . its area × 2.
Each Wheel . . . the wheel's area × 3 / number of wheel positions.

Except for gasbags, masts and open mounts, divide hit points by 10 if a super-light frame, 4 if an extra-light frame or by 2 if a light frame, or multiply hits by 2 if a heavy frame or 4 if an extra-heavy frame. Round hit points to the nearest whole number, with a minimum of 1 hit point.

Optionally, calculate component HPs (p. 183).

EXAMPLE

The Kitty Hawk's body has 250 (surface area) × 1.5 / 2 (light frame) = 187.5, rounded up to 188 hit points. Its turret has 24 (its area) × 1.5 / 2 (light frame) = 18 hit points. Each of its four wheels have 50 (wheels' area) × 3 / 4 (four wheels) / 2 (light frame) = 18.75 per wheel, rounded up to 19 hit points per wheel.

Special Structural Options

These options may be added after the structural weight and cost of the vehicle have been determined:

Compartmentalization (TL5)

Most large vehicles are divided into several compartments automatically. But a vehicle built at TL5 or higher can optionally be given Heavy or Total compartmentalization. This is most common on carefully-designed warships, but other vessels (such as well-protected space and ocean liners, battle tanks or ground attack aircraft and almost all submarines) use it as well.

The compartmentalization option gives a vehicle strengthened air- and water-tight interior walls and extra-strong pressure doors. It also covers careful spacing of fuel and power systems to reduce risk of fire, flooding or decompression.

Compartmentalization may be added to the body, as well as to turret or superstructure subassemblies. Heavy compartmentalization weighs one-tenth of the vehicle's structural weight divided by the total structural area of the vehicle and multiplied by the combined surface areas of the compartmentalized body or subassembly locations. Total compartmentalization weighs twice as much. Cost is $1 times the weight of the compartmentalization at TL6-, $5 times its weight at TL7+.

Improved Suspensions (TL7)

Any vehicle with skids, wheels, tracks, legs, halftracks, skitracks or a flexibody drivetrain can have an improved suspension. An improved suspension increases top ground speed and overall ground maneuverability and stability. There is no extra weight. The cost is $100 times the surface area of the motive subassembly (for wheels, tracks, etc.) – or for a flexibody drivetrain, $50 times the surface area of the body.



EXAMPLE

The Kitty Hawk has an improved suspension. The wheels' surface area is 50, so it costs $5,000.

Wing and Rotor Options

Folding Wings and Rotors (late TL6): Any type of wing or rotor may be designed to fold for compact stowage; this is common for carrier-borne aircraft, so they can better fit into hangars. Folding wings or rotors weigh 0.05 times the combined wing or rotor area divided by the total structural area and multiplied by the structural weight (in lbs.). They cost $25 per pound.

Variable Sweep Wings (TL7): Any standard, STOL or high-agility wings may have this option. It gives the vehicle "variable geometry" swing-wings capable of sweeping back for high speed dashes, or outward for greater lift and maneuverability. Swing-wings give a vehicle a lower stall speed (and hence a shorter takeoff and landing) and greater agility without any increased drag. The only drawbacks are the extra weight and cost. Swing-wings may have either manual or automatic wing sweep. The latter is more expensive but more effective. The option weighs 0.1 × (combined wing area/total structural area) × structural weight (in lbs.) and costs $0.25 × (combined wing area/total structural area) × structural cost. Double cost if automatic sweep! (See also p. 160.)

Controlled Instability (late TL7): This option designs a winged or rotor-equipped vehicle so that it is teetering on the edge of total instability. This makes it wildly agile in flight, but means it requires computerized or robotic controls to assist the pilot. If the computers ever fail, the aircraft will go out of control and crash! Winged aircraft featuring controlled instability often have somewhat odd wing designs, such as canards (small wings on the front of the fuselage) or forward-swept wings. Controlled instability costs $100 times the combined wing or rotor surface area.

Wheel Options

These options can be added to any vehicle with wheels:

Improved Brakes (TL7), such as anti-lock brakes. They add 5 mph/s to safe ground deceleration. The cost of improved brakes is $20 × the surface area of the wheels. The cost halves at TL8 and again at TL9+.

All-Wheel Steering (TL7): This option significantly increases maneuverability on the ground, as described in the *Performance* chapter. The cost of all-wheel steering is $100 times the surface area of the wheels, with a minimum cost of $5,000. Cost and minimum cost are halved at TL8 and again at TL9+.

Smartwheels (TL8): This option equips wheels with sensors that detect road conditions and wheels or tires that change their shape in response, increasing overall maneuverability. The effect is cumulative with bonuses for all-wheel steering and improved suspension. The cost of smart wheels is $80 × surface area of the wheels, with a minimum cost of $4,000. This cost halves at TL9 and again at TL10+. Smartwheels do not function if the vehicle loses power.

EXAMPLE

The Kitty Hawk has improved brakes (wheel area × $20 = $1,000) and all-wheel steering (wheel area × $100 = $5,000).

Roll Stabilizers (TL7)

Some modern water vehicles are fitted with these fin-like devices, which increase the stability of the vehicle in the water. A set of roll stabilizers weighs 0.05 × (body area/total structural area) × structural weight (in lbs.) and costs $0.1 × (body area/total structural area) × structural cost.

Part V: Surface Features

Surface features are layered atop the vehicle's structure and include things such as armor and stealth coatings.

A. Armor

This is a vehicle's hull. "Armor" includes both ordinary surface plating – whether it is wood, metal or other material – as well as actual armor plate. Almost every vehicle will have armor covering some part of its body. Vehicular armor is rated for its Damage Resistance (DR), the location it covers and the type of armor material. A vehicle with a flotation hull, submersible hull, slope, streamlining or rotors must have armor! Other vehicles may have armor. The only type of vehicle not likely to have armor is one where the components are not sheathed by the body's hull, such as a motorcycle.

EXAMPLE

Because the Kitty Hawk is submersible and streamlined, it must have armor.

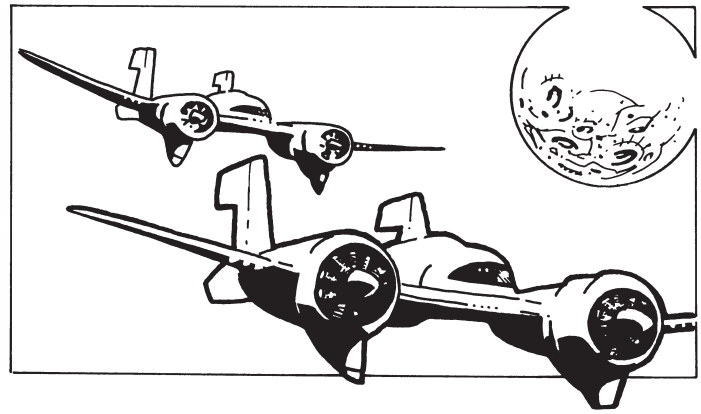
There are several kinds of armor: wood, metal, composite, laminate, ablative, nonrigid and reflex.

Wood (TL0) is just that. Wood is normally available in cheap, standard or expensive versions. Cheaper wood uses soft woods like pine, while more expensive wood has better workmanship and harder woods such as swamp oak or teak. Wood has a higher weight per point of DR than other armor types and is flammable, but it is inexpensive and is the standard vehicle armor until late TL5. Wooden armor becomes available in advanced type at TL10+, representing new and tougher bioengineered forms of wood.

Metal (TL1) is the most common armor material from late TL5 to TL7 due to its high strength-to-weight ratio. Metals in use include riveted iron and steel at TL5, cast or welded steel and aluminum at TL6, and aluminum, steel and titanium alloy at TL7. At TL8+ exotic materials appear including alloys created in zero-gravity conditions or, later, those built using nanomachines. No special rules apply to the DR provided by metal armor.

Composite (TL7) armor built at TL7 is made of materials such as rigid, resin-bonded Kevlar and carbon-aluminum composites, while ultra-tech composite armor may use far more exotic materials. It has the same DR as metal armor and weighs less, but it costs more. However, it is somewhat less sturdy and provides only half DR against crashes and collisions.

Laminate (TL7) armor has greater DR for its weight than metal armor, and its complex composition is formulated to resist shaped-charge



(HEDP and HEAT) rounds, giving *doubled* DR against them. An example is the Chobham armor used on modern, Western tanks: a sandwich of outer and inner hard steel plates containing layers of ceramic blocks held within a special resin, the whole sometimes reinforced with a metallic mesh. TL8+ laminate armor may be even more exotic: BPC (biphase carbide) from ***Ogre*** is an example.

Ablative (TL7) armor is easily chipped or melted away (ablated). This ablative process carries away part of the energy of the attack, but as the armor ablates, its DR is reduced. For every 10 points of damage an attack inflicted (regardless of whether its damage penetrated DR or not) one point of DR is destroyed afterward! For body, turret or superstructure armor, this loss only applies to the armor on the face being attacked. Lost DR can be replaced on the same basis as HP of damage are repaired. At extra expense, *Fireproof Ablative* material is also available.

Ablative armor built at TL7 is usually derived from glass-reinforced plastics such as fiberglass, while fireproof armor may use a ceramic coating. At TL8 and up, more sophisticated plastic-composite materials come into use – if a vehicle designer doesn't mind the fact that the armor can be blasted away, this makes ablative armor a very good choice, since it has an even lower weight per point of DR than laminate. The plastic armor used to protect ***Car Wars*** autos is TL8 expensive ablative armor.

Nonrigid (TL0) armor is made of very light, flexible material. It gets only one-quarter its normal DR vs. collisions or crashes. TL5- nonrigid armor uses bark, leather or cloth and is flammable. TL6 nonrigid armor uses synthetic materials like nylon. TL7 armor uses Kevlar, TL8-9 uses monocrystalline fibers while TL10+ uses nanotechnological materials such as "bioplas."

If an explosion, crushing or cutting attack hits a nonrigid armored vehicle, any roll on the damage dice of 5-6 (at TL7-) or 6 (at TL8+) inflicts 1 hit that is not absorbed by nonrigid DR. TL7 nonrigid armor gets only DR 1 vs. impaling attacks and TL8-9 nonrigid armor has a maximum DR 2 vs. impaling attacks. TL10+ nonrigid armor has full DR vs. impaling damage and can also "heal" itself to repair any rips or tears.

Reflex Armor (TL10) is electrically-active bioplastic armor with built-in sensors that turn it hard as steel just before suffering an impact. Normally it is treated as nonrigid armor, but its DR *doubles* and it protects like metal armor if its sensors detect the incoming attack in time. It automatically detects melee or thrown weapons, crashes or collisions, and low-velocity projectiles such as arrows. Most gun projectiles, missiles and sonic beams are detected on a roll of 14 or less on 3d. Electromag or gravitic gun rounds are detected on a 12 or less. Laser, blaster or other beam weapons are too fast to detect in time. Reflex armor's DR (before doubling) is limited to 5 × TL.

Selecting Armor

There are two ways to build armor: Overall Armor or Location Armor. Overall Armor is simplest, selecting a single DR and type of armor for the entire vehicle. Location Armor is more complex but permits the creation of vehicles that have thicker armor on some locations than on others, like modern tanks or battleships.

If the vehicle has slope, the location armor method must be used.

Overall Armor

Many vehicle designs have the same armor *everywhere.* A majority of civilian vehicles and many military ones (such as most aircraft) fit into this category. This allows a "quick armor design" procedure. Here's how to do it:

First, examine the *Armor Table* and pick a type and quality of armor (e.g., TL7 cheap metal) from those available.

Then determine the weight per point of DR by multiplying the vehicle's *structural surface area* by the weight modifier on the *Armor Table* for the chosen armor. Decide on the vehicle's DR. Multiply it by the weight per point of DR to get the actual armor weight.

Find the armor's cost by multiplying its weight by the cost modifier shown on the *Armor Table* for the chosen armor's type and quality. If the armor is ablative, it can be *fireproof* at double the cost.

Armor built this way gives the vehicle the same DR everywhere but open mounts and gas bags, which are DR 0. For a more complex way of handling armor, see *Location Armor.*

Armor Table

					Weight Modifier						*Cost*
Type	*TL4-*	*TL5*	*TL6*	*TL7*	*TL8*	*TL9*	*TL10*	*TL11*	*TL12*	*TL13*	*Modifier*
Wood											
cheap	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	$0.10
standard	1	1	1	1	1	1	1	1	1	1	$0.25
expensive	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	$0.50
advanced	n/a*	n/a	n/a	n/a	n/a	n/a	0.6	0.4	0.3	0.2	$1
Metal											
cheap	n/a	n/a	0.7	0.6	0.5	0.4	0.25	0.15	0.1	0.06	$1
standard	n/a	0.7	0.6	0.5	0.4	0.25	0.15	0.1	0.06	0.04	$2
expensive	0.7	0.6	0.5	0.4	0.25	0.15	0.1	0.06	0.04	0.025	$6
advanced	n/a	n/a	0.4	0.25	0.15	0.1	0.06	0.04	0.025	0.015	$20
Ablative											
cheap	n/a	n/a	n/a	0.3	0.1	0.08	0.05	0.03	0.02	0.012	$0.2
standard	n/a	n/a	n/a	0.25	0.08	0.05	0.03	0.02	0.012	0.008	$0.5
expensive	n/a	n/a	n/a	0.1	0.05	0.03	0.02	0.012	0.008	0.005	$2
advanced	n/a	n/a	n/a	0.08	0.03	0.02	0.012	0.008	0.005	0.003	$8
fireproof	n/a	n/a	n/a	×1	×1	×1	×1	×1	×1	×1	×2
Nonrigid											
if TL6-	0.06	0.06	0.06	0.055	0.05	0.045	0.04	0.03	0.02	0.015	$5
if TL7+	n/a	n/a	n/a	0.045	0.04	0.03	0.02	0.015	0.008	0.005	$100
Reflex	n/a	n/a	n/a	n/a	n/a	n/a	0.03	0.02	0.012	0.008	$400
Composite											
cheap	n/a	n/a	n/a	n/a	0.4	0.25	0.15	0.1	0.06	0.04	$1.5
standard	n/a	n/a	n/a	0.4	0.25	0.15	0.1	0.06	0.04	0.025	$5
expensive	n/a	n/a	n/a	0.25	0.15	0.1	0.06	0.04	0.025	0.015	$15
advanced	n/a	n/a	n/a	0.15	0.1	0.06	0.04	0.025	0.015	0.01	$50
Laminate											
cheap	n/a	n/a	n/a	n/a	0.4	0.25	0.15	0.1	0.06	0.04	$3
standard	n/a	n/a	n/a	0.4	0.25	0.15	0.1	0.06	0.04	0.025	$10
expensive	n/a	n/a	n/a	0.25	0.15	0.1	0.06	0.04	0.025	0.015	$30
advanced	n/a	n/a	n/a	0.15	0.1	0.06	0.04	0.025	0.015	0.01	$100

* N/a indicates a kind of armor not available at that TL.

Location Armor

A vehicle can have more armor on some locations than on others. Use the same rules as overall armor design, except that each body or subassembly has its weight and cost based on its individual surface area rather than the vehicle's structural area. Each location's DR and even armor material may vary.

An open mount subassembly may not be given armor. Gasbag subassemblies may be armored, but it is usually unwise to give them more than a few points of DR due to their very large area! Rotors must have at least DR 5.

Armor by Facing – Basic Option: Some vehicles, such as tanks, have body, superstructure or turret armor that varies in thickness. For instance, the front armor may be tougher than the back or top armor.

A body has six different "faces" – Front (F), back (B), right (R), left (L), top (T), underside (U). Each turret or superstructure has five different faces: the same as the body, excluding whatever face (usually underside) connects the turret or superstructure with the body or subassembly supporting it.

To vary a body's DR by face, multiply the body DR by six and then divide it among the vehicle's faces. To vary a superstructure's or turret's DR by face, multiply the turret DR by five and divide it among the turret's faces. DR can be distributed any way desired; *most* vehicle bodies have at least some DR on every face (except, perhaps, the top). If the vehicle is submersible, sealed or has Good or better streamlining, every body, turret and superstructure face *must* have DR.

Armor by Facing – Complex Option: For even more detail, armor can be bought for individual body or turret faces rather than for the entire location. This allows different armor quality and materials to be used on different faces. Use the rules for overall armor, but assume each body face has one-sixth the surface area of the entire body and each turret face has one-fifth the area of the entire turret.

Slope Effects: If a body facing, turret facing or superstructure facing has 30° slope, multiply its final DR by 1.5. If it has 60° slope, double its DR. The attack must both penetrate through a greater thickness of armor and is more likely to be deflected.

Record the DR of the body and each subassembly. If necessary, record separate DR values for different faces. After DR is determined, the passive defense (PD) can also be determined for each location that has DR.

EXAMPLE

We decide the Kitty Hawk will have TL7 advanced laminate on the body with DR 24: it weighs [250 sf (body surface area) × 24 (DR) × 0.15 (TL7 advanced laminate)] = 900 lbs. Its cost is 900 × $100 = $90,000.

The wheels will have the same armor, but only DR 10, so their weight is [10 (DR) × 50 (wheel area) × 0.15 (TL7 advanced laminate)] = 75 lbs. and cost is 75 × $100 = $7,500.

The pop turret will also have advanced laminate. We give it DR 14 laminate which weighs 14 × 0.15 × 24 = 50.4 lbs., while its cost is $5,040. We decide to vary the DR by face. We multiply the DR by five to DR 70 and then distribute these 70 points as follows: F22, R12, L12, T12, B12. Note that the underside of the turret has no armor.

Typical DRs

Stumped as to what DR to use? A useful guideline is frame strength (see p. 18): DR 1-2 for super-light or extra-light, 3-6 for light, 4-8 for medium, 5-20 for heavy and 10-40 for extra-heavy. Submersibles have several times this DR, while reentry vehicles should have DR 100+.

Vehicles designed to stand up to heavy direct fire, such as tanks, ground-attack aircraft and large, TL5-6 warships, will typically have DR capable of withstanding their own main guns or beams over their most vulnerable locations. For tanks, this is the front of the vehicle's body and turret, while for warships it is often the sides (and any vital turrets or superstructures).

Combat craft whose main armaments are missiles, bombs or indirect fire weapons often have little DR, relying on ECMs, agility or escort by other vehicles to avoid attack.

Armor Optional Rules

These rules add more complexity, but they are useful for designing certain types of vehicles:

Gun Shields

Open mounts cannot have all-around armor, but the front of an open mount can be armored – this is usually known as a gun shield. Build a gun shield's armor using one-fifth the surface area of the open mount.

Wheelguards and Armored Skirts

While it's possible to completely armor wheels, tracks, halftracks, skitracks, SEV skirts and GEV skirt subassemblies, they can also be given armored guards that cover only their upper half, either instead of or as well as more complete coverage.

Build these like ordinary subassembly armor, using only *half* the subassembly's area. These skirts or guards don't protect at all against attacks from below, such as spikes or mines, and only protect on a roll of 1-4 on 1 die vs. attacks coming from other directions. They can be combined with more complete coverage, e.g., a tank has DR 20 on its tracks and then is built with an additional DR 80 skirt, so it has DR 100 on a roll of 1- 4, but otherwise only DR 20.

Open Frame Armor

Any kind of armor except reflex or nonrigid can be an open framework, much like a roll cage. It protects normally vs. collisions, falls, rolls or swinging melee attacks, but has only a 2-in-6 chance of protecting vs. thrusting attacks, beams, arrows, bullets, or other small missiles. It has no effect at all against flamer or flamethrower attacks or explosive concussion damage. Open-frame armor has one-fifth normal weight; since cost is based on weight, this effectively makes it one-fifth as expensive.

Open frame armor cannot be used as overall or body armor on a vehicle with a flotation hull, or anywhere on vehicles that are streamlined, submersible or sealed (except on their open mounts).



Compound Armor

It is possible to layer a body, subassembly or armor location with different types of armor: for example, a vehicle could have metal armor with an additional layer of ablative armor underneath. Layered armor DR is added together, but keep track of the individual DRs of each layer because of their special characteristics. For example, if DR 25 laminate armor is layered over DR 20 metal armor, the laminate DR is doubled against shaped-charge attacks, but the metal armor's DR is not.

If ablative armor is layered under other armor and is destroyed, the armor atop it will also be destroyed!

What Armor Doesn't Protect

A vehicle's armor doesn't protect a character in an exposed seat or space against an attack from an angle above the vehicle and has only a 50% of protecting against an attack from any side except below. The same applies to anything in a cargo space designated as open cargo. It does not protect a character in an external seat or space at all, although a shot may hit the vehicle instead of the character!

Armor on a wheeled or halftrack subassembly protects the wheel but not the tire, which is still vulnerable to damage.

Armor PD

PD is determined by the DR of the outer layer of armor. If the armor varies by face, PD may also vary. Armor PD is determined using DR, according to the following table:

PD Table

DR	*1*	*2-4*	*5-15*	*16+*
PD	1	2	3	4

Nonrigid armor can have a maximum PD 2; at TL7+, nonrigid armor has only PD 1 vs. impaling attacks. PD 3 is the maximum PD for wooden armor.

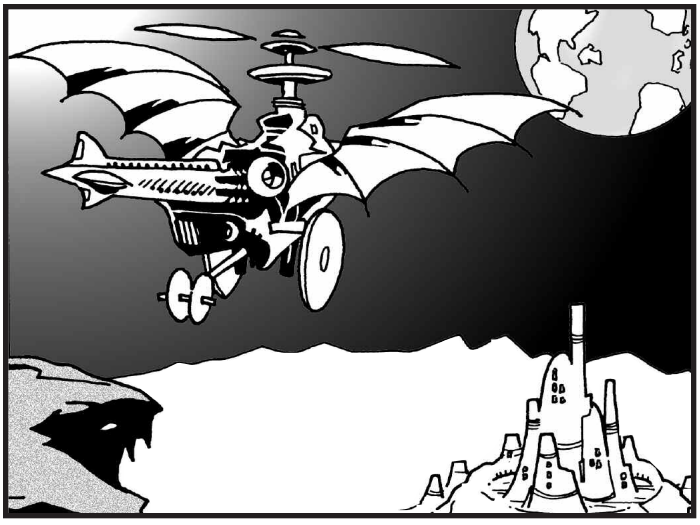
Slope and PD: As well as possibly increasing PD by boosting DR, slope will further increase Passive Defense on the sloped faces, provided that armor is either metal, composite or laminate. PD is increased as follows:

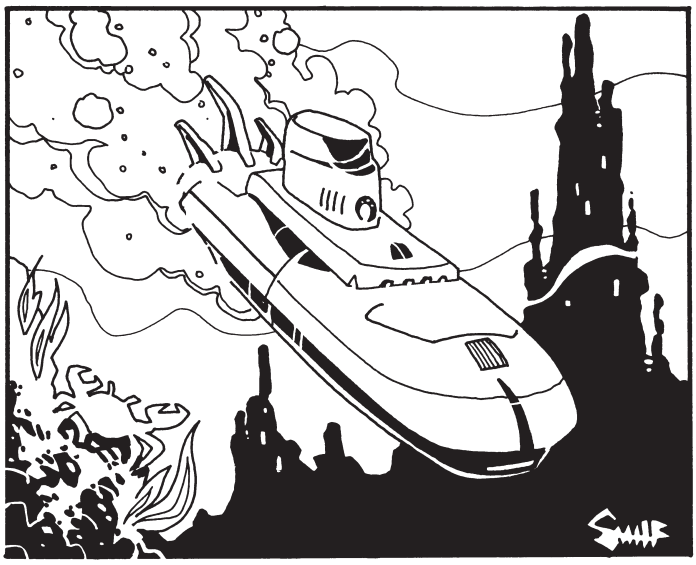
30° slope adds +1 to PD on the face that is sloped.

60° slope adds +2 to PD on the face that is sloped.

EXAMPLE

The Kitty Hawk's body has DR 24, so it is PD 4. So is the front of its turret. The back, right, left and top of its turret have DR 12, and so are only PD 3. Its wheels, with DR 10, are also PD 3.





B. Waterproofing and Sealing

A vehicle with a flotation hull must be sealed or waterproof. A vehicle with an NBC kit, limited life system, or full life support must be sealed, as must any body or subassembly (except a gasbag) that holds lifting gas.

Vehicles with the submersible option are automatically sealed and waterproofed for free.

Waterproof (TL0): Waterproofing a vehicle insures that it will not leak if floating or suffer corrosion from salt water, but does not protect it from the effects of corrosive atmospheres or extreme pressures. A vehicle with a submersible hull or one that is sealed is waterproof for free.

Sealed (TL5): The vehicle has its components protected against corrosion and the effects of sudden pressure changes, or high or low temperatures. Vehicles with submersible hulls are already sealed at no extra cost. A sealed vehicle must have DR 1 or more over its entire body (excluding gas bags and open mounts); open frame armor does not count toward this DR.

Waterproofing and Sealing Table

TL	*Type*	*Cost*
0	Waterproofed	$2
5-7	Sealed	$40
8	Sealed	$20
9+	Sealed	$10

Multiply cost by the vehicle's structural surface area. (While only the body of a watercraft is directly in the water, the rest of it is waterproofed to prevent corrosion from spray.)

The Kitty Hawk is submersible, so it is sealed and waterproof for free.

EXAMPLE

C. Other Surface and External Features

The *Surface and External Features* chapter (p. 91) covers a variety of miscellaneous features that can be added to the exterior of a vehicle. These include:

Concealment and Stealth Features (p. 91), to make the vehicle harder to detect.

Defensive Surface Features (p. 92), including radiation shields, special defenses against beam weapons, shaped-charge warheads and electrified vehicle surfaces.

Force Field Grids (p. 93), which surround the vehicle with defensive deflector fields or force screens.

Rams, Wheelblades, Plows and Bulldozers (p. 94), which can be added to the front of many vehicles.

Top Decks (p. 94), to give the vehicle a flat surface for cargo or the like, plus *Deck Features* (p. 94) such as flight decks for aircraft or covered decks.

Hardpoints (p. 94), such as pylons that can be attached under the body or wings, to which jettisonable stores such as bombs, missiles or drop tanks are attached.

Convertible Top Features (p. 95), covering hardtops and ragtops for vehicles with seats.

Special Tires (p. 95), for wheeled vehicles, such as racing, snow or puncture-resistant models.

Hitches and Pins (p. 95), to enable the vehicle to pull another vehicle, or be pulled by one.

Sidecars (p. 96), to add to two-wheeled vehicles.

Solar Cells (p. 96), for providing extra energy or recharging energy banks.

EXAMPLE

The Kitty Hawk will have *Concealment and Stealth* features (see p. 91) and *Special Tires* (p. 95). We end up adding basic stealth (648 lbs., $97,200, see p. 92) and giving its four wheels puncture-resistant tires ($1,000, see p. 95).



D. Vision – An Optional Rule

Knowing how well the crew and passengers can see out of the vehicle is important.

For each body or subassembly that contains seats, spaces or quarters, decide whether its occupants have a Good, Fair, Poor or No view out any canopy or windows. Exposed or external seats or spaces always have a Good view.

"Good" means a wide field of view – and also that shots can easily hit a poorly-armored canopy, windscreen or window! This is typical of autos and airplane cockpits. Any "window" critical hit in an area of the vehicle with Good view will strike a transparent area, ignoring some or all vehicle armor.

"Fair" means the occupants have a moderate field of view. This is typical of many aircraft and some commercial vehicles. Whoever mans the maneuver controls will be able to see forward and to the sides, but the view backward requires an external mirror. The GM can impose -1 on Vision rolls to spot things, especially if they are on the edge of the field of view. If a "window" critical hit is rolled and the occupants would be hit, roll 1d. On a 1-3, the person is protected by vehicle DR.

"Poor" means the occupants must use a tiny porthole, vision slit or viewing scope, or have no view at all. The person manning maneuver controls can only see forward. Having a Poor view means the occupants can't be hit by "window" critical hits, but all Vision rolls should be made at a -2 or worse penalty, and the occupants will have a blind spot – people who are right next to or standing upon the vehicle can easily move out of the crew's field of view.

No view is obvious. The occupants *cannot* see out, but then again, "window" critical hits can be ignored.

Vision can always be improved by opening a door, airlock or hatch and peering out, provided the outside environment allows it. (It's tricky or impossible at high speeds, or in a submarine, for instance!) Of course, this leaves the observer vulnerable to attacks. Even so, a tank commander will often ride with the top hatch "unbuttoned" so that he can get a good view. This is often fatal to tank commanders – but then so is not being able to see the enemy.

Crew stations with visual augmentation systems (low-light TV, etc.) or line-of-sight sensors can avoid the penalties for fair, poor or no view by using these systems instead.

In the event that a "window" critical hit does occur and a canopy, window, porthole or the like is actually hit, it offers no DR at TL5-. At TL6+, transparencies are assumed to have one-half the PD and DR of the location they look out of, rounding down, with a maximum of DR 10 at TL6 or DR 15 at TL7+. A window that is rolled down or a canopy that is open provides no DR.

We decide the Kitty Hawk has Good vision out its body. If a shot goes through a window into the body, the normal PD 4, DR 24 will be reduced PD 2, DR 12, as it hits armored glass.

EXAMPLE

Statistics

Everything that the vehicle needs is now installed or attached. Now we find out what it can do!

Weight and Mass Statistics

Empty Weight: First, add up the weight of all vehicle components, structures and features, except for fuel, ammunition, provisions, any carried vehicles and TL5- guns that require carriages. The resulting sum is the vehicle's *empty weight.*

Usual Internal Payload: Decide on the normal weight of occupants and cargo the vehicle carries. This is the "usual internal payload."

For most vehicles, we suggest a "generic" usual payload of 200 lbs. per crew member and passenger be provided for: this is the average

weight of a human, plus an extra third to cover worn or carried gear and weight variations. Then add 20 lbs. per cf of cargo space to represent a normal load of cargo.

If a vehicle is specifically built for someone, or designed to haul very heavy loads (like a railway car) feel free to allow up to 100 lbs. weight per cf of cargo space or customize the payload to the crew and passengers' exact weights (including worn or carried equipment).

Loaded Weight: The sum of empty weight, usual internal payload and the weight of all fuel, ammunition, provisions, any carried vehicles and TL5- guns that require carriages is the *loaded weight.*

If the vehicle has hardpoints, also record a "weight with hardpoints loaded" equal to the loaded weight plus the maximum load of the hardpoints. When performance calculations call for loaded weight, calculate two values: one with and one without the hardpoints loaded.

Design Check! If the vehicle has a maximum lift or flotation rating, make sure the loaded weight does not exceed these values. If it does, redesign the vehicle to reduce its weight. This can often be done simply by converting cargo space to empty space to reduce the usual payload, or eliminating some armor.

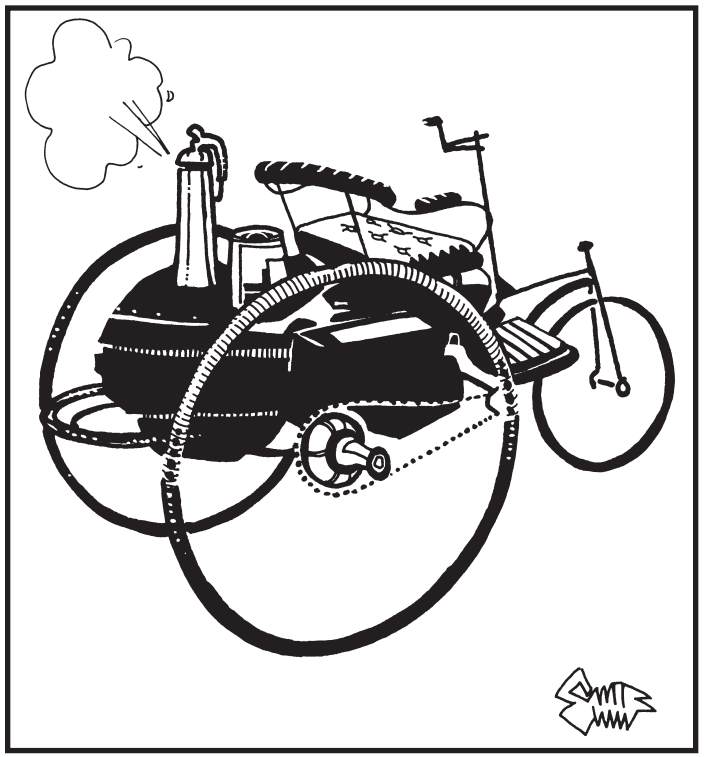
Loaded Mass in Tons: If the weight checks out, find the loaded mass in *tons.* This is used in some performance calculations. Divide the loaded weight by 2,000 to get it. (If the vehicle has hardpoints, calculate two loaded masses.) Round fractional loaded masses to two decimal places.

EXAMPLE

The empty weight of the Kitty Hawk is 5,976.9 lbs. without fuel and ammunition. We decide to use the standard guidelines for internal payload, so by using 200 lbs. per person and 20 lbs. per cf of cargo, we get an internal payload of 520 lbs. The loaded weight (adding 472 lbs. of fuel and ammunition and 520 lbs. of internal payload to the empty weight) is 6,968.9 lbs. The loaded mass in tons is 3.48 tons.

Other Statistics

Vehicle Volume and Size Modifier: Add up the volumes of the body and all subassemblies. This is the vehicle volume. Compare the vehicle volume to the table to find the Size Modifier (see p. B116). The vehicle's volume will probably fall between two entries on the table; use the higher one to find Size Modifier.



Size Modifier Table

Volume	*Modifier*	*Volume*	*Modifier*
0.1	-4	3,000	+5
0.3	-3	10,000	+6
1	-2	30,000	+7
3	-1	100,000	+8
10	+0	300,000	+9
30	+1	1,000,000	+10
100	+2	3,000,000	+11
300	+3	10,000,000	+12
1,000	+4	etc.	etc.

EXAMPLE

The vehicle volume of the Kitty Hawk is 280.25 cf. The Size Modifier is thus +3.

Submerged Weight and Mass: This only applies to submersible vessels. It is their weight in pounds and their mass when they have flooded their ballast tanks and are operating under water. Submerged weight is equal to loaded weight or 62.5 lbs. × total volume, whichever is greater. Submerged mass in tons is submerged weight/2,000.

EXAMPLE

The submerged weight is 62.5 lbs. × 280.25 cf = 17,515.625 lbs., or 8.76 tons.

Price: Add up the total cost of everything built into the vehicle except for ammunition and fuel to find out how much it costs. This is its price when purchased new. Buying a used vehicle or building one from salvaged parts can reduce the price. This is detailed in the *Vehicles in the Campaign* chapter.

EXAMPLE

The sticker price is $760,975, although the contragrav systems are technically priceless.

Health: This measures structural robustness. The heavier a vehicle is compared to its structural strength, the more strain it puts on its systems (especially wheels, wings and the like) and so the lower its HT will be. A vehicle can have a low Health but many hit points. Structural HT is calculated as follows:

Structural HT = (200 × BHP/Lwt.) + 5.

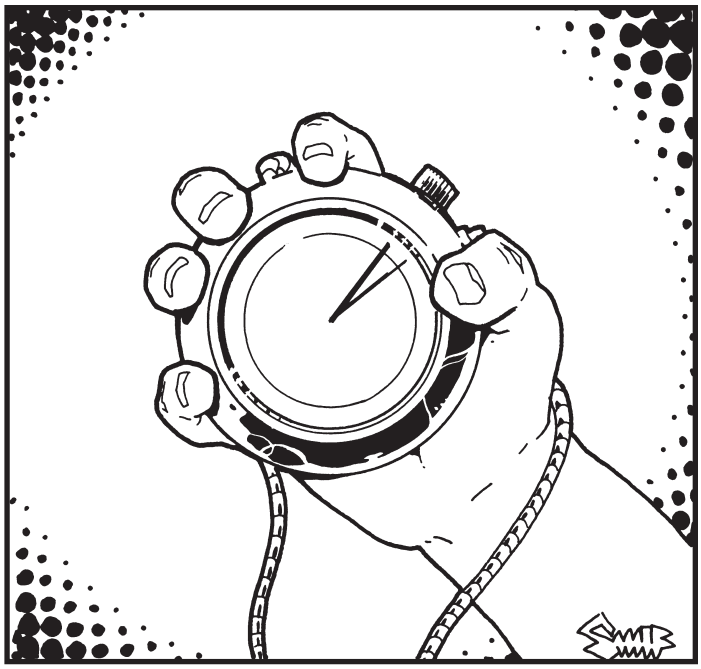
BHP = body hit points. *Lwt.* = loaded weight.

(If the vehicle has hardpoints, always use the weight with hardpoints loaded – do not calculate two different values.).

The maximum allowed structural HT is 12 or the vehicle's TL, whichever is greater. Round HT to the nearest whole number.

EXAMPLE

The Kitty Hawk's loaded weight is 6968.9 lbs. and its body hit points are 188. So the structural HT is (188 × 200 / 6968.9) + 5 = 10.39 rounded to HT 10.



Evaluating Performance

If the vehicle looks good and doesn't need any more modification, refer to the *Performance* chapter to calculate the vehicle's performance statistics.

EXAMPLE

We'll find out what the Kitty Hawk can do in the *Performance* chapter (p. 128).

Appendix

This appendix covers a few "meta-options" that fall outside the ordinary design sequence.

Component Armor

A component with both weight and volume can be armored; this is useful only if playing with the advanced damage system. Use the component's volume to compute its surface area and add armor normally. It gives no PD, but subtracts its DR from any damage to the component; in the case of crew stations or accommodations, it protects the user.

Ruggedized Components

Any component with *both* weight and volume may be "ruggedized." Such a component is less likely to be disabled, at the expense of greater weight and cost. Ordinary military equipment is not usually ruggedized in this sense; examples of ruggedized components in real vehicles include the engines of the A-10 Thunderbolt and the armored searchlights used on modern tanks. A ruggedized component is +50% to weight, volume and cost.

If using the advanced damage system, double the Hit Points of a ruggedized component. If using the basic damage system, a ruggedized component is not necessarily disabled when the area it is located in is disabled; instead, roll against vehicle HT (at -1 per multiple of basic HP that the area is below 0), and if successful, the component still works. A ruggedized component is still destroyed if the area containing it is destroyed.

Small Details

Vehicles come with a variety of "free" equipment.

Bilge Pumps: Large (100 cf or larger) watercraft are assumed to have bilge pumps appropriate to their TL at no extra cost (see p. 66).

Doors and Hatches: All vehicles large enough to need them are assumed to come with normal doors or hatches. On sealed vehicles, these are assumed to be airtight. Actual airlocks and large cargo ramps are exceptions – they count as accessories. Vehicles will usually not have more than one door per 25 sf or fraction of body, turret or superstructure surface area, and will often have fewer. The GM should prohibit any designs that abuse this.

Headlights: All TL5+ vehicles with power systems are assumed to have headlights and other running lights, free of charge.

Internal Intercoms: At TL5+, any vehicle big enough to need it is assumed to have some kind of internal communication system. This may involve voice tubes at TL5 or intercoms at TL6+.

Locks and Keys: At TL5+, people start adding locks to vehicle doors. At TL6, the familiar ignition key is standard on civilian vehicles with internal combustion power plants. They become available halfway through TL6 (with self-starting engines) and are standard at TL7+. They will probably continue in some form into TL8+ with a key or code used to lock the power plant on vehicles that don't require ignition. It should be noted that turning on the power plants of military ground vehicles (and most aircraft and ship engines) doesn't require an ignition key – they just have starter knobs.

Meteorological Instruments: Any TL1+ watercraft that is 3,000 cf or larger in size, and any TL6+ aircraft that is 500 cf or larger in size, can be assumed to have wind vanes, wind socks, thermometers, etc., appropriate to its TL, at no extra charge. See p. 55 for details.

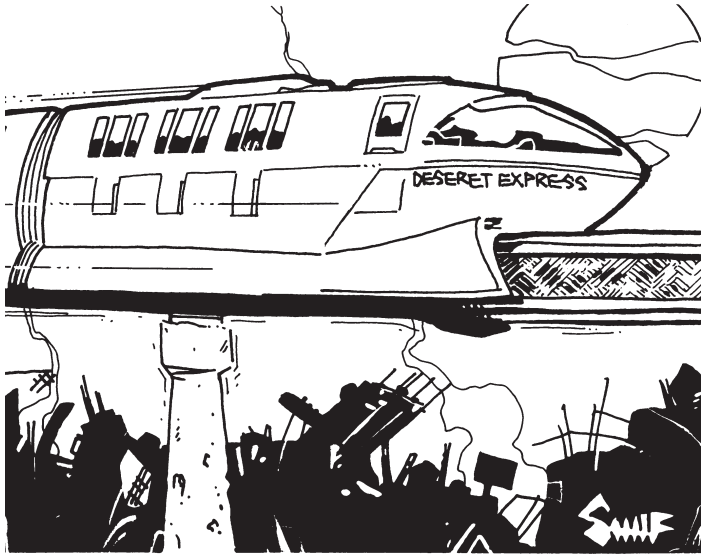
Safety Belts: Safety straps or belts can be assumed to be "free" with seats at TL6+, although not all vehicles have them.

Railroad Tracks

A vehicle with railway wheels runs on railroad tracks. These first become available around 1800, with the modern design ("t-rail") finalized about 1850. Rail costs $88,000 and weighs 352,000 lbs. per mile at TL5. Cost doubles at TL6 and is multiplied by 5 at TL7+.

Most tracks and railway wheels in a region will be designed to a standardized gauge (width), but some may be narrower or wider, preventing some vehicles from using them. This fact sometimes hinders international railway lines, and also means that if one nation invades another, they may find their rolling stock is incompatible with their victims'.

Electrified Rails (TL6): A vehicle using electric contact power (p. 87) has its wheeled drivetrain's power requirement met by electricity from the track. As long as the rails are provided with current, the vehicle will operate. A mile of electrified rails is four times as expensive as normal track.



PROPULSION AND LIFT SYSTEMS 2

PART I: PROPULSION SYSTEMS

Most vehicles will have one or more propulsion systems. The exceptions are vehicles built to be towed or launched by others, such as trailers or gliders.

The *Propulsion Systems* table below lists the available propulsion systems, the TL at which each system first appears, what subassemblies – if any – are required to use it, the function of the system, and the page it is described on.

Propulsion Systems Table

System	*TL*	*Subassembly*	*Function*	*Page*
Harnessed animals	0	none	A,G*,W,U	29
Rowing	0	none	W	29
Sails	1	masts	G*,W	30
Aerial sails	3	masts	A,G*,W	30
Rocket engine	3	none	A,G*,S,W,U	36
Aerial propellers	5	none	A,G*,W	33
Hydrojets	5	none	W,U	32
Paddle wheels	5	none	W	32
Screw propeller	5	none	W,U	32
Wheeled drivetrain	5	wheels	G,W	31
Helicopter drivetrain	6	rotors	A	33
Jet engine	6	none	A,G*,W	35
Tracked drivetrain	6	tracks	G,W	31
Leg drivetrain	7	legs	G,W,U	31
Magnetic levitation	7	none	A	38
Orion engine	7	none	S	37
Ornithopter drivetrain	7	two wings	A	34
Lightsail	7	none	S	31
Flexibody drivetrain	8	none	G,W,U	31
Reactionless thruster	9	none	A,G*,S,W,U	38
Stardrive	9	none	S	39
Teleportation drive	16	none	special	40
Parachronic conveyer	?	none	special	40

TL is the tech level at which that form of propulsion first became possible.

Subassembly shows what subassemblies, if any, are absolutely required in order to install that propulsion system.

Function indicates what the system is usable for:

A means the system is usable for aerial vehicle propulsion. Even if no subassembly is listed as required, a vehicle lacking wings, rotors or a lifting body must also later install an aerostatic lift system.

G marks the system as usable for ground vehicle propulsion.

* An asterisk means that ground propulsion is only possible if the vehicle has either a wheels or skids subassembly.

S means it is usable for space vehicle propulsion. Stardrives usually require a secondary propulsion system for slower-than-light travel as well.

W means the system is usable for water vehicle propulsion, provided the vehicle has the flotation feature, and for wheeled drivetrains only, off-road wheels. Tracked, wheeled and leg drivetrains are inferior compared to other systems; if installed they are often supplemented by other water propulsion.

U means the system is usable for underwater vehicle propulsion, provided the vehicle has the submersible feature. Leg drivetrains are inferior to other systems.

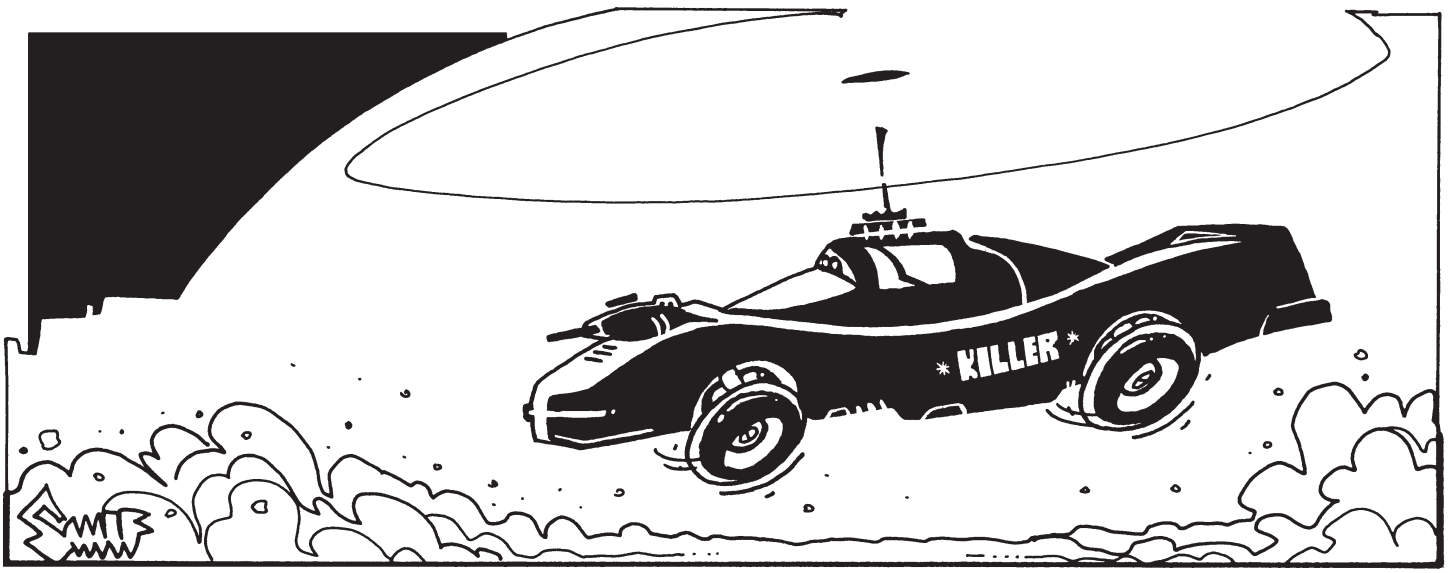
Page is the page where the system is described in detail.

Choose a propulsion system or systems that suit the vehicle's concept, and design their capabilities and statistics.

Note that a vehicle can generally have multiple propulsion systems, and that systems with the same function can combine their propulsive power.

EXAMPLE

Morgan wants the Kitty Hawk to be able to operate on the ground, in the air, in the water and underwater. We go through the list, check the descriptions, and select three propulsion systems: A wheeled drivetrain usable on the ground, a jet engine for air propulsion (also usable on the ground and on water); and a hydrojet for water and underwater propulsion.





The rest of this section provides detailed descriptions and statistics of the various propulsion systems a vehicle can use.

Harnessed animals, rowing, sails and lightsails are categorized as "unpowered" systems, while all others are "powered" systems.

This division will have some effect later on when determining the vehicle's crew requirements and statistics.

Harnessed Animal Propulsion

Probably the first harnessed animals were humans pulling sleds. Sometime afterward, it must have occurred to someone that attaching a group of trusty dogs to do the pulling was a lot less work. With the domestication of larger animals like oxen and horses, and the invention of the wheel, harnessed animals pulling wheeled or skid-equipped vehicles became the major means of heavy land transport until the invention of the steam engine resulted in the "horseless carriage" and the railroad.

Animals: Decide what species of beast of burden, and how many of them, will be harnessed to the vehicle. The significant attributes of any harnessed animal are its Strength (ST), Move and Size in hexes, and whether it moves on land, swims or can fly. Use of swimming or flying animals is not historical, but is possible if such animals are available and trainable.

Attributes of animals that can be used to pull vehicles can be found on pp. B141-144. See any of the ***GURPS Bestiary*** series books for other options.

A beast intended to pull a vehicle must be trainable. However, GMs of fantasy campaigns should feel free to allow chariots drawn by tigers, bears, giant lizards, mice, wolves, animated golems or other fantastic creatures – especially if the driver can speak with or magically control them. Zombies (human or animal) are very useful! In science fiction campaigns, alien animals or robots may be used, and cybernetic implants or telepathy may control normally untrainable creatures.

All animal-drawn vehicles must have a harness. This includes not just the actual harness, but also the pole or shafts and reins. A harness is an animal-drawn vehicle's "drive train," converting the power from the animals into vehicle movement. A harness is rated for its type, which determines its efficiency, and the type and maximum number of hexes of animals that can be harnessed to it. Decide what kind of harness will be used, determine its weight and cost (harnesses have no significant volume) based on the total hexes of animals harnessed to it, and record its efficiency. Types of harness include:

Rope Harness (TL0): This harness is a rope connecting the vehicle to the cloth, leather or synthetic collars of the pulling animals. While it is the least efficient of the harnesses, it is cheap and light.

Yoke-and-Pole Harness (TL1-2): This was the traditional harness for most of antiquity, including classical Greek and Roman civilization. Each animal pulled the wagon by a long pole attached to a yoke around the neck secured by a flexible throat harness. A yoke and pole are better than a rope harness, but not nearly as efficient as later designs.

Shaft-and-Collar Harness (TL3): This began to replace the yoke and pole in Europe sometime around the tenth century. Shafts ran beside the animal, lower than the yoke, and a stiff collar was substituted for the flexible throat harness. This had three advantages: the collar took pressure off the animal's windpipe, it allowed the animal's shoulders to bear the load, and the low shafts equalized the pull on either side, resulting in a steadier motion.

Whiffletree Harness (TL5+): This is a still more modern design, attaching the harness traces to a pivoted horizontal crossbar attached to the vehicle to improve efficiency and handling.

Harness Table

Type	*TL*	*Wt.*	*Cost*	*Efficiency*
Rope Harness	0	3	$10	0.0075
Yoke-and-Pole Harness	1	10	$50	0.01
Shaft-and-Collar Harness	3	10	$100	0.015
Whiffletree Harness	5	10	$150	0.02

Location: A harness has no volume, so location is irrelevant. It connects the vehicle's body with the animals.

Weight, Volume and Cost: Multiply the Wt. on the table by the hexes of harnessed animals to find the harness' weight. Multiply the Cost on the table by the hexes of harnessed animals to find the harness' cost. The harness has no volume or power requirement.

Motive Power: Harnessed land animals are rated for the "motive power" they can *generate* to pull the vehicle. Add the combined ST of all harnessed land animals together and multiply by the efficiency on the table. This determines the team's effective motive power in kW; the higher the motive power in relation to vehicle weight, the faster the vehicle will move. But regardless of motive power, the ultimate top speed will be limited to the *slowest* Move among its harnessed animals.

Motive Thrust: Swimming or flying animals are rated for the pounds of motive thrust they can generate to propel the vehicle in water (swimming animals) or the air (flying animals). Calculate as motive power but multiply by 20 if swimming, 2 if flying to get pounds of motive thrust.

If animals are injured or stop pulling, or the vehicle has fewer than its maximum number of animals, motive power or thrust will drop proportionately, reducing performance.

Rowing

Perhaps the earliest form of effective man-made vehicle is the rowboat or galley, using one or more rowers working paddles or oars to propel a vehicle through water.

The origin of paddles is lost in prehistory: the first depictions of large oared vessels are Egyptian carvings dating back as early as 2900 B.C. Oared galleys dominated naval warfare and coastal trade in the narrow waters of the Mediterranean from the Bronze Age to the Renaissance period.

An oared vessel is generally not as fast as one powered by sails (which appear at TL1); however, it is also not at the mercy of the wind! The big disadvantage of oars is that a large ship requires many rowers. A big ship like a Greek or Renaissance galley often required 50 to 200 oarsmen to reach a useful speed. On pirate and war vessels, rowers often doubled as soldiers, or vice versa; slave rowers are a mostly cinematic invention.

Design: Decide how many rowers the vehicle will use. The vehicle will need seats or crew spaces for that many rowers. On larger vessels, seats may be arranged so several rowers may use a single oar; as a result, the cost of oars and oarholes is *per rower,* not per oar.

Location: Rowing positions must be located in the body or in pods attached to the body.

Weight, Volume and Cost per rowing position is shown below. This includes paddles, or oars and oarlocks, and the space to use them but not weight, volume and cost of the seats, which will be covered under *Crew and Passengers.*

Rowing Positions Table

TL	*Wt.*	*Volume*	*Cost*
0-4	10	10	$20
5+	10	10	$30

Motive Thrust: Rowers are rated for the motive thrust they can generate. Add the combined Strength of all the rowers (normal men will average ST 10) and multiply by 0.5. This gives the effective motive thrust of the rowers in pounds. If using TL5+ rowing positions, multiply by 0.6 instead of 0.5, reflecting the development of more efficient modern oars and oarlocks.

If rowers are injured or stop rowing, or the vehicle has less than its maximum number of rowers, motive thrust will drop, reducing performance. Also, a sideswipe collision against a rowing vehicle will damage the actual oars or paddles and injure rowers: each 10 points of collision damage will disable one rowing position and do 2d crushing damage to the rower (starting with those nearest the collision) to a maximum of half the vessel's rowers. A disabled rowing position or rower can't contribute to motive thrust.



Sails

Sails use the wind for propulsion. While usually used by watercraft, sails can also propel a craft on land. For obvious reasons, sails only work in an environment where there is moving air, although there is no need for it to be breathable!

Sails first appeared in the third millennium B.C. Vessels powered primarily by sails dominated commerce from early antiquity until the beginning of the 19th century. The simple reason was their cargo capacity: they were capable of carrying enough rations to allow their small crews to make intercontinental journeys. Sailing ships made possible the great Age of Discovery and opened up the New World.

Sails can only be used if a vehicle has mast subassemblies, and may not be used on vehicles with Good or better streamlining.

The arrangement of sails on a mast is its *rigging.* A vehicle can have one of three basic types: a square rig, a fore-and-aft rig, or a full rig. Full rigs are only available if the vehicle has two or more masts.

A *square rig* (TL1) is a single broad, square sail facing toward the front of the craft, like the sail on a Greek galley or Viking longship. The sail is supported by a horizontal yardarm. Any vehicle can have a square rig.

A *fore-and-aft rig* (TL2) is a triangular sail of the sort seen on modern sail boats with the sail running parallel to the hull. For simplicity, we also include triangular *lateen-rigged* sails here. It has the advantage that it can sail more closely to the wind, allowing much higher speeds in adverse wind conditions.

A *full rig* (TL4) can only be used if the vehicle has *more than one* mast. It consists of both triangular and square sails, the latter with multiple horizontal *yardarms* one above the other, each yardarm with its own independently maneuverable sails controlled by a complicated network of ropes and rigging, with small outrigger sails (jibs and stays) attached in front of and behind the main sails. A full rig has more sail area, and thus gets more speed than any other kind of rig provided the wind is right, but is not as fast if the wind is coming from a less-than-optimum direction.

Next, determine the sail area in square feet. Sail area equals (average mast height) squared times half the number of masts. If the vehicle has a fore-and-aft rig or square rig multiply total area of sail by 0.8 to get the actual area.

Decide whether the sails use cloth (TL1), synthetic (TL7) or bioplas (TL10) material. Bioplas sails can regenerate rips and tears, and can function even in corrosive atmospheres. They regenerate 1 hit per 100 sf or fraction of area per six hours.

Weight and Cost: This is 1 lb. and $1 per sf of cloth sail, 0.5 lbs. and $10 per sf of synthetic sail or 0.25 lbs. and $100 per sf of bioplas sail. Sails do not add volume.

Motive Thrust: This depends on there being a wind! It is 0.4 lbs. × area of sail × wind force, where the wind force is rated according to the Beaufort scale: 0 is calm, 1 is light air, 2 is a light breeze, 3 is gentle breeze, 4 is a moderate breeze, 5 is a fresh breeze, 6 is a strong breeze, 7 and up are gale force winds. If wind exceeds scale 6 (scale 7 if bioplas sails), the sails should be furled or damage may occur – see *Sails and Wind* on p. 158. For purposes of calculating typical speed of a vessel under sail, use a fresh breeze, giving 2 lbs. thrust × area of sail. If more detail is desired, feel free to calculate motive thrust (and later, performances) at different wind scales.

Aerial Sails (TL3)

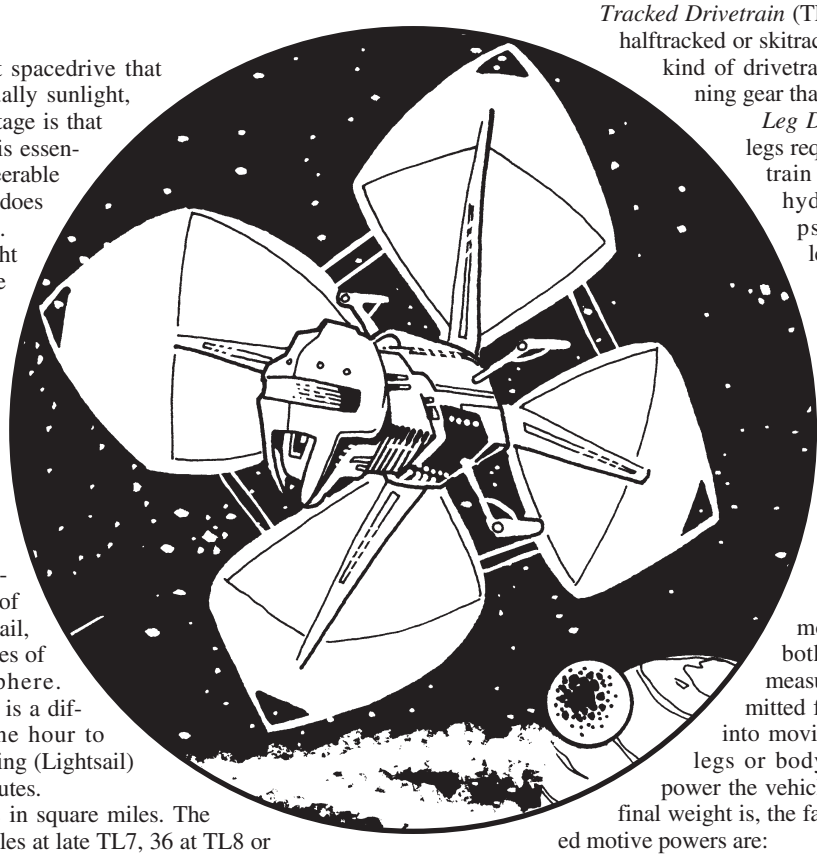
These are sails designed for use by wingless flying vehicles such as airships, or contragravity flyers. A flying vehicle lacks a keel in the water whose resistance keeps it from drifting in the direction of the wind, so normal sails are useless. Instead, if a vehicle intended to fly is to rely on sails, it must use a three-dimensional arrangement of outrigger sails and fins combined with ballast tanks for steering and trim control.

Aerial sails are built exactly like an ordinary fore-and-aft or full rig, but have 1.5 times the area and weight of sail, and twice the cost. They are also usable as normal sails for land or water propulsion, but excess masts and sail that would get in the way must first be removed and stowed. This takes 1 man-hour per 1,000 sf of sail, and reduces the sail area and motive thrust by a third.

Lightsails

A lightsail is a low-thrust spacedrive that uses the pressure of light, usually sunlight, for propulsion. Its main advantage is that it requires no fuel. A lightsail is essentially a very large, ultra-thin steerable mirror. Unlike normal sails, it does not require a mast subassembly.

Light pressure is very slight and varies inversely with the square of the distance from the system's star. As such, a lightsail is most useful within the inner part of a star system. A lightsail can maneuver and propel the vessel in any direction, by tilting the sail and using stellar gravity to assist in changing course.



Lightsails are very fragile. A ship with an unfurled lightsail cannot use any other form of thrust without damaging the sail, nor can it come within 200 miles of any world with an atmosphere. Furling or unfurling a lightsail is a difficult maneuver requiring one hour to accomplish. A successful Piloting (Lightsail) roll will cut this time to 15 minutes.

Decide how big the sail is in square miles. The maximum size is 1.6 square miles at late TL7, 36 at TL8 or 360,000 at TL9+. Then calculate its weight, cost and thrust using the table below:

Lightsail Table

TL and Type	*Weight*	*Cost*	*Thrust*
TL7 Lightsail	28,000	$7,000,000	4.64
TL8 Lightsail	6,500	$3,250,000	5.03
TL9+ Lightsail	400	$200,000	5.26

Location: When stowed, in body, pod or superstructure; when deployed, treat as sails.

Weight and Cost: The table shows the weight (lbs.) and cost per square mile of lightsail.

Volume: The lightsail's volume is its weight/200 cf.

Thrust: This is the pounds of thrust of the sail, per square mile of area, at a distance of one astronomical unit from a star of the same luminosity as our sun. (One AU is the average distance from the Earth to the Sun.) This is modified by the square of the distance: At a distance of 2 AU the thrust is one-fourth as much, at 3 AU it is one-ninth as much, and so on; similarly, at 0.5 AU it is four times as great and at 0.1 AU it would be 100 times greater. Around a star other than the sun, the thrust should be multiplied by that star's relative luminosity.

Wheeled, Tracked, Leg and Flexibody Drivetrains

These are transmissions or electric motors that convert power into movement of wheels, tracks, legs or body segments.

Wheeled Drivetrain (TL5): Any vehicle with a wheeled subassembly may have a wheeled drivetrain to enable it to use powered wheels for propulsion. Bicycles, locomotives, automobiles, trucks and motorcycles are all examples of vehicles that have wheeled drivetrains. Not all wheeled vehicles have wheeled drivetrains, of course; those with other propulsion systems – such as harnessed animals, propellers, or jet engines – can do without them!

If a TL6+ vehicle has a wheeled drivetrain, decide whether or not it also has all-wheel drive. This increases weight and cost, but improves the ability to travel off-road, as described under *Ground Pressure and Off-Road Speed,* p. 130.

Tracked Drivetrain (TL6): Any vehicle with a tracked, halftracked or skitracked subassembly must have this kind of drivetrain to transfer power to the running gear that works the tracks.

Leg Drivetrain (TL7): A vehicle with legs requires a leg drivetrain. The drivetrain represents the electric motors, hydraulic gears or myomer fiber pseudo-muscles that move the legs.

Flexibody Drivetrain (TL8): Ahypothetical technology with gears or myomer motors which transmit power to individual body segments on the vehicle. This lets it move in an undulating fashion, enabling it to slither like a worm or snake, or swim like a fish. A flexibody is slower (on land) than legs, but even better able to cross very rough terrain!

All drivetrains are rated for motive power in kilowatts. This is both the power requirement and a measure of how much power is transmitted from the vehicle's power system into moving the vehicle's wheels, tracks, legs or body segments. The more motive power the vehicle has in relation to whatever its final weight is, the faster it will move. Some suggested motive powers are:

Under 10 kW.....early steam carriage, battlesuit
11-30 kW.....motorcycle, primitive automobile, motorscooter
31-60 kW.....early auto or light truck, racing bike
61-120 kW.....modern auto or van, early heavy truck
121-250 kW.....modern sports car, light truck or light tank
251-500 kW.....early locomotive, medium tank, semi-truck
501-1,200 kW.....race car, locomotive, main battle tank
1,201-5,000 kW.....modern diesel locomotive, ultra-tech tank
5,001-100,000 kW+.....***Ogre***-era cybertank

After determining the motive power, work out the drivetrain's weight, volume, cost and power requirement using the table below:

Ground Drivetrain Table

		Weight in lbs. when Motive Power is . . .		
TL	*Type*	*under 5 kW*	*5 kW or more*	*Cost*
TL5-	Wheeled	20 × kW	(4 × kW) + 80	$2
TL6	Wheeled	10 × kW	(2 × kW) + 40	$4
	all-wheel drive	15 × kW	(3 × kW) + 60	$8
TL7	Wheeled	7.5 × kW	(1.5 × kW) + 30	$10
	all-wheel drive	10 × kW	(2 × kW) + 40	$20
TL8+	Wheeled	5 × kW	(1 × kW) + 20	$10
	all-wheel drive	7.5 × kW	(1.5 × kW) + 30	$20
TL6	Tracked	30 × kW	(6 × kW) + 120	$10
TL7	Tracked	20 × kW	(4 × kW) + 80	$20
TL8+	Tracked	15 × kW	(3 × kW) + 60	$20
TL7	Leg	80 × kW	(8 × kW) + 360	$50
TL8	Leg	60 × kW	(6 × kW) + 270	$50
TL9	Leg	40 × kW	(4 × kW) + 180	$50
TL10	Leg	30 × kW	(3 × kW) + 135	$50
TL11	Leg	20 × kW	(2 × kW) + 90	$50
TL12+	Leg	15 × kW	(1 × kW) + 70	$50
TL8	Flexibody	80 × kW	(8 × kW) + 360	$200
TL9	Flexibody	60 × kW	(6 × kW) + 270	$200
TL10	Flexibody	40 × kW	(4 × kW) + 180	$200
TL11	Flexibody	30 × kW	(3 × kW) + 135	$200
TL12+	Flexibody	20 × kW	(2 × kW) + 90	$200

Location: Wheeled, tracked and flexibody drivetrains must go in the body. Leg drivetrains go in the legs.

Weight: The weight as a function of motive power is shown on the table above.

Volume: The volume is weight/50 cf. Leg drivetrain components are divided into individual leg motors. Divide the volume equally among the vehicle's legs.

Cost: The cost of drivetrains is based on their weight multiplied by the number shown in the Cost column on the table. Leg drivetrain costs assume four or more legs. Double the cost for three legs and quadruple cost for two legs due to the extra stabilization and control systems needed.

Power Requirement: This is equal to the motive power.



EXAMPLE

The Kitty Hawk resembles a sports car, so we give it a 200 kW motive power wheeled drivetrain (about 268 horsepower) with all-wheel drive for better off-road performance. We have to put the drivetrain in the body. It weighs (2 × kW) + 40 lbs, or 440 lbs. Its volume is weight/50 cf, or 8.8 cf. It costs $20 × weight, or $8,800. Its power requirement is 200 kW.

Paddle Wheels, Hydrojets, Screw Propellers and MHD Tunnels

The invention of a reliable steam engine made possible mechanical propulsion that did not require either muscle or wind power. One of the first beneficiaries of this was watercraft, with the invention of the paddle wheel and hydrojet.

Paddle Wheels: (TL5): In service by 1800, these were the first successful means of powered water propulsion, extensively utilized by steam-powered watercraft prior to the invention of the screw propeller. By the 1820s, paddle-wheel steamers were found on rivers all around the world, and soon afterwards competed with sailing ships for oceanic trade. By 1850 paddle wheels began to disappear, but some paddle-wheel river boats remained in use in isolated regions well into the 20th century. Paddle wheels are heavy and bulky, but are the most effective propulsion system available until 1837. A vehicle may have one or more paddle wheels; odd numbers of paddle wheels are usually installed in the stern of the vehicle ("stern wheels"), while pairs are attached on either side ("side wheels"). Paddle wheels may not be used on vehicles with hydrofoils.

Hydrojets (TL5): These suck in water and expel it in high-speed jets. They are also called "aquajets" or "pumpjet propulsors." Hydrojet propulsion requires bulky pumps and is less efficient than a conventional propeller. Hydrojets were experimented with as early as 1790, and actually pre-date paddle wheels, but until the TL7 period, few were used on production watercraft. The main advantage of a hydrojet is that it can be considerably quieter than a propeller, making it of interest for military and covert operations. At TL8+, completely silent magneto-hydrodynamic pumpjets become available for use in salt water. A vehicle can have any number of hydrojets.

Screw Propellers (late TL5) are rear-mounted underwater propellers. Screws were introduced in 1837, and within a few decades had displaced paddle wheels as the primary propulsion system for watercraft. Few vehicles have more than four screw propellers.

Ducted Propellers (late TL7) are advanced screw propellers. They are somewhat quieter and more efficient than ordinary screw propellers, but are also more expensive.

Select the type of aquatic propulsion and assign its *power requirement* in kW. The higher the power requirement in relation to the vehicle's weight, the more motive thrust the vehicle will have, and the faster it will move. Some suggested ranges for motive powers are:

10-30 kW . . . . . .dinghy or inflatable boat
31-100 kW . . . . . .small powerboat or small riverboat
101-300 kW . . . . . .speedboat, yacht, 19th-century gunboat or riverboat
301-1,000 kW . . . . . .patrol boat, 19th-century freighter or destroyer
1,001-3,000 kW . . . . . .tramp freighter sub, or 19th-century cruiser
3,001-10,000 kW . . . . . .destroyer, freighter or 19th-century ironclad
10,001-30,000 kW . . . . . .light cruiser, modern frigate or nuclear sub
30,001-100,000 kW . . . .hvy. cruiser, modern destroyer or big freighter
100,001-400,000 kW . . . . . .battlecruiser, supertanker or cruise ship
400,001 or more kW . . . . . .carrier, fast battleship or fast ocean liner

Vessels with motive power over 30,000 kW usually divide the power among two or three screws or paddles.

Calculate the weight, volume, cost and motive thrust for each propulsion system using the table below.

Powered Aquatic Propulsion Table

		Weight in lbs. when Motive Power is		*Aquatic Motive*
TL	*Type*	*under 5 kW*	*5 or more kW*	*Thrust*
5+	Paddle Wheel	125 × kW	(25 × kW) + 500	8
5	Screw Propeller	50 × kW	(10 × kW) + 200	10
6+	Screw Propeller	25 × kW	(5 × kW) + 100	15
7+	Light Screw Propeller	5 × kW	(1 × kW) + 20	12
7+	Ducted Propeller	20 × kW	(4 × kW) + 80	20
5-6	Hydrojet	100 × kW	(20 × kW) + 400	7
7	Hydrojet	10 × kW	(2 × kW) + 40	12
8+	Hydrojet or MHD Tunnel	5 × kW	(1 × kW) + 20	20

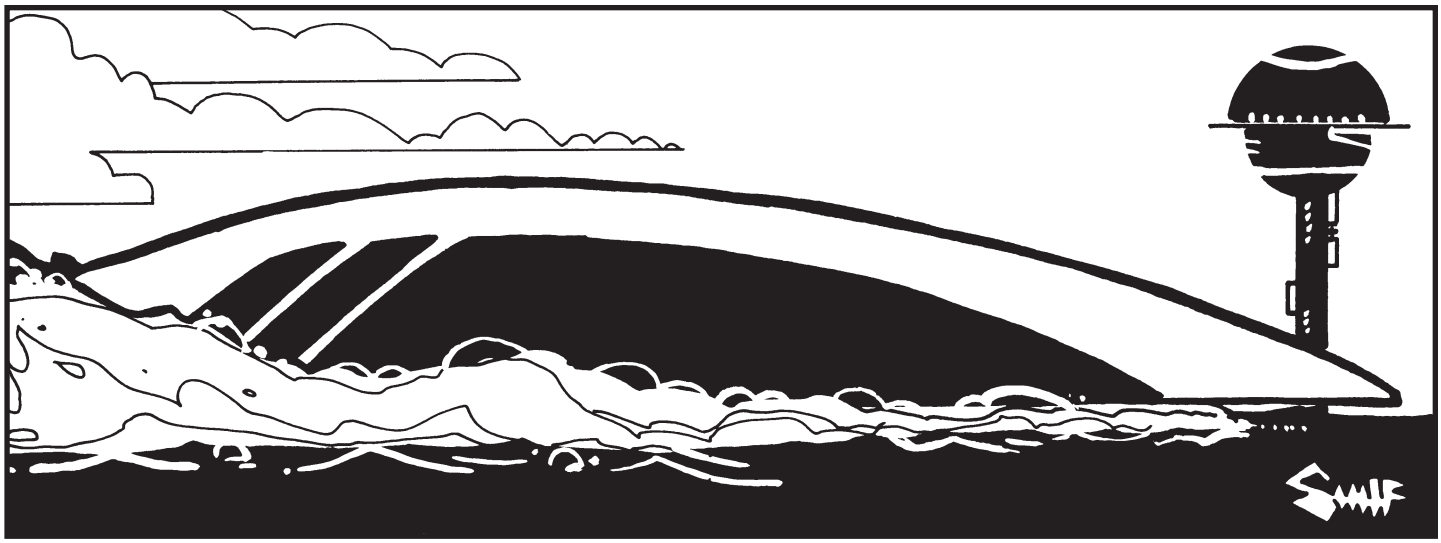
Location: Paddle wheels must go in the body. Propellers and MHD tunnels (see p. 84) may go in either the body or pods. Hydrojets may go in the body, pods, hydrofoils or legs.

Weight: Calculate the weight based on the chosen motive power, as shown on the table.

Volume: The volume is weight/50 cf.

Cost: The cost is $4 per pound for paddle wheels, $10 per pound for screw propellers, $20 per pound for ducted propellers and $40 per pound for hydrojets.

Aquatic Motive Thrust: This is the motive thrust of the system per kW of motive power when used to propel the vehicle through or under water. None of the aquatic propulsion systems can produce motive thrust in the air or on the ground.



EXAMPLE

We don't envision the Kitty Hawk being as fast in the water as on land, so we use a lower motive power: a 40 kW hydrojet. We place the hydrojet in the body. It weighs (2 × kW) + 40 lbs, or 120 lbs. Its volume is weight/50 cf or 2.4 cf. It costs $40 × weight, or $4,800. Its power requirement is 40 kW, and it has an aquatic motive thrust of 12 lbs. × motive power, or 480 lbs.

Aerial Propellers and Ducted Fans

These systems (collectively called airscrews) use powered propellers or ducted fan blades to produce thrust.

An aircraft or hovercraft can use airscrews for aerial propulsion. These can also propel a vehicle with skid or wheels subassemblies along the ground, and can propel any vehicle over water. They only work in an atmosphere, although oxygen in not required. They aren't useful for underwater propulsion.

Aerial Propellers (late TL5) are just that. They are the standard means of propelling TL6 aircraft and remain in wide use through TL7 and beyond. More advanced propellers use superior blade designs to generate more thrust. Aerial propellers also include turboprops – the latter are simply aerial propellers attached to vehicles using gas turbine power plants, rather than the more common gasoline engines.

Ducted Fans (TL7) are advanced aerial propellers in which the blades are entirely shrouded within a cowling. They are heavier, but also quieter and slightly more efficient. They otherwise function just like aerial propellers. They often propel hovercraft, but have also seen some use on experimental aircraft.

Motive Power: Select the power used by the propeller or fan. The higher the power in proportion to the vehicle's final weight, the more thrust it will generate and the faster the vehicle will go. No single prop or fan may have a motive power greater than 1,000 kW × (TL-4); e.g., a TL7 airscrew would be limited to 3,000 kW. A vehicle can have any number of props or fans; when pairs of props are mounted one per wing, each should have the same power requirement. Some typical airscrew craft:

Early TL6 (WW I) fighter or any
TL6 light plane: . . . . . .one 50-150 kW propeller
Late TL6 (WW II) fighter: . . . one or two 700-1,400 kW propellers
Late TL6 (WW II) bomber or
transport: . . . . . .two to four 500-1,000 kW propellers
TL7 light cabin plane: . . . . . .one or two 75-150 kW propellers
TL7 turboprop transport: . . . . . .four 2,500-3,000 kW propellers

After motive power is chosen, calculate the other statistics for each propeller or ducted fan as shown below:

Airscrew Table

TL	Type	Motive Thrust	Weight in lbs. when the Power Requirement is: under 5 kW	5 or more kW
5-6	Aerial Propeller	2.5	6 × kW	(0.6 × kW) + 27
Late 6	Aerial Propeller	3	4 × kW	(0.4 × kW) + 18
7+	Aerial Propeller	3.5	4 × kW	(0.4 × kW) + 18
7	Ducted Fan	4	6 × kW	(0.6 × kW) + 27
8+	Ducted Fan	4	4 × kW	(0.4 × kW) + 18

Motive Thrust: To find the pounds of thrust generated *multiply* the motive power by the number shown in the motive thrust column.

Location: Airscrews may be housed in either the body or pods; ducted fans may also go in wings.

Weight: The table shows the weight of the propulsion system based on its power requirement.

Volume: Volume of propellers is negligible since most of the volume is outside the vehicle. For fans, divide weight by 100 to get volume.

Cost: The cost is $5 per pound for TL5 and TL6 aerial propellers, $20 per pound for TL7+ aerial propellers, and $40 per pound for ducted fans.

Power Requirement: This is equal to motive power.

Helicopter Drivetrains

A helicopter drivetrain is needed if the vehicle has rotors and is to fly like a helicopter, using powered rotors mounted above the vehicle to provide lift and thrust. Only a vehicle with a top-and-tail rotor (TTR), coaxial rotor (CAR) or multiple main rotor (MMR) subassembly (p. 8) may use a helicopter drivetrain.

If a vehicle is to use a helicopter drivetrain, the number of drivetrains required depends on the type and number of rotors. A vehicle with a top and tail rotor (TTR) or coaxial rotor (CAR) arrangement requires one drivetrain. One with multiple main rotors (MMR) configuration requires *one drivetrain per rotor.* Helicopter drivetrains must match the rotor type: a vehicle with TTR rotors requires a TTR drivetrain, for instance.

To design a helicopter drivetrain, first select its *helicopter motive power.* This is the amount of power the drivetrain will use and transform into lift and thrust. The higher the motive power, the faster the helicopter will move and the more it will be able to lift. If a vehicle has multiple helicopter drivetrains, their motive powers are added together, but each drivetrain must have identical statistics. Some typical helicopter motive powers (per rotor):

Light or scout helicopter: . . . . . .200-500 kW (TTR)
Utility or attack helicopter: . . . . . .1,000-2,500 kW (CAR or TTR)
Naval, transport or heavy lift helicopter: . . . . . .3,000-6,000 kW (CAR, MMR or TTR)

The motive power determines the rotor's *helicopter lift.* This is the maximum weight the vehicle can carry and still fly, although aerostatic lift from other sources (such as lifting gas or contragravity) are cumulative with helicopter lift. When designing the vehicle, be sure to keep a running total of component and other weights, to ensure that the final helicopter design can lift itself! Helicopter lift is 10 lbs. times helicopter motive power if the vehicle has TTR or CAR rotors, 12 lbs. × combined motive power if MMR rotors.

The helicopter motive power also determines motive thrust. Motive thrust is 1.6 pounds per kW of motive power. Once motive power, lift and thrust are determined, work out each helicopter drivetrain's weight, volume, cost and power requirement as shown below:

Helicopter Drivetrain Table

TL	Type	Weight if Motive power is under 5 kW:	Weight if Motive power is 5 kW or more:
6	TTR or MMR Rotor Drivetrain	7 × kW	(1 × kW) + 30
7	CAR Rotor Drivetrain	6 × kW	(0.6 × kW) + 27
7	TTR or MMR Rotor Drivetrain	5.5 × kW	(0.5 × kW) + 25
8+	CAR Rotor Drivetrain	4 × kW	(0.4 × kW) + 18
8+	TTR or MMR Rotor Drivetrain	3.3 × kW	(0.3 × kW) + 15

Location: Drivetrains can go in the body, or any turret or superstructure atop the body. If using MMR rotors, helicopter drivetrains may also be placed in pods, at a maximum of one per pod.

Weight: The weight of the drivetrain per kW of motive power is shown on the table above.

Volume: The volume is weight/50 cf.

Cost: The cost is $25 × weight for TTR or MMR rotor drivetrains, or $50 × weight for CAR rotor drivetrains.

Power Requirement: This is the same as motive power.

Tilt-Rotors (late TL7)

A tilt-rotor is a winged helicopter that mounts its rotor blades in pivoting pods on its wings, so that when the vehicle is going fast enough it can swivel the pods (sometimes the whole wing as well) so they function like large propellers.

A vehicle with multiple main rotors *and* standard, high-agility or STOL wings *and* one pod attached to each wing *and* two helicopter drivetrains can be a tilt-rotor aircraft. An example of a tilt-rotor craft is the experimental V-22 Osprey tilt-rotor, which uses two 4,593 kW MMR drivetrains.

Add 50% to the weight, volume and cost of the MMR helicopter drivetrains for the tilting mechanism. The rotor drivetrains must be located in the wing pod subassemblies, one per pod.

A tilt-rotor's performance is calculated as if it were a helicopter. However, the vehicle can also fly like an airplane. When its rotors are tilted forward, recalculate its performance as if its helicopter drivetrains were not helicopter drivetrains but aerial propellers, giving no lift but giving a thrust equal to 3.5 times their motive power rather than 1.6 times motive power.

The vehicle can switch mode in flight, but can only change from airplane to helicopter mode if flying below 300 mph, and can only switch from helicopter to airplane mode if flying at greater than the propeller mode's stall speed. Switching modes takes two seconds, during which the vehicle is treated as being in the previous mode. While switching mode, it is -5 to Dodge or hazard control rolls, and may not accelerate, decelerate or maneuver.

Ornithopter Drivetrains

An ornithopter drivetrain allows an aircraft to use birdlike or insectoid flapping wings for lift and propulsion. Only a vehicle with a pair of wings may use an ornithopter drivetrain. At present, ornithopters remain largely experimental vehicles, but it is possible they may be developed in the future.

Ornithopters are theoretically better at low-speed maneuvering and short takeoffs than aircraft are and faster than helicopters, but their high weight and cost limit their utility.

The ornithopter drivetrain represents the motors or pseudo-muscles embedded in the wings that enable it to flap.

Motive Power: Select the ornithopter drivetrain's kW of motive power.

Ornithopter Lift: Like helicopters, ornithopters are rated for lift they can produce. Unlike a helicopter, an ornithopter's lift does not have to exceed its weight to fly. However, if the ornithopter lift exceeds the vehicle's final loaded weight, the vehicle can hover in mid air like a hummingbird. Otherwise, it will simply contribute to allowing the craft to fly at slower speeds without stalling (falling out of the air) and reduce the length of take off and landing runs. Ornithopter lift is twice thrust at TL7, 2.5 × thrust at TL8+.

Motive Thrust: Find the pounds of motive thrust the drivetrain produces by multiplying motive power by 2.

A vehicle can only use one ornithopter drivetrain at a time. The weight and volume of the drivetrain are divided evenly between the two wings.

Ornithopter Drivetrain Table

TL	Type	Weight if Motive power is under 5 kW:	Weight if Motive power is 5 kW or more:
7	Ornithopter Drivetrain	6 × kW	(3 × kW) + 15
8	Ornithopter Drivetrain	4 × kW	(2 × kW) + 10
9+	Ornithopter Drivetrain	3 × kW	(1.5 × kW) +7.5

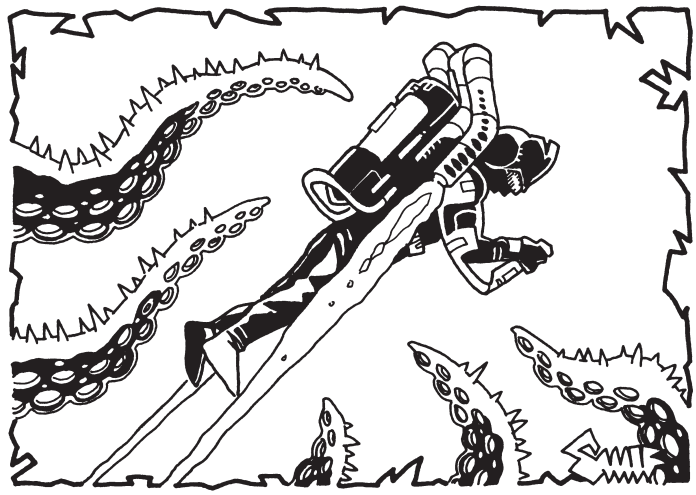
Location: Ornithopter drivetrains may only go in wings.

Weight: The weight per kW of motive power is shown on the table above.

Volume: The volume is weight/50 cf. Divide the volume of the ornithopter drivetrain between the two wings.

Cost: The cost is $100 × drivetrain weight.

Power Required: This is equal to the motive power.



Reaction Engines

Reaction engines include jet and rocket engines as well as some more exotic spacedrives. They are called reaction engines because they expel a reaction mass – usually a hot exhaust produced by burning fuel – to produce thrust. Reaction engines are rated for pounds of motive thrust, rather than for motive power.

Reaction engines are normally used mainly for aircraft and spacecraft, but they can be used to propel watercraft or wheeled or skid-equipped ground vehicles. Their main disadvantages are that they use a *lot* of fuel and aren't very quiet!

Any vehicle intended to fly without wings or rotors using reaction engines for thrust should have a thrust equal to or greater than its estimated final weight! This doesn't apply for vehicles that will use contragravity or lighter-than-air gas to cancel their weight, though – they can get by with very little thrust, often less than a tenth what a conventional craft needs!

Jet Engines

Jet engines are air-breathing reaction engines; all but the fusion air-ram require an atmosphere containing oxygen. They can be used for propulsion by aircraft or watercraft, as well as by ground vehicles that are equipped with skid or wheels subassemblies. There are several types of jet engines:

Turbojets (late TL6): A turbojet uses a turbine to suck air into the engine, combines it with jet fuel (kerosene), compresses it to the ignition point and then expels the hot gases to the rear of the engine to produce thrust. Turbojets only work in atmospheres with breathable levels of oxygen. The first turbojet was built in Britain in 1938, but Germany put the first jet aircraft into service (Me 262 fighter-bomber) in 1944.

Turbofans (late TL7): These engines are similar to turbojets, but use large fans to suck in and compress additional air which bypasses the combustion chamber and is expelled "cold" to increase thrust without using additional fuel. Turbofans are somewhat heavier than turbojets, but much more fuel-efficient. Turbofans first came into widespread use in the 1970s.

Ramjets (TL7): A ramjet is a simple form of jet engine that does not use a turbine. It only functions at high speeds (above about 375 mph at sea level) making some other form of propulsion necessary to enable the vehicle to reach that speed. A ramjet requires oxygen, but can operate in very thin atmospheres. TL8+ ramjets may be scramjets (supersonic combustion ramjets, designed to operate at very high speeds).

Turbo-Ramjets (late TL7): These are turbojets with variable geometry inlets allowing them to function as ramjets once the vehicle is moving faster than sound, considerably increasing their thrust. TL8+ turbo-ramjets include turbo-scramjets (supersonic combustion ramjets, designed to operate at very high speeds).

Hyperfans (TL9): These are advanced, hydrogen-burning turbofans. They may become common in times or places where petroleum-based jet fuel is unavailable or too expensive.

Afterburner (TL7): This is a device that augments the thrust of a jet engine by squirting raw fuel into the exhaust. It can be added to any kind of jet except a fusion air-ram. When turned on ("lit"), an afterburner adds to thrust but greatly increases fuel consumption. If an engine has an afterburner, list two thrust and fuel consumption values for it – one with and one without afterburner. Afterburners are mostly used in aircraft intended to be supersonic.

Fusion Air-Rams (TL10): These are fusion rockets that suck in air, heat it using a fusion reaction, then expel it as reaction mass. They operate for 2.5 years on an internal fuel supply, and while they only work in an atmosphere, its type or density (beyond a mere trace atmosphere) is irrelevant. The weight of the air-ram includes a high-efficiency fusion reactor that serves only to power the engine.

Jet engines are rated for their pounds of motive thrust. The more thrust in proportion to the vehicle's drag (determined by its final size and shape), the faster it will move.

Vehicles may have more than one jet engine. Each engine is built individually, and while having a single huge engine is a bit lighter and cheaper, using multiple engines offers a margin of safety in case one malfunctions or is disabled!

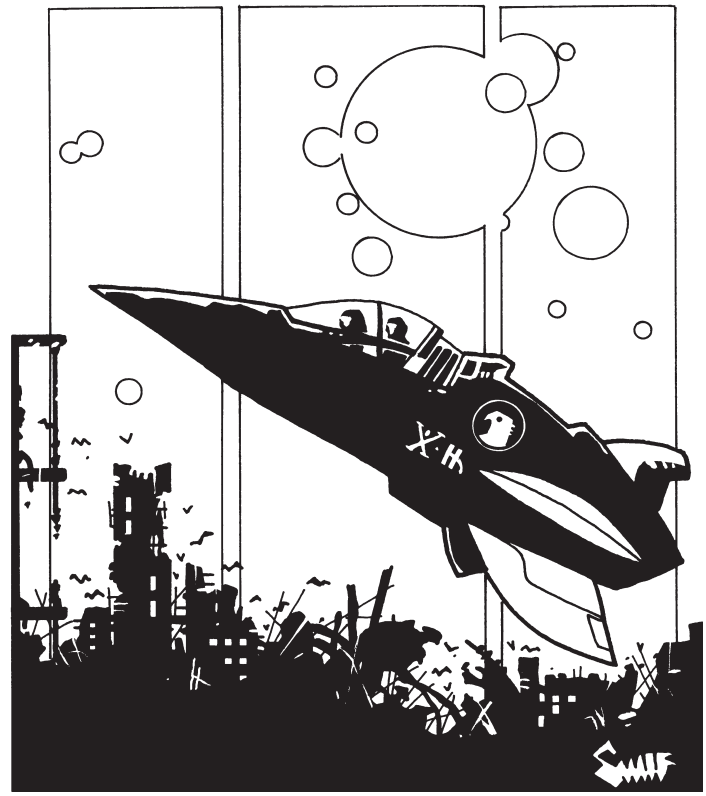
Decide what type of engine the vehicle will use, how many it will have, and what each engine's motive thrust will be. Some typical jet aircraft motive thrusts:

Late TL6 fighter: . . . . . one or two 1,500-2,000 lb. turbojets
Early TL7 fighter: . . . . . .one or two 5,000-15,000 lb. turbojets*
Late TL7 fighter: . . . . . .one or two 20,000-25,000 lb. turbofans*
TL7 attack bomber: . . . . .two 8,000-10,000 turbojets or turbofans*
TL7 strategic bomber: . . . . . .up to eight 15,000-20,000 turbofans
TL7 executive jet: . . . . . .one or two 3,000-5,000 lb. turbojets
TL7 airliner: . . . . . .two to four 10,000-15,000 lb. turbofans
TL7 superliner or
transport: . . . . . .two to four 40,000-50,000 lb. turbofans
* Includes afterburner; thrust is with afterburner lit.

For each engine the vehicle has, decide where it is located and calculate its statistics as shown below:

Jet Engine Table

TL	*Type*	*Weight (lbs.)*	*Fuel*
6	Turbojet	(0.3 × thrust) + 500	0.1J
7+	Turbojet	(0.15 × thrust) + 150	0.045J
7	Turbofan	(0.2 × thrust) + 200	0.03J
8	Turbofan	(0.1 × thrust) + 100	0.015J
7+	Ramjet	(0.1 × thrust)	0.125J
7	Turbo-Ramjet	(0.15 × thrust) + 300	0.05J
8+	Turbo-Ramjet	(0.125 × thrust) + 250	0.045J
9+	Hyperfan	(0.1 × thrust) + 50	0.2H
10+	Fusion Air-Ram	(0.05 × thrust) + 50	2.5 yr.



Location: The engine may be placed in the body, or a wing, pod, superstructure or leg.

Weight: The table shows the weight of the vehicle's propulsion system depending on motive thrust and type.

Volume: To find the volume, divide the weight by 50.

Cost: To find the cost of the propulsion system, multiply the weight by $50 for most jets or $100 for ramjets, turbo-ramjets or fusion air-rams.

Fuel Consumption: This is the fuel consumption in gallons per hour (gph) per pound of motive thrust. J indicates the fuel used is jet fuel, while H is hydrogen. The fusion air-ram runs for 2.5 years on internal fuel.

A note on fuel consumption: The figures for jet engines reflect an average cruising figure; operated at full output, these jets would use more fuel, but rather than requiring the calculation of multiple consumption figures, this averaged level has been used. An exception is noted for afterburners (below).

Power: Jets have no power requirement – the power is provided by burning fuel or (for the fusion air-ram) by a dedicated reactor optimized to do nothing else except heat the reaction mass.

Afterburner: An afterburner can be added to any jet engine except a fusion air-ram; this increases the engine's weight and volume by 10% and cost by 50%. When "lit," an afterburner on a turbofan or hyperfan increases rated thrust by 65% but multiplies listed fuel consumption by 4; on a turbojet, ramjet or turbo-ramjet, it increases rated thrust by 50% but multiplies listed fuel consumption by 3.5.

EXAMPLE

The Kitty Hawk has a jet engine. We consider adding two engines for safety, but decide on only one to save space. We use a TL7 turbofan with a mere 500 lbs. of motive thrust. Why not use more? Because we've decided the vehicle will use contragravity to lift it, so we don't need much thrust. We put the turbofan in the body. It weighs (0.2 × thrust) + 200 lbs., or 300 lbs. Its volume is weight/50 cf, or 6 cf. It costs $50 × weight, or $15,000. It has no power requirement, but uses 0.03 gph jet fuel × 500 lbs. thrust = 15 gph.

Rocket Engines and Spacedrives

Rocket engines are reaction engines that do not require air or oxygen to operate. They can be used for propulsion by aircraft, spacecraft, watercraft or underwater vehicles, as well as by ground vehicles that are equipped with skid or wheels subassemblies.

There are numerous types of rocket engines, from simple solid fuel rockets to antimatter drives. Like jet engines, they are rated for pounds of motive thrust. A vehicle can have multiple rocket engines, and can use more than one type. Many of the TL9+ rocket engines are unlikely to be used if reactionless thrusters are available (p. 38); they are included for cultures or backgrounds where this technology does not exist.

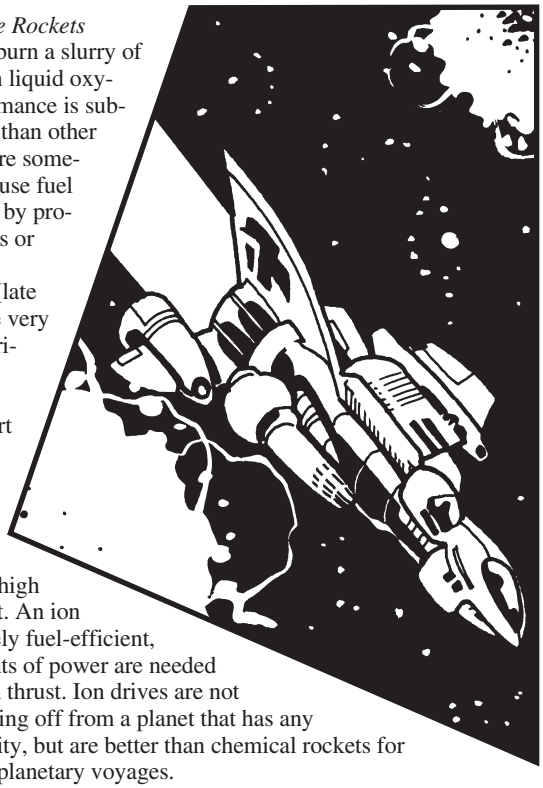
The types include:

Solid Fuel Chemical Rockets (TL3): These are the simplest and earliest type of chemical rockets, in which the fuel is a solid (or putty) at ordinary temperatures. Such rockets have no need for fuel tanks or moving parts because the casing that holds the fuel is also the combustion chamber; a solid fuel rocket can be stored with fuel, and launched on a moment's notice. However, once a solid fuel rocket is started (unlike all other types of rocket), it cannot be shut down. A solid fuel rocket cannot be quickly refuelled – replacement of the solid fuel core takes several hours at a specialized repair shop, and costs 20% of the rocket's cost. This means that on manned vehicles, solid fuel rockets are best used as "boosters" rather than as the main propulsion system.

Liquid-Fuel Chemical Rockets (TL6): These are rocket engines that burn a mixture of fuel and oxidizer, and expel the resulting hot gas exhaust to create thrust. Liquid-fuel rocket engines are quite lightweight, but they are extremely fuel-thirsty.

Metal Oxide Rockets (MOX) (TL8): burn a slurry of metal powder in liquid oxygen. The performance is substantially lower than other types but they are sometimes used because fuel can be obtained by processing asteroids or lunar rocks.

Ion Drives (late TL7): These are very low thrust electrical-acceleration propulsion systems that convert reaction mass into a stream of ions (charged atoms or molecules), which acts as a high velocity exhaust. An ion drive is extremely fuel-efficient, but huge amounts of power are needed to generate high thrust. Ion drives are not practical for taking off from a planet that has any significant gravity, but are better than chemical rockets for long, slow interplanetary voyages.



Fission Rockets (late TL7): These utilize a built-in fission reactor optimized to heat reaction mass and expel it to produce thrust. They are heavy and expensive, but offer more thrust than ion drives. Their exhaust is somewhat radioactive.

Fusion Rockets (TL9): These rockets incorporate an integral fusion reactor that heats reaction mass and expels it to produce thrust. The disadvantage is a very hot (and somewhat radioactive) exhaust. The *optimized* fusion rocket is designed for fuel efficiency at the expense of greater weight.

Antimatter Thermal Rocket (TL9): This rocket mixes minute quantities of antimatter with far larger amounts of normal fuel to generate heat and produce an extremely energetic exhaust. The antimatter rocket is far easier to build (even at low TLs) than an antimatter power plant – the only limitation is that antimatter is *extremely* expensive at TL9. See *Antimatter Fuel Bays* (p. 90) for rules covering antimatter storage and failsafes.

Antimatter Pion Rockets (TL9): A much more sophisticated space drive, this system mixes an *equal* quantity of matter and antimatter whose mutual annihilation generates energy. Part of this is in the form of pion particles, which are directed by magnetic fields rearward to provide thrust. The antimatter drive's main advantage is that it requires very little fuel and as such can accelerate for a long time, gradually building up to a very high velocity. Its disadvantage is that the exhaust is an intense plume of gamma rays and other radiation thousands of miles long! Antimatter pion rockets usually have some form of secondary drive for use when maneuvering in close proximity to other ships or space stations.

Rocket engines are rated for their pounds of motive thrust. The more thrust a vehicle has, the faster it will move and accelerate. As with jet engines, vehicles may have more than one rocket engine for added safety; each is built individually, but their thrust will add together.

Decide what type of engine the vehicle will use, how many it will have, and what each engine's motive thrust will be. For each engine the vehicle has, decide on its location and calculate its statistics as shown below. *Exception:* for solid fuel rockets, see p. 37.

Rocket Engines Table

TL	*Type*	*Weight*	*Fuel Usage*	*Power*
6	Liquid Fuel Rocket	0.015 × thrust	1.5R	0
7	Liquid Fuel Rocket	0.012 × thrust	1.25R	0
8+	Liquid Fuel Rocket	0.01 × thrust	1.1R	0
8+	MOX Rocket	0.025 × thrust	1.08MOX	0
7	Ion Drive	(1,000 × thrust) + 5	0.0017C	650
8+	Ion Drive	(200 × thrust) + 5	0.0017C	650
7	Fission Rocket	(0.325 × thrust) + 4,000	0.5W	0
8+	Fission Rocket	(0.15 × thrust) + 1,000	0.1W	0
7+	Orion Engine	see p. 37	special	0
9	Fusion Rocket	(0.05 × thrust) + 50	0.02W	0
9	Optimized Fusion	(3,000 × th.) + 20,000	0.004H	0
10+	Fusion Rocket	(0.025 × thrust) + 25	0.02W	0
10+	Optimized Fusion	(300 × thrust) + 2,000	0.004H	0
9	Antimatter Thermal	(0.02 × thrust) + 1,000	0.05W/AM	0
10+	Antimatter Thermal	(0.02 × thrust) + 100	0.05W/AM	0
9	Antimatter Pion	(1,000 × th.) + 20,000	M/AM	0
10+	Antimatter Pion	(200 × thrust) + 4,000	M/AM	0

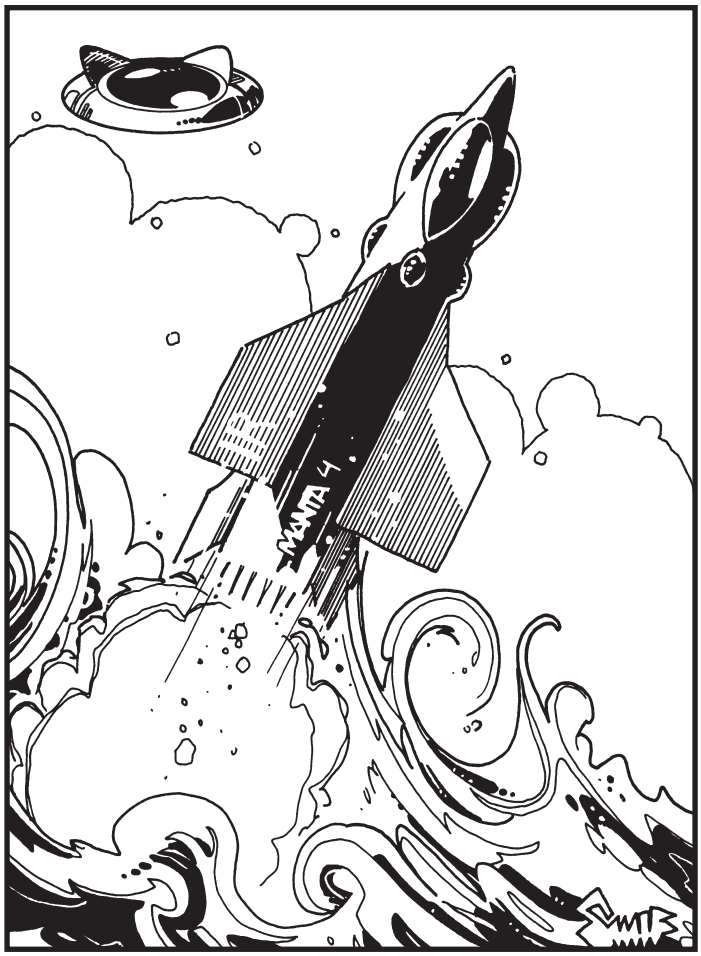
Location: The engine may be placed in the body, wing, pod, superstructure, or leg.

Weight: The table shows the weight of the propulsion system (in pounds) depending on motive thrust and type.

Volume: To find the volume, divide the weight by 50.

Cost: To find the cost of the propulsion system, multiply the weight by $25 if Liquid Fuel Rocket, or by $100 (any other system).

Power: This is the power consumption per pound of thrust. Systems with 0 power consumption usually convert their fuel into energy, or in the case of a fission or fusion systems, are self-contained reactors optimized for propulsion.



Fuel Consumption: Most reaction engines are rated for fuel and reaction mass consumption. Multiply the "fuel" number on the table by the chosen motive thrust to find the consumption in gallons per hour (gph). Fuel types are abbreviated as follows: R is rocket fuel, W is water, H is hydrogen, MOX is metal/liquid oxygen, C is cadmium. AM is antimatter: antimatter thermal rockets also consume 0.000004 grams of antimatter (generally anti-hydrogen) per hour per pound of thrust. M/AM is matter/antimatter: pion rockets consume 0.004 grams of antimatter and 0.000015 gallons of hydrogen per hour per pound of thrust.

Solid Fuel Rockets

Solid fuel rockets differ from more advanced models of chemical rocket in that the fuel is part of the rocket engine. As well as choosing a motive thrust, select a *burn time* (in minutes). This is the time the engine can fire for. A typical burn time is 1 to 3 minutes for a spaceship booster, or a couple of seconds for a booster intended for a car or aircraft.

After the rocket fuel has burned away, the rocket is useless. The remaining weight of the rocket casing is 15% of the fuelled rocket.

Solid Rocket Table

TL	*Weight*	*Cost*
3-4	1	$0.5
5	0.35	$0.5
6	0.27	$1
7	0.21	$5
8+	0.18	$5

Location: The engine may go in body, wings, pods or legs.

Weight in pounds is the chosen thrust (lbs.) times the burn time (minutes) times the weight shown on the table.

Volume is weight divided by 100.

Cost is weight multiplied by the number shown for cost.

Orion Engines

This is an exotic TL7 reaction engine designed for space travel. Orion is the ultimate in brute-force engines: it uses the detonation of a nuclear bomb to generate thrust. The system consists of a large hemispherical pusher plate fitted to shock absorbers and a system for setting off nuclear explosions at the center point of the hemisphere. The Orion engine takes its name from Project Orion, an abortive 1960s-era space program which originated the design. Orion engines are also sometimes known as nuclear pulse engines.

Decide the system's pulse rate (the detonation rate in bombs per second, or BPS); pulse rates may be fractional. BPS must be at least 0.1. Select the size of the nuclear bombs used (measured in kilotons, or kt).

Motive Thrust: This is equal to 400,000 lbs. × bomb size (kilotons) × pulse rate.

Then use the table below to determine the weight, volume and cost of the engine:

Orion Engine Weight Table

TL	*Weight (lbs.)*
7	100,000 + (100,000 × kt) + (10,000 × BPS)
8	100,000 + (50,000 × kt) + (5,000 × BPS)
9+	100,000 + (25,000 × kt) + (2,500 × BPS)

Location: In body.

Weight: This is calculated as shown above, based on TL, kilotons (kt) of bomb size and pulse rate (BPS) in bombs per second.

Volume: This is weight/100 cf.

Cost: This is weight × (square root of BPS).

The Orion engine will need to carry a certain number of nuclear bombs ("thrust bombs") to serve as fuel. The number of thrust bombs required is the amount of time the engine can thrust for times its detonation rate in BPS. The weight, volume and cost of thrust bombs depend on TL:

Thrust Bomb Table

TL	*Weight of Thrust Bombs*
7	40 lbs. + (2 lbs./kiloton)
8	20 lbs. + (1 lb./kiloton)
9	10 lbs. + (0.5 lb./kiloton)
10+	0.25 lb./kiloton

Location: Thrust bombs must be stored in the body.

Weight is shown on the table.

Volume is weight/50.

Cost is weight × $1,000.



Reactionless Thrusters

Reactionless thrusters directly transform energy into thrust through means inexplicable to 20th-century science, bypassing the need for reaction mass. In game terms, they function much the same way that rocket engines do, except that they do not need fuel. GMs of rigorously "hard science" campaigns should feel free to omit reactionless thrusters!

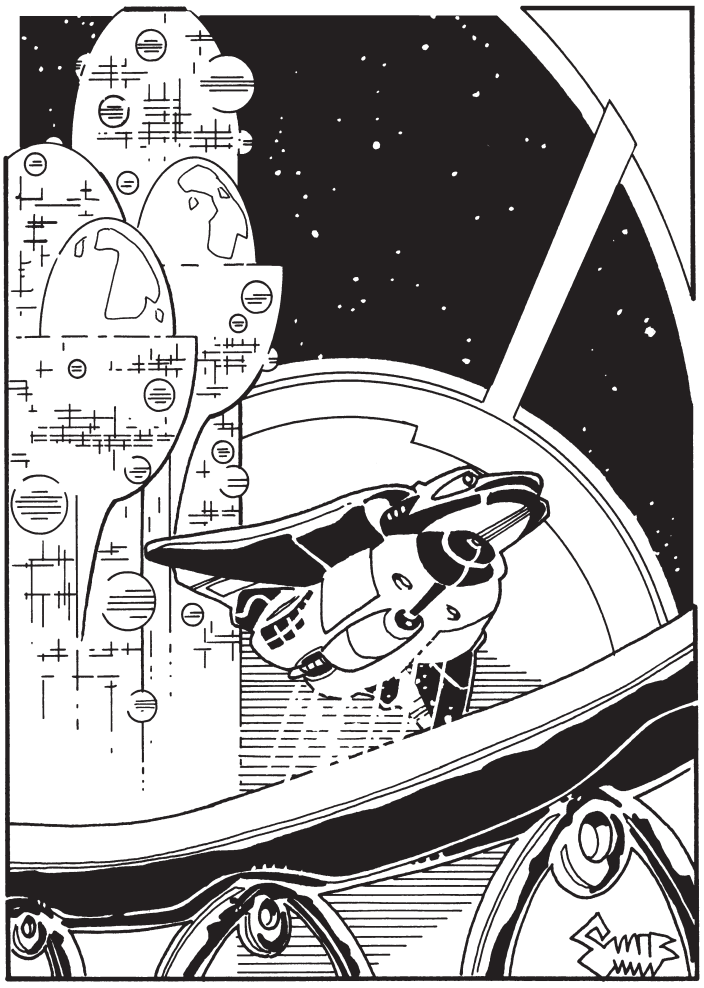
TL9 reactionless thrusters produce considerable waste heat discharge, as much as any rocket of equivalent thrust. TL10 thrusters produce some waste heat discharge, similar to a jet engine. TL11+ thrusters produce no waste heat and are invisible and silent. Most "grav" vehicles use TL11+ reactionless thrusters for propulsion and anti-gravity for lift; perhaps UFOs do also.

Reactionless thrusters built at TL10 and up come in both "standard" and "super" versions – the latter have more thrust for a given thruster weight, but are more expensive. At TL13+, ultra-powerful "mega thrusters" may be available. Not all universes will have them – GM's option.

Reactionless thrusters can be used for propulsion by aircraft, spacecraft, watercraft or underwater vehicles, and by ground vehicles equipped with skid or wheeled subassemblies.

Reactionless thrusters are rated for their pounds of motive thrust. Use the same suggested thrusts for reaction engines if you want fast vehicles with jet-aircraft speeds! However, at TL12+, many contragrav vehicles use reactionless engines. Combined with contragrav, a typical flight pack worn by a person would only need about 20 lbs. thrust, while a car might use about 200 lbs., and a grav truck or tank about 2,000 lbs.

The more thrust a vehicle has, the faster it will move and accelerate. As with rocket engines, vehicles may have more than one thruster for added safety; each is built individually, but they combine their thrusts. Decide what type of engine the vehicle will use, how many it will have, and what each engine's motive thrust will be. For each engine the vehicle has, decide on its location and calculate its statistics as shown below:



Reactionless Thrusters Table

TL	*Type*	*Weight*	*Power*	*Cost*
9	Standard Thruster	1 × thrust	0.5	$25
10	Standard Thruster	0.5 × thrust	0.5	$20
10	Super Thruster	0.2 × thrust	0.5	$100
11+	Standard Thruster	0.05 × thrust	0.05	$20
11+	Super Thruster	0.02 × thrust	0.05	$100
13+	Mega Thruster	0.001 × thrust	0.05	$4,000

Location: A thruster may be placed in the body, or a wing, pod, superstructure or leg.

Weight: The table shows the weight of the vehicle's propulsion system in pounds, depending on motive thrust and type.

Volume: To find the volume, divide the weight (after any modifiers) by 50.

Cost: To find the cost of the propulsion system, multiply the weight by the number shown. Minimum cost is $500 per thruster.

Power: This is the power consumption per pound of thrust.

Magnetic Levitation (Mag-Lev, TL7)

Magnetic levitation uses powerful electromagnets to suspend a wheelless vehicle above a metal rail. The vehicle is propelled by "surfing" the magnetic flux generated between the magnets in the vehicle and the rail. Since there is no direct contact between the vehicle and the rail, the only limitation on speed becomes air drag; velocities of 300 mph or better are common.

The main disadvantage of mag-lev propulsion is the relatively high start-up cost of constructing the specialized mag-lev rail. But because the train never actually contacts the rail, it does not require as much in the way of costly maintenance as conventional high-speed railway tracks do.

Historically, mag-lev was invented in the United States, but so far the technology has only seen serious commercial development in Japan and Germany, where mag-lev vehicles are in limited commercial service. By TL8, more mature mag-lev technology may offer successful competition to railway and air travel.

Mag-Lev Lifters: A mag-lev vehicle requires this component, representing the conventional or superconducting lift and propulsion magnets built into the vehicle. It is rated for pounds of magnetic lift; through magnetic interaction with the track, the mag-lev lifter also provides propulsive thrust. The vehicle will not be able to move if its final loaded weight is greater than the mag-lev lift of the drivetrain. As a result, keep a running total of weight when designing the vehicle! To allow for a heavy payload, it is wise to make sure the final design weight of the vehicle is only about 10-20% of the rated magnetic lift.

Unlike trains, where a single locomotive may pull several unpowered railway cars, all mag-lev cars must have mag-lev lifters. Calculate the lifter's statistics as shown below:

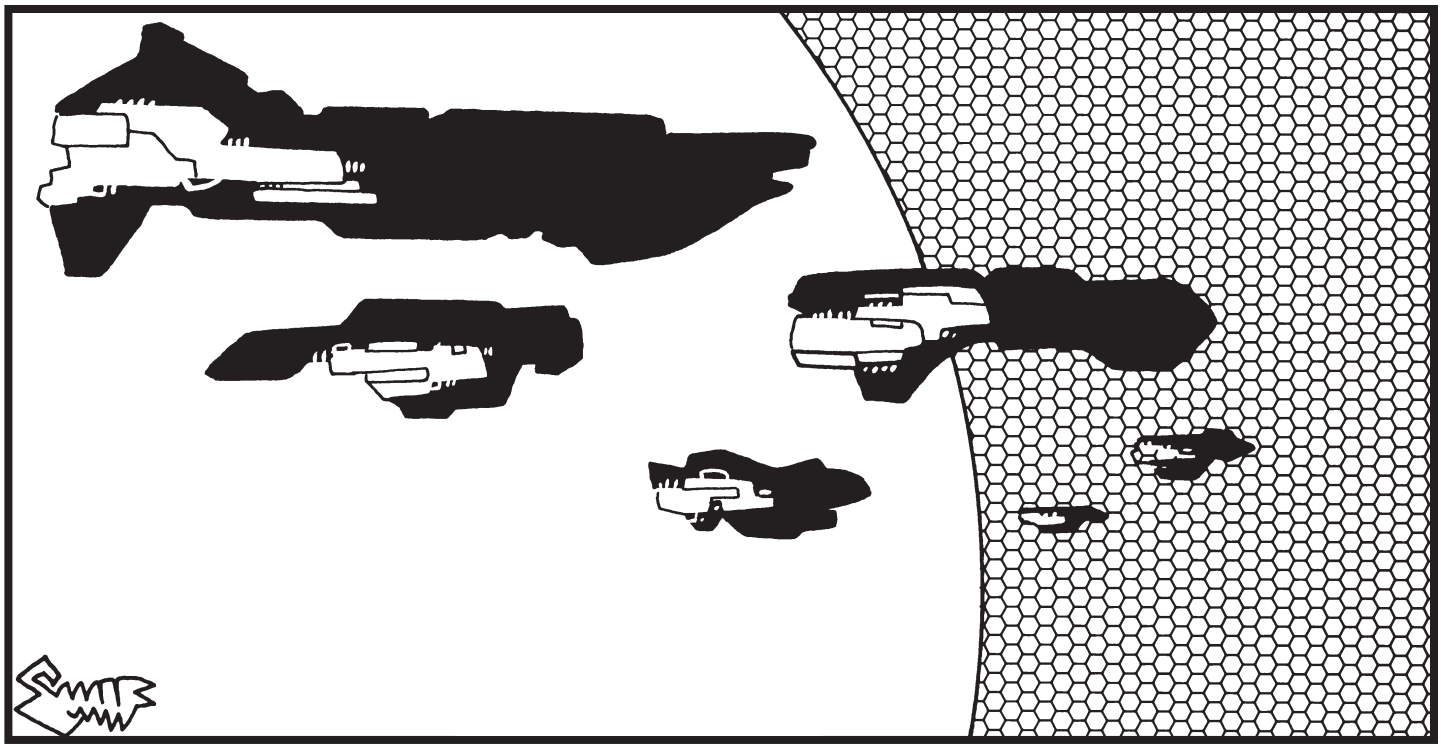
Mag-Lev Lift Table

TL	*Weight*	*Volume*	*Cost*	*Power*
7	0.05	0.001	$50	0.01
8	0.02	0.0004	$8	0.01
9+	0.01	0.0002	$2	0.01

Location: In body.

Weight, Volume, Cost and *Power* are per pound of mag-lev lift. Note that the power requirement can be met by an energy bank or power plant, or by the rail itself (see *Electric Contact Power,* p. 87).

Mag-Lev Rail Line: A mag-lev vehicle must run on a conductive rail line. To minimize the accelerations felt by passengers at high speeds, it must be kept relatively flat, with fairly gentle curves; therefore, it is generally elevated on pylons to easily clear ground contours. It must also be connected to a power grid. Power requirement is equal to the total mag-lev lift power requirements of all mag-lev vehicles using the track at the time; if the rail is also providing contact power, be sure to add this power requirement as well. Cost is $4,000,000 per mile of track at TL7, halved at TL8 and again at TL9+. At ten times cost, the mag-lev rail may be designed to run in an evacuated tunnel – this allows higher maximum speeds, but requires (for instance) airlocks built into the vehicle for passenger embarkation.



Stardrives

Stardrives are propulsion systems that enable spacecraft to travel faster than light over interstellar distances. The three most common ***GURPS Space*** stardrives are included here for GMs who wish to design spacecraft for ***Space*** campaigns using the more detailed ***GURPS Vehicles*** system. In many campaigns, only one – or none – of these stardrives will be available! The performance figures are based on the default values in ***GURPS Space,*** with some changes to better reflect the changes in scale and detail between the ***Space*** and ***Vehicles*** design systems.

Depending on the campaign, stardrives may have various special advantages or limitations. These are discussed fully in ***GURPS Space*** (pp. 22-26). In general, most stardrives only operate well beyond the reach of a planet's atmosphere or gravity, so ships will also require normal reaction drives or reactionless thrusters to get to the point the stardrive will take over. The three types of stardrive are:

Hyperdrive: This is the default TL10 faster-than-light drive. A hyperdrive has a "hypershunt" capacity, rated in *tons* of mass. This is the amount of mass it can shunt into hyperspace, a non-Einsteinian dimension whose physics permit faster-than-light travel. In hyperspace the FTL speed is *x* parsecs per day (*x* is set by the GM; the default is 0.2) *times* the hypershunt rating divided by the ship's mass in tons. GMs who want to disallow small "hyperspace torpedoes" and "hyperspace cars" can require a *minimum* hypershunt rating of 100 tons.

Jump Drive: This drive is used if space contains "jump points" connected to one another. A jump drive allows a ship to take advantage of such "weak points" or "wormholes" in space, moving from one to another without crossing the space in between. Jump drive travel is usually instantaneous (although this may vary in some campaigns), but jump points themselves are often located some distance away from planets or stars, requiring normal propulsion systems. Jump drives are rated for the mass they can carry with them into jump. If the ship masses more that, the drive won't work. In ***GURPS Space,*** jump drives are built in "engines," each capable of carrying 500 tons of mass into jump. The GM may require that all jump drives be rated for at least 500 tons, and that jump drives be built in such 500-ton increments.

Warp Drive: This is the most advanced form of FTL drive. It allows the ship to travel and maneuver at faster-than-light speeds while still interacting with the normal universe. The exact mechanism is up to the GM: perhaps it surrounds the ship it is mounted on in an energy field, such as a bubble of hyperspace, or maybe the drive moves the ship forward via teleportation, in a series of rapid "microjumps." Warp engines are rated for the "warp thrust" they produce, using "warp thrust factors" (WTF). One WTF propels one ton of mass at *x* parsecs/day. *X* is set by the GM; the default is one pc/day (about 220,000,000 miles per second). A warp drive-equipped ship has a speed in parsecs per day equal to its warp thrust factor divided by its loaded mass in tons.

If a vehicle has a stardrive, choose the drive's "hypershunt capacity," "jump capacity" or "warp thrust" in tons. Then decide the location of the drive, and calculate its weight, volume, cost and power requirements:

Stardrive Table

TL	*Type*	*Weight*	*Cost*
10	Hyperdrive	20	$400
11	Hyperdrive	10	$400
12+	Hyperdrive	10	$40
10	Jump Drive	8	$140
11	Jump Drive	4	$140
12+	Jump Drive	4	$14
10	Warp Drive	4,000 + (100 × WTF)	$500
11	Warp Drive	2,000 + (50 × WTF)	$500
12+	Warp Drive	2,000 + (50 × WTF)	$50

Location: In body, wings, pod, turret, superstructure or legs.

Weight is as shown on the table per warp thrust factor (WTF) or per *ton* of hypershunt or jump capacity.

Volume is weight/50 cf.

Cost is as shown on the table per ton of hypershunt or jump capacity, or per WTF. In addition, warp drives require an extra $20,000 at TL10-11 or $2,000 at TL12+.

Power requirement depends on the kind of drive:

A hyperdrive requires 360,000 kWs of energy per ton of hypershunt capacity to enter hyperspace, and continues to draw 10 kW per ton of capacity to remain there. A hypership will usually have an energy bank (p. 87) for the initial requirement, and a power plant (p. 82) to cover the continuing drain.

A jump drive requires 3,600,000 kWs of energy per ton of jump capacity to "open" a jump point. This is usually provided by an energy bank, rather than by a 3.6-gigawatt power plant!

A warp drive consumes 100 kW x WTF. This constant drain is usually met by a power plant.

Teleportation Drives

This TL16 (or possibly magical) device is similar to a jump drive, except that it can be used anywhere, even on a planet! It warps space around the vehicle, creating a quantum bridge between its own location and the intended destination – the vehicle vanishes and reappears instantly at its destination without crossing the intervening space. Its range is up to the GM; it could even be infinite.

Obviously, such a vehicle could unbalance a campaign. It is included because certain SF vehicles *do* have such an ultimate capability. One suggested limitation is to limit the range it can jump. Another limitation is to require Piloting (Teleportation) rolls, with a hefty minus (e.g., -10) for destinations never visited before; failure results in losing the vehicle *and* burning out the teleportation drive for several hours or days, while critical failure causes total destruction of the teleport drive or strands the vehicle in an entirely different dimension. The drive may also require a few hours (or longer) to "reset" after a single jump, preventing instant getaways.

A teleportation drive has twice the weight and volume and 10 times the cost and power requirement of a TL10 jump drive.

At the GM's discretion, a further doubling in weight, volume and cost could allow the teleportation drive-equipped vehicle to travel through time or parallel worlds as well as space, with whatever limitations the GM sets (see ***GURPS Time Travel***).

Parachronic Conveyers

A "parachronic generator" does not move an object in space or time – instead it shifts it "sideways" into a parallel or "alternate timeline." Rules for parachronic generators are described in the Infinite Worlds background in ***GURPS Time Travel*** (p. TT91). That background's Infinity Patrol outfits all manner of vehicles with parachronic generators, creating "mobile conveyers" – cars, tanks, planes or ships capable of traveling between adjacent parallel worlds. These vehicles may look like anything from any TL, but always contain a metal structure. In the Infinity Patrol background these generators are TL8; in other backgrounds, they may be any desired TL.

A standard "subquantum conveyer" generator can jump between very close alternate timelines. Some conveyers are "hardwired" to limit them to specific destinations. All can transport a weight of 200 lbs. for every pound the generator weighs, take up weight/50 cf, and cost (weight times $4,000). Power requirement is negligible.

A "quantum conveyer" is identical except that it costs 50% more. It has one special ability: it can travel between relatively distant alternate timelines if it is boosted with the help of a stationary, auditorium-sized "parachronic projector" installation.

A "two-quantum conveyer" has three times the weight and volume and eight times the cost of a subquantum conveyer. It has the same abilities as the other two types, but is also capable of even longer-ranged jumps into very distant alternate timelines if boosted with the help of a massive, city-block-sized projector installation.

Part II: Aerostatic Lift Systems

This section covers technologies that enable a vehicle to generate lift *aerostatically* – that is, without needing motion of an airfoil, such as wings or rotor blades. The main advantage of aerostatic lift is that it enables the vehicle to stop in mid-air, hover, or take off and land vertically.

Aerostatic lift systems may be used on their own, or they may be added to supplement wings or rotors. All are rated for their lift in pounds. A vehicle's final loaded weight must be less than the combined lift from all lift systems in order for the vehicle to fly or hover using them alone. However, even if lift is insufficient, they can also improve the short takeoff and landing performance of a rotary-wing or fixed-wing vehicle.

Since the vehicle's final weight won't be determined until it is fully-constructed and loaded, keep a running tally of the weight of components as they are installed, and if necessary, backtrack and delete components (or increase the lift capabilities) if their combined weight looks like it will exceed the lift.

EXAMPLE

The Kitty Hawk has aerostatic lift, and we decide the final vehicle might weigh as much as 10,000 lbs., loaded. So that's how much lift we'll give it. We've already decided to use contragravity (p. 41).

Lighter-than-Air Gas (TL5)

In the 18th century, it was discovered that a vehicle carrying enough lighter-than-air gas will also be lighter than air, and will rise up. This fact led to the first successful manned flights, in balloons, and later in self-propelled airships.

By 1800, hot-air and hydrogen balloons were common enough that adventurers would have no trouble finding someone to sell or build them one. Hydrogen fell out of favor for lifting gas after a series of disasters (the last of which was the *Hindenburg)* just before World War II.

Lighter-than-air gas is a cheap, low-tech way to get a vehicle to stay airborne. But it only works in an atmosphere heavier than the gas, and a *very* large volume of lighter-than-air gas is required to produce lift.

The choices for lifting gases are hot air (TL5), hydrogen (TL5) or helium (TL6).

Hot Air (TL5): When air is heated, it becomes lighter and rises. This fact was harnessed for flight in 1783 when the first manned hot-air balloon was flown; by 1800, hot-air balloons were everywhere. Hot air has little lifting power but is safe and cheap.

Hydrogen (TL5): The lightest of all gases, hydrogen is the most effective lifting agent but is also flammable. Historically, hydrogen was being used within a few months of hot air. It was favored for airships until a series of dramatic disasters in the 1930s led to its retirement.

Helium (TL6): This gas has somewhat less lifting power than hydrogen, but isn't flammable. It *is* expensive. Helium is light enough that it escapes from the Earth's atmosphere, with the only significant amounts being found underground. Historically, helium mining was a byproduct of the United States' natural-gas industry and was an American monopoly and strategic resource. At TL6, multiply helium prices by 10 inside the U.S. and by 100 outside it. The U.S. government's reluctance to approve export of helium to Nazi Germany led to the Zeppelins using hydrogen for lifting gas, with disastrous consequences.

Select the type of lifting gas. Decide the useful lift (in pounds) the gas will have (this is the lift produced after subtracting the weight of the gas itself). Then calculate the volume and cost of the lifting gas using the table below.

Lifting Gas Table

TL	*Type*	*Volume*	*Cost*
5	Hot Air	60	$0.01
5	Hydrogen	14.8	$0.07
6	Helium	16	$0.10

Location: Lifting gas can go in a gasbag subassembly outside the vehicle, or in a sealed body or pod. "Rigid" airships like Zeppelins usually fill most of the body with gas; nonrigid craft like blimps or balloons store it in a separate gasbag.

Volume: Multiply the useful *static lift* by the volume shown on the table (what's needed to generate 1 lb. of lift) to find the *volume* of gas required.

Cost: Multiply the *volume* required by the cost shown on the table to find the cost of the lifting gas. (Hot-air costs are actually for burner fuel.) The lifting-gas cost is charged for each flight or per week of continuous operation, to replace used gas and ballast.

Lift Fans and Engines (TL3)

Lift fans or engines simply involve installing fans or reaction engines (such as jets or rockets) to point downward, so that the thrust counterbalances some or all of the vehicle's weight.

Any ducted fan (p. 33), jet engine (p. 35), rocket engine (p. 36), orion engine (p. 37) or reactionless thruster (p. 38) can be built as a lift fan or engine, by mounting it to point downwards Instead of producing thrust, it produces pounds of lift. Lift engines and fans must be housed in the vehicle's body, wings or pods.

The disadvantage of using lift fans or engines for lift is that their thrust cannot then be used for propulsion: a second propulsion system is then necessary. An alternative solution is vectored thrust:

Vectored Thrust: Rather than buying a whole new lift engine or fan, an existing ducted fan, jet engine, rocket engine or reactionless thruster can be modified with the vectored thrust option. This enables the fan, engine or the engine's exhaust to tilt, vectoring a portion of the thrust downward. It can then divide thrust between lift and forward thrust. Normally the vehicle will allocate just enough lift to equal the vehicle's loaded weight, and use the rest for thrust. If the vehicle is also winged, it will then accelerate to a speed where its wings can provide all the lift, and at that point switch all lift to forward thrust, increasing its speed. Making a fan, engine or thruster "vectored thrust" multiplies its weight, volume and cost by 1.5.

Vertical Takeoff With Normal Engines: Even without lift engines or vectored thrust, a vehicle whose combined air thrust exceeds its loaded weight can lift off vertically if it is launched from a special gantry or launch pad. It just won't be able to land vertically, or to stop and hover in mid-air . . .

Hoverfans (TL7)

These lift fans rely on the air cushion principle to produce additional lift in proximity to the ground.

Any ducted fan built into the vehicle's body can be designated as a hoverfan. A hoverfan's *effective* lift is doubled when the vehicle is within a few feet of the ground.

If the vehicle has a GEV skirt or SEV sidewalls, instead of being doubled, the lift is multiplied by 4 (sidewalls) or 5 (GEV skirt).

Contragrav Generators (TL12)

Contragravity is a means of artificially "screening" the vehicle against a planet's gravity field, effectively negating some or all of its weight. Contragrav technology violates known physics; as such, GMs of "hard science" campaigns may opt to ban contragravity. On the other hand, this also means that a breakthrough in gravitic technology could allow contragrav to appear *earlier* than TL12 – say, at TL9, TL10 or TL11. The choice of TL12 is merely a default for the standard ***GURPS Space*** background.

If the vehicle has contragravity, decide how many pounds of lift the contragrav generator provides. In order to fly, the lift should exceed the vehicle's expected final weight. Note that contragravity does not propel the vehicle, it only lifts it. A vehicle with contragrav usually uses a TL11+ reactionless thruster (p. 38) for in-flight propulsion, but may use any form of thrust, such as a propeller or jet engine. The weight, volume and cost of a contragrav generator depend on TL:

Contragravity Table

TL	*Weight*	*Cost*	*Power*
12	(lift/1,000) + 20	$(lift/40) + $2,500	Lift/1,000 kW
13+	(lift/2,000) + 10	$(lift/200) + $500	Lift/1,000 kW

Location: Contragrav generators may go in the body or in pods.
Weight, Cost and *Power* are based on the generator's pounds of lift.
Volume is weight/50 cf.

EXAMPLE

The Kitty Hawk is built with a TL13 contragrav generator. We install a generator with 10,000 lbs. lift. It weighs (lift/2,000) + 10, or 15 lbs., takes up 15/50, or 0.3 cf and costs (lift/200) + $500 = $550. It requires lift/1,000 kW, or 10 kW power.

Levitation (Special)

This is a supernatural or super-scientific form of contragravity in which the vehicle's body is made of or coated with an exotic material that enables it to defy gravity. Some possible means of levitation are:

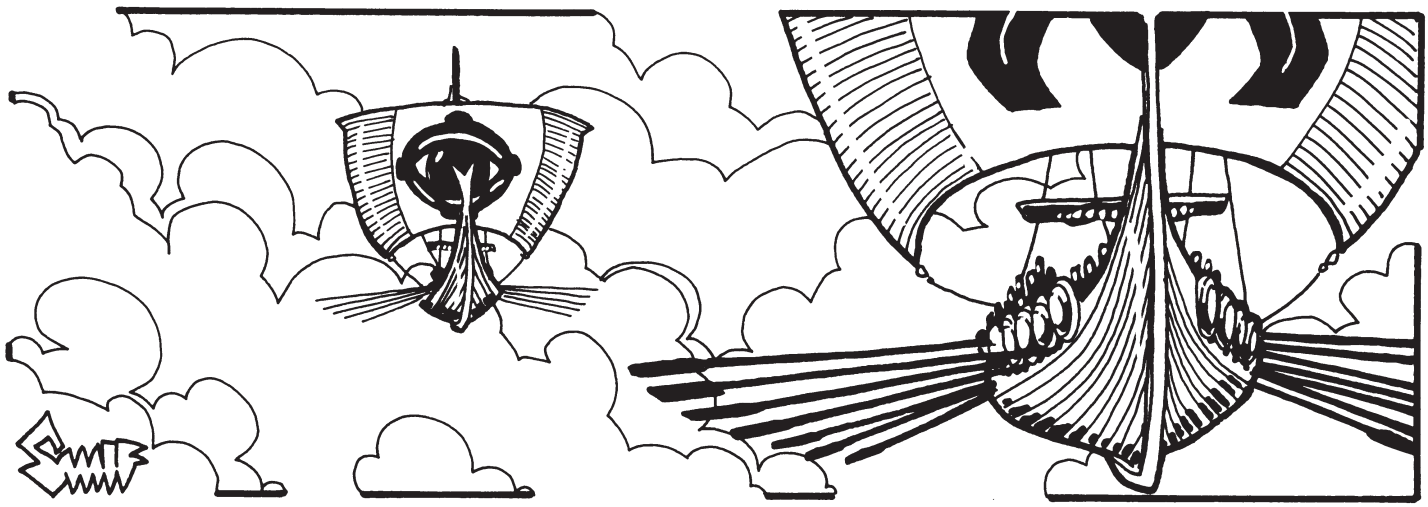
Magic Levitation (TL0): A vehicle body can be enchanted with the Levitation spell, using the same method that is used to create flying carpets (see p. M70). The energy cost is a flat 700 energy per 250 pounds of lift (or fraction thereof).

Anti-Gravity Coating (TL1): The body can be made or panelled with a naturally-occurring antigravity material. How common or rare that material is, and whether it is animal, vegetable or mineral, is up to the GM. The coating simply neutralizes all of the vehicle's weight, automatically producing lift that is equal to the vehicle's current weight. The cost is determined at the end of the design process and is based on the surface area of the vehicle. If the material is uncommon but not rare, a suggested cost is $10 times surface area in square feet.

Superscience (TL5): As above, except the body is coated with a material that does not naturally occur, but was instead invented from rare and unlikely ingredients (e.g., an antigravity paste made from a mixture of rare earths bombarded by X-rays). Assuming the inventor parts with the secret, the cost is likely to be higher: perhaps $100 times surface area in square feet.

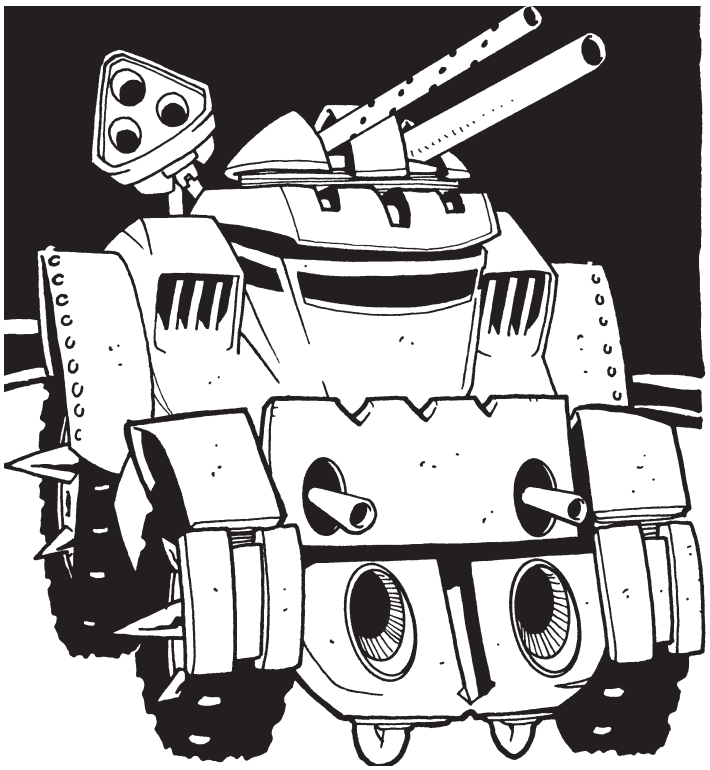
A levitating vehicle will simply drift in the wind like a balloon unless it is given a propulsion system.

Since the levitation is usually a property of the body, loss of body hit points results in diminishment of flight capability. Normally, a levitator's operator can cause it to gain or lose up to 2 yards of altitude per second. When it loses one-quarter or more of its body hits, this changes: it can only gain 1 yard, but it can lose up to 3 yards. When it loses one-half or more of its body hits, it cannot take off or gain altitude, but may drop up to 4 yards per second. When it loses three-quarters or more of its hit points, it *must* lose anywhere from 1 to 5 yards of altitude per turn. When the vehicle loses all hit points, it will fall.



ARMAMENTS 3

This section describes a wide variety of weapons built using the design rules in Chapter 9; the technology behind these weapons is explained there as well. The weapons described here are merely a sampling, and only scratch the surface of the wide array of armament that can be mounted on vehicles; virtually *any* weapon can be designed using the *Weaponry* chapter.



Weapon Descriptions

The *Armament Tables* on pp. 43-44 give the information needed to mount each weapon in a vehicle, in a format similar to that used in the ***Basic Set.*** An explanation of the headings on the tables:

Name: This always includes the bore size (the diameter of projectile it fires) so that the rules in the *Weaponry* chapter can be used to give the weapon other types of ammunition. Otherwise, names are descriptive only; e.g., a "120mm tank gun" doesn't have to go in a tank – it can be mounted in any kind of vehicle.

Malf: The malfunction chance. It is used with the optional malfunction rules described in ***High-Tech.*** "Crit." means a malfunction occurs on a critical failure. "Ver." means a malfunction is very rare – if a critical failure occurs, reroll: only on a second critical failure does a malfunction occur. A number means a malfunction occurs on that roll or higher; thus, 16 means a 16, 17 or 18 is a malfunction. In general, a malfunction means the weapon can't be fired until the problem is fixed. Time to fix a malfunction is one turn for a weapon with RoF 1 or more; this also requires an Armoury skill roll. If RoF is below 1, time to fix a malfunction is equal to the time to load and fire one shot; e.g., if RoF is 1/15, one roll is allowed every 15 seconds. *Exception:* No skill roll is required to fix a revolver malfunction, and only one turn.

Type: This is the same as in the ***Basic Set,*** with one new type: "Exp." indicates the weapon's attack inflicts explosive concussion damage (see p. B121) over an area.

Damage: The damage the weapon inflicts. A number in parenthesis following damage is an armor divisor: DR is divided by that number against the attack. In the case of AP-type projectiles, damage is also divided by two after the armor is penetrated. See also the specialized *Damage Divisor* rules, p. 188. A number in brackets following damage is the fragmentation damage (see p. B121) of an explosion. "Spcl." is "special" – see the weapon description.

SS and *Acc:* The Snap Shot and Accuracy numbers work the same way as in the ***Basic Set.***

1/2D: The range beyond which the weapon does one-half normal damage. After 1/2D range, Acc normally drops to 0. Weapons doing Exp. damage do not have damage halved past the 1/2D range, but do lose Accuracy. Some weapons don't have a 1/2D range.

Max: The maximum range of the weapon.

RoF: Rate of fire. A RoF with an "NR" after it (e.g., "1NR") means the weapon is not easily reloaded – reloading must be done outside the vehicle. If a weapon has a RoF like 2:5 or 3:6, it is a single-shot weapon with multiple barrels: it can fire a number of shots (all at once or in succession) equal to the number before the colon, and it then takes the number of turns shown after the colon to reload *each* barrel.

Wt.: The weight of the weapon in pounds, without ammunition. Use this weight when installing it in the vehicle. Weight is also used to derive volume, which is *not* on the table. Volume depends on how the weapon is mounted, and is normally weight/50 cf. A weapon may be *concealed* in the vehicle – buried entirely inside it – but in this case, it takes up more space: volume is weight/20 cf.

WPS: The weight per shot – the weight in pounds of a single shot, including propellent, projectile and casing.

VPS: The volume of a single shot in cf.

CPS: The cost of a single shot.

Ldrs.: The number of crew members required to load the weapon.

Pow.: The power (in kW) required to fire the weapon at its full rate of fire.

These additional combat statistics apply only to missiles and torpedoes:

Rating: A launcher can fire any missile or torpedo of its diameter whose weight does not exceed its rating. Aside from RoF and SS, combat stats will depend on what is loaded.

Min: The minimum range of the weapon. Artillery cannot shoot at targets closer than this; missiles fired at targets under minimum range do not receive an Accuracy bonus, and guidance systems will not activate.

Spd is a missile's or torpedo's speed in yards per second.

End is the number of seconds a missile or torpedo can travel before running out of fuel and crashing.

Guid. is the guidance system used by a missile or torpedo. See the *Combat* chapter for an explanation of how the different guidance systems work in play.

Skill rates the sophistication of guidance systems. How it is used in described in the *Combat* chapter.

No "Shots" statistic is given, as it depends on how many rounds are carried aboard (see *WPS, VPS* and *CPS*). "Rcl" and "ST" are also omitted; they don't apply to vehicle-mounted weapons.

Mechanical Artillery and Guns

This table provides statistics for catapults and guns. These statistics may vary considerably from those for similar weapons in ***GURPS High-Tech.*** This is to bring them in line with the weapon and armor rules in this book, which consider several factors that ***High-Tech*** neglects. Where the two supplements disagree, assume that ***GURPS Vehicles*** takes precedence.

Abbreviations Used In Table: HMG = "Heavy Machine Gun," GPMG = "General-Purpose Machine Gun," GL = "Grenade Launcher."

Other Notes: 7.62mm = 0.30 caliber. 12.7mm = 0.50 caliber. RoF for 37mm rotary cannon is (DX + Skill)/4. Any weapon mounted to use indirect fire can do so at 2.5 times the listed Max range.

Mechanical Artillery and Guns Table

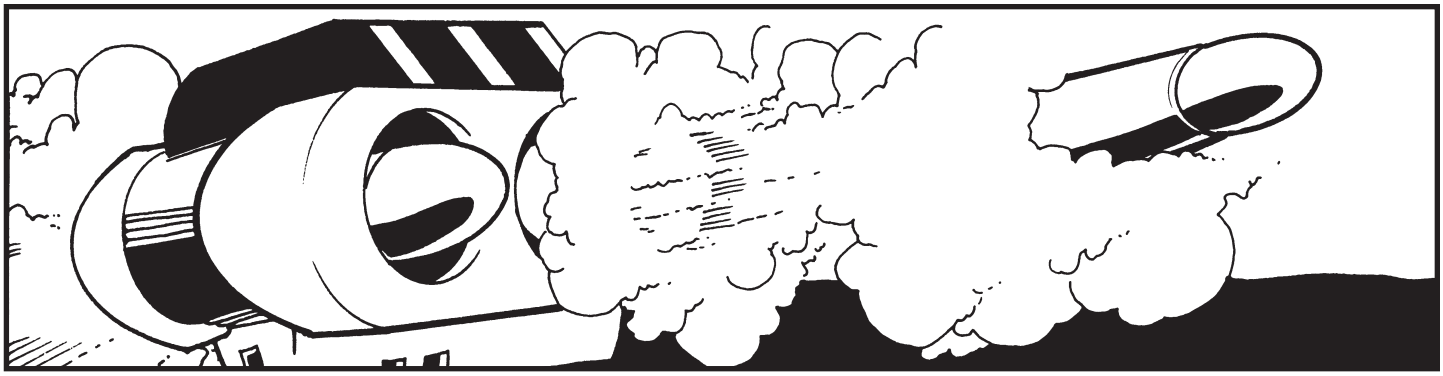
Name	*Malf*	*Type*	*Damage*	*SS*	*Acc*	*1/2D*	*Max*	*RoF*	*Wt*	*Cost*	*WPS*	*VPS*	*CPS*	*Ldrs.*
TL2 Catapults														
Ballista	Crit.	Imp	6d+2	20	6	430	540	1/35	200	$5,200	1.6	0.032	$3.2	2
Onager	Crit.	Cr	13d	30	2	240	300	1/50	2,000	$8,800	10	0.2	$5	3
TL4 Naval Guns														
50mm Swivel	14	Cr	15d	20	5	360	1,900	1/60	200	$800	1.5	0.01	$0.3	0
12-pounder	14	Cr	6d×6	30	6	550	2,400	1/60	4,400	$9,200	19	0.13	$3.8	5
32-pounder	14	Cr	6d×8	30	6	640	2,700	1/80	8,200	$17,000	49	0.33	$9.8	9
TL5 Guns														
37mm Rotary	16	Cr	17d×1	20	12	560	3,400	Var.	350	$1,400	2.8	0.019	$0.56	0
105mm Nav. Gun(1)	16	Cr	6d×8(0.5)	30	13	950	4,600	1/9	3,000	$8,000	43	0.43	$26	2
254mm Nav. Gun(1)	16	Cr	6d×19(0.5)	30	15	1,500	6,100	1/42	12,000	$31,000	920	6.1	$180	6
TL6 Guns														
7.62mm MG	Crit.	Cr	7d	17	13	700	3,900	10	20	$300	0.055	0.00037	$0.028	0
12.7mm HMG	Crit.	Cr	13d + 1	20	14	1,100	5,100	10	73	$1,100	0.31	0.002	$0.16	0
20mm Cannon	Crit.	Cr	3d×7	20	14	1,400	5,900	10	180	$1,900	0.6	0.004	$0.3	0
40mm Cannon(2)	Crit.	Cr	6d×6(0.5)	25	15	1,600	6,400	6	810	$5,100	2.7	0.027	$4.2	0
75mm Tank Gun(3)	Crit.	Cr	6d×9(2)	25	15	1,500	6,100	1/4	2,000	$11,000	27	0.18	$42	1
88mm Tank Gun(3)	Crit.	Cr	6d×11(2)	30	15	1,600	6,400	1/4	2,800	$15,000	43	0.29	$66	1
105mm Howitzer(4)	Crit.	Exp	6d×9 [10d]	30	14	1,100	5,100	1/5	2,400	$13,000	43	0.43	$64	1
127mm Nav. Gun(2)	Crit.	Cr	6d×13(0.5)	30	14	1,300	5,600	1/6	3,500	$18,000	77	0.77	$120	1
TL7 Guns														
7.62mm MG	Crit.	Cr	7d	17	13	780	4,100	20	16	$1,200	0.055	0.00037	$0.11	0
20mm Gatling(2)	Ver.	Cr	3d×7(0.5)	20	15	1,500	6,100	100	300	$19,000	0.4	0.004	$2.4	0
25mm Gatling(2)	Ver.	Cr	6d×4(0.5)	20	15	1,700	6,600	40	330	$20,000	0.8	0.008	$4.8	0
30mm Chaingun(5)	Ver.	Exp	2d+1(5)[2d]	20	14	1,000	4,800	8	250	$17,000	1.1	0.011	$10	0
40mm GL(5)	Crit.	Exp	3d(5)[4d]	20	9	180	1,800	6	72	$5,400	1.2	0.012	$11	0
76mm Naval Gun(6)	Crit.	Exp	6d×4[6d]	30	16	2,500	8,500	1/2	4,300	$110,000	19	0.19	$280	0
81mm Mortar(4)	Crit.	Exp	6d×5[6d]	20	10	460	3,000	1/5	98	$5,900	10	0.1	$60	1
105mm Tank Gun(7)	Crit.	Cr	6d×22(2)	30	15	2,800	11,000	1/5	3,300	$88,000	49	0.49	$750	1
120mm Tank Gun(8)	Crit.	Cr	6d×30(3)	30	15	3,200	11,000	1/6	4,300	$90,000	49	0.49	$5,300	1
TL8 Guns														
15mm Chaingun(3)	Ver.(Crit.)	Cr	16d×1(2)	20	14	1,300	5,600	20	51	$11,000	0.26	0.0017	$3	0
45mm Railgun(8)	Ver.	Cr	6d×72(3)	30	20	18,000	38,000	1	6,100	$2.5 mil.	2.3	0.023	$324	0
TL9 Guns														
10mm Gauss Gun(9)	Ver.	Cr	6d×4(2)	20	15	2,700	10,000	20	34	$20,000	0.033	0.00033	$2	0
80mm Mortar(5)	Ver.	Exp	6d×20(5)[6d]	20	11	680	4,500	3	350	$17,000	4.7	0.046	$84	0

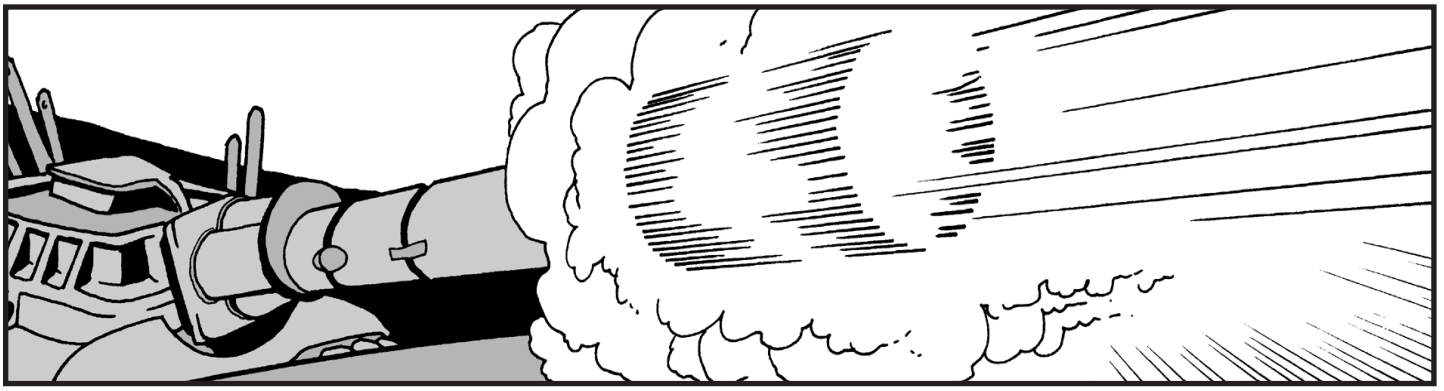
Footnotes:

Gun ammunition is Solid unless noted. Exceptions: (1) SAPLE, (2) SAPHE, (3) AP or APC, (4) HE, (5)HEDP, (6) HEPF, (7) APDS, (8) APFS-DSDU and (9) APS.

SAPLE or SAPHE explodes for extra damage after doing Cr. damage, doing the following: TL5 105mm: Exp. 6d×5[10d]. TL5254mm: Exp. 6d×64[12d]. TL6 127mm: Exp. 6d×16[10d]. TL6 40mm: Exp. 3d[4d]. TL7 20mm: Exp. 1d-2[2d].TL7 25mm: Exp. 1d[2d].

Power requirement is 0 for all weapons save 30mm chaingun (1.4 kW), 20mm Gatling (6 kW), 25mm Gatling(4.8 kW), 15mm chaingun (1 kW), 10mm Gauss gun (1,000 kW), 45mm railgun (20,400 kW).





Launchers, Missiles and Torpedoes

These tables cover a few typical torpedo and guided missile weapon systems. For rules on how these weapons are used, see the *Combat* chapter. For descriptions of guidance systems, see the *Weaponry* chapter.

Abbreviations: IR = "Infrared," IRH = "Infrared Homing," WG = "Wire-Guided," SAM = "Surface-to-Air Missile," ATGM = "Anti-Tank Guided Missile," OH = "Optical Homing," BPEH = "Brilliant Passive Electromagnetic Homing," SRGM = "Short-Range Guided Missile," Lt. = light.

Launcher Table

Name	*SS*	*RoF*	*Wt.*	*Cost*	*Ldrs.*	*Rating*
TL6 Launchers						
533mm Torpedo Tube	30	1/18	6,000	$31,000	1	3,000
TL7 Launchers						
127mm SAM Launcher	25	1/3	500	$17,500	0	200
152mm Tube Launcher	20	2:5	140	$8,500	0	50
Ultra-Tech Launchers						
TL9 60mm Mini Launcher	14	1	12.5	$234	0	5
TL10 100mm Sprint Launcher	20	1/3	108	$1,925	0	54

Torpedo and Missile Table

Name	*Malf*	*Guid*	*Type*	*Damage*	*Spd*	*End*	*Max*	*Min*	*Skill*	*WPS*	*VPS*	*CPS*
TL6 Torpedoes												
533mm Torpedo(1)	Crit.	–	Exp.	6d×3,200	20	810	16,200	0	0	3,000	60	$9,600
TL7 Missiles												
127mm IR-homing(2)	Crit.	IRH	Exp.	6d×64[10d]	800	22	17,600	100	14	185	3.7	$22,000
152mm ATGM(3)	Crit.	WG	Exp.	6d×10(10)	300	13	3,900	100	OG	47	0.94	$8,200
Ultra-Tech Missiles												
TL9 60mm Lt. SRGM(3, 4)	Crit.	OH	Exp.	6d×10(10)	400	5.6	2,240	0	14	5	0.1	$850
TL10 100mm Sprint(3, 5)	Crit.	BPEH	Exp.	6d×25(10)	1,000	28	28,000	0	17	54	1	$70,000

Footnotes:

(1) HEC warhead. (2) HEPF warhead. (3) HEAT warhead. (4) Lt. SRGM can pop up. (5) Sprint missile separates into three warheads before attacking, each of which rolls to hit separately; damage is per warhead.

The 533mm torpedo tube uses 533mm torpedoes. The 127mm SAM launcher uses the 127mm IR homing missile. The 152mm tube launcher uses the 152mm ATGM, which is operator-guided (see the *Weaponry* chapter). The 80mm mini launcher uses Lt. SRGMs.

Torpedoes and missiles can be attached to hardpoints instead of being loaded into launchers, as long as the hardpoint has enough rated load. Torpedoes and missiles on hardpoints are SS 30, RoF 1NR. Hardpoints (p. 94) are surface features, added near the end of vehicle design.

Beam Weapons

A short selection of beam weapons is given below. To design more, see the *Weaponry* chapter.

Beam Weapons Table

Name	*Malf*	*Type*	*Damage*	*SS*	*Acc*	*1/2D*	*Max*	*RoF*	*Wt.*	*Cost*	*Pow.*
TL8 Laser Cannon(1)	Ver.	Imp.	6d×5	20	21	6000	18,000	8	150	$18,000	57,600
TL8 Heavy N-PAWS(4)	Crit.	Imp.	6d×100	30	27	40,000	120,000	1	5,600	$290,000	180,000
TL9 Gatling Laser(2)	Ver.	Imp.	20d	17	20	4,000	12,000	4	25	$20,000	14,400
TL9 Space Combat Laser(3)	Ver.	Imp.	6d×12	30	27	57,000	171,000	4	3,900	$205,000	93,312
TL10 Gatling X-Laser(5)	Ver.	Imp.	30d(2)	20	21	4,500	13,500	4	25	$40,000	38,390
TL10 X-ray Lasercannon(5)	Ver.	Imp.	60d(2)	25	24	18,000	54,000	8	1,600	$120,000	307,123
TL12 Heavy Fusion Gun(6)	Ver.	Spcl.	6d×400	30	20	7,200	21,600	1	1,500	$1,000,000	3,240,000

Footnotes:

Beam type is: (1) laser, (2) rainbow laser, (3) ultraviolet laser, (4) neutral particle beam, (5) x-ray laser, (6) fusion beam.

Lasers and X-ray lasers with RoF 4+ use the laser autofire rules described under *Damage from a Burst* on p. B120.

Beam weapon ranges increase drastically in vacuum – see the *Combat* chapter.

Weapon Accessories

A weapon can be equipped with one or more accessories to link it to other weapons, adjust its arc of fire, or stabilize the weapon against vehicle movement.

EXAMPLE

The Kitty Hawk will have stabilized weapons.

Links

A group of weapons can be linked together, enabling one gunner to aim and fire some or all of the weapons in the group with the touch of a single button – that is, a single Aim or Attack maneuver. Guns that require loaders, as well as missiles or torpedoes that are wire or communicator-guided, may *not* be linked.

Linked weapons should all face in the same direction, but do not have to be in the same location; however, weapons in a particular open mount can only be linked with other weapons in the same mount. In addition, launchers can only be linked with other launchers. Weapons may be cross-linked to allow different combinations of weapons to be fired.

Links are available at TL3 and up for launchers, or at TL6 and up for guns; they cost $50 per set of weapons in the link.

Stabilization Gear

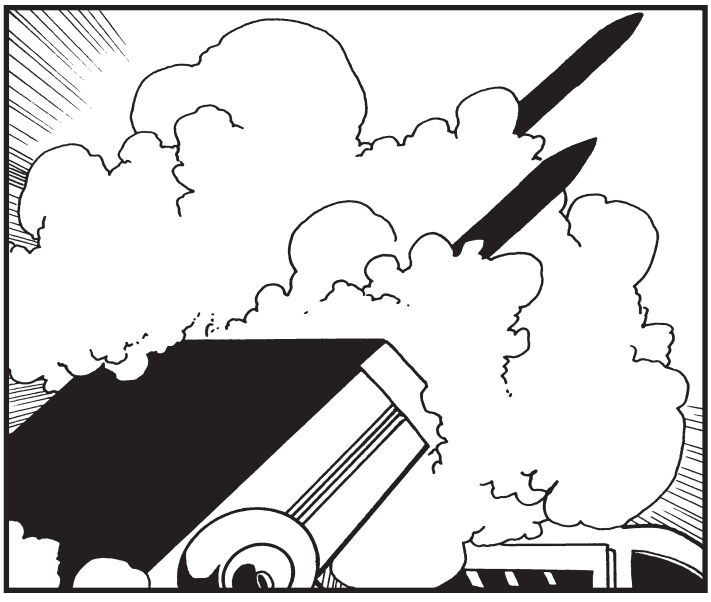
A weapon stabilizer can be added to any vehicular weapon. It gyroscopically stabilizes the weapon, keeping it pointed in the same direction, regardless of the movement of the vehicle. The effect is to reduce the penalties suffered when firing while the vehicle is moving. There are two kinds of stabilization gear:

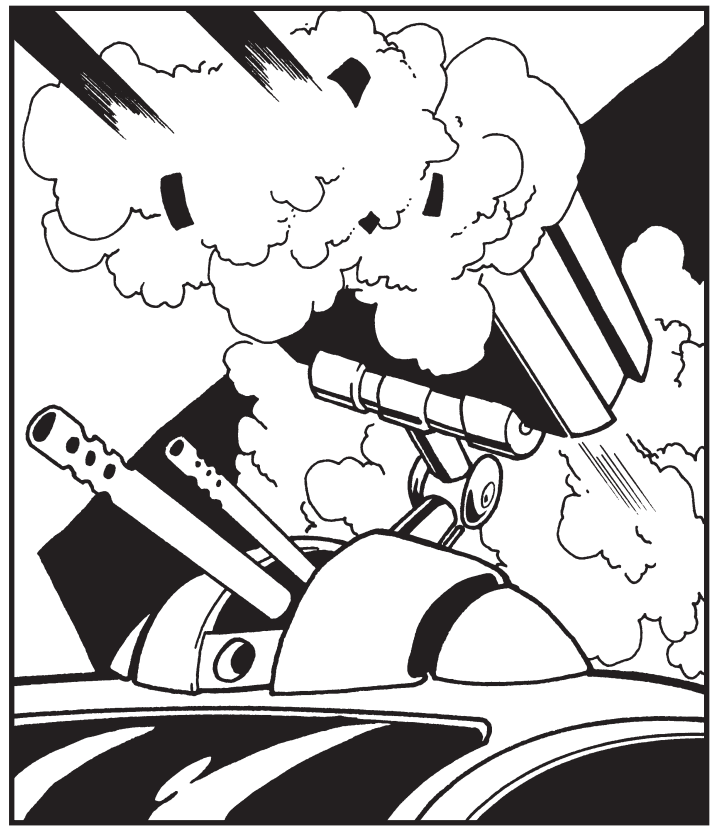
Partial Stabilization (late TL6): The weapon is stabilized in elevation only. Partial stabilization reduces movement penalties by 1.

Full Stabilization (TL7): The weapon is stabilized in all planes. Full stabilization reduces movement penalties by 3.

Stabilization Gear Table

TL	*Type*	*Weight*	*Volume*	*Cost*
6	Partial Stabilization	0.05	0.05	$5
7	Full Stabilization	0.1	0.1	$10





The weight (lbs.) and volume (cf) are found by multiplying the weapon's empty weight and volume by the numbers shown on the table. The cost is found by multiplying the weapon's empty weight by the number shown for cost.

Location: The stabilization gear is housed in the same part of the vehicle as the weapon.

EXAMPLE

The Kitty Hawk's 7.62mm minigun and 40mm grenade launcher both have full stabilization. The stabilization gear goes in the turret with the weapons. The minigun and grenade launcher weigh 33 lbs. and 72 lbs. respectively when empty, so the stabilization weighs 3.3 lbs. and 7.2 lbs. Their respective volumes are 1.65 and 3.6 cf, so the stabilization volume is 0.165 and 0.36 cf. Cost is $10 times weight: $330 for the minigun and $720 for the grenade launcher.

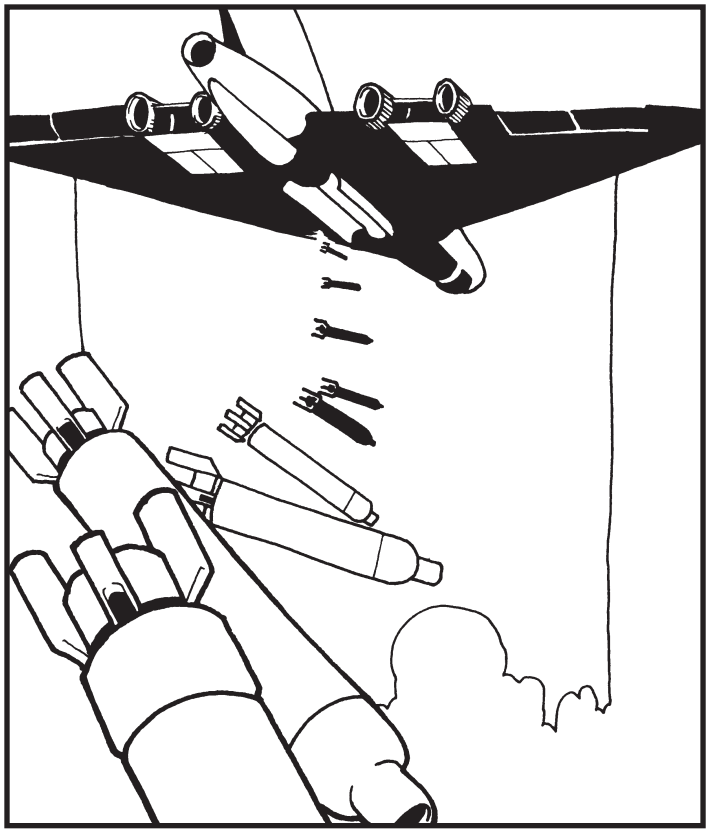
Special Mountings

Normally, a weapon fires in the direction it is facing, with a limited arc of fire of about 15° to either side. This can be increased by giving the weapon a special mounting.

Special mountings are not available for muzzleloaders on gun carriages. The options include:

High-Angle Mounting (TL5): This is the standard mounting for indirect-fire artillery such as mortars, howitzers and artillery rockets, as well for anti-aircraft guns or missiles that don't use universal mounts. It allows a weapon to elevate between 45° and 90°. It can use indirect fire (see pp. 179-181), but cannot be used in direct fire against targets that are at less than 45° elevation above the vehicle. A weapon can have this option if located in a body, or a superstructure, open mount or turret attached above the body. A high-angle mounting has no extra cost, weight or volume, but it is incompatible with universal, cyberslave or casemate mounts. Tripod-mounted weapons may also have high-angle mounts.

Universal Mount (TL5): A universal mount can be added to any forward, rear, back or front-facing weapon that is built into a turret, superstructure or open mount subassembly. It increases the vertical arc of fire to 90°.



If the subassembly is above the vehicle's body, the arc is 90° above the vehicle, allowing it to fire straight up.

If the subassembly is below the vehicle's body, the arc is 90° below the vehicle, allowing it to fire straight down.

If the subassembly is on the side of the vehicle, it can fire 45° up or down.

Casemate Mount (TL5): This swivel system can be added to any weapon that will be installed in a body or superstructure. It increases the horizontal arc over which the weapon can fire to 90° (usually 45° each to right and left).

Door Mount (TL5): Only available for weapons concealed in a body or superstructure that face either right, left or back. The weapon is mounted on a pedestal next to a door in the vehicle. When the door is open, the weapon can be fired out of it with a 45° horizontal and 45° vertical arc of fire, but the weapon and gunner can be attacked without benefit of vehicle armor. When the door is closed, the weapon and gunner are protected. A vehicle with Very Good or better streamlining may not have a door mount.

Cyberslave (TL8): Similar to a casemate mount, but fitted with high-speed hydraulics – it halves the SS number of any weapon so equipped. It can be installed in a turret, body, open mount or superstructure. Most weapons on ***Car Wars*** automobiles use cyberslaves.

Weapon Mount Table

Type	*TL*	*Weight*	*Volume*	*Cost*
Universal Mount	5	0.5	0.5	$1
Casemate Mount	5	0.5	0.5	$1
Door Mount	5	0.5	0.5	$1
Cyberslave	8	1	1	$50

The weight (lbs.) and volume (cf) of the accessory is found by multiplying the modified weapon's empty weight and volume by the numbers shown on the table. For all mounts, cost is found by multiplying the weapon's empty weight by the number shown for *cost.*

Location: Mounts must be located in the same part of the vehicle as the weapons they equip.

Weapon Bays (TL6)

This is an internal bay with racks and underside doors for stowing and releasing weapons such as bombs. A weapon bay contains "internal hardpoints" that can be used to carry a certain weight of bombs, mines and missiles. These hardpoints function exactly like other hardpoints (p. 94), except they do not induce drag in aircraft.

A weapon bay is rated for the maximum load its internal hardpoints can carry. It weighs 0.05 lbs., takes up 0.03 cf and costs $0.1 per pound of internal hardpoint load.

A weapon bay may only be used if the vehicle is flying, or is in or under water. Opening or closing the doors takes 2 seconds; while the doors are open, any "Body" hit from below the vehicle has a 1-in-6 chance of ignoring body DR and penetrating the bay. If the weapon bay is 20 cf or larger, it may be built to be accessible from inside the vehicle, and is usable as an emergency entrance or exit.

Anti-Blast Magazines (TL7)

Ammunition explosions are a danger to any military vehicle that uses large-caliber (20mm or more) conventional or electrothermal ammunition, or which carries any missile or torpedo.

This option stores the ammunition in a special compartment designed to vector the blast away harmlessly should it explode. An anti-blast magazine is 25 lbs. and $250 per cf (or fraction thereof) of ammunition stored in it; there is no extra volume.



INSTRUMENTS AND ELECTRONICS 4

This chapter describes a wide variety of electronic and optical equipment.

Location: All systems described in this chapter can be placed in the body, superstructures, pods, turrets, arms, wings, open mounts or legs. A few sensors and targeting systems have additional restrictions, which will be noted in their own descriptions.

Communication Systems

Most military and many civilian vehicles have some form of communication system, which may range in sophistication from a signal flag to a laser communication array.

Pre-Radio Communications

These depend on visual or audible signals. In the noise and smoke of a battle involving firearms, they aren't very effective!

Semaphore and Signal Hoists (TL1): This involves raising or lowering different combinations of flags or flashing signal lights; smoke signals are also possible, but aren't very safe on a vehicle!

Hand flags can be read at up to three miles away with a telescope, weather and terrain permitting. At night, lanterns and torches can be used. If the vehicle has masts or a superstructure, the range can be extended: use the *Horizon* rules on p. 168. A simple prearranged signal takes no skill to read, but may require a Vision roll.

More complex messages require the Semaphore skill, and both parties must be using the same known code. This is a Mental/Easy skill similar to Telegraphy (p. B55), but it takes more time to manipulate signals than to press a key: maximum rate is one word per minute per point of skill. Halve the rate for night messages, as lanterns and torches are harder to use. Once electric lights appear, a flashlight or searchlight can be flashed at two words per minute times skill. Speed is based on the lower of the receiver's or sender's skill: if the sender is going faster, the message will still be sent, but the receiver won't catch all of it! Cost and weight of signal hoists can be ignored: most vehicles have flags or lights anyway, or can easily improvise them.

Musical Instruments (TL1): Horns, drums and the like can be used to send simple, prearranged signals audible over a few miles. They won't be much use in any battle involving firearms, though!

Carrier Pigeons (TL4): Homing pigeons instinctively return to the place where they were raised. A message can be strapped to a pigeon's leg, making it a swift, long-distance messenger that can be carried by and released from a vehicle to send reports back home. A pigeon costs about $35, and can carry a message 50 miles per day. Roll 3d to see if the bird succeeds: on any roll of 16-18, it has met some misadventure on the way. On an 18, the message has fallen into the hands of someone who shouldn't get it. Homing pigeons were not widely used until TL4, but in theory could be used in any culture where writing and ink exist. A cage for a homing pigeon, sans pigeon, is 20 lbs., 2 cf and $10.

Communicators (TL6)

Normal communicators are radios, sending signals by modulating the intensity, frequency or phase of long-wavelength electromagnetic radiation. Radios can send code, voice, text, video or data transmissions; to display text, video or data signals, install a computer terminal (p. 62). They are broadcast systems, and anyone with a radio tuned to the proper frequency can listen in on a radio signal; radio transmissions can also be jammed.

Range can be extended on a successful Electronics Operation (Communications) roll, at -1 per extra 10% added to range, to a maximum extension of 100%. Unless noted, communicators can't penetrate water and (except FTL) get 10× range in space.

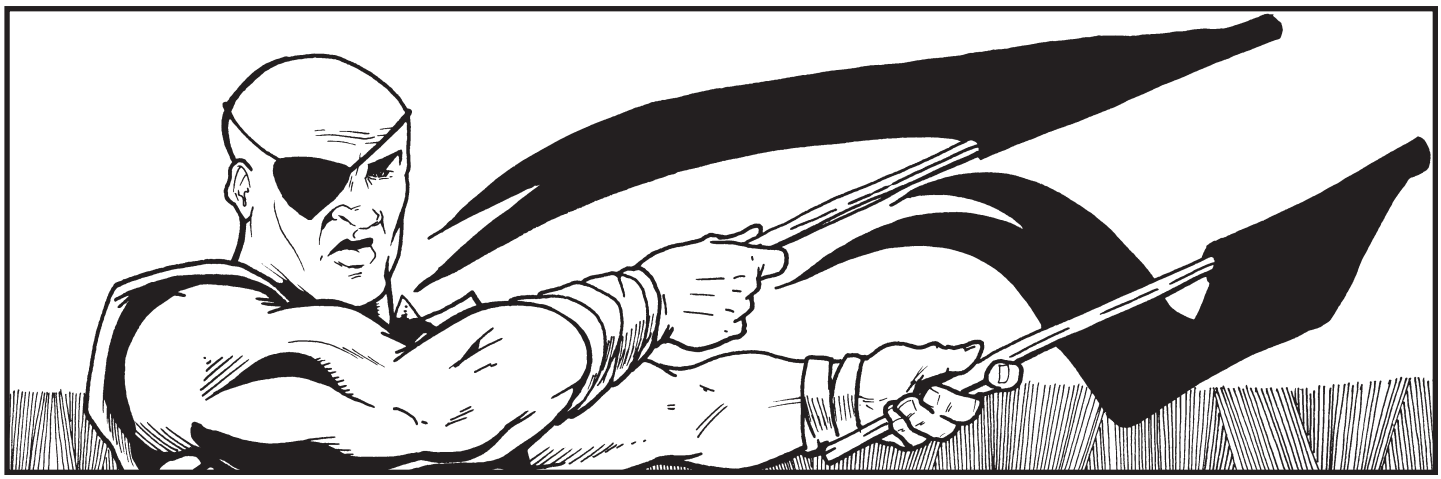
Communications are normally limited to the speed of light (186,000 miles per second). For planetary communications, this is effectively instantaneous, but in space, a lag between sending a message and receiving a reply may be noticeable.

A communicator can be given several options to modify its effectiveness. Unless explicitly noted, most options are *not* compatible with other options.

Option – Receive Only: The communicator can only receive transmissions, not send. This greatly reduces weight and cost! This option can be combined with any other option.

Option – Tight-Beam Radio (TL7): This is an ultra-high-frequency directional signal or an actual microwave beam. Only receivers within a 20° cone can pick up the signal. Tight-beam signals are often sent up to satellites and then relayed down again.

Option – VLF Radio (TL7): This options means the communicator uses very low frequencies which can travel underwater (but counting each mile of water penetrated as 100 miles of range). Transmission rate





is slow: text must be sent, instead of voice, at only a few characters a second. Transmission rate is normal when not transmitting underwater.

Option – Cellular Phone (late TL7): This is a radio-telephone designed to connect to the local cellular telephone system, after which it can make regular phone calls. The extra phone bill costs at least $20/month. At TL8+, this option is free for radios.

Options – Sensitive (TL6) and *Very Sensitive* (TL7): These options give the communicator a large or very large antenna array that can pick up signals at 10 (sensitive) or 100 (very sensitive) times the normal range of the transmitting communicator. This does not improve their ability to transmit signals of their own! A communicator can't be both sensitive and very sensitive, but this option can be combined with other options.

Option – Radio Jammer (TL6): A jammer is an untuned radio transmitter that projects a blanket of powerful "noise" to drown signals in static. It prevents reception of radio signals within its range, including by the jamming vehicle. Radio reception is only possible if (distance to the transmitter/transmitter range) is less than (distance to the jammer/jammer range). Even then, radio reception requires an Electronics Operation (Communications) skill roll and is resolved at -5.

Option – ELF Receiver (TL7): This allows the radio to receive (not send) extremely low frequency radio signals. These can penetrate any depth of water, making them very useful for communication with submarines. However, the transmitters require vast acres of antenna grids. ELF transmitters are not used on vehicles – only the receivers are. If this option is taken, the radio cannot be used to transmit normal messages. The radio consists of the receiver and a long antenna released to trail behind the vehicle; retracting or extending the antenna takes about 30 seconds. ELF transmission speed is very slow – only a few characters *per minute.* Therefore, voice reception is impossible, and only text or code can be received.

Option – Laser (late TL7): Taking this option means the communicator uses a modulated laser beam instead of radio waves. Its signal can only be picked up by another laser communicator. The laser beam is extremely narrow – more so than tight-beam radio. The user must precisely aim the communication beam at the receiver, which must be in a direct and unobstructed line of sight. Communication over the horizon is only possible using relays of communicators. Because of the narrow beam, a laser communicator cannot eavesdrop on another laser transmission unless directly in the path of the beam – which would prevent it reaching its intended recipient anyway.

Option – Neutrino (TL10): This is a tight-beam communicator using modulated pulses of anti-neutrinos instead of radio. Like neutrinos, anti-neutrinos are particles that can penetrate almost anything, but are slightly easier to detect and receive, hence their usefulness in a communication system. A neutrino communicator can reach underwater without penalty, and unlike other tight-beam communicators, it can penetrate solid objects and is not blocked by the horizon. Its signal can be picked up only by other neutrino communicators.

Option – Gravity Ripple (TL12): This is a broadcast communicator that uses modulated contragravity waves instead of radio waves. It uses the same rules as TL10+ radios, but is not vulnerable to systems or conditions that jam or detect radio. Gravity ripples have longer range than radio waves, and can reach underwater or through objects. At the GM's option, proximity to intense gravity sources (e.g., neutron stars, pulsars, black holes) may disrupt gravity ripple communications.

Option – FTL (TL?): Faster-than-light communications systems may be possible in some campaigns. See p. S27-29 for a discussion of the effects such "FTL radio" can have on a campaign. If a default FTL radio is needed, assume that it functions like an ordinary radio, except that speed increases from the speed of light to 0.1 parsec per day (although GMs may wish to make this slower, faster, or even instantaneous) and range is measured in parsecs instead of miles. At the GM's option, this option can be combined with any other option (e.g., an FTL analogue to laser rather than radio).

If a communicator is desired, choose its type, range (short, medium, long, very long or extreme), and decide what options, if any, it will have. Then determine its statistics as shown below:

Communicator Table

TL	*Weight*	*Cost*	*Range*	*Power*
6	10	$200	10	0.1
7	2	$400	30	0.01
8	1	$200	100	0.01
9	0.5	$100	1,000	0.01
10+	0.25	$50	5,000	0.01
Range				
Short	×0.25	×0.25	×0.1	×0.1
Medium	×1	×1	×1	×1
Long	×10	×3	×10	×4
Very Long	×100	×10	×100	×10
Extreme	×1,000	×30	×1,000	×40
Options				
Receive Only	×0.2	×0.1	×1	×0.1
Radio Jammer	×1	×1	×0.001	×1
Sensitive	×10	×3	special	×2
Very Sensitive	×100	×10	special	×5
Tight-Beam Radio	×5	×5	×10	×1
Cellular Phone**	×2	×1 or ×2	×1	×1
VLF Radio	×10	×10	×1	×1
ELF Receiver	×1,000	×1,000	×1	×1
Laser	×10	×12.5	×2	×10
Neutrino***	×120	×400	×2	×100
Gravity	×1	×1	×2	×1
FTL	×4 mil.	×1 mil.	×0.0002*	×1 mil.

Multiply weight, cost, power and range as shown for the options on the table. Volume is equal to weight/50 cf. If power consumption works out to 0.01 kW or less, treat it as negligible.

* Range of FTL radio is measured in *parsecs,* not miles.

** No extra cost if communicator can be used only as a cellular phone and cannot also function as a radio, or at TL8+. Otherwise, ×2 cost.

*** For neutrino at TL11+, halve weight, volume and cost, and add 50% to range. At TL12+, quarter weight, volume and cost, and add 100% to range.

EXAMPLE

We decide the Kitty Hawk has a communicator with the medium range and cellular phone options. It goes in the body. At TL7, a communicator is 2 lbs. × 1 (medium range) × 2 (cellular phone) = 4 lbs., takes up 4 lbs./50 = 0.08 cf, costs $400 × 1 (medium range) × 2 (cellular phone also usable as radio) = $800, has a range of 30 miles × 1 (medium range) × 1 (cellular phone) = 30 miles, and uses 0.01 × 1 (medium range) × 1 (cellular phone) = 0.01 kW, a negligible amount of power.

Scramblers

For extra cost, any communicator can be equipped with a scrambler system. This makes the transmission signal difficult to detect (using frequency agility) and/or encrypts it. If both sender and receiver use scramblers with the same settings, a message will be gibberish to anyone else listening in. A computer can be used to decode some or all of a scrambled message – see the *Cryptanalysis* skill on p. B245.

A scrambler system is $2,000 at TL6, $1,000 at TL7, $500 at TL8, $250 at TL9 or $125 at TL10+. The scrambler option simply adds to the cost of the communicator and is not a separate device. Scramblers are generally unnecessary on laser or neutrino communicators, since the beams are very hard to intercept.

EXAMPLE

The Kitty Hawk has a scrambler for its radio that costs $1,000.

Headlights and Searchlights

Most modern vehicles use lights as a simple, cheap form of night vision.

Headlights (late TL5+): All powered vehicles built by late TL5 are assumed to have lights (for "free") that clearly illuminate an area in front of the vehicle for about (TL × 5) yards and that can be seen at 20 times that distance. These are sufficient for normal nighttime travel. At TL7+, the lights also cut fog penalties by half.

Searchlights (late TL5): These project a bright beam of visible light, illuminating a 2-yard radius per mile of range. The beam itself can be spotted at twice its range. Aiming a searchlight is a combat action. A vehicle or object caught in the beam can be attacked with no penalty for darkness. A searchlight can be used to blind a single, sighted individual who is exposed or looking out a window or canopy for as long as the searchlight is aimed at him. This is a ranged attack; a roll to hit (give the light SS 20 and Accuracy 15) is required each turn. The subject is blinded for as long as he faces the light (plus, at night, 1d more seconds on a failed HT roll).

Infrared Searchlights (late TL6): Sometimes called "active infrared," these searchlights project beams of infrared light that are invisible to normal vision. The infrared searchlight includes its own image converter that can detect objects illuminated by the searchlight's beam by day or night. Passive infrared, thermograph and PESA sensors (see p. 50) can detect its beam out to twice its normal range. IR searchlights are ineffective underwater. They are historically available circa 1943 to the U.S. government, and generally available by TL7.

Searchlight Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
5	Searchlight	40	0.8	$50	1
6	Searchlight	20	0.4	$100	1
6	IR Searchlight	30	0.6	$500	1
7+	Searchlight	10	0.2	$500	1
7+	IR Searchlight	15	0.3	$1,000	1

Weight, Volume, Cost and Power are per mile of searchlight range, up to a maximum of (TL) miles; however, a searchlight beam is limited to direct line of sight, and cannot illuminate targets past the visual horizon.

The Kitty Hawk has headlights; there is no extra weight, volume or cost.

EXAMPLE

Sensors

Sensors enable a vehicle operator to detect distant or hidden objects. The different types of sensors are described individually, but fall into three general categories:

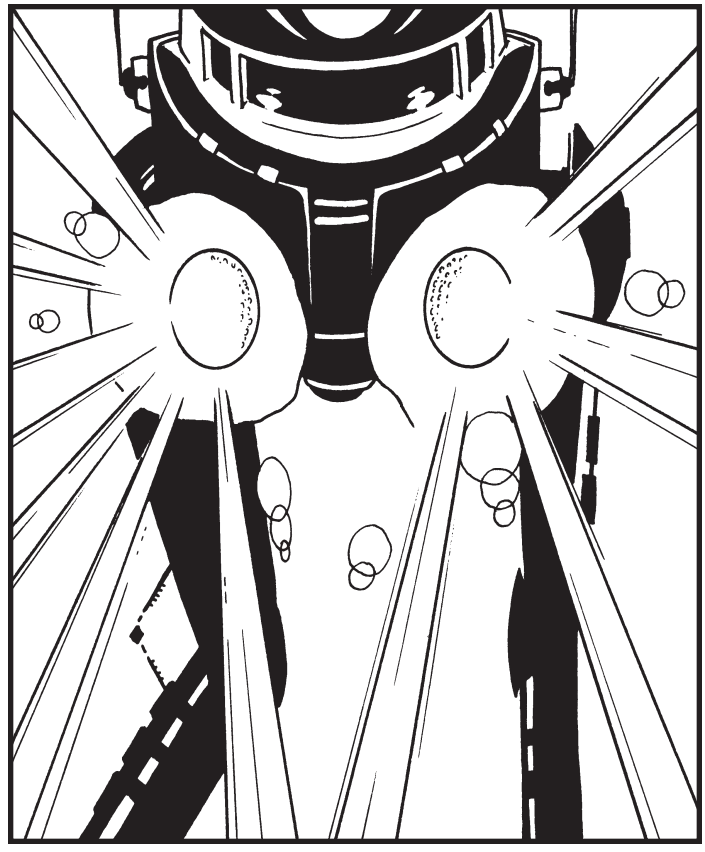
Visual Augmentation Sensors, which enhance the user's vision – telescopes, light amplification and low-light TV.

Line-of-Sight (LOS) Sensors, which need an unblocked line of sight to the object being detected, but which have high enough resolution to be used instead of normal vision when making attacks or maneuvering. LOS sensors include radar, ladar, active sonar, passive infrared, thermograph, passive radar and PESA (see p. 50).

Indirect Sensors that are not precise enough to replace vision when attacking or navigating, but which don't require any line of sight. They include passive sonars, geophones, sound detectors, MADs (see p. 54), gravscanners and multiscanners.

Direction: Only indirect sensors are omnidirectional. Otherwise, decide which side of the vehicle the sensor will look out of: front, back, right, left, top or bottom. A sensor can only detect objects it is facing. For universal coverage, either install several sensors or install them in rotating open mounts or turrets.

Rules for using sensors are covered in the *Sighting and Detection* chapter.



Visual Augmentation Systems (VAS)

These are optical and electro-optical sensors that augment human vision. Long-distance viewing is limited to an unblocked line of sight.

Telescopes (TL4): A telescope uses optical lenses to enhance human distance vision. It essentially does two things: it gathers light over a larger area of space, allowing detection of fainter objects, and it improves resolution, allowing detection of finer detail. Because the field of view decreases as the magnification increases, a telescope is most effective when identifying objects already detected by other sensors, or where hours or days can be spent searching, as in astronomy. In darkness, telescopes can only spot objects that emit light, such as stars or lighted buildings, or are illuminated by other light sources, like the moon or an object silhouetted against a light or source of reflected light. Telescopes are rated for their maximum magnification.

Light Amplification (TL7): This is a simple "starlight" scope that electronically amplifies light levels. It does do not have any magnification ability, and so has no vision bonus. It does give a person looking through it effective but color-blind Night Vision, as per the advantage (p. B22) allowing the user to see in anything but total darkness without penalty. It may not be used with a telescope, but see *low-light TV* below.

Low-Light TV (LLTV, late TL7): This TV camera with telescopic optics is downlinked to a view screen inside the vehicle. It functions exactly like a telescope, but incorporates a light-amplification system as well. It still can't see through smoke, fog, mist, foliage or clouds, however, making it of limited use in any kind of adverse weather.

Passive Electromagnetic Sensor Array (PESA, TL8): See p. 53. These multi-purpose sensors also include a low-light TV function. If a PESA is going to be installed, a low-light TV is usually unecessary except as a cheaper backup.

Visual Augmentation System Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
4	Telescope	2.5	0.05	$25	0
5	Telescope	2	0.04	$20	0
6	Telescope	1.5	0.03	$15	0
7+	Telescope	1	0.02	$40	neg.
7	Light Amp.	2	0.04	$400	neg.
8	Light Amp.	neg.	neg.	$200	neg.
9+	Light Amp.	neg.	neg.	$100	neg.
7	Low-Light TV	1.25	0.025	$1,000	neg.
8	Low-Light TV	0.5	0.01	$250	neg.
9	Low-Light TV	0.25	0.005	$125	neg.
10+	Low-Light TV	0.125	0.0025	$62.5	neg.

Weight, Volume, Cost and Power: Light amplifiers use the weight, volume, cost and power shown on the table. For telescopes, select the optical magnification and multiply weight, volume and cost by magnification. For low-light TV, select the optical magnification and multiply weight, volume and cost by magnification; treat any magnification of less than ×5 as ×5 when calculating cost (not weight or volume). If a telescope or LLTV weighs under 25 lbs., it is also available in hand-held form: divide weight, volume and cost by 5 as it doesn't need the controls and mountings a vehicular system requires!

EXAMPLE

We decide the Kitty Hawk has a TL7 light amplification system in the turret, facing forward (2 lbs., 0.04 cf, $400).

Vision Bonus: Telescopes and LLTV with magnifications greater than ×1 have Vision bonuses. These add to Vision rolls to detect objects at long ranges.

Magnification to Vision Bonus Table

Power	*Bonus*	*Power*	*Bonus*
×1.5	+1	×45	+5/+10
×2	+1/+2	×70	+6/+11
×3	+2/+3	×100	+6/+12
×5	+2/+4	×150	+7/+13
×7	+3/+5	×200	+7/+14
×10	+3/+6	×300	+8/+15
×15	+4/+7	×450	+8/+16
×20	+4/+8	×700	+9/+17
×30	+4/+9	×1,000	+9/+18

Find the magnification of the telescope, low-light TV or PESA in the Power column; if the actual magnification is between two values, use the lower. The number in the adjacent Bonus column is the VAS Vision bonus.

Note that a split bonus is usually given: the second and higher number only applies when attempting to get a better view of objects that have already been detected visually or by another sensor. This is because high-magnification sensors drastically reduce the field of view, which increases the difficulty of the search or requires the use of a lower magnification setting. All TL6+ telescopes and LLTV cameras are assumed to be able to "zoom" from ×1 to their maximum magnification.



Extendable Sensor Periscopes

An extendable sensor periscope is a tube and viewer containing an arrangement of mirrors or prisms to permit observation from outside a direct line of sight, e.g., while underwater or behind a ridge line. A periscope can be extended or retracted in 2 seconds.

Periscopes that do not extend out of the vehicle, such as those used by tank crewmen to see out, need not be purchased – like headlights and windows, they are subsumed into the vehicle's basic equipment.

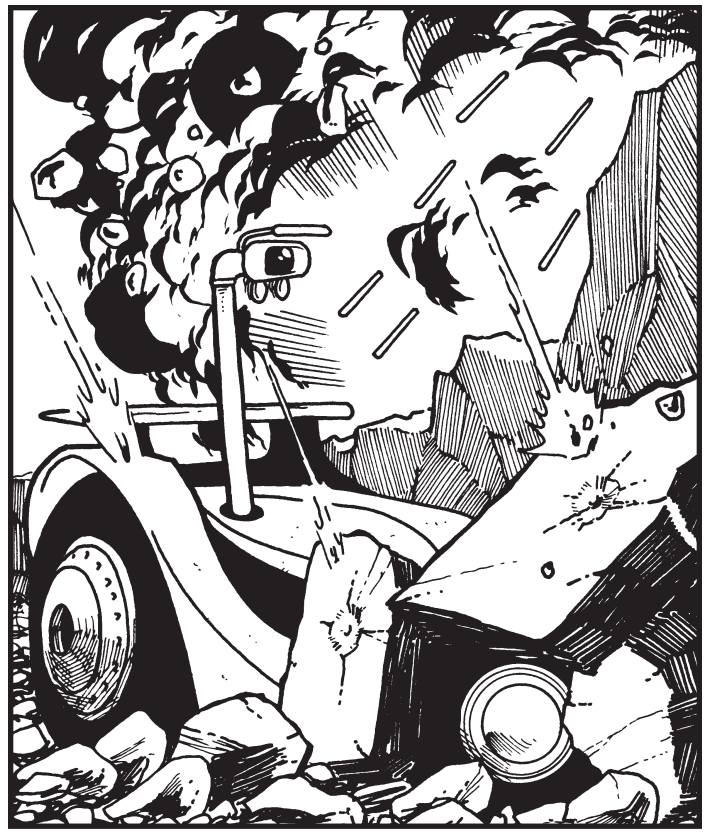
A periscope may be up to 60 feet long. A periscope on a naval submarine is normally between 30 and 60 feet long (this is "periscope depth") to allow observation from well below the waves. Those mounted on ground vehicles rarely exceed 6 feet. Periscopes on helicopters ("mast-mounted sights") may be built to protrude above the rotor assembly; this generally requires at least 3 feet.

To build a periscope, decide which telescopes or other sensors can be used to see through it. The periscope's weight, volume and cost are 10% of the weight, volume and cost of the sensors it can use per foot of length (or fraction thereof). The periscope must be housed in the same part of the vehicle as the system it is equipped with.

To build a visual periscope that is a simple viewer with no magnification, fit it with a telescope or LLTV built at ×1 magnification.

EXAMPLE

We decide the Kitty Hawk's thermograph (see p. 54) is in a sensor periscope with an 8' extension, installed in the turret. The periscope's weight, volume and cost are 10% × 8' = 80% of the thermograph's 15 lbs., 0.3 cf and $48,000, or 12 lbs., 0.24 cf and $38,400.



Radar (late TL6) and Ladar (TL8)

Radar ("RAdio Detecting And Ranging") emits pulses of radio or microwave energy. These pulses are scattered back when they hit solid objects. The sensor collects and analyzes these reflections, measuring the time between the pulse and return in order to determine the object's position, range and speed. Targets spotted by radar are normally just blips on a screen, with their exact shape (unless they are the size of large buildings) a mystery. Radars are blocked by solid objects and cannot normally see over the horizon. They do not work underwater, but fog, smoke or darkness have no effect on them. Radar is an active sensor – its beam can be detected by radar detector or locator systems at twice its actual range.

A radar can be modified with a variety of options. From TL6 to early TL7 all radars must have *either* the air search or ground search options; at late TL7+ this restriction is removed, representing the development of advanced multi-mode and pulse-doppler radars.

A radar can be used to "target" objects, providing a +2 bonus to hit with vehicle-mounted weapons. This bonus is not cumulative with that provided by laser rangefinders. A TL6 or early TL7 radar can only target one object at a time, and when it does, advanced radar detectors (p. 59) will be warned that a radar has "locked on" and is targeting them. More sophisticated sensors use a "track while scanning" system and do not provide this warning.

Option – No Targeting (TL6): A radar-type sensor with this option lacks precise ranging and target-tracking capabilities. It cannot be used to aim weapons in lieu of visual sighting, or to guide semi-active homing weapons. This option is taken by most radars used by civilian vehicles, and by radars intended mainly for long-range searches.

Option – Surface Search (TL6): This optimizes the sensor for detecting targets on water or ground, reducing its cost. It is at -5 to detect targets silhouetted against the sky or space. A radar may not have both the surface-search and air-search options!

Option – Air Search (TL6): This optimizes the sensor for detecting airborne targets, reducing its cost. It is at -5 to detect any target silhouetted against ground or water.

Option – Low-Res Imaging Radar (late TL7): This is a radar modified for much higher resolution, enabling it to determine a target's general shape and size. It is incompatible with high-res imaging radar, ladar or AESA options.

Option – High-Res Imaging Radar (late TL7): This option uses millimetric radar frequencies, allowing resolutions approaching human vision to be achieved. Flat details (like writing) and color still cannot be resolved. High-res imaging radar is not compatible with the low-res imaging, ladar or AESA options.

Option – Ladar (TL8): Taking this option means that the radar is actually a ladar (LAser Detecting And Ranging), sensor. A ladar, sometimes also called LIDAR (Laser Imaging, Detecting And Ranging), functions much like an imaging radar but is harder to detect or confuse with conventional electronic warfare systems such as radar detectors or jammers. Its disadvantage is that it is ineffective in smoke, fog or heavy rain, or in exotic Prism and Blackout smoke clouds. Ladar works underwater at 5% of its normal range (which gives -8 Scan). Ladar is not compatible with either the imaging radar or AESA options.

Option – Active Electromagnetic Sensor Array (AESA, TL8): This option gives the "radar" the ability to switch between search radar mode, low-res imaging radar mode, high-res imaging radar mode and ladar mode. When in low-res imaging radar or ladar mode, range is halved (which gives -2 Scan). When in high-res imaging radar mode, range is 1/50 normal (each mile of range is treated as 35 yards; also recalculate Scan). Switching can be done at the start of any turn. It is incompatible with either imaging radar or ladar options.

Option – FTL Radar (TL?): Ordinary radars and ladars are limited to the speed of light. If some form of faster-than-light drive technology exists, the GM may rule that FTL sensors were also developed. This "FTL radar" option may work in whatever way the GM wants – perhaps it uses "subspace" or "hyperspace" waves. In any case, it enables the sensor to reach maximum range and return at faster-than-light speeds, detecting objects in much less than a second. FTL radar is usually subject to whatever restrictions the GM has decided affect warp drive, e.g., if a nearby planet's gravity distorts warp drive, this would prevent FTL radar being used by vehicles on a planet or in orbit.

If a radar is desired, select the maximum range in miles for an ordinary radar or light-seconds (each 186,000 miles, minimum one light second) for an FTL radar, and decide what options, if any, it has. Then calculate its statistics as shown below:

Radar Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
Late 6	Radar	20	0.4	$1,000	0.25
Early 7	Radar	10	0.2	$2,000	0.25
Late 7	Radar	5	0.1	$4,000	0.25
8	Radar	2	0.04	$1,000	0.25
9	Radar	1	0.02	$500	0.25
10	Radar	0.5	0.01	$250	0.25
11+	Radar	0.25	0.005	$125	0.25
Options					
Air Search		×1	×1	×0.5*	×1
Surface Search		×1	×1	×0.5*	×1
No Targeting		×0.5	×0.5	×0.5	×1
Low-Res Imaging Radar		×2	×2	×5	×2
High-Res Imaging Radar		×50	×50	×100	×50
Ladar (TL8)		×2	×2	×5	×2
AESA (TL8)		×1.5	×1.5	×5	×1
FTL Radar (TL ?)		×2	×2	×10	×2

* ×1 cost modifier for late TL6 or early TL7 radars.

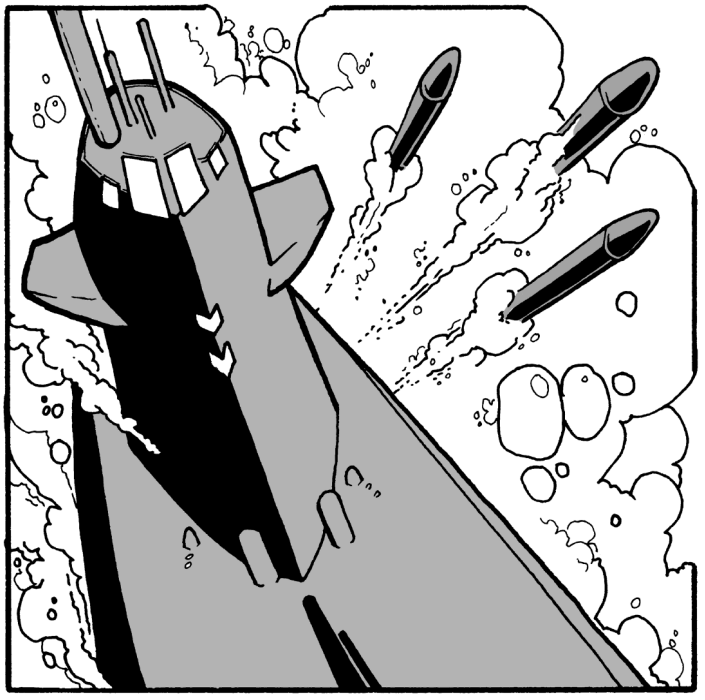
Multiply the range of the sensor in miles by the numbers shown on the table to find its weight, volume, cost and power requirement. *Exception:* If a sensor has over 125 miles range, its cost is the number shown on the table multiplied by [100 + (1/5 its range)].

If the radar has any options, multiply its weight, volume, cost and power as shown on the table. All multipliers are cumulative. Then calculate the radar's Scan rating, which is added to detection rolls when using the detection rules in Chapter 13. Scan depends on range, as shown below:

Range to Scan Table

Range	*Scan*	*Range*	*Scan*	*Range*	*Scan*	*Range*	*Scan*
0.1 mile	5	3 miles	14	100 mi.	23	3,000 mi.	32
0.15 mile	6	4.5 mi.	15	150 mi.	24	4,500 mi.	33
0.2 mile	7	7 mi.	16	200 mi.	25	7,000 mi.	34
0.3 mile	8	10 mi.	17	300 mi.	26	10,000 mi.	35
0.5 mile	9	15 mi.	18	450 mi.	27	15,000 mi.	36
0.7 mile	10	20 mi.	19	700 mi.	28	20,000 mi.	37
1 mile	11	30 mi.	20	1,000 mi.	29	30,000 mi.	38
1.5 miles	12	45 mi.	21	1,500 mi.	30	45,000 mi.	39
2 miles	13	70 mi.	22	2,000 mi.	31	etc.	etc.

. . . with each factor of 10 increasing Scan by +6; e.g., range 70,000 is 10 times greater than range 7,000, so Scan is 34 + 6 = 40.



Find the range of the sensor in miles in the Range column; if it falls between two values, use the lower. The number in the adjacent Scan column is the sensor's Scan. Approximate Scan ratings for FTL radars (p. 51) can be found by reading the table in light-seconds instead of miles and adding 32. Thus, 10 light-second range is Scan 49. In space, non-FTL radars, ladars and AESAs get 10× range (and thus +6 Scan).

EXAMPLE

For use in air combat and navigation, we decide the Kitty Hawk has a late TL7 radar with a 10-mile range. We put it in the body, facing forward. Multiplying the numbers on the table by 10, we find it weighs 50 lbs., takes up 1 cf, costs $40,000 and requires 2.5 kW power. With a 10-mile range, it has Scan 17.

Sonar

Sonar (SOund Navigation And Ranging) uses sound waves for detection. It is available in three main types: active, passive (also called a hydrophone) and active/passive.

Active Sonar (TL6): This system detects objects by bouncing a beam of sound off the target and measuring the time it takes for the echo to return. Also called an echo sounder, it was historically developed in the 1920s. Active sonar detection provides the range, size and direction of an object; repeated pulses can determine course and speed of a moving object, and get a very rough idea of its shape. Since sound travels much better underwater than in air, sonar is best used for underwater detection; in air, its range is 10% of normal and Scan is -6. It is ineffective in vacuum.

Besides spotting moving objects such as submarines or schools of fish, active sonar can find the depth of water by measuring the distance to the bottom (useful to avoid running aground) and locate stationary, silent objects like wrecks or terrain features on the ocean floor. Active sonars with less than 1-mile range are often used by civilian vessels for navigation, oceanographic research and archaeology. Naval vessels usually have powerful active sonars with 2-20-mile ranges for use in detecting quiet-running submarines, but are often shy about using them, since the sonar pulse gives away the vessel's position to any craft equipped with hydrophones (below), out to twice the range of the active sonar.

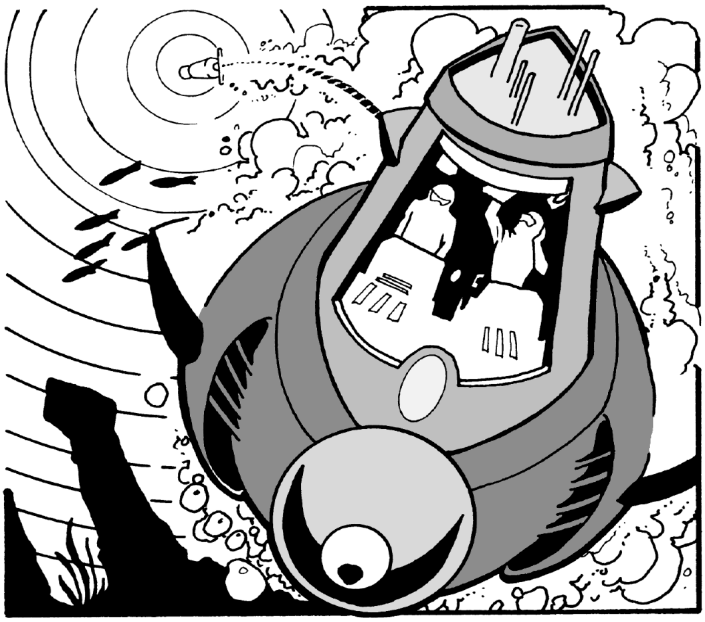
Active sonar can also be used for targeting weapons fire, feeding ranging information to a gunner. This allows a vehicle to attack targets that cannot be seen visually.

Passive Sonar (TL6): A passive sonar, or hydrophone, is a very sensitive underwater sound detector. A passive sonar can only detect objects that are making noise in water, and only if both the sonar and the object are in water, but does not require any line of sight. A passive sonar cannot determine the exact location of an object well enough to be used to aim a direct-fire weapon, nor can it discern an object's size or shape. It can find the approximate distance, course and speed of an object, and most importantly, can classify objects by their acoustic signature. Naval sonar operators become familiar with the different noises underwater objects produce, and can tell the difference between a school of whales and a ship's or submarine's propeller on a successful skill roll.

At TL7+, ships with passive sonars normally use transmission profiling software (p. 63), which allows very exact identification of familiar targets – for instance, "We picked up the propeller noise of a British Trafalgar-class nuclear submarine running at 20 knots. Hmm. Sounds like someone just dropped a wrench aboard. Wait. Now they're flooding their torpedo tubes . . ."

Active/Passive (late TL6): Added to an active sonar, this allows it to switch to passive mode, functioning as a passive sonar at twice its active range (giving +2 to Scan).

Option – Depth Finding (TL7): Commercial vessels often mount very limited active sonars *solely* useful for finding the depth to the bottom. Build these by taking this option. Except in very deep water, a range of 0.1 miles is usually suitable. Depth finding sonar can be set to sound an alarm if the depth goes below a preset limit. Using this system or an ordinary active sonar gives a +1 bonus to Navigation if the GM requires skill rolls to pilot a vessel close to shore or shoals.



Option – Dipping Sonar (TL7): Any type of sonar must be in the water to detect anything underwater. To allow aircraft to use sonar, "dipping sonar" was developed. This mounts the sonar on a cable which is dipped into the water. The aircraft must be hovering or moving slowly (under 20 mph) within 100 feet of the water, which basically restricts it to helicopters, airships, grav vehicles or the like. It takes 30 seconds to extend or retract the sonar; if the craft exceeds 20 mph or maneuvers violently (over 2 g) without first retracting it, the sonar will be destroyed.

Option – Towed Array (TL7): Moving watercraft (including submarines) may not use passive sonars to detect targets that are in an arc *behind* them due to the noise of their propulsion systems. To solve this problem (and also allow use of a larger antenna) they trail a hydrophone array on a long cable. This is called a towed array. A deployed trailing passive sonar gives a -1 to watercraft control rolls, but allows detection behind the craft. Extending or retracting it takes one minute.

Option – No Targeting (TL6): The sonar cannot be used for targeting weapons fire.

If a sonar is desired, select the type, options (if any) and range in miles (minimum 0.1 mile); range may be up to TL × 3 miles for active sonar or TL × 8 miles for passive sonar (× 20 if towed array). Then determine the other statistics as shown below:

Sonar Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
6	Active Sonar	200	4	$4,000	2.5
Early 7	Active Sonar	100	2	$6,000	2.5
Late 7	Active Sonar	50	1	$8,000	2.5
8+	Active Sonar	20	0.4	$2,000	2.5
Early 6	Passive Sonar	150	3	$3,000	neg.
Late 6	Passive Sonar	100	2	$2,000	neg.
Early 7	Passive Sonar	50	1	$3,000	neg.
Late 7	Passive Sonar	25	0.5	$4,000	neg.
8+	Passive Sonar	10	0.2	$1,000	neg.
Options					
Active/Passive*		×1.5	×1.5	×1.5	×1
Depth Finding*		×1	×1	×0.25	×1
Dipping Sonar		×1.5	×1.5	×1.5	×1
Towed Array**		×1.5	×1.5	×4	×1
No Targeting*		×1	×1	×0.5	×1

* Active sonar only. ** Passive sonar only.

The table shows the basic weight (lbs.), volume (cf), cost and power consumption of sonar *per mile of range.* If the sonar has any options, multiply these statistics as shown on the table. All multipliers are cumulative. Then calculate the Scan rating using the *Range to Scan* table on p. 52.

Location Restriction: If the sonar is intended to be used in water, it should be either a dipping sonar or go in a location that will be submerged – an underside turret, not a topside turret, for instance.

EXAMPLE

The radar is useless underwater, so we decide the Kitty Hawk will have a late-TL7 active sonar with active/passive option and a 0.5-mile range. It goes in the body, facing forward. Multiplying by 0.5 for range, and then applying the multipliers for the active/passive option, we find it weighs 37.5 lbs., takes up 0.75 cf, costs $6,000 and requires 1.25 kW power. With a 0.5-mile range, we find it has Scan 9. Since it has the active/passive option, it can also be used as a passive sonar with double range.

Thermal and Passive Electromagnetic Imaging Sensors

These sensors allow a user to see beyond the visual range of the electromagnetic spectrum. They generally work in the infrared (IR) range, detecting the heat an object emits and comparing to the background. Since an object is rarely the exact same temperature as its background, IR usually gives a reasonably good idea of an object's shape. However, details the same temperature as the rest of the object (e.g., writing) are never visible. Infrared sensors cannot see over the visual horizon, but they can penetrate darkness and normal smoke or fog. However, their vision is degraded by falling snow, rain or hot smoke (e.g., from burning white phosphorous) to the same degree as human vision would be. They can be blinded by very hot objects, such as flares or fires. Special IR Cloaking (p. 91) systems can reduce an object's infrared emissions, making it harder to spot.

There are two main kinds of infrared sensor: passive IR and thermograph.

Passive Infrared (TL7): This sensor gives the user the equivalent of the Infravision advantage (p. B237). Passive infrared sensors were developed experimentally in late TL6, but did not become widely available until the middle of TL7. Passive infrared sensors can be enhanced by the use of the infrared searchlights ("active infrared") described on p. 49.

Thermograph (late TL7): This is an advanced, high-resolution infrared sensor. Thermographs (also called thermal imagers) use a specially-cooled heat sensor to increase their sensitivity, and electronically enhance the infrared emissions into a television-style visual image. Treat a thermograph as Infravision (p. B237) but there is no -1 penalty for night combat and an extra +1 to Tracking bonus. Also, its resolution is sensitive enough to be able to see heat shapes concealed behind brush or through thin walls, although this requires a roll at a penalty equal to the wall's (HT + DR). Thermographs are very useful for espionage operations and urban combat!

Passive Radar (TL8): This is a passive millimetric-band sensor. All objects radiate millimetre wave electromagnetic signals much like they do heat. A passive radar assembles these signals into a picture in much the same way as a thermograph. Passive radar is used to supplement or replace thermographs at higher TLs, as it is less vulnerable to certain countermeasures.

Passive Electromagnetic Sensor Array (TL8): A PESA or "radiation imager" combines passive radar and thermograph sensors into a single unit, and often adds some ultraviolet imaging capability. It can also be set to function in the visible light range, working much like a low-light TV with magnification equal to its maximum effective range in miles. (If its effective range is less than 1 mile, it has ×1 magnification.) For a PESA's Vision bonus, refer to the *Magnification to Vision Bonus* table on p. 50 – or simply subtract 10 from its Scan for the higher bonus and then halve that for the lower bonus.

All infrared, thermograph, passive radar and PESA sensors are rated for their *maximum effective range* in miles (for PESAs, this is the range using thermal imaging). Decide what the sensor's maximum effective range is (minimum 0.25 miles; at TL7, thermographs may not have a maximum effective range greater than 25 miles, but there is no other



restriction). Then use the table below to work out weight, volume and cost. Since sensors cannot see over the horizon, those intended for use on ground vehicles rarely require a range greater than 5 miles!

Without an atmosphere to diffuse and absorb the target's emissions, these sensors are far more effective. Treat them as having 10 × their usual maximum effective range (giving +6 Scan) in a vacuum.

Thermal and Passive Electromagnetic Sensors Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
7	Passive IR	10	0.2	$4,000	neg.
8	Passive IR	4	0.08	$1,000	neg.
9	Passive IR	2	0.04	$500	neg.
10+	Passive IR	1	0.02	$250	neg.
7	Thermograph	5	0.1	$16,000	neg.
8	Thermograph	2	0.04	$4,000	neg.
9	Thermograph	1	0.02	$2,000	neg.
10+	Thermograph	0.5	0.01	$1,000	neg.
8	Passive Radar	2	0.04	$6,000	neg.
9	Passive Radar	1	0.02	$3,000	neg.
10+	Passive Radar	0.5	0.01	$1,500	neg.
8	PESA	4	0.08	$16,000	neg.
9	PESA	2	0.04	$8,000	neg.
10	PESA	1	0.02	$4,000	neg.
11+	PESA	0.5	0.01	$2,000	neg.

Multiply the range of the sensor in miles by the numbers shown on the table to find its weight, volume and cost. *Exception*: If a sensor has a range of over 125 miles, its cost is the number shown on the table multiplied by [100 + (1/5 its range)].

Then calculate the sensor's Scan rating using the *Range to Scan* table on p. 52.

EXAMPLE

The Kitty Hawk has a thermograph with a 3-mile range mounted in the turret (turret, 15 lbs., 0.3 cf, $48,000, Scan 14).

Other Sensors

More specialized sensors are also available:

Geophone (TL7): This is a seismic detector used to sense ground vibrations. It can normally only detect objects that are moving on the ground. It does not require a line of sight, and can work through walls, other solid objects or over the horizon. It can determine the approximate distance, direction, mass and speed of a moving object, but cannot determine the exact location well enough to be used to aim a direct-fire weapon, nor to detect an object's size or shape.

Magnetic Anomaly Detector (MAD, TL7): A MAD detects the fluctuations in the Earth's magnetic field caused by the movement of large ferrous objects, and can locate the position of such objects and classify them by their mass and speed, although not their shape. At TL7, MAD is mainly used to detect submarines or shipwrecks. It also detects the magnetic fields produced by mag-lev, MHD technology, operating fusion or antimatter devices and any discharge of a particle beam, flamer or electromag weapon at five times its normal range. Use of a MAD does not require line of sight. It works in any direction, and can scan through walls, solid objects or over the horizon.

Multiscanner (TL9): This is a multi-function energy scanner that can be used in three modes to detect and classify matter or energy. Used as a *bioscanner,* it can detect life forms and can locate particular species – or even specific people, if genetic "fingerprints" are on file. As a *chemscanner,* it can scan for minerals, metals and chemical compounds, and can be used to detect or analyze explosives or drugs, or even determine the DR of an object. As a *radscanner,* it can detect energy sources of all kinds and can be set to scan for specific types of radiation (gamma ray, radio, neutrino, radar, etc.) and can also detect the scanning radiation used by chem and bioscanners.

Note that chemscanners, radscanners and bioscanners can also be bought separately. They have half the cost, weight and volume of an equivalent multiscanner. (The multiscanner gets an overall break in cost and weight because many of the components can be used in all three modes.)

Gravscanner (TL11): Also known as a gravitic anomaly detector or gradar (GRAvity Detecting And Ranging), this is a sophisticated sensor that can detect objects and classify them by their mass and speed. It can detect the use of gravity-manipulation devices like artificial gravity or contragravity, gravity beams, gravitic guns and tractor beams at up to five times its normal range.

If a geophone, MAD, multiscanner or gravscanner is desired, select its normal range in miles, and determine its statistics as shown below:

Other Sensors Table

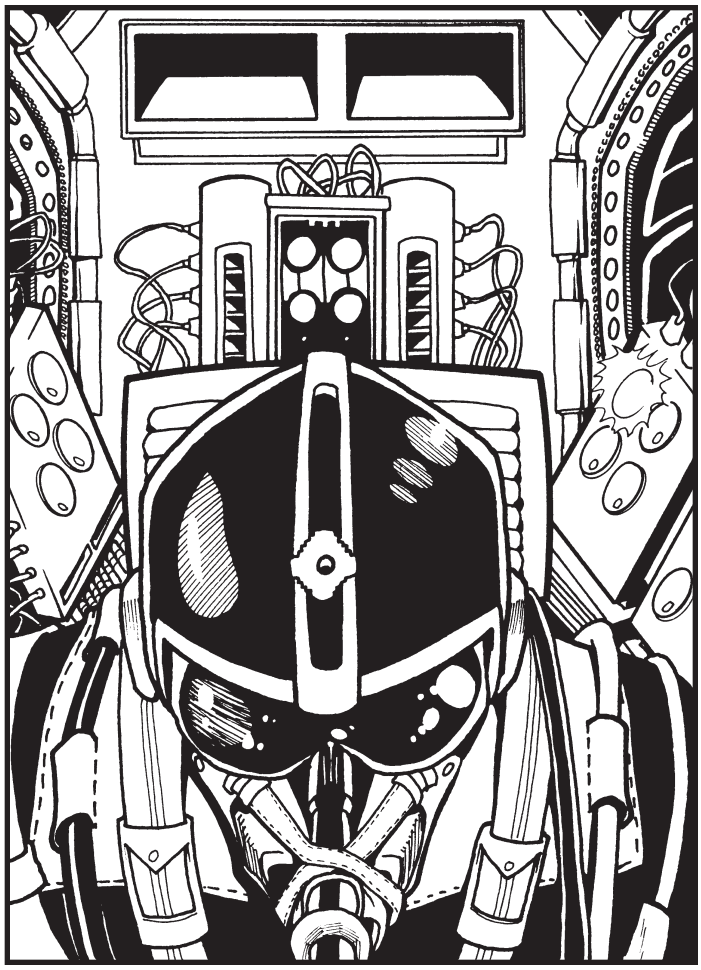
TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
7	Geophone or MAD	50	1	$50,000	neg.
8	Geophone or MAD	20	0.4	$20,000	neg.
9+	Geophone or MAD	10	0.2	$10,000	neg.
9	Multiscanner	10	0.2	$10,000	neg.
10	Multiscanner	2.5	0.05	$2,500	neg.
11+	Multiscanner	0.5	0.01	$500	neg.
9	Chem-, Rad- or Bioscanner	5	0.1	$5,000	neg.
10	Chem-, Rad- or Bioscanner	1.25	0.025	$1,250	neg.
11+	Chem-, Rad- or Bioscanner	0.25	0.005	$250	neg.
11	Gravscanner	50	1	$50,000	neg.
12	Gravscanner	20	0.4	$20,000	neg.
13+	Gravscanner	10	0.2	$10,000	neg.

The table shows the basic weight (lbs.), volume (cf.), cost and power consumption of the sensor per mile of range. *Exception:* if a sensor has a range of over 25 miles, its cost is the number shown on the table multiplied by [20 + (1/5 its range)].

Decide where the sensor is located – geophones must be located in the body or legs, or in an arm that can touch the ground. Then calculate the sensor's Scan rating using the *Range to Scan* table on p. 52.

Sound Detectors

These are sensitive microphone arrays used for detection in atmosphere (as opposed to underwater). Sound detectors are available starting in late TL6.



A sound detector may be either "ranging" or "surveillance."

A ranging sound detector (TL6) simply locates the position of a loud noise but does not allow the user to "listen" to it. It is mainly used for locating firing artillery batteries.

A surveillance sound detector (TL7) can locate and then "zoom in" on a sound, allowing the user to filter out background noise and hear distant conversations or the like.

For both types, a successful skill roll against Electronics Operation (Sensors) may be required at the GM's discretion.

A sound detector's sensitivity is rated in levels, up to a maximum of (TL+ 7) levels. Decide how many levels the sensor has, and calculate its weight, volume and cost using the table below:

Sound Detector Table

TL	*Weight*	*Volume*	*Cost*	*Power*
6	5	0.5	$400	neg.
7	0.5	0.01	$400	neg.
8	0.2	0.004	$100	neg.
9	0.1	0.002	$50	neg.
10	0.05	0.001	$25	neg.
11+	0.025	0.0005	$12.5	neg.

Weight, volume and cost are per level. Multiply cost by ten for surveillance sound detectors.

The table below shows how far away a user can be from various sounds and still locate and understand them with the same clarity as normal conversation one yard away.

Each level of sound detector doubles the range (move down one range line) at which a sound can be located (ranging) or located and understood (surveillance). For instance, 20 decibel sound (a whispered conversation) can only be heard and understood at 1/2 yard normally. A person using a level 10 surveillance sound detector can locate and understand a whisper at 512 yards.

Sound Intensity Table

Sound level (decibels)	*Example*	*Range (yards)*
1	breathing	1/8 (1)
10	whispered word	1/4 (2)
20	whispered conversation	1/2 (4)
30	normal conversation	1 (8)
40	hooves, running, beating wings	2 (16)
50	hydrojet, loud conversation	4 (32)
60	turbine or nuclear engine	8 (64)
70	steam or internal combustion engine	16 (128)
80	screw or paddle wheel	32 (256)
90	rotors, aerial propellers	64 (512)
100	artillery fire	128 (1024)
110	jet engine	256 (2048)
120	rocket engine	512 (4096)
+10		×2

The number in parentheses on the table is the maximum range at which the sound can be heard but its location and origin *not* clearly distinguished.

Sound baffling on a vehicle will subtract (TL-4) × 10 decibels if basic, or TL × 10 if radical from its engine or propeller noise.

Sonobuoys and Other Remote Sensors

Modern submarine-hunting aircraft often carry hydrophones or sonars built into small buoys.

These are dropped into the water by the aircraft (from a weapon bay) to relay data back to it. Other types of vehicles may also use this type of sensor – spacecraft may carry remote sensor buoys that can be dropped to survey certain areas, and so on.

This sort of remote sensor is usually built as an immobile "vehicle" consisting of a sensor, a communicator with Datalink, a vehicular parachute (p. 71) and an energy bank. Then give it a body (make it big enough to float), a few points of DR and (for sonobouys) waterproofing, and the device is ready to use.

Scientific Sensors

These systems are used for surveying and scientific research. Space probes, laboratory ships and scout ships will usually carry some or all of these scientific sensors.

Meteorological Instruments (TL1): Instruments that can measure temperature, humidity, wind speed, etc., outside the vehicle are free for any vehicle with navigational or survey instruments. Quality varies with TL: at TL5+, add TL-4 to Meteorology skill.

Astronomical Telescopes (TL4) are built as telescopes or low-light TVs (p. 50). Instruments intended for serious modern astronomy should be at least 200× magnification and carefully stabilized – use the rules for *Weapon Stabilization,* p. 45. Without stabilization, Astronomy skill rolls are made at a -4 penalty. Ten days and a successful Astronomy skill roll would enable a user to map a star system (locate planets and moons and calculate their orbits) with the help of a computer with a Cartography or Astronomy program. Doing the same job by hand would take years.

Astronomical Instruments (TL7): This is the sort of sensor array typically used by survey spacecraft or satellites for the careful detection and study of stellar objects, dust clouds, etc. It includes an array of infrared, ultraviolet, high-energy and radio telescopes, as well as field and particle sensors. Build the system as if it were a low-light TV with 200× or better magnification and full stabilization (see p. 50), then multiply the cost by ten. In a pinch, it can function as an infrared sensor (or, at 100 times range, as a radio receiver) but as it is optimized for use in astronomy rather than tactical search, only one detection roll is allowed per hour. It can also give a (TL-6) bonus to skill when making Astrogation rolls to locate a ship's position in interstellar space, or to Physics rolls made to analyze unusual astronomical objects.

Planetary Survey Array (TL7): This basic tool of remote orbital or aerial surveying consists of an array of specialized cameras, radiometers sensitive to various bands of the electromagnetic spectrum, etc. To

extract data about a region requires at least one low orbital pass or air overflight and a roll against an appropriate skill (usually Planetology or Meteorology, depending on whether the surface or atmosphere is being studied). All kinds of useful data can be found: atmospheric composition, meteorological conditions, soil temperature and moisture, snow boundaries, ice floe movement, surface mineral composition, species and health of plants, sediment and biological loads of ocean waters, etc. They are available in low-, medium- and high-resolution systems. Medium-res systems give +1 to skill; high-res give +2 to skill.

Scientific Sensors Table

TL	*System*	*Weight*	*Volume*	*Cost*	*Power*
	Planetary Survey Array				
7	Low-Resolution	100	2	$50,000	0.05
7	Medium-Resolution	500	10	$500,000	0.5
8	High-Resolution	4,000	80	$5,000,000	5

Weight, volume and cost are halved one TL after the sensor first appears, and are halved again after two or more TLs.

Audiovisual Systems

These devices are used for recording and storing information, such as pictures or sound. They are often used for military photo-reconnaissance, science, news gathering or film making.

Sound System or *Flight Recorder* (TL6): A sound system is an audio player/recorder. In addition to its use as a entertainment system, this can also be used as the tape recorder/playback system needed for electronic intelligence vessels. Use the same stats for cockpit flight recorders ("black boxes") like those installed in airliners. The system cannot play back recordings unless removed from the vehicle, but is tough enough to survive crash, explosion or fire.

Vehicle Camera (TL6): This is a telephoto camera designed to film automatically once activated (make only one Photography roll; anything but a critical failure means it's not professional quality, but the picture is still taken). At TL6, it can take one hour of black-and-white footage or several thousand still photos. TL7 models use color film. Late TL7 to TL9 models use digital data storage (no developing required) and typically hold one computer disk's worth of information and can transmit live feed (or upload to a computer somewhere using a communicator capable of data transmission). At TL10+, it takes holographic pictures. Military aircraft often mount a vehicle camera adjacent to a main weapon, to take pictures of whatever is attacked.

Recon Camera (TL6): As above, but this is a military reconnaissance model, with superior telephoto or electro-optical lenses enabling it to produce very sharp images from high altitudes. A TL7 model could read a license plate from several miles up (if license plates were on the roofs of cars) and higher-TL models are better.

Infrared and Low-Light Cameras (TL7): A normal or recon camera can be modified with infrared and/or low-light capability at extra cost. Infrared cameras take pictures using infrared film. Low-light cameras use electronic light amplification, allowing them to take pictures in anything but absolute darkness.

No Need for Cameras? Any vehicle with a PESA or low-light TV and a computer (p. 60) can function as a digital camera, capturing images and storing them in computer memory.

AV System Table

TL	*Type*	*Weight*	*Volume*	*Cost*
6	Sound System or Flight recorder	40	2	$100
7	Sound System or Flight recorder	20	1	$400
Cameras				
6	Vehicle Camera	10	0.2	$200
6	Recon Camera	50	1	$2,500
7	Digital Vehicle Camera	5	0.1	$1,000
7	Digital Recon Camera	50	1	$25,000
7	Infrared Camera	×1	×1	×2
7	Low-Light Camera	×1	×1	×2

Weight, volume and cost of TL7+ systems are halved one TL after they first appear and are halved again two or more TLs after they first appear. Power is negligible.

EXAMPLE

The Kitty Hawk will have a sound system (body, 20 lbs., 1 cf, $400).

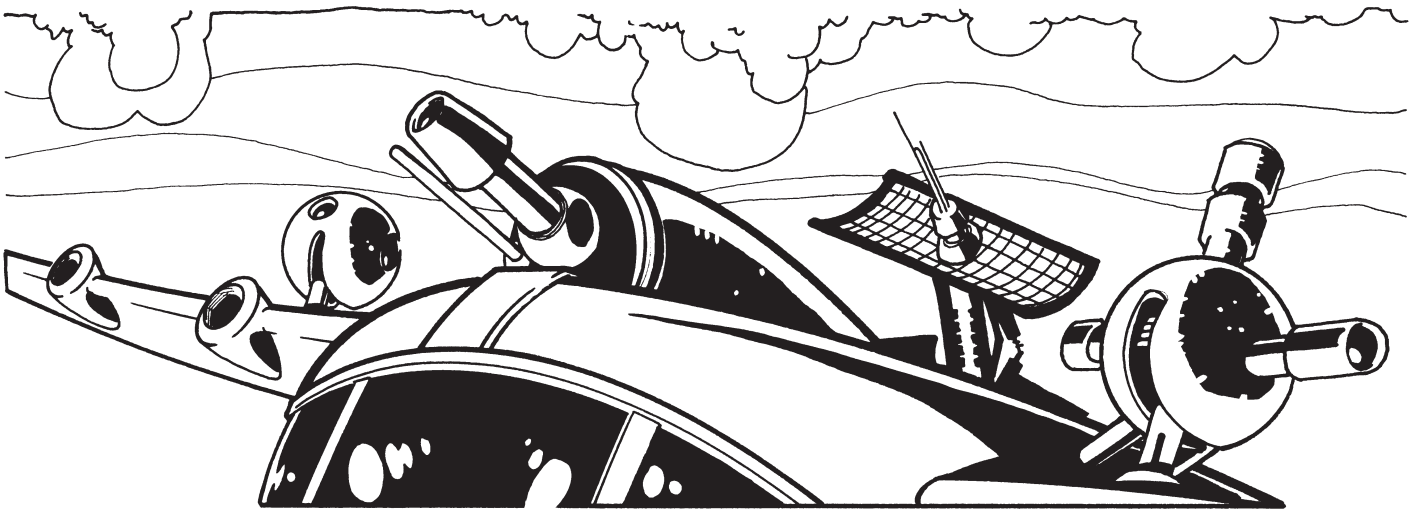
Navigation Systems

Vehicles intended to travel long distances, especially at sea, at night, over trackless wastes or at high altitudes, should be given navigation equipment to help them remain on course and avoid collisions.

Navigation Instruments: These permit navigation out of sight of familiar landmarks through the use of charts and instruments. The effect of instruments depends on TL:

At TL3, the magnetic compass allows location of magnetic north; otherwise, the only method of fixing *exact* position is by dead reckoning – that is, keeping an accurate, continuous record of how far and in what direction the vehicle has traveled and comparing to available charts, if any. Without proper timekeeping and measuring instruments, this is very difficult.

At TL4, the astrolabe or sextant lets the navigator find latitude (position north or south of the equator) by measuring stellar position. Longitude still requires dead reckoning. TL4 instruments give a +1 bonus on Navigation skill.



At TL5, precise chronometers give a +2 bonus when using dead reckoning and *much* more importantly, allow you to keep a reference time that solves the problem of longitude.

At TL6, gyroscopic compasses and better star-tracking devices give a +3 bonus to all Navigation rolls. More importantly, navigation instruments can now process information from a network of ground stations, which can provide the vehicle with information on its approximate position. When combined with a radio (p. 47) capable of contacting such a station, radio-triangulation (available historically circa 1920) allows fixing the vehicle's position accurate to 1 mile. At TL7 and up, many vehicles may still be equipped with TL6 instruments, rather than paying the extra cost for TL7 hardware.

At TL7+, instruments give a +4 to skill when using dead reckoning, and with radio assistance are accurate to within 100 yards. With the addition of a *GPS* or inertial navigation system (late TL7, see below), exceedingly precise navigation is possible without the need to rely on ground stations.

At five times cost, any TL4+ navigation instruments may be available as "precision" instruments with an additional +1 bonus.

Navigational Radars (late TL6): Radar is often used to help a vehicle navigate in low visibility, at night or while flying at low altitudes, or to detect weather conditions. A typical navigational radar is built as a radar with a range of 5-10 miles and the "no targeting" option; see *Radar,* p. 51. Versions with ranges of 0.1 to 0.25 miles are used on ships and ground vehicles. This "anti-collision radar" warns the driver if he's likely to collide with an obstacle, halving the penalties for driving at night or through fog. In addition, if the vehicle has ejection seats, a force screen or a stasis web, it may activate that safety system *automatically* in the event of a high-speed collision – the precise speed is set by the owner.

Autopilot (TL6): This is a simple mechanical or electronic device that, once set, keeps a watercraft or aircraft on a steady course at a constant speed. It is impractical on land, except when traveling in a straight line over flat and featureless terrain. Most late TL6 aircraft and motorboats have one. If the vehicle is to do anything more complex than move on a fixed heading, Vehicle Operation software is needed instead.

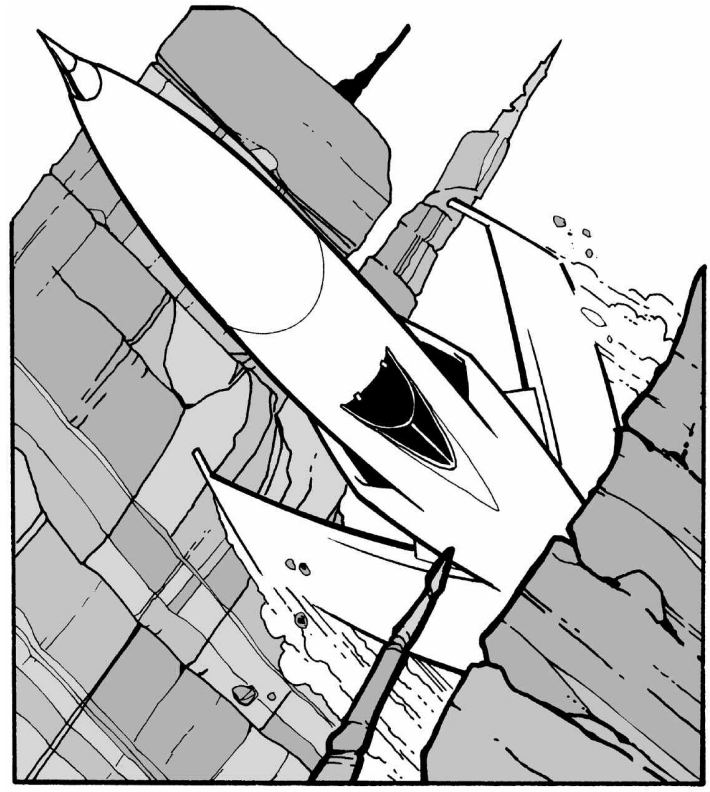
IFF (TL6): This stands for "identify friend or foe." It is a specialized transmitter and receiver unit used to identify vehicles that have been detected but whose identity is in question. A military IFF is programmed with an identification code and a list of current "friendly" codes. The IFF can be triggered to "interrogate" a vehicle that has been detected, sending an encoded communicator pulse. If the target has an IFF or transponder of its own, and the incoming pulse is from an IFF code that it has been programmed to recognize, it will automatically send back a coded reply. If that reply matches the current list of friendly codes the interrogating IFF was programmed with, the interrogating IFF classes the target as "friend." If there is no reply, or it is an incorrect code, the IFF reads the target as "foe." For obvious reasons, a military will change its IFF codes on a regular basis!

Civilian aircraft (and in future, maybe other vehicles) may be legally required to use a version of IFF known as a *transponder*. Transponders allow air traffic control systems (and the military) to identify the civilian vehicle. Instead of being a secret code, a civilian transponder's signal is normally just the vehicle's flight number or serial number. A transponder cannot interrogate other vehicles' IFF. Falsifying a signal or turning a transponder off is a serious offense!

In either case, range is equal to that of a radio of the same TL with the long range option.

Inertial Navigation System (INS, TL7): This sophisticated system can calculate the vehicle's exact location and heading without using satellite assistance. It uses gyroscopic systems, occasionally updated by geo-magnetic, GPS or star tracking, to continuously fix the vehicle's position relative to known map coordinates. This can be vital if GPS-type systems are unavailable or cannot be relied upon (e.g., if the enemy can shoot down satellites). An INS is useful for precise "blind" navigation at night, or across water or trackless wastes.

An early TL7 INS is accurate to about 1 yard per mile. A late TL7+ INS is accurate to *at least* one foot per ten miles. In conjunction with good maps (physical or electronic), an INS adds +5 to Navigation skill (+1 per TL over 7) and effectively gives the vehicle operator Absolute Direction. This bonus is not cumulative with TL5- navigational instruments, and TL6 navigational instruments only get a further +1 bonus from INS.



Global Positioning System (GPS, late TL7): This links the vehicle to an orbital navigation satellite network (or a friendly spacecraft), enabling the operator to always know his exact position if he then consults a properly-scaled map. The vehicle operator effectively has Absolute Direction (accurate to about 25 yards for civilian systems, 5 yards for military systems) as long as it is in communications contact with a "constellation" of friendly navigation satellites (or spacecraft). A GPS system alone is much less expensive than a full TL7 navigation suite, but – *provided* navigation satellites are available – is at least as accurate.

A GPS system can store the coordinates of a location it has visited (called a "way point") in memory. It can then later direct the user to that way point or (if the vehicle's communication systems have a digital datalink) transmit that way-point data to other GPS systems.

At present, military and commercially-available civilian GPS systems use the same satellites but (for example) the United States government can command the satellites so that – in times of crisis – only military GPS sets receive extremely detailed information. It is possible that other government or corporate satellite systems installed in the future may have similar restrictions installed by *their* masters.

GPS systems are often used in conjunction with computers or dedicated computers (p. 61) using navigation programs (p. 63), allowing the vehicle's location to be displayed on a map as it moves.

Terrain-Following Radar (TFR, late TL7): Used by aircraft, this is a downward-looking navigational radar that relays instructions to the aircraft's flight controls, allowing automatic, trouble-free, contour-hugging navigation at very low altitudes at full speed by night and in any weather. The aircraft automatically maintains a constant preset altitude above the *highest* terrain feature – trees, houses, hills, or whatever – that is below the aircraft. While TFR is engaged, the pilot cannot climb or dive: altitude control is handled by the radar. Its use increases the ease of low-level flight, and is a necessity for the treetop-hugging, under-the-enemy's-radar attacks that characterize TL7+ air-to-ground combat. The minimum altitude at which TFR can operate is 30/(TL-6) yards. (A terrain-following radar's emissions can be sensed by a radar detector as if it were a radar pointing downward with a range of 100 yards.)

Navigation Systems Table

TL	System	Weight	Volume	Cost	Power
3	Navigation Instruments	20	0.4	$50	0
4	Navigation Instruments	30	0.6	$100	0
5	Navigation Instruments	30	0.6	$200	0
6	Navigation Instruments	20	0.4	$500	neg.
7+	Navigation Instruments	20	0.4	$1,000	neg.
4+	"Precision" Instruments	×1	×1	×5	×1
6	IFF*	20	0.4	$1,000	neg.
7	IFF*	10	0.2	$2,000	neg.
8+	IFF*	5	0.1	$1,000	neg.
7	Inertial Navigation System	40	0.8	$50,000	neg.
8	Inertial Navigation System	20	0.4	$25,000	neg.
9+	Inertial Navigation System	10	0.2	$12,500	neg.
7	Global Positioning System	1	0.02	$200	neg.
8	Global Positioning System	0.5	0.01	$100	neg.
9+	Global Positioning System	0.25	0.005	$50	neg.
7+	Military GPS	×4	×4	×15	neg.
6+	Autopilot	5	0.1	$200	neg.
7	Terrain Following Radar	25	0.5	$20,000	0.25
8	Terrain Following Radar	10	0.2	$4,000	0.25
9	Terrain Following Radar	5	0.1	$2,000	0.25
10	Terrain Following Radar	2.5	0.05	$1,000	0.25
11+	Terrain Following Radar	1.25	0.025	$500	0.25

* Halve cost, weight and volume for a transponder.

For anti-collision and navigation radar, see *Radar* on p. 51.

EXAMPLE

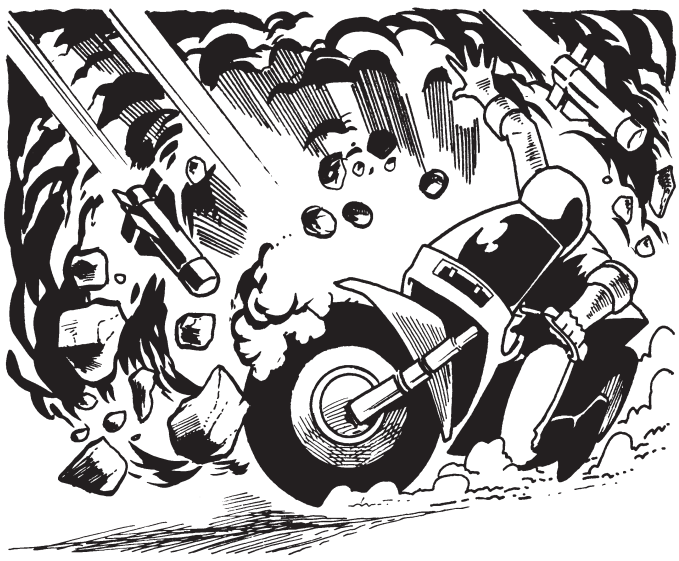
The Kitty Hawk will have a Military GPS in the body: 4 lbs., 0.08 cf, $3,000.

Targeting Systems

A targeting system assists in aiming or targeting weapons. Ordinary optical or electro-optical sights and rangefinders are not included in targeting systems – they are part of the weapon itself, and give the weapon its basic Accuracy bonus.

Bombsight (TL6): A bombsight is needed if the vehicle is to drop bombs with any accuracy (see *Bombing,* p. 114). They come in three types: optical (TL5), improved optical (late TL6) and advanced (TL7). A vehicle without a bombsight is at -4 to hit when dropping bombs. An improved optical bombsight gives a +2 bonus to hit. An advanced bombsight gives a bonus of +4 to hit. Only one bombsight can be used at a time, and using it requires an Aim maneuver.

Fire Direction Center (FDC, late TL5): This consists of an array of plotting tables and map displays (electronic at TL7+) used to assist in the indirect fire of batteries of artillery or naval guns. In a TL5-6 warship, the FDC is often installed high in an armored superstructure; TL7+ FDCs are usually in the bowels of the ship. A given FDC can give a bonus to hit against a *single target* when indirect fire is used: +2 at TL5, +3 at TL6, +4 at TL7+. This applies to all gunners of indirect-fire weapons in communication with the FDC. These bonuses are not cumulative with those of other FDCs, but *are* cumulative with those from fire-direction software (p. 62). A FDC requires a crew of two – and at least one communicator – per two gunners or forward observers it will direct. Unlike targeting sensors and computers, a FDC cannot assist in direct fire.



HUDWAC (late TL7): A HUDWAC is a Heads-Up Display Weapon Aiming Computer. It ties the vehicle's weapons systems into an integrated targeting display which is then projected in front of the user's eyes (or if he has a neural interface, into his brain). This allows rapid engagement of targets. A TL7-8 HUD reduces the weapons' SS number by 2. A TL9+ HUD reduces SS number by 5. One user needs one HUDWAC; if a vehicle has multiple gunners, get multiple HUDWACs.

Any HUDWAC may be fitted with a pupil scanner at extra cost. This uses a laser to scan the user's eyeballs, and trains weapons and sensors wherever the user looks. This reduces the SS of any weapon mounted in an arm, turret, open mount, or casemate mount by a *further* 2 points.

Laser Rangefinder (late TL7): A laser rangefinder is a relatively inexpensive alternative to using a targeting radar or ladar. It allows a gunner to precisely estimate distances using a laser beam. It adds +2 to weapon Accuracy when aiming at an object in line-of-sight and within the laser rangefinder's range. A single laser rangefinder can only be used to aim at one object per turn. If a vehicle locks multiple laser rangefinders and/or targeting ladars or radars onto the same target, use only the highest single bonus.

Laser Designator (late TL7): A laser designator is designed to illuminate ("paint") a target with a laser beam. The beam is coded so that friendly, semi-active laser homing missiles and laser-guided bombs will be able to sense the beam and home in on it. Each laser designator can paint only one target at a time. To illuminate a target, the designator must be in line of sight of the target, and the operator must take continuous Aim maneuvers until the munitions hit. At TL8-, a laser designator cannot work through smoke, thick fog, snowstorms or water. At TL9, a laser designator is not affected by smoke or fog, only by special, anti-laser prismatic smoke. At TL10+, even prismatic smoke does not affect it. A laser designator beam is normally invisible. However, a target with a radar/laser detector (p. 59) may be able to sense both the beam and the location of the vehicle using the designator.

Unless it has the "no targeting" option, any ladar can function exactly like a laser designator with the same range.

Laser Spot Tracker (TL7): This is a sensitive optical device that allows the operator to automatically spot any target in front of and in line of sight of the tracker (which must be mounted to face in a particular direction) that has been illuminated by a friendly laser designator. It is usually mounted on strike aircraft to allow the gunner to know how and when to fire laser-guided bombs and missiles without needing to be in direct communication with the ground forces or other craft who may be designating targets.

Targeting Computer (late TL5): Vehicles often incorporated computers (p. 60) that have been given the dedicated option and designed to run only targeting programs (p. 63). Bonuses from multiple targeting computers are not cumulative.

Targeting Radar or Ladar (late TL6): Vehicle radars and ladars can be used to provide bonuses to hit. If a target is being tracked by radar, imaging radar or ladar, or by an AESA, and the sensor does not have the "no targeting" option, then there is a +2 bonus to hit. A sonar can work the same way, but only gives a +1 bonus. These bonuses are never cumulative with each other, or with multiple systems, and are not cumulative with laser rangefinders. They *are* cumulative with targeting computers.

Targeting Systems Table

TL	Type	Weight	Volume	Cost	Power
6	Optical Bombsight	5	0.1	$200	0
6	Improved Bombsight	5	0.1	$2,000	0
7-8	Advanced Bombsight	10	0.2	$10,000	neg.
9	Advanced Bombsight	5	0.1	$5,000	neg.
10+	Advanced Bombsight	2.5	0.05	$2,500	neg.
5	Fire Direction Center	4000	400	$25,000	neg.
6	Fire Direction Center	3000	300	$50,000	neg.
7+	Fire Direction Center	2000	200	$250,000	neg.
7	HUDWAC	10	0.2	$5,000	neg.
8	HUDWAC	neg.	neg.	$500	neg.
9+	HUDWAC	neg.	neg.	$250	neg.
7+	Pupil Scanner for HUDWAC	neg.	neg.	×4	neg.
7	Laser Rangefinder	10*	0.2*	$4,000*	neg.
8	Laser Rangefinder	4*	0.08*	$1,000*	neg.
9+	Laser Rangefinder	2*	0.04*	$500*	neg.
7	Laser Designator	5*	0.1*	$2,000*	neg.
8	Laser Designator	2*	0.04*	$500*	neg.
9+	Laser Designator	1*	0.02*	$250*	neg.
7	Laser Spot Tracker	20	0.4	$10,000	neg.
8	Laser Spot Tracker	10	0.2	$5,000	neg.
9+	Laser Spot Tracker	5	0.1	$2,500	neg.

* Per 5 miles of range.

Location Restrictions: HUDWACs and pupil scanners must go in the same body or subassembly as the gunner(s) who will use them; a fire direction center must go in the same body or subassembly as those who will man it.

EXAMPLE

The Kitty Hawk has a HUDWAC with pupil scanner in the body: 10 lbs., 0.2 cf, $20,000. This will reduce SS by 4. Its radar can also provide a +2 bonus to hit.

Electronic Countermeasures

This class of devices (abbreviated ECM) is used to detect, locate, jam or confuse electronic emissions such as radio or radar. While they are mainly military devices, ECM systems are carried even by civilian vehicles in some jurisdictions – the ubiquitous radar detector is a good example.

Radar Detector (late TL6): This is a sensor that automatically warns the user of radar emissions (usually with a beeping tone). It is sometimes known as a "radar warning receiver." A detector can detect a radar or area radar jammer that is turned on, in line of sight (i.e., not behind a hill or over the horizon), and emitting in the vehicle's direction at out to twice a radar's or 20 times a jammer's usual range.

Advanced Radar Detector (TL7): This is the same as a radar detector, except it also gives a range and bearing to the radar, and can also inform the user if a radar is operating in targeting mode (providing a bonus to hit or guiding missiles). If the vehicle has a computer with the Transmission Profiling program (p. 63), it can distinguish between different, unique models of radar ("That sounds like a Russian High-Lark radar: it must be a MiG-23 fighter"). Any multiscanner (p. 54) can also function as an advanced radar detector when in radscanner mode.

Laser Sensor (late TL7): A laser sensor detects any laser (weapon, communicator, rangefinder, designator, ladar, etc.) which is in use, in range and directly aimed at the vehicle. Note that this is less effective than a radar detector; this is because laser beams are much narrower. The laser sensor is an interesting example of technology outracing the author's imagination: in ***Ultra-Tech,*** they were pegged as TL9 devices, while today you can buy laser sensors for your car!

Laser/Radar Detector (late TL7): A combination radar detector and laser sensor. Like a radar detector, it is available in an "advanced" model that also functions as an advanced radar detector.

Radio Direction Finder (TL6): This device intercepts and pinpoints radio broadcasts. A radio direction finder can receive radio transmissions on any normal, police or military frequency. It can also locate the point of origin of these transmissions, though doing so takes at least ten seconds. Locating a broadcast requires the direction finder to be within the broadcasting radio's range. A Contest of Electronics Operation (Communications) skill with the radio operator is needed to get a fix on it, if the operator is trying to make it difficult; use an ordinary skill roll otherwise. Each additional radio direction finder, set at least 100 yards apart, gives a +1 to skill due to triangulation. A successful roll reveals the general distance and direction; success by 5 or more gives an exact location. On a failure, the GM may allow repeated rolls to succeed, rolling every minute or so. Any multiscanner (p. 54) can also function as a radio direction finder when in radscanner mode.

Radio Jammer (TL6): See radios, p. 48.

Area Radar Jammer (late TL6): This device projects a signal that interferes with radio transmission and radar. It has a "Jammer" rating that subtracts from all rolls for radio communication or radar (but not ladar) detection, by friend or foe, within its range. It is only effective against radars of equal or lower TL. The jamming field has a radius equal to five miles times the jamming bonus. The location of the jamming field itself (but not what is in it) is detected automatically by any radar within 20 times the jammer's range.

Deceptive Radar Jammer (DJ, TL7): Deceptive jammers are designed to confuse sensors. Unlike area jammers, which use brute force, a deceptive jammer relies on electronic trickery: it generally detects an incoming sensor pulse, then fools the sensor by mimicking the signal and sending it back in an altered form. Those built at TL7-9 are only effective against radar, but TL10+ deceptive jammers use "distortion field" technology (similar to that used by the distortion belt described in ***GURPS Space*** and ***Ultra-Tech***) to confuse many other types of sensors.

The effects of deceptive jammers are described in the *Sighting and Detection* chapter. Essentially, they have a "Jammer" rating, which is used to trick – "spoof" in military jargon – a sensor into seeing multiple targets instead of the correct one, or giving incorrect range readings. This throws homing weapons off course and makes targeting the vehicle difficult.

Infrared Jammer (IRJ, late TL7): Sometimes referred to as a "heated brick," this system emits thermal radiation (and, at higher TLs, other radiation) to distract and confuse infrared-homing (IRH) missiles of the same or lower TL. It has no effect on sensors. The effects are similar to a deceptive jammer (above), but are instead effective against IRH missiles. At TL10+, infrared jammers are rendered obsolete by the advanced "distortion field" deceptive jammer.

Dischargers (late TL6): A discharger is a mortar or launcher box for various decoys. Dischargers are the most basic anti-detection and anti-missile countermeasures. They are normally used on warships and military aircraft, but sometimes on other vehicles as well. Each discharger holds one decoy; vehicles sometimes mount 20 or more dischargers. A TL7+ radar or laser detector or locator can be set to automatically trigger a discharger.

Dischargers on aircraft and submarines are usually mounted to fire behind and below the craft, while those on a surface vehicle fire upward at a point about 20 yards in front of it (although dischargers in a turret or open mount can rotate and fire in whatever the direction the mount is facing).

There are several kinds of decoys that can be loaded into and launched from a standard discharger. For technological descriptions, see the *Weaponry* chapter sidebars. For effects, see the sidebars in Chapters 13 and 14. Types include:

Chaff (TL6), used to jam radar and, at TL8+, ladar.

Smoke (TL6), used to create a thick smoke screen.

Flares (TL7), used to jam infrared-homing missiles, and also somewhat effective against passive radar homing missiles.

Sonar Decoys (TL7) release bubbles or emit false noises to fool sonar-homing torpedoes.

Hot Smoke (late TL7) is smoke that is also effective against infrared and thermographs.

Prism (TL8) is a cloud of laser-reflecting crystals, which jam ladar, laser targeting, lasercoms and laser weapons.

Blackout Gas (TL8) combines much of the effect of prism and hot smoke.

The "burst radius," or radius of the area of effect, is about 100 yards for chaff or sonar decoys and 20 yards for other types.

Any or all of a vehicle's dischargers may be fired each turn. Firing a discharger is not a combat maneuver; it can be combined with Dodging. If a crew station controls multiple types of discharger, it may use one of each in a single turn.

Radar Reflector (TL6): This is a radar reflecting device that makes a vehicle look *larger* to radar when it is set up. It can up to quadruple the apparent size of a vehicle on a radar screen, effectively adding +1 to +4 to the Size Modifier (user's choice) for the purpose of radar detection. It has no effect on imaging radar or ladar. It is normally used by the military to trick other vehicles (making a destroyer look like a battleship, for instance). On a critical success by a radar operator detecting the vehicle, the fact that there is "something odd" about the radar return is guessed. Otherwise, the sensor operator will be deceived. A reflector takes ten minutes to set up or readjust, half that to take down; if mounted on an aircraft, it can't be removed or adjusted until after the craft lands.

Blip Enhancer (TL7): This is an electronic device that does the same thing as a radar reflector, but can be turned on or off instantly. Blip enhancers are available to deceive radar at TL7, infrared detection and MADs at TL8, ladar and imaging radar at TL10 and gravscanners at TL12+.

TEMPEST (Transient Electromagnetic Pulse Surveillance Technology) Equipment (late TL7): This sensor can read the data displayed on a computer monitor as it is typed in, by picking up its radio frequency emissions at a distance. Thus, a vehicle parked or hovering outside could eavesdrop on a computer user. It has a range of 100 yards and requires an Electronics Operation (Computers) skill roll to properly use. It cannot read data on hardened systems.



Electronic Warfare Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
6	Radar Detector	10	0.2	$400	neg.
7	Radar Detector	1	0.02	$100	neg.
8+	Radar Detector	0.5	0.01	$50	neg.
6+	"Advanced" Version	×20	×20	×20	neg.
7	Laser Sensor	1	0.02	$100	neg.
8+	Laser Sensor	0.5	0.01	$50	neg.
7	Radar/Laser Detector	1.5	0.03	$150	neg.
8+	Radar/Laser Detector	0.75	0.015	$75	neg.
7+	"Advanced" Version	×20	×20	×20	neg.
6+	Radio Direction Finder	*	*	*	*
6	Area Jammer	100†	4†	$20,000†	500†
7	Area Jammer	40†	0.8†	$8,000†	200†
8	Area Jammer	20†	0.4†	$4,000†	100†
9	Area Jammer	10†	0.2†	$2,000†	50†
10+	Area Jammer	5†	0.1†	$1,000†	25†
7	Deceptive Jammer	100†	4†	$100,000†	10†
8	Deceptive Jammer	40†	0.8†	$40,000†	4†
9	Deceptive Jammer	20†	0.4†	$20,000†	2†
10	Deceptive Jammer	10†	0.2†	$10,000†	1†
11+	Deceptive Jammer	5†	0.1†	$5,000†	0.5†
7	Infrared Jammer	50†	1†	$100,000†	0.25†
8	Infrared Jammer	20†	0.4†	$40,000†	0.25†
9+	Infrared Jammer	10†	0.2†	$20,000†	0.25†
6+	Decoy Discharger (loaded)	20	1	$100	0
var.**	Decoy Reload	10	0.5	$20**	0
6+	Radar Reflector	‡	‡	‡	‡
7	Blip Enhancer	400	8	$40,000	10
8	Blip Enhancer	150	3	$15,000	5
9+	Blip Enhancer	50	1	$5,000	2.5
7	TEMPEST Equipment	75	1.5	$500,000	neg.
8	TEMPEST Equipment	20	0.4	$50,000	neg.
9+	TEMPEST Equipment	10	0.2	$25,000	neg.

* Built as a radio (p. 47), often but not always with "receive only," at 5 × normal radio cost.

** See descriptions of decoy types for availability by TL. Cost of all reloads is $20, except ordinary smoke ($10), blackout gas ($30) and sonar decoys ($50).

† For a jammer rating of 2. Maximum rating is (TL-4)×2 or 20, whichever is less. Select the desired jammer rating and multiply weight, volume, power and cost as shown:

3: ×1.5	6: ×5	9: ×15	12: ×50	15: ×150	18: ×450
4: ×2	7: ×7	10: ×20	13: ×70	16: ×200	19: ×700
5: ×3	8: ×10	11: ×30	14: ×100	17: ×300	20: ×1,000

‡ Not a permanent vehicle fixture. Add it after the vehicle is designed, attached to a deck or open cargo area on a ground or water vehicle, or attached to a hardpoint if the vehicle flies. Weight and cost are 0.1 lb. and $1 × vehicle's total surface area. Storage volume (as cargo) is weight/20 cf.

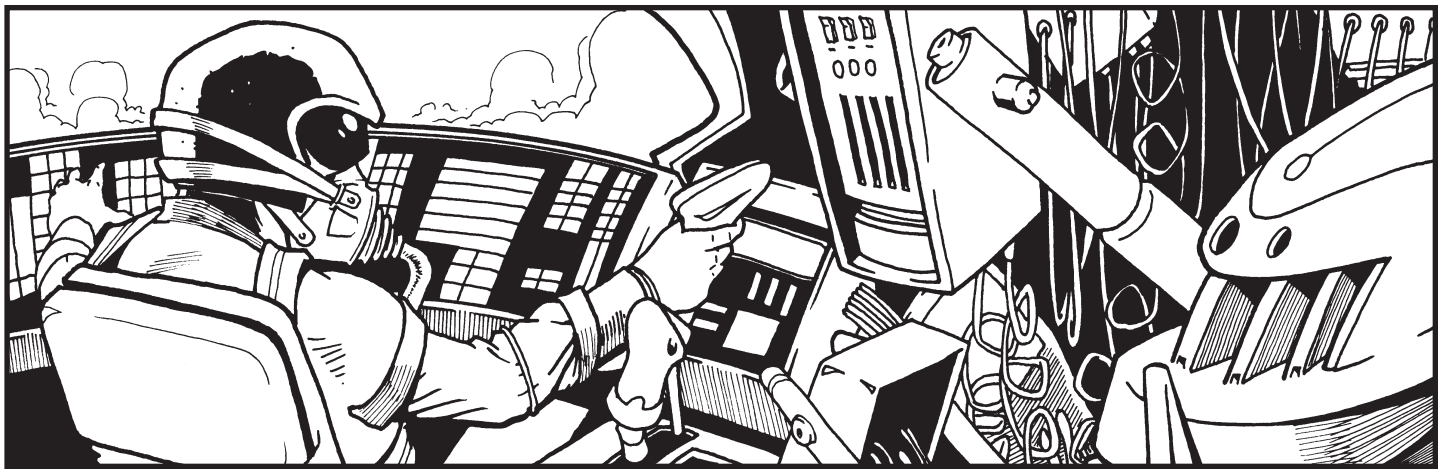
Morgan would love to load the vehicle down with countermeasures, but she's worried about weight. She settles for a TL7 advanced radar/laser detector (body, 30 lbs., 0.6 cf, $3,000, neg. power), and a TL7 decoy discharger (body, 20 lbs., 1 cf, $100) with four chaff, four flare and two sonar decoy reloads (body, 100 lbs., 5 cf, $260).

EXAMPLE

Computers

Vehicles may have computers installed in them to run software, allowing them to assist or replace human crew members.

Computers have a *Complexity* rating, which governs the type of software they can run and how fast they can run it. Each jump of +1 Complexity marks an order of magnitude performance increase.



Programs are also rated for their Complexity. A computer cannot run programs of higher TLs or Complexity than its own. The number of programs that can be run concurrently is based on Complexity: a computer can run two programs of its own Complexity, or 20 programs of one lower Complexity, and so on. This can be combined, e.g., a computer could run one program of its own Complexity and ten programs of one lower Complexity level.

Running or switching a program takes one second. Maximum memory storage (for databases) is 100 gigs × Complexity at TL8+, 10 gigs × Complexity at TL7.

Several options may be added to any computer to alter its capabilities. For strict accuracy, all computers up to late TL6 should be built with the "dedicated" option, representing simple mechanical or electromechanical analog computers.

Compact (TL6): The computer is substantially reduced in size and weight, but is much more expensive as a result.

Dedicated (TL5): A dedicated computer can only run a single software program, frequently a Targeting or Vehicle Operation program. Historically, all computers up to late TL6 should be built as dedicated computers.

Dumb (TL7): The computer is less sophisticated than usual. This subtracts 1 from Complexity but makes it much cheaper.

Genius (TL7): The computer uses state-of-the-art processing technology. This adds 1 to its Complexity, but greatly increases price.

Hardened (TL7): The computer is built with optical systems, or more sophisticated forms of hardening at higher TLs, in order to resist attacks such as electromagnetic pulses or paralysis beams that do special damage to computers, as well as computer surveillance systems such as TEMPEST.

High Capacity (TL7): The capacity of a system can be enhanced by 50% (to *three* programs of its own Complexity, etc.) for a 50% price increase.

Neural-Net (TL8): The computer is built to simulate the way an animal (such as human) brain structure works. This makes it self-programming. The "Megacomputer" described in ***Space*** and ***Ultra-Tech*** is a TL9 macroframe with the neural-net option. A neural-net's main advantage is its ability to learn programs on its own, gaining skills in much the same way as a human with Eidetic Memory 2.

By itself, the neural-net option gives an effective IQ of Complexity + 4 for learning purposes, but no DX; the computer cannot learn DX-based skills. Combined with a robot brain, this option makes the computer semi-sentient, with limited self-initiative; however, it has no interest in anything beyond following its user's orders – it is not "self-aware." Treat this like a normal robot brain, but one that can *learn.* It has its usual DX, but its effective IQ is Complexity + 4.

Robot Brain (Late TL7): The computer has a brain optimized to control the vehicle as a robot. This option gives it a built-in operating system that allows it to move, control its limbs (if any), run built-in equipment, process information from its sensors, and understand orders to the limit of its IQ. The vehicle has an effective DX of (Complexity/2) + 8 and IQ of Complexity + 3. It is programmed to obey its owner and will follow commands literally. The disadvantage of this option is that it *halves* the number of programs a robot can run (one program of its own Complexity, ten of one Complexity level lower, etc.). For full details of robot brains, see pp. R57-65.

Sentient (TL10): Any computer with a Complexity of 6 or higher (after options) can be built to be sentient. A sentient computer is a fully self-aware "Artificial Intelligence," or "AI," with the same capabilities as a neural-net but with an IQ equal to Complexity + 5. The robot brain option is still required to give the computer a DX and enable it to learn DX-based skills.

Select the computer from the table below (small to macroframe), decide which options it has, and work out and record its statistics:

Computer Table

Type of Computer	*Wt.*	*Vol.*	*Cost*	*Pow.*	*Complexity*
Macroframe	4000	80	2 million	10	TL-2
Mainframe	500	10	$200,000	1	TL-3
Microframe	200	4	$40,000	0.1	TL-4
Minicomputer	40	0.8	$15,000	neg.	TL-5
Small computer	2	0.04	$1,000	neg.	TL-6
TL Modifier					
Built at late TL5	×5	×5	×2	×20	-2**
Built at TL6	×2	×2	×1.5	×10	-2**
Built at TL7 or TL8	×1	×1	×1	×1	–
Built at TL9	×1/2	×1/2	×1/2	×1	–
Built at TL10+	×1/4	×1/4	×1/4	×1	–
Options					
Compact	×1/2	×1/2	×2	×1	–
Dedicated	×1/2	×1/2	×1/5	×1	–
Dumb	×1	×1	×1/5*	×1	-1
Genius	×1	×1	×7*	×1	+1
Hardened	×3	×3	×5	×1	–
High-Capacity	×1	×1	×1.5	×1	–
Neural-Net	×1	×1	×2	×1	–
Robot Brain	×1	×1	×1	×1	–
Sentient	×1	×1	×3	×1	–

Weight: This is the weight of the computer. If the computer has multiple modifiers or options that affect weight, then all multipliers that affect weight are applied in succession.

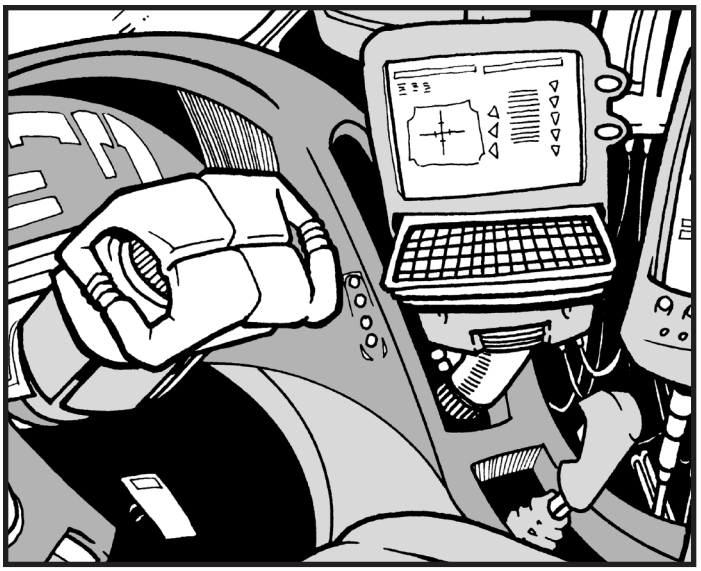
Volume: Just as with weight, if a computer has TL modifiers or options that affect volume, multiply volume by each modifier in turn.

Cost: Just as with weight, if a computer has TL modifiers or options that affect cost, multiply the cost by each in turn.

* For small computers, "genius" multiplies cost by 20 instead of 7, and "dumb" multiplies cost by 1/20 instead of 1/5. For mainframe and macroframe computers, "genius" multiplies cost by 20 as well; "dumb" versions still cost only 1/5 as much.

Complexity: The computer's Complexity is based on its type and TL, modified by the options chosen. For example, a TL10 minicomputer with genius option has TL10 - 5 + 1 = Complexity 6.

** Penalty does not apply if computer has "dedicated" option.



EXAMPLE

Morgan installs a TL7 minicomputer (40 lbs., 0.8 cf, $15,000, Complexity 2, neg. power) and modifies it with the genius option (increases cost to $105,000 and Complexity to 3). She puts it in the body.

Terminals

All computers but dedicated ones require at least one terminal if they are to be used by humans. Each terminal allows one person to use the computer. Note that terminals do *not* come with computers. Unless the computer is intended strictly for an unmanned vehicle or battlesuit, or as a backup, it should have at least one terminal!

A single terminal *can* be connected to multiple computers, giving a single user access to them all; however, the user is still restricted to working with one computer at a time, and it takes one second to switch a terminal between computers.

Adding a terminal to a computer does not increase its capacity in any way. If multiple users try to exceed its capacity (e.g., by running more programs of a given complexity than the computer can handle), then they will simply be unable to do so.

Terminals are assumed to have a keyboard and monitor; at high TLs, they may use holographics. TL8+ terminals for Complexity 3 or higher computers come with a sound synthesizer, enabling them to convey information through speech, play music, etc.

Terminal Table

TL	*Weight*	*Vol.*	*Cost*	*Power*
5-6	100	5	$2,000	0.1
7-8	40	2	$1,000	neg.
9	20	1	$500	neg.
10+	10	0.5	$250	neg.

Weight, volume, cost and power are for typical vehicle terminals suitable for use in control stations. Personal terminals (e.g., on laptops) may be cheaper, smaller and lighter.

See *neural interface* (p. 64) for a high-tech alternative to terminals.

EXAMPLE

She adds two TL7 terminals in the body for a total of 80 lbs., 4 cf and $2,000.

Software

Software is computer programs. The cost listed is for an original copy of the program with documentation. Programs are rated for Complexity, as described under *Computers* (p. 60); a computer can only run a program of Complexity less than or equal to its own.

Some programs, such as Gunner or Targeting, provide bonuses to operator skill, or have built-in skill levels. More expensive and sophisticated versions of these programs may be purchased: for every +1 skill over and above this, double the cost and *increase the program's Complexity by one.* (This is a expansion of the Expert System rules in ***Ultra-Tech*** and ***Space,*** replacing the previous rules for automatic skill bonuses at increasing TLs.) This does not apply to *skill programs* for robot brains, which provide character points toward a skill rather than a level or bonus.

Note that bonuses to the same skill from multiple programs are not cumulative.

Software doesn't have to be determined when the vehicle is designed – programs can be installed later. The exception is for dedicated computers, which must have one piece of software built into them.

We'll add the Kitty Hawk's software later. Morgan will probably write her own or pirate it anyway . . .

EXAMPLE

Types of Software

Fire Direction (TL6): This is used to calculate trajectories for indirect fire weapons, enabling more accurate aiming of artillery barrages or naval gunfire. A Complexity 1 system adds +2 to the attack chance in indirect fire.

Database (TL7): Holds basic information. Normal cost is about $1,000 per gigabyte for sensitive or technical information. Database access is considered a Complexity 1 task. Some useful vehicular databases:

Lengthy novel . . . . . .0.01 gig
Complete national road atlas . . . . . .0.1 gig
Navigation charts of entire ocean or country . . . . . .1 gig
Detailed global navigation charts . . . . . .100 gig
Vehicle recognition manual . . . . . .1 gig*
Plans of 100 simple or ten complex vehicles . . . . . .1 gig
Hydrophonic database for passive sonar (p. 52) . . . . . .10 gig
Public or school library . . . . . .100 gig
City or community college library . . . . . .1,000 gig
Big city or university library . . . . . .10,000 gig
Large university or copyright library . . . . . .100,000 gig
Everything ever printed . . . . . .100,000,000 gig (?)

* Allows sensors to recognize "known" vehicles; buy separate ones for ground vehicles, aircraft, spacecraft and watercraft.





Cartography (TL7): This is a mapping package that enables a radar- or planetary-survey-array-equipped aircraft to map areas it flies over. It also allows spaceships or satellites to produce entire planetary maps if orbiting within sensor range, provided they make enough orbits. (Making such a map of the Earth would require about 600 hours at TL7, or only a few hours by late TL8.) To really capture detail, or look for features that are not obvious, the vehicle will need a planetary survey array (p. 55) rather than a simple radar.

Computer Navigation (TL7): This software allows a computer to determine its position by comparing input from a high-resolution sensor with a map database of the region. It requires a LLTV, radar, ladar, AESA, thermograph or PESA (if underwater, a ladar or active sonar) and an accurate map database of the local terrain. Combined with a robot brain, this allows the vehicle to pilot itself to a specified location on the map automatically. Some cruise missiles do this at late TL7!

Datalink (TL7): This enables a computer link to be established by communicator with another electronic device, such as a radar or computer, displaying its data on its screen, using its information for targeting purposes, and so on. Datalink is very useful for military vehicles, since it allows several computers on different vehicles to share sensor, targeting and navigation information. Furthermore, text communications are less likely to be misunderstood in the confusion of battle.

Targeting (TL7): This is a computer program that performs ballistic calculations to correct a weapon's aim, accounts for variables such as wind, movement, elevation, ammunition type, wear-and-tear on the barrel, and so on. A Complexity 1 targeting program gives a +2 bonus. Each weapon or set of linked weapons to be assisted requires a separate copy of the program. This bonus can be added to the skill of a robot skill program, but is not cumulative with a Gunner program.

Transmission Profiling (TL7): This program takes input from a communications receiver, radar detector, or multiscanner in radscanner mode and compares it with a database in an effort to tell you what sort of equipment produced the signal. This can be fairly detailed – e.g., "It is a Hunter Industries 500 kW Air Search Radar, one from a lot with model numbers beginning with XJ2K4, and it isn't using the frequency-shift pattern used by the Federation Marines, which means it is probably one of the four sold to the Chulan Space Guard . . ." Of course, information is critically dependent on the database!

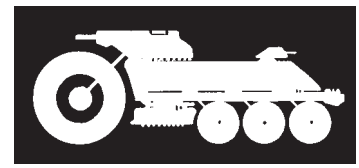
Gunner (late TL7): This is a sophisticated, intelligent target-engagement program, designed to operate autonomously. It lets the computer program act as a gunner with a skill of 12, and reduces SS as if it were equipped with a HUD of its TL. If a human gunner or robot brain skill program (see below) has a higher skill, it gives a +2 to hit. A single Gunner program can control one weapon or set of linked weapons. To use a Gunner program, the vehicle must have radar, ladar, active sonar, LLTV, infrared or PESA. The program's skill and bonuses replace those of the prerequisite Targeting program – they are not cumulative with it. Vehicles with robot brains can fire without Gunner programs, but if a Gunner program is running, a robot brain can control one additional weapon or set of linked weapons, enabling it to make multiple attacks. CIWS and point-defense systems are often controlled by Gunner programs. This allows rapid reaction times, but only limited judgement about valid targets.

Damage Control (TL8): This software must be used with a database for the vehicle (which should be updated whenever the craft is refitted). Any attempt at damage control repairs is made at +2 if this program is running and in communication with the crew or damage control robots.

Personality Simulation (TL8): This program enables the vehicle computer to simulate emotions, quirks, etc., and use highly idiomatic speech. The "limited" version gives the computer a simple personality (up to five quirks and a single mental disadvantage are appropriate). The "full" version gives the computer a simulation of a real or made-up personality with same behavior (and quirks and mental disadvantages) as the personage it simulates.

Robot Skill Programs (TL8): These can only be run by computers with the robot brain, neural-net or sentient options. Each skill program grants the computer a number of character points in a specific skill. In theory, any skill can be bought as a skill program, but to properly use many of them will require the vehicle to have limbs or built-in equipment, and tasks that require true creativity or empathy (GM's option) are impossible unless the computer is sentient. Note that neural-nets and sentient computers can only learn IQ-based skills. Use the table on p. B44 to determine the skill level. The more points the program grants, the higher the Complexity:

Points	*Complexity*
0.5	1
1	2
2	3
3-4	4
5-8	5



Each 8 extra skill points (or fraction thereof) increases Complexity by +1. Mental skill programs cost $2,000 per character point, while physical skills cost $4,000 per point. For programs granting more than eight character points to a skill, multiply cost by 2.5; for more than 20 points, multiply by 5. At TL9, halve the cost; at TL10+, quarter the cost.

Skill points placed in mental skills count quadruple; regardless of skill points, no robot skill program's skill level can exceed that of the programmer (as set by the GM). Multiply character points *after* calculating the Complexity and cost of the program.

Routine Vehicle Operation (TL8): This program enables the computer to control the vehicle. It has skill 12 in a single vehicle operation skill such as Driving or Piloting. This does not cover combat operations – the vehicle will steer around obstacles but not perform dangerous maneuvers, "push the edge" or Dodge.

Computer Programs Table

TL	*Type of Program*	*Cost*	*Complexity*
7	Cartography	$5,000	3
7	Computer Navigation	$500	2
8	Damage Control	$2,000	2
7	Datalink	$400	1
6	Fire Direction	$2,000	1
7	Gunner	$45,000	4
	Personality Simulation:		
8	*limited*	$8,000	4
8	*full*	$20,000	5
8	Robot Skill Programs	varies	varies
	Routine Vehicle Operation:		
8	*for Piloting skills*	$8,000	2
8	*for other skills*	$3,000	2
7	Targeting	$1,000	1
7	Transmission Profiling	$8,000	3

The cost of all TL6-8 programs is halved at TL9 and halved again at TL10+. Each increase of +1 to Complexity doubles cost.



Neural Interface Systems

A neural interface system allows a crew member to control the vehicle mentally, as if it were part of his body. A neural-interface system can only be added to a vehicle that already has computerized controls. It allows the user to connect with any of the vehicle's computers as if using a terminal, but without actually needing a terminal. The user can then maneuver the vehicle and control any of its weapons or electronic systems that are not being operated by other interface or computer terminal users.

In addition, neural interface gives a +4 to the user's skill with vehicle operation (Piloting, Driving, etc.) skills, as well as all vehicle-mounted weapons (except those in open mounts), sensors and other electronic equipment.

Cinematic Option: A neural interface with a vehicle that is "species compatible" gives the driver, pilot or helmsman a further +1 bonus to the vehicle operation skill. Species-compatible vehicles are those that closely resemble the user's own form, regardless of their size. For a human, this means a vehicle with two arms and two legs (a turret to act as a head is optional).

Neural interface systems are rated for the number of users they can handle. In theory, a single person with neural interface can run everything in a vehicle, but in practice, a large vehicle with many systems usually has several interfaces.

Surgical Neural Interface (TL8): The user's nervous system is surgically linked to the vehicle controls. He can't come out! "Installing" each user takes major surgery, which requires a week of recovery. Cost and time to detach the user from the vehicle are half that required to install him.

Interface Web (TL9): To use an interface web, the user must climb into a special "tank," remove his clothing, attach interface wires with electrode disks to all areas of his body and don a special crown or helmet; this takes 15 seconds. His body is then "put to sleep" and his brain and nervous system are synchronized with the vehicle; this takes another three seconds. He is then ready to control the vehicle. To leave the web takes the same amount of time: three seconds to shut down the interface and for the user's body to "awaken," and 15 seconds to remove the connections (they can be ripped out, damaging the machine, in only five seconds).

Auto-Interface Web (TL9): As above, but automated: the user strips and crawls into the web, and then the cybernetic cables whip about the user like snakes, automatically attaching themselves. This takes only three seconds. As a result, the user can be ready to control the vehicle only 6 seconds after entering it. The detachment procedure is similarly swift.

Socket Interface (TL10): The vehicle comes with an interface jack with a fiber-optic cable built into the control panel (or replacing manual controls, if desired). The user takes two seconds to plug the cable jack into either a neural interface helmet he is wearing, or a neural interface implant socket that is surgically implanted into his body. In theory, only one jack is needed to control the vehicle and all its equipment. A socket interface costs only $500 for the vehicle, but the cost to fit a person with an implant jack is $6,000; a neural interface helmet is $10,000 and weighs 3 lbs. This weight and the cost of the implant jack or helmet is for the user, and should not be included in the vehicle's statistics.

Neural Induction Field (TL10): An expensive system in which the control seat is within a powerful induction field. The user simply sits down, flips a switch, and he's interfaced as above. No surgery, implants or control wires are needed.

Neural Interface Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
8	Surgical Interface	20	0.4	$10,000	neg.
9	Interface Web	25	0.5	$20,000	neg.
9	Auto-Interface Web	50	1	$40,000	neg.
10	Socket Interface	0	0	$500	neg.
10	Induction Field	25	0.5	$50,000	neg.

All figures are per user. At the GM's option, some or all of these systems may appear at TL8 in a "cyberpunk" campaign. Halve cost one TL after the system appears, and quarter it two or more TLs after it appears.

Psionic Technology

Psionic technology uses electronics or biotechnology to augment the powers of the mind – or protect against them.

Psionic shielding for vehicles is covered on p. 92, and is normally added later in the design process, after armor is installed. Numerous other forms of psi-tech device exist, but for reasons of space, designers are referred to ***GURPS Psionics.*** Here's how to convert devices described in ***Psionics*** into statistics usable in ***GURPS Vehicles:***

Weight and Cost: As listed. One ton = 2,000 lbs.

Volume: Use weight/50 cf for most systems, weight/100 for PK batteries. If a volume in cy is listed, multiply by 27 to get the volume in cf.

Power: Most power drains can be considered negligible, with the following exceptions: thanatos field (400 kW), web central processor or jump beacon (100 kW), mind probe (0.9 kW), sensory deprivation tank (0.3 kW) and amplifier throne (0.1 kW).

Energy Storage: A PK battery E cell stores (TL-6) × 180,000 kWs. Divide this by 10 for D cells, by 100 for C cells, and so on.

Two devices require special notes:

Psiberplas (p. P69) can be used as a vehicle armor. Treat it as TL10 nonrigid armor, but at double the cost. A vehicle occupant can "tweak" the psiberplas to alter its color or texture as described on p. P69.

Telepathic switches (p. P61) can be fitted to a vehicle with computerized controls (p. 73). They cost $10,000 per computer terminal, or ten times that for a "secure" system.

MISCELLANEOUS EQUIPMENT 5

This chapter describes other equipment that can be installed in or on vehicles.

Robot Arms and Arm Motors

Vehicles need one arm motor for every arm subassembly they have. A normal arm motor is designed to control a jointed arm ending in a manipulator equivalent to a human hand. The arm will be able to do everything that a human arm and hand of the same strength can do. Each arm motor is rated for strength (ST). A vehicle with more than one arm may have arms of different ST. An arm motor can also have a variety of options which will affect the capabilities of the arm it is installed in.

Bad Grip: The arm lacks the dexterity of a normal arm – instead of an actual hand, it has a simple gripper. This makes the arm motor much cheaper, since it doesn't need fine motor control. The vehicle operator will be -4 to DX (or -4 on skill) when using the arm for any task requiring fine manipulation. This penalty does not apply to tasks involving gadgets or weapons built into the arm itself!

Poor Coordination: The arm has an innate lack of coordination – perhaps it is a simple hydraulic arm, for instance. It is used at -4 to DX (including DX-based skills).

Cheap: An arm can be built using less-advanced technology. This makes it heavier and more bulky, but less costly.

Extendable: This allows the arm to double its length, either by actually telescoping out, or by actually stretching – perhaps using a thin, optical cable.

Striker: If the arm motor is given this option, its arm will not incorporate a hand or equivalent manipulator. This makes the arm motor cheaper and lighter. The arm can still push or strike blows (hence its name) but has no manipulatory ability. Weapons and tools built into the arm can still be used, however.

Realistically, all arms built at TL7 should have one of these options: bad grip, striker, or poor coordination.

For each individual arm the vehicle has, pick any options, then design its arm motor by choosing that arm's ST and working out the arm motor's statistics as shown on the table below:

Arm Motor Table

TL of Arm	*Weight*	*Volume*	*Cost*
7	0.3	0.006	$600
8	0.2	0.004	$400
9	0.15	0.003	$300
10	0.1	0.002	$200
11	0.075	0.0015	$150
12+	0.05	0.001	$100
Modifiers			
Bad Grip	×1	×1	×0.5
Cheap	×2	×2	×0.5
Extendable	×2	×2	×2
Poor Coordination	×1	×1	×0.5
Striker	×0.5	×0.5	×0.2

Weight, Volume and Cost: This is per point of ST. Calculate them individually for each arm the vehicle has.

Power Requirement: Each arm requires ST/200 kW of power.

Location: Must be housed in arms.

Fire Extinguishers

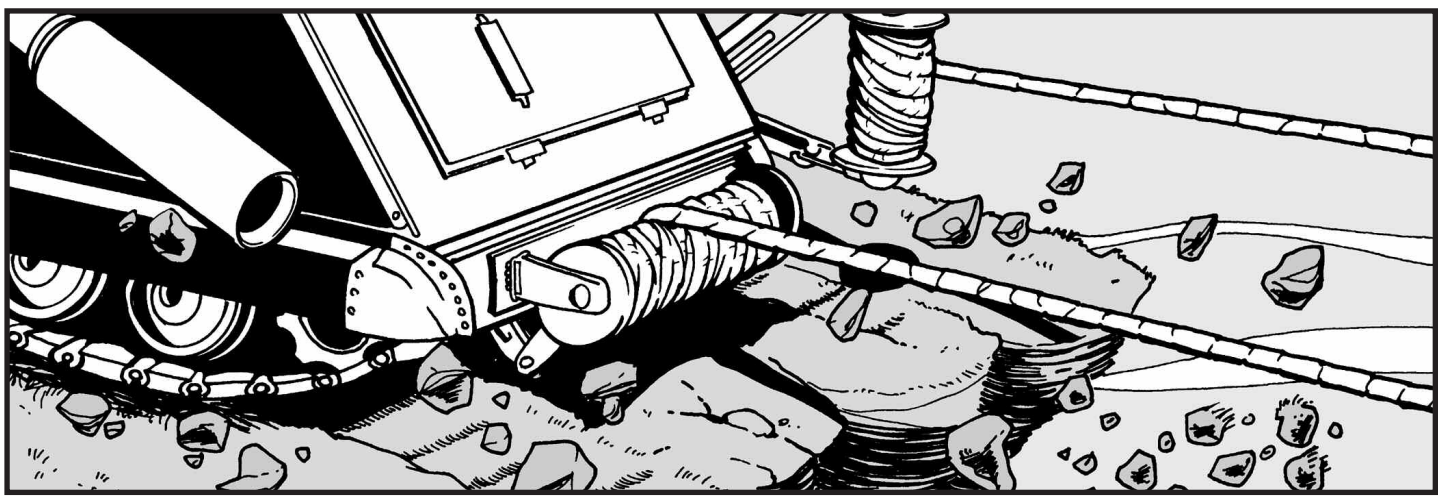
Many vehicles carry extinguishers to help put out fires. The effects of fire extinguishers are described in the rules for *Fire and Explosion,* p. 184. Fires can also be put out manually, using buckets, hand-held extinguishers, and so on.

Fire Extinguisher System (TL6): An array of extinguishers or hoses mounted inside the vehicle. 150 lbs., 3 cf, $300. At TL8+, it is automatic.

Full Fire Suppression System (TL7): An improved, fully-automatic version of the above, using inert gases to put out fires in milliseconds. 200 lbs., 4 cf, $5,000.

Compact Fire Suppression System (TL7): This performs nearly as well as a full fire suppression system, but is smaller and cheaper. It is 50 lbs., 1 cf, $500.

Weight, volume and cost remain constant at higher TLs, although effectiveness increases. A single extinguisher array will do for most vehicles, but very large craft may have many such systems.



Location: Fire extinguishers are housed in the body. The system is assumed to have outlets in various parts of the vehicle.

EXAMPLE

The Kitty Hawk has a compact fire suppression system: (body, 50 lbs., 1 cf, $500).

Bilge Pumps

Watercraft often spring leaks, and should be given one or more sets of pumps to remove the water that comes through them. Pumps are 200 lbs., 10 cf and $500 each, and can remove 10 lbs. × TL of water every minute. Those of TL6 or less must be worked by one crewman each; TL7+ bilge pumps consume 1 kW of power each while operating.

Large water vehicles (over 100 cf) can be assumed to have bilge pumps automatically – one per 1,000 cf or fraction of vehicle size. There is no weight, volume or cost for this (although TL7+ pumps still require 1 kW/pump). Thus, bilge pumps need only be purchased for vehicles the designer believes will be relatively small – and even then, they are optional.

Location: Bilge pumps are housed in the body.

EXAMPLE

We expect the Kitty Hawk will have one bilge pump – no weight, volume or cost, but it will require 1 kW.

Labs and Workshops

Large vehicles can have laboratories or workshops built into them.

Workshop (TL5): This is an elaborate portable repair shop for Mechanic, Engineering, Electronics, or Armoury skill. Each type must be installed separately, or a "complete workshop" encompassing all types may be installed at some overall saving in weight and cost. A workshop has many tools and a wide range of generic "spares" that can be tooled to specific requirements. Up to three people can work in a workshop at once, or one person in a mini-workshop. Large vehicles (e.g., ships) may have several workshops. Using a workshop to make repairs or modifications adds +2 to user's skill. Using the wrong type of shop is better than nothing, allowing work at a -1 penalty (-2 for a mini-workshop) instead of +2 bonus. Workshops do not improve at higher TLs, but a workshop from the same or higher TL as the device that is being worked on is required: using a workshop of one TL lower is possible, but at -3 instead of +2.

Science Lab (TL5): This is an equipment-filled laboratory built into the vehicle; a lab is designed for a specific Scientific Skill (see pp. B59-62). A science lab gives a +2 skill bonus in situations where using lab equipment would be a benefit, provided (GM's option) the lab's TL is up to handling the task at hand. The GM can also rule that a lab is a prerequisite: the lab gives no bonus, but work is impossible without it. Each lab can only work on one task at a time.

Labs and Workshops Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
5	Early Science Lab	20,000	1,000	$20,000	1*
6	Science Lab	20,000	1,000	$200,000	1*
7+	Science Lab	20,000	1,000	$1,000,000	3*
5+	Workshop	10,000	400	$19,000	1
5+	Complete Workshop	30,000	1,200	$60,000	1
5+	Mini-Workshop	3,000†	135†	$4,000†	0.5
5+	Complete Mini-Workshop	10,500	513	$19,000	0.5

* Multiply power requirement by 100 for a physics lab.

† For electronics shops, cost is ×1.75, weight is ×0.5 and volume is ×0.8.

Location: May be housed in the body, superstructure, turrets or pods.

Heavy Equipment

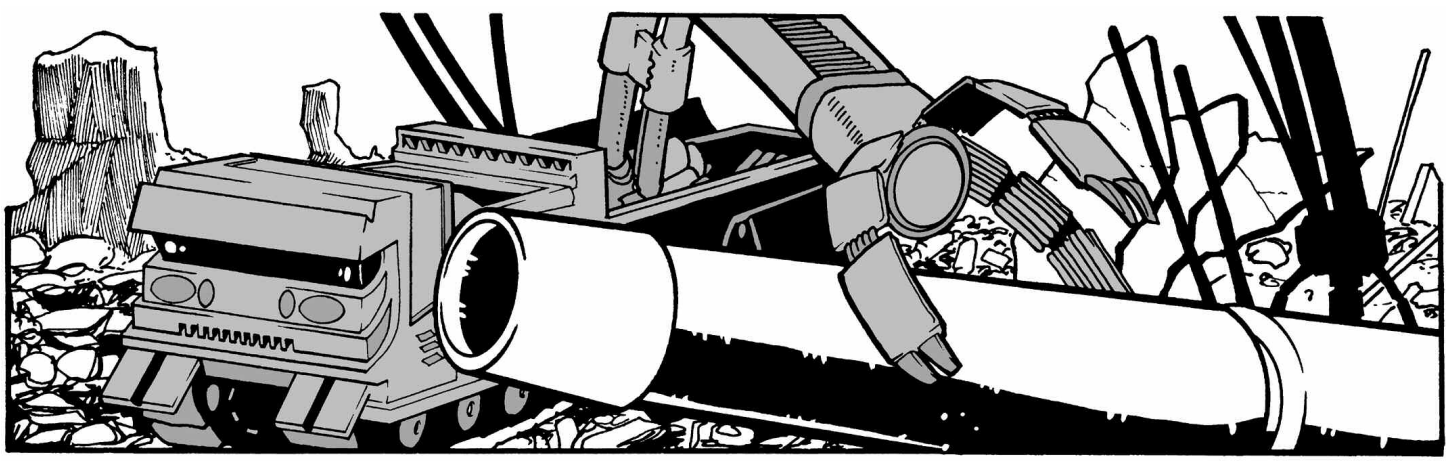
This section describes equipment used for "heavy" tasks such as construction, combat engineering, and loading or launching vehicles.

Extendable Ladder (TL5): This is a ladder of the sort used by fire-fighting vehicles; other vehicles may also carry them, of course.

Crane (TL5): Cranes are used to elevate and move heavy loads. A small crane is often used on tow trucks, and can substitute for a tow hook when hauling trailers or other vehicles. A big crane on a high superstructure is often used in construction. Using the crane requires one person to operate it (this may be the vehicle's driver, if he isn't driving the vehicle at the time) and is a long action; roll vs. Professional Skill (Crane Operation) to perform delicate tasks, grab people, etc. Aside from their obvious uses in construction, cranes are often mounted on ships to hoist small boats or seaplanes onto deck.

A crane may be equipped with a hook or a bucket. At TL6+, it can be equipped with an electromagnet instead, which doubles the power requirement to 2 kW per ton of lifting capacity.

Winch (TL5): This is a revolving-drum towing device with attached harness or hook, normally installed next to a door or over a floor hatch. A built-in motor draws the cable back to the reel, allowing the vehicle to pull something that weighs less than it toward it, or allowing the vehicle to pull itself toward the object, if the object is immobile or heavier than



the vehicle. Winches are rated for their lifting capacity in pounds. Winch speed is four yards per turn (half-speed if pulling more than half its maximum weight). If towing something horizontally across a smooth, level surface, halve the effective weight, or divide effective weight by 20 if the object has wheels (e.g., if towing a car or trailer). Multiple winches may also be used to lift very heavy objects.

Power Shovel (TL6): A powered scoop or shovel designed for digging and moving earth. It can dig and move earth like a man with a shovel and pick with its rated ST (see pp. B90-91). Digging requires the attention of the operator (usually the driver). He cannot fire weapons or maneuver while operating the shovel.

Wrecking Crane (TL6): This is a crane with a wrecking ball instead of a hook. This prevents it from lifting things but allows it to do 6d cr. damage per ton an ordinary crane of the same size can lift. Roll vs. Professional Skill (Crane Operation)-3 to hit, as a combat action. One attack may be made every three turns.

Forklift (TL6): A pair of hydraulic lifting blades for lifting and moving objects, mounted on the front of the vehicle. A forklift is rated for the weight it can lift. In a frontal ram or collision with a forklift-equipped vehicle with lowered blades, the forklift inflicts +1d damage. The blades have DR 10 and 20 hit points, and will absorb this damage before it is applied to the vehicle.

Vehicular Bridge (TL6): This is a folding bridge with hydraulic emplacing equipment to allow it to be rapidly installed over a river, gorge or stream. It is rated for its length in yards. The bridge itself has DR 10 and 100 hit points, with a breach capacity (see *Damaging Buildings* on p. 166) of 3 per yard of length. The bridge can support up to 10,000 lbs. To support more, multiply the weight and cost by desired load/10,000 lbs. Emplacing it is a long action that requires 1 minute per yard of bridge length, and is done by hydraulics from inside the vehicle. The GM may require a Driving (Construction Equipment) roll to do so successfully; failure wastes time and requires another try; critical failure dumps the bridge into the river or gorge.

Launch Catapult (TL6): A launch catapult can be installed in the body of any vehicle that is intended to launch aircraft (such as an aircraft carrier). A catapult may be hydraulic (TL6), steam (TL7) or electromagnetic (TL8+). It adds (500 mph/s/loaded mass of aircraft in tons) to acceleration for the first second of aircraft takeoff at TL6, (1000 mph/s/loaded mass) at TL7, or (1,500 mph/s/loaded mass) at TL8+, with an upper limit of 20 mph/s × (TL-5) added to acceleration, regardless of craft weight.

Skyhook (TL7): A skyhook is an extraction system designed to enable a moving airplane to pick up someone or something on the ground that has been equipped with a properly-rigged *skyhook harness* (see p. 204). It is a V-shaped "hook" attached to the nose of a flying vehicle, along with winching equipment and modified doors. The vehicle must also have the cargo ramp (p. 69) accessory, facing the rear.

The procedure is as follows:

The pilot looks for a balloon, which is tethered by a long cable to the harness-equipped cargo. He then maneuvers to snag the cable with the skyhook. To do so, he must fly no higher than 300 yards above the ground and should slow to about 80 mph (if his aircraft can go that slowly without stalling). Success takes a Piloting roll (the GM may modify this for bad weather, poor visibility or the like). A failed roll means he misses the cable, and must circle around for a second try – the time this takes depends on the aircraft's turning capabilities and speed. A critical failure hits the cable or balloon with a wing, destroying it, knocking down the man on the ground, and preventing extraction. Success means the balloon and cable have been snagged. The harnessed person is jerked off his feet and into the air, and the catcher's winch begins to reel him in (this usually takes about 30 seconds). If the aircraft was moving too fast, the sudden jerk may be dangerous. The subject takes 1d-2 damage at 80-99 mph, 2d-4 at 100-119 mph, and so on.

Bore (TL7): A bore is a powerful tunneling system that enables a vehicle to burrow through the ground. A bore may be attached to any vehicle designed for ground movement. A bore is rated for the cubic feet per hour of hard rock through which it can tunnel. The vehicle's subterranean speed in yards per *hour* can be determined by dividing the bore's tunneling speed by the vehicle's (surface area/10). It can bore through soft rock at double speed, through clay at triple speed, or ordinary soil or sand at quadruple speed.

Super-Bore (TL8): This is a "cinematic" bore design that can tunnel at far faster rates, using ultra-tech gadgetry like monomolecular drills, plasma beams, and so on. A super-bore is more expensive than an ordinary bore, but its drilling capacity is measured in cf per minute rather than per hour!

Subterranean navigation can be tricky, unless using an inertial navigation system or some sort of rock-penetrating sensor. Geology rolls may be needed to avoid getting lost. Deep-drilling bore vehicles may be subject to intense heat and pressure, and should be armored and equipped with life-support systems.

Energy Drill (TL8): This is a powerful drill used by ultra-tech mining, engineering and rescue vehicles. Energy drills are bought as laser, plasma beam or disintegrator weapons, but cost only half as much. They can be used as weapons, but are -5 to Acc and +5 to SS, since they lack proper sights.

Tractor Beam (TL11): A tractor beam is a focused gravitic force beam that can pull its target toward the beam generator. Tractor beams are the cranes and extension ladders of TL11+ societies: they are used for cargo handling, construction, or rescue. A tractor beam is rated for ST, and can exert relatively gross force on objects, pulling them towards the beam generator. Strength of the beam is halved every 100 yards (double this distance every TL over 11). Operating any tractor beam requires a combat action, and uses the professional skill of Tractor Beam/TL (Physical/Easy), defaulting to Gunner (beam weapon)-2 or DX-4. Rolls should be required when delicate manipulation is called for, or when trying to grab a moving target. Treat this as a ranged attack, with a beam having SS 20, Acc 15.

A *pressor beam* (TL12+) is like a tractor beam but pushes instead of pulls. Combination beams are also available at TL12+.

Heavy Equipment Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
5+	Extendable Ladder	60	3	$100	0
5	Crane	2,000	40	$400	1
6	Crane	1,500	30	$800	1
7+	Crane	1,000	20	$4,000	1
5	Winch	150	3	$50	0.05
6	Winch	100	2	$100	0.05
7	Winch	50	1	$400	0.05
8+	Winch	25	0.5	$200	0.05
6	Power Shovel	600	1.2	$300	0.125
7+	Power Shovel	300	0.6	$1,500	0.125
6	Wrecking Crane	1,550	30	$1,000	1
7+	Wrecking Crane	1,100	20	$4,000	1
6	Forklift	300	6	$80	0.2
7+	Forklift	200	4	$400	0.2
6+	Vehicular Bridge	400	8	$800	1
6+	Launch Catapult	40,000	800	$200,000	500
7+	Skyhook	400	8	$8,000	0
7	Bore	200	8	$80	0.2
8	Bore	100	4	$80	0.2
9	Bore	50	2	$40	0.2
10+	Bore	25	1	$20	0.2
8+	Super-Bore	×2	×2	×10	×10
8+	Energy Drill	†	†	†	†
11+	Tractor Beam	2,000*	40*	$5,000*	*
12+	Pressor Beam	2,000*	40*	$5,000*	*
12+	Combination Beam	2,000*	50*	$8,000*	*

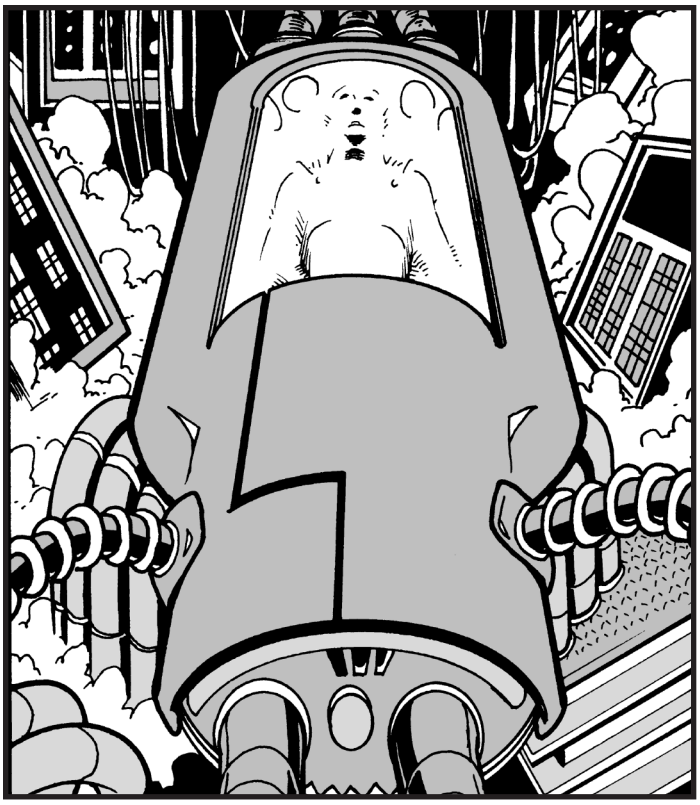
Weight, Volume, Cost and *Power:*

For *extendable ladders, cranes* and *wrecking cranes,* this is per 6 feet of height. Lifting capacity of a crane is one ton per 6 feet of height; damage done by a wrecking crane is 6d per 6 feet of height. Double the power requirement for a crane equipped with an electromagnet.

For *power shovels, winches* and *forklifts,* this is per ST 10 (200 lbs). of digging, hauling or lifting capacity. Cable length of a winch is *ST* yards.

For *vehicular bridges,* this is per yard of bridge length for a bridge supporting 10,000 lbs. To support heavier loads, *also* multiply by the desired weight/10,000 lbs.

For *launch catapults* and *skyhooks,* a flat figure is given.



For *bores,* this is per cubic foot (0.037 cy) per hour of tunneling ability. If a *super-bore,* multiply the weight, cost, volume and power requirement of an ordinary bore as shown.

* For *tractor, pressor* and *combination beams,* add 200 lbs., 4 cf, $200 and 100 kW for every 100 ST the beam can exert.

† *Energy drills* are built as beam weapons, but at half cost.

Location: Forklifts, launch catapults, winches, skyhook systems and bores must be housed in the body. Vehicular bridges must be housed in a superstructure. Cranes and wrecking cranes must be housed in a turret or superstructure. Power shovels may be housed in the body, turret or superstructure. Other systems on this table may be housed in the body, pod, turret, superstructure, arm, wing or leg.

Emergency and Medical Equipment

Medical equipment is used to save lives. It is commonly mounted on ambulance or hospital vehicles, and in large ships that will be at sea or in space for long periods of time. We also cover police/ambulance sirens in this section.

The types of equipment available include:

Operating Room (TL5): This consists of one or more operating tables on which one person can lie, plus associated equipment (anaesthetic pumps, wash-up, surgical tools, lights, etc.). It includes all necessary gear to perform surgery with no penalty, and gives a +2 bonus to First Aid skill. At higher TLs, it provides no additional bonus, but fulfills all equipment requirements of that tech level's Surgery and First Aid skills. It's hard to perform surgery if a vehicle is jerking about: apply the same penalties that apply to firing from a moving vehicle to Surgery rolls. If desired, "Weapon Stabilization" (p. 45) can be purchased for an operating room.

Stretcher Pallet (TL4): A stretcher-bed for one person, equipped with safety straps and suitable for use in an ambulance or medevac aircraft.

Hospital Bed (TL1): Buy hospital beds exactly like bunks or quarters (p. 76).

Emergency Support Unit (TL8): The ESU is a portable life-support system. If an injured patient is hooked up to it, the ESU maintains the patient's biological functions even if his organs are not functioning. In game terms, the ESU can keep alive someone who has failed a HT roll and "died," as long as he is not at or below -5 × HT, and has not been "dead" for more than five minutes. Attaching the ESU's life-support system takes (20-TL) seconds and requires the technician to make a Physician roll (at -1 for every multiple of negative HT the patient is at below 0 HT, and a -2 per failed attempt). Success means the person is in a coma rather than dead, but will die if taken off life support; critical failure means the patient is dead. Revival from the coma is possible if the patient is ever healed back to above fully-negative HT. The ESU can also perform less critical tasks, such as blood transfusions (it includes enough generic blood substitute for two whole-blood transfusions) and revival of persons in suspended animation.

Emergency Lights and Siren (TL6): This is a siren and flashing light, as used by police cars, ambulances, fire engines, etc. It is useful for clearing the road (when operating, it adds +4 to Vision rolls and +8 to Hearing rolls to detect the vehicle). Turning the lights and siren on or off is a combat action. The siren and lights are assumed to be mounted on top of the vehicle, and take up no space inside it.

Cryonic ("Freeze") Capsule (TL9): Holds one person in suspended animation, during which time he will neither age nor decay, and requires no life support. Suspended animation is more fully described on p. S66. Cryonic capsules have a back-up E cell which powers them for six months if vehicle power is lost.

Automed (TL9): An automed is a robotic diagnosis and repair bed for one person. It is described fully on pp. S70 and UT94. An automed can also function as an ESU (see above).

Diagnosis Table (TL9): A computerized table with a full range of biological and medical scanners, the readings from which are projected on an overhead screen. Adds +5 to Diagnosis skill at TL9, +6 at TL10+. Used as a cheaper alternative to automeds.

Emergency and Medical Equipment Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
5-6	Operating Room	500*	200*	$10,000*	0.5*
7+	Operating Room	250*	200*	$50,000*	0.5*
4	Stretcher Pallet	50	40	$100	0
8	Emergency Support Unit	100	5	$30,000	0.1
9	Emergency Support Unit	100	5	$15,000	0.1
10+	Emergency Support Unit	100	5	$7,500	0.1
6+	Emergency Lights and Siren	0	0	$50	neg.
9	Cryonic (Freeze) Capsule	1,000	50	$55,000	0.2
9	Automed	600	100	$50,000	0.1
10	Automed	500	75	$50,000	0.1
11+	Automed	400	50	$50,000	0.1
9+	Diagnosis Table	250	80	$12,000	neg.

* Per operating table.

Location: May be housed in the body, turrets, superstructures or pods.

Entertainment Facilities

These are normally seen on large passenger vessels like ocean liners, river boats, airships and airliners.

Stage (TL1): This is a stage area usable for dancing, plays, nightclub acts and so on. At TL6 and up, it includes increasingly sophisticated electric lights and sound systems.

Hall, Bar or Conference Room (TL1): A large room with tables. Usable as a restaurant, bar, conference room, etc. It can comfortably accommodate ten people per 100 square feet. Weight and cost include furnishings.

Swimming Pool (TL1): Large commercial ships often have swimming pools. Build a swimming pool like a hall (above) and then design the pool by adding a water tank (see *Fuel Tanks* on p. 88) of equivalent volume (about 6 gallons per cf of hall volume).

Movie Screen and Projector (TL6): This is a screen for displaying motion pictures plus a projector. Such systems are common on TL7 passenger ships and aircraft. By adding several passenger seats (p. 76) and

a crew station (p. 73) for a projectionist, a separate movie theater can be created. Alternatively, the screen can be mounted where passenger seats can see it, in which case only the space for the screen and projector are required. The "small screen" is about the size of typical airliner movie screens; the "big screen" is a theater-sized screen, likely to be found only in ocean liners or large passenger spacecraft.

Holoventure Zone (TL9): This is an entertainment area which uses sophisticated holographic projectors to create special effects, including cloaking actors (sometimes robots) and props in different, seemingly-realistic guises. Besides playing games, a holoventure zone may be used for more serious affairs, such as mission rehearsals. The zone requires a Complexity 7+ computer and holoventure program (cost $10,000+) to run. Scenarios can be supervised by the computer operator or wholly computer-generated. TL13+ holoventure computer systems may be able to "create" seemingly-real objects by using gravitic force fields and/or tractor/pressor beams and clothing them with holograms.

Neural Interface Entertainment (TL varies): A vehicle equipped with a neural interface (see p. 64) and a Complexity 5+ computer (p. 60) can run "dream game" entertainment programs. These are more fully described in ***GURPS Ultra-Tech,*** but offer the ultimate virtual reality experience. The more sophisticated programs cost about $4,000; a commercial vessel may provide the service free to crew and paying passengers, or charge for it, typically at $2 per minute. Luxury craft at high TLs may have lounges or cabins equipped with neural induction helmets or fields for those passengers who don't have their own interface implants.

Entertainment Facilities Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
5-	Stage	250*	1,000*	$100*	0
6+	Stage	250*	1,000*	$1,000*	0.1*
	Movie Screen and Projector:				
6+	with small screen	100	100	$1,000	0.5
6+	with big screen	200	1,000	$5,000	0.5
5-	Hall or Conference Room	80*	1,000*	$50*	0
6+	Hall or Conference Room	80*	1,000*	$500*	0.1*
9+	Holoventure Zone	600*	1,200*	$100,000*	1*
var.	Neural Interface Entertainment	var.	var.	var.	neg.

* Per 100 square feet of stage, pool or hall area. Price of a holoventure zone is halved at TL10 and again at TL11+.

Location: May be housed in the body, turrets, superstructures or pods.

Vehicle Access

These are means of getting into or out of a vehicle.

Doors and Hatches (TL1): Ordinary doors and hatches are free.

Cargo Ramp (TL1): A vehicle with 50 cf or more of cargo space (or 6+ passengers) may also have a large back or front drop ramp at no extra cost, if the designer wishes. Width of the ramp is roughly proportional to the size of the cargo bay. This leads into the cargo or passenger compartment, and allows speedy loading or unloading. Raising or lowering the ramp takes 2 seconds. When the ramp is down, any attack which is aimed at the ramp side and scores a body hit has a 50% chance (roll 1-3 on 1d) of ignoring PD and DR. If a vehicle has a lowered cargo ramp, another vehicle up to half the size of the cargo compartment may drive in or out. (Vehicles with wings or rotors must have the folding wing or folding rotor option to do this, while vehicles with sails or gasbags must furl their sails or deflate their gasbags.).

Airlock (TL6): Any vehicle with a life system or NBC kit may have airlocks, enabling entry or exit into a hostile environment without contaminating the vehicle. Airlocks on different vehicles may be built to a standard design so that vehicles can mate airlocks directly. An airlock is rated for the number of people it can hold; each person can be replaced by 10 cf of cargo. Cycling an airlock takes (16-TL) seconds × the pressure difference (in atmospheres) between the two sides.



Membrane Airlock (TL10): These are cell-like "curtain" membranes made of bioplastic that are selectively permeable to atmosphere. They work like normal airlocks but take only 2 seconds to cycle.

Forcelock (TL11): These are "doors" that use an ultra-tech deflector field to maintain a pressure differential without impeding the passage of solid objects. The field is PD 4, DR 0, and can be adjusted to cover a 3 yd. × 1 yd. portal; multiple units can be used to cover larger openings. A forcelock does not need to cycle and has no chamber – it's simply a hole sealed by a specialized force field. (If the vehicle loses power, an automatic door hatch slides shut to prevent pressure loss.)

Passage Tube (TL7): This is a flexible tube that connects the airlocks of two ships in space. It holds pressure, permitting occupants to move between the vessels without space suits. A standard tube is 100 feet long and 8 feet in diameter, and hooks to generic fittings around external airlocks. It normally takes an hour or so to rig in free fall (30 minutes with two or more people working) – this requires a Mechanic (Starships) roll. The tube has PD 3, DR 12; an "armored" tube with DR 20 is also available.

Airlock Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Pow.*
6	Airlock, per person	750	75	$500	neg.*
7+	Airlock, per person	500	50	$1,000	neg.*
10+	Membrane Airlock, per person	250	25	$2,000	neg.*
11+	Forcelock	25	2.5	$3,000	2
7+	Passage Tube	1,000	40	$1,000	0
7+	Armored Passage Tube	2,000	40	$3,000	0

* Can be released manually if power is lost, unsealing the vehicle.

Location: May be housed in the body, turrets, superstructures, pods, or (rarely) arms or legs. Should normally go where cargo, passengers or crew will be located.

Teleport Projectors (TL16)

These are two-way teleportation devices that can "beam" someone or something somewhere. Conservation of energy isn't a problem: an orbiting space ship can teleport someone up from a planet below, if it has proper coordinates. They dump the excess energy into hyperspace or otherwise deal with it.

GMs should rule on whether teleport projectors exist: they can easily unbalance a campaign by making it too easy to get people out of danger. They can also teleport bombs. Reality stabilizers – and, at the GM's option, force screens – cannot be penetrated by teleport projectors.

A standard teleport projector is a platform 1 yard across. The controls are set for specific destination coordinates within its range and it is activated. Anything standing on the projector platform is teleported to the destination – and anything occupying the destination point is teleported back to the platform. Normally, this is just air (or nothing, if teleporting into space) but part of a solid object can also be transported. If a person were teleported into solid rock, he'd be alive (but entombed and suffocating) and a block of stone would be sitting on the teleport platform. Projector rooms are sealed and include systems to quickly remove water or gasses produced by teleporting underwater or into alien atmospheres.

Range of a projector is 10,000 miles. Using it takes 10 seconds and a skill roll vs. Electronics Operation (Teleportation), with a -1 per 1,000 miles. Add +4 if teleporting to a cooperating projector platform. Failure means a near miss, critical failure means a disaster (perhaps the victim is trapped underground and then the teleporter *breaks*).

A teleport projector is 4,000 lbs., 80 cf, $5,000,000 and 10,000 kW per hex of teleportation capacity. It is TL16, but at the GM's option may be available in lower-TL campaigns.

Security and Dirty Tricks Equipment

These systems are designed to protect the vehicle from intruders or to provide defensive "dirty tricks" like spraying oil slicks.

Brigs and Restraints (TL1): Any crew or passenger seat can be equipped with manacles (and bars or wire mesh areas separating them from other compartments), while quarters can be built with barred doors and sturdy locks. This costs an extra 10% of seat or quarters cost, and is useful for brigs, prison vans, slave ships, galleys with slave rowers, etc. At TL11+, force fields can be assumed to replace conventional locks or bars (power requirement then becomes negligible).

Burglar Alarm (TL6): An electronic burglar alarm sets off a siren and locks the vehicle's ignition system if the vehicle's locks are tampered with. Breaking into a vehicle without setting off the alarm requires a Contest of Skills vs. the alarm's skill of 15, using Electronics Operation (Security System)/TL or Traps/TL, with modifiers as per Lockpicking skill, (p. B67). If the roll fails, the alarm sounds a siren or flashes the vehicle's lights. A TL7+ burglar alarm may also lock the vehicle's ignition systems and other controls, or send a signal to a pager or radio carried by the owner. Alarms may also be built to trigger booby traps or even self-destruct systems, at the designer's option – see *electrified surface* on p. 93 for one possibility.

High-Security Alarm (TL7): As above, except the alarm's skill is 20.

Intruder Defenses: Manual or computer-controlled weapons and sensors can be built inside a vehicle as well as outside. A ranged weapon inside a vehicle takes up weight/20 cf and is assumed to come with a swivelling mount to aim and fire. Field of fire is limited to a single room or corridor. See also pp. UT88-90.

Mutable License Plate (TL7): This set of license plates can change its designation at the touch of a button. At TL7 the license plate rotates, revealing a new side. At TL8+ it may use high-tech electrically-active materials to change its numbers and letters to any desired designation. Of course, at high TLs, physical license plates on road vehicles may be replaced by electronic transponders.

Oil Sprayer (TL6): This produces a 5 yd. × 2 yd. oil slick behind a vehicle. Driving into the slick requires a Driving roll at -3 (as a Hazard) to avoid losing control. The sprayer contains enough oil for 25 slicks and costs $5 to refill.

Paint Sprayer (TL7): This produces a 5 yd. × 2 yd. cloud of paint behind the vehicle that persists for 1 second before falling to the ground. Anyone firing through the paint cloud suffers the normal penalties for blind fire (although the cloud doesn't block non-visual sensors). A vehicle entering the cloud will be coated with paint. This blocks windows, causing a -2 on Vision and vehicle control rolls, and also effectively neutralizes Chameleon systems, until the paint is cleaned off. A paint sprayer has 25 shots and costs $25 to refill.

Self-Destruct (TL3): Vehicles may have built-in explosives, either as a self-destruct system or to turn the vehicle into a kamikaze weapon. For weight, volume and cost, treat the self-destruct as a bomb (p. 113) of the given TL, but with half the normal weight and cost. All types of explosive warhead are available. The cost includes fusing, which may be set for contact, operator control, timed fuse or (at TL6+) detonation upon receiving a communication signal. Explosives may even be set to detonate if the vehicle's burglar alarm (above) goes off.

Nuclear and antimatter power plants may also be set to self-destruct – see the *Nuclear Power Plant Explosions* sidebar on p. 186.

Smokescreen (TL5): This produces a 5 yd. × 2 yd. cloud of smoke. Anyone firing through the smoke suffers the normal penalties for blind fire unless using non-visual imaging or active sensors like infrared or radar. The screen remains in the air for 300 seconds/wind speed in mph (max. 300 seconds). A smokescreen has 10 shots and costs $25 to refill. A smoke screen can also spray any of the specialized smokes or gases described under *CHEM* warheads in the sidebars of Chapter 9.

Spike Dropper (TL5): This device drops caltrops – tetrahedral spikes – behind a vehicle. The caltrops fall to the ground over a 2 yd. × 2 yd. area. Any tracked, legged, or wheeled vehicle driving through the area may be damaged: roll 1d for each track, tire or leg; on a 1-4 it takes 2d damage to the motive subassembly (wheels will take damage to tires). A spike dropper has enough spikes for ten uses; refills cost $200.

Security and Dirty Tricks Equipment Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
1+	Brigs and Restraints	0	0	+10%	none
6	Burglar Alarm	neg.	neg.	$120	neg.
7+	Burglar Alarm	neg.	neg.	$600	neg.
7+	High-Security Alarm	neg.	neg.	$3,000	neg.
7	Intruder Defenses	varies	varies	varies	varies
7+	Mutable License Plate	1	0.3	$500	neg.
6	Oil Sprayer	75	1.5	$500	none
7	Paint Sprayer	75	1.5	$650	none
3+	Self-Destruct	varies	varies	varies	none
5	Smokescreen	75	1.5	$350	none
5	Spike Dropper	75	1.5	$350	none

Location: May be housed in the body, turrets, superstructures, pods, arms or legs. License plates normally go on the body; brigs and restraints go with seats or accommodations.

EXAMPLE

Morgan doesn't want anyone stealing the Kitty Hawk, so she adds a high-security alarm (body, $3,000, neg.). A mutable license plate sounds like a good idea as well (body, 1 lb., 0.3 cf, $500). Finally she adds a smokescreen (body, 75 lbs., 1.5 cf,. $350).

Vehicle Storage

A vehicle can contain hangar space for other vehicles. Vehicle stowage is rated for the cubic feet of vehicle that can be stored, although the actual volume required is often greater.

Vehicle Bay (TL5): A vehicle bay holds a single *specific* auxiliary vehicle very snugly. To enter the craft one steps through a door (or a slide or whatever) that leads directly into the craft. The craft then leaves through a set of small hangar doors. Opening or closing the doors takes two seconds.

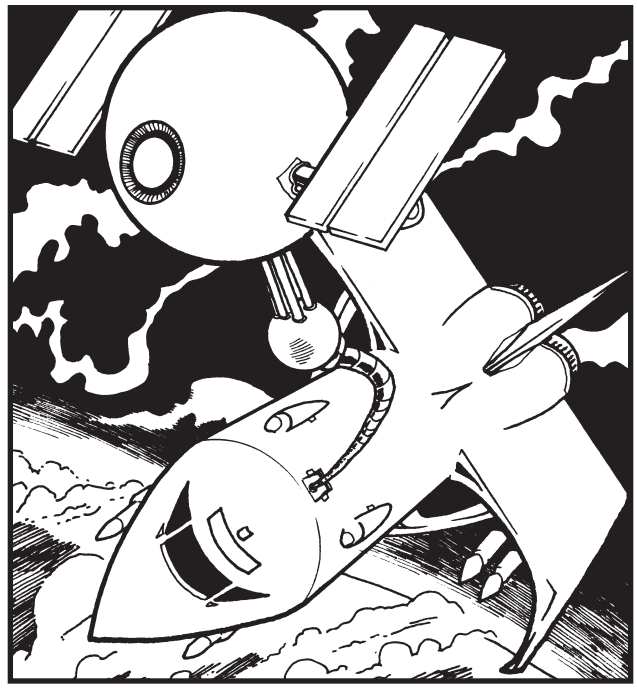
Hanger Bay (TL5): A vehicle can be given a large bay in which other, smaller vehicles can be stored, ready for instant launch. Craft in a hanger bay can refuel from the vehicle's fuel tank (provided they use the

same fuel) or recharge from its energy bank. Unlike a vehicle bay, a hanger bay is not specific to a single vehicle type; any vehicle can be carried in it. The weight of a hanger bay includes any necessary elevators or ramps to carry vehicles onto a flight deck.

Dry Dock (TL6): This is a floodable hangar. It enables watercraft to dock inside a larger vehicle. Pumping water in or out takes 1 second per cf of hangar volume.

Space Dock (TL6): This is an airlock hangar bay; it is treated as a hangar bay, except that it can be totally evacuated or filled with air.

External Cradle (TL1): Ships often attach smaller craft, such as lifeboats, to their decks or sides; a few enormous aircraft (such as blimps) have also used this system to carry other aircraft. The smaller vehicle is carried outside the vehicle's hull, and is not protected by armor, life support, etc. If a flying vehicle is carrying vehicles in external cradles, add their aerodynamic drag to the vehicle's when calculating aerodynamic drag (p. 134). The cradle includes a winch or boom for releasing and recovering the vehicle. This generally takes at least a minute and (if the vehicles are moving) requires matching velocities. For flying vehicles, this sort of rendezvous is generally only possible in zero-G, or if one of the two vehicles has no stall speed. In bad conditions (rushed docking, high winds, rough seas, low visibility, etc.) GMs may optionally require vehicle control rolls to avoid one vehicle crashing into the other.



Hardpoint Launch (TL5): Air- and spacecraft with hardpoints under the wing or the body (p. 94) can launch small vehicles from them, just as if they were dropping bombs or firing rockets. Since hardpoints are designed for launching such objects, there is no extra cost for this; all that is needed is a craft light enough to be carried by that hardpoint! Reattaching the vehicle to the hardpoint after launch may require a minute or more of careful maneuvering – use the same procedure as for cradles, above.

Vehicle Storage Table

Type	*Weight*	*Volume*	*Cost*
Vehicle Bay	10*	1.05*	$15*
Hanger Bay	30†	1.5†	$25†
Dry Dock	40†	2†	$50†
Space Dock	40†	2†	$100†
External Cradle	0.1‡	0.002‡	$1‡

* Per cf of craft to be carried in the bay. Weight and cost will not exceed 1,000 lbs. and $3,000, regardless of volume.

† Per total cf of craft that can be stored. Weight and cost will not exceed 2,000 lbs. and $5,000, regardless of volume.

‡ Per *pound of weight* of craft that can be launched and/or recovered by the cradle.

Location: May be placed in the body, superstructure, turrets, pods, or (rarely) wings, arms or legs.

Landing Aids

This equipment is normally used to help a vehicle that is flying to land safely. Vehicular parachutes are also sometimes used for deceleration by high-speed ground vehicles.

Arrestor Hook (TL6): An arrestor hook is a retractable hook used to snag an arrestor wire on a flight deck (p. 94), providing 80-mph/s deceleration. If this does not stop the vehicle, the wire snaps. It is recommended for winged vehicles lacking vectored thrust that are intended to land on aircraft carriers.

Vehicular Parachute (TL6): These are often installed on aircraft and race cars. When deployed by a vehicle that weighs no more than the parachute's rated load, the chute provides an additional 18 mph/s of deceleration. The deceleration continues until the chute is jettisoned. If deployed while the vehicle is in the air, this slows its fall. If deployed while on the ground, this decelerates it. If the vehicle weighs more than the rated weight of the chute, the deceleration is only 18 mph/s × (rated weight/loaded weight of vehicle). Up to a maximum of three chutes can be used at once: rather than adding their deceleration together, treat them as a single chute with their combined rated weights. Parachutes only work in "Thin" or denser atmospheres.

Parachutes must be replaced after use. Control rolls made while a vehicle is using a braking chute, except for rolls to handle rapid deceleration, are at -4. Once deployed, the chute can be deliberately attacked at +4 to hit, but only concussion damage from nearby explosions (a shell will go right through), flamethrowers or fusion beams can do any damage. Damage of 50 hit points or more disables the chute.

Landing Aids Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
6	Arrestor Hook	150	7.5	$200	0
7+	Arrestor Hook	100	5	$1,000	0
6	Vehicular Parachute	15*	0.6*	$20*	0
7+	Vehicular Parachute	10*	0.4*	$100*	0

* Per 1,000 lbs. of rated weight.

Location: Arrestor hooks must go in the body. Vehicular parachutes may be placed in the body, or in any superstructure, turrets or pods atop the body.

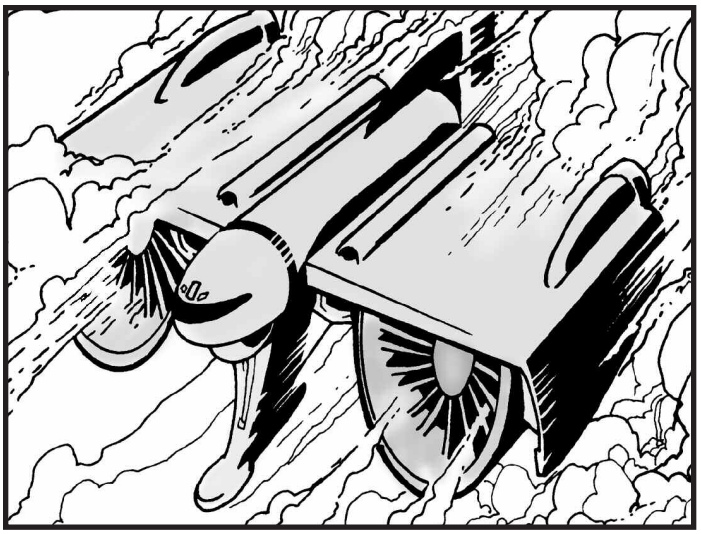
Fuel Transfer and Processing Equipment

These accessories are used to process or transfer fuel. It is usually best to wait until the vehicle's power plant type has been decided upon before installing fuel accessories.

Refuelling Probe (TL7): A refuelling probe allows a vehicle to accept fuel transfers from tankers or other vehicles fitted with refuelling drogues, greatly extending its potential range. The procedure and transfer takes a few minutes, and requires mating the probe with the *refuelling drogue* (see below). It can be done while on the move, even by flying aircraft. However, both vehicles must have tanks that use the same fuel type. Many TL7 combat aircraft have refuelling probes. Spacecraft may also have them! Note that the drogue and probe must be designed to be compatible – those used by non-allied nations are unlikely to be, for example.

Refuelling Drogue (TL7): A maneuverable fuel hose mounted in a tanker vehicle that is steered to mate with the refuelling probe. When deployed, the drogue is about 30 yards long, trailing behind the tanker. Fuel can be transferred at a rate of 190 gallons per minute.

Fuel Electrolysis System (TL7): This device converts water (as pumped in from an ocean or melted ice) into liquid hydrogen (H) and oxygen (LOX). Decide on the number of gallons of water processed per hour (gph); this will determine the weight, cost and volume as shown on the table below. For every gallon of water "cracked," 1.58 gallons of liquid hydrogen and 0.76 gallons of liquid oxygen are produced.



Hydrogen Fuel Scoops (TL8): Spacecraft often use hydrogen for power plants or reaction drives. Hydrogen can be refined from water using a fuel electrolysis system, but bodies with liquid or frozen water may be rare. A more common "free" source of hydrogen is the atmosphere of gas giants: a ship equipped with fuel scoops can dive into such an atmosphere and scoop hydrogen into its tanks. Fuel scoops are combination gas tanks and compressor/intake systems powered by the speed of airflow through the atmosphere. Their statistics are not worked out until after fuel tanks are installed (p. 88): weight, cost and volume are equal to the square root of the fuel tank's weight, cost and volume. Scoops must be located in the body or wings. Note that fuel gathered this way is raw gas, and cannot be used until processed (see below).

Atmosphere Processor (TL8): This purifies gas giant atmosphere into fuel. It is rated for the number of gallons of gas giant atmosphere that can be purified into fuel per hour. For every gallon of tankage filled with raw gas giant atmosphere, 0.002 gallons of usable fuel are produced.

Fuel Accessory Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
7	Refuelling Probe	100	5	$5,000	neg.
7	Refuelling Drogue	600	30	$10,000	0
7+	Fuel Electrolysis	10*	0.5*	$500*	14*
8+	Atmosphere Processor	1*	0.05*	$100*	0.3*

* Per gallon of water or raw atmosphere processed per hour.

Weight, cost and *volume* are halved one TL after the device first appears, and halved again two TLs after it first appears. Power remains the same.

Location: A refuelling probe or drogue goes in the body, a pod, or a wing. A fuel electrolysis system or atmosphere processor may go in the body, a superstructure, a turret or a pod.

Screen Generators (TL9)

These systems generate energy fields that blanket a large area, providing specialized forms of projection.

Nuclear Dampers (TL15)

A nuclear damper projects a field that prevents the uncontrolled release of nuclear energy. While a nuclear damper is operating, no nuclear warhead can explode within its radius of effect. It does not interfere with the controlled release of nuclear energy (for example, in a power plant). A nuclear explosion outside the radius can still cause concussion or radiation damage to those inside the field. Turning a nuclear damper on or off is a combat action.

Nuclear Dampers Table

TL	*Weight*	*Volume*	*Cost*	*Power*
15	500	10	$250,000	1,000
16	250	5	$125,000	1,000

Weight, volume, cost and *power* are for a damper field covering a 5-mile radius. Each additional 5 miles of radius *doubles* weight, volume, cost and power requirement.

Location: May be housed in the body, superstructure, turrets, open mounts, pods, wings, arms or legs.

Reality Stabilizers (TL16)

A reality stabilizer, also known as a Space And Time Anomaly Neutralizer, or SATAN field, strengthens the fabric of local space-time within an area of effect centered on the field generator, negating the effects of certain devices that rely on warping or manipulating space, time or gravity. These include all FTL technologies (drives, sensors and communications), displacer and tachyon beams, teleportation, stasis devices, time and dimensional travel, force screens, deflectors, nuclear dampers and all gravity-manipulation technologies (contragravity, gravity ripple communicators, artificial gravity and gravitic guns). Any device that uses these technologies simply ceases to work while within the field. A reality stabilizer is available in small (5-mile radius), medium (20-mile radius) and heavy (100-mile radius) versions. The radius can be made as small as desired by the operator, but the field is always centered on the device.

Reality Stabilizer Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
16	Small Reality Stabilizer	30	0.6	$60,000	12.5
16	Medium Reality Stabilizer	500	10	$250,000	250
16	Heavy Reality Stabilizer	8,000	135	$1,000,000	5,000

Weight, volume and *cost* are halved one TL after the item first appears, and halved again two or more TLs after the item first appears.

Location: May be housed in the body, superstructure, turrets, pods, wings, arms or legs.

Force Screens and Deflectors (TL11+)

These types of force fields protect a vehicle much like armor does, giving it DR and PD. They are added late in the design process, after the size of vehicle that is to be protected has been determined (see *Force Field Grids* on p. 93).

Modular Sockets

A modular socket is a space in the vehicle designed to accept different components. It is rated for the exact volume of the module it can accept – for example, a socket rated for 0.4 cf can accept any module of exactly that size and weight. A modular socket has no weight. Its volume is equal to the volume of the socket. It costs $500 per cf of volume.

A *module* is something that can be inserted into a particular modular socket in a vehicle. It must be either a weapon or an accessory. A module's volume must be exactly equal to the socket's rated volume. (Adjust the loaded weight of the craft if it carries modules of differing weight). A module can contain multiple components, and "waste" weight and volume can be added to it. A module's cost is equal to the sum of the cost of all components in it, plus 20%.

For the sake of convenience, if a module contains a power-using component, then that component can be given its own power cell, built into the module. That way, the vehicle's endurance won't change when a module is changed. Realistically, though, modular sockets will include power conduits, and modules that require power can run off of the vehicle's power plant if sufficient power is available.

When inserted into the vehicle, a module adds its weight to the vehicle's usual loaded weight. Its volume isn't added, since that's already allowed for in the socket. Removing a module takes 30 seconds, unless the module is so heavy that it requires several people or a crane to lift. Inserting a module takes twice as long.

CREW AND PASSENGERS 6

This chapter covers requirements and components specific to vehicles with crew or passengers.

Maneuver Controls

These are the controls used to maneuver, accelerate and decelerate the vehicle. A vehicle automatically has one set of maneuver controls if it has a propulsion system, wings, rotors or some form of aerostatic lift. Decide what types of controls it uses:

Primitive (TL0): These are rudimentary at best, with no instrumentation. A vehicle cannot have primitive controls if it is a submersible, has a powered propulsion system requiring more than 10 kW of power, has any jet engine, rocket engine or spacedrive except a solid fuel rocket, or has any reactionless thruster.

Mechanical (TL5): These are mechanical or electro-mechanical controls plus analog instrumentation such as gauges and dials. Mechanical controls are the default controls vehicles are assumed to have if they cannot use primitive controls and superior electronic or computerized controls are not installed.

Electronic (TL7): These are sensitive "fly by wire" (or "drive by wire") controls that replace normal mechanical or hydraulic control lines with electronics or fiber optics. A vehicle with electronic controls has improved maneuverability, but at somewhat greater expense. At TL7, they cost $5,000 or 10% of the combined cost of all powered propulsion systems, whichever is greater. At TL8+, electronic controls cost only $500, regardless of propulsion system cost.

Computerized (late TL7): Computerized controls can only be installed in a vehicle that has a computer and one or more computer terminals or a battlesuit. Computerized controls are electronic controls augmented by digital databuses which link all systems together through the vehicle computer and report on vehicle readiness, damage, engine conditions and so on. Data is presented on multi-function display computer menus rather than normal dials and gauges. At TL7, computerized controls cost $10,000 or 20% of the combined cost of all powered propulsion systems in the vehicle, whichever is greater. At TL8+, computerized controls cost $1,000 (free if battlesuit).

Weight, Volume and Location: Maneuver controls have no extra weight or volume, but they should be assigned a location – usually in the body of the vehicle.

EXAMPLE

The Kitty Hawk requires controls. We decide they will be computerized: it has a computer and terminals, and expense is no object! Since the vehicle is TL7, the cost is 20% of combined propulsion system cost or $10,000, whichever is greater. The combined cost of all of the Kitty Hawk's propulsion systems is $28,600: 20% of that is only $5,720, so the minimum cost of $10,000 is used instead.

Duplicate Maneuver Controls (TL6): Normally a vehicle needs only one set of maneuver controls. But at TL6 and up, extra sets of mechanical, electronic or computerized controls can, optionally, be added: this will allow a second crew member to have his own maneuver controls, which can be useful as a backup system in the event of damage or injury, or to allow an instructor to train a student. The duplicate controls must be located in the body, a superstructure, turret or pod.

Duplicate mechanical controls weigh 50 lbs. and take up 1 cf. They cost $100 or 1% of the cost of the vehicle's powered propulsion systems, whichever is greater.

Duplicate electronic controls weigh 50 lbs. and take up 1 cf. They cost half what the vehicle's electronic controls originally cost.

Duplicate computerized controls weigh 25 lbs., take up 0.5 cf, and cost half what the vehicle's computerized controls originally cost. The vehicle cannot have more sets of maneuver controls than it has computer terminals or neural interface systems.

EXAMPLE

The Kitty Hawk has one set of maneuver controls. We don't install duplicate controls.

Diving Controls

Diving controls are used by a submarine crew member to manipulate diving planes and change depth. A manned vehicle automatically has one set of diving controls if it has a submersible hull. Treat as maneuver controls for weight, volume and location.

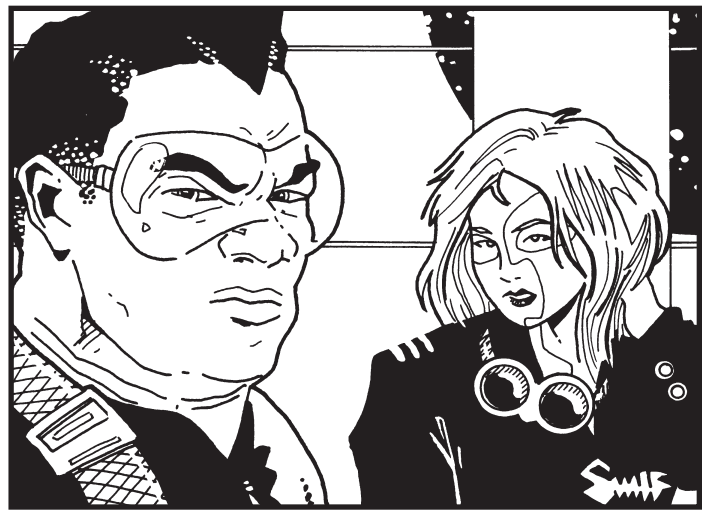
A vehicle can have extra sets of diving controls; the weight and volume are the same as for duplicate maneuver controls (above). The cost is $100 if the vehicle has mechanical controls, $5,000 if it has TL7 electronic controls, $500 if it has TL8+ electronic controls, $10,000 if it has TL7 computerized controls and $1,000 if it has TL8+ computerized controls.

EXAMPLE

The Kitty Hawk has a submersible hull, so it needs diving controls. We decide not to include duplicate controls. Computerized diving controls cost $10,000.

Crew Stations

A crew station (sometimes called a "workspace" or a "station") is a position manned by a single crew member. It controls one or more vehicle systems, and includes a seat or workspace to operate those controls. Each crew station is permanently assigned control of certain vehicular



components, such as maneuver controls, diving controls, weapons or electronics, and these systems can only be controlled from that station.

Determine how many crew stations the vehicle needs and what they control. This depends on TL and on how many different types of gadgets are built into the vehicle.

A crew station must be assigned to each of these components: each set of maneuver controls, each set of diving controls, each ranged weapon, and each communicator, navigation aid, sensor, targeting system, countermeasure, computer terminal or neural interface.

On vehicles built before TL6, each of these components must have its own crew station: one to maneuver the vehicle, one for each weapon, and so on.

At TL6+ and up, a crew station can be assigned to control multiple systems. The only restrictions are that duplicate maneuver or diving controls be assigned to different control stations, *and no station controls a component assigned to another, different station.* Having multiple components operated by a single station reduces the crew requirement, but also increases workload for the crew member who will man that station!

At late TL7 and up, a vehicle with *computerized* controls can further streamline this procedure. Instead of assigning individual components to different crew stations, assign computer terminals or neural interfaces. The person manning that crew station can then use its terminal or neural interface to access and control any of the vehicle's systems.

Decide how many crew stations the vehicle requires, give each a name, and decide what components each one controls. Crew station names are up to the designer: they should describe the main function of the person who mans the station. For instance, a crew station in an automobile with maneuver controls would probably be named "driver," while one in a modern tank that controlled the radio and sensors might be titled "commander."

EXAMPLE

The Kitty Hawk has computerized controls. It has two computer terminals, so it could have up to two crew stations. We decide to install only one crew station. We allocate the maneuver controls, the diving controls and both computer terminals to it. We name the crew station "pilot."

EXAMPLE 2

The Kitty Hawk was easy – that's another advantage of computerized controls. Let's try something more difficult – a 1960s-era TL7 tank built with mechanical controls. It has maneuver controls, a radio, two machine guns, an infrared searchlight and a 90mm gun. Since the vehicle has manual controls, each of these systems must be assigned to crew stations. We could give the vehicle as many as six crew stations – and if it were built at TL5 or less, we'd have to do that. Instead, we give it only three: we name the first "driver" and decide to assign it the maneuver controls. We name the second "commander" and assign it control of the radio *and* one machine gun. We name the third "gunner" and assign it the main gun, infrared searchlight and the other machine gun. The tank will probably need a fourth crew member to load the gun, but he doesn't require a crew station.

Once the number, names and functions of crew stations on the vehicle have been determined, decide what type of crew stations the vehicle uses:

Cramped Crew Station (CCS): This is a seat or workspace with very little room. Cramped stations are typical of vehicles like submarines, race cars or Russian tanks, where space is either at a premium or the designer isn't too concerned about crew comfort.



Normal Crew Station (NCS): This has somewhat more elbow room and is more comfortable to work at. Normal crew stations are typical of most military ground vehicles and some civilian craft.

Roomy Crew Station (RCS): Roomy crew stations are typical of vehicles built for comfort, like civilian automobiles, or those with a great deal of room, like surface ships.

Exposed Cramped (XCCS), Normal (XNCS) or Roomy (XRCS) Crew Station: This is the same as any of the above crew stations, but is open to the elements, with no side or top protection. It is typical of crew stations in vehicles like wagons, chariots, jeeps, convertibles, open boats or early aircraft. An exposed crew station takes up less volume, since the operator is not entirely in the vehicle.

Cycle Crew Station: A compact control panel and seat entirely outside the vehicle. It is used on small vehicles like motorcycles or ultralight aircraft. It can only be used on vehicles that require only one crew station, do not have streamlining of any sort, and which, at this stage in the design process, have less than 30 cf of components. The occupant of a cycle crew station is not protected by vehicle armor.

Harness or Strap-On Crew Station: This is used if the occupant "wears" the vehicle like a jetpack or rides it like skis. If the vehicle is powered, controls and displays are usually on a belt, arm, backpack or helmet. A strap-on crew station can only be used on vehicles that require a single crew station and do not have streamlining or hydrodynamic lines. "Removing" the vehicle takes a second; "attaching" it takes about ten seconds. When designing the vehicle, the total weight should be kept to a weight that the person wearing it can carry!

Battlesuit System: See p. 80.

Bridge Access Space: Optionally, large craft may group important crew stations together as a "bridge." These often have extra access space, enabling officers to easily move about, supervising subordinates.

Each crew station is a component. Determine its location in the vehicle and its weight, volume and cost:

Crew Station Table

Type	*Weight*	*Volume*	*Cost*
Cramped	20	20	$100
Normal	30	30	$100
Roomy	40	40	$100
Exposed	×1	×0.5	×1
Cycle	10	0	$50
Harness	2	0	$25
Bridge Access Space	–	×3	–

Location: Cycle and harness crew stations are placed in the body. Cramped, normal or roomy crew stations may be placed in the body or in superstructures, turrets, open mounts, pods, arms, legs or wings. However, there are some restrictions based on what systems the station controls: stations controlling TL5- weapons must be in the same location as the weapon. Crew stations with computer terminals or interfaces must be in the same location as that terminal or interface.

Battlesuit crew stations use special rules – see p. 80.

EXAMPLE

We decide the Kitty Hawk's one crew station is normal. We put it in the body. It is 30 lbs., 30 cf and costs $100.

Occupancy

Decide whether the vehicle is designed for *short occupancy* or *long occupancy*.

A short occupancy vehicle is only comfortable for a few hours at a time, after which its occupants will want to exit to rest, eat, relieve themselves and stretch. Vehicles with cycle, harness or battlesuit crew stations must be short occupancy.

A vehicle intended for long occupancy is habitable for days, weeks or months but requires additional quarters, extra access space (see p. 14) and possibly extra crew to perform duties such as maintenance or cooking.

EXAMPLE

The Kitty Hawk is designed for short occupancy.



Crew Requirements

A vehicle with a cycle, strap-on or battlesuit crew station can only have one crew member. Otherwise, requirements depend on what components it has and what kind of mission it must perform:

Crew Stations: A vehicle should have one crew member for each crew station it has, although a vehicle can operate with fewer crew simply by manning only some of the crew stations. It won't be able to do everything, but as long as the maneuver controls are manned (for instance) it can still be steered. Each crew station crew member is normally given the title of the crew station as his job title.

Rowers: Vehicles that use rowers require one rower per rowing position.

Loaders: Vehicles whose weapons need loaders require one or more loaders per weapon that needs loading. Sometimes a loader also mans a crew station; if so, he can't operate the crew station and load at the same time.

Sails: If the vehicle has sails, it may require sailors to man them. A vehicle with TL7+ sails and electronic or computerized controls does not require any sailors. Otherwise, the number of sailors is (square root of sum of all mast heights), divided by five if fore-and-aft rig, four otherwise. Sailors do not require crew stations: they are out working on deck, clambering around amidst the rigging, and so on.

Lifting Gas: If the vehicle uses lifting gas, it may require riggers to tend the gas cells. If the vehicle has electronic or computerized controls, no riggers are required, as electronic sensors perform this job. Otherwise one rigger is needed per full 200,000 cf of lifting gas the vehicle has. The rigger's duties are much like those of a sailor, clambering about amidst the various lifting gas cells to continually monitor their pressure, check for and patch leaks, and control the release of ballast. On a vehicle with less than 200,000 cf of lifting gas, the person manning whatever control station controls maneuver controls handles this task. As with sailors, riggers do not have crew stations – their jobs have them roving about inside and sometimes outside the vehicle's body instead.

Mechanics: Mechanics perform routine maintenance within a vehicle. They are needed if repairs or maintenance are to be performed on power, lift or propulsion systems *during* a journey. Any vehicle may carry mechanics "just in case." Some vehicles may *require* mechanics: if the vehicle is designed for long occupancy and/or was built at TL5 or less, add up the total kW of power requirement for all power-using propulsion systems and all power-using aerostatic lift systems aboard, including those in auxiliary vehicles such as ship's boats or shuttlecraft. Then divide by 250 if TL5-, 500 if TL6, 1,000 if TL7, 5,000 if TL8, 50,000 if TL9, 250,000 if TL10, 500,000 if TL11, 1,000,000 if TL12-13, or 5,000,000 if TL14+. (If the vehicle has a hyperdrive, count only the lower power requirement needed to keep it in hyperspace, not the greater power needed to enter hyperspace!) Find the square root of the quotient (round down). The result is the number of crew required for routine maintenance, stoking, monitoring engines and so on. Mechanics do not require crew stations, as their jobs take them throughout the entire vehicle, but usually require workshops (see p. 66).

Stokers: Vehicles that burn coal or wood require stokers. Stokers are treated exactly like mechanics (above), and are already included in the usual compliment of mechanics required by a long-occupancy vehicle. However, stokers are *always* required for coal or wood-burning vehicles: even short-occupancy vehicles will have to carry them.

Paying Passengers: If the vehicle is to carry paying passengers, it will need one passenger attendant (styled as a "steward," "conductor," "porter" or "flight attendant") per 100 steerage passengers, 50 second-class, 20 first-class or four luxury passengers. Decide how many passengers of each class the vehicle normally carries, and select that many passenger attendants.

Auxiliary Vehicles: If the vehicle carries other vehicles, calculate their crew requirements as well, and add them to the total crew requirements! However, if the auxiliary vehicle will not be used very often, it does not need a dedicated auxiliary crew – the crew will man it on an ad hoc basis.

Laboratories: A vehicle with laboratories may carry scientists to man them. Alternatively, the regular crew may also do lab work, but they can't fulfill other duties while they are doing so.

Medical Equipment: If the vehicle has sickbays, stretchers or operating tables, it will usually carry at least one medic. At *least* one medic is needed per operating table intended to be used simultaneously. If the vehicle is built for long occupancy, at least one medic should be carried per 50 (TL4), 100 (TL5-7) or 200 (TL8+) people on board, although automeds can substitute for human medics if necessary.

Service Crew: If vehicle is built for long occupancy and has over 20 other occupants, it requires at least one service crew member (e.g., a cook) per 200 occupants, or fraction thereof. Service crew are assisted by other crew on a rotational basis.

Military Craft: These often carry many times the normal required number of mechanics, loaders or sailors to replace losses and perform damage control duties.

A military vehicle with more than one crew member, or any vehicle with over a dozen crew, should have one designated "captain" or "commander." The captain often has a crew station assigned to him as well, but sometimes may have no other duties besides command.

In a commercial or military vehicle, about one crew member in eight will be an officer or senior enlisted man, although this ratio may vary. In terms of vehicle design, the only real distinction is that officers are sometimes given better quarters.

Crew Size: Add up the number of crew positions to get the crew size. Vehicles built for long occupancy and intended to operate continuously often have two (sometimes three) shifts: simply double or triple the crew size. The second captain is normally called a "first officer" or "executive officer."

EXAMPLE

The Kitty Hawk requires only one crew member, to man the pilot crew station – in other words, a pilot.

Accommodations

If the vehicle is built for short occupancy, it requires either a *seat* or *standing room* (see below) for every crew member who lacks a crew station, except sailors or lifting gas riggers. Unless the vehicle was built with a battlesuit or strap-on crew station, it can then be given additional seats or standing room to carry passengers as well.

A vehicle designed for long occupancy requires quarters (below) for every crew member. Additional quarters may be carried for passengers.

EXAMPLE

The Kitty Hawk already has a crew station for its one crew member. We decide to add an additional seat for a single passenger.

Seats and Standing Room

Seats are just that – seats inside the vehicle. They are further divided into roomy, normal or cramped seats, much like crew stations. Roomy seats are typical of most front seats in comfortable cars, or seats in airliners, normal seats are like front seats in small cars and back seats in large ones, while cramped seats are typical of back seats in mid-size or compact cars, commuter buses, or armored personnel carriers.

Standing Room is room for a person to stand, usually with a handhold. Like a seat, standing room is classed as cramped, normal or roomy. It is common instead of seats in animal-drawn vehicles, small boats, ships and balloons – any craft where swift accelerations and



violent maneuvers are rare. Also, buses and commuter trains often have extra cramped standing room equal to their number of seats.

Exposed Seats or Standing Room are just like ordinary seats or standing room, except the occupant is partly outside the vehicle's structure. Chariots, wagons, jeeps, open boats, convertibles and many early airplanes often use them.

Cycle Seats: If the vehicle has a cycle crew station, passengers are normally also in cycle seats.

The table shows the weight, volume and cost of a single seat or standing room:

Seats and Standing Room Table

Type	*Weight*	*Volume*	*Cost*
Cramped Seat	20	20	$100
Normal Seat	30	30	$100
Roomy Seat	40	40	$100
Cramped Standing Room	0	20	0
Normal Standing Room	0	30	0
Roomy Standing Room	0	40	0
Exposed	×1	×0.5	×1
Cycle seat	5	0	$50

Standing room has no weight or cost: the volume required is the same, since the extra space that was occupied by the seat is countered by the fact that standing people take up more space.

Location: Seats or standing room may go in the body, superstructure, turrets, pods, arms, legs or wings as desired. Seats or standing room for rowers must be located with the rowing position. Seats or standing room for loaders must be in the same location as either the weapon or the ammunition being loaded.

EXAMPLE

The Kitty Hawk has one seat (other than its crew station's). We decide it is normal and in the body (30 lbs., 30 cf, $100).

Quarters

Quarters consist of bunks and cabins. Any vehicle with bunks or cabins is assumed to include access (passages, ladders or elevators) and cooking, laundry and waste disposal facilities commensurate with the

number and quality of its accommodations. Additional "common living space" can be added to make a more spacious vehicle, if desired. This has no cost in and of itself (treat it as "empty space"), but it will make the vehicle larger and ultimately more costly.

A *bunk* is a bunk or hammock for a single person, usually in a cramped alcove or in a room with other bunks. It includes a locker or space for storing personal possessions. Note that it is common in vehicles with bunks to also give each crew member a fixed allowance of cargo space for stowing personal possessions.

A *cabin* is a furnished room. It can house one or two people. A "luxury" cabin is a larger cabin with superior fittings. Optionally, two or more cabins may be combined into a suite.

Crew members may be housed either in bunks or cabins. Traditionally, ordinary crew each have a bunk, officers are housed two to a cabin, and the captain has a private cabin. If the vehicle has multiple shifts and the crewmen are willing to tolerate some discomfort, two or three crew members who work different shifts may share the same bunk.

Non-paying passengers can be housed as crew. For paying passengers, steerage ("third-class") passengers each require a bunk. Second-class passengers require one cabin for every two passengers, rounding up. First-class passengers each require their own cabin. Luxury passengers each require their own luxury cabin.

Aside from crowding, quality of life in quarters depends on whether or not the vehicle has an environmental control system (see below) and how good the food is! Late TL5 and up cabins in vehicles with environmental control or life systems are assumed to have modern conveniences such as air conditioning and running water.

Quarters Table

Type	*Weight*	*Volume**	*Cost*
Hammock	100	100	$20
Bunk	200	100	$100
Cabin	2,000	500	$3,000
Luxury Cabin	4,000	1,000	$10,000

* Note that although cost and weight are fixed, more volume can always be added for spacious vehicles; the volumes given here are minimums.

Location: Quarters can be located in the body, or in superstructures, turrets, pods, arms, legs or wings.

Bunks and Short Occupancy Vehicles: Vehicles intended mainly for short occupancy sometimes carry a few bunks as well to improve comfort. Also, a pair of roomy seats that occupy the same location in the vehicle can be built so that both the seats can be folded up to form a single bunk. This adds 50% to the combined seats' weight and cost, but does not increase their volume. A small galley for cooking on short-occupancy vehicles is available at half the cost, weight and volume of a bunk.

Environmental Systems

These systems become available at TL5+ and are designed to provide comfort and life support to a vehicle's occupants. They include environmental control, NBC kits and life systems. Environmental control is used to enhance occupant comfort. NBC kits are used to allow a vehicle to survive in a toxic but otherwise breathable environment. Limited or full life systems are needed if the vehicle is to provide breathable air for its occupants. Submarines, spacecraft, aircraft flying at high altitude and any vehicle operating in an area without a breathable atmosphere should have a life system.

Environmental Control (late TL5): This is a basic light, heat, air conditioning and ventilation system for the vehicle. If added, it improves the quality of life and allows occupants to operate at up to 120°F or down to -30°F without penalty or fatigue (see p. B130); treat higher or lower temperatures as if they were 40° closer to optimum.

NBC (Nuclear-Biological-Chemical) Kit (TL7): This is an environmental control system, plus sensors to detect contaminants, filters, and an overpressure system (the interior is kept at higher air pressure than outside) to keep impure air out. It defends against nuclear fallout, germs or chemicals such as pollution or poison gas. Only people entirely inside the vehicle may benefit from an NBC kit, and the vehicle must be sealed. Filters must be changed periodically (depending on the degree of contamination, but usually at least once every 2 days) at a cost of 1% of the system cost. Spare filters have 5% of the weight and volume of the system. At TL10+, self-regenerating filters are available (no extra cost) that do not have to be cleaned.

Limited Life System (late TL5): This functions as an environmental control system, above, and also provides additional "bottled" oxygen and water for as long as power and supplies last. This is the most common kind of life system on aircraft, space shuttles and non-nuclear submarines. Its endurance is measured in man-days, i.e., 100 man-days of endurance sustains one man for 100 days, two for 50 days, three for 33.3 days, etc. Life support can be turned on or off; a submarine cruising on the surface could turn off life support to conserve air supplies. A limited life system may also be given a half or quarter man-day of life support at fractional weight, volume and cost. The *minimum* man-days (to provide basic environmental control) is 0.25 man-days per person the vehicle is designed to carry. The life system will provide air for days equal to the number of man-days divided by the number of people using the system. Any limited life system with an air supply of 240 man-hours or more is assumed to have the ability to replenish itself by converting ordinary air into bottled oxygen.

Full Life System (TL7): This is a self-regenerating oxygen and water purification plant of the type found on nuclear submarines or long-range spacecraft. It works indefinitely. Statistics depend on the number of people supported and the tech level. At TL11+, these systems are mostly replaced by very small full life systems using molecular recycling technology similar to the cybersuit (p. UT76 or S63).



Environmental Systems Table

TL	Type	Weight	Volume	Cost	Power
5	Environmental Control	20	0.4	$10	0.25
6	Environmental Control	10	0.2	$20	0.25
7+	Environmental Control	5	0.1	$50	0.25
7	NBC Kit	25	0.5	$5,000	0.25
8	NBC Kit	10	0.2	$2,000	0.25
9+	NBC Kit	5	0.1	$1,000	0.25
5	Limited Life System	300	6	$100	0.5
6	Limited Life System	250	5	$200	0.5
7	Limited Life System	200	4	$1,000	0.5
8	Limited Life System	150	3	$500	0.5
9	Limited Life System	100	2	$500	0.5
10+	Limited Life System	50	1	$500	0.5
7	Full Life System	4,000	50	$5,000	–
	plus, per person	1,000	50	$500	10
8	Full Life System	2,000	25	$5,000	–
	plus, per person	500	25	$500	10
9	Full Life System	800	10	$5,000	–
	plus, per person	200	10	$500	10
10	Full Life System	400	5	$5,000	–
	plus, per person	200	5	$500	10
11+	Full Life System	–	–	–	–
	plus, per person	20	1	$500	0.1

Location: Environmental systems should be located in a location that also houses crew stations or accommodations.

Environmental control and NBC Kit weight, volume, cost and power are multiplied by the number of people the vehicle is designed to carry.

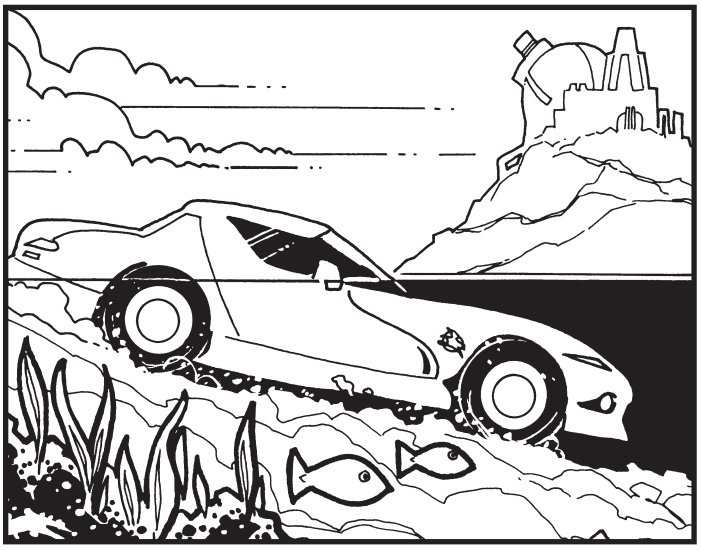
For limited life systems, multiply the weight, volume and cost by the number of man-days the vehicle provides support for, with a minimum of one-quarter man-day per person the vehicle carries. Power is *per person* rather than per man-day.

A full life system has a basic flat weight, volume and cost, plus an extra weight, volume, cost and power requirement per person the vehicle carries.

A "total" life system that produces food as well, and so does not require provisions, is ×2 weight and cost, ×4 volume.

EXAMPLE

The Kitty Hawk is designed to be submersible, so we need a life system. The vehicle carries two people. We give it a limited life system with one man-day of support, which functions as environmental control, and which will give each person 12 hours of air. We place the life system in the body: it is 200 lbs., 4 cf and $1,000. Since power is based on the total people carried rather than man-days, it requires 1 kW power.





Provisions

Provisions – including food and drink, plus storage facilities – are 12 pounds, 0.24 cf and $6 per man-day, and should be carried as cargo. At TL0-4, provisions will tend to spoil after a month or so. At TL5+, canning and preservation techniques eliminate this problem, allowing increasingly better food to be carried on long trips. Vehicles with life systems have lower requirements: 2 pounds, 0.04 cf and $6 per man-day.

Artificial Gravity

Since space is a zero-gravity environment, spacecraft are often equipped with some form of artificial gravity to simulate the effects of living in a gravity field. Working in zero-gravity or microgravity is tricky, and once a character is used to it, readjusting to gravity can take days or weeks. As well, while humans can live in zero-gravity for weeks or months, there is some evidence that long-term exposure to zero gravity is unhealthy. So far, this has no been conclusively proven one way or another. See p. S73 for detailed rules on zero-gravity and microgravity.

No manned spacecraft has to have to have artificial gravity, but gravity *will* improve crew and passenger comfort! Perhaps more importantly, artificial gravity frees the occupants of the need to re-acclimate themselves to gravity when they disembark on a planet. This is nice for passengers and can be of crucial importance for soldiers who have to fight on planet!

Artificial Gravity Units (TL10)

These "grav units" are available only if the GM rules that gravity-manipulation technology exists in the campaign; they are an early form of contragrav. They are special generator plates that use super science to artificially generate a gravity field.

If a vehicle has grav units, decide how many cubic feet of vehicle they cover. Normally this is the living and working space: the combined volume of all seats, standing room and quarters in the vehicle, plus the volume of any rooms such as sickbays, workshops, laboratories or conference rooms.

One grav unit is needed if the volume to be covered is 27,000 cf or less. If the volume to be affected is greater, multiple units are needed, one per extra 27,000 cf or fraction thereof. Weight, volume, cost and power of a grav unit depend on TL:

Grav Unit Table

TL	Weight	Volume	Cost	Power
10	16,000	135	$100,000	1,000
11+	2,000	27	$20,000	1,000

A single gravity unit is adjustable from microgravity to three gravities (3 G). Multiple units can be bought and "stacked" in the same area of effect to proportionately increase the upper limit on G: two stacked units could provide up to 6 G, and so on.

Location: Grav units must be placed in a body, turret, superstructure, pod, arm or leg, somewhere that is within the area they are providing artificial gravity for.

Safety Equipment

Safety equipment such as seat belts or ejection seats can optionally be added to protect crew and passengers. At TL6-, many vehicles are built without safety equipment, but at TL7+, it is very common.

All crew stations and seats can be assumed to come with safety belts or straps, if these are desired.

Ejection (TL7): This option may be added to any crew station or seat. An ejection seat uses a rocket to fire the occupant out of the vehicle, then deploys a parachute to land him safely. For ejection rules, see *Ejecting* on p. 161 in Chapter 12.

Crew Escape Capsule (TL7): A single body or subassembly can be equipped with a jettisonable escape capsule *instead* of separate ejection seats for the crew. Find the cost, weight and volume to buy a separate ejection seat for *every* crew member in that body or subassembly, then *double* it. Capsule release is dealt with under the *Ejecting* rules (p. 161); note that all crew members are ejected at once. The capsule is sealed if the vehicle is (in which case it can also float), and any unpowered environmental system in the same location as the capsule can be defined as being part of the capsule as well. Ejecting the capsule automatically disables the vehicle, but this is usually the only way to safely eject from a spacecraft or hypersonic aircraft. The capsule release controls must be assigned to a specific crew station during the design process.

Airbags and Crashwebs (TL7): Airbags are used at TL7, while crashwebs are their ultra-tech equivalents, using advanced technology related to tangler weapons. They reduce the damage from a crash, as described in the *Vehicle Action* chapter. Airbags and crashwebs may protect crew stations or seats.

G-Seat (TL7): Any crew station or seat may have this option – a sharply-raked seat back and careful ergonomic design that makes high-G maneuvering more comfortable. This reduces the G-force *felt* by the occupant during high-G maneuvers (see p. 153), although it has no effect on the *actual* G-force of the maneuver.

Womb Tank (TL8): This is an option that may be added to any crew station, seat or standing room that is not "exposed," and may also be added to quarters. It is a gel-filled fluid bath that provides superior protection against shocks and acceleration, and has double the effect of crash webs against any crash-induced whiplash and collision damage. Getting in or out takes 30 seconds, however.

Gravity Web (TL12): These are strong contragrav generators that protect a crew station or seat if the vehicle undergoes high acceleration. The effect is to reduce the G-forces experienced by the occupant by 2 G at TL12, 4 G at TL13, 8 G at TL14, 16 G at TL15, and 32 G at TL16. Also, treat collision speeds as 20 mph slower per G of compensation when calculating whiplash and concussion damage for the occupant. For instance, a 100-mph collision speed would be felt by a TL13 grav compensator-equipped person as only a 20-mph collision. These reductions are cumulative with the effects of seatbelts, crashwebs and airbags. The web is disabled if the vehicle loses power.

Safety Systems Table

TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
7+	Ejection Seat	100	5	$50,000	0
7	Airbag	10	1	$200	0
8+	Crashweb	5	0.5	$100	0
7+	G-Seat	0	0	$500	0
8+	Womb Tank	*	*	*	0
12+	Gravity Web	20	0.4	$2,500	0.5

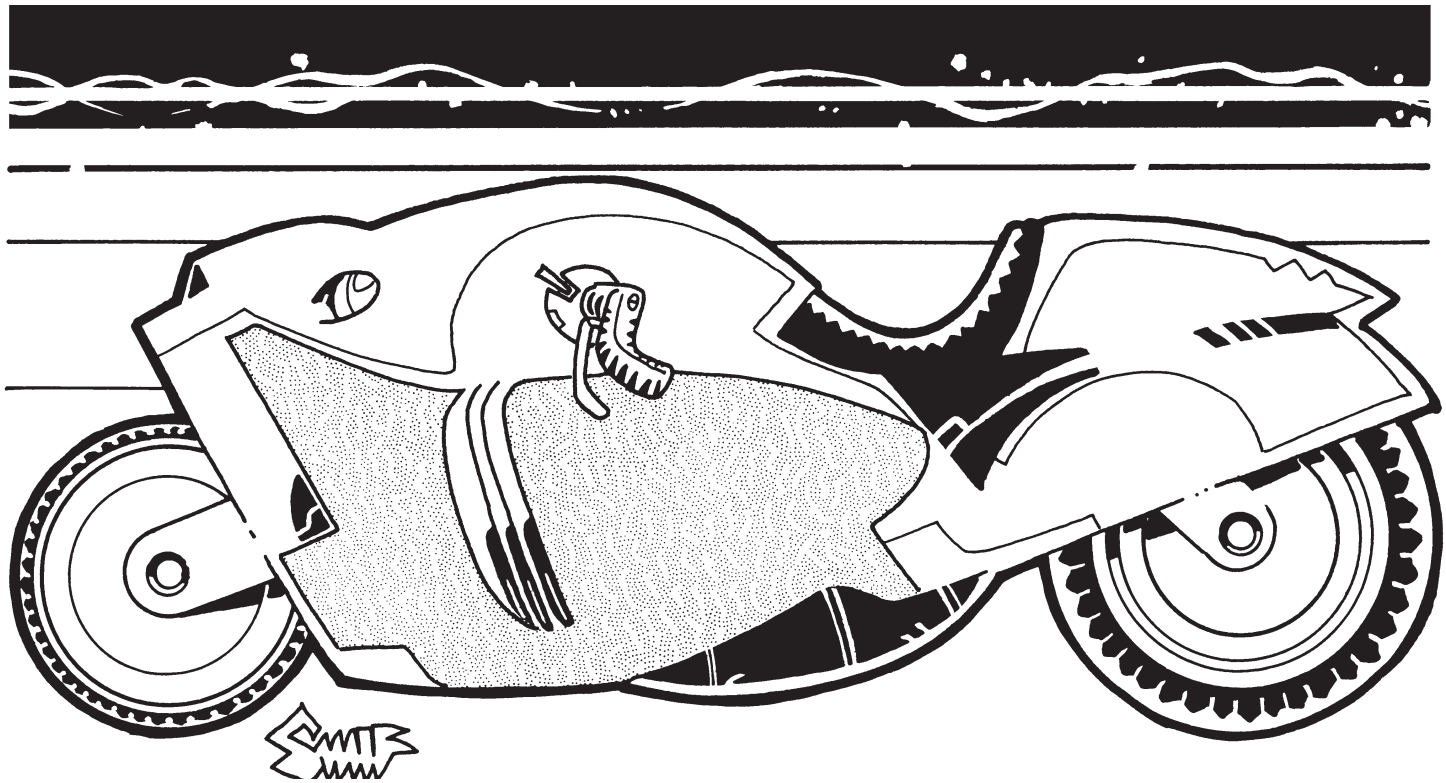
* Weight is 10 lbs. per cf of volume of seat, standing room or quarters so equipped. Volume is weight/50. Cost $50 per pound it weighs.

Location: Safety systems must be placed in the same location as the crew station, seat, standing room or quarters they are protecting. Decide which station, seat, etc. the system protects!

Weight, Volume, Cost and Power: This is per person so equipped.

EXAMPLE

We equip the vehicle with two ejection seats (for the crew station and passenger seat). We also add two airbags.





Grav Compensators (TL12)

A grav compensator is a specialized form of contragravity field that "cancels" the effect of high-G accelerations. This reduces stress on the vehicle and the G-force experienced by the occupants, but it does not make maneuvers any less difficult. A grav compensator can reduce experienced G forces by (4,000,000 × number of compensators)/vehicle loaded weight. Maximum reduction, regardless of the number of compensators, is 2 G, so if the vehicle weight is equal or less than 2,000,000 lbs. × number of compensators, don't bother using the formula: the G reduction is always 2 G. Effectiveness and maximum G reduction are doubled for every TL above TL12, e.g., a TL14 grav compensator would reduce experienced G by (16,000,000 × number of compensators)/loaded weight, to a maximum of 8 G.

Each grav compensator weighs 2,000 lbs., takes up 40 cf, costs $20,000 and requires 1,000 kW.

Appendix – Battlesuit Systems

A battlesuit is a suit of powered armor worn by a living operator, controlled by kinesthetic feedback (for example, the wearer tries to move his arm, and pressure sensors in the suit sense the movement and signal motors to move the suit's arm). A vehicle can be a battlesuit if it has the same basic shape as the intended wearer, uses electronic or computerized controls, and substitutes a "battlesuit system" for an ordinary crew station (see *Crew Stations* on p. 73). For humans, a battlesuit has a turret on top of the body, two arms and two legs. The suit fits the wearer like a glove; only skintight outfits or nothing can be worn inside the suit, unless the suit has no armor, or only open frame armor, in which case normal clothing can be worn.

A battlesuit should be custom-fitted to an individual or given size and weight of person. For simplicity decide what weight of person the suit will fit and assume it can fit anyone up to 20% lighter than that weight. This is the "pilot weight."

The battlesuit system – controls and pilot – counts as a component, just like a crew station. It enables the pilot to control all systems on the vehicle. In a form-fitting suit, the battlesuit system has *multiple* locations spread across the vehicle's arms, legs, turret and body. The system takes up (pilot weight/100) cf in the body, (pilot weight/400) cf in one turret, (pilot weight/1,000) cf in each of two arms, and (pilot weight/400) cf in each of two legs. Alternatively, a non-form fitting suit is possible with the pilot placed entirely within a body or head, taking up (pilot weight/50) cf.

The battlesuit system weighs 0.2 lbs. × pilot weight *excluding* the weight of the pilot. The cost is $3,000 + (pilot weight × $20). At TL9, halve the cost; quarter it at TL10+.

In combat, treat a battlesuit as a vehicle. If part of the suit containing the pilot is reduced below 0 hit points, apply half the excess damage to whatever part of the pilot was in that location. For example, if the turret were reduced to -17 hit points, the pilot's head would take 8 hits of damage if the suit were form-fitting. If the suit were not form-fitting, the pilot would only take damage if the battlesuit system occupied the turret; in this case, the damage would be applied to a random hit location.

A battlesuit is operated using Battlesuit skill (p. B49). When making DX rolls, use the lower of DX or Battlesuit skill; when making DX-based skill rolls, use the lower of the pilot's skill-1 or his Battlesuit skill-1. Putting on a suit takes about four minutes; removing it takes half that. For an extra $500, a suit can be designed for "quick access," taking only (30-Battlesuit skill) seconds to don, or half that to remove.

An exoskeleton is a lightly-armored battlesuit, not generally used for combat. If a battlesuit has less than DR 30 armor and no internal weapons except tools (e.g., energy drills, welding torches), it functions the same way as a battlesuit but is operated using the Exoskeleton skill, as described on p. B247.

If a battlesuit or exoskeleton is 50 cf or larger in size, substitute Driving (Mecha) skill instead. The operation remains the same.

POWER AND FUEL 7

This chapter describes means of powering vehicles and the fuels and fuel tanks used by power plants and reaction engines.

Power Systems

A vehicle requires a power system if it has any power requirements, measured in kW. Add up the power requirements of all systems in the vehicle to find out how much power is needed. These power requirements can be met by draining energy from an energy bank or through the output of a power plant.

A *power plant,* like a gasoline engine or a nuclear reactor, produces power constantly (as long as it is fuelled). A power plant is rated for a power output in kilowatts, which can be used to fulfil the vehicle's power requirements.

An *energy bank* (such as a battery or power cell) stores a finite amount of energy, which is drained as it is used. It is rated for the number of kilowatt-seconds (kWs) of energy it stores. One kWs provides one kW of power for one second.

Power plants are generally better for the long haul, while energy banks permit greater power outputs for much shorter periods. Power plants often require oxygen to operate (and those that do not are often very expensive). Energy banks are cheap and work anywhere.

A vehicle will often have both a power plant and an energy bank, combining their benefits. If the vehicle has a system that requires short bursts of power (e.g., a hyperdrive, jump drive, electromag or gravitic gun, or beam weapon) adding an energy bank solely for the purpose of supplying that system is a good idea, while the power plant handles all routine power requirements. Submarines with air-breathing power plants often rely on energy banks when submerged, but use a power plant to recharge the 'banks when surfaced.

If a vehicle is to have a power system, decide whether it will have a power plant (see below), an energy bank (see p. 87) or both. Jet engines also function as power plants – if a vehicle has one, see *Jet Engines and Power,* below, to determine how much auxiliary power the engine generates.

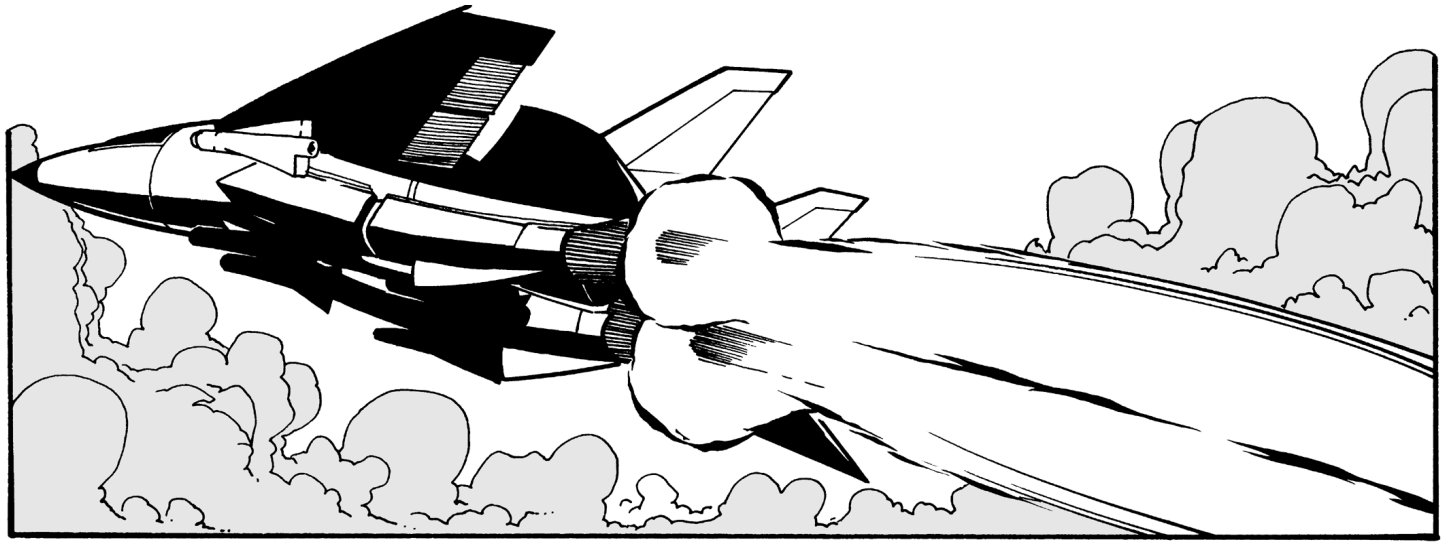
When a power plant or energy bank is installed, indicate what power-using systems it powers. Sometimes this is obvious – a single power plant or energy bank will run everything – but not always. For instance, if a vehicle has a radio using 0.1 kW and a drivetrain that uses 100 kW, it is more elegant to build a 100 kW power plant and then install a small energy bank to run the radio when it is in use. So, the power plant would be indicated as running "drivetrain" with other systems left to the energy bank. Also, some systems that use power can be designated as not running at the same time as others; this will reduce the total power requirement, since not everything needs be powered at once.

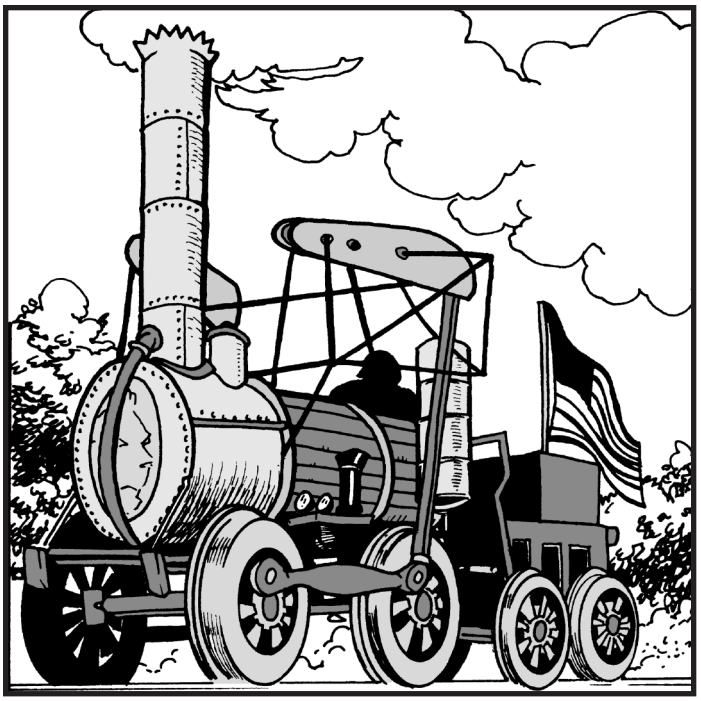
EXAMPLE

Adding up the power requirements of all systems, Morgan finds that Kitty Hawk has all systems, a total power requirement of 255.75 kW if it ran everything at once. However, on the ground, the hydrojet isn't used (the bilge pump and sonar probably won't be, but we might pump water out or do sonar scans while on the ground, so we count it in), so that's only 215.75 kW. In the air, the wheeled drivetrain, sonar, bilge pump and hydrojet aren't any use, so that's only 13.5 kW. On water, the wheeled drivetrain isn't used, so that's only 55.75 kW. And underwater, only the hydrojet, bilge pump, sonar and lifesystem will be used, so that's only 43.25 kW. Based on this, it looks like a power system capable of providing about 216 kW is a good idea.

Jet Engines and Power

Jet engines can produce power as well as thrust. This is how jet aircraft operate lights, radios, radars and other accessories. Assume a jet engine will produce enough excess power (via simple turbine-pump generator included with the engine) to operate systems requiring "negligible" power. It will generate a further power output in kilowatts equal to (thrust in lbs./100). This extra power may only be used to operate equipment or weapons, or recharge energy banks. If more power is needed, the vehicle will have to install an energy bank or a power plant.





EXAMPLE

The jet engine on Kitty Hawk generates 5 kW of power when it's running. Since we don't expect to run the jet all the time, we'll leave this as an "auxiliary" power system and not count it toward the 216 kW power requirement we need.

Power Plants

Power plants are rated for output, in kilowatts (kW). This is the amount of power they produce, which can be used to power systems built into the vehicle or to recharge energy banks.

Choice of Output and Allocation of Power: Unless the vehicle also has an energy bank, the power plant's output should be enough to meet all the power requirements of vehicle's systems. If the vehicle is going to have an energy bank as well, or if it has more than one power plant, indicate exactly what power-using systems each power plant normally powers.

Multiple Power Plants: A vehicle will sometimes have multiple power plants of the same or different type. These can either add their output together, or be designated as an auxiliary power system that only works (and uses fuel!) when the main system is shut down or out of action.

Choosing a Power Plant: There are many types of power plants available. They fall into several broad categories, each of which are treated separately: muscle engines (TL1); steam engines (TL5); internal combustion engines (late TL5 and up); fuel cells (TL7); gas and MHD turbines (TL7-8); nuclear, antimatter and mass-energy conversion (TL7 and up) and exotic (TL varies). Examine the various systems available at the vehicle's TL, especially their weight per kW, fuel consumption and cost. The choice comes down to selecting the best tradeoff between weight (the lower the weight per kW, the better), cost (the cheaper, the better), and fuel economy (the less fuel burned, the better) since lighter-weight plants are usually more expensive or burn more fuel. Another important consideration is whether or not the power plant works without oxygen: ideally, space vehicles and submarines should have power plants that don't need air to function, although submarines often rely on an energy bank when underwater.

Examining what's available at TL7, we decide on a gas turbine as the primary power source (p. 84) to provide the 216 kW we need on the ground. However, we will also install an energy bank, which we use to power the vehicle in other regimes, allowing us to turn off the power plant and save fuel.

EXAMPLE

A Note on Fuel Consumption

In this chapter, the fuel consumption figure listed for a power plant that consumes fuel is lower than it would be if the engine were operating at full power output. This is because power plants rarely do that! Rather than require a complicated set of fuel consumption and fuel efficiency figures at different power outputs – and require performance to vary – a somewhat lower consumption figure has been used, based on a more average rate of power output and usage.

Muscle Engines

A muscle engine is a muscle-powered "power plant." It uses pedals, levers, turn cranks or treadmills to generate power that may be used to provide energy for vehicle systems, just like any other power plant.

A muscle engine is rated for the maximum output of the engine, in kW. The actual output of a muscle engine is equal to 0.02 kW × combined ST of the operators using it, up to the maximum output. Suggested maximum output for an ordinary bicycle-type engine is 0.4 kW. Each operator must be given a crew station in the same part of the vehicle as the engine.

A vehicle can have multiple muscle engines, if desired.

Muscle Engine Table

TL	*Weight*	*Volume*	*Cost*
1-4	100	5	$500
5	50	2.5	$100
6	25	1.25	$25
7+	10	0.5	$50

Location: Muscle engines can go in the body, pods or wings. They can also go in turrets, superstructures, arms or legs, but rarely do.

Weight, volume and cost are per kW of maximum output.

Steam Engines

Steam engines burn fuel to heat water, turning it into steam. The steam is held under pressure in a boiler, and vented into an engine where it works a cylinder to drive a piston. The vertical motion of the piston is usually converted into a more useful rotary motion by the vehicle's propulsion system. The weight, volume and cost of all steam engines include boiler, water tanks and engine.

All steam engines require a thin or denser atmosphere that contains oxygen in order to function.

Early Steam Engines (TL5) first become available circa 1690, but these were low-pressure systems. Models generating sufficient power to be useful on vehicles become available around 1800.

Forced-Draft Steam Engines (late TL5) begin to replace early steam engines around 1850. They use higher working pressures to obtain more efficiency.

Triple-Expansion Steam Engines (late TL5) come into use around 1885. They uses a high-pressure boiler and an engine with three cylinders working in turn instead of one or two, giving a smoother and more powerful action.

Steam Turbines (TL6) were first used in 1896. A jet of steam is used to turn the vanes of a rotor, further increasing efficiency. They can burn coal or (by mid-TL6) diesel fuel – decide which the particular engine uses. Coal is heavier, but its advantage over diesel is that its cost per kW per hour is somewhat less.

All steam engines take a long time to start, since they must build up a head of steam within the boiler. A TL5- engine starts in 5 minutes, plus one minute per 10 kW of output. A TL6+ steam turbine takes only half as long to start.

Steam Engine Table

TL	Type	Weight if output is under 5kW	Weight if output is 5kW or more	Cost	Fuel Used
5	Early Steam	200×kW	(100×kW)+500	$0.2	0.1C/0.4Wd
5	Forced-Draft	150¥kW	(75¥kW)+375	$0.4	0.06C/0.24Wd
5	Triple-Expansion	100×kW	(50×kW)+250	$0.8	0.05C/0.2Wd
6	Steam Turbine	125×kW	(25×kW)+500	$1	0.04C/0.06D
7+	Steam Turbine	100×kW	(20×kW)+400	$2	0.02C/0.05D

Location: Steam engines must go in the body.

Weight: Calculate the weight of the power plant as shown on the table above, based on output. There are two columns, one for power plants with outputs under 5 kW, the other for larger power plants.

Volume: Divide weight by 50 to find volume in cf.

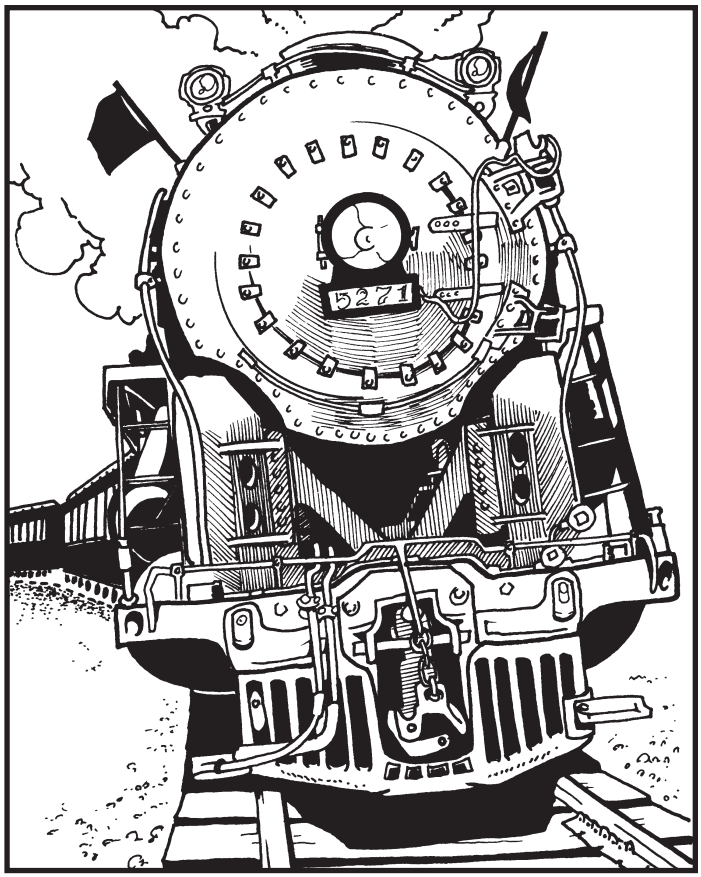
Cost: This is the cost per pound of power plant weight.

Fuel Usage: This is the fuel consumption, per kW of output, in cf per hour (cfh) of coal (C) or wood (Wd), or gallons per hour (gph) of diesel fuel (D). If two types are listed, it can use either. Assume that water is replenished when fuel is taken on.

Internal Combustion Engines

These power plants burn fuel and air inside the engine, rather than using an external boiler like a steam engine. They are sometimes referred to as "reciprocating" engines because of the motion of the pistons used to compress the fuel in many engines of this type. They require oxygen at about Earth-normal pressure to work; thus, they do not function underwater, in vacuum, or in any atmosphere other than oxygen-nitrogen with pressure between "thin" and "dense."

Gasoline Engines (TL6) are the most common engines of the 20th century. They burn a mixture of gasoline fuel and air. The expansion of the heated gasses normally works pistons that drive a shaft, providing the rotary action needed to turn wheels, propellers, or the like. Gasoline engines come in standard and high-power (HP) models. HP engines are highly-tuned engines of the sort used in aircraft, race cars or expensive sports cars. They include rotary engines such as the Wankel. Turbo or superchargers are available for standard and HP engines. They increase power output (in game terms, by reducing the weight per kW) by pre-compressing the air pulled into the engine. A turbocharger uses the exhaust stream to drive an air compressor, a supercharger uses the drive shaft to do the same thing, while a turbo-supercharger is a combination system used mainly by aircraft. For game purposes they are identical.



Diesel Engines (TL6): Diesels are similar to gasoline engines but have a different fuel ignition system. Where gasoline engines use an electric spark for ignition, diesels compress the fuel to ignite it. Diesels are generally heavier per kW of output than gasoline engines but have two big advantages: diesel fuel is cheaper and less flammable than gasoline. Economy and safety make diesels the engine of choice for modern commercial and military applications where high performance is not essential. Diesels are also common on airships. As with gasoline engines, diesels come in standard and high-power models with or without turbocharging. They are also available in "marine" versions – these are heavy but cheap water-cooled diesels typically used by ships.

Ceramic Engines (TL8) are advanced rotary or diesel engines made of lightweight materials and capable of using most types of fuel. They are similar in function to gasoline engines and usually burn diesel fuel, although they can use gasoline or alcohol as well. They are available in standard, high-power and turbocharged models.

Hydrogen Combustion Engines (TL8) burn hydrogen and air to produce hot gasses that spin a turbine or power a rotary engine.

Internal combustion engines designed before about 1930 (early TL6) don't have a handy electrical ignition. They require hand-cranking to start. This takes a roll against Driving or Mechanic and ten seconds per attempt, with penalties up to -4 in cold weather; critical failure does 1d damage to the cranker's arm. Late TL6 engines start using a key or knob in 4 seconds, while TL7+ engines start in about two seconds. Double these times for diesels!

Internal Combustion Engine Table

Type	Weight if output is under 5kW	Weight if output is 5kW or more	Cost	Fuel
Late TL5 Gasoline	40×kW	(20×kW)+100	$1	0.06G
TL6 Standard Gasoline	12×kW	(6×kW) + 30	$2	0.045G
if turbo or supercharged	8.5 ×kW	(4.5×kW) + 20	$4	0.045G
TL6 HP Gasoline	6×kW	(3×kW) + 15	$8	0.05Av
if turbo or supercharged	5×kW	(2.5×kW) + 12.5	$20	0.05Av
TL7 Standard Gasoline	10×kW	(5×kW) + 25	$5	0.04G
if turbo or supercharged	8×kW	(4×kW) + 20	$10	0.04G
TL7 HP Gasoline	5×kW	(2.5×kW)+12.5	$20	0.045Av
if turbo or supercharged	4.25×kW	(2.25×kW) + 10	$40	0.045Av
TL6 Marine Diesel	30×kW	(18×kW) + 60	$1	0.04D
TL6 Standard Diesel	20×kW	(12×kW) + 40	$2	0.04D
TL6 HP Diesel	10×kW	(6×kW) + 20	$6	0.045D
TL7 Marine Diesel	20×kW	(12×kW) + 40	$2	0.035D
TL7 Standard Diesel	14×kW	(8×kW) + 30	$4	0.035D
if turbocharged	12×kW	(6×kW) + 30	$6	0.035D
TL7 HP Diesel	8×kW	(4×kW) + 20	$10	0.04D
if turbocharged	6×kW	(3×kW) + 15	$20	0.04D
TL8+ Ceramic Engine	6×kW	(3×kW) + 15	$6	0.03M
if turbo or supercharged	4×kW	(2×kW) + 10	$12	0.03M
TL8+ HP Ceramic Engine	4×kW	(1.5×kW) + 12.5	$20	0.04Av
if turbo or supercharged	2.5×kW	(1×kW) + 7.5	$40	0.04Av
TL8+ Hydrogen Combustion	3×kW	(1.2×kW) + 9	$30	0.25H

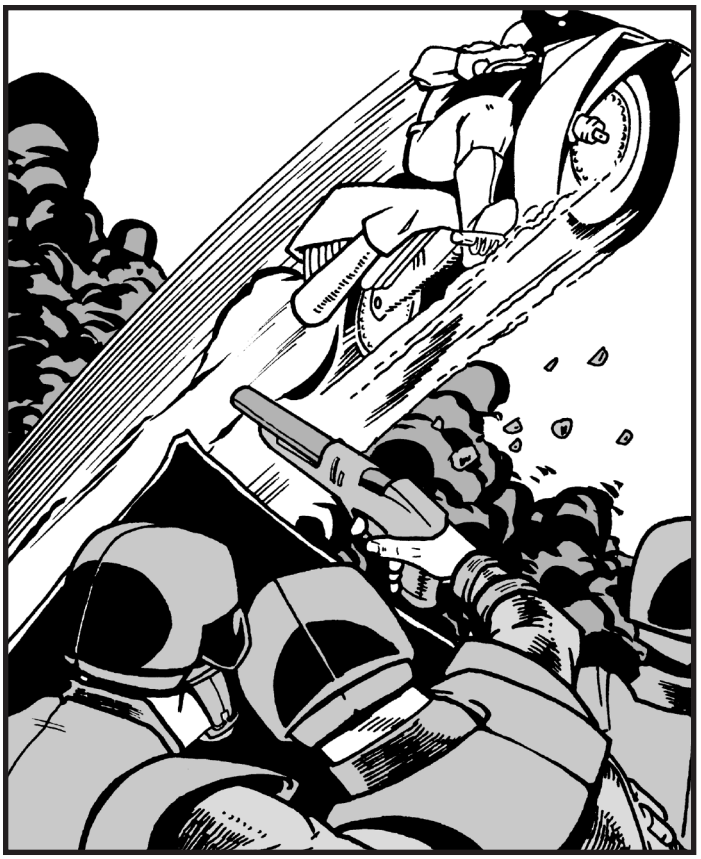
Location: Internal combustion engines can go in the body, pods or wings.

Weight: Calculate the weight of the power plant as shown on the table above, based on output. Note that there are two columns, one for power plants with outputs under 5 kW, the other for larger power plants.

Volume: Divide weight by 50 to find volume in cf.

Cost: This is the cost per pound of power plant weight.

Fuel: This is the fuel consumption in gallons per hour (gph) of fuel per kW of output. The letter next to consumption indicates the fuel type: G (gasoline), H (hydrogen), D (diesel oil), M (multi-fuel, using gasoline, diesel, alcohol or aviation gas), Av (aviation gasoline). A multifuel engine will need 1.2 × as much fuel if burning alcohol.



Option – Nitrous Oxide Booster

A gasoline, diesel or ceramic engine on a vehicle with a wheeled drivetrain, ducted fan or aerial propeller system may use a nitrous oxide booster. A tank of nitrous oxide adds 20% of the power plant's output to the effective motive power or motive thrust: recalculate acceleration and top speed based on this. The effects last 5 seconds and then the tank is used up. Each tank must be placed in the same location as the engine, and is 0.1 lbs., 0.0075 cf and $2.5 per kW of power required. Multiple tanks can increase the length of the boost, but otherwise the effect is not cumulative. Each time a tank is used, roll 1d. On a roll of 6, the power plant starts to complain (cough, cough). There is no immediate effect – but if nitrous oxide is used again without cleaning the engine, the power plant will break down!

Snorkels

The invention of the snorkel (late TL6) made prolonged underwater cruising possible for vehicles with air-breathing engines. Essentially a long breathing tube, a snorkel allows a submarine (or a vehicle driving along the bottom) to use an air-breathing engine while submerged. Maximum depth at which a snorkel can be used is about 10 yards.

A snorkel has a weight, cost and volume equal to 1% of the weight, cost and volume of an air-breathing power plant. A snorkel has a size modifier of 0 for spotting purposes. It can go anywhere in the vehicle, usually in a top superstructure or turret.

Alcohol and Propane Fuel Conversions

Alcohol and propane fuels are not listed on the power plant table above, but vehicle engines may be built to use them.

Any TL6-8 gasoline or diesel power plant that uses gasoline or diesel fuel (but not aviation gas!) can be purchased in an alcohol-burning version instead. The fuel consumption rate remains the same, but effective engine power output drops by 15%.

Converting an existing TL6 or early TL7 plant to alcohol burning costs 10% of the plant's cost. At late TL7, the use of fuel injection, pollution control gear and engine electronics prevents the conversion, although engines can still be purchased specifically as alcohol or propane burners.

Any power plant that uses gasoline fuel (not aviation gas) can be modified to use propane fuel instead. A propane engine's weight, cost and volume is 10% greater than gasoline for the same power output, and fuel consumption is 50% greater.

The advantages of propane fuel conversion are mainly in conservation of petroleum resources, price economy (if gasoline becomes scarce, propane can be cheaper) and pollution control.

Gas and MHD Turbines

Gas turbines (TL7) are derived from jet engine technology. They burn fuel and air, but unlike a reciprocating engine the expanding gasses spin a turbine blade rather than working a piston. This gives a simpler, smoother action and generally makes the power plant lighter per kW of output. On the down side, turbines are more expensive to manufacture and have a higher average fuel consumption. Gas turbines were first used on aircraft to power aerial propellers ("turboprops"). They have since become quite popular on helicopters, hovercraft and high-performance ships, and are now coming into use on armored fighting vehicles. Unless specially modified, gas turbines do not work underwater or within vacuum, trace or very thin atmospheres. Gas turbines come in standard, high power (HP) and more fuel-efficient "optimized" versions. Standard and HP turbines are the most common types used on military aircraft.

Magneto-hydrodynamic Turbines (MHD turbine, TL8) are hydrogen burning turbine engines that are coupled to a MHD generator. They use magnetic fields and an ionized plasma rather than gas as their working medium, which gives them a very high operating temperature and somewhat greater efficiency than gas turbines. MHD turbines normally require free oxygen like gas turbines, but can be very easily modified to use a "closed cycle" oxygen supply to function without external air. MHD turbines may replace the gas turbine in futuristic vehicles.

Gas and MHD turbines take one second to start.

Gas and MHD Turbines Table

TL	*Type*	*Weight if output is under 5kW*	*Weight if output is 5kW or more*	*Cost*	*Fuel Used*
Gas Turbines					
7	Optimized Gas Turbine	15×kW	(3×kW) + 60	$20	0.05M
7	Standard Gas Turbine	10×kW	(2×kW) + 40	$20	0.06M
7	HP Gas Turbine	4×kW	(1×kW) + 15	$50	0.07J
8+	Optimized Gas Turbine	7×kW	(2×kW) + 25	$12	0.045M
8+	Standard Gas Turbine	4×kW	(1×kW) + 15	$30	0.055M
8+	HP Gas Turbine	2.5×kW	(0.5×kW) + 10	$80	0.06J
MHD Turbines					
8	Standard MHD Turbine	10×kW	(1×kW) + 45	$40*	0.2H
8	HP MHD Turbine	6×kW	(0.4×kW) + 28	$200*	0.225H
9	Standard MHD Turbine	8×kW	(1×kW) + 35	$20*	0.18H
9	HP MHD Turbine	6×kW	(0.4×kW) + 28	$80*	0.2H
10+	Standard MHD Turbine	6×kW	(0.6×kW) + 27	$20*	0.15H
10+	HP MHD Turbine	4.5×kW	(0.3×kW) + 21	$60*	0.18H

Location: These power plants can go in the body, pods or wings.

Weight: Calculate the weight of the power plant as shown on the table above, based on output.

Volume: Divide weight by 50 to find volume in cf.

Cost: This is the cost per pound of power plant weight. An asterisk indicates the power plant has a minimum cost of $500, regardless of weight.

Fuel Usage: This is the fuel consumption in gallons per hour (gph) of fuel per kW of output. The letter next to consumption indicates the fuel type: M (multi-fuel, using gasoline, diesel, alcohol, aviation gas or jet fuel), J (jet fuel). A multifuel engine will need 1.2 times as much fuel if burning alcohol. H indicates the engine uses hydrogen fuel.

Closed-Cycle Operation: Gas Turbine and MHD power plants can be designed as closed-cycle engines that operate in the absence of oxygen.

For closed-cycle gas turbines, add 50% to the weight, volume and cost of the engine. Add an additional fuel consumption of 2.35 gph of oxygen (LOX) per gph of other fuel consumed.

For closed-cycle MHD turbines, there is no increase in cost, weight or volume. Just add an oxygen (LOX) fuel consumption of 0.5 gph per gph of hydrogen consumption.

EXAMPLE

We give Kitty Hawk a 216 kW standard gas turbine, which meets almost all of its normal power requirements. We put it in the body. It weighs (2 × kW) + 40 lbs, or 472 lbs. It takes up weight/50 cf, or 9.44 cf. It costs weight × $20, or $9,440. It guzzles 0.06 × 216 kW = 12.96 gallons per hour of gasoline, diesel, aviation gas or jet fuel. However, it only works in atmosphere!

Fuel Cells

Fuel cells (TL7) are electric power plants that generate energy chemically, using oxygen and hydrogen as fuel. They also *produce* water, usually released as water vapor. Normally, fuel is hydrogen, with the necessary oxygen extracted from the atmosphere, but a vehicle can also carry an oxygen supply to allow it to function in environments lacking free oxygen. Fuel cells are quiet and non-polluting, making them popular among the environmentally conscious, or in areas where fossil fuels are mostly exhausted!

Fuel cells take 1 minute to start at TL7, but only two seconds to start at TL8+.

Snorkels (p. 84) are also available for fuel cells.

Fuel Cell Table

TL	*Type*	*Weight if output is*		*Cost*	*Fuel Used*
		under 5kW	*5kW or more*		
7	Fuel Cell	20×kW	(10×kW) + 50	$20	0.15H
8	Fuel Cell	10×kW	(5×kW) + 25	$5	0.13H
9+	Fuel Cell	10×kW	(5×kW) + 25	$5	0.115H

Location: These power plants can go in the body, pods, or wings.

Weight: Calculate the weight of the power plant as shown on the table above, based on output. Note that there are two columns, one for power plants with outputs 5 kW or less, the other for larger power plants.

Volume: Divide weight by 50 to find volume in cf.

Cost: This is the cost per pound of power plant weight. There is a minimum cost of $500, regardless of weight.

Fuel Usage: This is the consumption in gallons per hour (gph) of hydrogen per kW of output.

Closed Cycle Operation: Fuel cells can be easily modified to operate in the absence of oxygen (e.g., underwater or in space). This adds a liquid oxygen (LOX) fuel consumption equal to half the hydrogen consumption.

Nuclear, Antimatter and Mass-Conversion Reactors

These power plants use radioactive decay, nuclear fission, nuclear fusion or the annihilation of matter and/or antimatter to generate power. They are most effective when vast amounts of power or operating durations measured in months or years are required.

Fission (TL7) plants produce power by splitting atoms. The heat this produces either vaporizes a working medium like water to create steam which spins a turbine or, at TL9+, generates electricity directly through thermoelectric materials. One uranium fuel rod is needed per 1,000 kW (per 10,000 kW at TL9+). Each costs $80,000, and lasts for 2 years. The weight and volume of rods in use are included in the reactor's weight and volume.

Radiothermal Generators (RTG) (late TL6) use a thermoelectric system to convert the heat produced by a decaying radioisotope to energy. They have no moving parts and do not use fuel: the radioisotope is good for several years, after which the power plant itself should be removed and replaced with another. While heavy and expensive, they are very useful in situations where a power plant is required that can operate untended and continuously for a decade or more. TL7 radiothermal generators are typically used in deep-space probes and orbital satellites.

Nuclear Power Units (NPU) (TL8) are high-performance radiothermal generators using more volatile isotopes. At TL10 and up, they can also represent exotic "cold fusion" technology if the GM decides that such systems exist in the campaign.

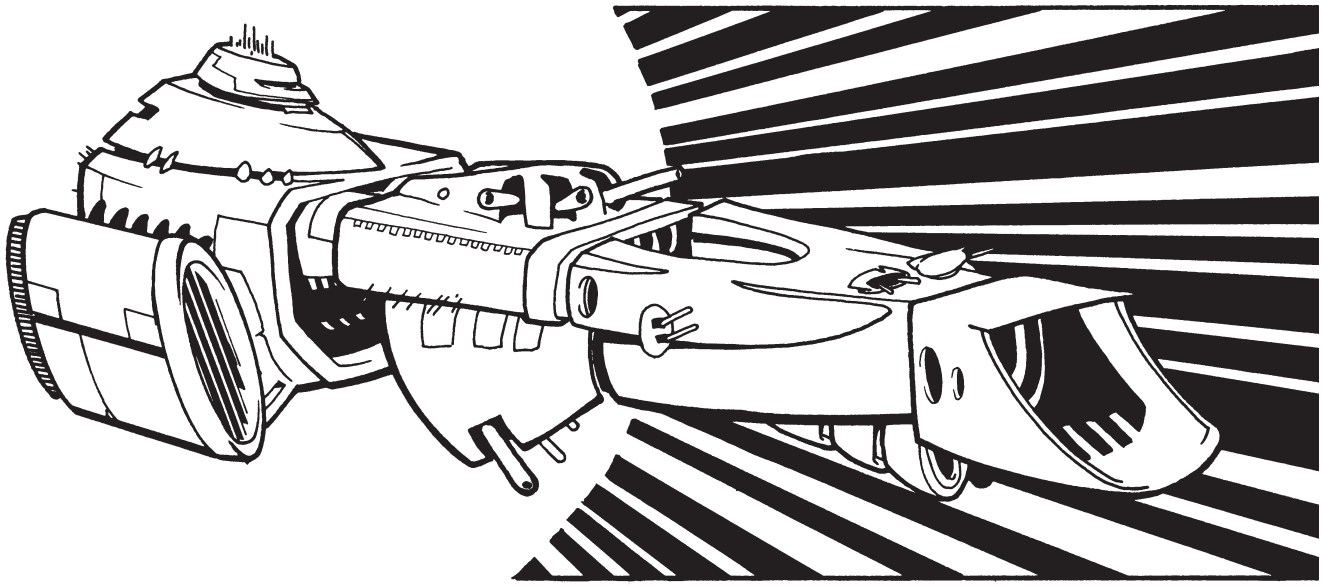
Fusion (TL9) power plants generate energy by fusing hydrogen into helium through a thermonuclear reaction. No refuelling is necessary: the power plant's internal hydrogen fuel tank lasts for 200 years.

Antimatter (TL11) plants produce energy through the mutual annihilation of matter and antimatter. A gram of antihydrogen powers a 1,000 kW plant for 2.5 years and costs $1,000. At TL12+, each gram runs the power plant for 5 years. See *Antimatter Fuel Bays* (p. 90) for rules covering antimatter storage and failsafes.

Total Conversion (TL14) power plants produce power by total conversion of mass into energy with 100% efficiency. They use trivial amounts of any kind of matter as fuel.

Cosmic (TL16) power plants produce power through means unexplainable by modern science. For example, a cosmic power plant may draw energy from another antimatter dimension, or even a magical universe. They provide power indefinitely.

All of these power plants normally run continuously until their fuel is exhausted, hence they are given an endurance in years rather than a fuel consumption. Radiothermal generators cannot be shut down. Otherwise, turning on (or shutting down) one of these power plants takes *at least* two minutes at TL7, one minute at TL8-9, 10 seconds at TL10-13 or 1 second at TL14+.



Nuclear, Antimatter and Mass-Energy Conversion Power Table

TL	Type	Weight if output is under 5kW	Weight if output is 5kW or more	Cost	Years
Fission Reactors					
7	Fission Reactor	no	(8×kW) + 20,000	$200	2
8	Fission Reactor	no	(4×kW) + 4,000	$100	2
9	Fission Reactor	no	(1×kW) + 1,000	$40	2
10+	Fission Reactor	no	(1×kW) + 1,000	$20	2
Radiothermal Generators					
6	RTG	1000×kW	(200×kW) + 4,000	$5000	14
7	RTG	300×kW	(50×kW) + 1,250	$1000	14
8	RTG	50×kW	(10×kW) + 200	$50	14
9	RTG	20×kW	(5×kW) + 75	$50	14
10	RTG	12×kW	(2×kW) + 50	$50	14
11+	RTG	6×kW	(1×kW) + 25	$50	14
Nuclear Power Units					
8	NPU	no	(8×kW) + 200	$200	0.5
9	NPU	12×kW	(2×kW) + 50	$200	1
10	NPU	6×kW	(1×kW) + 25	$200	2
11	NPU	4×kW	(0.4×kW) + 18	$200	5
12+	NPU	2×kW	(0.2×kW) + 9	$200	10
Fusion Reactors					
9	Fusion Reactor	no	(1×kW) + 20,000	$200	200
10	Fusion Reactor	no	(0.2×kW) + 2,000	$50	200
11+	Fusion Reactor	no	(0.2×kW) + 2,000	$25	200
Antimatter Reactors					
11	Antimatter Reactor	no	(0.1×kW) + 4,000	$20	2.5
12	Antimatter Reactor	no	(0.05×kW) + 2,000	$20	5
13	Antimatter Reactor	no	0.05×kW	$20	5
Total Conversion					
14	Total Conversion	no	0.02×kW	$30	infinite
16	Cosmic Power Plant	1×kW	(0.01×kW) + 4.95	$2	infinite

Location: These power plants can go in the body, pods, or wings.

Weight: Calculate the weight of the power plant as shown on the table above, based on output. Note that there are two columns, one for power plants with outputs under 5 kW, the other for larger power plants. A "no" in the under 5 kW column means a power plant cannot be built with less than 5 kW output.

Volume: Divide weight by 50 to find volume in cf except for NPUs or RTGs; for those, divide the weight by 100.

Cost: This is the cost per pound of power plant weight. Some power plants have minimum or extra costs. There is an extra cost for the reactor core of some systems: TL7 fission ($400,000), TL8 fission ($200,000), TL9 fission ($40,000), TL9 fusion ($1,000,000), TL10 fusion ($200,000), TL11 fusion ($100,000); TL11 antimatter ($200,000), TL12 antimatter ($100,000). There is also a minimum cost: all systems except RTGs have a minimum cost of $20,000; RTGs have a minimum cost of $2,000.

Years: This is the number of years the power plant can operate for using its internal built-in fuel supply. Total conversion power plants have a negligible fuel requirement and can operate indefinitely on minute amounts of matter.

Exotic Power Plants

These power plants are primarily intended for use in fantasy, science fantasy, supers or horror games.

Bioconvertors are bio-mechanical machines living inside the vehicle, eating food and producing bioelectrical or mechanical energy. They generate energy using food and atmospheric oxygen, and have a "mouth" into which water and food (anything biological) must be placed. All bioconvertors require 1 gallon of water per kW of output per day. Herbivore bioconvertors also eat ten pounds per day of any plant material per kW. Carnivore bioconvertors require two pounds of meat per day per kW. Omnivore bioconvertors require either meat or plant material. Finally, the Vampire bioconvertor requires 1 gallon of blood per kW per day. (An average human body has 1.5 gallons of blood.) It would require TL10 genetic engineering to build them, but wizards or alien cultures with advanced biotechnology might create them at much lower TLs, perhaps by breeding exotic animals.

Soulburner is a generic term for a necromantic machine fuelled by life-force. It does not use normal fuel. Instead, an intelligent, sentient being must be placed within it. A soulburner's victim loses HT every 10 hours equal to the power output of the soulburner in kW. For example, a person placed within a 30 kW soulburner loses 30 HT every 10 hours, or 3 HT per hour. When a victim dies, he must be replaced if the power plant is to continue operation. Soulburners do not function in no-mana areas. A vehicular soulburner can be created by a TL1+ mage who knows the Enchant, Summon Demon and Steal HT spells; the Soulburner requires 600 energy to create per kW of power output. Damage caused by a soulburner heals at the normal healing rate. Regeneration, medicine or Healing spells do not speed recovery.

Air-Golems (p. M70) can be used to drive muscle engines (p. 82). Each air golem is the equivalent of a ST 15 person, thus generating 0.3 kW of power.

Elemental Furnaces (also called "infernal combustion engines") are magical steam engines using bound fire and air (for combustion) elementals. An elemental furnace functions like a TL5 steam engine, except that it can be built by any TL4 blacksmith working with a mage and requires no fuel. It requires a mage with the Fireproof, Air Golem, Control and Summon Fire Elemental and Control and Summon Air Elemental spells to create it, costing 300 energy per kW of power output. Also, any ordinary, TL5+ steam engine may be "elemental-enhanced" with a bound fire elemental to provide extra control. The air spells are not needed and energy cost is halved; elemental enhancement adds 100% to the engine's power output.

Mana Engines are technomagic devices that gather ambient magical energy (in the same way a mana organ does in a magical creature) and transform it into electrical power. They do not require fuel, but do not function in no-mana zones. To create a mana engine requires a variant of the Powerstone spell cast on a rune-carved copper or silver metal sphere or block, which then produces a controllable amount of electrical power. The energy cost is 100 per kW of power output. The spell's prerequisite is the Power spell.



Exotic Power Plants Table

TL	Type	Weight if output is under 5kW	Weight if output is 5kW or more	Cost
Magical				
1-4	Mana Engine	50×kW	(25×kW) + 125	$20*
5-7	Mana Engine	10×kW	(5×kW) + 25	$50*
8+	Mana Engine	2×kW	(1×kW) + 5	$50*
1-4	Soulburner	no	(2×kW) + 500	$100
5-7	Soulburner	no	(0.2×kW) + 500	$100
8+	Soulburner	no	(0.02×kW) + 500	$100
4	Elemental Furnace	50×kW	(25×kW) + 125	$2
Bioconvertors				
10	Carnivore	20×kW	(10×kW) + 50	$100**
10	Herbivore	30×kW	(15×kW) + 75	$50**
10	Omnivore	25×kW	(12×kW) + 65	$100**
10	Vampire	16×kW	(8×kW) + 40	$200**

Location: These power plants can go in the body, pods, or wings.

Weight: Calculate the weight of the power plant as shown on the table above, based on output. Note that there are two columns, one for power plants with outputs under 5 kW, the other for larger power plants. A "no" in the "under 5 kW" column means a power plant cannot be built with less than 5 kW output.

Volume: Divide weight by 50 to find volume in cf.

Cost: This is the cost per pound of power plant weight. Some power plants have minimum costs. They are:

* Minimum cost is $1,000, regardless of weight.

** Minimum cost is $4,000, regardless of weight.

The costs listed for magical power plants do not include the costs of the various enchantments, since these will vary depending on how common magic is. In a "common magic" setting (see ***GURPS Magic***), add an additional $25 per energy point to the cost of the power plant.

Fuel Usage: Most exotic power plants do not require fuel. Bioconvertors devour water and solid food, while soulburners devour life force.

Electric Contact Power (TL6)

Rather than having an internal power plant, a vehicle with a wheeled drivetrain may be built to draw power from an electrified railway track (if it has railway wheels) or from an overhead wire (any wheeled vehicle). A vehicle with a mag-lev lifter can also be given this option, but "contact" with a mag-lev track is electromagnetic, not physical. The various power pick-ups and transformers needed for this are treated exactly as if they were a power plant.

Electric Contact Power Table

TL	Wt.	Cost
6	10	$4
7	5	$8
8	2	$8
9+	1	$8



Location: These power plants must go in the body; power plants drawing power from an overhead wire may go in top-mounted turrets, superstructures or open mounts instead of the body.

Weight: Weight is per kW of power it can draw from the rail.

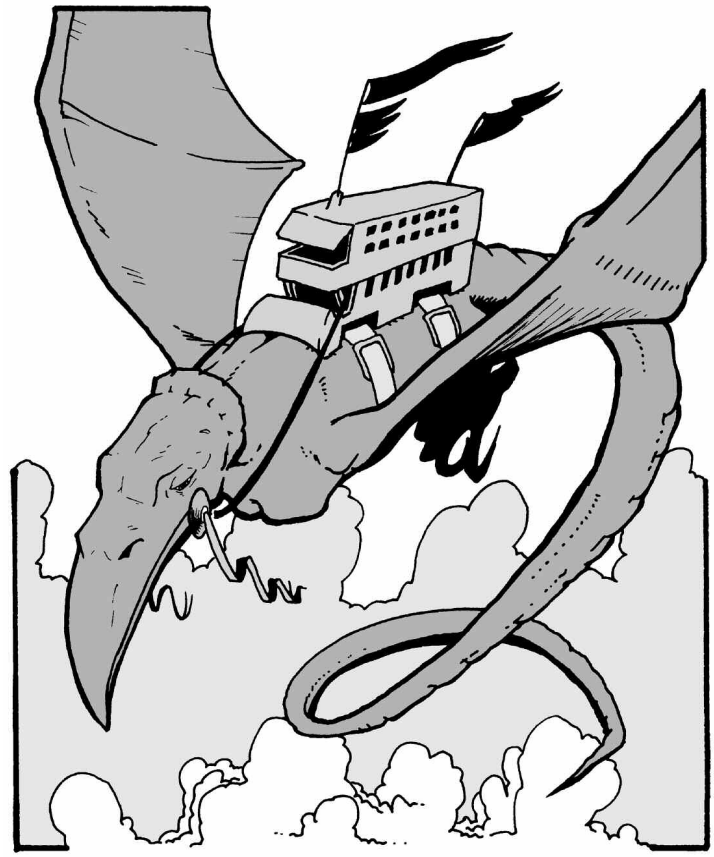
Volume is weight/50 cf.

Cost: is multiplied by weight to get the actual cost.

Beamed Power (TL8)

Beamed power involves beaming energy using a transmitter (usually a microwave beam or laser) from a power station to a receiver. It is generally used to allow a vehicle that lacks a power plant to receive power from a larger, stationary ground station. However, some large vehicles (e.g., aircraft carriers) might use beamed power to power smaller craft. Beamed power is most practical for aircraft, since they can easily maintain a line of sight to the power beam.

A *beamed power transmitter* (TL8) is built exactly like a continuous-beam maser or laser beam weapon (p. 123) except that after designing it, the transmitter's SS is 5 higher and its damage when used as a weapon is halved. It transmits 1 kW of power to the receiver per kJ of beam output, halved at half damage range. To operate, the power transmitter must be hooked up to a power plant or energy bank of some sort. The transmitter beam requires line of sight to the receiver (so the beam is blocked by hills, other vehicles, etc.). If anything except the receiver gets in the way of the power beam, it will take damage as if the beam had been used as a weapon.



A beamed power transmitter should normally be mounted in a rotating turret to allow it to track the power receiver.

A *beamed power receiver* (TL8) functions like a power plant as long as it is receiving power from a beamed transmitter. A power receiver can be designed to receive *either* laser or maser beamed power, not both. It may be installed in any vehicle at a base cost of $1,000 plus a weight, volume and cost that depends on the maximum amount of power that can be received: 5 lbs., 0.1 cf and $1 per kW of transmission beam power. If a more powerful beam is used than the receiver can handle, it will be destroyed, and the vehicle housing it will take damage.

Energy Banks

An energy bank stores electrical power. A vehicle may have one instead of or as well as a power plant. If the vehicle's power plant output does not match the power requirements of all simultaneously-operating systems, then the vehicle must have an energy bank. Note that it is a good idea to install an energy bank if a deflector or force screen is to be used, unless you have added some spare power capacity to your power plant, because fields are added as surface features late in the design process, after the power plant has already gone in, and produce additional power demands.

Energy stored in an energy bank is measured in kilowatt-seconds (kWs) – one kilowatt of power for one second. Each kWs of stored power provides the same power as a 1-kW power plant – but only for a second. Or it could provide 0.5 kW for 2 seconds, 0.001 kW for 1,000 seconds, and so on. Then the energy bank is drained of power until it is recharged.

Thus, a vehicle whose systems require 1 kW of power would drain 1 kWs every second, or 60 kWs every minute, or 3,600 kWs every hour. Similarly, if it had an energy weapon that used 180 kWs of energy every shot and it fired five shots, it would drain 900 kWs.

An energy bank is useful if the vehicle has a power plant, since it can make up any shortfall when power requirements exceed power plant output. As long as the vehicle has an energy bank, the actual power requirement doesn't have to be known to the last kilowatt while the vehicle is being designed. For instance, consider a vehicle with both a power plant and an energy bank; if the power plant generates 100 kW but the vehicle needs 105 kW to operate several systems at once, the vehicle will still function perfectly well: the power plant provides 100 kW, and the remaining 5 kW are provided by the energy bank, which would be drained at a rate of 5 kWs per second (18,000 per hour).

To design an energy bank, decide how many kWs of power it will store. For comparison purposes, a typical car battery stores about 2,000 kWs, while a large ultra-tech power cell (an "E cell," at 20 lbs. and $2,000) stores about (TL-6) × 180,000 kWs. Then select the type of energy bank: clockwork, batteries, flywheels, rechargeable power cells or non-rechargeable power cells.

Clockwork (TL4) also represents springs, giant rubber bands, etc. It is the simplest method of storing energy.

Lead-Acid Batteries (late TL5) are early battery designs. TL6 lead-acid batteries remain in use through TL7, as a cheaper alternative to advanced batteries.

Advanced Batteries (TL7) represent various contemporary and projected battery technologies.

Flywheels (TL6) store energy in a rapidly-rotating wheel.

Non-Rechargeable Power Cells (TL8): These are volatile electrochemical or nuclear-thermal batteries using exotic fuels (e.g., californium, metastable helium). They can't be reused once drained – remove the cells and install new ones at full cost. A power cell storing 180,000 kWs × (TL-6) is the same as an "E cell" from ***GURPS Ultra-Tech.*** It is 20 lbs., 0.2 cf and $2,000.

Rechargeable Power Cells (TL8): These are either sophisticated photonic or superconductor loops. They can be recharged. A power cell storing 90,000 kWs × (TL-6) is the equivalent of a rechargeable "E cell" from ***GURPS Space.*** It is 20 lbs., 0.2 cf and $2,000.

Then find the weight, volume and cost using the following table:

Energy Bank Design Table

TL	*Type*	*Weight*	*Cost*
4+	Clockwork	0.25	$20
5	Lead-Acid Battery	0.03	$0.25
6	Lead-Acid Battery	0.025	$0.5
7+	Lead-Acid Battery	0.02	$1.25
7	Advanced Battery	0.005	$10
8+	Advanced Battery	0.001	$30
6	Flywheel	0.8	$0.5
7	Flywheel	0.01	$5
8	Flywheel	0.005	$10
8	Rechargeable Power Cell	0.00011	$100
8	Power Cell	0.000055	$100
9	Rechargeable Power Cell	0.000074	$100
9	Power Cell	0.000037	$100
10	Rechargeable Power Cell	0.000056	$100
10	Power Cell	0.000028	$100
11	Rechargeable Power Cell	0.000044	$100
11	Power Cell	0.000022	$100
12	Rechargeable Power Cell	0.000037	$100
12	Power Cell	0.0000185	$100
13	Rechargeable Power Cell	0.000032	$100
13	Power Cell	0.000016	$100
14	Rechargeable Power Cell	0.000028	$100
14	Power Cell	0.000014	$100
15	Rechargeable Power Cell	0.000025	$100
15	Power Cell	0.0000125	$100
16	Rechargeable Power Cell	0.000022	$100
16	Power Cell	0.000011	$100

Location: Energy banks can go in the body, or in turrets, superstructures, pods, wings, arms, or legs.

Weight: Multiply the weight given on the table by the energy stored (in kWs) to find the weight (lbs.).

Volume: To find volume, divide weight by 200 if a lead-acid battery, by 100 if a TL7 advanced battery or any power cell, or by 50 if clockwork, flywheel or TL8+ advanced battery.

Cost: Multiply weight by the number shown under *Cost* to find the actual cost.

Recharging: Batteries, flywheels and rechargeable power cells can be recharged by plugging into any power plant. Every second that 1 kW is channelled into the power cell restores 1 kWs of power. Clockwork must be physically rewound, taking 50 seconds per kWs of stored power, divided by winder's ST. A power plant can be used to rewind the clockwork instead: the gear differential adds 5% to the clockwork's weight, cost and volume, and the effective ST of the motor is 50 × kW. Other power cells cannot be recharged.

EXAMPLE

We want to install an energy bank capable of powering Kitty Hawk underwater, where the gas turbine can't breath. We decide to use TL7 advanced batteries. We've already seen that only 43.25 kW of power is needed to run Kitty Hawk underwater. Morgan would like Kitty Hawk to be able to cruise underwater for at least an hour. This is 3,600 seconds, so that means that 43.25 × 3,600 = 157,700 kWs are needed. Using advanced batteries, that is 778.5 lbs., 7.785 cf and $7,785.

Fuel

Any vehicle with a power plant, jet or rocket engine that has a rated fuel consumption requires fuel plus either fuel bunkers (for coal or wood, see below) or fuel tanks (for other types of fuel, see p. 89).

EXAMPLE

Kitty Hawk's jet engine burns jet fuel; its gas turbine can use several types of fuel, but we decide it normally burns jet fuel too, so they can share the same tank.

Coal, Wood and Fuel Bunkers

Coal and wood are both solid hydrocarbon materials that can be burned in steam engines. Coal has more energy, but wood is almost always cheaper and easier to find. If the vehicle's power plant burns coal or wood fuel, it must have a fuel bunker.

A bunker is rated for the cubic feet of coal or wood it can store. Its empty weight, volume and cost is 6 lbs., 1.2 cf, and $1 per cf of fuel storage.

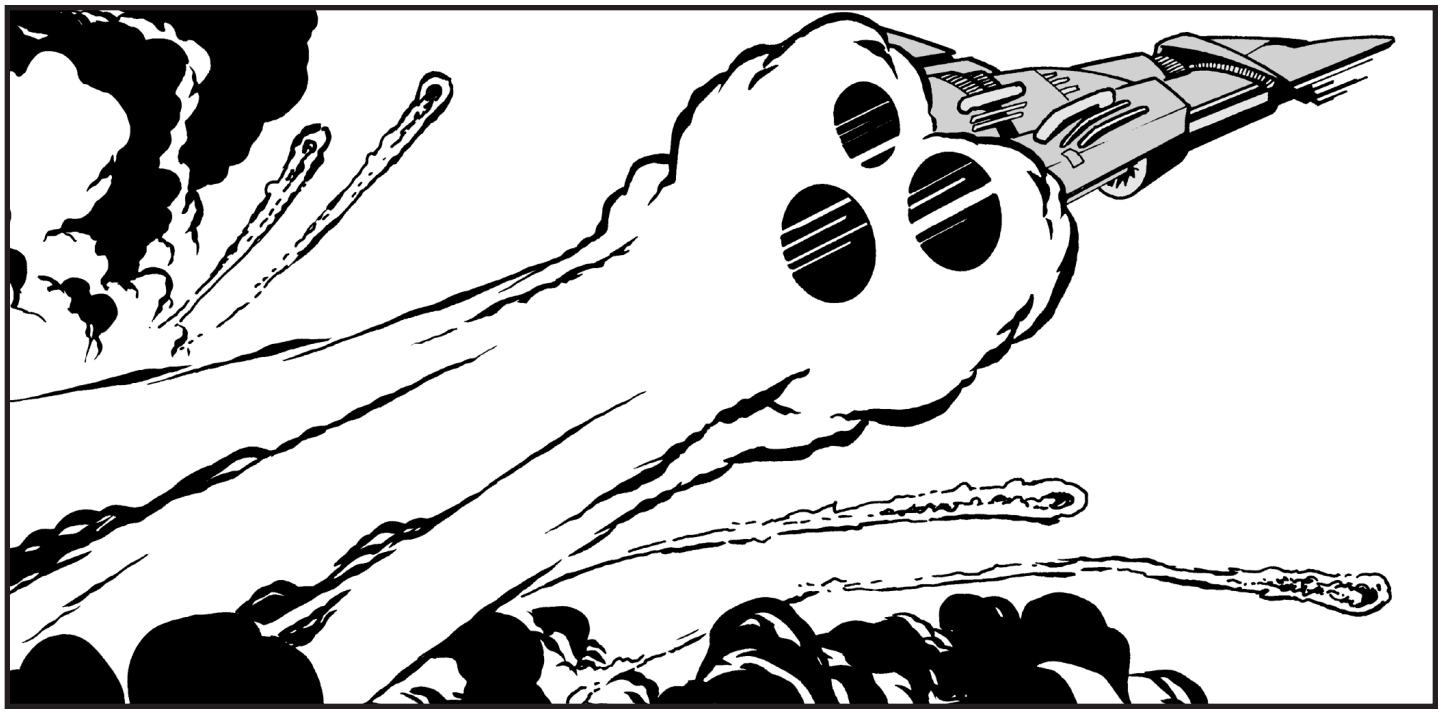
To decide how big a bunker is needed, multiply the cubic feet per hour of coal or wood the vehicle's power plant consumes by the number of hours for which it is to power the vehicle before requiring refuelling. Ground vehicles like steam locomotives are normally designed with less than a day's fuel, while steam boats and ships often carry fuel to last for several days.

Location: Fuel bunkers can go in the body, wings, pods, turrets, superstructures, open mounts, arms or legs.

Weight & Cost of Solid Fuel: Coal is 50 lbs. and $1 per cf, wood is 30 lbs. and $0.2 per cf.

Fuel Tanks

Vehicles that have reaction engines or power plants with a fuel requirement measured in gallons per hour must install a fuel tank. If a power plant or engine that needs fuel is not provided with fuel, it does not function.



Fuel tanks may have various options, which will affect weight and cost:

Light (TL5) fuel tanks are built using more costly but lighter-weight materials. They are fairly common on aircraft and racing vehicles, but are somewhat more likely to catch fire.

Ultralight (TL6) fuel tanks use very expensive, very light materials, but are more vulnerable to catching fire. They are used where weight is absolutely crucial, e.g., on spacecraft. A tank cannot be both light and ultralight.

Self-sealing (TL6) fuel tanks will seal after being damaged. As a result, they do not leak, are less likely to catch fire, and limit the damage from fuel tank explosions. See pp. 183-184 for the benefits of self-sealing tanks in combat. They are heavier and more expensive. A light or ultralight tank can also be self-sealing.

To install a tank in the vehicle, decide on its capacity in gallons, whether or not it is has any options, and the type of fuel it holds.

A good way to select the capacity is to multiply the gallons per hour of fuel the power plant or engine consumes by the number of hours of endurance between refuellings. Fuel for aircraft and ground vehicles is usually between one and twelve hours, while ocean-going ships often carry several days' fuel.

If the vehicle requires two different kinds of fuel (e.g., one for a reaction engine and one for a power plant) install two separate tanks. Separate tanks can be installed in different locations in the vehicle. The table below shows the cost, weight and volume of the fuel tank per gallon of fuel. The "fire" column is the modifier to the chance of the tank catching fire (if it contains a flammable liquid or gas).

Fuel Tank Table

TL	*Type*	*Weight*	*Vol.*	*Cost*	*Fire*
5	Standard Tank	2.5	0.15	$1	+1
6	Standard Tank	1.5	0.15	$2	+1
7	Standard Tank	1	0.15	$5	0
8+	Standard Tank	0.5	0.15	$5	-2
Options					
Light		×0.5	×1	×2	+1
Ultralight		×0.1	×1	×5	+2
Self-sealing		×2	×1	×2	-1

Location: Fuel tanks can go in the body, wings, pods, turrets, superstructures, open mounts, arms or legs.

Weight, volume and cost are per gallon. The actual weight of the fuel itself is not included.

Fire: Some fuel types have a "Fire" number. The type of tank will modify that number as shown above.

After the fuel tank is installed, refer to the *Reaction Mass and Fuel Table* on p. 90 to find out how much a full tank of fuel weighs and costs. The fuel in the tank will increase the loaded weight of the vehicle, but not its empty weight.

EXAMPLE

The gas turbine uses 12.96 gph of jet fuel, diesel, gasoline or aviation gas; the jet engine uses 15 gph jet fuel. We decide on a 60-gallon tank, with the light and self-sealing options. This works out to 60 lbs., 9 cf, $1,200 and Fire +0.

Types of Liquid Fuel

The perfect fuel should be naturally abundant or cheap to refine, be safe and easy to handle, and store a lot of potential energy that can be easily released by the power plant or engine. No one has come up with a fuel that does all that at once, so there are a lot of choices!

Water isn't a fuel as such, but is used in steam engines and as a reaction mass in many space drives, especially fusion rockets.

Gasoline is a hydrocarbon petroleum distillate with a high thermal energy. It is the commonest type of fuel for TL6-7 ground vehicles. Prior to the twentieth century, gasoline was a largely useless waste product produced while refining lamp oil. However, gasoline proved to be the ideal fuel for internal combustion power plants, and by the middle of the TL6 period it had become vital to the twentieth-century economy. It is flammable.

Diesel fuels are similar to gasoline, but cheaper to produce. They can only be used in special diesel or multi-fuel engines. Aside from economy, they are less likely to catch fire than gasoline, making them useful for military vehicles. Due to diesel's cheapness, diesel-fuelled engines are very common in cargo trucks, ocean vessels and construction machinery.

Aviation Gas is higher-octane gasoline, used in high-performance power plants like aircraft engines. It is more costly and flammable than regular gasoline.

Jet Fuel is basically kerosene, and is heavier and more expensive than gasoline. Different grades of jet fuel exist for different engines, but in game terms the effects are the same, although the GM may decide that, for instance, a TL8 high-performance turbofan will lose a small percentage of its thrust if run on the same fuel as a TL7 basic turbofan.



Propane and *Liquified Natural Gas* are flammable gases, stored as cryogenic liquids. They are available at late TL7. Propane-burning engines are less powerful but more fuel-efficient than gasoline-burning ones.

Alcohol fuels may be *ethanol* (grain alcohol) or *methanol* (wood alcohol). They are much less efficient than gasoline, but can be distilled from fermented vegetable matter, which makes them useful in areas that lack petroleum. In any place lacking accessible petroleum reserves (maybe Earth, in the future), many internal combustion engines will run on alcohol fuels instead of gasoline.

Hydrogen is liquified hydrogen. As the most abundant element in the universe, it is cheap and can easily be refined from water or, in space, from the atmospheres of gas giants like Jupiter. It is combined with atmospheric oxygen and used in fuel cells, burned with oxygen in hydrogen engines or hyperfan jet engines, and serves as reaction mass for numerous space drives.

Liquid Oxygen ("LOX") is a common oxidizer for closed-cycle engines. It is most often used with hydrogen to allow fuel cells to function in the absence of oxygen. Drawbacks include the fact that it is a cryogenic material, and that it evaporates in storage.

Cadmium is the reaction mass of choice for high-performance ion rockets. It is ionized and expelled as a high-energy particle beam to propel the vehicle. Cadmium is extremely toxic, so any workers handling it need protective suits.

Metal/LOX is a cryogenic slurry of a metal powder in liquid oxygen. The exact metal may vary, but aluminum and magnesium are common in rock, and perform about equally. It is a tricky fuel to burn, requiring tougher pumps and engine parts to resist abrasion from both the metal powder and the exhaust, which is essentially hot, fine sand. The advantage of Metal/LOX is that it can be produced from lunar materials or powdered asteroid, making it more available in space.

Rocket fuel represents various non-cryogenic, liquid rocket propellants that either combine fuel and oxidizer in a single liquid compound (monopropellant) or as a pair of miscible liquids (multi-propellant). Almost all rocket fuels are toxic, corrosive and likely to ignite. Old, impure or improperly-stored rocket fuels have a disturbing tendency to explode spontaneously. Rockets fuels are often poisonous, corrosive or give off toxic vapors. The GM may require any TL6 vehicle with a tank of rocket fuel to make a Fire roll whenever it takes any hard jolt or impact, including aircraft landings. This may be extended to any TL7 fuel tank that has been reused without careful cleaning and inspection, or which has been contaminated.

Weight and cost of fuel per gallon are shown below, along with the base chance that the fuel will ignite if the tank is damaged:

Reaction Mass and Fuel Table

Fuel	*Weight*	*Cost*	*Fire*
Alcohol	5.8	$0.5	10
Aviation Gas	6.5	$2	13
Cadmium	67	$860	–
Diesel	6	$1.2	9
Gasoline	6	$1.5	11
Jet Fuel	6.5	$3	13
Rocket Fuel	10	$2	13
Water	8.5	–	–
Cryogenic Fuels & Reaction Masses			
Hydrogen	0.58	$0.1	13
Metal/LOX	12	$15	13
Oxygen (LOX)	9.6	$0.1	13*
Propane/LNG	4.2	$0.5	13

Weight is the weight per gallon of fuel or reaction mass.

Cost is the cost per gallon of fuel at TL7+. Divide cost by 5 at TL6-. In some backgrounds, fuel costs may be much higher: for instance, in a world where fossil fuels have been exhausted, exorbitant prices may be charged for any remaining stocks of gasoline, diesel, aviation gas and jet fuel.

Fire: Some fuel types have a "Fire" number. This or less is the chance on 3d that the fuel will catch fire under the conditions described in the *Combat* chapter (e.g., damage).

* LOX itself does not burn, but almost *anything* that is flammable will be ignited by a spark, or even moderate heat, in the presence of pure oxygen! For this reason, LOX has an effective Fire number of 13; treat this as 8 if the vehicle and its contents are *totally* fireproof (GM's option).

EXAMPLE

Sixty gallons of jet fuel is 390 lbs., Fire 13 and fuels the turbofan for 4 hours or the gas turbine for 4.62 hours, or both at once for 2.145 hours. If Kitty Hawk can't get jet fuel, she can top off at a normal gas pump with diesel or gasoline, but that can only be used to run the turbine, not the more fastidious turbofan.

Antimatter Fuel Bays

A vehicle with an antimatter reactor or reaction engine must store antimatter fuel in an antimatter fuel bay, or "trap." The weights and costs below include a dedicated, internal RTG or NPU for power; an antimatter fuel bay has no power requirement, and containment will be maintained even if the vehicle loses power.

Antimatter Storage Table

TL	*Type*	*Weight*	*Volume*	*Cost*
9	Antimatter bay	500	5	$5,000
10	Antimatter bay	200	2	$2,000
11	Antimatter bay	100	1	$1,000
12	Antimatter bay	50	0.5	$500
13	Antimatter bay	25	0.25	$250

Weight, Volume and *Cost* are per gram of antimatter stored.

Failsafe systems can be added. These backups make a damaged trap less likely to explode. Add 100% to weight, volume and cost for each -1 penalty to the chance of an explosion occurring. If desired, failsafes can also be added to an antimatter reactor or engine, using the same rules.

Antimatter

Antimatter (usually in the form of antihydrogen) is unavailable in any significant amount until TL8, and is not used in engines or reactors until TL9. The cost of a gram of antimatter is $100,000 at TL9, $10,000 at TL10, $1,000 at TL11, $500 at TL12 and $250 at TL13+.



SURFACE AND EXTERNAL FEATURES 8

This chapter covers a variety of miscellaneous features that can be added to the exterior of a vehicle.

Concealment and Stealth Features

These features are designed to make the vehicle harder to detect.

Camouflage Paint (TL0): A good paint job can make a vehicle harder to spot. Appropriate camouflage (e.g., black paint at night, desert camo in the desert, dazzle camouflage designed to confuse the eye at sea, etc.) gives a -2 to Vision rolls to spot the vehicle. A neutral color scheme gives no modifier. A contrasting camouflage job (e.g., jungle camouflage in the arctic), or an especially bright paint job, makes the vehicle easier to see – +2 to Vision rolls. The first paint job comes with the vehicle. Repainting a vehicle can take a day or so – more for large ships or intricate schemes. A new paint job takes 1 minute times surface area to spray on. Divide this by the number of people painting. If using rollers and brushes rather than spray paint, multiply time by 5.

Infrared Cloaking (late TL7): This makes the vehicle harder to spot with infrared, thermograph or a PESA using thermograph mode, and more difficult for heat-seeking (infrared, or IR-homing) missiles or projectiles to track it. Two levels are available, basic and radical cloaking. IR cloaking subtracts the system's (TL-4) if basic or (TL-4) × 2 if radical from rolls to attack or spot the vehicle with these sensors, or to track the vehicle with infrared homing missiles.

Emission Cloaking (TL8): This is like IR cloaking, but also masks the vehicle's non-acoustic noise (such as EM emissions), magnetic, millimetric and (at high TLs) gravitic emissions as well.

Sound Baffling (TL7): A vehicle with sound baffling is less noisy – submarines, sub-hunting warships and combat helicopters often have sound baffling to make them harder to detect, but it can also reduce noise pollution! Sound baffling represents a variety of internal and surface measures to reduce the vehicle's noise level. Care is taken to mask sounds emitted from the vehicle, especially those of propellers and engines. Equipment is carefully mounted so its vibrations are reduced. A vehicle with sound baffling may have either basic or radical levels. Radical sound baffling is even more obsessive in its quest for noiselessness: the vehicle's surface may be covered with special tiles designed to degrade sonar detection. At higher TLs, the vehicle surface may actually alter its shape to absorb sound. Basic sound baffling subtracts its TL-4 from rolls to hear the vehicle or detect it with any form of microphone, sound detector or passive sonar. Radical sound baffling is twice as effective: -2 × (TL-4); it also subtracts TL-4 from attempts at active sonar sensing.

Stealth (late TL7): A vehicle can be constructed using special materials and shapes to make it harder to be detected by radar or imaging radar. At TL7, this involves the use of "radar absorbent materials" (RAM) such as iron ferrite paints and carbon composites with special electrical properties. Radar can be further degraded by altering the design of the body, reducing the number of vertical surfaces and replacing sharp angles with curves or carefully-faceted shapes. At TL8+, stealth progresses to the extent that the outer skin of the vehicle may be embedded with phased arrays of smart, microscopic active transmitters that automatically blend the vehicle's electromagnetic signature into the local environment.

There are two levels of stealth, basic and radical. Radical stealth cannot be combined with basic stealth, nor can it be added to vehicles with open mount, biplane wing, triplane wing or mast subassemblies, or with exposed or cycle seats. Either kind of stealth loses its effectiveness if the vehicle has loaded hardpoints (though unloaded hardpoints are fine, and the vehicle will become stealthy again after dropping its load).

Basic stealth subtracts its TL-4 from radar detection; radical stealth subtracts (TL-4) × 2. At TL8+, stealth is also effective against ladar. A vehicle with basic stealth normally has some smooth contours, but can pass as an ordinary vehicle. One with radical stealth always *looks* stealthy – think of the B-2 bomber or F-117 strike fighter's appearance.

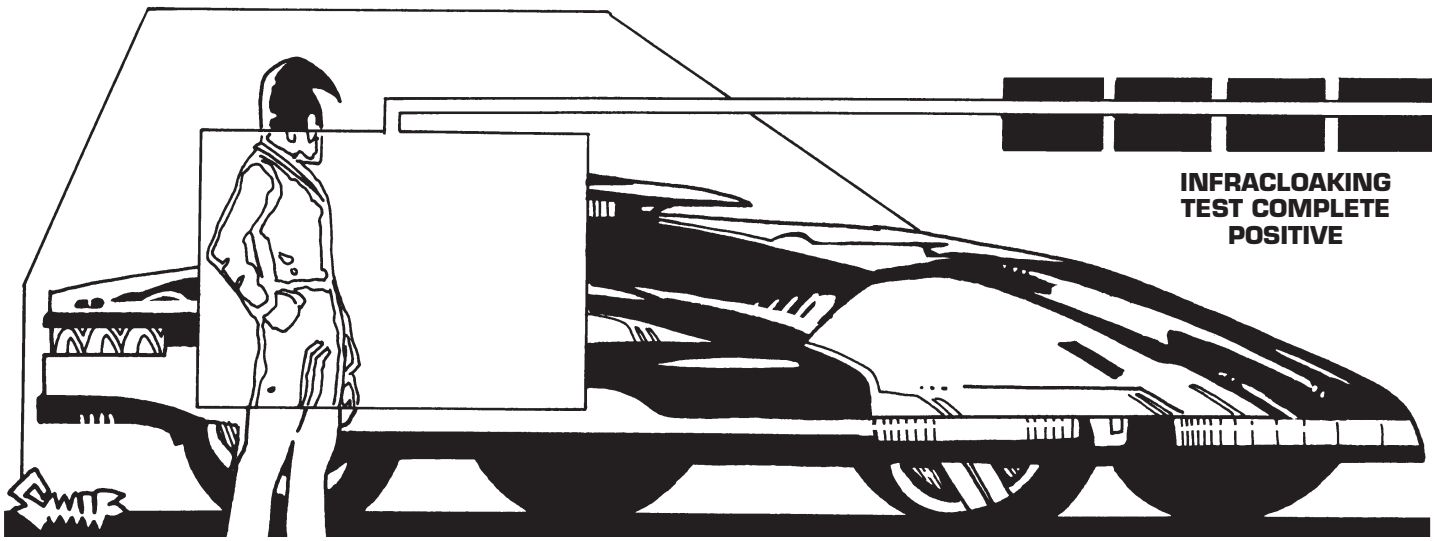
Liquid Crystal Skin (TL8): A simple system that allows the vehicle to assume any paint job or camouflage pattern. The pattern must be manually locked in, and takes five seconds to select.

Chameleon Systems (TL8): These systems give the vehicle sensor-equipped skin that automatically alters its appearance to blend in with any background. This reduces the chance of visually spotting the vehicle, or of hitting it.

A TL8 *basic chameleon system* system is -3 (-1 if moving) to be visually spotted or hit, or detected by ladar.

A TL9 *instant chameleon system* is -6 (-3 if moving) to be visually spotted or hit, or detected by ladar.

A TL10 *intruder chameleon system* makes the vehicle nearly invisible: -10 (-6 if moving) to be visually spotted or hit, or detected by ladar.



The automatic camouflage feature can also be turned off, allowing the vehicle to electronically "paint" itself with whatever color scheme or markings are desired, or give itself a silvery skin identical to a reflective surface.

Psi-Shielding (TL8): This generates a psychic barrier identical to a telepathic Mind Shield. The shield subtracts 6 from the skill of any use of Telepathy, friendly or hostile, against or by the occupants of the vehicle, exactly as if it were a Mind Shield used by a telepath with a skill of 3 and a Power of 6. The shield circuits automatically warn the vehicle crew when a telepath *fails* to penetrate the shields, but provide no warning if a telepath succeeds. Psi-shielding is available at TL8; at each TL after its introduction, the Power of a psi shield increases by 2.

Concealment and Stealth Features Table

TL	*Type*	*Weight*	*Cost*	*Power*
0	Camouflage	0	$0.1	0
7	Basic Infrared Cloaking	2	$300	0
7	Radical Infrared Cloaking	4	$3,000	0
8	Basic Emission Cloaking	2	$300	0
8	Radical Emission Cloaking	4	$3,000	0
7	Basic Sound Baffling	2	$100	0
7	Radical Sound Baffling	4	$1,000	0
7	Basic Stealth	2	$300	0
7	Radical Stealth	4	$3,000	0
8	Basic Chameleon	0.4	$80	neg.
9	Instant Chameleon	0.5	$100	neg.
10	Intruder Chameleon	0.6	$400	neg.
8	Liquid Crystal Skin	0.2	$40	neg.
8	Psi Shielding	0.1	$100	neg.

Multiply weight and cost by the total surface area of the vehicle. *Exception:* For sound baffling, ignore area of skids, masts and gas bags.

Except for camouflage, weight and cost are halved one TL after the system's introduction, and halved again two or more TLs after introduction.

EXAMPLE

We decide that the Kitty Hawk will have basic stealth. Weight and cost are based on the 324 sf surface area. It weighs 2 lbs. × 324 sf = 648 lbs. and costs $300 × 324 sf = $97,200.

Defensive Surface Features

This subset of armor includes features designed to protect the vehicle from special dangers (like radiation or laser beams).

Radiation Shielding (TL7): This protects the vehicle and its occupants against radiation. It is measured in protection factors (PF). Divide the rads of received radiation by the PF of the shielding. PF is 10 at TL7, 100 at TL8, 1,000 at TL9-10, 10,000 at TL11-12, 100,000 at TL13+. Radiation shielding alone will not protect the occupants against airborne contamination, such as a radioactive cloud, dust or bomb debris – for that, a sealed vehicle with a life system or NBC kit is also needed.

Vehicles with heavy armor (DR 100+ laminate or metal) or a force screen may omit radiation shielding, since such armor and force screens already provide significant incidental protection (see p. 167). Two or more layers of shielding can also be used, adding their PF together; each layer has the full cost and weight given on the table. Likewise, the PF from armor or force screens is added to the PF from radiation shielding.

Reflective Surface (TL7): This gives the vehicle PD 6, or +1 to PD (whichever is better, enabling the vehicle to have up to PD 7) vs. laser beams (but not x-ray or graser beams). However, it adds +2 to the chance of being detected by radar. It cannot be added to a vehicle with chameleon or stealth systems.

Retro-Reflective Coating (TL9): As above, but covered with an array of tiny mirrors designed to bounce any laser beam (but not X-ray laser or graser beams) *back at the attacker!* This occurs if the coating's PD bonus makes the difference on a Dodge roll vs. the incoming attack. A retro-reflective coating adds +4 to the chance of a vehicle being detected by radar. It cannot be added to a vehicle with chameleon or stealth systems.

Thermal Superconductor Armor (TL11): This coating may only be added over armor. It doubles armor DR against shaped-charge (HEAT and HEDP) explosive warheads, disruptors, lasers, x-ray lasers, grasers, flamers and fusion guns.

Defensive Surface Features Table

TL	*Type*	*Weight*	*Cost*
7	Radiation Shielding	2	$20
7	Reflective Surface	0	$30
9	Retro-Reflective Surface	0	$150
11	Thermal Superconductor Armor	0.25	$250

Multiply weight and cost by the surface areas of the body and/or subassemblies being protected by the features.

Weight and cost are halved one TL after the system's introduction, and halved again two or more TLs after introduction.

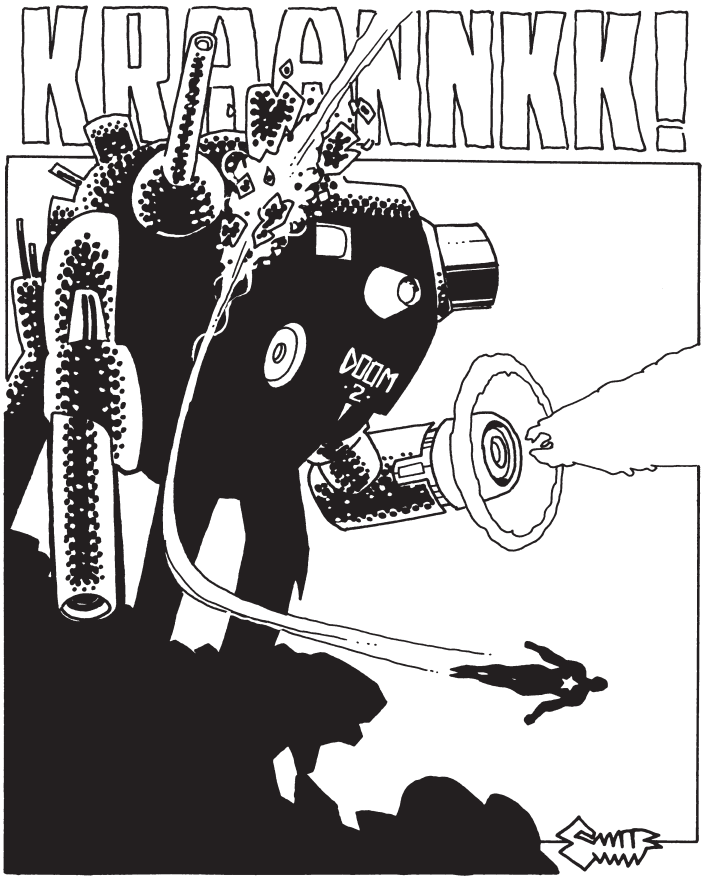
Reactive Armor (late TL7)

Reactive armor is a special type of armor that can be applied to a vehicle over regular armor. It is normally used by armored vehicles such as tanks. Reactive armor was introduced on tanks by the Israeli Defense Force in the early 1980s. It is now also used on Russian and U.S. Marine Corps tanks.

Reactive armor plates (RAP) are cinder block-sized explosive tiles intended to protect against the deadly shaped-charge (HEAT or HEDP) ammunition used by many cannon and missile warheads.

As a shaped-charge warhead hits a RAP, the explosive in the RAP detonates and blasts the metal plate forward, disrupting the formation of the jet of molten metal that the shaped-charge warhead relies on for penetration.

RAPs may be attached to any body, turret or superstructure that has DR 50 or better. Keep track of the number of shaped-charge hits on each side of any location fitted with RAP, since as individual plates are used up, the coverage they provide declines. When a shaped-charge warhead



hits a location fitted with RAP, roll 2d. Subtract 1 for every prior hit by a shaped-charge warhead on that same location. If the result is 0 or less, an area that is not covered by a RAP is hit and no extra protection is provided. Otherwise, the RAP destroys the shaped-charge warhead harmlessly.

Reactive Armor Plates can be detonated harmlessly by hits from non-shaped-charge attacks. Any attack that does 100 or more points of damage (before subtracting DR!) also counts as a "prior hit by a shaped charge" for purposes of determining whether or not RAPs successfully stop shaped-charge hits. If a non-shaped-charge weapon doing explosive (exp.) damage or a vehicle collision occurs against a vehicle equipped with RAPs, it counts as one hit *per* 100 points of concussion or collision damage inflicted.

When a RAP detonates (for any reason) it inflicts 6d×2 explosive concussion damage. At TL8+, RAPs can be deliberately detonated by the vehicle operator from within the vehicle – this can be useful for removing nearby hostile infantry, for instance. Each detonation counts as a "prior hit."

RAP protection weighs 8 lbs. and costs $20, both multiplied by the surface area of the location being protected. RAP arrays can be repaired for 2% of the original cost per "hit" they have taken.

Electrified Surfaces (TL7)

This feature is sometimes given to anti-riot vehicles, to discourage rioters climbing up on them. It is also useful for keeping animals away, and discouraging people from tampering with the vehicle!

Conductive wires are embedded in the vehicle surface. The system can be set for "stun" or "kill." When turned on, any grounded object touching or touched by the outside of the vehicle will take 2d damage (if set to "stun") or 10d damage (if set on "kill"). Totally metal armor protects with only DR 1. A HT roll is also required if any damage penetrates DR and the character is still conscious: failure means the character passes out for 25-HT turns. (If a vehicle has arms, a touch will also carry a shock.) Turning an electrified body on or off is a combat action. It is disabled if the vehicle loses power. An electrified surface may be designed to activate if a burglar alarm detects tampering with the locks.

An electrified surface weighs 0.2 lbs. and cost $10, both multiplied by the surface areas of those parts of the vehicle that are electrified. The vehicle must have either a power plant with 20 kW or more output (in which case the actual power requirement is relatively negligible), or an energy bank. If it has an energy bank, 20 kWs will be drained when the system zaps someone on the "kill" setting, or 4 kWs on the "stun" setting.

Force Field Grids

Deflector fields and force screens come under the category of force field grids. These systems allow the vehicle to generate one or more types of protective force field around it.

Deflector Field (TL11): This is a force field generator grid derived from gravity manipulation technology. It adds to a vehicle's passive defense, bending space to deflect energy beams and physical projectiles. It does not increase DR at all (see *Force Screen,* below). The deflector field is visible as a faint shimmer around the vehicle. A deflector field can also be tuned to keep out rain, wind and atmospheric contaminants. An operating deflector field gives the vehicle an overall PD 8. If part or all of the vehicle has PD 8 or better already, the field adds +1 to that location's PD instead.

Force Screen (TL11): This is a different class of force field generator from a deflector. Force screens protect the vehicle from any direction by absorbing the energy of attacks, providing damage resistance (DR) much like armor, but not increasing PD. They may be used in conjunction with deflectors and armor – always subtract force screen DR before armor DR. Force screens do not hamper the vehicle's own fire.

A force screen can be overloaded by a powerful attack. If the damage from a single hit (or total burst damage from an automatic fire laser) exceeds *half* the force screen's DR, the force screen *gains* an "energy level." If the damage *exceeds* the force screen's DR, it gains two energy levels instead. After gaining one energy level, the force screen glows red. After gaining two levels, it glows orange, then yellow (three levels), green (four levels), blue (five levels), indigo (six levels), and violet (seven levels). Upon gaining eight levels, it overloads, and the generator melts and is destroyed.



A force screen sheds one energy level every 10 seconds, radiating energy in the form of neutrinos and visible light. A force screen cannot be safely turned off until it has shed all accumulated energy levels. If turned off prematurely, the shield generator overloads and is totally destroyed.

Force screens do not block slow-moving objects (under a few yards per second). If a vehicle's door is open, an active force screen won't keep out intruders. Force screens cannot be penetrated by active sensors (sonar, radar, ladar, chemscanners, bioscanners), though the presence of the field itself can be detected.

Variable Force Screens (TL12): These work exactly like normal force screens, except that the vehicle operator can opt to "reinforce" a single facing. This doubles the DR of the screen on that facing, but halves its DR on the opposite facing. Thus, if the captain of a ship ordered "reinforce front screens," the screen's DR would double against attacks on the vehicle's front, while attacks on its back would encounter only half the screen's DR. Changing the face reinforced, or reverting to full coverage, can be done at the start of the vehicle operator's turn. Variable force screens cost twice as much as regular ones.

Force Field Grid Table

TL	*Type*	*Weight*	*Cost*	*Power*
11	Deflector Field	0.1	$250	3.6
12	Deflector Field	0.05	$125	3.6
13+	Deflector Field	0.025	$62.5	1.8
11	Force Screen	0.008	$10	0.01
12	Force Screen	0.004	$5	0.01
13	Force Screen	0.002	$2.5	0.01
14	Force Screen	0.001	$1.25	0.01
15+	Force Screen	0.0005	$0.625	0.01

Multiply weight, cost and power requirement by the vehicle's total surface area. For force screens, also multiply weight, cost and power by the desired *damage resistance* of the screen. Thus, a screen with DR 1,000 has 1,000 times the listed weight, cost and power requirement per square foot. Minimum force screen DR is 100.

Rams, Wheelblades, Plows and Bulldozers

These are modifications to the front of the vehicle. They use a variation of the *Armor* rules, and can only be added after the surface area of the vehicle has been determined.

Ram (TL1): A ram is a beak-like, metal-shod ramming prow mounted in front of the vehicle. Rams were historically used on ships, but there is no reason why ground vehicles can't use them. However, rams may not attached to vehicles with harnessed animals! A ram increases the damage inflicted by the ram-equipped vehicle in a frontal collision, adding +1 per die to damage. It also reduces *collision* damage which strikes the front of the vehicle by 1 point per die of damage. A ram is 1 lb. × body area and costs $2 × body area.

Wheelblades (TL1): A vehicle with wheels can be given scythe blades attached to them. Wheelblades allow the vehicle to do *cutting* collision damage if it sideswipes someone, but if it fails to penetrate DR, the blades snap off at the base. Wheelblades weigh 0.1 lbs. per sf of wheel area for blades on either side of the vehicle, half that for a single side. Cost is $100 × weight. Retractable blades are available at TL7+: they cost and weigh twice as much, and take one turn to retract or extend.

Bulldozer Blades and Plows (TL1): These are earthmoving blades attached to the front of a vehicle. They can be added to any vehicle with railway, standard or off-road wheels, tracks, halftracks, skitracks or contragravity. They can clear or plow a path as wide as the vehicle. In a frontal collision, they function as rams but only adding or subtracting +1 per *two* dice of damage, e.g., a 20d collision would do 20d+10. Bulldozer blades or plows weigh 2 lbs. × body area and cost $4 × body area.

Top Decks

A top deck is a flat area on top of the vehicle's body, often (but not always) with a siding or rail. Ships usually have a top deck to enable the vehicle occupants to get up on it and walk around. A top deck may also be used to stow cargo, although the cargo will be exposed to the elements and hostile fire. Pick-up and flatbed trucks are examples of land vehicles with top decks designed for cargo; container ships are an example of watercraft with open cargo decks.



A top deck is rated for its deck area in square feet. To find the area of a top deck, take 1/3 the area of the vehicle body, subtract 1/5 the area of any turrets or superstructures attached to the body and 1/10 the volume of any open cargo in the body. Divide the remainder by 2 if the vehicle has masts, gas bags, or streamlining of good or better. The result is the area of the top deck. If the result is less than zero, the vehicle has no top deck.

Vehicles with a superstructure may have a top deck on the superstructure as well as or instead of on the body. Calculate as above, substituting "superstructure" for "body" and superstructure area/3 for body area/3.

Several features can be added to any vehicle with a top deck:

Covered Deck: Vehicles with open decks may cover a portion of that deck space with a fabric frame: this is typical of cargo trucks, covered wagons, galleys, etc. Vehicles with sails may only cover 20% of deck space, due to the need for room to work the sails; aircraft may not land on a covered flight deck. Setting up or removing the cover takes 1 second per sf, divided by the number of people doing the work (minimum 10 seconds). A vehicle with a covered deck will catch fire on a roll of 10 or less (8 or less at TL7+) if a flame attack (see p. 184) hits the body. A covered deck is $0.5 and 0.05 lb. per sf of deck space covered.

Flight Deck (TL6): A vehicle with a top deck may use all or part of it as a flight deck – a runway for aircraft. The length of the flight deck in feet is equal to three times the square root of flight deck area.

Vehicles may be stowed on deck. Each takes up surface area/4 sf, or surface area/2 sf if they are winged or rotary winged aircraft *and lack folding wings or rotors.*

A flying vehicle with no stall speed can land on a flight deck if there is room. Landing an aircraft with a stall speed (like a normal airplane) is trickier. At least half the deck must be clear of parked vehicles. The aircraft uses normal landing rules (see p. 156) and enters one end of the flight deck. For a perfect landing, it must able to decelerate to 0 speed before running out of flight deck. (If 80 mph or less speed is left, an arrestor wire and safety net barrier can catch it – otherwise it goes off the end of the deck.) The roll to land a vehicle with a stall speed on a flight deck is at -1 for every full 20 mph of stall speed. Add +4 if using an arrestor hook. See *Routine Travel* (p. 143) for the necessity for landing rolls, and effects of failure. A vehicle that fails to land will normally crash (stalling off the deck) unless it can accelerate back up to its stall speed before hitting the ground.

Each sf of flight deck area costs $1 and masses 0.1 lb., which includes a hardened deck with safety nets and arrestor wires to catch landing airplanes. Normally, one aircraft with a stall speed can land or take off every minute.

Various options are available for flight decks:

Landing Pads: If the flight deck is designed solely for vertical takeoff and landing aircraft (craft with no stall speed, like helicopters), it can be a simple "landing pad." Weight and cost are halved.

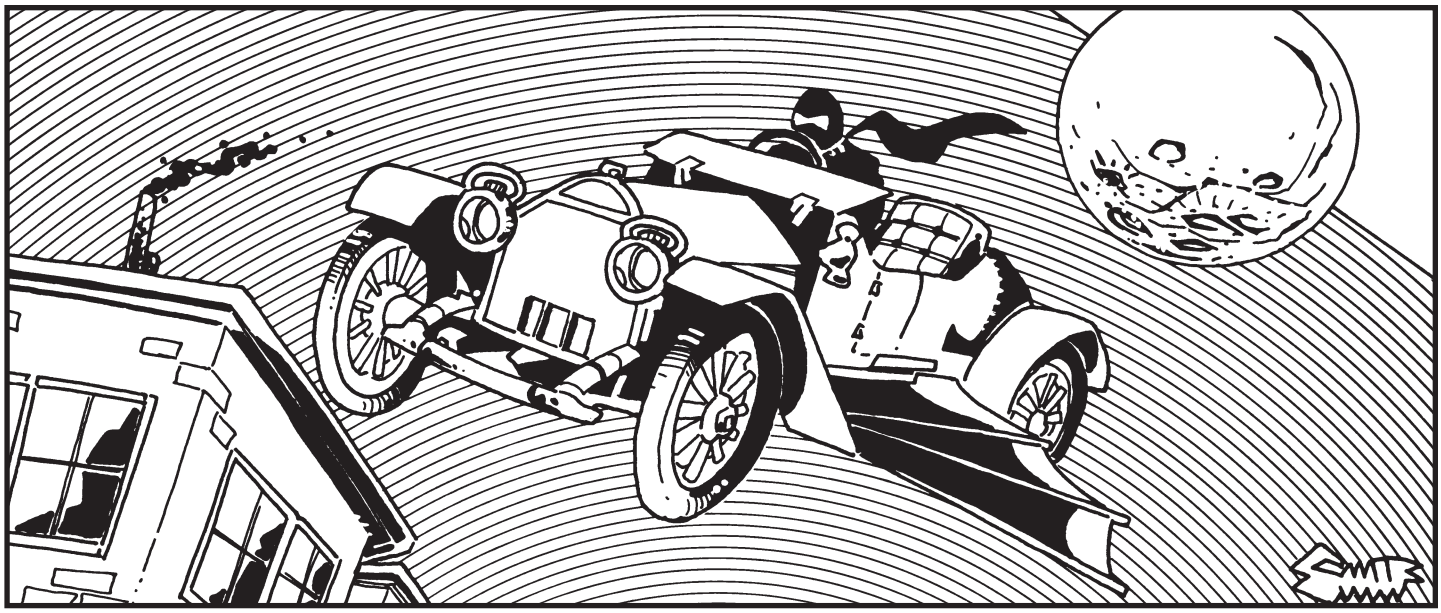
Angled Flight Decks (TL7): This angles the deck so that one landing and one takeoff can be performed at the same time, speeding up operations. Add 50% to cost.

Hardpoints

Hardpoints are reinforced points on the underside of a vehicle's body or wings to which external, jettisonable stores such as bombs, missiles or equipment pods can be attached. Some anthropomorphic vehicles also mount them on arms.

Only bodies, wings and arms can have hardpoints; however, hardpoints may not be added to a vehicle's *body* if it has a hydrodynamic hull, GEV or SEV subassemblies, tracks, halftracks or skitracks, railway wheels or a flexibody drivetrain.

Each hardpoint is rated for the maximum weight it can carry – its load capacity. Within these weight limits, a single hardpoint can be loaded with *one* equipment pod (see below), or one or more missiles, torpedoes, bombs or mines. If multiple weapons are clustered together, a special adaptor is required; this is assumed to be included with the weapons, but all clustered weapons must be identical. A single hardpoint typically carries no more than three weapons of the same size, but real combat aircraft occasionally use adaptors that allow four, six or



more smaller weapons to be carried on one hardpoint. Links (p. 45) must be purchased to allow clustered weapons to be fired selectively; otherwise, they are all dropped or fired at once. Items carried on a hardpoint are collectively referred to as "external stores."

If a vehicle will have hardpoints, decide how many the body, each wing and each arm has. Then determine what the load capacity (in pounds) of each hardpoint is. The number and capacity of hardpoints on each wing should be the same.

Control of all a vehicle's hardpoints (which includes firing weapons) must be assigned to one of the vehicle's crew stations, usually the same one that handles maneuver controls.

A single arm, wing or body may have a number of hardpoints whose *total* load capacity is no greater than 20 lbs. × its hit points. Each hardpoint weighs 0.05 lbs. and costs $0.1 per pound of load capacity. Hardpoints are assumed to be "tapped," allowing the vehicle to draw fuel from drop tanks and provide power to pods containing electronics. An untapped hardpoint, only capable of carrying and dropping unpowered weapons, costs half as much.

Equipment Pods

While some stores, such as bombs, are directly attached to hardpoints, other items attached to hardpoints are enclosed in external "equipment pods." These are detachable and are not the same as pod subassemblies permanently attached to the vehicle.

A hardpoint can carry an equipment pod instead of missiles or bombs, provided the pod is within the hardpoint's weight limit. Pods usually carry fuel (drop tanks), sensors, electronic countermeasures, targeting systems or weapons, but passenger or cargo pods (for instance) are possible. If a weapon in a pod requires ammunition, the ammunition must also be placed in the pod, as must any loaders required.

An equipment pod is built as if it were a vehicle body containing the equipment held in the pod, except that it has no subassemblies, propulsion system or crew. The only thing it actually requires is hull structural material, though most pods will also have armor. It may need a power system (usually an energy bank) if it has power-using components. Aside from its hit points, DR and PD, design weight, loaded weight and cost, its statistics can be ignored; it has no performance statistics, for instance. Like other hardpoint loads, an equipment pod can be jettisoned by the vehicle operator.

Booster Rockets: Solid fuel rockets (only) can be placed in equipment pods, to serve as rocket boosters.

Convertible Top Features

These can be added to any vehicle with seats.

Convertible Hardtop: A vehicle with six or fewer seats, excluding exposed seats, may have a detachable hardtop. The vehicle may not have top-mounted superstructures or turrets. Treat the seats as exposed when the hardtop is removed, giving a better all-round view but reducing protection against attacks or the elements, and (if the vehicle is sealed) unsealing it. It takes 10 seconds to attach or remove the top. This costs $100 per seat.

Convertible Ragtop: A vehicle with exposed seats may have a fabric top. When in use, the top restricts overhead vision, but protects against weather conditions. At TL5- the top must be manually removed (takes 10 seconds per seat). At TL6+, the top is designed to fold up automatically. Add 5 lbs. and $50 per open seat.

Special Tires

Normal tires are included in the cost of TL5+ wheeled subassemblies. However, more expensive tires are available. Cost is based on the number of wheel positions in the vehicle's wheeled subassembly. Available types include:

Snow Tires (TL6) add +2 to Driver skill – but only to cancel the penalty for driving a wheeled vehicle on snow! They cost an extra $100 per wheel ($200 per wheel if the wheeled subassembly's surface area is 200 sf or larger).

Racing Tires (TL7) improve maneuverability, but only on a smooth-surfaced race track. On normal roads, they take 1 hit of damage per hour (per minute off-road). They cost an extra $250 per tire ($500 per tire if the vehicle's wheeled subassembly is 200 sf in area or larger). They add +0.25 to gMR.

Puncture-Resistant (PR) Tires (TL7) give tires a DR of (TL-4) instead of DR2. They cost an extra $250 per tire ($500 per tire if the wheeled subassembly is 200 sf in area or larger). They regenerate damage (to the tire, not the wheel) at 1 hit per turn.

EXAMPLE

The Kitty Hawk has puncture-resistant tires. They cost $1,000.

Hitches and Pins: Pulling Other Vehicles

A vehicle can be equipped to tow another vehicle, or to be towed itself. Normally, only vehicles that float or those equipped with wheels or skids are built to be towed, but this is not an absolute requirement!

Hitch: This is a hook, "fifth wheel" or other device that enables a vehicle to pull another vehicle. A hitch weighs 0.1 lbs. and costs $0.1, both times the vehicle's body hit points. A hitch enables it to tow a

vehicle weighing up to (50 × the towing vehicle's body hit points) lbs. Attaching or detaching a hitched vehicle takes at least 10 seconds and requires exiting the vehicle. At TL6+, a remote-controlled hitch that can be detached from inside a towing vehicle is available for double cost.

Pin: A vehicle that is designed to be towed requires a *pin.* A pin weighs 0.1 lb. and costs $0.05, both multiplied by the vehicle's body hit points. At TL6+, an *explosive* pin is available for five times the cost. This allows the towed vehicle to be released instantly as a combat action, either from within the towing vehicle or the towed vehicle (designer's choice). A vehicle can have both a pin and a hitch.

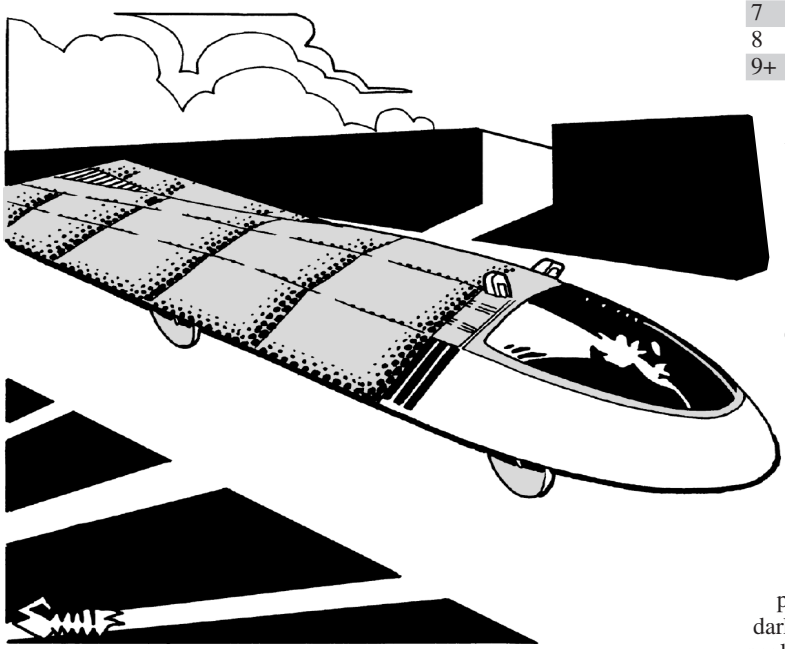
A vehicle with non-railway wheels, tracks, halftracks, skitracks or skids can be hitched behind and towed by any vehicle with a ground performance. Calculate the top speed, acceleration and deceleration of the combination as if it were a new vehicle with the combined loaded weight of both vehicles and the motive system of the towing vehicle. gMR and gSR are based on the combined body volume of both vehicles, the motive system of the towing vehicle, and if both vehicles have wheels, the combined number of wheels; the combination's gMR cannot exceed 0.25 G. Ground pressure and off-road speed are calculated individually for each vehicle, and then the lowest off-road speed is used.

Vehicles with railway wheels can tow or push one or more vehicles that also have railway wheels along a railway track. Calculate the combination's performance as if the vehicles were a single vehicle with a combined loaded weight equal to all of those in the train. Note that hitches must bear the weight of *all* the vehicles behind them. More than one vehicle in the train can provide motive power to push or pull it.

A vehicle that floats can tow other floating vehicles. Calculate the hydrodynamic drag, top speed and acceleration of the combination as if it were a new vehicle with the combined loaded weight of all vehicles being pulled. wDecel, wSR and wMR are based on the lowest from among all the vehicles towing or being towed, and wMR may never be higher than 0.25 G.

A vehicle that is moving on the ground alongside a watercourse can tow a floating vehicle. Use the ground vehicle's performance normally, but recalculate its top speed and acceleration, increasing its effective loaded weight by the hydrodynamic drag of the vehicle in the water. Other statistics are normal, except that gMR cannot exceed 0.25 G.

A vehicle that is moving on the ground can tow a flying vehicle. Calculate the ground vehicle's performance normally, but recalculate its top speed and acceleration, increasing its effective loaded weight by the aerodynamic drag of the flying vehicle. The new top speed must exceed the stall speed of the aircraft, or it will not take off. Other statistics are normal, except that gMR cannot exceed 0.25 G.



A flying vehicle can tow another flying vehicle. Calculate the aerodynamic drag, top speed and acceleration of the combination as if it were a new vehicle with the combined loaded weight of all vehicles being pulled. The aDecel, aSR and aMR are based on the lowest from among all the vehicles towing or being towed, and aMR may never be higher than 0.25 G.

Sidecars

A vehicle with standard, heavy or off-road wheels that has two wheels may be designed to accept a sidecar. The attachment costs $1 times the vehicle's body hit points. A sidecar is built with a standard, heavy or off-road wheeled subassembly with one wheel and must have between 50% and 150% of the volume of the vehicle it is attached to. It must have the same type of wheeled subassembly as the vehicle it is attached to.

The combination is treated *exactly* like one vehicle with three wheels and the combined weight and volume. Recalculate performance accordingly. Detaching a sidecar takes 30 seconds. An optional "quick release" system allowing release in one second is available for $100. A sidecar that is released while its vehicle is moving will crash, unless it has a propulsion system of its own.

Solar Cells (TL7)

Any vehicle can be covered with photoelectric collectors (solar cells). These convert light (usually sunlight) into electric power. They generally serve as a backup power supply or a means of recharging energy banks, but some vehicles may be entirely solar-powered. Because the power output is generally very low (and subject to interruption if something blocks light) they are usually used in conjunction with rechargeable energy banks (p. 087). The energy banks can then take over if the solar power is interrupted, and the solar collectors can recharge the energy banks.

The total area that can be covered is (body + superstructure + turret + wing area)/2. A vehicle with stealth, infrared cloaking, a chameleon system or liquid crystal skin cannot use solar cells unless they are built at TL11+, or are mounted on panels (see below). At TL10+, gasbag and sail area can also be used for solar cells, and should be added in the formula above. Solar cells cannot be placed on other subassemblies.

To determine the weight (lbs.), cost and power output (kW) of a solar cell array, decide how many square feet it covers and multiply by the values on the following table:

Solar Cell Table

TL	*Weight*	*Cost*	*kW*
7	0.4	$30	0.02
8	0.1	$30	0.04
9+	0.1	$30	0.08

Panels: Solar cells can also be mounted on panels extending from the vehicle. Determine the weight and cost of the panel by selecting an area, then multiplying by the entries on the *Vehicle Structure Table* on p. 19 (most panels are extra-light or super-light). Add panel area to the formula above and calculate solar cell weight, cost and output normally. A panel's hit points equal its area × 0.2, modified by the strength selected. A vehicle with an extended panel is automatically unstreamlined, and counts the panel area for computing aerodynamic drag. For double weight and cost, the panel can be retractable. A retracted panel occupies (weight of panel plus solar cells)/50 cf, and produces no power, but it does not impair streamlining and is not easily damaged. Retracting a panel takes 10 seconds, during which it is considered extended, but provides no power.

The output assumes Earth-normal sunlight. Around another star, multiply output by the relative luminosity of the star. At a distance other than one astronomical unit (AU) – the average distance from Earth to the sun – from a star, divide the output by the distance in AU squared. In artificial light, solar cells will generally provide about 1% of power, though this varies. In any environment dark enough to provide a -1 or worse vision penalty, solar cells provide negligible power.

WEAPONRY 9

This chapter presents four detailed weapon design systems: *Mechanical Artillery,* covering catapults, ballistas and similar weapons; *Gun Design,* covering guns; *Launcher Design,* for missiles, rockets and torpedoes and *Beam Weapon Design,* for energy weapons. There are also detailed sidebars on *Bombs, Mines* and *Liquid Projector Design.*

As an alternative to designing a weapon from scratch, the *Armaments* chapter (p. 42) features a selection of "generic" weapons ready to be installed in a vehicle.

Mechanical Artillery

These are mechanical bolt or stone throwing devices, similar to giant crossbows or slings. To build a mechanical artillery piece follow the design sequence below:

Stone or Bolt Thrower?

Decide whether the weapon is a stone thrower, bolt thrower or repeating bolt thrower.

Stone Throwers (TL1) normally fire stones in a ballistic arc, but a sufficiently big stone thrower can toss practically anything, from live sheep to nuclear bombs.

Bolt Throwers (TL1) project large arrows, like giant crossbow bolts. They fire their missiles with a flatter trajectory and are more accurate than stone throwers. However, the bow mechanism is also heavier and somewhat more expensive.

Repeating Bolt Throwers (TL2) are identical to bolt throwers, but use a gravity-fed magazine and/or turn-crank to increase rate of fire. Historically, they were only built in China.

Set the tech level the weapon is built at. Then decide whether the weapon is spring (TL1), torsion (TL2) or counterweight-powered (TL3). Only stone throwers can be counterweight engines.

Spring-Powered weapons use the elasticity of a wood or metal bow or board to propel projectiles. They are the cheapest type, but also the least efficient. Giant crossbows like the scorpion and some early catapults were spring-powered.

Torsion-Powered weapons use the potential energy stored in a wound-up skein of fiber (often the hair of local women from whatever town was building the engine) to power the weapon. The ballista, onager and catapult are examples of torsion-powered weapons.

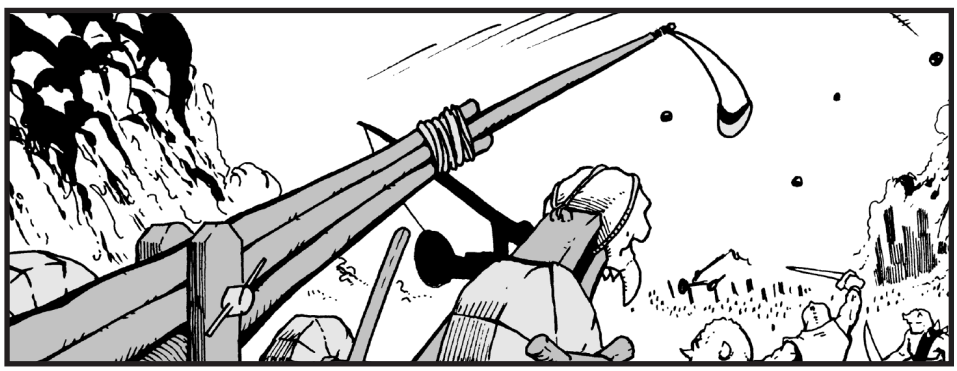
Counterweight weapons use a long sling arm counterbalanced by a heavy weighted box and held back by cords. When these are released, the box falls, the arm snaps up, and the projectile goes flying. They are quite heavy and slow-firing, and are only useful for indirect fire (pp. 179-181). An example of a counterweight weapon is the medieval trebuchet.

Strength

Select the Strength (ST) of the weapon. This determines how powerful it is, in much the same way as it is set for a crossbow.

For bolt throwers, maximum practical ST is 75 if spring-powered or 150 if torsion-powered. For repeating bolt throwers, ST may not exceed the bolt thrower's TL × 5.

For stone throwers, one-tenth ST is the weight of projectile it will throw. Thus, the chosen ST should be ten times the intended projectile weight in pounds. The maximum ST allowed for spring engines is 50, and for torsion engines is 500; there is no maximum ST for counterweight engines.



Real-World Weapons

The statistics generated by this design system give a fairly good approximation of reality. However, they abstract many factors that can alter weapon performance. For instance, a ***GURPS*** TL generally represents a period of 50 or more years. While the rules lump a weapon built at 1900 and one built at 1945 together into TL6, obviously manufacturing and design techniques will have advanced considerably throughout the period.

For these reasons, a weapon built using this chapter may vary somewhat from any one particular "real-life" example. If this happens, you can either declare that this is simply a different model of weapon, or you can adjust the statistics to match those from the source material – feel free to do either. This is quite realistic, as no one gun is going to be the same as another. Altering reliability by one step, adding or subtracting 1 to 3 from Accuracy and SS, or adjusting statistics like Damage, 1/2D range, Max range, RoF, the Rcl and ST of hand-held weapons, and all weights and costs by up to +/-20% will usually suffice, and shouldn't affect game balance much – provided, of course, it is the GM who does the adjusting!

Expressing Dice of Damage

The formulae that are used to determine a weapon's dice of damage sometimes gives fractional or unwieldy results.

The GM should feel free to round fractions off to whole numbers as desired – in the *Armaments* chapter, for instance, damages have been rounded so as to best conform with similar weapons in ***Basic Set*** and ***High-Tech.***

When creating new types, these rules of thumb are suggested:

For fractional damages of less than 1d, a fraction of less than 0.1 is no damage, 0.1 to 0.2 is 1d-4 damage, 0.21 to 0.4 is 1d-3, one of 0.41-0.6 is 1d-2, one of 0.61 to 0.8 is 1d-1, while one of 0.81 to 0.99 is 1d.

For fractional damage between 1d and 24d, the damage is often rounded up to the nearest whole number. However, at the GM's option, a fraction of 0.21-0.4 can be read as a +1 damage bonus, one of 0.41 to 0.6 as a +2 damage bonus, one of 0.61 to 0.8 can be rounded up to next die with a -1 penalty, while 0.81 or more is rounded to the next die. Thus, 2.2 would be 2d, 2.4 would be 2d+1, 2.5 would be 2d+2, 2.7 would be 3d-1 while 2.85 would be 3d.

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Expressing Dice of Damage (Continued)

For damage of 24d or more, ***GURPS*** usually expresses damage in the form 6d × *n.* To get *n,* divide damage dice by 6 and round to the nearest whole number or two digits. Thus, 142d would round to 6d × 24. One may use whatever multiplier happens to be convenient – e.g., 315d of damage might be written as 3d × 105, 5d × 63, 7d × 45 or 9d × 35 – but the 6d spread is the most statistically pleasing, and the number of dice chosen should fall between 4 and 8 whenever possible.

Direct vs. Indirect Fire

Direct fire is normal ***GURPS*** ranged combat. It takes place when the gunner can see the target and fires the projectile more-or-less straight at it.

Indirect fire is used to send a projectile on a high ballistic arc, like an artillery shell. It allows firing over obstacles and at much longer ranges, but is far less accurate. Indirect fire is most effective with explosive ammunition, since indirect-fired projectiles often lack the velocity to easily penetrate armor. Indirect fire requires special rules – see *Indirect Fire* on pp. 179-181 of the *Combat* chapter.

What Bore Size Do I Need?

Light machine gun: 7.62mm (".30 caliber").
Heavy machine gun: 12.7mm (".50 caliber").
Aircraft Autocannon: 20mm, also 23mm, 25mm, 27mm, 30mm.
Shipboard Anti-Aircraft Guns: 20mm, 37mm, 40mm, 57mm.
WWI and Early WWII-era Tank Guns: 37mm, 50mm, 57mm, 75mm.
Late WWII Tank Guns: 76mm, 85mm, 88mm, 90mm, 128mm.
Modern NATO/Western tank guns: 105mm, 120mm.
Modern Russian tank guns: 100mm, 115mm, 125mm.
Howitzers: 75mm, 105mm, 122mm, 152mm, 155mm, 203mm.
Mortars: 60mm, 90mm, 105mm, 120mm.
Grenade Launchers: 30mm (Russian), 40mm (Western).
Age of Sail Cannon: 50mm-200mm.
Big TL5 to TL7 naval guns: 152mm, 203mm, 300mm, 400mm.

Magazine Capacity

If the weapon is a repeating bolt thrower, it is fed by a magazine attached to the weapon: select the magazine capacity (normally between five and 50 shots).

Ammunition

Select the types of ammunition the weapon will use.

Bolt throwers and repeating bolt throwers fire *bolts.*

Stone throwers fire *stones.*

A stone thrower can also fling *bombs* or *mines.* Design them normally using the *Bombs* (p. 113) or *Mines* (p. 115) rules. Favored types at low tech levels are low-explosive and various chemical fillers, such as Greek fire. The maximum weight of bomb or mine that can be flung is 1/10 the ST of the engine.

Other ammunition can also be tossed by a stone thrower, provided it weighs no more than 1/10 engine ST. A favorite choice for sieges are rotting carcasses or the severed heads of enemy soldiers, in order to spread disease and demoralization.

Statistics for Mechanical Artillery

Based on the other characteristics of the weapon, calculate each of the combat statistics described below:

Malfunction (Malf.)

This is the weapon's Malfunction number. If an attack roll is equal to or higher than Malf, the weapon has malfunctioned and is disabled until repaired – a cord snapped, for example. Malfunction number is Crit. for all engines except repeating bolt throwers, indicating a malfunction occurs only on a critical miss. Malf. is 16 for repeating bolt throwers.

Type

This depends on the ammunition: crushing (cr.) for stones, impaling (imp.) for bolts and special (spcl.) for chemical.

Damage (DAM)

This is the damage the weapon inflicts. Damage is based on the weapon's ST, rather than the user's, much like a crossbow. Refer to the *Super-Strength* table on p. B248 if necessary.

For stones, damage is the *swinging* damage for the ST of the weapon. If the weapon is a counterweight stone thrower, add +1 to damage *per die.* Thus, 12d swing damage becomes 12d+12.

For bolts, damage is based on the *thrusting* damage for the weapon's ST. Add +4 if ST 20 or less, add 1d if ST 21 or more.

For bombs or mines, the effect depends on the mine or bomb design. The effect of special "biological" ammunition like severed heads or dead horses is up to the GM; a direct hit will do half the damage of a stone.

Half Damage Range (1/2D)

This is the range beyond which damage is halved and Accuracy drops to 0.

For bolt throwers or repeating bolt throwers of ST 20 or less, 1/2D is ST × 20 yards. For those of ST 21+, 1/2D is 380 + ST yards.

For stone throwers of ST 20 or less, 1/2D is ST × 10 yards. For those of ST 21+, 1/2D is 190 + (ST/2) yards. If a counterweight engine, multiply range by 0.75.

Damage for mines or bombs is unaffected by 1/2D range, but accuracy will still drop to zero beyond it.

Maximum Range (Max)

This is the weapon's maximum range. It is 1.25 × 1/2D range.

Minimum Range (Min)

Counterweight stone throwers have a *minimum range* equal to 25% of their maximum range. Because they fling stones in a high, ballistic arc, they cannot hit targets closer than their minimum range.

Accuracy (Acc)

The weapon's Accuracy is 6 for a bolt thrower, 5 for a repeating bolt thrower, 2 for a stone thrower. Subtract 1 from Accuracy for counterweight engines.

Weight (Wt.)

This is the weight of the weapon without ammunition. It is found using this formula:

Wt. of bolt thrower = ST × ST × P × T × 0.1.
Wt. of repeating bolt thrower = ST × ST × P × T × M × 0.1.
Wt. of stone thrower = ST × ST × P × T × 0.25.

Where:
ST is the ST of the engine.
P is 1 for spring, 0.8 for torsion, 0.5 for counterweight.
M is 1 plus 0.05 per ready shot, e.g., if 10 ready shots, M would be 1.5.
T is 1 at TL4-, 0.75 at TL5, 0.6 at TL6, 0.5 at TL7+.

Snap Shot (SS)

This is the weapon's Snap Shot number. It depends mainly on the weapon's weight:
If under 15 lbs., SS 12.
If 15-25 lbs. SS 15.
If 26-400 lbs. SS is 20.
If 401 lbs. or more, SS is 25.
Add 5 to SS for all stone throwers. All counterweight weapons have a minimum SS 25, regardless of weight.

Rate of Fire (RoF)

For bolt throwers or stone throwers, the time to load and fire is 10 times the square root of ST for counterweight engines, or five times the square root of ST for torsion or spring engines.

For repeating bolt throwers, the time to load and fire is twice the square root of ST.

Round the load-and-fire time to the nearest whole number, then express it as a fraction (e.g., time of 20 is 1/20) to get RoF.

Cost

This is the basic cost of the weapon. If weight is under 100 lbs., use the formula:

Cost = $25 × Wt. × M × P.

If weight is 100 or more lbs., use the formula:

Cost = ($2,400 + $1 × Wt.) × M × P.

Where:
Wt. is the unloaded weight.
M is 1 if spring engine, 2 if torsion or counterweight engine.
P is 1 if stone or bolt thrower, 2 if repeating bolt thrower.



How Long Is My Barrel?

Real gun barrels are sometimes measured in their length in calibers, each caliber being a multiple of bore size. Thus a 20mm, 40-caliber gun is actually 800mm long, or 40 times its bore size.

While ***GURPS Vehicles*** uses a more abstract measurement, here are some rules of thumb: an *extremely short* barrel is under 10 calibers, a *very short* barrel is 10-19 calibers, a *short* barrel is around 20-39 calibers, a *medium* barrel is 40-59 calibers, a *long* barrel is 60-79 calibers, a *very long* barrel is 80-100 calibers, and an *extremely long* barrel is anything longer. If electromag or grav guns, double the resulting barrel length if low powered or quadruple if normal powered.

One-Shot Railguns

A 20mm or larger electromag gun can be designed so that its rails collapse as it fires, burning the weapon out in one powerful shot. Design such a weapon like an electromag breechloader, then *halve* the final cost, weight and volume of the weapon. Decide on its ammunition type and load it with one shot of that ammo. Kinetic energy damage is increased by 50%. The weapon's *RoF* statistic becomes "1NR" (one shot, non-reloadable), and the entire weapon must be replaced after firing.

GURPS Space Firepower Ratings

GMs using ***Vehicles*** to design spacecraft may wish to use the abstract combat system in ***GURPS Space*** to resolve battles. This conversion system abstracts many weapon characteristics, but gives playable results:

FP is based on the *dice of damage* the weapon inflicts. Only weapons that can function in vacuum can be used for space combat.

FP is equal to dice of damage/100 for guns and non-nuclear missiles. For nuclear and antimatter missiles, it is assumed the explosion is a proximity blast occurring some distance from the target. Thus, FP is equal to the warhead yield in kilotons × 10.

If an attack has an armor divisor, multiply dice of damage by that divisor when calculating FP, e.g., 20d(2) is treated as 40d.

For automatic fire lasers multiply FP by RoF. Otherwise, multiply FP by the square root of RoF (first converting fractional RoFs to decimals, e.g., 1/4 is 0.25).

It is up to the GM whether to bother with results that give fractional FPs, or to simply round to the nearest whole number.

Range of weapons does not affect firepower. However, the GM, based on the combat situation, should rule on whether a particular weapon has sufficient range to engage a target.

Cheap Vehicular Weapons

Any mechanical artillery piece, gun, launcher, liquid projector or beam weapon can be built with less than the usual attention to quality control. This increases Malf. by one step, subtracts 1 from Accuracy, and cuts the actual cost in half. The same can be done with ammunition; effects are cumulative.

When Malf. is increased by a step, Ver. becomes Crit., Crit. becomes 16, and if Malf. is 16 or less, one is subtracted from it – e.g., a Malf of 14 would become 13.

Example: A Russian 125mm gun is built as a "cheap" weapon. It would get a Malf. of a 16 instead of Crit. and would be -1 Acc, but costs half as much, which is a good thing if you have several thousand tanks to equip . . .

Fine and Very Fine Weapons

At TL5+, any weapon can be custom-built by hand instead of mass-produced, with special attention being paid to quality. This requires enormous effort and expenditure for a very small gain. Normally, this is only done for special-purpose, hand-held smallarms (target pistols, sniper rifles, etc.), but it is (in principle) also possible for vehicular weaponry. Fine and Very Fine weapons cost 5 and 30 times the design price respectively. A weapon can be Fine or Very Fine (Accurate), or Fine (Reliable). A weapon cannot be Very Fine (Reliable), nor can it be both Accurate *and* Reliable. A Fine (Accurate) weapon gets +1 Acc; a Very Fine one gets +2. A Fine (Reliable) weapon has its Malf. increased by one step, to a maximum of Ver. (Crit.).

Ammunition in Combat

All special rules for using various types of ammunition are described in the *Ammunition – Special Rules* section on p. 188 of the *Combat* chapter. These sidebars provide notes on the technology and effectiveness of the ammunition.

Kinetic-Energy-Class Ammunition

These ammunition types inflict damage through the kinetic energy of their impact. Unless noted otherwise, their effects are incorporated into the weapon design rules.

Solid (TL3): A nonexplosive projectile. Solid ammunition includes ordinary lead bullets, and all non-explosive cannon shells that are not specially-hardened to pierce armor.

Chainshot (TL3): This consists of two solid rounds with a length of chain stretched between them. It was often used in the Age of Sail to destroy masts and rigging, but modern "bolo" rounds have also been developed using a similar principle.

Continued on next page . . .

Weight Per Shot (WPS)

This is the weight in pounds of each shot. If a stone thrower, weight per shot is equal to ST/10 lbs. If a bolt thrower or repeating bolt thrower, use the following formula:

WPS = ST × ST/1600

For mines or bombs, it is whatever the projectile weighs.

Volume Per Shot (VPS)

This is the cubic feet of space each shot takes up, including storage room. It is equal to WPS/50 cf.

Cost Per Shot (CPS)

For bolts, this is equal to the WPS × $2 or $2, whichever is larger. For stones, CPS is WPS × $0.5. For mines or bombs, it is whatever the projectile cost.

Shots

This is the number of shots the weapon has ready to fire. Bolt throwers and stone throwers have one ready shot. For repeating bolt throwers, this is their magazine capacity.

Crew

If the weapon's ST does not exceed the gunner's ST by more than four, then *only* a gunner is required – he can ready the weapon on his own, without requiring any loaders.

If the weapon's ST *does* exceed the gunner's by more than four, a minimum of one loader will be required to assist him. A counterweight engine will require a total crew size of ST/20, while a torsion or spring engine will require a total crew size of ST/40. In both cases, the minimum crew size for such a weapon is two regardless of ST: one gunner and at least one loader.

Gun Design

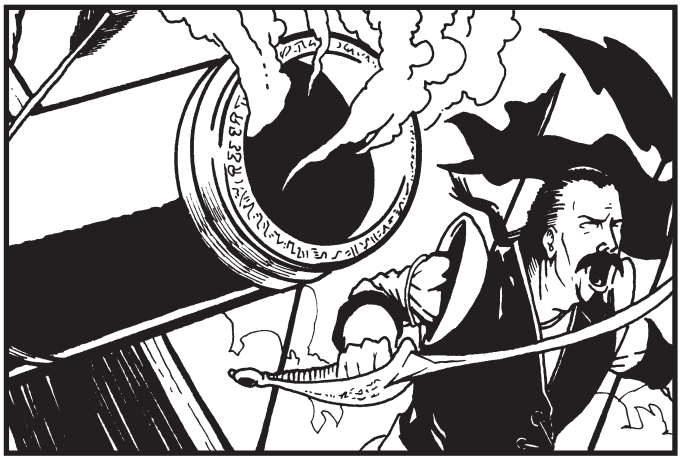
Guns use a chemical propellant or energy impulse to fire a solid projectile out a barrel. Historically, the first "gunnes" appeared in the late Middle Ages (TL3). The earliest guns were more dangerous to their firers than their targets, but weapon development was rapid. By the 17th century (TL4), sailing ships carried banks of ship-killing cannon, while on the battlefield, guns eclipsed swords, bows and pikes. From TL5 on into the far future, continuing advances in weapon and ammunition design keep guns in use as vehicular weapons.

This system is designed to build TL3 to TL16 guns from cannon and machine guns to gravitic railguns. Decide on the tech level of the weapon and then follow the steps below.

EXAMPLE

We decide to build a TL7 gun for the Kitty Hawk.

Bore Size



The bore size of a weapon is the diameter of the projectile it fires, measured in millimeters (mm). The larger the bore size, the heavier the weapon, but the greater the damage and range.

The minimum bore size is 10mm at TL3-5, 5mm at TL6, 3mm at TL7 and 1mm at TL8+. These rules impose no maximum bore size but it is suggested guns not be built much larger than 800mm.

Smallarms and Cannon: These rules sometimes refer to guns as either smallarms or cannon. A smallarm is a gun with a bore size below 20mm; a cannon is a gun of 20mm or greater bore.

Note that for high-tech saboted and superwire ammunition, the diameter of round that a given bore size fires includes a peel-away sabot: the actual penetrator is considerably narrower.

Inches and Pounds: Historically, some guns were measured in units other than mm. Bore size in inches is easy to convert: multiply by 25.4 to get mm. Many guns were also rated as "# pounder" (or lbr.), where # was the (nominal) weight in pounds of the projectile, excluding propellant or shell casing. The conversion of lbr. to mm is less exact, but a suggested bore size is the cube root of (lbr. × 125,000) for TL4- and early TL5 guns, or cube root of (lbr. × 37,000) for more modern weapons. Feel free to adjust the result by +/- 10% to reflect individual guns.

EXAMPLE

We give the gun a bore size of 7.62mm, making it a smallarm.

Gun Technology

Decide whether the gun uses conventional smoothbore, conventional rifled, electromag or gravitic technology.

Conventional Smoothbore (TL3) guns use the expanding gasses produced by chemical propellants such as gunpowder to propel a round down a smooth barrel. At the very end of TL5, early black powder propellants are replaced by modern "nitro" or "smokeless" propellants, which remain in use through TL7.

Conventional Rifled (TL4/TL5) guns are similar to conventional smoothbores, but fire a projectile along a grooved barrel. The grooves spin the fired projectile, stabilizing it in flight and making it much more accurate. Rifled projectiles are generally conical in shape. Rifling the barrel slows the projectile slightly, so when firing solid projectiles, a slightly larger bore size is needed to give the same range and punch as an equivalent smoothbore. Rifled guns are available as late TL4 smallarms, but not until late TL5 for cannon.

Electromag (TL8) guns, called Gauss guns, railguns, coil guns or massdrivers, use electromagnetic rails or rings in the barrel to accelerate a ferrous or conductor-sheathed projectile to very high velocities. Ammunition is quite light, as it does not require propellant.

Gravitic (TL11) or "grav" guns use a gravitic pressor-beam impulse for propulsion and contragravity technology for recoil compensation. Their advantages and disadvantages are otherwise much the same as electromag guns.

EXAMPLE

We decide the gun is a conventional rifled weapon.

Design Options

Guns can *optionally* be given any of these features:

Low- and Extra-Low-Powered: This option means the weapon is somewhat underpowered in proportion to other weapons of the same bore size, type and TL. The gun (and ammunition, for a conventional gun) can be made much lighter as a result, but range suffers, as does damage from non-explosive rounds. Examples of "low-powered" guns include mortars, heavy grenade launchers, recoilless rifles, shotguns, pistols and submachine guns. Light grenade launchers are examples of guns that are "extra-low-powered" in proportion to their bore size.

Recoilless (late TL6): Any extra-low- or low-powered gun can be given this option. Recoil is cancelled by ejecting a counter-mass such as backward-vented hot propellant gases (TL6) or harmless plastic flakes or cold gas (late TL7). Recoilless ammunition is heavier and more expensive, but the weapon is lighter as there is no need for a heavy recoil-absorbing mechanism. A recoilless gun that ejects hot propellant gases creates a lethal back-blast in a cone behind it of bore size/10 yards length, inflicting 4d fire damage. A gun with a lethal back-blast can only be housed in a pod or external mount.

Gun/Launcher (TL7): Guns can be built as combination gun and missile launchers, capable of firing either gun ammunition or missiles. After building the weapon as a gun, refer to the *Launcher* section to add the missile launcher system.

EXAMPLE

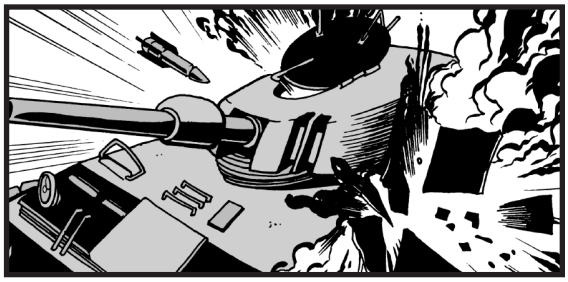
We give the gun no special options.

Kinetic-Energy-Class Ammunition (Continued)

AP, Armor Piercing (TL6): These are specially-hardened or shaped bullets designed to penetrate armor. They do less damage than solid rounds against flesh, so they are most often loaded when the enemy is likely to be a vehicle or someone in body armor. (The standard cannon AP round varies by tech level, but is usually APC.)

APC, Armor Piercing Capped (TL6): This is a solid metal cannon shell with a hardened steel cap or tip to greatly improve armor penetration over solid rounds. It was the standard anti-armor kinetic round for tank cannon until the mid-1940s.

API, Armor Piercing Incendiary (TL6): Identical to APC, except the round contains some incendiary material to improve the chance of starting a fire.



APCR, Armor Piercing Composite Rigid (late TL6): This cannon ammunition was developed mid-way through World War II. It consists of a light outer casing with a very dense tungsten or very hard tungsten carbide penetrator embedded in it. It has a higher velocity than APC and hence does more damage, but is more expensive.

APDS, Armor Piercing Discarding Sabot (TL7): The next step after APCR, this sheaths the dense tungsten penetrator in a light sabot (pronounced *say-bow*). When the shot leaves the barrel, the sabot falls away. The lighter sub-caliber penetrator continues on, with a much higher velocity and flatter trajectory, making it better able to go through armor and giving it superior range. APDS rounds were introduced late in World War II but not perfected until TL7; treat late WWII APDS as APCR instead.

APFSDS, Armor Piercing Fin Stabilized Discarding Sabot (TL7): This replaced APDS on many guns in the mid-1970s. Its penetrator is a "long rod" – a hardened tungsten dart some 15 to 20 times as long as it is wide that can easily bite into armor and which retains greater kinetic energy. The length of the penetrator means it must be fin-stabilized to avoid it tumbling in flight, rather than using rifling. This makes it slightly less effective when fired from conventional rifled guns, since a special mechanism has to be used to cancel its spin.

APS, Armor Piercing Saboted (late TL7): This is an APDS or APFSDS round designed for use by smallarms.

Continued on next page . . .



Kinetic-Energy-Class Ammunition (Continued)

"DU" (Depleted Uranium) (late TL7): APDU, APDSDU and APFSDSDU ammunition are identical to APCR, APDS and APFSDS except they use depleted uranium rather than tungsten as a penetrator. Depleted uranium is spent fission reactor fuel, and is only mildly radioactive, but is used because it is extremely dense, giving it excellent armor piercing capability (reflected by a higher armor divisor). It also has incendiary qualities. When a target is hit by DU, there is usually a brilliant flash of white light. This is an ordinary chemical reaction caused by the uranium penetrator striking a hard target, not a nuclear effect. Fuel and explosive ammunition are very likely to catch fire.

"HD" (Hyper-Dense) (TL11): APHD, APSHD, APDSHD, APFSDSHD rounds are like APCR, APS, APDS and APFSDS except they use a superior penetrator made of hyper-dense "collapsed" matter produced using advanced materials technology.

Superwire (TL9+): Superconductor-sheathed, memory-metal, monowire projectiles fired from electromagnetic or gravitic guns. They are stored as long coils of wire, and are snipped off into short lengths, turning rigid within the accelerator barrel.

HP, Hollow Point (TL6): An expanding or hollow point smallarms bullet with better damage against flesh but poor armor penetration.

Needle (TL8): Very small caliber (2mm or less) smallarms fire needles that do impaling damage, instead of bullets.

Plastic Bullets (TL6): These are rubber or plastic bullets used for riot suppression.

Baton (TL6): These are large rubber or plastic shells specially-designed for reduced lethality.

Shotshell (TL3): A multiple-pellet smallarms load, usually used in shotguns, blunderbusses, etc. The pellets begin to spread immediately after the round is fired, giving a very short range but deadly effect.

Canister (TL4): A shotgun round for cannon shells.

Shrapnel (TL5): This is a higher-tech form of canister: a thin-cased shell filled with bullets, with a small timed charge to burst it at the desired distance.

Beehive (TL7): This is a shrapnel round loaded with finned darts (known as flechettes) instead of pellets. It has superior range and inflicts impaling damage.

Barrel Length

Select the barrel length: The longer the barrel, the greater the range and accuracy. Barrel length increases damage when firing non-explosive ammunition like cannonballs or armor-piercing shot. A longer barrel also makes the gun heavier and more expensive, and allows it to safely fire more powerful ammunition.

Select one of these barrel lengths for the gun. If two TLs are listed, the first is for smallarms, the second for cannon.

Extremely Short (TL3), such as most pre-17th century cannon, modern grenade launchers, and snub-nose pistols.

Very Short (TL4) such as 16th-18th century cannon, modern mortars and most pistols.

Short (TL4) such as modern howitzers and shorter-barrelled tank guns, most 19th century naval guns, and the majority of shotguns, short-barrelled muskets and submachine guns.

Medium (TL4/5) such as the majority of modern naval and tank cannon, longer-barrelled muskets, and modern carbines.

Long (TL5/6), such as long-barrelled tank and naval guns, most autocannon, and many modern machine guns and rifles.

Very long (TL6), such as heavy machine guns, long-barrelled autocannon, and some sniper rifles.

Extremely long (TL6), such as railway guns designed for long-range bombardment and some ultra-tech electromag railguns.

The barrel length is rated *in proportion to the bore size.* While a howitzer has a barrel many times longer than a submachine gun's, both are "short" since both have a similar length relative to the diameter of the projectile they fire.

EXAMPLE

We decide the gun has a long barrel.

Loading Mechanism

The loading mechanism affects how quickly the gun can fire, how reliable it is, and how many shots it will hold ready.

Cannon may be given either muzzleloader (TL3), breechloader (TL3), slow autoloader (TL6), fast autoloader (TL6), heavy automatic (TL7) or electric Gatling (TL7) loading mechanisms. Revolver (TL5) and mechanical Gatling (TL5) loading mechanisms are also options.

Smallarms may be given either muzzleloader (TL3), breechloader (TL3), revolver (TL5), manual repeater (TL5), mechanical Gatling (TL5), fast autoloader (TL6), light automatic (TL6), heavy automatic (TL6) or electric Gatling (TL7) mechanisms.

Muzzleloader (TL3): The weapon is reloaded by dropping or ramming the ammunition down the mouth of the barrel. Rate of fire is slow, and with large weapons, extra loaders may be required to assist. Muzzleloading is not obsolete even at high TLs, as it allows a simpler and lighter weapon. Rifle grenade launchers and light mortars are examples of modern muzzleloaders.

One disadvantage of early muzzleloaders was that large guns could not be easily reloaded when installed on a vehicle: the barrel was right next to the gun port, or protruded over the edge of the deck, and someone had to be able to reach the barrel to ram powder and shot down its mouth. The solution was to mount the gun on a sliding or wheeled carriage which would recoil back when fired and could then be hauled back into place after reloading using ropes. TL3 to early TL5 muzzleloaders over 60mm (120mm if low- or very-low-powered) require a carriage.

Breechloader (TL3): The weapon is reloaded after each shot is fired by inserting the ammunition through an opening (breech) in the back of the weapon, which is faster than muzzleloading. In large weapons, one or more loaders may be required to assist. Breechloaders only become reliable in late TL5. Earlier, difficulties in sealing the breech against the escape of propellant gas make them *very* malfunction-prone.

Manual Repeater (TL5): These require the gunner to work a lever, bolt, pump, slide or crank to load a new round from the magazine into the chamber, and then a separate trigger pull to fire. Rounds are normally stored internally in a clip or tube, but TL6+ manual repeaters can optionally be built to use box magazines; while magazine weight increases, so does RoF.

Revolver (TL5): This uses a rotating cylinder to store rounds. TL5 revolvers are single action and require re-cocking after each shot; TL6 are double action, allowing more rapid fire. The main limit on a revolver is the small number of rounds that can be carried in it. The revolver mechanism is mainly used for pistols, but some modern grenade launchers use it as well. A revolver weapon can be loaded with different ammunition in each chamber, permitting the gunner to select the type of round to be fired by rotating the cylinder (a Ready maneuver). If the weapon is a revolver, select the number of chambers in its cylinder (at least three): this will determine the shots it can fire before reloading and will also affect the weapon's weight.

Mechanical Gatling (TL5): This is a mechanical, repeating weapon using multiple barrels (the exact number need not be specified in the design – it was usually a half-dozen or so), where the mechanism is turned by some form of hand-crank or lever. This type includes American Gatling guns as well as the operationally similar Nordenfeldt and Hotchkiss rotary cannon.

Slow and Fast Autoloader (TL6): The gun taps the gas, recoil or electrical power of the firing weapon to load itself after firing, or uses a mechanical loading mechanism to do the same. Slow autoloading weapons have lower rates of fire than fast autoloaders.

Light and Heavy Automatic (TL6): The gun uses a mechanism that taps the gas or recoil produced by firing to reload a new shot and eject the old casing so that shots continue to fire as long as the trigger is held down. Heavy automatic weapons use belts, drums or cassettes of ammunition. Light automatic weapons use a less rugged barrel and mechanism, fire shorter bursts and use detachable box magazines rather than belts.

At TL7+, any autoloader or automatic mechanism may be *electric.* This means it uses an electric motor rather than gas or recoil action. This is sometimes called a *chain gun* action. It gives superior reliability, but there is a power requirement. Electromag or gravitic guns with light or heavy automatic actions are *always* electric, tapping a portion of the electrical power used to propel their rounds to work their mechanism.

Electric Gatling (TL7): This is an electric automatic weapon with multiple barrels. This weapon uses the "Gatling" principle to fire. After each shot is fired, another barrel rotates into place and the next shot is fired through it. This allows each barrel to cool between shots, allowing very high rates of fire. Decide how many barrels (up to seven) the weapon has – more barrels means a better rate of fire but greater weight – and record it as "six-barrel electric Gatling" or the like.

EXAMPLE

We decide the gun is a six-barrel electric Gatling.

Option – Extra Barrels

A muzzleloading or breechloading gun can be built with multiple fixed barrels. The most common uses of this are double-barrelled shotguns and multi-barrel heavy mortars for firing spreads of depth charges against submarines. The rate of fire of a weapon with extra barrels will be slower than that of a true Gatling gun, but the weapon can fire each barrel singly or in combination. Record the number of barrels using the format "*n*b" where *n* is the number of barrels, e.g., 6b.

Gun Statistics

Malfunction (Malf.)

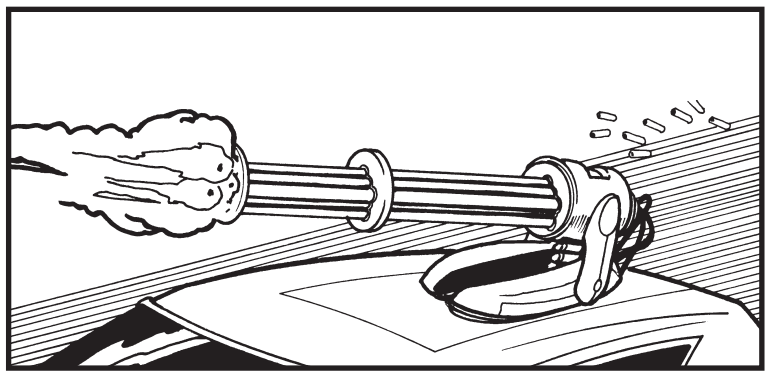
The weapon's malfunction number. If the die roll to hit is equal or greater than this, the weapon malfunctions and ceases to work. Determine Malf. using this table:

Malfunction Table

TL	*Malf.*
3	13*
4- mid-5	14*
late 5	16
6+	Crit.

* A breechloading *cannon* built at TL4 or less is more likely to malfunction. Reduce Malf. by 3, e.g., 13 becomes 10.

"Crit." means it only malfunctions on a critical failure. Crit. improves to "Ver." ("verify") if the gun has an electric loading mechanism, *or* caseless or liquid propellant, *or* a reputation for quality (see below). This means the weapon is very reliable: on a critical failure, roll against unmodified weapon skill to verify the critical failure, with only a failure meaning a malfunction occurs. Otherwise, it is just a



Explosive-Class Ammunition

This ammunition inflicts damage primarily through a chemical explosive filler.

LE, Low Explosive (TL5): A pre-20th century black powder-based explosive with a casing designed to split into sharp fragments.

HE, High Explosive (TL6): A modern explosive round using TNT or a more advanced filler, such as Composition B, inside a casing designed to split into multiple sharp fragments. HE is very effective against structures or unarmored people, but less so against armored vehicles. Ultra-tech rounds use much more advanced explosive materials.

HEC, High-Explosive Concussion (late TL6): This is simply a high-explosive round without a heavy fragmenting case but with more explosive filler.

SAPLE (TL5) or SAPHE (TL6), *Semi-Armor-Piercing Explosive:* A semi-armor piercing round is a LE or HE warhead with a delay-impact fuse so it does not detonate immediately upon striking armor, instead penetrating (doing crushing damage) and then exploding. This makes it much more effective against armor. SAPLE and SAPHE are the standard rounds fired by TL5-TL6 warships and are often used by aircraft cannon.

APEX, Armor-Piercing Explosive (TL7): This is a hardened round with a smaller explosive charge than SAPHE but better penetration against armor.

HEDC, High-Explosive Depth Charge (TL6): This is an HE warhead with either a timer or pressure-sensitive fuse that will only explode after being fired into liquid and dropping to a pre-set depth. They are normally used to attack submarines.

HEPF, HE Proximity-Fused (late TL6): These rounds are ordinary HE rounds with one exception: they have a tiny radar (or for late TL7+ systems, sometimes a laser) that arms the fuse an instant after firing and detonates when the round comes within a set distance of the target or the ground. They are very effective against aircraft and are commonly used by anti-aircraft guns and in warheads on air-to-air and surface-to-air missiles.

HESH, High-Explosive Squash Head (TL7): This is also called High Explosive Plastic (HEP). It is an explosive "shaped plastic" anti-armor round that is different in principle from HEAT. A HESH round hits armor, flattens out and explodes: the shock wave of the explosion is transmitted through the armor, which shakes things loose and causes bits of armor and equipment to fly around, injuring the crew and inflicting damage. Today, HESH are mainly used by the British army (they were used extensively in the fighting in Iraq) and by those who buy British weapons. As tank armor continues to improve, they may become more popular.

Shaped-Charge-Class Ammunition

HEAT, High-Explosive Anti-Tank (late TL6): A HEAT warhead is a specially-constructed and shaped explosive charge. It consists of a cone-shaped charge of high explosive which, detonated moments before impact by means of a fuse or probe on the tip of the round, will explode in such a way that it transforms the metal liner of the round into a pencil-thin jet of hyper velocity metal travelling at up to 25 times the speed of sound. The kinetic energy of this jet enables it to penetrate deep into very tough armor. Although the penetrating jet's diameter is very small, it is lethal by virtue of setting fire to fuel or ammunition, boring through vital components, or killing crew members. HEAT warheads were first developed in 1942 and were used by a variety of World War II anti-tank weapons such as the famous Bazooka rocket. Today, HEAT is the standard warhead used by anti-tank rockets, missiles and many cannon shells.

HEDP, High-Explosive Dual Purpose (TL7): This is a HEAT round with a heavy fragmenting case but somewhat reduced armor penetration. It is a compromise round between HE and HEAT. Modern tanks often carry a mix of HEDP, for use vs. softer targets like infantry and light vehicles, and APFSDSDU, for other tanks.

Bursting Rounds – CHEM (TL6)

These contain chemicals of one sort or another. They are rated for a burst radius in yards, and cover that area with gas or liquid. The exact filler should be specified, and some will increase the round's cost beyond that of an ordinary chem round. The fillers they may be given include:

Smoke (TL6): Covers an area with dense chemical smoke. It impairs vision, the use of VAS sensors such as low-light TV, and laser or laser-based devices, but is easily seen through by other sensors, like infrared or radar.

WP, White Phosphorous Smoke (TL6): A combination anti-personnel incendiary and smoke screen, "Willy-Pete" rounds explode, scattering burning white phosphorous fragments and creating an instant smoke screen. Double the cost.

Prismatic Smoke (TL8): This is identical to normal smoke, except the cloud forms immediately, and it impairs lasers. Double the cost.

Hot Smoke (late TL7) is much the same as ordinary smoke but forms instantly, incorporates particles that block infrared and thermograph sensors, and only lasts half as long. It costs twice as much as normal.

Blackout Gas (TL8): Creates a nearly opaque cloud of thick, inky black smoke in the area of effect that totally blocks vision and lasers, and impairs infrared-type sensors. Triple the cost.

miss. Crit. improves to "Ver. (Crit.)" if the gun has two or more of the three traits listed above. Treat this exactly as Ver., except that the second skill roll must be a critical failure for a malfunction to occur.

Gun/Launcher: If the weapon is a gun/launcher, its malfunction chance remains the same as any other gun. But any time a round is fired and the number is *one less* than the normal Malf. chance (e.g., 16, if a malfunction is on a critical) the vibration from firing has damaged the missile launch system electronics. This prevents a guided missile being launched, but has no effect on the launch of unguided missiles.

Reputation for Quality: The GM may designate some types of weapons as especially reliable. These are well known for their service reliability (e.g., the M1911 Colt .45 or the M2 .50 Browning machine gun). Such a weapon is not necessarily heavier or more expensive, but it is one level more reliable than usual.

EXAMPLE

Malf. is normally critical (Crit.) at TL6+, but since the weapon has an electric Gatling loading mechanism, its Malf. becomes Ver. The gun is very unlikely to jam!

Type and Damage (DAM)

If the weapon will fire solid kinetic-energy type projectiles, calculate the basic crushing damage it does when firing a solid round. This will then be used to derive the damage of all other, more advanced forms of kinetic energy ammunition.

KE DAM = B × L × G × T × P.

B is bore size in mm.

L depends on barrel length, and is 0.3 if extremely short, 0.45 if very short, 0.6 if short, 0.75 if medium, 0.9 if long, 1.05 if very long or 1.2 if extremely long.

G is 1 if a conventional gun, 4 if electromag, 6 if gravitic.

T is 1 if TL6+, 0.75 if any TL5 gun except muzzleloaders, 0.666 if TL5 muzzleloader or TL4- gun.

P is 0.25 if extra-low-powered gun, 0.5 if low-powered, 1 otherwise.

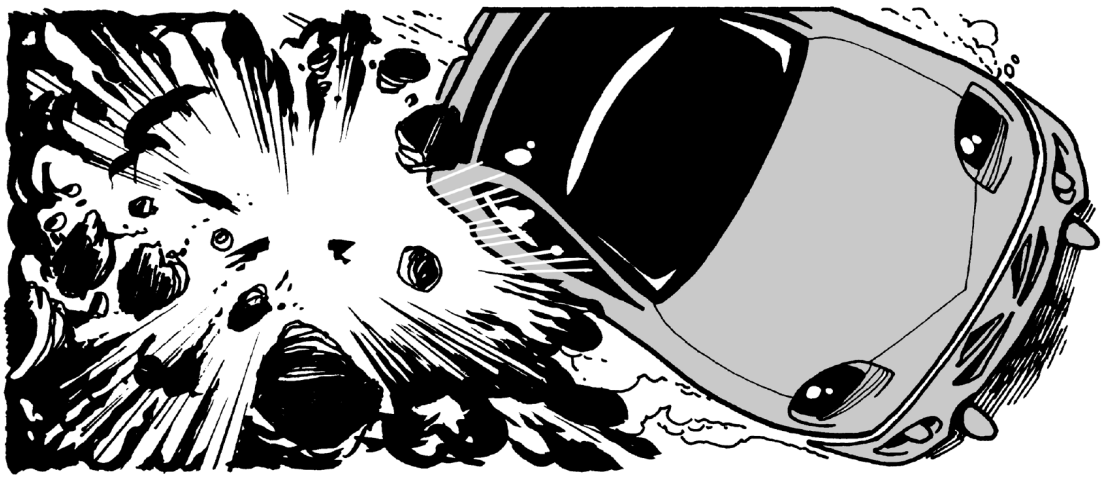
EXAMPLE

We multiply B (7.62) × L (0.9, long barrel) × G (1, conventional gun) × T (1, TL7+ gun) × P (1) = 6.858 dice of damage. We decide to round this to 7d damage to match other *GURPS* 7.62mm ammunition.

Often, the damage formula will give awkward numbers, like 97.5 dice of damage. The sidebar, *Expressing Dice of Damage* (p. 97) explains how to handle this.

Damage of Other Ammunition

This can be determined after the weapon is actually designed, depending on the type of ammunition it is loaded with: the damage of explosive ammunition is solely based on bore size and TL, while that of non-explosive rounds is derived from that of solid KE Damage. See the *Ammunition Table* on p. 112.



Half-Damage Range (1/2D)



This is the range beyond which accuracy drops to 0, and furthermore, at which the crushing or impaling damage is halved. (Rounds doing Exp. or Spcl. damage are unaffected.) To determine a gun's 1/2D range (in yards) use this formula:

1/2D = (square root of B) × S × G × L × P × T.

B is bore size in mm.

S is 375 if bore size is 6mm or more, 250 if below 6mm.

G is 1 if conventional gun, 4 if electromag gun, 6 if gravitic gun.

L depends on barrel length and is 0.15 if extremely short, 0.27 if very short, 0.33 if short, 0.5 if medium, 0.75 if long, 0.9 if very long, 1.2 if extremely long.

P is 0.25 if extra-low-powered gun, 0.5 if low-powered gun, 1 otherwise.

T is 1 if TL7+, 0.9 if TL6, 0.75 if late TL5 rifled gun, 0.5 if other TL5- gun.

If calculated 1/2D range is 1,000 yards or more, round to the nearest 100 yards (nearest 1,000 if 10,000 yards or more). If 1/2D range is greater than 100 yards but less than 1,000 yards, round to the nearest 10 yards. Otherwise round to nearest yard.

EXAMPLE

To find the 1/2D range we multiply B (square root of the 7.62mm bore size, or 2.76) × S (375) × G (1, conventional gun) × L (0.75, long barrel) × P (1) × T (1, TL7+ gun) = 776.37, which we round to 780 yards.

Maximum Range (Max)

This is the gun's maximum range, assuming a moderately flat trajectory. The maximum range is determined as follows:

Max = [(square root of 1/2D range) × R] + 1/2D range.

R is 80 for TL6- smoothbore guns, 120 otherwise.

If Max range is 1,000 yards or more, round to the nearest 100 yards (nearest 1,000 if 10,000 yards or more). If range is greater than 100 yards but less than 1,000 yards, round to the nearest 10 yards. Otherwise round to the nearest yard.

EXAMPLE

Max range is calculated as (square root of 780) × 120 ("otherwise") + 780 = 4,131.4. We round to 4,100.

Indirect Fire Range: If the round is fired *indirectly* on a high ballistic arc, its range is 2.5 times the *Max range*. However, indirect fire (pp. 179-181) rules will apply, which always results in a sizable penalty to hit.

Accuracy (Acc)

This is the gun's Accuracy. It depends on the 1/2D range in yards:

Gun Accuracy Table

1/2D Range	*Acc*	*1/2D Range*	*Acc*
below 70	6	700-999	13
70-99	7	1,000-1,499	14
100-149	8	1,500-1,999	15
150-199	9	2,000-2,999	16
200-299	10	3,000-4,449	17
300-449	11	4,500-6,999	18
450-699	12	7,000 or more	19

These modifiers affect accuracy:

If conventional smoothbore gun: Halve Acc at TL3-5, rounding down; -2 Acc at TL6+.

Loading mechanism: -1 if conventional smallarm (bore size under 20mm) that is autoloading or light automatic.

CLGP: These use special rules – see *CLGP* sidebar on p. 181.

Bursting Rounds – More CHEM

These CHEM warheads can also contain offensive chemical weapon agents. ***GURPS*** measures poisons and drugs in "doses." The cost of these "doses" is added to the CPS for a CHEM round as determined from the *Ammunition Table* on p. 112. The number of "doses" required for a CHEM round is:

Doses = R × (R - 1)/3

Where *R* is the burst radius of the CHEM round. The minimum number of "doses" is 1.

Tear Gas (TL6): See B132. Cost is $0.5 per dose.

Mustard Gas (TL6): See B132. Cost is $1 per dose.

Nerve Gas (late TL6): This lethal gas causes the nervous system to malfunction, resulting in death. It is actually a fine liquid aerosol spray rather than a true gas; only a fully-sealed suit or vehicle is effective against it. It dissipates within minutes. Cost is $5 per dose.

Persistent Nerve Gas (late TL6): This is nerve gas that will not dissipate for several days! Cost is $5 per dose.

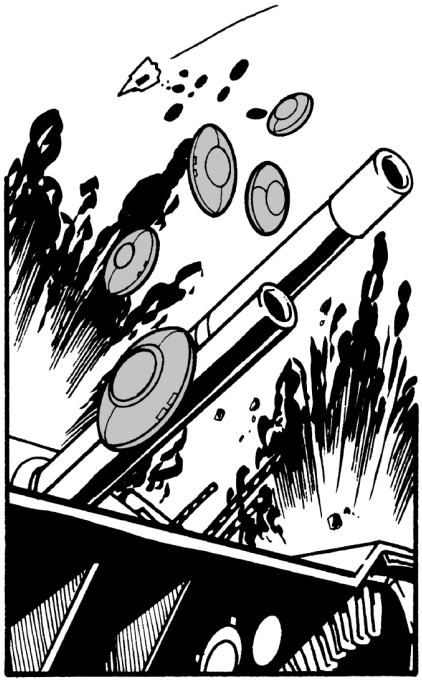
Pesticides and Herbicides (TL6): These are useful for spraying crops, killing insects or defoliating vegetation. Exact effects are up to the GM. Some are harmless; others will have the same effect as tear gas or even nerve gas on anyone in the cloud! Cost is $0.5 per dose.

Sleep Gas (TL8): A high-tech respiratory agent that will knock out anyone in the cloud who is not wearing a gas mask. Cost is $5 per dose.

Bioagents (TL6): These are disease spores. Exact effect depends on the disease they are designed to spread. Bioagents are considered "weapons of mass destruction" because they can spread uncontrollably to infect wide areas. Cost is normally $10 per dose, but may vary.

Nanotechnological Agents (TL9+): These spread clouds of nanomachines. Effects vary from destruction to mutation; see p. RO70-71 for details.

Other Agents: The GM should feel free to come up with more exotic chemical warheads. For some examples, see p. RO26.



Bursting Rounds – Submunition Warheads

These scatter numerous, small, grenade-like projectiles over their burst radius. They can only be fired indirectly to attack surface targets – they are generally used by artillery to kill concentrations of enemy soldiers or vehicles.

See *Bursting Class – Submunitions* on p. 192 for details of their combat effects.

ICM (TL7): This stands for "improved conventional munitions" or "cluster munitions" and refers to their superior effect over ordinary artillery HE. ICM burst overhead, scattering grenade-sized bomblets with dual-purpose shaped-charge and high-explosive warheads. The term "pink mist" was coined to describe the effect of a cluster munition attack on people.

SICM (TL8): "Smart ICM" consists of a round filled with a smaller number of submunitions than ICM, but each one has its own homing warhead and target seeker. These "skeets" spiral down on parachutes or seed-like foils looking for targets, and when they find one, they explode in mid-air. The explosive shapes the submunition's metal into something known as an explosively forged fragment (EFP). The EFP is a chunk of dense metal that shoots downward at an extremely high velocity, hopefully penetrating the roof of the target vehicle. If they fail to explode but hit the ground, they remain as land mines!

SATNUC (TL9): This stands for SATuration NUclear Cluster. SATNUC are much like SICM, except that instead of an EFP warhead, each submunition is armed with tiny smart-nuke with a shaped charge effect! "Pink mist" does not begin to describe the effect. These weapons are the standard indirect-fire nuclear weapons used in the game ***Ogre.***

Continued on next page . . .

EXAMPLE

The Accuracy number for 1/2D range of 780 is 13, and there are no applicable modifiers.

Weight (Wt.)

This is the weight of the unloaded weapon, without any ammunition.

Conventional Guns: To find the weight of a conventional smoothbore or rifled gun, use this formula:

Ewt. = B × B × L × P × S × T × R.

B is bore size in mm.

L is 0.1 if the barrel is extremely short, 0.2 if very short, 0.3 if short, 0.5 if medium, 0.75 if long, 1 if very long or 1.25 if extremely long.

P is 0.25 if extra-low-power, 0.5 if low-power, 1 otherwise, unless weapon is light or heavy automatic; then, P is 0.5 if extra-low-power, 0.8 if low-power, 1 otherwise.

S depends on bore size.* It is 0.25 if up to 25mm, 0.375 if 26mm-40mm, 0.5 if 41-50mm, 0.75 if 51-60mm, 1 if over 60mm.

T is 2.5 at TL3, 2 at TL4, 1.5 at TL5, 1.2 at TL6, 1 at TL7, 0.6 at TL8+.

R is 0.4 if muzzleloader (0.8 if it requires a carriage); 0.6 if breechloader; 0.6 + (0.05 per chamber) if revolver; 0.75 if manual repeater or slow autoloader; 1 if fast autoloader or light automatic; 1.5 if heavy automatic or mechanical Gatling; 1.2 + (0.3 per barrel) if electric Gatling.

Extra barrels: If a non-Gatling weapon has extra barrels, multiply weight by 0.7 + (0.3 per barrel).

* At TL6+, treat bore size as half its actual diameter if low-power or 1/4 diameter if extra-low-power.

Round off weight to two digits.

EXAMPLE

The gun's weight is calculated using the formula given above. It works out to: B (7.62) × B (7.62) × L (0.75) × P (1) × S (0.25) × T (1) × R (3, since it has six barrels) = 32.661225 lbs. We round off to 33 lbs.

Electromag and Gravitic Guns: To find the weight (Wt.) of one of these weapons use this formula:

Ewt. = B × B × L × G × P × T × R.

B is bore size in mm.

L is 0.1 if the barrel is extremely short, 0.25 if very short, 0.6 if short, 1 if medium, 1.5 if long, 2 if very long or 3 if extremely long.

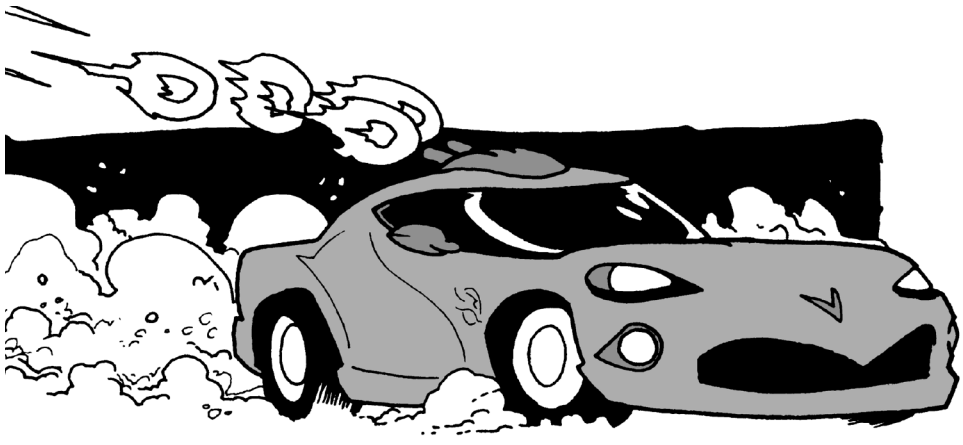
G is 1 if electromag, 1.2 if gravitic.

P is 0.05 if extra-low-power, 0.25 if low-power, 1 otherwise.

T is 1 at TL8, 0.6 at TL9, 0.4 at TL10+.

R is 0.4 if muzzleloader (0.8 if it requires a carriage); 0.6 if breechloader; 0.6 (+ 0.05 per chamber) if revolver; 0.75 if manual repeater or slow autoloader; 1 if fast autoloader or light automatic; 1.5 if heavy automatic or mechanical Gatling; 1.2 + (0.3 per barrel) if electric Gatling.

Extra barrels: If a non-Gatling weapon has extra barrels, multiply weight by 0.7 + (0.3 per barrel).



Snap Shot (SS)

This is the gun's Snap Shot number. The base SS depends on the weapon's unloaded weight (Ewt):

Under 2.5 lbs., SS 11.
2.5 to 10 lbs., SS 12.
10-14 lbs., SS 14.
15-25 lbs., SS is 17.
26-400 lbs. SS is 20.
401-2,000 lbs., SS is 25.
For larger weapons, SS is 30.

Gun/Launchers: Put off calculating SS number until the launcher part of the weapon is designed, as it may increase Ewt.



EXAMPLE

The SS number is simple: the weapon weighs 33 lbs., so SS is 20.

Rate of Fire (RoF)

This is the number of shots the gun can fire in a single second. It mainly depends on the loading mechanism and bore size, with some element of choice. Note that many guns are often built with a lower RoF than the theoretical maximum allowed for their mechanism and bore size to conserve ammunition and (for unconventional guns) conserve power.

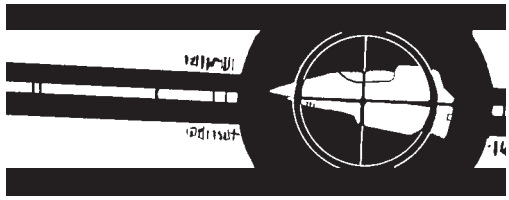
If a weapon has multiple barrels, this will further increase RoF – see below. When calculating RoF statistics, always round fractional RoFs of 1 or more to the nearest whole number; if RoF is less than 1, round loading time to the nearest whole number before finding RoF.

Muzzleloader: If bore size is under 120mm, RoF is 1/90 at TL3, 1/60 at TL4, 1/20 at TL5, 1/8 at TL6+. Exception: if weapon is low- or extra-low-powered, RoF doubles, e.g., 1/8 would become 1/4. If bore size is over 120mm, find the seconds required to load and fire by dividing bore size by 1.33 at TL3, 2 at TL4, 6 at TL5, or 15 at TL6+. Convert this load-and-fire time into a fraction to get RoF, e.g., 6 seconds becomes RoF 1/6. Again, double the RoF if weapon is extra-low- or low-powered.

Breechloader: If bore size is up to 60mm, RoF is 1/40 at TL3, 1/20 at TL4, 1/5 at TL5, or 1/3 at TL6+. Otherwise, find the seconds needed to load and fire by dividing bore size by 1.5 at TL3, 3 at TL4, 12 at TL5, or 20 at TL6+ and convert the time into a fraction to get the actual RoF, e.g., 4 becomes 1/4.

Revolver: If bore is under 60mm, RoF is 1 if TL5 or 3~ if TL6+. If larger, RoF is 1/2 at TL5, 1 at TL6+.

Manual Repeater: RoF is 1/2 unless weapon uses box magazine (RoF 1) or is low- or extra-low-powered (RoF becomes 3~).



Mechanical Gatling: RoF is (DX+Skill)/2 up to 60mm bore size, (DX+Skill)/3 otherwise.

Slow Autoloader: RoF is 1 if bore size is up to 30mm. If bore size is over 30mm, find the seconds required to load and fire the weapon by dividing bore size by 20. Then turn the time to load-and-fire into a fraction to get the actual RoF, e.g., 2 becomes 1/2.

Fast Autoloader: If bore size less than 20mm, RoF is 3~. If 20.1mm up to 30mm, RoF is 2~. If 31-60mm, RoF is 1. Otherwise, find the seconds required to load and fire the weapon by dividing bore size by 40. Then turn the time to load-and-fire into a fraction to get the actual RoF, e.g., 3 becomes 1/3.

Light Automatic: If bore size is up to 10mm, choose a RoF from 3 to 16. If bore size is greater, the RoF may be up to (160/bore size).

Heavy Automatic: If bore size is up to 20mm, pick any RoF from 3 to 20. If bore size is over 20mm, pick a RoF up to (400/bore size).

Electric Gatling: If bore size is up to 20mm, pick a RoF up to (16.67 × number of barrels). If bore size is over 20mm pick a RoF up to (334/bore size) × number of barrels.

Extra Barrels for Muzzleloaders and Breechloaders: If one of these weapons has extra barrels, it can fire a number of shots equal to the number of barrels, singly or simultaneously, but will take the normal time to reload *each* barrel after firing. Record this as two numbers separated by a colon. The first is the number of barrels, the second is the turns it takes to reload a single barrel. Thus a weapon with RoF 1/4 with three barrels would be written as RoF 3:4. This means it can fire three shots but takes four turns to reload *per* barrel after firing.

Bursting Rounds – Submunition Warheads (Continued)

Bursting Rounds – Other Types

Chaff (TL6) bursts into a cloud of conductive strips cut to lengths designed to reflect radar signals, which produces a huge, diffuse target that can distract incoming missiles or give the vehicle something to hide behind. TL6 chaff was aluminum foil; modern chaff is usually aluminized glass fiber or silvered nylon. Ultra-tech chaff may be much more complex, and also affects ladar: one possibility is chaff that *alters its shape* as it falls to better reflect particular wavelengths of radar or ladar; ultra-tech chaff may also absorb energy instead of reflecting it. For burst radius, weight, volume and cost, treat it as a CHEM round, but burst radius is five times normal.

Starshell (TL6): Also called illuminating or flare rounds, these are million-candlepower parachute flares. To function properly, they must be fired high into the air where they float, supported by a balloon, parachute or the like. For burst radius, weight, volume and cost, treat it as a CHEM round, but "burst radius" (i.e., the area illuminated) is 100 times normal.

FASCAM (Field Artillery Scatterable Mines) (TL7): This dispenses a cluster of pressure-sensitive anti-armor mines over the area of effect.

Napalm (late TL6) is an incendiary chemical agent. Napalm shells and firebombs contain a mix of 25% gasoline, 25% benzene, and 50% powdered aluminum or polystyrene. Napalm uses phosphorous as an igniter: when the casing is cracked, the phosphorous ignites spontaneously on contact with air, which sets off the napalm. At high TLs, napalm is still used, though the availability of sealed, airtight armor at TL8+ makes it less useful against soldiers. It is very effective versus lightly-armored guerrillas, anti-corporate demonstrators, etc. For burst radius, weight, volume and cost, treat it as a CHEM round.

Super-Napalm (TL9) is like napalm but much more effective. It is also twice as costly.

Tangler (TL8): This anti-personnel bursting ammunition type is normally fired from conventional, very-short-barrelled, 40mm, extra-low-power guns, but it can be used in any kind of round. It expands out into a net of sticky capture strands that can immobilize anyone within the area of effect! For burst radius, cost, etc., treat as CHEM.

Nuclear Weapons

Nuclear weapons were first developed in the United States during World War II, and used to end that war in 1945 by devastating Hiroshima and Nagasaki in Japan.

A nuclear explosion occurs when atoms are violently split apart (fission, as in an atomic bomb) or fused together (fusion, as in a hydrogen bomb). A similar effect can result from the direct conversion of matter into energy (in an antimatter bomb).

Any fission, fusion or antimatter explosion produces an immediate blinding flash of bluish-white light and ultraviolet radiation. Air is heated to about 18,000,000°, creating an expanding fireball and wave of heat. This is followed by a concussion, and in atmosphere, by a secondary blast of hurricane-force winds produced by the heated air. If the weapon exploded near the ground, dust and debris will be sucked into the air, forming a mushroom-shaped cloud. Some of the debris in this cloud is radioactive, and when it falls to earth will contaminate an area downwind with "nuclear fallout."

There are several types of nuclear weapon.

A *fission* (or "atomic bomb") warhead consists of a radioactive, neutron-emitting material (plutonium or uranium 235) in a neutron-reflective case surrounded by a shaped, high-explosive detonator. When that explodes, it collapses the bomb material into a supercritical mass which undergoes rapid nuclear fission.

A classic *fusion* (or "hydrogen bomb") warhead is a "double stage" weapon: it consists of a hydrogen isotope core surrounded by a shell of fission bomb material. The fission bomb is triggered, and the heat and pressure causes the hydrogen isotopes in the core to undergo a more powerful fusion reaction, releasing much more energy. Many fusion bombs are designed with a "third stage" – a second shell of normally inert uranium around the fission bomb material. The initial explosions release high energy neutrons, setting off the outer uranium shell in a second fission reaction. The result is a much more powerful "fission-fusion-fission" blast.

Higher-TL hydrogen bombs may use more sophisticated laser fusion triggers – see *Micronuke Warheads* on p. 110. The main advantage of this is that the fusion explosion can be triggered without the need for a fission explosion. This means that smaller explosions are possible, and also "cleaner" explosions, since it is the fission blast that is responsible for most of the fallout.

Antimatter bombs hold antimatter in a magnetic or gravitic "bottle" to keep it from touching normal matter. When the warhead is triggered, the bottle collapses, bringing it into contact with the normal matter in the warhead casing. The antimatter and an equal amount of matter instantly annihilate each other, releasing tremendous energy. Due to the cost of producing antimatter, these bombs are very rare until TL10+, when fusion power allows cheaper production of antimatter. However, given enough antimatter, the bomb itself is a relatively simple device: antimatter can be produced and contained today.

EXAMPLE

The weapon is an electric Gatling and the 7.62mm bore size is less than 20mm so RoF can be up to 16.7 × 6 (number of barrels) = 100. We select RoF 100.

Weight Per Shot (WPS)

This is the weight of a single round of ammunition including both the projectile *and* propellant charge (if any). To find WPS use the appropriate formula:

TL5- smoothbore gun: **WPS = (B cubed/125,000) × P × L.**

Other conventional gun: **WPS = B cubed × D × P × L.**

Electromag or grav gun: **WPS = B cubed × D × P.**

Where:

B is bore size in mm.

D is 0.0000375 if cannon, 0.00005 if smallarm.

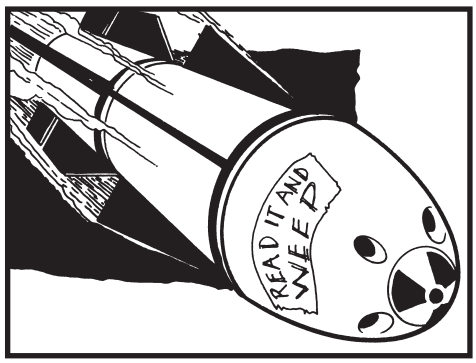
P is 0.2 if extra-low-powered, 0.5 if low-powered, 1 otherwise.

L depends on barrel length:

If smallarm, 3 if barrel is very long or extremely long, 2.5 if medium or long, 1.5 otherwise.

If cannon, 2 if barrel is very or extremely long, 1.7 if medium or long, 1.5 otherwise.

Other Modifiers: Multiply weight of all recoilless or rocket-assisted ammunition by 1.5.



EXAMPLE

The weapon is "any other gun" so we calculate WPS as B (7.62mm) cubed × D (0.00005 since it is a smallarm) × P (1) × L (2.5 for long barrel on a smallarm), or 0.05530 lbs. We round to two places and record a WPS of 0.055 lbs.

Volume Per Shot (VPS)

Gun ammunition requires WPS/150 cf.

EXAMPLE

WPS 0.055/150 = 0.000366, which we round to a VPS of 0.00037.

Cost Per Shot (CPS)

The cost per shot is the cost of a single round of gun ammunition, including propellant. Find the cost of one round using the formula:

CPS = WPS × Cl / Tl.

Where:

WPS is weight per shot.

Cl is $8 if electromag or gravitic gun, $2 otherwise.

Tl is 10 if TL5-, 4 if TL6, 1 if TL7+.

Round CPS off to two places.

EXAMPLE

The minigun's CPS is WPS (0.055) × Cl ($2) × TL (1) = $0.11.

Power

This only applies for weapons that are electromag or gravitic guns, or weapons with electric automatic or electric Gatling loading mechanisms.

Conventional gun with electric automatic or electric Gatling loading mechanism:

Pow. = 0.1 kW × WPS × RoF.

Electromag gun with or without electric mechanism:

Pow. = 5,000 kW × WPS × L × P × RoF.

Gravitic gun with or without electric mechanism:

Pow. = 500 kW × WPS × L × P × RoF.

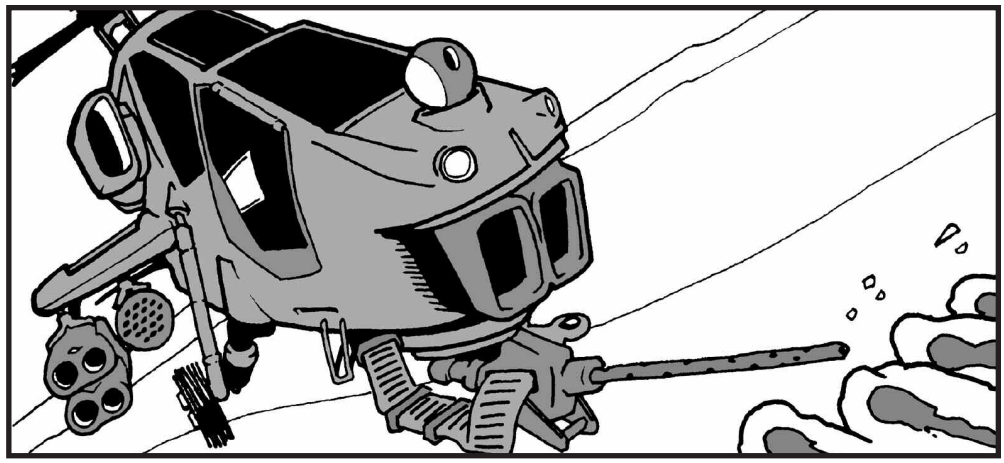
Where:

WPS is the weight per shot.

L depends on barrel length: 0.1 if extremely short, 0.2 if very short, 0.4 if short, 0.6 if medium, 0.8 if long, 1 if very long, 1.2 if extremely long.

P depends on gun power: 0.0625 if extra low, 0.25 if low, 1 otherwise.

RoF is the Rate of Fire.



EXAMPLE

The gun is a conventional gun with electric Gatling loading mechanism and RoF 100, so power = 0.1 kW × 0.055 (WPS) × 100 = 0.55 kW.

Loaders (Ldrs.)

Some weapons may require a crew of one or more loaders to assist the gunner in reloading the weapon or working the mechanism. Only muzzleloading, breechloading, revolver or manual repeater weapons over 66mm may require loaders. Number of loaders required (Ldrs.) is equal to:

Ldrs. = [(B/66)-1] × C × T.

B is bore size.

T is 4 at TL3, 3 at TL4-5, 2 at late TL5, or 1 at TL6+.

C is 1 unless weapon is a muzzleloader that requires a gun carriage, then C is 2.

Round all fractions up! A result of 0.1 would still mean one loader is required.

EXAMPLE

No loaders are required.

Cost

This is the weapon's price. It depends on empty weight and other factors. (If building a gun/launcher, put off calculating gun cost until after the launcher part of the weapon is designed, since the weapon's full weight will not be known until then.)

Cost is based on weight (Wt.) using the formula below:

If Wt. is under 10 lbs. cost = ($50 × Wt.) + $250.

If Wt. is 10 to 100 lbs. cost = $75 × Wt.

If Wt. is over 100 lbs., cost is ($25 × Wt.) + $5,000.

Some features modify the final cost of the gun. All are cumulative:

Conventional Gun: Divide cost by 10 if TL3-5, by 5 if TL6, by 2 if TL9, and by 4 if TL10+. Multiply cost by 0.8 if gun is smoothbore. Multiply cost by 1.5 if gun uses either an electric or electric Gatling loading mechanism.

Electromag Gun: Multiply cost by 16 at TL8, by 8 at TL9, or by 4 at TL10+.

Gravitic Gun: Multiply cost by1 6 at TL11, by 8 at TL12, or by 4 at TL13+.

Any Gun/Launcher: Double cost in addition to other modifiers!

Round off cost to two places.

Tactical and Strategic Nukes

Nuclear weapon yield is normally measured in kilotons (kt., explosive force equal to a thousand tons of TNT) or megatons (Mt., equal in explosive force to a million tons of TNT).

The division between a tactical and strategic nuclear weapon is tenuous – the Cold War joke was that a tactical nuclear weapon was one that landed on Germany. In general, tactical nuclear weapons have yields under ten kilotons and are intended for smashing armies and supply sites. Strategic nukes are of ten or more kilotons yield and are used to destroy cities and "hard" targets like underground missile silos or command posts.

Use of nuclear weapons on or above an inhabited world is often restrained due to political, humanitarian and environmental considerations. Beyond a planet's orbit, there is less to damage: nukes of all sizes are attractive weapons for space missiles.

1 kiloton: Concussion damage is 12d × 2,000,000. For every 128 yards from the impact site, quarter concussion damage. Minimum bore size to fire is 125mm at TL7, 100mm at TL8, 75mm at TL9, 50mm at TL10 and 25mm at TL11+. Cost is the same as a weapon with a HEAT warhead, plus $36,000.

10 kiloton: A small strategic or large tactical weapon, similar in yield to the bomb dropped on Hiroshima. Concussion damage is 12d × 20,000,000. For every 256 yards from the impact site, quarter damage. Minimum bore size to fire is 150mm at TL7, 125mm at TL8, 100mm at TL9, 75mm at TL10, and 50mm at TL11+. Cost is the same as a weapon with a HEAT warhead, plus $42,000.

100 kiloton: A "strategic" weapon able to totally destroy a city. It does 12d × 200,000,000 concussion damage. For every 512 yards from the impact point, quarter the damage. Minimum size to fire is 200mm at TL7, 175mm at TL8, 150mm at TL9, 125mm at TL10, and 100mm at TL11+. Cost is the same as a weapon with a HEAT warhead, plus $48,000.

Continued on next page . . .

Tactical and Strategic Nukes (Continued)

1 megaton: A large "strategic" bomb, capable of wrecking everything within a five mile radius and causing serious damage out to about 9 miles. It does 12d × 2,000,000,000 concussion damage. For every 1,024 yards from the impact point, quarter the damage. Minimum size to fire is 250mm at TL7, 225mm at TL8, 200mm at TL9, 175mm at TL10 and 150mm at TL11+. Cost is the same as a weapon with a HEAT warhead, plus $64,000.

Extra cost of nuclear weapons is halved at TL9-14 and halved again at TL15+.

Micronuke Warheads (TL9)

A micronuke is usually a laser-triggered deuterium fusion warhead, although antimatter warheads are also used. Unlike earlier multi-stage fission-fusion-fission bombs, the idea of a micronuke is to create a *small* explosion – one that permits a truly tactical nuclear weapon, packing the punch of no more than a ton or so of conventional explosive in a projectile the size of a grenade.

Micronukes can be used in any gun or launcher warhead. Minimum weapon size is 40mm at TL9, 30mm at TL10, 20mm at TL11, 15mm at TL12, 12mm at TL13, 10mm at TL14, 7.5mm at TL15, 5mm at TL16. CPS is equal to the cost of a round with a HEAT warhead, with an extra cost shown below:

0.0001 kiloton: 12d × 200 concussion damage. For every 8 yards from impact point, quarter the damage. Extra cost is $6,000.

0.001 kiloton: 12d × 2,000 concussion damage. For every 16 yards from impact point, quarter the damage. Extra cost is $9,000.

0.01 kiloton: 12d × 20,000 concussion damage. For every 32 yards from impact point, quarter the damage. Extra cost is $12,000.

0.1 kiloton: 12d × 200,000 concussion damage. For every 64 yards from the impact point, quarter the damage. Extra cost is $15,000.

Halve extra cost at TL15+.

Advanced Conventional Guns

Conventional guns of sufficient TL may optionally have one of these special options. If so, design the weapon and ammunition normally, then after the design is finished, make the indicated modifications as described below.

Plastic-Cased Ammunition (late TL7)

Plastic-cased ammunition uses a lightweight plastic case rather than a conventional brass or other metal case. Until TL8, this is not available for light or heavy automatic or electric Gatling guns. Divide WPS and VPS by 1.5, but double CPS.

Continued on next page . . .

EXAMPLE

The minigun's cost is based on its 33 lb. weight: weight × $75, or $2,475. Then, because it is a conventional gun and has an electric loading mechanism, we multiply that cost by 1.5 to $3,712.5. Again, we round off to two places, leaving a final cost of $3,700.

Shots

This is the number of shots ready to be fired without someone having to physically insert another round of ammunition or a magazine into the weapon.

For muzzleloading or breechloading weapons, Shots equals the number of barrels (normally one). For revolvers, Shots equals the number of chambers. Otherwise, record "var.," indicating that the number of shots varies depending on how much ready ammunition is carried aboard the vehicle, ready to be fed into the weapon.

We're now done – the gun is ready to be installed in a vehicle! Come up with a name for the gun and record the statistics in an easy to use format. For instance:

"Minigun: 7.62mm conventional, rifled, 6-barrel electric Gatling gun. (Wt. 33 lbs., $3,700. Solid ammo: WPS 0.055 lbs., VPS 0.00037, CPS $0.11, Pow. 0.55 kW.)"

	Malf.	*Type*	*Damage*	*SS*	*Acc*	*1/2D*	*Max*	*RoF*	*Shots*
7.62mm Minigun	Ver.	Cr.	7d	20	13	780	4,100	100	var.

Other Ammunition

The basic weapon statistics provide the combat statistics for a weapon that uses ordinary solid rounds. Obviously, weapons will not always use this simplest of projectiles! Select the basic types of ammunition that the weapon uses. This will determine the effect the round has when it strikes its target. For detailed descriptions, refer to the sidebars of this chapter.

Ammunition comes in several main categories:

Kinetic-energy rounds do their main damage through the kinetic energy of their impact, generally doing crushing damage.

Explosive rounds are filled with explosive filler. They do explosive concussion damage, and sometimes scatter lethal fragments about as well.

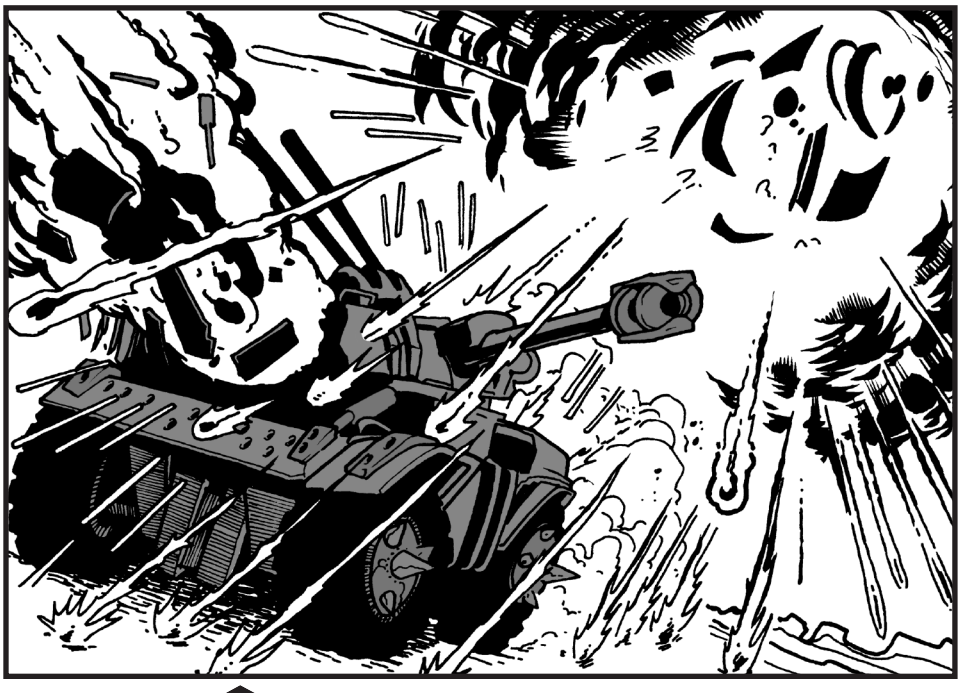
Kinetic energy/explosive rounds are fused to penetrate into armor before exploding. They inflict both crushing and explosive damage.

Shaped-charge rounds use a specially-shaped hollow explosive charge that can penetrate deep into armor.

Multiple projectile rounds contain many small pellets or darts.

Bursting rounds burst over an area, scattering bomblets, mines, flares, or chemicals such as gas or smoke.

Decide what ammunition the gun uses. Most guns can use dozens of different types of ammunition. Just pick the ammunition types you want to work out the gun's combat statistics for.



Ammunition Types by Class and TL

TL	Class
	Kinetic-Energy
3	Solid – a solid projectile. Cheap but effective!
4*	Chainshot – two balls linked by a chain.
6†	AP – an armor-piercing bullet.
6*	APC – an armor-piercing cannon round.
6*	API – an AP cannon round with added incendiary material.
6*	APCR – superior AP cannon round with a rigid tungsten core.
6†	HP – hollow point, a bullet designed to expand in flesh.
6†	Plastic – a plastic or rubber bullet.
6*	Baton – a non-lethal anti-riot round.
7*	APDS – improved APCR cannon round with discarding sabot.
7†	APS – an armor-piercing, saboted bullet.
7*	APDU – improved APCR with depleted uranium core.
7*	APDSDU – improved APDS with dense, depleted uranium core.
7*	APFSDS – hypervelocity, fin-stabilized APDS dart.
7*	APFSDSDU – hypervelocity, fin-stabilized APDSDU dart.
8‡	Needle – a sliver-like projectile.
9‡	Superwire – a superconducting monowire projectile.
11†	APSHD – an advanced, hyperdense, saboted bullet.
11*	APDSHD – ultra-tech APDS with hyper-dense core.
11*	APFSDSHD – hypervelocity, fin-stabilized APDSHD dart.
	Explosive
5§	LE – Low Explosive, a fused round filled with black powder.
6§	HE – High Explosive, a modern explosive, fragmenting round.
6§	HEC – HE Concussion, with big blast, little fragmentation.
6**	HEDC – HE Depth Charge round for attacking submarines.
6§	HEPF – HE Proximity-Fused round for anti-aircraft fire.
7§	HESH – HE Squash-Head, plastic explosive built to defeat armor.
7**	Nuclear or Micronuke – BOOM! See sidebars, pp. 108 to 110.
	Kinetic/Explosive
5§	SAPLE – LE fused to go off after piercing armor.
6§	SAPHE– HE fused to go off after piercing armor.
7§	APEX – armor piercing explosive cannon round.
	Shaped-Charge
6§	HEAT – a shaped-charge, armor-piercing "anti-tank" round.
7§	HEDP – HE Dual Purpose, a fragmentation and HEAT round.
	Multiple Projectile
3§†	Shotshell – multiple shotgun pellets.
4*	Canister – a spray of pellets, grapeshot or scrap.
5**	Shrapnel – a bursting shell filled with bullets.
7§	Beehive – high-tech shrapnel using anti-personnel darts.
	Bursting
5§	CHEM – Chemical, a gas or smoke-filled round.
7††	FASCAM – Drops a field of scattered anti-armor mines.
7††	ICM – cluster munitions that scatter grenades over an area.
8††	SICM – "Smart" ICM that home in on targets.
9††	SATNUC – smart ICM with tiny, shaped nuclear warheads.

† Only available for smallarms of greater than 2mm bore size.

‡ Only available for smallarms of 2mm or less bore size. Superwire is only usable in electromag or gravitic guns.

* Only available for cannon.

** Minimum bore size is 60mm; nuclear rounds may have other restrictions (see sidebars, pp. 108-110).

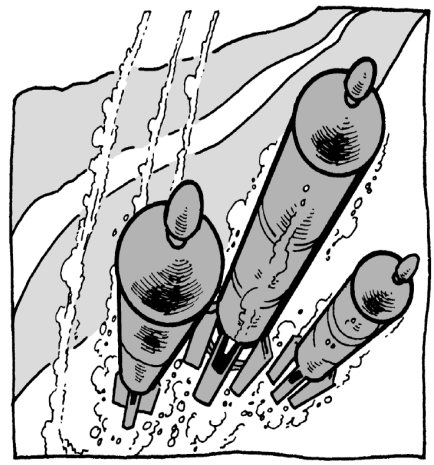
†† Minimum bore size is 120mm at TL7-, 80mm at TL8+.

§ Minimum bore size is 10mm, except HEAT, HEDP, HESH whose minimum bore size is 20mm at TL6-7, 15mm at TL8, 10mm at TL9+.

See the ammunition sidebars for descriptions of each type!

We decide the gun fires solid ammunition.

EXAMPLE



Advanced Conventional Guns (Continued)

Caseless (TL8)

Caseless weapons embed the projectile in a "cake" of solid propellant. This means the weapon has no cartridge ejection port, enabling the mechanism to be better protected from dirt, etc. Reduce the chance of malfunction by one step (e.g., "Crit." becomes "Ver."), to a minimum of "Ver. (Crit.)." Also, caseless rounds are lighter and more compact, so WPS and VPS are halved. However, the extra complexity doubles the gun's Cost.

Liquid Propellant (TL8)

Instead of using solid propellant, the weapon injects high-energy liquid propellants (stored with the projectiles) into the chamber of the weapon just before firing, using a computer to select the exact amount of propellant needed to send the round the desired distance. They are treated exactly like caseless guns, except that cost is tripled rather than doubled.

By varying the amount of propellant used, the gunner may choose to fire normal, low, or hyper velocity shots. Hyper velocity adds +1 to Acc and multiplies KE damage, and 1/2D and Max ranges by 1.5. Low-velocity shots have -2 Acc and half KE damage, 1/2D and Max, but the gun is effectively silent, and recoil is also halved. Normal shots are unchanged.

Electrothermal (TL8)

These guns use an electric charge to vaporize a propellant into steam or plasma, which expands and smoothly accelerates the round down the barrel at high velocity. Unlike conventional guns, they also require a power supply. They get +1 Accuracy, and multiply KE damage and 1/2D and Max ranges by 1.5. Their WPS, CPS and VPS are divided by 2.5, but weapon cost *quadruples*. They also require power. Calculate the power requirement as if the weapon were an electromag gun, then divide by 10. For hand weapons, add power cells using the rules for electromag guns.

Optional Missile Rules

These rules allow missiles to be customized for special applications:

Submarine-Launched Missiles

Missiles with inertial guidance or inertial guidance with some form of terminal homing can be launched from an underwater vehicle. The missile will rise out of the water, and then proceed normally to its target as directed by its guidance system.

To launch successfully, the submarine should be no deeper underwater than 1 yard per 2 miles of missile direct-fire range.

Missiles Carrying Torpedoes

A TL7+ missile may carry a torpedo as a warhead (this is often called a "stand off torpedo"). The missile must be given an inertial guidance system. The missile is fired at a particular map reference. When it reaches the destination, it breaks up and releases the torpedo (often by parachute), which then plunges into the water and turns on its guidance system. It will seek out the nearest vehicle within range and home in on it.

Design the missile normally, but use the torpedo weight as the warhead weight (Wwt).

Space-Combat Missiles

A rocket or missile intended for space(ship)-to-space(ship) combat has different characteristics than one intended for use on a planet. A weapon launched in space can't use fins for guidance, atmospheric drag doesn't limit its speed, it needn't be streamlined, and so on.

Ideally, a space-combat missile should be built as an unmanned vehicle with a computer for control and a self-destruct device (see p. 70), and its performance calculated as if it were any other vehicle. In particular, this is suggested for building long-range, reactionless drive or FTL missiles which, with an appropriate power plant, could cruise for days or weeks, since they require no fuel!

However, ordinary missiles, provided they do not have sonar or wire guidance, can be easily modified for use in space combat. When designing the motor, specify an acceleration in *G* rather than a speed in yards per second. Then record the G for speed – it is the missile's sAccel rating – and calculate Endurance as follows:

END = (MWt/WPS) × (P/G).

Where:

MWt is the motor weight.

WPS is the weight per shot of the missile.

P is 280 at TL4-, 455 at TL5, 665 at TL6, 980 at TL7, 1120 at TL8-10, and 1750 at TL11+.

G is the desired acceleration in *gravities.*

END is the number of seconds of acceleration of the missile at that G. If the formula results in END under 0.5 seconds, the missile design is not feasible. Alter speed and try again!

Cannon-Launched Guided Projectiles (CLGP, late TL7): A projectile may be given a terminal guidance system to help hit targets when fired indirectly (see sidebar, pp. 179-181). The minimum size round that can accept a CLGP system is 70mm at TL7, 40mm at TL8, 20mm at TL9, 10mm at TL10, and 5mm at TL11+. SICM and SATNUC do not require CLGP – they already use a form of it.

Rocket Assist (TL7): Gun ammunition of 20mm or larger bore size may be given a rocket booster. This increases range but also ammunition weight and cost.

Ammunition Statistics

Type is the type of damage the ammunition inflicts.

Damage is the formula used to calculate the weapon's damage. A number in parenthesis such as (2) is an armor divisor: armor DR is divided by that number vs. a direct hit. Note that a (0.5) divisor actually *doubles* the protection of armor DR. For bursting-class rounds (CHEM, FASCAM, ICM, SICM and SATNUC), "damage" is the burst radius in yards.

Damage for kinetic energy rounds often has a ×1.33 or ×1.66 multiplier. If the round does 6d × *n* KE damage, a ×1.33 multiplier can be added by changing damage to 8d × *n* and a ×1.66 multiplier is 10d × *n.*

Rng is the multiple (or divisor) applied to the weapon's 1/2D and Max ranges when firing that ammunition. "–" indicates range is unchanged.

WPS of "–" indicates the ammunition has the normal weight per shot. Otherwise, multiply or divide WPS as shown, e.g., /1.5 means that ammunition's weight is divided by 1.5.

CPS of "–" indicates the ammunition has the normal cost per shot. Otherwise multiply CPS as shown for this ammunition type, e.g., ×3 means that ammunition's CPS is triple normal.

Acc is the modifier to Accuracy when firing that ammunition.

Ammunition Table

Ammunition	*Type*	*Damage*	*Rng*	*WPS*	*CPS*	*Acc*
Solid	Cr.	KE	–	–	–	–
Chainshot	Cr.	0.5×KE	/2	–	–	+2
AP or APC	Cr.	KE(2)	–	–	×3	–
API	Cr.	KE(2)	–	–	×4	–
APCR	Cr.	1.33×KE(2)	–	–	×5	–
HP	Cr.	KE(0.5)	–	–	×1.5	–
Plastic	Cr.	0.5×KE	×0.5	–	–	–
Baton	Cr.	0.66×KE	×0.2	–	×2	–
Needle	Imp.	0.66×KE	×0.66	–	×2	–
APDS	Cr.	1.66×KE(2)	×1.5	/1.5	×5	–
APS	Cr.	1.28×KE(2)	×1.5	/1.5	×5	–
APDU	Cr.	1.33×KE(3)	–	–	×6	–
APDSDU	Cr.	1.66×KE(3)	×1.5	/1.5	×10	–
APFSDS	Cr.	2×KE(2)†	×1.5	/1.5	×8	+1
APFSDSDU	Cr.	2×KE(3)†	×1.5	/1.5	×12	+1
Superwire	Imp.	0.25×KE(10)	/2	–	×100	-2
APSHD	Cr.	1.33×KE(5)	×1.5	/1.5	×20	–
APDSHD	Cr.	1.66×KE(5)	×1.5	/1.5	×20	–
APFSDSHD	Cr.	2×KE(5)†	×1.5	/1.5	×30	+1
LE	Exp.*	C×X/16,000	–	/1.5	×2	–
HE	Exp.*	C×X/16,000	–	/1.5	×2	–
HEC	Exp.	C×X/12,000	–	/1.5	×2	–
HEDC	Exp.*	C×X/16,000	–	/1.5	×3	–
HEPF	Exp.*	C×X/16,000	–	/1.5	×5	–
HESH	Exp.	C×X/16,000	–	/1.5	×4	–
Micronuke	Exp.	sidebar, p. 110	–	–	spcl.	–
SAPLE	Cr.	KE(0.5)	–	/1.5	×2	–
plus	Exp.*	C×X/16,000	–	–	–	–
SAPHE	Cr.	KE(0.5)	–	/1.5	×2	–
plus	Exp.*	C×X/16,000	–	–	–	–
APEX	Cr.	KE(2)	–	–	×5	–
plus	Exp.*	C×X/24,000	–	–	–	–
HEAT	Exp.	B×S×H(10)	–	/1.5	×3	–
HEDP	Exp.*	B×S×H(5)	–	/1.5	×3	–
Shotshell	Cr.	0.75×KE	/10	/2	–	-1
Canister	Cr.	(2.7×KE)/B	/6	/1.5	–	-5
Shrapnel	Cr.	1d	–	–	×3	–
Beehive	Imp.	(2.7×KE)/B	–	/1.5	×4	–
CHEM	Spcl.	0.00375×B×B	–	/1.5	×2	–
FASCAM	Spcl.	0.0075×B×B	–	/1.5	×10	–
ICM	Spcl.	0.0075×B×B	–	/1.5	×10	–
SICM	Spcl.	0.0075×B×B	–	/1.5	×100	–
SATNUC	Spcl.	0.015×B×B	–	/1.5	×200	–
Rocket assist	–	–	×1.5	×1.5	×3	-1

KE is the base kinetic energy damage of the weapon – the crushing damage it does with a solid shot.

B is the bore size in mm.

C is the bore size *cubed* – B × B × B. Exception: If under 20mm, C is 400 × B.

X is 0.375 if TL5-, 0.75 if TL6, 1 if TL7, 3 if TL8, 4.5 if TL9+.

S depends on bore size, and is 0.2 if 44mm or less, 0.3 if 45-49mm, 0.5 if 50-54 mm, 0.7 if 55 to 59 mm, and 1 if 60mm or greater.

H is 0.25 if TL6, 0.375 if TL7, 1 if TL8, 1.5 if TL9+.

* Also inflicts fragmentation damage as described on p. B121-122 if bore size is 20mm or larger: [2d] for 20-34 mm rounds, [4d] for 35-59 mm, [6d] for 60-94mm, [10d] for 95-160 mm, [12d] for larger warheads. Fragment damage is recorded in square brackets after the explosive damage, e.g., 6d×10[10d].

† Damage multiplier is 1.84 × KE instead of 2 × KE if weapon is a rifled gun. A damage of 6d × n becomes 11d × n.

Special Cases

For CLGP, add $1,000 at TL7, $500 at TL8, $200 at TL9 or $100 at TL10+. For SICM, minimum CPS is $1,000 at TL8, $500 at TL9, $200 at TL10 or $100 at TL11+. If SATNUC, minimum CPS is $5,000 at TL9, $2,500 at TL10+. For nuclear warhead cost, refer to the nuclear weapons sidebar (p. 109). HEAT/HEDP damage only applies to direct hits; calculate damage for near misses as if an HE warhead.

Launcher, Torpedo and Missile Design

Launchers fire self-propelled projectiles, such as rockets, guided missiles and torpedoes. At TL6 and up, these projectiles can be guided. Because the projectiles are self-propelled, a launcher is much lighter than an equivalent-sized gun: it doesn't need strong, reinforced barrels or a recoil carriage. On the other hand, the ammunition – individual missiles and torpedoes – is heavier and more costly than most bullets or shells. As a result, launchers usually have fewer shots than guns.

The same launcher can fire both torpedoes and missiles.

Torpedo and Missile Design

The ammunition for a launcher should be designed before the launcher itself. Missile and torpedo design is more complex than design of gun projectiles, because each missile or torpedo is really a tiny self-propelled vehicle of its own!

To design a missile or torpedo, follow these steps:

Missile or Torpedo?

Decide if the round is a missile (TL3) or a torpedo (late TL5).

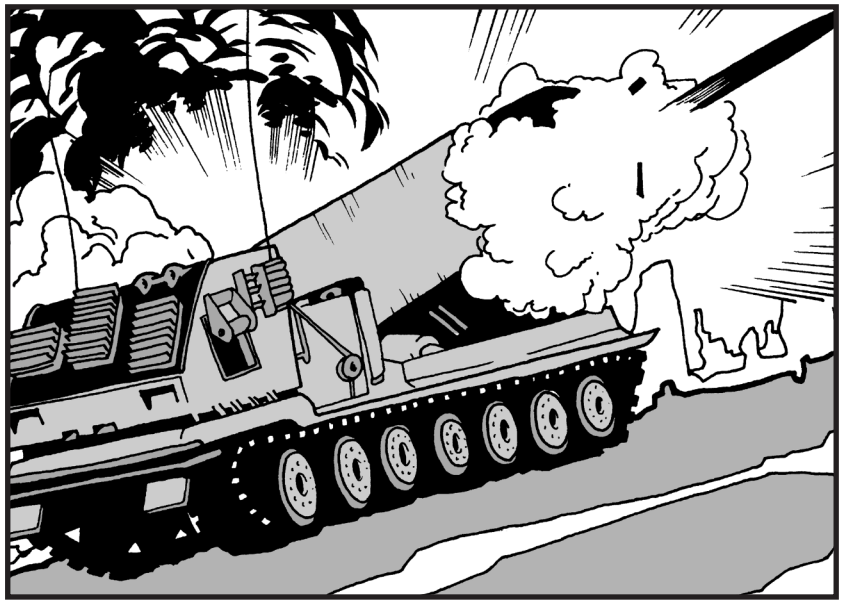
Missiles are self-propelled flying projectiles with their own rocket engine, jet engine or reactionless thruster, such as rockets or guided missiles.

Torpedoes are self-propelled aquatic projectiles, usually propelled by their own hydrojet, propeller or reactionless thruster, and powered by steam, compressed air, a battery or a power cell.

Diameter

This is the diameter of the missile or torpedo in millimeters, and governs both how powerful a warhead it has as well as limiting its maximum range. The minimum diameter is 10mm. Maximum suggested diameter is 3,000mm.

Most battlefield rockets and missiles have a diameter of 60-360mm, while ship-killing torpedoes are in the 300-600mm range.



Bombs

The first aerial bombs were hand grenades dropped from a spotter plane by the observer sitting behind the pilot. Basic aircraft bombs – known as "iron bombs" to distinguish them from other types – are metal canisters filled with high explosive (just like an HE shell) and fitted with stabilizing fins. Since they don't have to withstand the same firing stresses as shells, a larger percentage of the weight of an aerial bomb can be explosive, making them more powerful than a similar-sized shell.

Following the First World War, the technology of destruction progressed rapidly. The Spanish Civil War demonstrated the power of aerial bombardment. At the start of WWII, HE bombs weighed between 100 and 2,000 lbs. By the end of the war, strategic bombers had access to bombs weighing up to 22,000 lbs. for special purposes (like destroying hardened submarine pens) as well as various exotic types, and ultimately, the atomic bomb.

Building Bombs

Iron Bombs is the name usually given to ordinary unguided bombs. They are built exactly like missiles or torpedoes except they have no motor or guidance: just a warhead. They can be built at any TL, but are rare until TL6 when both fuses and flying machines become reliable.

Retarded Bombs (TL6) are iron bombs that use a drogue parachute to slow their fall, allowing an aircraft to drop bombs at lower altitudes without being caught in their blast; the effects of retarded bombs are further described in the *Bombing* rules on p. 114. Add 20% to the CPS of the bomb.

Smart Bombs (TL6) were experimented with in World War II, but were first widely used near the end of the Vietnam War. Smart bombs are built as guided missiles, except they lack a motor. They usually have TV guidance or semi-active laser homing, but may have any guidance system except inertial, wire-guided or brilliant. They are unpowered, using their fins to steer themselves as they drop toward their targets, and – as Desert Storm demonstrated – are very accurate.

Special Warhead – Fuel-Air Explosive (FAE) (TL7): This warhead is a special type, often used in retarded or smart bombs. Minimum size is 200mm at TL7, 150mm at TL8, or 100mm at TL9+. When an FAE explodes, it first produces a cloud of volatile gas and then ignites the gas, producing a huge fireball and concussion wave. Treat it exactly like an HEC warhead, but the bomb inflicts 5 × normal damage. The warhead costs ten times as much as a normal HEC warhead.

Continued on next page . . .

Bombs (Continued)

Statistics

Most bombs do normal damage using the rules for missiles. When working out the crushing damage from bombs with kinetic-energy warheads, use a speed of 80 (a typical terminal velocity – about 160 mph – for a falling bomb).

Self-Destruct Systems

Vehicles may be fitted with built-in bombs as explosive devices – this may be a self-destruct system (see p. 70), or can be used to create kamikaze craft or robot missiles. They may be detonated by operator command or by computer control.

Carrying Bombs

Bombs are treated as ammunition rather than weapons; as such, they aren't included as part of vehicle design itself. Instead, a certain weight of bombs can be attached to a vehicle that has been designed with external hardpoints (p. 94) or a weapon bay (p. 46). The total load of bombs that can be carried is limited by the capacity of the weapon bay, or by the number of hardpoints and the maximum load they can carry.

Bombing

Bombing depends on the skill of the crew, the equipment, and the altitude and speed of the aircraft at the time of the drop. Remember to count altitude when calculating the speed/range modifier (when working out diagonal distances, 1 yard of vertical and 1 yard of horizontal distance count as 1.5 yards). If multiple bombs are dropped, the GM should distribute the bombs in a "footprint" within the area they actually hit, using dramatic license where appropriate. See p. 113 for bomb types and damage.

The aircraft must be flying straight at the target: it can't otherwise maneuver on the turn it is bombing. Make a roll against Gunner (Bombs)-9. Apply normal combat modifiers for target size and speed/range. Don't forget modifiers for darkness. Subtract 4 if not using a bombsight, add +2 if using an improved optical bombsight or +4 if using an advanced bombsight, and add any bonuses for Targeting or Gunner (Bombs) software. Treat any bombsight bonuses as the bomb's Acc; it takes one turn of Aiming to gain them. Due to the automatic -9 penalty to skill, almost any bombing roll will be a miss – use the *Scattering* rules on p. 176 to determine by how far! A critical failure only occurs on a roll of 18: the bomb bay door jams, the bombs land on friendly troops, or someone set the fuses wrong and the bombs' warheads don't go off (this happened during the Falklands War).

Bombs should be dropped at reasonably high altitude – normally 500 yards is considered safe with most non-nuclear bombs. At low altitudes, fragments from the bomb may damage the aircraft!

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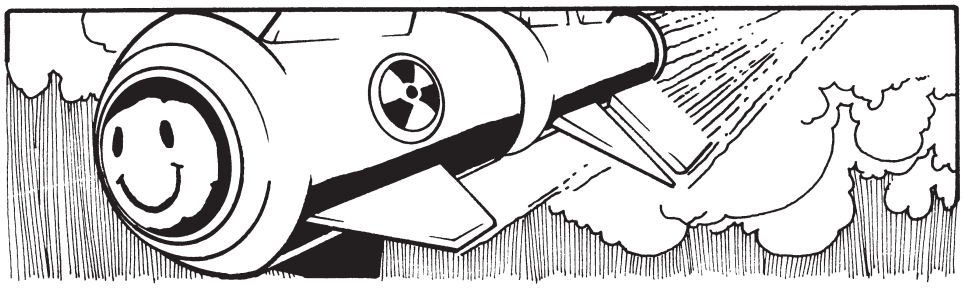


Warheads

The warhead is the business end of the missile or torpedo.

First decide if the warhead is *small, modest, normal, big* or *huge.* A larger warhead generally means more explosive damage but a considerably heavier and more expensive round.

Next, select the type of warhead from one of the types available at the weapon's TL:

TL3+: Solid*, LE.
TL6+: AP*, API*, CHEM, HE, HEAT, HEC, HEDC, HEPF, SAPHE*.
TL7+: HEDP, HESH, Hollow Point*, APDU*, APEX*, Nuclear, Beehive*, FASCAM*, ICM*.
TL8+: SICM*.
TL9+: Micronuke, SATNUC*.
TL11+: APHD*.
* These warheads are unavailable for torpedoes.

See the sidebars for explanations of what each type does.

Warhead weight (Wwt.): Calculate the warhead weight in pounds as follows:

Wwt. = (D cubed/125,000) × W.

Where *D* is the diameter in mm, and *W* is 0.25 if small, 0.5 if modest, 1 if normal, 1.5 if big or 2 if huge. Round weight to two digits.

Warhead cost (Wcost): Calculate the warhead cost. This is equal to warhead weight multiplied as shown below:

×$10 if Solid.
×$20 if LE, CHEM, HE, HEC, HEDC, Hollow Point, SAPHE.
×$30 if AP, APDU, HEAT, HEDP.
×$40 if APHD, API, Beehive, HESH.
×$50 if APEX, HEPF.
×$100 if FASCAM, ICM.
×$1,000 if SICM.
×$1,500 if Micronuke.
×$2,000 if SATNUC.

Divide the warhead cost by 10 at TL5-, and by 4 at TL6. Cost is unchanged at TL7+.

Guidance

Missiles or torpedoes built at TL6+ may optionally be equipped with a guidance system to improve the chance of hitting. The minimum size for guided projectiles is 140mm at TL6, 70mm at TL7, 40mm at TL8, 20mm at TL9 and 10mm at TL10+. If guided, select a guidance system from the options below.

Inertial Guidance (IG, TL6): The weapon is programmed to travel to a particular map-reference point, staying on course with a gyroscope or other inertial navigation system. This guidance system or brilliant guidance is used for very-long-range missiles, and are the only types usable with indirect fire.

Passive Sonar-Homing (PSH, late TL6): The weapon uses an acoustic sensor to find its target, a method first used in World War II. Sonar homing is usable only for torpedoes, not for missiles.

Active Sonar-Homing (ASH, late TL6): The weapon uses a small active sonar to find its target. This is more effective than PSH, but has the disadvantage that the sonar's noise can be detected by the target, warning of impending doom.

Wire-Guided (WG, late TL6): A gunner steers the missile or torpedo like a remote-control airplane. The weapon receives signals from a wire that trails between it and its launcher. The gunner steers the missile via a joystick while keeping his sight aimed at the target, or by late TL7, simply trains the sight on the target while the missile steers itself. A distraction (like maneuvering or dodging enemy fire) will result in loss of control. Since they are connected to the launcher by a wire, these missiles cannot be very fast or long-ranged. TL8+ systems use an optical fiber rather than a wire, but are otherwise identical.

Communicator-Guided (CG, TL6): This is like wire-guided, except that signals are sent to the missile or torpedo through a radio (RCG), laser (LCG) or neutrino (NCG) communicator. This allows a greater range than wire guidance and can be used from a moving vehicle, but is vulnerable to any countermeasures that would jam the communicator signal. The vehicle must also have a communicator with range at least equal to the missile's or torpedo's range to transmit guidance instructions. RCG systems are not usable on torpedoes or bus missiles (p. 117).

TV-Guided (TVG, TL7): The missile has an electro-optical sensor – a television camera – in its nose that transmits a picture to the gunner's monitor. It is then steered by its operator to the target. The gunner does not have to keep the target in sight. The gunner must have a communicator with range at least equal to the missile's or torpedo's range, and also requires a computer terminal. Like communicator guidance, TVG comes in radio (RTVG), laser (LTVG) or neutrino (NTVG). TVG is not available for bus missiles (p. 117).

Wire-Guided/Active Sonar-Homing (WGSH, TL7): The weapon is normally treated as using wire guidance, but can also switch to active sonar and use it instead of the wires. This system is common on modern submarine torpedoes. It is not usable for missiles.

Infrared Homing (IRH, TL7): A "heat-seeking" sensor on the weapon homes in on infrared radiation. Early-TL7 "rear-aspect" IRH is only sensitive enough to track very hot objects: the exhaust pipes of engines, fires, or (by accident) the sun. Due to this lack of sensitivity, early-TL7 IRH missiles are generally only effective against aircraft, and only when fired at the rear where they can easily lock onto the super-hot metal of the engine exhaust pipes. Late-TL7 "all-aspect" IRH weapons use an improved sensor that can detect the warm metal of a vehicle's surface as well as the engine, enabling them to attack targets from any angle. IRH is not usable on torpedoes.

Imaging Infrared Homing (IIRH, late TL7): These are advanced thermal imaging seekers that lock onto an actual image of the target rather than simply its heat contrast. IIRH is not usable on torpedoes.

Anti-Radiation Missile Homing (ARM, TL7): The missile has a sensor that detects operating radars, radios and active radar jammers, and homes in on them. ARM guidance missiles are often launched in advance of a major air or missile attack to suppress hostile air search and SAM-guidance radars, forcing the enemy to turn off their systems or lose them to missile strikes. Then, with the enemy blinded, the main wave of attacking aircraft or missiles strikes. It is not usable on torpedoes.

Semi-Active Radar Homing (SARH, TL7): The missile flies toward the target that is being "illuminated" by an external radar. The missile uses a seeker to sense these radar reflections and home in on them. The illuminating radar is often on the firing vehicle, but may be elsewhere. It must continually track the target for the missile to hit. SARH guidance is usually used for TL7, long-range air-to-air and surface-to-air missiles. It not usable on torpedoes.

Semi-Active Laser Homing (SALH, TL7): This works the same way as SARH except that a laser designator or ladar must be used instead of a radar. Although more vulnerable to atmospheric problems (e.g., clouds, fog), laser designator equipment is harder to jam and is usually more portable than radars, so that even individual infantrymen can carry it. SALH weapons are also known as "laser-guided." The clever and smart missiles in ***Ultra-Tech*** are examples of SALH weapons.

Active Radar Homing (ARH, late TL7): The missile flies in the direction the target was last seen, then when it gets close, it turns on its own small radar set to search for the target. ARH guidance is not usable for torpedoes.

Active Ladar Homing (ALH, TL8): The missile flies in the direction the target was last seen, then when it gets close it turns on its own small ladar set to search for the target. ALH guidance is not usable for torpedoes.

Optical Homing (OH, TL8): The missile has a computer capable of recognizing vehicle silhouettes and an optical sensor. It is rather ineffective when used on torpedoes.

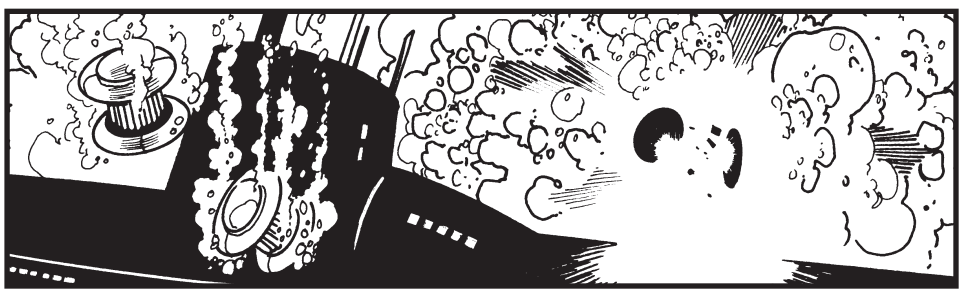
Passive Electromagnetic Homing (PEH, TL8): This is a guidance system that can be set for either IRH, ARM, PRH or OH before firing. It is not usable on torpedoes.

Passive Radar Homing (PRH, TL8): This uses a passive sensor that homes in on the contrast between the target's millimetric radiation emissions and the surrounding environment. In effect it is very similar to IRH, but countermeasures can be more difficult. PRH is not usable on torpedoes.

Multiscanner Homing (MH, TL10): Uses a multiscanner (p. 54) to home in on emissions from the target.

Neutrino Homing (NH, TL10): The sensor homes in on neutrino emissions from nuclear power units, radiothermal generators, operating force screens and fission, antimatter or fusion power plants. (Neutrino communicator beams are too narrow to be homed in on.) Unless the user wishes to attack a star, this guidance system is mainly useful for engaging ultra-tech vehicles, but it is very hard to jam or confuse.

Option – Brilliant (Late TL7): The weapon is programmed to travel to a pre-set distance and then activate a second, "terminal homing" guidance system to seek out and destroy any targets it spots. The advantage of this is that the weapon can be launched without a target being detected.



Bombing (Continued)

The target range must be within 50%-150% of altitude, i.e., a bomb dropped from 1,000 yards up may only be aimed at a target within 500 to 1,500 yards. At TL7+, retarded bombs become available, which can use a parachute to slow their fall. These reduce the parameters to within 10%-150% of altitude.

Bombs cannot be dropped from an aircraft that is rolling!

Dive-bombing (TL6): Some planes can deliver bombs in a flat, accurate trajectory by *diving* at the target. A plane must have an aDecel of 20 mph/s (and thus aMR 5+) or more to do this. It must dedicate at least 50 percent of its speed to diving (see p. 155) for each turn of the dive. Each consecutive turn of diving reduces the -9 bombing penalty by 1, until it is canceled out after nine seconds of diving. The pilot may Aim normally during the dive. The bomb must be carried on a hardpoint, limiting Gunner skill to Piloting-3 (see p. 177). All benefits of diving are lost if the pilot loses sight of the target. Range to target is determined at the end of the dive. Relative speed between plane and target will be 0, making the dive-bomber a target itself!

Smart Bombs (TL7): A "smart bomb" is normally an ordinary bomb with fins and a guidance package clipped to it. Treat smart bombs as *missiles* (p. 113) with (normally) TVG or laser guidance. The bomb moves at a speed equal to the aircraft's speed, and must lose 10% of its altitude every turn.

Mines

Mines are explosive booby traps that wait for someone to approach before detonation. Some require contact; others are proximity sensor-equipped to attack anyone close by, or only certain types of targets.

Naval Mines (TL5)

These may be simple moored or floating mines, or more sophisticated systems equipped with magnetic or acoustic sensors. They can be dropped by any naval vessel, carried by an aircraft and dropped from its weapon bay or hardpoints, or launched from a launch tube. The earliest mines were free-floating, and were used during the 19th century. Naval mines can be categorized as *contact* mines, which the vessel must bump into in order to detonate, and *proximity* mines, which detonate when a vessel simply passes close by. At TL7 and up, *attack* mines that launch torpedoes or missiles exist. These are best designed as water vehicles with an unstreamlined, unpowered hull, a torpedo tube, sensors, and a computer.

The GM should decide how large an area a minefield covers. A single mine's "danger area" is one square mile. Typically, no more than one to six mines will be in each area, so once these have been set off or spotted, that area is (probably) safe. Roll 3d per mile spent travelling through the danger area of a mine field for the mine's "attack." If the mines are contact-detonated, a roll of 3 indicates the ship has encountered a mine. If the mines are proximity-detonated, the chance of encountering a mine is the vessel's Size Modifier + (TL-6) or 3, whichever is greater.

Continued on next page . . .

Mines (Continued)

If a mine is encountered, its assumed that it will hit the vessel unless it is spotted first – make Vision rolls or sensor rolls at -5. A spotted mine can either be destroyed by gunfire or evaded.

Building Naval Mines: Build individual naval mines like torpedoes, but without a motor. Contact mines have no guidance system. Proximity mines are treated as having sonar-homing guidance systems, but at one-half cost. Some sophisticated TL7+ naval mines are really robots – build them as underwater vehicles with no propulsion system, but with their own sensors, computer and torpedo launchers.

Effects: When a mine explodes, damage to the vessel is below the waterline.

Carrying Mines

Naval mines can be carried in weapon bays (p. 46), on hardpoints (p. 94) or in launch tubes (p. 120) that can fit a weapon of the same diameter and weight as the mine. Like bombs, mines are considered ammunition. Naval mines can also be carried as cargo and laid by rolling them overboard.

Naval Minesweeping

Minesweeping involves moving slowly through a suspected minefield, and hoping to spot and remove the mine before it hits the ship. The basic way to do so is to try to spot the mine visually or with sensors, then mark its position or use weapons to destroy it.

Against TL5-7 mines, two vessels may work together, stringing a cable between them to set off any moored or drifting mines encountered; the cable is often electrified to set off magnetic mines. This is only possible in good weather, and lowers speed to 10 mph, but adds +2 to the chance of encountering all TL5-7 mines and +4 vs. TL6 proximity mines. If the mine is encountered, it will hit the cable and explode harmlessly on a roll of 1-4 on 1d. At TL7+, helicopters can tow special minesweeping sleds trailing below them (1,200 lbs., 60 cf, $25,000), adding 3 to the chance of encountering mines of their TL or less; if a mine is encountered, it is harmlessly detonated.

Land Mines

Land vehicle underside and motive systems are often poorly armored: a few mines can be as effective as an armored company in stopping an advance or in cutting a supply line. Land mines are built like missiles, but may not have kinetic-energy-class warheads. Instead of a guidance system or motor, they have a "trigger."

Continued on next page . . .

The terminal guidance system must also be chosen. The options are active sonar homing (BASH), passive sonar homing (BPSH), active radar homing (BARH), semi-active ladar homing (BSALH), active ladar homing (BALH), anti-radar missile homing (BARM), infrared homing (BIRH), imaging infrared homing (BIIRH), optical homing (BOH), multiscanner homing (BMH), neutrino homing (BNH), passive radar homing (BPRH) and passive electromagnetic homing (BPEH). BASH and BPSH guidance are only usable for torpedoes; BNH, BSALH, BALH and BOH are usable with torpedoes or missiles; the other types are usable with missiles.

Option – Mid-Course Update (MU) (TL7): This can be given to a brilliant or inertial guidance weapon. It allows the weapon to have its targeting information reprogrammed at some point during the weapon's flight, provided the weapon has not travelled any farther than half its maximum range and the weapon is in range of the gunner's communicator. Brilliant weapons cannot be reprogrammed after they have turned on their terminal homing. A weapon with MU may also be ordered by the gunner to self-destruct at any point in its flight.

Option – Pop-Up (PU) (late TL7): This can be given to a guided missile (except one using inertial guidance) intended for use against ground or water targets. It allows the weapon to pop up and attack the top of the vehicle rather than the side it was facing.

Skill: This represents the effectiveness of the guidance system. An "OG" indicates the system is operator-guided, requiring a gunner to steer the weapon toward its target.

Guidance Weight: Calculate the guidance system weight (Gwt.) using the table below, based on the TL of the system and the type of weapon. For brilliant weapons, add the weight of a brilliant guidance system to the weight of the chosen terminal guidance system. If a weapon has two types of guidance (e.g., Wire-Guided/Active Sonar-Homing), add the weights of the two systems together.

Guidance Table

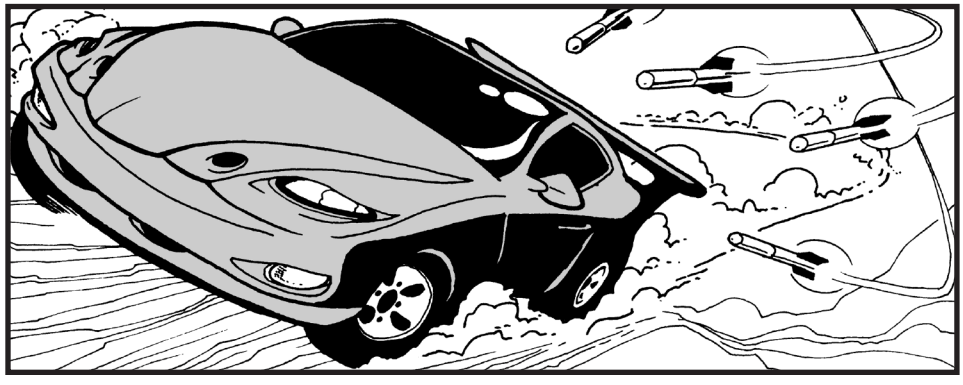
Type	*TL6*	*TL7*	*TL8*	*TL9*	*TL10*	*TL11+*	*Cost*	*Skill*
IG	20	5	2	1	0.25	0.1	$10,000	–
PSH	10	5	2.5	1	1	1	$3,000	TL+8
ASH	20	10	5	2.5	2.5	2.5	$3,000	TL+6
WG	20	10	5	5	5	5	$500	OG
CG	10	2.5	1	0.5	0.25	0.1	$2,000	OG
TVG	no	15	5	2.5	1	0.5	$4,000	OG
IRH	no	2.5	1	0.5	0.25	0.1	$2,000	TL+7
IIRH	no	2.5	1	0.5	0.25	0.1	$3,000	TL+7
ARM	no	5	2	1	0.5	0.25	$10,000	TL+4
SARH	no	5	2	1	0.5	0.25	$4,000	TL+4
SALH	no	2.5	1	0.5	0.5	0.25	$4,000	TL+5
ARH	no	10	4	2	1	0.5	$10,000	TL+8
ALH	no	no	4	2	1	0.5	$10,000	TL+7
OH	no	2.5	1	0.5	0.25	0.1	$2,000	TL+7
PEH	no	no	2	1	0.5	0.25	$20,000	TL+7
PRH	no	no	1	0.5	0.25	0.1	$3,000	TL+6
MH	no	no	no	no	2	1	$1,000	TL+3
NH	no	no	no	no	0.25	0.1	$4,000	TL+6
Brilliant*	no	+5	+2	+1	+0.25	+0.1	+$10,000	–

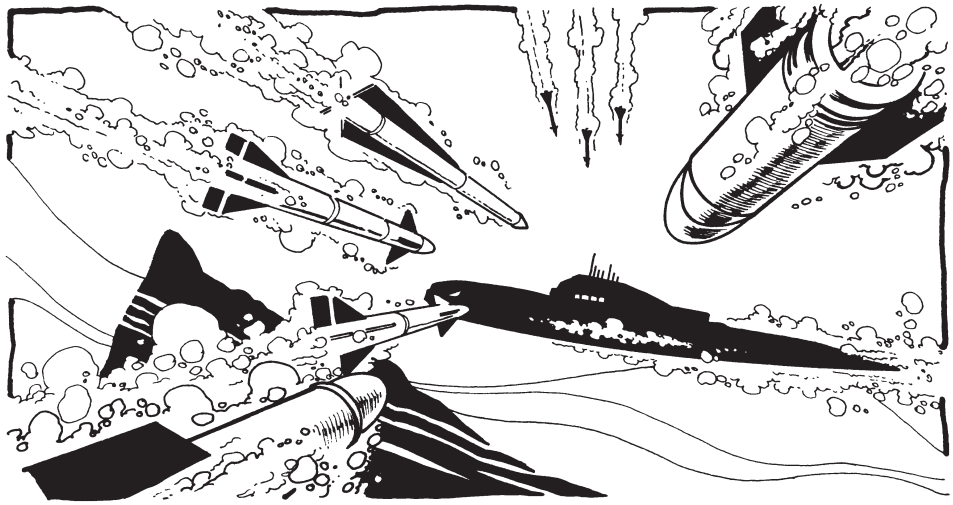
A larger guidance system can be added to improve skill. For each +2 to skill, double weight; e.g., +6 skill would be 8 × weight. Or, a "compact" guidance system with half the normal weight can be taken in return for a -2 penalty to skill. In addition to these options, a "cheap" guidance system can be used that leaves weight unaffected, is -1 to skill but reduces cost (see below).

Guidance System Cost: Calculate the guidance system's cost (Gcost) as equal to the cost shown on the table multiplied by the guidance system's weight: Gcost = Gwt. × Cost. Treat weight as one-half what it actually is for a "cheap" system.

*For brilliant systems, add the costs of brilliant guidance and terminal homing systems together and multiply by the sum of the brilliant guidance and terminal homing system weights.

MU and PU: After all other calculations, multiply the cost of the guidance system by 1.2 if capable of mid-course update (MU), by 1.25 if pop-up (PU) capable, or by 1.5 if capable of both.





Payloads

Determine the payload weight of the missile or torpedo. Payload weight (Pwt.) equals the sum of warhead and guidance system weights:

Pwt. = Gwt. + Wwt.

Determine the payload cost of the missile or torpedo. This is equal to the guidance and warhead costs:

Pcost = Gcost + Wcost.

Bus Missiles (late-TL7): Missiles can be fitted with multiple warheads. Such a "bus" missile separates the warheads somewhat before impact (or if fired indirectly, as the round tops its ballistic curve). Each warhead attacks the target separately; if the weapon is guided, each can also maneuver to attack different targets at a distance from the point of separation no greater than 1/10 weapon's maximum range. For a bus missile, decide how many warheads it carries (up to a suggested maximum of 10) and multiply the Pwt. and Pcost by that number to get their actual values.

Motors

Decide on the speed of the missile or torpedo in yards per second. Maximum speed for torpedoes is TL × 10. Maximum speed for missiles is TL × 1200, but wire-guided or sonar-homing weapons may not exceed 300 yards per second. Missiles with speeds over 360 are supersonic. Those with speeds over 800 are hypersonic. Faster torpedoes and missiles have a somewhat shorter range than slower ones. Minimum missile speed is 75.

Space missiles can be built as well – see sidebar on p. 112 for changes to motor rules.

Next, whether the weapon is a missile or torpedo, specify its *motor weight* (Mwt.) in pounds. This is the combined weight of the system's motor, power system, propellant, streamlining, attitude jets, etc. The higher the motor weight compared to the payload weight and to speed, the longer the missile's range.

Motor weight (Mwt.) may be set at any weight up to eleven times the actual payload weight. A weight of from 1 to 3 times payload weight is normal for subsonic missiles or torpedoes, from 4 to 10 times Pwt. is typical of supersonic or hypersonic missiles. Big (over 300mm) weapons tend toward the lower end of these ratios, while small (150mm or less) weapons lean toward the high end of them. Space missile motors have no upper limit on weight.

Motor Cost: Determine the motor cost (Mcost). For guided weapons, it costs $10 × Mwt at TL5-, $20 × Mwt at TL6, $100 × Mwt. at TL7-8, or $50 × Mwt at TL9+. For unguided weapons it costs $1 × Mwt at TL5-, $2 × Mwt at TL6, $20 × Mwt. at TL7-8, or $10 × Mwt at TL9+.

Stealth

At late TL7 and up, any missile or torpedo can be *stealthy,* making it harder to detect with sensors. At TL7, missiles with speeds over 800 cannot be stealthy. This restriction does not apply at TL8+.

Stealth on a missile has the same effect as the basic stealth vehicular surface feature (p. 91). Stealth on a torpedo has the same effect as the basic sound baffling surface feature (p. 91).

Stealth will greatly increase the weapon's cost.

Weight Per Shot

WPS is the complete weight of the missile or torpedo. WPS is the sum of the weapon's motor weight and payload weight:

WPS = Mwt. + Pwt.

Volume Per Shot

VPS is the storage volume of the weapon. It is equal to WPS/50 cf.

Land Mines (Continued)

Pressure Trigger (TL6): This is a trigger that sets off the mine when someone or something moves onto it. It is set for a specific weight. (Note that since the trigger sticks out of the ground, the entire weight of a vehicle driving over it is bearing on it, not just the vehicle's ground pressure!) Pressure mines are normally set for a minimum weight that will set them off, so (for instance) they can be tailored to go off when driven over by vehicles, but not by people. A pressure trigger is 0.5 lbs. at TL6, 0.25 lbs. at TL7, neg. weight at TL8+. It costs $10 at all TLs.

Command Trigger (TL5): The mine is detonated by remote control. Treat it as a wire guidance (for command wires) or communicator guidance system for a missile, in all usual varieties, but with one-tenth the cost.

Smart Trigger (TL7): The mine is triggered by built-in acoustic sensors, and can be set to explode if someone or something comes within 5 yards of the mine, or to wait for contact. Smart mines are programmed to differentiate between vibrations caused by different types of vehicles, enabling them to be set to only attack or ignore particular motive systems (e.g., "tracked" versus "wheeled") or specific loaded weight ranges (e.g., 2 to 3 ton vehicles). If the characteristics of enemy vehicles are known, and they are different from those on one's own side, this can be very useful! Smart mines weigh the same as other mines, but add 100% to cost. The chance of them going off is the target's Size Modifier + (mine TL-3), rolled on 3d. Treat the guidance system as a sonar-homing system for purposes of installation, but with half weight and cost.

Parachute Mines (TL6): Mines can be dropped out of aircraft on parachutes. Add 10% to the weight and cost of the mine for the chute.

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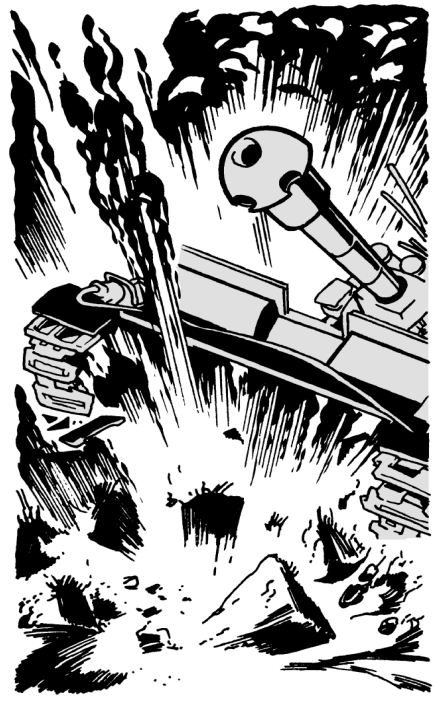


Land Mines (Continued)

Carrying Mines

Mines can be carried in weapon bays (p. 46), on hardpoints (p. 94) or in launch tubes (p. 120) that can fit a weapon of the same diameter and weight as the mine. Like bombs, mines are considered ammunition. Mines can also be carried as cargo and emplaced by hand. Placing a mine manually takes about 5 seconds, or it can be dropped. Actually hiding a mine (burying and camouflaging it) takes a minute in normal soil (10 seconds in sand, snow, etc.), but makes the mine harder (-2) to spot.

Spotting and Removing Land Mines

Explosives and bulldozer blades are often used to detonate mines in a vehicle's path. A Vision or Traps roll is required to spot a mine before hitting it – don't forget to apply the penalties for smoke or darkness! Metal detectors can find TL6 mines within 2 yards on a successful Electronic Operations (Sensors or Security Systems) roll. Handheld chemical sniffers and TL9+ multiscanners on chemscanner mode are effective at detecting the chemical explosives used in mines on a successful Electronics Operation (Sensors or Security Systems) roll, but high-tech mines use explosives that are harder to detect: -3 per TL after TL6. Most TL7 antitank mines can be safely removed by anyone who spots them. TL8+ mines may detonate if touched – an Explosive Ordnance Disposal roll at -4 will be needed to safely disarm them.

Off-Route and Robot Mines

Some advanced "off-route" or "robot" mines can actually lie in wait and then fire torpedoes, missiles or even energy beams at targets they detect. In ***GURPS Vehicles,*** these should be built as unmanned vehicles containing a computer, sensors, and a weapon.

Liquid Projector Design

Liquid projectors are pumps that squirt high-pressure jets of water or burning fuel. They include water cannon and flamethrowers.

Liquid projectors are available beginning at TL2, although the techniques of making workable flamethrowers may be secret. Historically, only the Byzantine empire, with its Greek fire, and medieval China were able to develop an effective formula for "liquid fire" that could be used in low-tech flamethrowers.

To design a liquid projector, first decide whether it is a flamethrower or water cannon. Then decide if it is a light, medium or heavy weapon, and select the number of shots its liquid tank holds.

Continued on next page . . .

Cost Per Shot

CPS is the cost of the missile or torpedo. Use this formula:

CPS = Pcost. + Mcost.

Where:

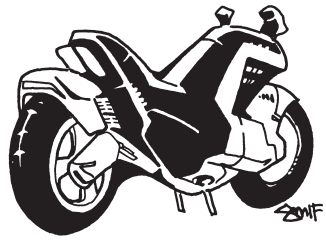
Pcost. is the payload cost, *Mcost.* is the motor cost. If the weapon is *stealthy,* increase the CPS by WPS × $2,000 at TL7, $1,000 at TL8 or $500 at TL9+. Round final cost to two digits.

Missile and Torpedo Statistics

Now that the basic design decisions have been made, we can calculate the statistics of the weapon; because missiles and torpedoes are self-propelled, their combat statistics have little to do with their launcher.

Malf.

The weapon's malfunction (Malf.) chance. If the die roll to hit is equal to or greater than the Malf. chance, the weapon malfunctions and ceases to work. This depends on TL:



Malfunction Table

TL	*Unguided Malf.*	*Guided Malf.*
3	13	–
4	14	–
5	16	–
6	Crit.	15
7	Crit.	16 or Crit.
8+	Crit.	Crit.

"Crit." means it only malfunctions on a critical failure.

For most TL7 guided missiles and torpedoes, Malf. is Crit.; however, Malf. 16 is applied to *early TL7* weapons using guidance systems other than wire guidance, sonar or infrared homing.

Guid.

This is the guidance system used. Record the abbreviation for the chosen guidance system here (e.g., IRH for infrared homing), adding MU if the weapon has mid-course update. Record "no" if unguided.

Type

This statistic depends on the type of warhead:

Solid, HP, AP, API, APDU and APHD is Cr. (crushing) damage.

Beehive is Imp. (impaling).

LE, HE, HEC, HESH, HEDC, HEPF, nuclear and micronuke is Exp. (explosive).

HEAT and HEDP ammunition is Exp. (explosive).

APEX and SAPHE ammunition is Cr. (crushing).

For other rounds, record Spcl. (special).

Damage (Dam.)

This is the dice of damage the weapon inflicts. Exception: for bursting-class weapons, it is the burst radius in yards. As with gun damage, damages over 20d are normally expressed as "6d × n," where *n* is (dice of damage/6), but other convenient dice spreads may be used if desired.

DAM depends on the *class* of ammunition as follows:

Kinetic Energy (Crushing or Impaling) Damage

Missiles with Cr. or Imp. damage have their dice of damage (DAM) calculated using this formula:

DAM = D × V × A × W.

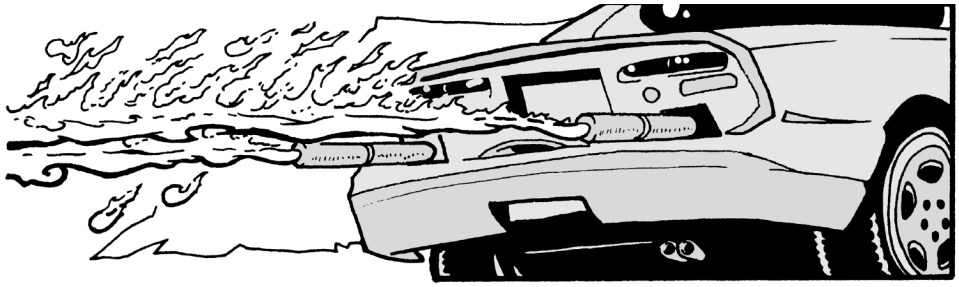
Where:

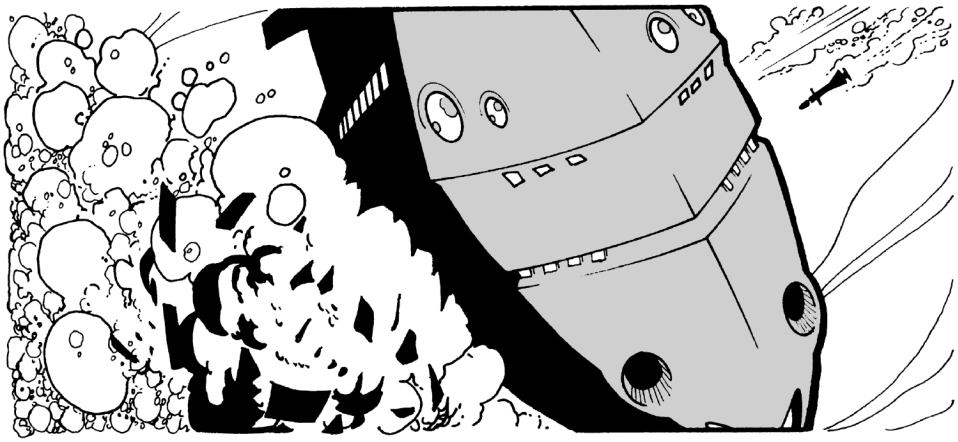
D is the missile's diameter in mm.

V is 1/800 the missile's speed in yards per second, e.g., if Spd is 400, V would be 0.5.

A depends on warhead type: 0.25 if beehive, 1 otherwise.

W is warhead size: small 0.5, modest 0.625, normal 0.8, big 0.9, huge 1.





Armor Divisor: Some types of kinetic-energy ammunition have *armor divisors* which affect their ability to penetrate armor: AP (2), API (2), APEX (2), APDU (3), APHD (5). When struck, effective armor DR is divided by the armor divisor.

Kinetic Damage from Missiles at Close Range: Missile ammunition takes a small amount of time to accelerate. It does half kinetic damage at a range of 1 yard, 2/3 damage at a range of 2 yards, and full damage thereafter.

Missiles with SAPHE and APEX warheads also do explosive damage.

Explosive Damage

For missiles and torpedoes with Exp. type damage, except for HEAT and HEDP types, the dice of explosive damage (Dam.) is calculated using the *Ammunition Table* on p. 112, treating the missile's or torpedo's diameter as if it were a gun's bore size, then multiplying the resulting damage depending on warhead size: 0.5 if small, 1 if modest, 2 if normal, 3 if big or 4 if huge.

Shaped-Charge Damage: For HEDP and HEAT warheads, use the same procedure, but multiply effective diameter by 1 if small, 1.25 if modest, 1.6 if normal, 1.8 if big or 2 if huge. If weapon has the pop-up feature, divide DAM by 1.5.

Be sure to record the armor divisor and fragmentation damage from the table as well, if applicable.

Special Damage

Ammunition doing "special" damage includes CHEM, ICM, SICM, FASCAM and SATNUC. Instead of damage dice, a burst radius in yards is recorded; the exact effect on anyone within the area is described in the sidebar. The radius is calculated using the *Ammunition Table* (p. 112), using the missile's or torpedo's diameter as if it were a gun's bore size, then multiplying the resulting radius depending on warhead size: 1 if small, 1.4 if modest, 2 if normal, 2.4 if big or 2.8 if huge.

Snap Shot (SS)

This depends on the launcher. See *Launcher Design,* p. 120.

Speed (Spd)

This is the missile's or torpedo's speed in yards per second. Record the Spd that was decided upon when designing the motor.

For space missiles (see sidebar, p. 112), record the G.

Skill

Record the guidance system's skill rating here. If the weapon has multiple guidance systems, record them in the order they are listed under Guid., separated by a slash.

Endurance (End)

This is the number of seconds the missile or torpedo can travel. In a torpedo, the motor runs the entire time. In missiles, the motor often burns out part way through the flight, and the weapon glides for the rest of its flight. Use this formula to determine the basic endurance for a missile or torpedo:

$$\textbf{End} = (\textbf{Mwt.} / \textbf{WPS}) \times \textbf{E} \times (\textbf{T} / \textbf{V}).$$

Mwt. is motor weight.

WPS is weight per shot.

E is Mwt./10, with a minimum of 0.1 and no maximum.

T depends on the motor's TL: 10 at TL3-5, 30 at TL6, 60 at TL7, 120 at TL8, 240 at TL9, 360 at TL10, 480 at TL11+.

V is (speed/10) squared for a torpedo. For a missile with speed of 400 or less, V is (speed/100) squared. E.g., if a missile speed of 400, V is 16. For a missile with speed over 400, V is [(speed/200)+2] squared. Round V to two digits.

Liquid Projector Design (Continued)

Crew Requirements

TL4- flamethrowers and water cannon are manually pumped. In addition to the gunner, a TL4- water cannon or flamethrower requires an extra crew of one if medium or two if heavy.

Combat Statistics

At this point, everything necessary to install the liquid projector in a vehicle is known. To find the combat statistics, follow this procedure:

Malf

This is 14 at TL3-, 15 at TL4, 16 at TL5, and Crit. at TL6+. On a critical failure with a flamethrower, roll 3 dice: 5 or less means non-ignition – the target is sprayed but there is no flame. 6-17 means no fuel is sprayed. 18 is a backfire; the weapon is destroyed and does the equivalent of one shot of damage to the firer's hex and all adjacent hexes.

Type

Record Spcl. ("Special") on the record sheet. Use these rules when firing such a weapon:

Water cannon project a high-speed jet of water (see the sidebar on p. 122 for other options). Damage from a water cannon is only knockback (1 hex of knockback per 8 points of damage for an adult human; for non-humans, a good rule of thumb is to divide their weight by 20 to find the damage required to inflict one hex of knockback). If a person is knocked back into something solid, assess 1d damage for every 2.5 hexes of knockback. Water cannon can also be used to put out fires.

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Liquid Projector Design (Continued)

Flamethrowers fire a high-pressure stream of Greek fire (TL4-5), napalm (TL6-8) or super-napalm (TL9+). As with lasers, damage from multiple hits in a burst is added together before subtracting DR. Only sealed armor protects fully; non-sealed armor (including non-sealed robots or vehicles) gets only one-fifth DR. Once it hits, the fire sticks and continues to burn for 10d turns, doing 1d damage per second (armor protecting as above). Only total immersion in water or the like will extinguish it. Flame damage has almost no penetrating ability against cover; *double* the PD of the target against a flamethrower.

Damage (DAM)

Consult the damage table below to find the dice of damage inflicted:

Liquid Projector Damage Table

Weapon	*TL4-*	*TL5*	*TL6-8*	*TL9+*
Flamethrower	1d	2d	3d	5d
Water cannon	2d	3d	4d	4d

Snap Shot (SS)

All TL3-5 weapons have SS 10. All TL6+ weapons have SS 5.

Accuracy

Accuracy is equal to TL (maximum 8). Add 1 to Acc for a medium or 2 for a heavy projector.

1/2D Range

This is TL × 5 for a light projector, TL × 7 for a medium projector and TL × 10 for a heavy projector. Divide by 2 for manually-pumped (TL4-) weapons.

Max Range

This TL × 7 for a light projector or TL × 10 for a medium projector and TL × 15 for a heavy projector. Divide by 2 for manually-pumped (TL4-) weapons.

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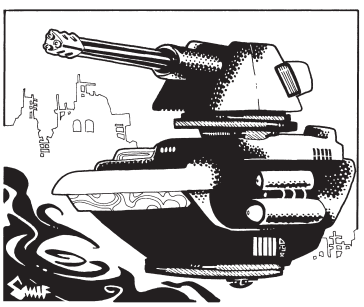


Pre-calculated V for common missile speeds: V is 1 if 100, 4 if 200, 9 if 300, 16 if 400, 20.25 if 500, 25 if 600, 36 if 800, 49 if 1,000, 64 if 1,200, 81 if 1,400, 100 if 1,600.

Pre-calculated V for common torpedo speeds: V is 1 if 10, 2.25 if 15, 4 if 20, 6.25 if 25, 9 if 30, 16 if 40, 25 if 50.

If End is under 0.5, lower Spd and try again! Otherwise, record Spd and End.

Space Missiles: These use a different formula; see sidebar, p. 112.

Maximum Range (Max)

This is the maximum range in yards the missile or torpedo can travel. It is equal to Endurance times Speed.

However, if the missile or torpedo is wire-guided, range cannot exceed 5 miles if a missile or 20 miles if a torpedo.

Indirect Fire Range: A missile with no guidance, or one with either inertial or brilliant guidance, may be fired indirectly on an arching, ballistic trajectory against a stationary target area. The effective range will be multiplied by five.

Space Missiles: Maximum range is inapplicable, except for WG missiles.

1/2D Range (1/2D)

Torpedoes and guided missiles have no 1/2D range. Unguided missiles have a 1/2D range equal to their (Endurance or 1.66, whichever is less) multiplied by their Speed in yards per second.

Unguided space missiles (*Space-Combat Missiles* sidebar, p. 112) multiply 1/2D range by (Endurance squared, or 2.75, whichever is less) times their G.

Minimum Range (Min)

This is the minimum range at which the weapon can be used. Only missiles and torpedoes with HEPF warheads, wire guidance, communicator guidance or TV guidance have a minimum range.

Min. is 200 yards if TL6 or early TL7, 100 yards at late TL7, 50 yards at TL8+, or half maximum range, whichever is less.

Accuracy (Acc)

Accuracy depends on whether the weapon is guided or unguided.

Unguided Missile or Torpedo: Accuracy for torpedoes is non-applicable: record "–". Accuracy for missiles is based on the speed of the missile and its maximum range. Find Acc by looking up the *lower* of maximum range or *twice* Speed on the table below:

Unguided Missile Accuracy Table

Max/2Spd	*Acc*	*Max/2Spd*	*Acc*
below 70	6	700-999	13
70-99	7	1,000-1,499	14
100-149	8	1,500-1,999	15
150-199	9	2,000-2,999	16
200-299	10	3,000-4,449	17
300-449	11	4,500-6,999	18
450-699	12	7,000 or more	19

Guided Missile or Torpedo: Accuracy is not applicable, since the weapon is guided to its target. Record a "–".

Launcher Design

Now that the missile or torpedo is designed, decide on the type of launcher that can fire it.

The same launcher may be loaded with very different missiles or torpedoes from the ones it was designed to use, provided the weight and diameter parameters are met. For example, "torpedo tubes" on modern nuclear submarines are often loaded with a mix of torpedoes and surface-to-surface missiles.

Hardpoint: Instead of having a launcher, a weapon may be directly attached to a hardpoint under a vehicle's body or wings, or carried within an internal weapon bay. The hardpoints themselves are part of the vehicle, rather than weapons, and are described later in the design process (p. 94).

Hardpoints are rated for the maximum weight they can carry, and can launch any missile or torpedo whose weight is no greater than that maximum and no less than one-tenth that maximum. Note that on real-world aircraft, a wing-tip hardpoint is often called a "rail" instead.

Launch Tube: This is a hollow tube containing a missile. A launch tube must be given both a diameter in millimeters and a *maximum load* – these set the diameter and the maximum weight of weapon it can fire. This maximum load is normally equal to the weight of the missile or torpedo it is intended to launch. A launch tube can also fire a smaller round, as long as its diameter is no less than 80% of the tube diameter and its weight is no less than half the tube's rated load. Launch tubes installed in open mounts may actually be *launch rails* or *launch gantries.*

After choosing its diameter and maximum load, decide whether the tube is disposable (TL3), muzzleloading (TL3), breechloading (TL3), slow autoloading (TL6), fast autoloading (TL6), manual repeater (TL5), revolver (TL5), light automatic (TL6) or heavy automatic (TL6). Disposable tubes are very light, but are destroyed once fired. Other types work like loading mechanisms for guns. Launch tubes intended to fire torpedoes may not be muzzleloading!

Gun/Launcher: At TL7 or up, a gun (see *Gun Design,* p. 100) with a muzzleloader, autoloader, manual repeater or breechloader loading mechanism can be modified to function as a launch tube. Select the maximum weight of missile it can fire. It can only fire missiles the same diameter as its bore size. The weight and cost of the gun/launcher will be increased, as described below. Gun/launchers may not fire wire-guided missiles (including TL8+ fiber optic versions and wire-guided/active sonar-homing weapons).

Multiple Tubes

Launch tubes with disposable, muzzleloader or breechloader mechanisms can be built with more than one tube for a higher rate of fire. Record the number using the format "*n*t" where *n* is the number of tubes, e.g., 6t. Some, none or all tubes can be fired at once.

Statistics for Launchers

Most of a launcher's combat statistics are based solely on the missile or torpedo it fires. The exceptions are:

Weight (Wt.)

This is the empty weight of the launcher without any missiles or torpedoes. Do not calculate this for hardpoints.

Launch Tube Wt. = (R-T) × mWPS × M.
Gun/Launcher Wt. = mWPS + Gwt.

Where:

mWPS is the rated maximum load of the tube.

R depends on the tube's loading mechanism: 1 if disposable, 1.5 if muzzleloading, 2 if breechloading, 2.5 if manual repeater or slow autoloader, 1.9 (plus 0.1 per chamber) if revolver, 3 if fast autoloader, 3.5 if light automatic, 4.5 if heavy automatic.

T is 0 at TL7-, 0.5 at TL8+.

Gwt. is the weight of the gun before being modified as a gun/launcher.

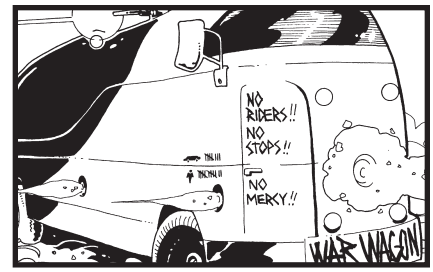
M is always 1 if the weapon has one tube. If weapon has multiple tubes, M is 1 plus 0.4 per extra tube.

Snap Shot (SS)

The base Snap Shot number depends on the launcher's weight. For hardpoints, use SS 20.

Under 2.5 lbs., SS 11.
2.5 to 10 lbs., SS 12.
10-14 lbs., SS 14.
15-25 lbs., SS is 17.
26-400 lbs. SS is 20.
401-2,000 lbs., SS is 25.
For larger weapons, SS is 30.

Gun/Launchers: This is based on the gun, not the launcher.



Liquid Projector Design (Continued)

Weight (Wt.)

This is the weight of a liquid projector, without ammunition, at a given TL. Use this formula:

Wt. = L × W × T + (T × S).

L is 160 if water cannon or 200 if a flamethrower.

W is 2 if heavy, 1 if medium or 0.5 if light.

T is 1.25 if TL5-, 0.75 if TL6, 0.5 if TL7, 0.25 if TL8+.

S is the number of shots the weapon can fire from its tank.

Rate of Fire (RoF)

This depends on TL and whether the weapon is a flamethrower or a water cannon:

Liquid Projector RoF Table

Type	*TL5-*	*TL6*	*TL7+*
Flamethrower	1	3~	4
Water cannon	4	8	8

Cost

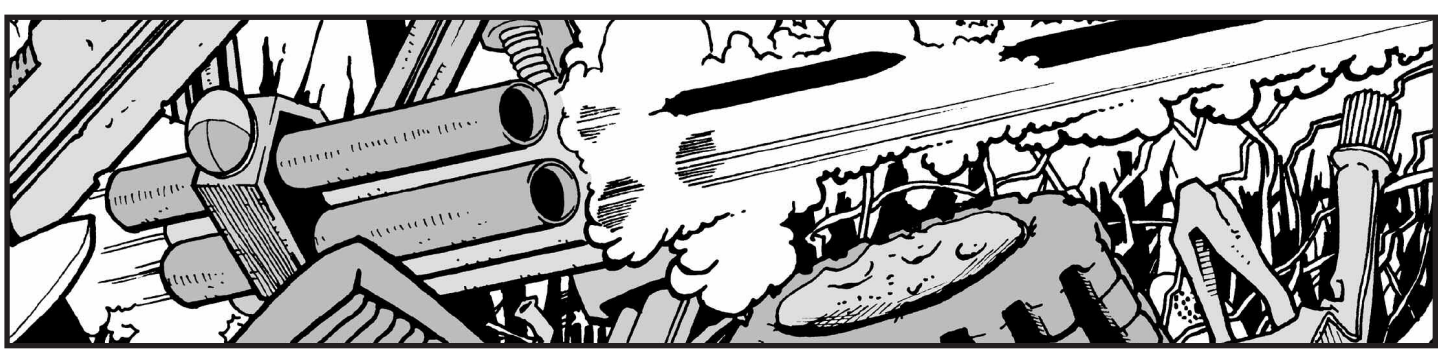
This is weight × $5 at TL6-, weight × $25 at TL7+.

Weight and Cost Per Shot

Weight per shot (WPS) is 3 lbs. for a flamethrower or 4.25 lbs. for a water cannon. Cost per shot (CPS) is $0.5 if a flamethrower, free if water cannon. Volume is not considered, since the shots occupy space within the weapon's tank. If a water cannon is being used to fire something other than water (see below), then use the WPS and CPS given for that substance. These rules assume that one shot is about half a gallon of liquid.

Shots

As already determined. A water cannon can also be hooked up to a water main or hydrant to give it "unlimited ammo."





Unusual Water Cannon Ammo

Players will want to load their water cannon with all manner of strange and wonderful things. Here are two examples:

Acid (TL5)

Industrial-strength acid (like hydrochloric or sulphuric acid) sprayed from a water cannon is treated as water, except CPS is $0.5 and it does 1d-1 damage. DR protects normally. If it hits an unprotected face (or penetrates armor on the face), the victim must make a HT roll to avoid getting acid in his eyes. If the eyes were targeted and hit, this occurs automatically. If acid splashes into the eyes, more than 2 points of damage causes blindness. Use the rules for crippling injuries on p. B129 to determine if this is permanent or temporary. The main problem with loading acid is that the acid will eat through the reservoir within minutes. A corrosion-resistant weapon that can shoot acid costs double.

Fire Extinguisher Foam (TL6)

Usable from water cannon, each shot puts out a fire in a hex on a 1-4 on 1d. CPS is $0.5, WPS is 4.25 lbs. Foam does knockback as per a water cannon, except that a hit to the exposed face will stun and blind the target if a HT-3 roll is failed; roll against HT-3 each turn to recover.

FTL Beams (TL?)

If warp drive technology exists, it may be possible (and necessary!) to have faster-than-light energy beams. This option can be added to any energy beam except a stunner or screamer. It jackets the beam or bolt inside a spacewarp tunnel or bubble, enabling it to travel out to its maximum range instantaneously, or nearly so, regardless of the distance. An FTL beam weapon has doubled weight (and thus cost) and doubled power requirement. It also has an *additional* +4 bonus to its Accuracy.

If FTL beams are available, FTL communications and sensors will usually be available as well.

Loaders

A tube launcher that is muzzleloading, breechloading, revolver or manual repeater *may* require a crew of loaders. The number of loaders required is (tube diameter/250)-1. Round number of loaders to the nearest whole number. Hardpoints require no loaders.

Rate of Fire

Rate of Fire is the number of shots that can be fired per second, and depends on the weapon's loading mechanism. Use the formulae below to determine RoF. When calculating RoF statistics, always round fractional RoFs to the nearest whole number.

For hardpoints and disposable tube launchers, record "1NR" as RoF, indicating they get one shot and then are not reloadable in combat. For other tube launchers, this depends on the weapon's loading mechanism:

Muzzleloader: If missile diameter is under 120mm, RoF is 1/45 at TL3, 1/30 at TL4, 1/10 at TL5, 1/6 at TL6+. If missile diameter is 120mm or over, find the seconds required to load and fire by dividing diameter by 2.66 at TL3, 4 at TL4, 12 at TL5, or 20 at TL6+. Convert this load-and-fire time into a fraction to get RoF, e.g., 6 seconds becomes RoF 1/6.

Breechloader: If missile diameter is up to 60mm, RoF is 1/20 at TL3, 1/10 at TL4, 1/5 at TL5, or 1/2 at TL6+. Otherwise, find the seconds needed to load and fire by dividing missile diameter by 3 at TL3, 6 at TL4, 12 at TL5, or 30 at TL6+. Then convert the time to load-and-fire into a fraction to get the actual RoF, e.g., 4 becomes 1/4.

Revolver: If missile diameter is under 40mm, RoF is 1 if TL5 or 3~ if TL6+. If a larger weapon, RoF is 1/2 at TL5, 1 at TL6+.

Manual Repeater: RoF is 1 at TL5 or 2~ at TL6+.

Fast Autoloader: If missile diameter less than 15mm, RoF is 3~. If 15.1mm up to 20mm, RoF is 2~. If 20-60mm, RoF is 1. Otherwise, find the seconds required to load and fire the weapon by dividing missile diameter by 60. Then turn the time to load-and-fire into a fraction to get the actual RoF, e.g., 3 becomes 1/3.

Slow Autoloader: RoF is 1 if missile diameter up to 40mm. If missile diameter over 40mm, find the seconds required to load and fire the weapon by dividing missile diameter by 40. Then turn the time to load-and-fire into a fraction to get the actual RoF, e.g., 2 becomes 1/2.

Light Automatic: RoF may be up to (160/missile diameter).

Heavy Automatic: If missile diameter is up to 20mm, pick any RoF from 3 to 20. If missile diameter is over 20mm, pick a RoF up to (400/missile diameter).

Extra Tubes for Disposable Launchers, Muzzleloaders and Breechloaders: If one of these weapons has extra tubes, it can fire a number of shots equal to the number of tubes, singly or simultaneously, but it will take the normal time to reload *each* tube after firing. Record this as two numbers separated by a colon. The first is the number of tubes, the second is turns it takes to reload, or NR if disposable. Thus, a launcher with RoF 1/4 and three tubes would be written as RoF 3:4. This means each of three tubes can fire once but it takes four turns to reload *per* tube after firing.

Shots

This is the number of shots that the launcher can fire before it needs to be manually reloaded.

Hardpoints have one shot. For muzzleloading, disposable or breechloading weapons, Shots is equal to the number of tubes. For revolvers, Shots is equal to the number of cylinders. Otherwise, record "var.," indicating that the number of shots simply depends on how much ready ammunition is carried on the vehicle.

Cost

This depends on the launcher's weight. Do not calculate cost for hardpoints.

For gun/launchers, calculate the cost of the weapon as if it were a gun, bearing in mind the additional weight of the launcher system.

For tube launchers, cost is based on weight (Wt.) using the formula below:

If Wt. is under 10 lbs., cost = ($50 × Wt.) + $250.

If Wt. is 10 to 100 lbs., cost = $75 × Wt.

If Wt. is over 100 lbs., cost is ($25 × Wt.) + $5,000.

Divide cost by 10 if TL3-5, by 5 if TL6, by 2 if TL9, and by 4 if TL10+. Double cost if the launcher is automatic, divide by 10 if disposable.

Beam Weapon Design

This system is used to design energy beam weapons, like lasers or particle beams. To design a beam weapon, follow the steps in the order given below.

Beam Type and TL

Select a beam type and the TL. The beam types are described below. The *Combat* chapter describes how the special effects of each beam type work in play.

Laser (TL8): Laser stands for Light Amplification by Stimulated Emission of Radiation. Laser weapons fire a high-energy beam of coherent light, but are degraded by rain, fog or smoke. The beam is silent and invisible in vacuum. In atmosphere, weapons-grade lasers ionize the air, leaving a line of tiny sparks and making an audible "Crack!" as air rushes into the vacuum left in the beam's wake. Most lasers are assumed to use visible light beams. However, a laser may instead be an infrared (IR) laser or an ultraviolet (UV) laser. IR laser beams are much harder to spot, but the weapons have a slightly shorter range. UV lasers have longer ranges in a vacuum (such as space) but are less effective in atmosphere. At TL9+, lasers may (at increased expense) be "rainbow lasers" which can alter their frequency from infrared to visible light to ultraviolet, selecting the best wavelength for the environment. This also gives them a much better ability to penetrate anti-laser countermeasures.

Disruptors (TL8): These weapons are microwave-frequency lasers, or "masers." Disruptors are more effective against unarmored targets than lasers, because the beam cooks and disrupts internal organs. Microwaves also interfere with electronics. However, disruptor beams are likely to bounce off metal and laminate armor, as this reflects microwaves.

Charged Particle Beam (TL8): These are a family of similar weapons that magnetically accelerate ions or subatomic particles to relativistic speeds, creating a charged particle beam that resembles a coherent lightning bolt. The radiation produced can also disable electronics. Charged particle beams have one problem: in vacuum or trace atmospheres, the particles repel each other and the beam breaks apart harmlessly, making them entirely useless as a space weapon. Charged particle beams are often referred to as "blasters."

Neutral Particle Beam (TL8): These weapons use a more complex accelerator arrangement to generate beams of neutral particles. A neutral particle beam can be used in vacuum or trace atmospheres without degrading, making it a useful weapon for space combat. At the flip of a switch, the accelerator can be reconfigured to fire charged particle beams instead, allowing the weapon to function as a normal blaster. Neutral particle beam weapons are somewhat heavier and more expensive than charged particle beams.

Flamer (TL9): A flamer projects a stream of star-hot ionized plasma that can *melt* armor right off the target. Flamers are also known as plasma guns. A flamer beam can be used much like a flamethrower, attacking more than one target.

Screamer (TL9): These weapons generate a beam of concentrated sound, the vibrations of which can shatter solids and cause horrible damage to organic beings. They are ineffective in the absence of atmosphere, but will work underwater.

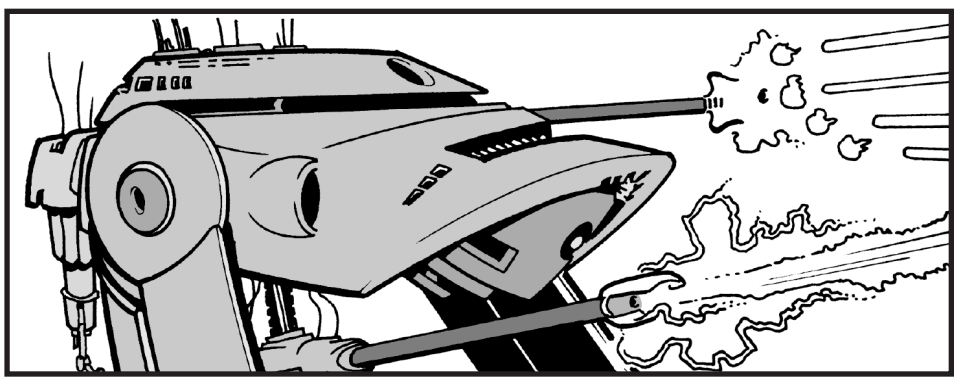
Stunner (TL9): This is a sonic weapon designed to disable without killing. Instead of damage, it has a "HT modifier" that affects the roll to resist it.

Paralysis Beam (TL10): These weapons fire an electromagnetic beam that scrambles electronics and also affects the nervous system of living things, causing instant paralysis. Like stunners, they have a HT modifier. They are ineffective vs. targets in sealed armor.

Military Paralysis Beam (TL10): This is a more expensive paralysis beam weapon that can affect shielded robots, and organic beings behind sealed armor.

X-ray Laser (TL10): These advanced laser weapons fire beams of coherent x-rays; they are also called x-lasers or xasers. They have superior armor penetration and damage.

Fusion Beam (TL12): These weapons heat plasma to fusion temperatures and then release it as a high velocity bolt rather than as a stream. Sometimes the fusion beam is "jacketed" in a force field tube. Fusion beams may also be used to represent "energy torpedoes" or "plasma torpedoes."



Blue-Green Lasers

Lasers (but not UV or IR lasers) can be optimized for underwater roles by designing them to use blue-green beams. A blue-green laser's 1/2D and Max ranges are halved, but it has the same range underwater as it does in atmosphere. After the laser is designed, add +20% to its final cost. Rainbow lasers can already be tuned to fire blue-green beams – they don't need this option.

Hand-Held Weapons

While this chapter in ***GURPS Vehicles*** is designed mainly for vehicular weapons, the rules for creating bolt throwers, guns, beam weapons, launchers and liquid projectors are applicable to hand-held weapons. Some vehicles (like giant robots) even carry huge hand-held weapons! Hand-held anti-armor weapons such as anti-tank missiles and rockets are an important factor in vehicular combat.

Any vehicular weapon can be modified to be hand-held if the expected user is strong enough to carry it and its ammunition. As a general rule, weapons intended to be carried by a single person shouldn't weigh more than about twice their ST. Larger weapons can be built, but they will usually have to be tripod-mounted.

Design a hand-held weapon exactly like a vehicular weapon and calculate its combat statistics normally.

Grip

A hand-held weapon requires a grip of some sort. Select either a pistol grip, shoulder stock or shoulder stock with bipod, with the option of adding a tripod to any of these grips.

Pistol Grip: The weapon has a simple pistol grip. Unless also fitted with a tripod (below), the weapon is less accurate than a vehicular weapon, but it is more handy.

Shoulder Stock: The weapon has a rifle-like stock (and possibly a pistol grip as well), allowing it to be braced two-handed against the shoulder for greater accuracy. However, it is still less accurate than a vehicle-mounted weapon.

Shoulder Stock with Bipod: As above, plus the weapon has a folding or fixed rest, allowing stable fire from a prone position which cancels the accuracy penalties of a shoulder stock. If fired while the user is prone, add +1 to Accuracy.

Tripods: In addition to one of the above grips, a hand-held weapon may be given a tripod mount. It takes 3 seconds to set a weapon up on its tripod. When set up, the gunner must be prone or kneeling to fire it, but ST minimums are ignored and Acc is increased to cancel any penalty for a pistol grip or shoulder stock. The tripod can also be detached or attached in about 30 seconds and carried separately. A tripod weighs the same as the weapon's empty weight and costs $10 per pound of tripod weight.

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Hand-Held Weapons (Continued)

Empty Weight

For guns, launchers, liquid projectors or beams, multiply this by 1.2 if a shoulder stock and by 1.5 if a shoulder stock/bipod.

For hand-held bolt-throwers, multiply this by 0.5 if pistol grip, 0.6 if a shoulder stock and by 0.75 if a shoulder stock/bipod.

Combat Statistics

A hand-held weapon's statistics are identical to the vehicular weapon's statistics, except as follows:

SS and Acc

If a gun or mechanical artillery piece has only a pistol grip, subtract 2 from SS and 5 from Acc. If a gun or mechanical artillery piece has a shoulder stock or shoulder stock/bipod, subtract 2 from Acc. If it also has a tripod, there is no Acc penalty while the weapon is being fired from the tripod.

If a launcher fires unguided missiles or torpedoes, treat it as a gun above. If it fires guided missiles, Acc is irrelevant.

If a beam weapon has a pistol grip, subtract 2 from SS and 5 from Acc. If a beam weapon has a shoulder stock or shoulder stock/bipod, subtract 1 from Acc. Maximum Acc for a hand-held beam weapon (unless on tripod) is 15; if it is higher, reduce it to 15.

RoF

RoF is unchanged for guns, beams or launchers. For hand-held stone or bolt throwers, the RoF now depends on the user's ST, in the same way as a crossbow (see p. B114). Hand-held repeating bolt-throwers take the same time to cock, but there is no need to draw and place a bolt, shaving two seconds off the time required for readying.

Shots

While a vehicle weapon may have "var." shots, this is not true of a hand-held weapon. Weapons with "var." shots must be assigned a number of Shots, and must be designated as using either magazines or belted ammunition, as follows:

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Gravity Beam (TL12): These weapons are offshoots of TL12 contragrav and tractor beam technology. Unlike gravguns, which simply use gravity technology to accelerate projectiles, gravity beams actually project focused "coherent gravity" as an oscillating tractor/pressor beam. Damage is low, but this setting can reach inside all but the thickest armor, causing the inside of a target – or part of the target – to vibrate to pieces! Gravity beams can also be used as non-lethal weapons, focusing a high-impact "force beam" of gravity on a single target. A non-lethal "kinetic stunner" gravity beam can be bought that can only project a force beam, if desired.

Antiparticle Beam (TL12): These are high-energy particle accelerators that generate a beam of antimatter particles. In ***GURPS Ultra-Tech*****,** these weapons are known as "pulsars." They produce kinetic damage, explosive effects much like fusion beams and also deliver radiation damage.

Graser (TL14): These weapons are extremely high-energy lasers firing coherent gamma-ray beams. They function like lasers, except DR protects at one-fifth normal value! Like x-ray lasers, atmospheric conditions and countermeasures have no effect.

Disintegrator (TL15): The ultimate beam weapon, projecting a field that disrupts the nuclear forces that bind atoms together. There is no beam per se – the disintegrator weapon simply destroys matter at a specific point. The weapon's sights allow for normal direct fire, but indirect fire is possible (using the indirect fire rules) to "shoot through" walls, hills, etc. Armor is largely ineffective.

Displacer (TL16): Also called a "tachyon shotgun" or "vortex beam," this weapon rips a hole in the fabric of space/time. Everything in the area of effect will be sucked in and warped off to some random location in the universe.

Beam Output

Select the weapon's beam output, measured in kilojoules (kJ). This is the energy the beam emits, and will determine damage, weight and other performance characteristics. It is also used to describe the weapon: a "1,200 kJ laser" for example.

See *Damage* (p. 125) for how beam output translates into damage. Smallarm beam weapons usually have beam outputs below 1,600 kJ, weapons equivalent to light beam cannon have outputs in the 1,600-160,000 kJ range, while heavy beam cannon tend to have outputs over 160,000 kJ. Some weapons have minimum outputs. Minimum output for most beam weapons is about 60 kJ. For particle beams built at TL8 or antiparticle beams built at TL12 (but not TL9+ particle or TL13+ antiparticle beams) minimum output is 10,000 kJ. Minimum output for displacers is 24,000 kJ.

Cyclic Rate

Select the number of shots per second that the weapon can fire: this may be 1/2, 1, or any number greater than one up to a maximum of 20. Weapons with RoF 4 or more use automatic fire. Automatic fire lasers, x-ray lasers and grasers are particularly effective. Displacers cannot be built with RoF 4 or more.

Options

Beam weapons may have any of these options. None are required.

Long, Very Long or Extreme Range: These options give the weapon a larger-than-usual beam-focusing apparatus, extending its range compared to that of other weapons at the expense of additional weight and cost. Very long and extreme range weapons are recommended for space combat.

Close Range: This option (not compatible with the above options) gives the weapon a smaller-than-usual beam-focusing apparatus, reducing its range.

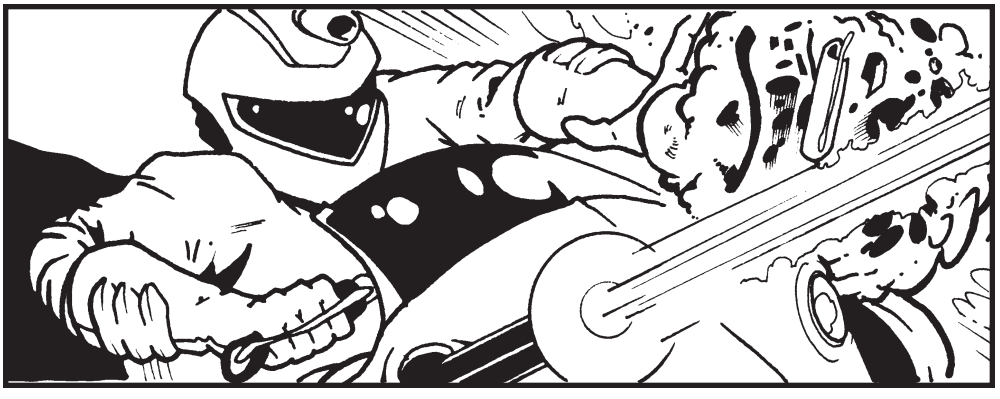
Compact: This option substitutes compact, high-tech components for more routine systems, reducing the weapon's weight and volume but increasing cost.

Statistics

Malfunction (Malf.)

The malfunction chance of the weapon. This is normally Ver., indicating the weapon is very reliable, with these exceptions: disruptor and particle beams built at TL8-9, as well as all disintegrators and displacers, are Crit., while laser weapons become Ver. (Crit.) one TL after the type is introduced.

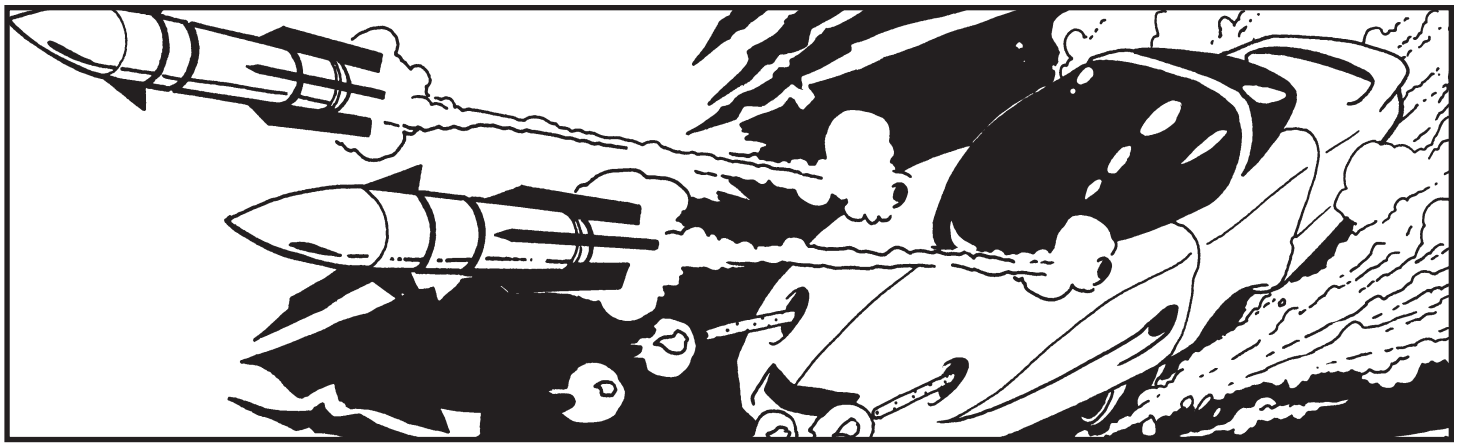
Reputation for Quality: Certain weapons known for their reliability (or lack thereof) may, at the GM's discretion, have their Malf. raised or lowered by one level, to a maximum of Ver. (Crit.).



Type

Lasers, charged and neutral particle beams, x-ray lasers, gravity beams and grasers do Imp. (impaling) damage.

Disruptors, flamers, screamers, stunners, paralysis beams, fusion beams, antiparticle beams, disintegrators and displacers do Spcl. (special) damage.



Damage (Dam.)

Calculate damage for all beam weapons using this formula:

Damage = (square root of O*) × B × T.

O is the beam's output in kJ.

* If output is under 1,000 kJ, multiply *0* by 0.03 instead of finding its sqare root. If output is over 1,000,000 kJ substitute [10 x (cuberoot of O)] for (square root of O).

B depends on beam type and is 0.066 for displacer, 0.04 for gravity, 0.4 for stunner, 0.36 for disintegrator, 0.5 for laser, X-ray laser, or graser, 1.6 for particle or disruptor, 0.3 for paralysis, 2 for antiparticle, flamer, 2.5 for screamer, and 4 for fusion.

T depends on TL, and is 1 for the TL where the beam is first introduced, 1.2857 for the first TL after, 1.5714 for the second TL after and 1.8571 for all subsequent TLs. *Note:* Particle beams under 10,000 kJ, and all rainbow lasers, are TL9; antiparticle beams under 10,000 kJ are TL13.

For most weapons, this formula yields the dice of damage (DAM). There are three exceptions:

Stunners: The formula instead yields the HT penalty (i.e., a negative number), equal in absolute value to the dice of damage; e.g., 2 dice of damage becomes a -2 HT modifier.

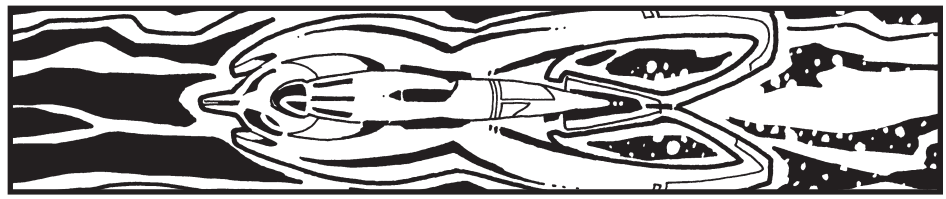
Paralysis Beams: Use the same procedure as stunners, then add 4 to the final result *unless* the weapon is a military paralysis beam: thus, 4 dice of damage yields a 0 HT modifier, while 3 dice yields a +1 modifier.

Displacers: The dice of damage instead becomes the radius of effect. Thus, 2 dice of damage is a 2 yard radius.

Armor Divisors: X-ray lasers, gravity beams, antiparticle beams, grasers and disintegrators are better at penetrating DR than their raw damage suggests. Record an Armor Divisor in parenthesis following their dice of damage. The divisors are:

Type	*Divisor*
X-ray laser or anti-particle beam	(2)
Graser	(5)
Disintegrator or gravity beam	(100)

Effective DR against the beam's damage is divided by the armor divisor, e.g., against a graser, armor protects at 1/5 its DR.



Half Damage Range (1/2D)

This is the beam weapon's 1/2D range. While range for energy weapons is not *physically* dependent on output, more powerful energy weapons are also assumed to have larger focusing arrays or longer beam tunnels, and as such have a longer *effective* range.

All beam weapons except paralysis beams, disintegrators and displacers have a 1/2D range. If the weapon has a 1/2D range, determine it using this formula:

1/2D Range = (square root of O) × R × B × T

O is the beam's output in kJ.

R is 8 if extreme range option, 4 if very long range option, 2 if long range option, 0.25 if close range option, 1 otherwise.

B is 12 if fusion or stunner, 18 if flamer or screamer, 36 if gravity, 15 if charged or neutral particle, antiparticle or disruptor, 200 if laser*, 75 if X-ray laser or graser.

* If UV laser, B is 60; if IR laser, B is 170.

T depends on TL, and is 1 at the TL where the beam is introduced, 1.1 one TL later, 1.2 two TLs later, and 1.3 three or more TLs later.

If range is less than 100 yards, round to the nearest ten yards; if between 100 and 10,000 yards, round to nearest 100 yds. If range is 10,000 yards or more, round to the nearest 1,000 yds.

Hand-Held Weapons (Continued)

Manual repeater, autoloading or light automatic weapons use either a fixed internal magazine (TL5+) or detachable box (TL6+) magazine. Decide how many shots it holds. The number for internal magazines or box magazines intended to fit within a pistol grip may not exceed one-quarter the empty weight of the weapon divided by the weight per shot of its ammunition.

Heavy automatic or Gatling weapons use ammunition belts (sometimes housed in a cassette). Decide how many Shots a normal belt of ammunition has. Usually this is from 50 to 500 shots, depending on how much weight the expected user is to carry.

Electric, electrothermal, electromag, gravitic and beam weapons also require power cells to provide energy for each shot. Determine the number of C cells required using the formula:

Required number of C cells = Shots × EPS / P.

Where:

Shots is the weapon's Shots statistic.

EPS is the weapon's energy per shot, equal to Pow./RoF.

P is 3,600 if TL8, 5,400 if TL9, 7,200 if TL10, 9,000 if TL11, 10,800 if TL12, 12,600 if TL13, 14,400 if TL14, 16,200 if TL15, or 18,000 if TL16.

Round fractions *up!*

It can be more efficient to use cells larger or smaller than C cells. If the number of cells required is 0.1 or less, use a single B cell instead. One D cell can replace 10 C cells; one E cell can replace 100.

Record the type (B, C, D, E) and number of power cells after a "/" following the number of shots the weapon has, e.g., for 20 shots powered by 2 B cells, record 20/2B, while 50 on one E cell is 50/E.

Continued on next page . . .

Hand-Held Weapons (Continued)

Rcl.

This is the weapon's recoil. This statistic is only calculated for hand-held guns, beams and launchers (*not* mechanical artillery or liquid projectors).

Rcl. for guns with a "recoilless" option, launchers, and all beam weapons except particle beams is "0." For particle beams, recoil is -1.

For other weapons, the formula for recoil is:

Rcl. = B × B × L × P × G × R × T × S / (Ewt.+5).

B equals bore size.

L depends on barrel length: 0.1 if extremely short, 0.25 if very short, 0.5 if short, 0.75 if medium, 1 if long, 1.2 if very long, 1.5 if extremely long.

P is 0.25 if extra-low-power, 0.5 if low-power, 1 otherwise.

G is 1 for most weapons, but 0.25 if gravitic gun.

R is 1.5 if muzzleloader, 0.9 if fast autoloading, light automatic, or heavy automatic, 1 otherwise.

T is 0.666 at TL3-5, 0.75 at late TL5, 1 at TL6+.

S is 0.25 if tripod mount, 0.5 if shoulder stock or shoulder stock/bipod, 0.75 if pistol grip.

Ewt. is the empty weight of the weapon.

Round any resulting fractions to the nearest whole number, except that the minimum recoil is -1.

Loaded Wt.

This is the gun's loaded weight. Loaded weight is only recorded for hand-held weapons, since vehicular weapons store their ammunition separately within the vehicle.

Loaded weight (LWt.) uses this formula:

LWt. = (WPS × Shots × B) + P + Wt.

Where:

WPS is weight per shot.

Shots is the weapon's Shots statistic.

B is 1.4 if the weapon has a box magazine, 1 if belt, internal magazine or no magazine.

P is the weight of all power cells installed in the weapon, at 0.05 lbs. per B cell, 0.5 lbs. per C cell, 5 lbs. per D cell, or 20 lbs. per E cell.

Wt. is the empty weight of the weapon.

ST

Strength required to wield the weapon is calculated using this formula. Note that if a weapon is equipped with a tripod, the ST requirement only applies when it is being used off the tripod!

ST = [(loaded weight/G) + 5] × R.

G is 12 if shoulder stock/bipod, 8 if shoulder stock, 4 if pistol grip or tripod mount.

R is 1.25 plus one-quarter the absolute value of the recoil penalty. Thus, with a recoil of -1, R is 1.5, while with recoil -2, R is 1.75.

Maximum Range (Max)

This is the weapon's maximum range in yards. For all weapons except paralysis beams, disintegrators and displacers, calculate Max as follows:

Lasers, Screamers, X-ray lasers, Grasers, Disruptors: Three times 1/2D range if damage is 20d or more, otherwise, twice the 1/2D range.

Particle and Antiparticle Beams: Three times 1/2D range if damage is 100d or more, otherwise twice the 1/2D range.

Flamers and Fusion Beams: Three times 1/2D range if damage is 10d or more, otherwise twice the 1/2D range.

Gravity Beams: Three times 1/2D range if damage is 3d or more, otherwise twice the 1/2D range.

Stunners: Three times the 1/2D range if HT roll is HT-6 or worse, otherwise twice the 1/2D range.

For paralysis beams, disintegrators and displacers, calculate Max range as follows:

Max Range = (square root of O) × R × B ×T.

O is the beam's output in kJ.

R is 8 if extreme range option, 4 if very long range option, 2 if long range option, 0.25 if close range option, 1 otherwise.

B is 1.3 if displacer, 24 if paralysis, 70 if disintegrator.

T depends on TL, and is 1 at the TL where the beam is introduced, 1.1 one TL later, 1.2 two TLs later, and 1.3 three or more TLs later.

If range is less than 100 yards, round to the nearest ten yards; if between 100 and 10,000 yards, round to nearest 100 yds. If range is 10,000 yards or more, round to the nearest 1,000 yds.

1/2D and Max Ranges in Vacuum: A weapon's base 1/2D and Max ranges are those achievable in a standard Earth-like atmosphere. In vacuum or trace atmospheres, the ranges of some beams are altered: ×0 for a screamer or stunner (that is, they have no range), ×0.01 for a charged particle beam, ×10 for a laser, IR laser, disruptor, flamer or antiparticle beam, ×50 for a UV or rainbow laser or neutral particle beam and ×100 for an x-ray laser or graser.

Accuracy (Acc)

For most weapons, Accuracy depends on the 1/2D range (in standard atmosphere) in yards; for weapons with no 1/2D range (paralysis beams, disintegrators and displacers), use Max range instead of 1/2D range:

Beam Weapon Accuracy Table

Range	*Acc*	*Range*	*Acc*	*Range*	*Acc*
below 150	11	1,000-1,499	17	10,000-14,999	23
150-199	12	1,500-1,999	18	15,000-19,999	24
200-299	13	2,000-2,999	19	20,000-29,999	25
300-449	14	3,000-4,499	20	30,000-44,999	26
450-699	15	4,500-6,999	21	45,000-69,999	27
700-999	16	7,000-9,999	22	70,000-99,999	28

And so on. For paralysis beams, fusion beams, screamers and displacers, subtract 2 from Accuracy. For flamers treat any Acc under 20 as 20 – the wider beam spread makes it easier to hit.

Weight

This is the empty weight of the weapon, without any power cells. Find it using this formula:

Ewt. = (O/B) × S × L × F × R.

O is the beam output in kJ.

B depends on beam type, and is 12 if stunner or flamer, 24 if laser or screamer, 32 if rainbow laser, 72 if X-ray laser, 64 if neutral particle, 128 if graser, 72 if charged particle, 36 if disruptor, 80 if paralysis, 240 if antiparticle or fusion, 180 if disintegrator or gravity, 1,350 if displacer.

S varies with beam output: 0.5 if 6,400 kJ or less, 1 if over 6,400 kJ.

L is 0.5 if compact option, 1 otherwise.

F is 0.666 if RoF 1/2, 1 if RoF 1, 1.25 if RoF 2, 1.5 if RoF 3~, (RoF/4) + 1 if RoF 4 or more. Exception: for lasers, x-ray lasers and grasers with a RoF 4 or more, F is RoF/2.

R is 4 if extreme range option, 2 if very long range option, 1.5 if long range option, 0.666 if close range option, 1 otherwise.

Round weight to two digits.



Snap Shot (SS)

The base Snap Shot number depends on the weapon's empty weight.

Under 2.5 lbs., SS 11.
2.5 to 10 lbs., SS 12.
10-14 lbs., SS 14.
15-25 lbs., SS is 17.
26-400 lbs., SS is 20.
401-2,000 lbs., SS is 25.
For larger weapons, SS is 30.
Flamers: Halve SS number.

Rate of Fire (RoF)

This is equal to the cyclic rate of the weapon. Lasers, x-ray lasers and grasers with automatic fire capability use the "laser automatic fire" rules, adding together damage from all groups that hit the same target before subtracting DR.

Power Requirement (Pow.)

"Pow." is the kilowatts of power the weapon requires to fire at its full rate of fire.

Pow. = O × E × RoF.

O is the output in kJ.

E is 2 for a disruptor, gravity beam, laser or particle beam, 2.25 if rainbow laser, 2.5 for an antiparticle beam, disintegrator, screamer or stunner, 2.666 for an x-ray laser, 3 for a graser or paralysis beam, 5 for a flamer, 9 for a fusion beam and 10 for a displacer beam.

RoF is the chosen RoF.

Round to the nearest whole number.

Shots

A beam weapon is only rated for shots if it uses its own power cells rather than vehicle power.

If a weapon will have its own power cells, decide on a minimum number of shots it can fire before running out of energy – at least equal to Rate of Fire! Then determine the minimum number of *C cells* required using the formula:

Minimum # of C cells = # of shots × EPS/P.

Where:

EPS is the energy per shot of the weapon, equal to Pow./RoF.

P is 3,600 if TL8, 5,400 if TL9, 7,200 if TL10, 9,000 if TL11, 10,800 if TL12, 12,600 if TL13, 14,400 if TL14, 16,200 if TL15, or 18,000 if TL16.

If the number of cells required is *not* an even number, then round up to get the actual number of cells needed. The weapon's number of shots is multiplied the ratio of cells installed to cells required. Thus, if we needed 2.5 C cells to get 40 shots, we would have to install 3 C cells, but the actual number of shots we would get would increase to (3/2.5) × 40 = 48.

If the number of C cells installed is greater than 10, it is more efficient to use larger D or E cells: one D cell can replace 10 C cells; one E cell can replace 100 C cells.

Record the number of shots and the type of power cells that are used using the format **#/nC,** where **#** is the number of shots, **C** is the type of power cell (C,D,E) and **n** is the number of power cells if more than one. Thus 100 shots on one D cell is 100/D, while 20 shots on three E cells is 20/3E.

Cost

This depends on empty weight (Ewt.) and beam type:

Under 10 lbs.: cost = (weight × $200) + $1,000.

10 to 100 lbs.: cost = (weight × $300).

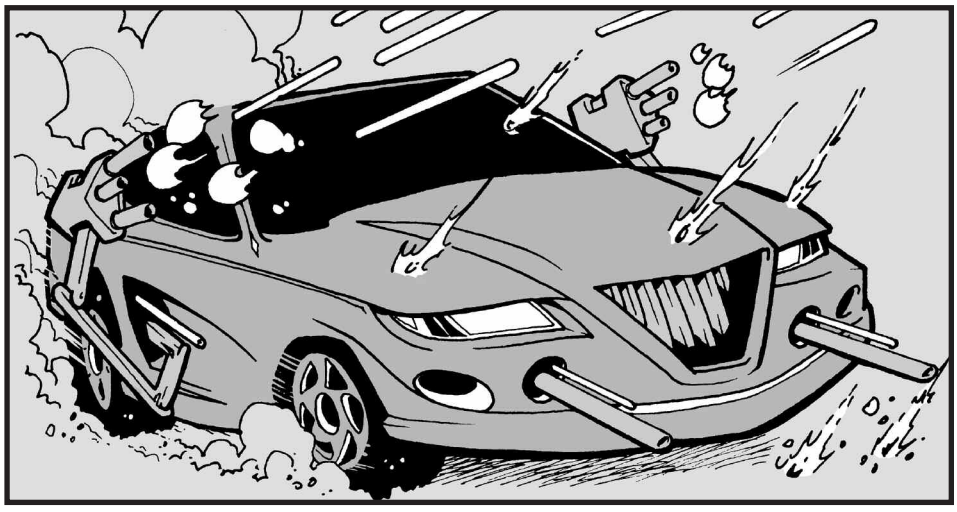
Over 100 lbs.: cost = (weight × $100) + $20,000.

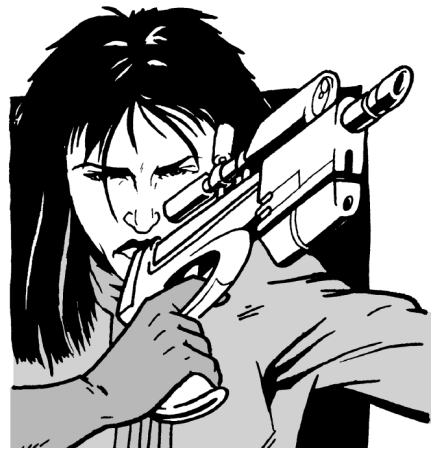
Beam Type: Some beam weapons are more or less expensive. Multiply cost by 0.5 if a laser (except rainbow models) or non-military paralysis beam, by 0.666 if a rainbow or X-ray laser, by 1.333 if a gravity beam or graser, by 4 if a displacer, by 3.5 if a disintegrator, by 6 if a fusion beam or by 7.5 if an antiparticle beam.

Options: Quadruple cost of any "compact" beam weapon.

Cost and TL: One TL after the beam type that was used first appears, halve cost. Two TLs afterward, divide cost by four.

Round off to two digits.





Accessories for Hand-Held Weapons

Sighting Devices

Sights can be added to smallarms. These can be targeting sensors (see *Sensors* p. 49). The following are often added:

Telescopic Sight (Scope): A typical sight gives +1 to Accuracy for aimed shots only. Weight and cost: TL5 (4 lbs., $100), TL6 (2 lbs., $100), TL7+ (1 lb., $500). Add 50% to cost and weight for a +2 bonus, double for a +3 bonus.

Laser Sight (TL7): When turned on, this device projects a dot on the target to aid in aiming. This adds +2 to Accuracy and reduces the Snap Shot penalty to -1 at ranges up to 50 yards, and to -2 at ranges between 50 and 100 yards. Snap Shots are still at -4 beyond 100 yards. Laser sights are available in red or high-visibility yellow models, or in versions where the sighting spot is invisible except to infrared. Negligible weight, $200 at late TL7; cost is halved at TL8 and again at TL9+. Lasers, X-ray lasers and grasers pay only 1/10 as much.

HUD Sight (TL8): Links the weapon by cable to a goggle or helmet head up display so that a sighting box surrounds wherever the gun is pointing, making aiming easier. Reduce SS by 2 for an ordinary TL8- HUD, or by 5 for TL9+ HUD. $500 per weapon at TL8, $250 at TL9, $125 at TL10+; weight is negligible for the sight – see p. UT65 for the HUD itself.

Silencers

A good commercial silencer quiets a gunshot so that a person in the immediate area (e.g., an adjoining room) has to make a Hearing-4 roll to notice it, or a Hearing roll if in the same room. Silencers are available for weapons with breechloader, manual repeater and autoloader mechanisms, and at double cost and weight for light automatic and electric Gatling mechanisms. A typical silencer is 1 lb. and $200. See p. HT98 for detailed rules on silencers. Cr. or Imp. damage of a silenced weapon is halved unless the weapon is extra-low- or low-powered, and damage of a low-powered weapon is reduced by -1 per die.

PERFORMANCE: 10

"But, but – my Kitty's not supersonic!"

"She can outrun a helicopter, outswim a shark, and do 100 mph on the freeway," Cassidy said reasonably. "She's also bulletproof and gets good gas mileage. Isn't that enough?"

"Well, we don't have any more time to modify it," Morgan shrugged. "So let's roll."

A vehicle's performance statistics are divided into several categories: ground (p. 128), water (p. 130), submerged (p. 132), air (p. 133), mag-lev (p. 136), hovercraft (p. 136) and space performance (p. 136). Only calculate the performance characteristics for those modes the vehicle will use!

EXAMPLE

Kitty Hawk will have ground, water, submerged and air performances.

Ground Performance

A vehicle has a ground performance – that is, it can move on the ground – if it has skids, wheels, tracks, halftracks, skitracks or legs. It can also move on the ground if it has a flexibody drivetrain. Each of these methods – wheels, tracks, and so on – is referred to as a particular "motive system."

Ground Speed

This is the top speed the vehicle can accelerate to on the ground. Speed is measured in mph. It is calculated separately for each motive system the vehicle may have:

Wheels: Add the motive powers of the wheeled drivetrain and any harnessed land or flying animals to one-quarter the thrust from all sails, airscrews, jets, rockets and reactionless thrusters in use. Divide this sum by vehicle loaded mass in tons. Find the square root of that quotient. Multiply by motive system *speed factor* (see below) to get ground speed. If the vehicle used harnessed animals, the final speed cannot exceed the slowest harnessed animal's speed.

Skids: Use the same procedure as with wheels, excluding the motive power of any wheeled drivetrains.

Tracks, Halftracks or Skitracks: Divide the tracked drivetrain's motive power by the loaded mass in tons. Find the square root of the quotient. Then multiply by the motive system's *speed factor* (see below) to get ground speed.

Legs or Flexibody: Use the same method as with tracks, but substituting the leg or flexibody drivetrain's motive power for the tracked drivetrain's.

Speed Factor Table

Motive System	*Speed Factor*
Skids	6
Wheels at TL4-	8
Wheels at TL5	12*
Wheels at TL6+	16*
Tracks at TL6	10
Tracks at TL7+	12
Skitracks at TL6	8
Skitracks at TL7+	10
Halftracks at TL6	12
Halftracks at TL7+	14
Two Legs	8
Three Legs	10
Four or more Legs	12
Flexibody drivetrain	4

An improved suspension adds 2 to the speed factor of wheels and 1 to the speed factor of other motive systems.

* If the wheels are *railway wheels* running on rails, double speed factor (*after* improved suspension modifiers), but the vehicle cannot move when *not* on the railway track.

Streamlining Effects and Speed Limits: If speed works out to 50 mph or more and the vehicle has streamlining, add 5% to top speed if Fair streamlining or 10% if Good or better streamlining. Top speed can never exceed 600 mph unless the vehicle has Good or better streamlining.

Round all fractional Speeds to the nearest whole number. *Exception*: If speed is 20 mph or more, round to the nearest 5 mph. The speed of a vehicle pulled by harnessed animals may not exceed (slowest animal's Move × 2 mph).





EXAMPLE

Kitty Hawk uses a wheeled motive system. The sum of the wheeled drivetrain's 200 kW motive power plus a quarter of the jet engine's 500-lb. thrust = 325 kW. We divide that by the loaded mass of 3.48 tons (getting 93.39), find the square root of that, getting 9.66 and multiply by the speed factor (18 – 16 for wheels at TL6+, increased by 2 for Kitty Hawk's improved suspension) giving a total speed of 173.88 mph. Since this is over 50 mph and the vehicle has fair streamlining, we add 5% to get an actual top speed of 182.57 mph, which we round to 185 mph. Since we might not always use the jet engine, we also calculate top speed without that extra 500 lbs. thrust, and get 143 mph, which we round to 145 mph.

Ground Acceleration (gAccel)

This is measured in mph per second. It is the maximum that a vehicle moving on the ground can increase its speed by each second until top ground speed is reached.

gAccel = (top speed/Sf) × 0.8.

Sf is the speed factor as calculated above.

Round gAccel to the nearest mph/s if under 5 mph/s, otherwise to the nearest 5 mph/s.

EXAMPLE

The gAccel for Kitty Hawk is 185/18 × 0.8 = 8.22 mph/s, rounded to 10 mph/s. Without the jet engine, it's 6.44 mph/s, rounded to 5 mph/s.

Exception – Vehicles with Legs: Vehicles with legs have a reasonably high acceleration from a standing stop since the legs can "kick start" them by jumping forward. At higher speeds, the rate of acceleration is closer to a conventional vehicle. For vehicles using legs at a Ground Speed of less than 30 mph, gAccel is 4 × top speed/speed factor. For vehicles using legs at a Ground Speed of 30 mph or more, gAccel is (0.8 × top speed/speed factor) + 12 mph/s if the vehicle has two legs, + 9.6 mph/s if three legs or + 8 mph/s if it has four or more legs.

Ground Deceleration (gDecel)

This is the maximum deceleration in mph per second safely possible while maneuvering on the ground. gDecel depends on the motive system in use:

Ground Deceleration Table

Skids	5 mph/s
Wheels	10mph/s*
Tracked or Halftracked	20 mph/s*
Skitracked	15 mph/s
Legs	20 mph/s
Flexibody	20 mph/s

* Improved brakes and smartwheels each add 5 mph/s to wheeled gDecel; these bonuses are cumulative.

EXAMPLE

The gDecel for Kitty Hawk is 15 mph, thanks to its improved brakes.

Ground Stability and Maneuver Ratings

Ground Stability Rating (gSR) is a measure of stability when moving on the ground.

Ground Maneuver Rating (gMR) is the maximum *safe* "G" (gravities) the vehicle can pull while maneuvering on the ground.

Both gMR and gSR are determined using the table below: cross-index the motive system the vehicle is using and the vehicle's body volume and find the results in the gMR and gSR columns. Then apply the modifiers shown below the table.

gMR and gSR Table

Motive System	*Body's Volume* 30 cf or less		31 to 100 cf		101 to 300 cf		301 to 3,000 cf		3,001 cf or more	
	gMR	*gSR*	*gMR*	*gSR*	*gMR*	*gSR*	*gMR*	*gSR*	*gMR*	*gSR*
Skids	1.25	2	1	3	0.75	3	0.25	4	0.125	4
1 Wheel	1.5	1	1.25	1	0.5	1	0.25	1	0.125	1
2 Wheels	1.5	2	1.25	2	0.5	2	0.25	2	0.125	2
3 Wheels	1.25	2	1	3	0.75	3	0.25	4	0.125	4
4-6 Wheels	1	3	0.75	4	0.75	4	0.5	4	0.125	4
8+ Wheels	0.75	3	0.5	3	0.25	4	0.25	5	0.125	5
Tracks	0.5	3	0.25	4	0.25	5	0.25	6	0.125	6
Skitracks	0.5	3	0.25	4	0.25	4	0.25	5	0.125	5
Halftracks	0.5	3	0.25	4	0.25	4	0.25	5	0.125	5
2 Legs	2.5	1	2	1	1.5	2	1	2	0.5	2
3 Legs	2	2	1.5	2	1	3	0.75	3	0.5	3
4+ Legs	1.25	3	1	3	0.75	4	0.5	4	0.5	4
Flexibody	2.5	3	2	3	1.5	4	1	4	0.5	4

gMR Modifiers: The following enhancements each add 0.25 to gMR: improved suspension, electronic or computerized controls, responsive structure, and, for wheels only, all-wheel steering and smartwheels. *Exception:* if the gMR began at 0.125, the first enhancement increases it to 0.25, and then any subsequent enhancements add 0.25 each. Regardless of motive system or enhancements, gMR cannot exceed 0.5 if the vehicle has small or railway wheels, or uses harnessed animals or sails, or has non-folded wings or rotors.

gSR Modifiers: Improved suspension adds 1 to SR. Small wheels subtract 1 from SR. Legs built at TL7 or less subtract 1 from SR. If the vehicle is worn as a harness, subtract 1 from SR.

Motive System: Animal-powered vehicles with 2 wheels set side by side (such as carriages or chariots) should use the entry for 3 Wheels, as the animal serves as a third wheel when considering the balance of the vehicle.

Option: TL7 vehicles with wheeled or tracked drivetrains and manual controls may be designated with "automatic" or "manual" transmissions. An automatic is +1 to Driving if the character has Driving 10 or less, but -1 to Driving if he has Driving 13 or more. A manual transmission has no modifier, but a -3 unfamiliarity penalty if the character has only driven automatics.

EXAMPLE

Base gMR for Kitty Hawk is 0.75, since its volume is between 100 and 300 cf; this is increased by 0.25 each for improved suspension, all-wheel steering and computerized controls to 1.5. gSR is 4, increased by improved suspension to 5.

Ground Pressure and Off-Road Speed

Ground pressure is how much force the vehicle's motive system exerts on a given square foot of ground. It is the weight of the vehicle divided by the nominal area the vehicle has in contact with the ground.

Determine the contact area of the vehicle as follows:

Contact Area Table

Motive System in Use	*Contact Area Equals*
Railway Wheels	wheel surface area/66
Off-road Wheels	wheel surface area/33
Other Wheels at TL5-	wheel surface area/66
Other Wheels at TL6+	wheel surface area/50
Tracks	track surface area/5
Halftracks	halftrack surface area/20
Skitracks	skitrack surface area/10
Skids	skid surface area/10
Legs	combined surface area of all legs/12.5
Flexibody	body surface area/6

EXAMPLE

Kitty Hawk's contact area is 50 (surface area of wheels)/50 ("other wheels at TL6+") = 1.



Divide the loaded weight of the vehicle in pounds (including hardpoint load but *minus* any contragravity lift) by the contact area to find the ground pressure. Contragrav may not reduce loaded weight to below 10% of original loaded weight. Then consult the table below to find the vehicle's off-road speed:

Ground Pressure (GP) Table

Ground Pressure	*Description of GP*	*Off-Road Speed I*	*II*	*III*	*IV*
150 or less	extremely low	full	full	4/5	2/3
151-900	very low	full	4/5	2/3	1/2
901-1,800	low	4/5	2/3	1/2	1/3
1,801-2,700	moderate	2/3	1/2	1/3	1/4
2,701-7,500	high	1/2	1/3	1/4	1/6
7,501-15,000	very high	1/3	1/4	1/6	1/8
15,001 or more	extremely high	1/4	1/6	1/8	no

Off-Road Speed: This is the fraction of top speed that the vehicle can reach when travelling off road. There are four categories. Record the speed from the appropriate category that the vehicle's motive system falls into.

I: The speed in the first category is used for vehicles with legs, or flexibody drivetrains.

II: The speed in the second category is used for vehicles with tracks.

III: The speed in the third category is used for vehicles with standard, heavy or off-road wheels *with* all-wheel drive, or for vehicles with halftrack or skitrack motive systems.

IV: The speed in the fourth category is used for vehicles with standard, heavy or off-road wheels *without* all-wheel drive, or vehicles with skids.

Vehicles with railway wheels have no off-road speed. A fractional off-road speed is the best fraction of top speed that the vehicle can reach when not moving on a road or upon a similar hard surface. "Full" means the vehicle operates at full speed off-road; "no" means it cannot move off-road.

Kitty Hawk's effective loaded weight minus contragravity lift is 0, but there is a limit of 10% of loaded weight, or 696.89 lbs., since it requires some weight for traction! 696.89/1 (contact area) = "very low" ground pressure. Since it has standard wheels with all-wheel drive (category III), it's off-road speed is a very good 2/3 of top speed! Without the contragrav, it would have a ground pressure of 6968.9, or "high" ground pressure.

EXAMPLE

Water Performance

A vehicle has a water performance – the ability to operate like a boat or ship – if it is waterproof, sealed or submersible, and if the weight of water its hull can displace exceeds its loaded weight.

In game terms, this means that the vehicle's loaded weight must not exceed its flotation rating in order to be able to float.

Kitty Hawk's loaded weight is less than its flotation, so it can float.

EXAMPLE

Hydrodynamic Drag

This is based on the wetted area of the vessel, which largely conforms with its loaded weight in pounds. Hydrodynamic drag for surface watercraft is:

Drag = [cube root of (loaded weight - contragravity lift*)] squared / Hl.

Hl is 20 if very fine lines, 15 if fine lines, 10 if average lines, 5 if mediocre or submarine lines, or 1 if the vehicle lacks a hydrodynamic hull. Increase Hl by 10% if the vehicle has a trimaran hull or 20% if a catamaran hull.

* Contragravity lift may not reduce loaded weight to less than 10% of original loaded weight.

Round drag to the nearest whole number.

EXAMPLE

The loaded weight is 6968.9 lbs. but the contragrav lift is 10,000 lbs.; as a result, we again treat the loaded weight as only 696.89 lbs., since it can't drop below 10% for these calculations. We find the cube root of 696.89, or 8.86, square it to get 78.6 and divide by one as the vehicle lacks a hydrodynamic hull, for a hydrodynamic drag of 78.6, rounded to 79. Without contragrav, it is 365.

Water Speed

This is measured in mph (multiply by 0.87 to get speed in knots). To calculate it, total up the vehicle's aquatic motive thrust. This is dependant on the propulsion systems in use:

Airscrews, ducted screw propellers, harnessed swimming animals, hydrojets, jet engines, oars, paddle wheels, reactionless thrusters, rockets, sails and screw propellers contribute their rated motive thrust.

Flexibody drivetrains contribute 5 lbs. of thrust per kW of motive power.

Tracked drivetrains driving skitracks, halftracks or tracks, legged drivetrains driving legs, and wheeled drivetrains with off-road wheels each contribute 2 lbs. of thrust per kW of motive power.

Add up the thrust from all usable propulsion systems that will be used simultaneously to find the aquatic motive thrust.

EXAMPLE

Kitty Hawk has a jet engine (500 lbs. thrust) and a hydrojet (480 lbs. thrust) = 980 lbs. thrust.

Divide aquatic motive thrust by hydrodynamic drag. (Note that both figures may differ for surface and underwater travel.) Find the cube root of the result. Multiply by 6. The result is the top speed in mph. The formula is:

Top water speed = [cube root of (Ath/Hdr)] × 6.

Where *Ath* is aquatic motive thrust and *Hdr* is hydrodynamic drag.

Round to the nearest mph if speed is under 20 mph, otherwise round to the nearest 5 mph. The speed of a vehicle pulled by harnessed animals may not exceed (slowest animal's Move × 2 mph).

EXAMPLE

We divide the aquatic motive thrust of 980 lbs. by the hydrodynamic drag of 79 to get 12.4, find the cube root of that (2.31) and multiply by 6 to get 13.86, rounded to 14 mph. Without the jet engine, the thrust drops to 480, which gives a speed of 11 mph. Lacking contragrav, top speeds drop to 8 mph and 7 mph.





Hydrofoils: If a vehicle with hydrofoils has a surface top speed of 20 + (body area/100) mph or more it can rise up on its foils, dramatically lowering the water resistance and multiplying top speed by 1.5.

Planing: If a vehicle's aquatic thrust is at least [(H1 × 5) + 5]% of its loaded weight, it gets extra speed by planing – skimming over the water. Multiply its top speed by 2. If a hydrofoil, calculate planing, then apply hydrofoil modifier.

Sails: If the vehicle has sails and some other propulsion system, calculate speed both with and without sail thrust, since the second speed will be needed if there is no wind.

Streamlining Effects and Speed Limits: If speed works out to 50 mph or more, add 5% to top speed if Fair streamlining or 10% if Good or better streamlining. Top speed can never exceed 150 mph unless the vehicle has Very Good or better streamlining.

EXAMPLE

While Kitty Hawk has streamlining, its speed is not high enough to gain any benefit from it on the water.

Water Acceleration

Use whatever propulsion systems determined top water speed to calculate water acceleration (wAccel) in mph per second. Use the formula:

wAccel = (Ath/Lwt.) × 20.

Where *Ath* is the aquatic thrust and *Lwt.* is the usual loaded weight in pounds; note that contragrav does not affect this weight. If below 1 mph/s, round to one decimal place; if 1-5 mph/s, round to the nearest mph/s; if above 5 mph/s, round to the nearest 5 mph/s.

EXAMPLE

Kitty Hawk's Ath is 980 lbs.; divided by its loaded weight and multiplied by 20, we get a wAccel of 2.81, rounded to 3 mph/s. Without the jet engine, it is only 1.37 mph/s, rounded to 1 mph/s.

Water Maneuver and Stability Ratings

A watercraft's stability and maneuverability are based on size and TL of its body. This is because low-TL vehicles have rudimentary controls: the stern rudder, for instance, was not invented until TL3 and improved at TL4, while the modern ship's wheel is TL5. While this is a minor inconvenience with small vessels, with larger vessels it becomes more significant.

Water Maneuver Rating (wMR) is the maximum *safe* "G" (gravities) the vehicle can safely pull while maneuvering in or under water.

Water Stability Rating (wSR) is the vehicle's stability when moving through or under water.

Cross-index the TL of the vehicle's structure with the body volume to find the wSR and wMR. Then apply all of the relevant modifiers to wMR and wSR shown below the table.

wMR and wSR Table

TL	Vehicle's Body Volume in Cf											
	up to 100 cf		101 to 1,000 cf		1,001 to 10,000 cf		10,001 to 100,000cf		100,001 to 1,000,000		Over one million cf	
	wMR	wSR	wMR	wSR	wMR	wSR	wMR	wSR	wMR	wSR	wMR	wSR
0	0.25	1	0.05	2	0.01	3	0.005	4	0.002	5	0.001	5
1-2	0.25	1	0.1	2	0.02	3	0.01	4	0.005	6	0.002	6
3	0.25	2	0.1	3	0.05	4	0.02	5	0.01	6	0.005	7
4	0.25	2	0.1	3	0.05	4	0.05	5	0.02	6	0.01	7
5-6	0.25	3	0.1	4	0.05	5	0.05	6	0.02	7	0.02	8
7-8	0.5	3	0.25	4	0.1	5	0.1	6	0.05	7	0.02	8
9-10	0.75	4	0.5	5	0.25	6	0.1	6	0.05	7	0.02	8
11+	1	4	0.75	5	0.5	6	0.25	6	0.1	7	0.05	8

wMR: Shift wMR one size category to the left for each of the following options: electronic or computerized controls, a responsive structure, using a flexibody drivetrain for propulsion. Once the leftmost column ("up to 100 cf") is reached, add +0.25 to wMR for each remaining option instead.

wSR: The wSR is modified as follows:

Electronic or computerized controls . . . . . +1
Roll stabilizers . . . . . +1
Average hydrodynamic lines . . . . . -1
Fine, Very Fine or Submarine lines . . . . . -2
Catamaran or trimaran hull . . . . . +2
Vehicle has sails, area of sail is:
10 to 20 sf times hydrodynamic drag. . . . . -1
more than 20 sf times hydrodynamic drag . . . . . -2
Minimum wSR is 1

EXAMPLE

Kitty Hawk's wMR and wSR are based on its volume (which is between 101 and 1,000 cf), and at TL7 work out to wMR 0.25 and wSR 4. Due to its computerized controls, its wMR is shifted one place to 0.5, while its wSR is increased by +1, to wSR 5.

Water Deceleration (wDecel)

The base deceleration safely possible while maneuvering on water in mph per second is:

100 × (wMR/Hl),

with a maximum of 10 mph/s, where *wMR* is water maneuver rating and *Hl* is the streamlining factor defined under *Hydrodynamic Drag,* above.

The vehicle can add half its wAccel to water deceleration, rounding up, but show the increased deceleration in parenthesis e.g., 1(5), since it won't be usable if the vehicle loses power.

EXAMPLE

Kitty Hawk's wDecel works out to 10 mph/s. We can also add half the wAccel, if we need to.

Draft

Draft is the minimum depth of liquid the vehicle can operate in without running aground. It is calculated as follows:

Draft in feet = [(cube root of Lwt.)/15] × Hl.

Where:

Lwt. is loaded weight in pounds, minus any contragrav lift (minimum 0).

Hl is 1 if no hydrodynamic lines, 1.1 if mediocre, 1.2 if average, 1.3 if fine, 1.4 if very fine, 2 if submarine lines.

Vehicles moving as hydrofoils have their draft halved.

Round draft to one decimal place.

EXAMPLE

Kitty Hawk's draft is effectively 0, thanks to its contragrav. Without contragrav, it works out to [19.1 (cube root of loaded weight) / 15] × 1 (no hydrodynamic lines) = 1.27', rounded to 1.3'.

Submerged Performance

A vehicle has a submerged performance – the ability to swim underwater like a submarine – if it has the *submersible* body feature.

Although not considered "submerged performance," any vehicle with a ground performance can drive along the bottom of a body of water provided it doesn't float, has a sealed or submersible body and power and propulsion systems that do not require air, plus a limited or full lifesystem (or oxygen-equipped suits) for any occupants.

Submerged Hydrodynamic Drag

This is calculated in much the same way as for surface watercraft, but with some differences. Contragrav does not affect submerged drag! Use the formula:

Drag = (cube root of submerged weight) squared / Ls,

Ls if 10 if submarine lines, 6 if very fine lines, 4 if fine lines, 3 if average lines, 2 if mediocre lines, or 1 if the vehicle lacks a hydrodynamic hull.

Round drag to the nearest whole number.

EXAMPLE

Kitty Hawk's submerged weight is 17,515.625 lbs., so its submerged drag is the cube root of that, squared, divided by 1 for no lines, or 674.45, rounded to 674.



Underwater Top Speed

This is measured in mph. Add up the thrust from all usable propulsion systems that will be used simultaneously to find the submerged motive thrust.

These include screw propellers, harnessed swimming animals, ducted screw propellers, hydrojets, rockets, and reactionless thrusters. Flexibody drivetrains contribute 5 lbs. of thrust per kW of motive power. Legged drivetrains driving legs contribute 2 lbs. of thrust per kW of motive power.

Any propulsion systems powered by air-breathing power plants cannot be used while submerged!

Divide submerged motive thrust by hydrodynamic drag. (Note that both figures may differ for surface and underwater travel.) Find the cube root of the result. Multiply by 6. The result is the top speed in mph. The formula is:

Submerged speed = [cube root of (Sth/Hdr)] × 6.

Where *Sth* is submerged motive thrust and Hdr is hydrodynamic drag.

Round to the nearest mph if below 20 mph, otherwise to the nearest 5 mph. The speed of a vehicle pulled by harnessed animals may not exceed (slowest animal's Move × 2 mph).

EXAMPLE

Kitty Hawk's submerged thrust is only 480 lbs. since it can't use the air-breathing jet engine. Top speed is cube root of (480/674) × 6 = 5.35 mph, rounded to 5 mph.

Underwater Acceleration

Use whatever propulsion systems determined submerged motive thrust to calculate underwater acceleration (uAccel) in mph. Use the formula:

uAccel = Sth/Swt × 20 mph/s.

Where *Sth* is the submerged motive thrust and *Swt.* is the submerged weight in pounds. Round to two places.

If below 1 mph/s, round to one place; if 1-5 mph/s, round to the nearest mph/s, if above 5 mph/s, round to the nearest 5 mph/s.

EXAMPLE

Kitty Hawk, with 480 lbs. thrust and submerged weight of 17,515.625 lbs., has a uAccel of 0.548 mph/s, rounded to 0.5 mph/s.

Underwater Deceleration, MR, SR and Draft

Use the same statistics as in water performance, except that when submerged, draft is simply (cube root of submerged weight)/3.

EXAMPLE

Kitty Hawk's uDecel, uMR and uSR are the same as its wDecel, wMR and wSR. Its submerged draft is 25.97 (cube root of submerged weight) / 3 = 8.65 feet, rounded to 9'.

Crush Depth

This is how deep a submersible vessel may safely dive underwater; it also applies to vehicles driving on the bottom. It is based on the DR of pressurized areas of the vehicle. A pressurized area is any body or subassembly that contains crew positions, passenger seats or spaces, or accommodations.

To determine crush depth, measured in yards, find the pressurized body or subassembly with the lowest DR. Add 10 to this DR, then multiply the sum by 0.25 if the vehicle structure has an extra-light frame, × 0.5 if light, × 1 if medium, × 2 if heavy or × 4 if extra-heavy. Multiply this by 10 yards. Divide by 2 if the vehicle lacks a submersible hull. This gives the crush depth in yards.

If the vehicle dives below crush depth, it must make Health rolls to avoid the pressure collapsing its hull, with fatal results. Note that unmanned vehicles do not have a crush depth.

EXAMPLE

Kitty Hawk's crush depth is based on its lowest pressurized DR; its wheels and turret have lower DR than the body, but they aren't pressured, so we use the body's DR 24. That gives it (24 + 10) × 0.5 (light) × 10 yards = 170 yards.

Aerial Performance

A vehicle with wings (except stub wings), a lifting body or rotors can fly. So can one with aerostatic lift (from lifting gas, lift fans/engines, vectored thrust or contragrav) that is in excess of its weight.

Stall Speed

Stall speed is the minimum speed in mph the vehicle must be moving at to have sufficient lift to take off and, once in flight, to remain airborne.

Stall speed can be reduced or negated by the total *static lift* of the vehicle: this is the sum of the pounds of lift from ornithopter wings, helicopter rotors, lifting gas, lift engines and fans, vectored thrust used for lift, contragravity and levitation.

If static lift exceeds the vehicle's loaded weight, then stall speed is automatically 0.

Otherwise, stall speed largely depends on the vehicle's *lift area.* This is found by adding the entire combined surface area of all the wings and rotors to 10% of the area of the body (30% for lifting bodies). Treat STOL wings as having 1.5 times their actual area and flarecraft wings and rotors as three times their actual area for this purpose. Use lift area and the formula below to calculate stall speed:

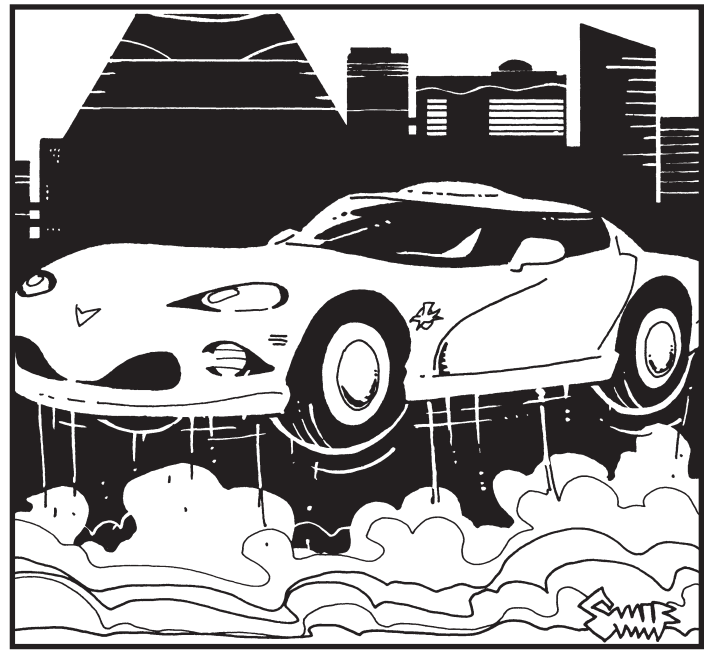
Stall Speed = [(Lwt-Static Lift)/Lift Area] × Sl × Rs.

Lwt. is loaded weight in pounds.

Sl is 1 if no streamlining; if streamlining, it is 1 if fair, 1.05 if good, 1.1 if very good, 1.15 if superior, 1.2 if excellent or 1.3 if radical.

Rs is 2 mph for most vehicles, but is 1.5 mph if vehicle has responsive structure.

Round stall speed to the nearest 5 mph.





Hover Capability: If stall speed is 0, the vehicle can take off and land vertically, and, after decelerating to 0 speed, can hover in midair. A vehicle with no stall speed can even fly sideways or backwards at up to 1/20 its top speed. A winged aircraft that can do this is called a VTOL aircraft (Vertical Take Off and Landing).

STOVL Capability: If static lift is less than the loaded weight but is greater than the aircraft's weight *excluding* the weight of a hardpoint load, the aircraft is said to be "STOVL" capable – Short Take Off, Vertical Landing. STOVL capability means that after dropping (or not carrying) stores on its hardpoints, its stall speed drops to 0, giving it the ability to hover and land vertically, as above.

Takeoff and Landing Distances: If stall speed is greater than 0, the aircraft will have to accelerate to that speed using its gAccel before it can take off. Similarly, when landing, it touches down at stall speed and must use its gDecel to come to a complete stop. Both takeoff and landing will require minimum runway lengths, given by:

Takeoff run (yards) = (S × S)/(4 × gAccel).
Landing run (yards) = (S × S)/(4 × gDecel).

Where *S* is stall speed (in mph), and *gAccel* and *gDecel* are the vehicle's usual ground performance stats (in mph/s).

EXAMPLE

With a contragrav lift of 10,000 lbs., which is more than its loaded weight, Kitty Hawk has a stall speed of 0 and can hover.

Can the Vehicle Fly?

To take off from the ground on its own, a vehicle must either have a modified stall speed of 0 or be able to reach its stall speed while still using ground movement. Thus, its top ground speed must equal or exceed its stall speed.

The same is true for vehicles taking off from water: their stall speed must be 0, or their top water speed must be able to equal or exceed stall speed for the vehicle to be able to fly.

If a vehicle's stall speed is higher than its top ground speed, it can't take off from the ground unaided. The same applies to water speed. However, all is not lost: the vehicle can still fly if towed or launched from another craft at a speed greater than its stall speed. Note that unpowered gliders always have a top ground speed lower than stall speed!

Flarecraft: A vehicle with flarecraft wings is limited to flight at a maximum altitude of (square root of combined wing area) feet, up to a maximum of 6'.

With a stall speed of 0, Kitty Hawk can fly.

EXAMPLE

Aerial Motive Thrust

This is the amount of thrust the vehicle can use to propel itself once it is flying.

It is equal to the thrust of aerial propellers, ducted fans, ornithopter drivetrains, helicopter rotors, aerial sails, harnessed flying animals, jet engines (except ramjets – see p. 135), rocket engines, Orion engines and reactionless thrusters. Do *not* include thrust produced by lift engines or fans.

If an engine or fan has the *vectored thrust* option, omit whatever portion of its thrust was used to lift the vehicle into the air unless the vehicle has wings (except stub wings), rotors, or a lifting body. Vectored thrust required to lift the vehicle is equal to the loaded weight of the vehicle minus aerostatic lift from other sources, e.g., lifting gas, contragrav, levitation, helicopter rotors, lift engines or lift fans.

If a vehicle has an afterburner, calculate two sets of aerial motive thrust – one with the afterburner, one without.

Kitty Hawk's aerial motive thrust is 500 lbs. from its jet engine.

EXAMPLE

Aerial Top Speed

This is the top speed of the vehicle in the air. To find it, first calculate the vehicle's *aerodynamic drag*.

Aerodynamic Drag = [(Sa-R)/ Sl] + D.

Sa is the total surface area of the vehicle.

R is the surface area of anything retractable (e.g., pop turrets, retractable skids or retractable wheels).

Sl depends on streamlining: 1 if none, 2 if fair, 3 if good, 5 if very good, 10 if superior, 20 if excellent, 40 if radical streamlining. Add 20% to Sl if vehicle has a responsive structure.

D is the sum of: 10 for each person in an exposed seat, 15 for each person in a cycle seat or exposed standing room; 20 if the vehicle is worn as a harness; the total surface area of any vehicles carried on deck or in external cradles; 5 per loaded hardpoint the vehicle has (but only if calculating performance with hardpoints loaded).

Kitty Hawk's aerodynamic drag is the total surface area of 324 minus the area of the pop turret (24) equals 300, which we divide by 2 for fair streamlining, getting 150. No other modifiers apply.

EXAMPLE

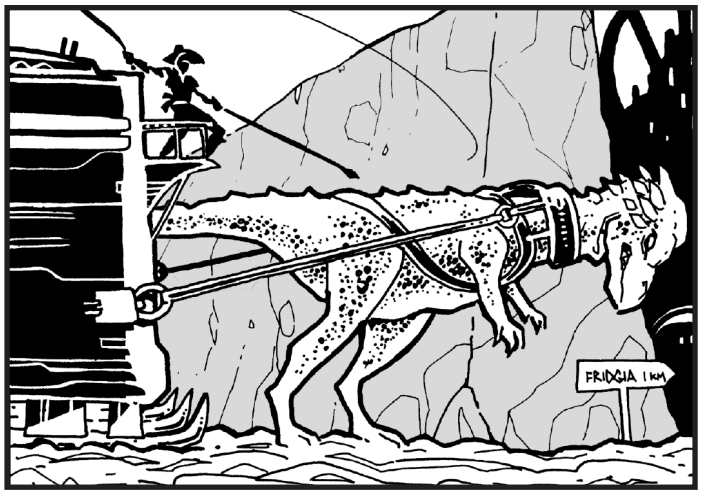
Top Speed: Use the aerodynamic drag and aerial motive thrust to determine the aerial top speed (in mph) using the following formula:

Top speed = square root of [7,500 × (Amt/Adr)].

Amt is aerial motive thrust.

Adr is aerodynamic drag.

Round the result to the nearest 5 mph if over 20 mph, otherwise to the nearest mph.



EXAMPLE

Kitty Hawk's top speed is the square root of (7,500 × 500 thrust / 150 drag) or 158.1 mph, rounded to 160 mph. It can zip along at about the speed of a fast helicopter.

Certain vehicle designs are restricted in maximum speed. If calculated top speed exceeds these limits, reduce it to the limit:

Harnessed animals	their Move × 2 mph
Aerial sails	100 mph
TL6 rotors	150 mph
TL7+ rotors	300 mph
Flarecraft wings	400 mph
No, Fair or Good streamlining	600 mph
Aerial propellers	600 mph
Very Good streamlining	740 mph*
DR is under 5**	600 mph
DR is under 20**	2,000 mph

*Except lifting bodies.

** Only DR from metal, composite or laminate armor counts; if it has various DRs on different locations, use the lowest DR excluding DRs of retractable subassemblies.

These are also limits on speed when a vehicle is gliding or in a dive.

EXAMPLE

None of these restrictions affect Kitty Hawk's speed: while it would be limited to 600 mph by its streamlining, it can't go that fast, except in a dive.

Jet Engine Limits: A turbojet or turbofan engine becomes ineffective at speeds over about 2,000 mph, a turbo-ramjet at over 4,000 mph, a ramjet at over 6,000 mph (TL7) or 12,000 mph (TL8+). If the vehicle goes faster, reduce it to this limit. *Exception:* If the vehicle still has some aerial propulsion systems that still work at this speed (e.g., in a vehicle being propelled by turbojets and rockets, the rockets would still work past 2,000 mph) recalculate speed using just the working propulsion system's thrust. If this new top speed exceeds the jet speed limit, use it; otherwise, top speed equals the jet's limit.

Ramjets and Turbo-ramjets: A ramjet only works if the vehicle is moving at 375 mph or greater speed, while a turbo-ramjet switches to more efficient ramjet mode at that speed. If a vehicle has either and can reach a top speed of at least 375 mph, recalculate top speed by adding thrust equal to (0.2 × any turbo-ramjet's original thrust) plus the entire thrust of any ramjets.

Aerial Acceleration

Use the aerial motive thrust to calculate aerial acceleration (aAccel) in mph per second. The formula is:

aAccel = (Amt/Lwt) × 20.

Amt is total aerial motive thrust.

Lwt is the usual loaded weight in pounds.

Round to the nearest whole number. For craft with afterburners, calculate two sets of aAccel, with and without afterburner.

EXAMPLE

Kitty Hawk's aAccel is 500 lbs. thrust/6,968.9 lbs. weight × 20 = 1.43, rounded to 1 mph/s.

Aerial Maneuver Rating

Aerial maneuver rating (aMR) is the maximum safe g (gravities) that the vehicle can pull in flight while turning or maneuvering.

If vehicle's stall speed is 0: The vehicle's aMR is (TL-Size Modifier)/2. Treat TL as one higher if it has either a responsive structure or either electronic or computerized controls, and as two higher if it has both. If aMR works out to 0 or less, treat it as 0.125.

If vehicle has a lifting body but no wings: aMR is 0.125, or 0.25 if it has electronic or computerized controls. Double this if vehicle has a responsive structure.

If vehicle has wings or rotors: aMR is calculated using this formula:

aMR = [(Whp + Rhp)/Lwt.] × TL × 30.

Whp is the sum of all wings' hit points.

Rhp is the sum of all rotors' hit points.

Lwt. is loaded weight in pounds.

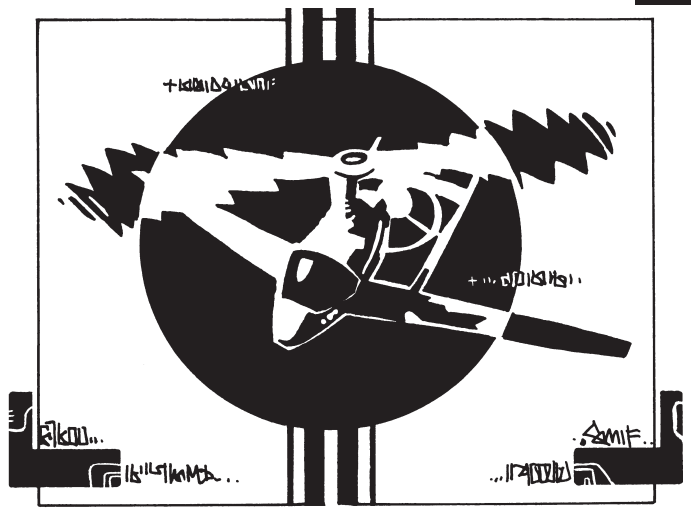
TL is the Tech Level of the wings or rotors. Add one to effective TL for each of these features the vehicle has: responsive structure, high agility wings, variable sweep and computerized controls (this is cumulative). If the vehicle has controlled instability, add *two* to effective TL. If the vehicle has MMR rotors, treat it as one TL *lower.*

Round to the nearest half or whole number.

If the vehicle has a stall speed of 0 *and either* has wings or rotors (like a helicopter or a vertical take off jet aircraft) *or* is a lifting body with no wings, use the higher result of the two formulae to get aMR.

EXAMPLE

Since Kitty Hawk has no wings or rotors, its aMR is its TL of 7, increased by 1 for computerized controls to 8, minus its size modifier of +3, giving 5, which we then divide by 2 to get an aMR of 2.5 g. This is comparable to most helicopters.



Aerial Stability Rating

The aSR is based on the vehicle volume and various modifiers, and is calculated using the table below:

Aerial Stability Rating Table

Vehicle Has...	*SR*
Volume under 99 cf	2
Volume 100-999 cf	3
Volume 1,000-9,999 cf	4
Volume 10,000-99,999 cf	5
Volume 100,000 cf or greater	6
Electronic or computerized controls	+1
Built at TL6-	-1
Built at TL8+	+1
No wings, or only stub wings	-1*
Lifting body	-1
Biplane or triplane wings	-1
Controlled instability	-1
Both radical stealth and wings	-1

* Vehicles with coaxial rotors ignore this penalty.

Minimum aSR is 1.

EXAMPLE

Kitty Hawk's aSR is 3 for its volume +1 for computerized controls -1 for no wings = 3.

Aerial Deceleration

The maximum aerial deceleration in mph/s (aDecel) is equal to the vehicle's aMR × 4.

EXAMPLE

Kitty Hawk's aDecel is its aMR × 4, or 10 mph/s. Kitty Hawk doesn't have a mag-lev, hovercraft or space performance, so we've finished the vehicle!

Mag-Lev Performance

Mag-lev vehicle performance is calculated much the same as air performance. A mag-lev vehicle can only move if its mag-lev lift exceeds the vehicle's loaded weight.

Stall speed is automatically 0.

Motive thrust is equal to the 20% of mag-lev lift (in lbs.), plus the thrust of any aerial propellers, ducted fans, jet engines, rocket engines or reactionless thrusters.

Aerodynamic drag is calculated the same way as for air performance.

Speed and *Acceleration* are calculated normally, the same way as for aerial performance.

mMR is 0.125 at TL7, 0.25 at TL8+, while *mSR* is 6.

Deceleration is 40 mph/s × mMR.

Hovercraft Performance

A vehicle that has hoverfans may be able to perform as a hovercraft, using an air cushion to hover a few inches or feet off the surface of ground or water (if a GEV skirt) or water only (if SEV sidewalls) with less thrust than would be needed to fly.

Total the lift of all hoverfans, lift fans, contragravity, lifting gas and lift engines. Since the hovercraft is operating in "ground effect," the lift of hoverfans is increased: multiply by 5 if GEV skirt, by 4 if SEV sidewalls, or by 2 otherwise. If the total modified lift is greater than the vehicles's loaded weight, it can hover at an altitude of (2 × lift/loaded weight) feet over the ground or water, to a maximum altitude of 6 feet.

Vectored-thrust engines or fans may convert some or all of their thrust to lift in order to enable the vehicle to hover. Each pound of thrust adds 1 pound to lift, but thrust used for lift may not be used for propulsion. Thus, there is no point in adding more lift than is necessary to exceed loaded weight.

Motive Thrust, Speed and Acceleration: If the vehicle can hover, find its motive thrust, speed, and acceleration (hAccel) using the methods given under *Aerial Performance,* above. If it has SEV sidewalls, multiply top speed by 0.8. However, top hover speed cannot exceed 300 mph. When calculating motive thrust, remember that vectored thrust engines and fans can only contribute the portion of their thrust that was not used for lift!

Hover Maneuver Rating (hMR): This is calculated the same way as MR for an aircraft with no stall speed. If SEV sidewalls, add +0.25 to hMR.

Hover Stability Rating (hSR): This is calculated the same way as for an aircraft, but add +1 if SEV sidewalls.

hDecel: The maximum hover deceleration in mph (hDecel) is equal to the vehicle's hMR × 4.

Space Performance

A vehicle with a rocket or other non-air-breathing reaction engine, or a reactionless thruster, may maneuver in normal space. So may a vehicle with a warp drive.

A manned vehicle can only operate in space if the crew have suits or appropriate life support. Similarly, a power plant can only function in space if it does not require air (or is closed-cycle).

A space vehicle is rated for space acceleration and maneuver rating:

Space Acceleration: Space acceleration (sAccel) is normally measured in gravities (G). To find sAccel, divide the total motive thrust of all rockets and spacedrives that are used together by the loaded mass in pounds. To convert G to mph/s, multiply sAccel by 20 for an even number, or by 21.9 for strict realism.



Space Deceleration: A vehicle in space can decelerate by spinning about and thrusting in the opposite direction. This is normally accomplished with small attitude jets, which are included as part of any space propulsion system (these jets are too small to be of use when maneuvering in atmosphere). Such a maneuver normally takes 10 seconds × the vehicle's Size Modifier (minimum 1 second) to execute. Many space vehicles have-vectored thrust engines; such vehicles can decelerate *without* having to turn around first.

Space Maneuver Rating: Space Maneuver Rating (sMR) equals sAccel. Spacecraft do not require a Stability Rating.

FTL Speed

This is the vehicle's speed when travelling faster than light, usually rated in parsecs per day. It is only possible if the vehicle has a stardrive. With a jump drive or teleportation drive, this is an all-or-nothing capability: if the ship's loaded mass is less than the drive's jump capacity, it can travel faster than light. Otherwise, it cannot.

For hyperdrive or warp drives, speed is based on hypershunt capacity or warp thrust factor divided by loaded mass in tons and multiplied by *x* (see p. 39). However, hypershunt capacity must at least equal loaded mass for a ship to use hyperdrive.

Recording Vehicle Statistics

A standard format is used to record vehicle statistics, while giving full details of component weight, volume, etc. For a more compact descriptive format, see Chapter 11.

Kitty Hawk (TL7)

An "omnicar," Kitty Hawk represents top-of-the-line TL7 vehicle technology assisted by TL13 contragravity generators. It was built by Cassidy Jones and Captain Morgan West using "black program" CIA funds as a special operations vehicle. Outwardly it resembles a luxury sports car. But inside?

Subassemblies and Body Features: Four standard wheels. Pop turret with full rotation (atop body). Flotation and submersible hull (flotation 62.5 lbs./cf, 15,468.75 lbs.), fair streamlining.

Propulsion: 200 kW wheeled drivetrain with all-wheel drive (body, 440 lbs., 8.8 cf, $8,800, 200 kW). 40 kW hydrojet (body, 120 lbs., 2.4 cf, $4,800, 40 kW) with 480 lbs. aquatic motive thrust. 500 lbs. thrust turbofan (body, 300 lbs., 6 cf, $15,000) uses 15 gph jet fuel.

Aerostatic Lift: 10,000 lb.-lift TL13 contragrav generator (body, 15 lbs., 0.3 cf, $550, 10 kW).

Weaponry: 7.62mm minigun, concealed (turret, 33 lbs., 1.65 cf, $3,700, Pow 0.55). 40mm GL, concealed (turret, 72 lbs, 3.6 cf, $5,400). 400 shots 7.62mm solid (turret, 22 lbs., 0.148 cf, $44). 50 shots 40mm HEDP (turret, 60 lbs., 0.6 cf, $550).

Weapon Accessories: Full stabilization for minigun (turret, 3.3 lbs., 0.165 cf, $330). Full stabilization for grenade launcher (turret, 7.2 lbs., 0.36 cf, $720).

Communications: TL7 communicator with medium range and cellular phone (body, 4 lbs., 0.08 cf, $800, 30 mile range), with scrambler ($1,000).

Sensors: Headlights. TL7 light amplification (body, 2 lbs., 0.04 cf and $400). TL7 radar, 10 mile range (body, 50 lbs., 1 cf, $40,000, 2.5 kW, Scan 17). TL7 active sonar with active/passive option, 0.5 mile range (body, 37.5 lbs., 0.75 cf, 1.25 kW, $6,000, Scan 9). TL7 thermograph, 3 mile range (turret, 7.5 lbs., 0.15 cf, $48,000, Scan 14). Eight-foot periscope for thermograph (turret, 15 lbs., 0.3 cf, $38,400).

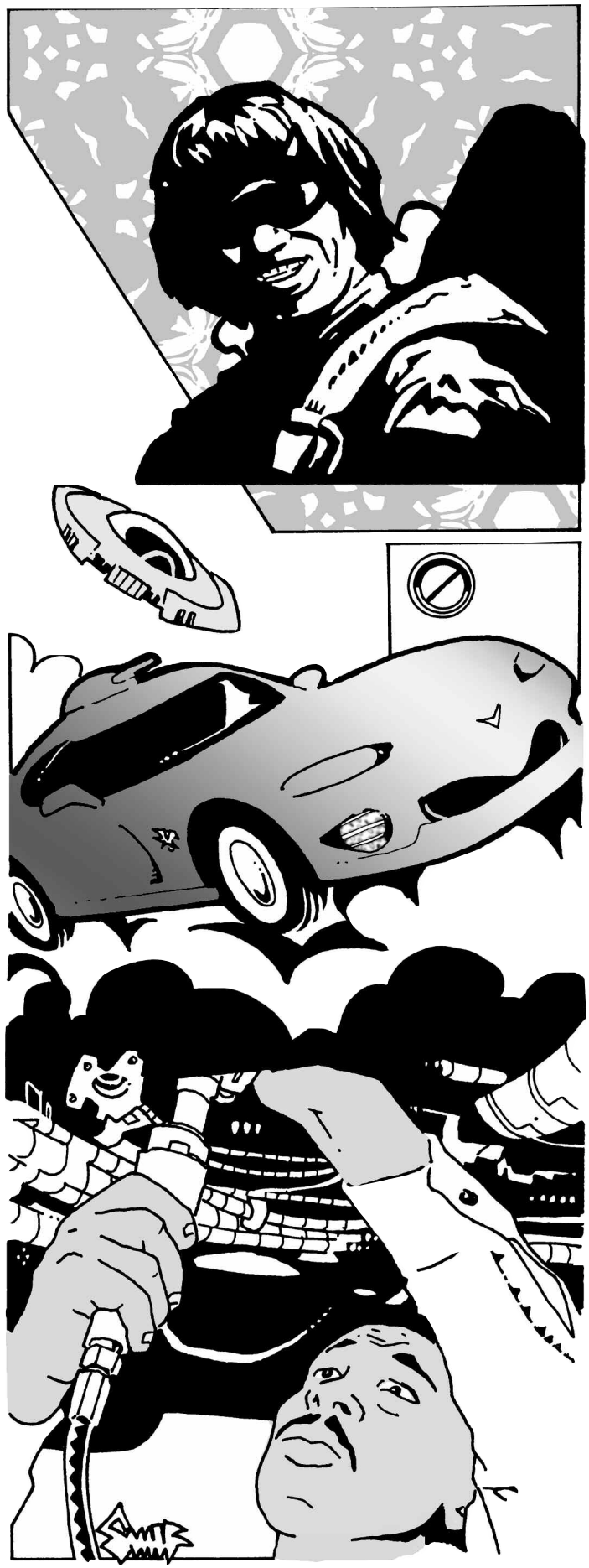
Audio/Visual: TL7 Sound system (body, 20 lbs., 1 cf, $400).

Navigation: TL7 Military GPS (body, 4 lbs., 0.08 cf, $3,000).

Targeting: TL7 HUDWAC with pupil scanner (body, 10 lbs., 0.2 cf, $20,000).

ECM: TL7 advanced radar/laser detector (body, 30 lbs., 0.6 cf, $3,000, neg.). TL7 decoy discharger (body, 20 lbs., 1 cf, $100) with four chaff, four flare and two sonar decoy reloads (body, 100 lbs., 5 cf, $260).

Computers: TL7 minicomputer with genius option (body, 40 lbs., 0.8 cf, $105,000, complexity 3). Two TL7 computer terminals (body, total of 80 lbs., 4 cf and $2,000).



Miscellaneous: TL7 compact fire suppression system (body, 50 lbs., 1 cf, $500). TL7 hi-security alarm ($3,000). TL7 mutable license plate (body, 1 lb., 0.3 cf, $500). TL7 smokescreen (body, 75 lbs., 1.5 cf,. $350). Bilge pump (free, 1 kW of power).

Vehicle Controls: Computerized maneuver controls ($10,000). Computerized diving controls ($10,000).

Crew Stations: "Pilot" runs controls and two computer terminals from normal crew station (body, 30 lbs., 30 cf, $200).

Occupancy: Short. *Crew Requirements:* Pilot.

Accommodations: One normal seat (body, 30 lbs., 30 cf, $100).

Environmental Systems: TL7 limited life system with one man-day of support for two people (body, 200 lbs., 4 cf, $1,000, 1 kW).

Safety Systems: TL7 ejection seat for crew station and normal seat (body, each 100 lbs., 5 cf, $50,000). Airbags for both front seats (body, each 10 lbs., 1 cf, $100).

Power Systems: TL7 216 kW standard gas turbine (body, 472 lbs., 9.44 cf, $9,440, uses 12.96 gph jet fuel). On the ground or in air, it powers everything but the hydrojet; on water, everything but the wheeled drivetrain. Underwater, the turbine is shut down. Instead, TL7, 155,700 kWs advanced batteries (body, 778.5 lbs., 7,785 cf, $7,785) power hydrojet, bilge pump, sonar and lifesystem (43.25 kW) good for 3,600 seconds, or one hour. When turbofan operates, 5 kW extra power are available; this is often used to recharge the energy bank.

Fuel: 60 gallon light, self-sealing tank (body, 60 lbs., 9 cf, $1,200, fire +0). Holds 60 gallons jet fuel (390 lbs., fire 13). This fuels the turbofan for 4 hours, the turbine for 4.62 hours, or both at once for 2.145 hours.

Access, Cargo and Empty Space: Access space (body, 26.64 cf). Cargo space (body, 6 cf). Empty space (turret, 0.937 cf), (body, 0.685 cf).

Volumes: Turret (8 cf, takes up 9.6 cf in body). Body (247.5 cf, flotation 15,468.75 lbs.). Wheels (24.75 cf).

Surface Area: Turret 24, body 250, wheels 50, total and structural surface area 324.

Structure: Light frame, very expensive materials modified by streamlining and submersible (972 lbs., $97,200).

Hit Points: Body 188, turret 18, each wheel 19.

Structural Options: Improved suspension ($5,000), improved brakes ($1,000), all-wheel steering ($5,000).

Armor: Body has DR 24 advanced laminate (900 lbs., $90,000). Wheels have DR 10 advanced laminate (75 lbs, $7,500). Pop turret has advanced laminate F22, B12, R12, L12, T12. (50.4 lbs., $5,040). Kitty Hawk's body and turret front have PD 4. The back, right, left and top of its turret and its wheels are PD 3.

Other Surface Features: Basic stealth (648 lbs., $97,200). Puncture-resistant tires ($1,000).

Statistics: Empty weight 5,976.9 lbs., internal payload 520 lbs., fuel and ammo 472 lbs., loaded weight 6,968.9 lbs., (3.09 tons), submerged weight 17,515.625 lbs. Volume 280.25 cf. Size modifier +3. Cost $760,975. HT 10.

Ground Performance: Top speed 185 mph (145 mph without jet engine). gAccel 10 mph/s (5 mph/s without jet engine). gDecel 15 mph/s. gMR 1.5. gSR 5. Off-road 2/3 with contragrav, 1/4 without.

Water Performance: Can float. Hydrodynamic drag 79 with contragrav, 365 without. Top speed 14 mph (11 mph without jet). Without contragrav, top speeds are 8 mph and 7 mph. wAccel 3 mph/s (1 mph/s without jet). wMR 0.5. wSR 5. wDecel 10 mph/s. Draft none with contragrav, 1.3' without.

Submerged Performance: Submerged drag 332. Top speed 5 mph, uAccel 0.5 mph/s. uMR 0.5. uSR 5. Draft 9'. Crush depth 170 yards.

Air Performance: Stall speed 0, can hover, can fly. Aerodynamic drag 150. Top speed 160 mph. aAccel 1 mph/s. aMR 2.5. aSR 3. aDecel 10 mph/s.

Appendix 1 – Cube Roots

Several ***GURPS Vehicles*** calculations require finding a cube root. Most calculators and spreadsheets can calculate cube roots, but not all. Here is a simplified (i.e., rounded-off) cube root table that can be used if all else fails!

If a number falls between two values on the table, use the nearer, or the higher, if both are equally close.

Simplified Cube Root Table

Number	*Cube Root*	*Number*	*Cube Root*
0.015	0.25	1,331	11
0.125	0.5	1,728	12
0.42	0.75	2,197	13
1	1	2,744	14
1.9	1.25	3,375	15
3.3	1.5	4,096	16
5.3	1.75	4,913	17
8	2	5,832	18
11	2.25	6,859	19
15	2.5	8,000	20
20	2.75	12,167	23
27	3	15,625	25
34	3.25	19,683	27
42	3.5	27,000	30
52	3.75	35,937	33
64	4	42,875	35
76	4.25	50,653	37
91	4.5	64,000	40
107	4.75	79,507	43
125	5	91,125	45
166	5.5	103,823	47
216	6	125,000	50
275	6.5	216,000	60
343	7	343,000	70
422	7.5	512,000	80
512	8	729,000	90
614	8.5	1,000,000	100
729	9	1,728,000	120
857	9.5	3,375,000	150
1,000	10	8,000,000	200

Appendix 2 – GURPS Space: Defense Factors

The ***Vehicles*** rules can be used to design spaceships and space weaponry that work with the ***GURPS Space*** combat system. The resulting vehicles will be similar, but not identical, to spaceships built using ***GURPS Space.***

To find a ship's Defense Factor for use with ***GURPS Space*** combat rules, use the following chart:

DR to DF

DR	*DF*	*DR*	*DF*
under 70	0	560-1,019	4
70-139	1	1,020-2,039	5
140-279	2	2,040-4,079	6
280-559	3	4,080-8,160	7
etc.	etc.		



If a ship has deflectors, add 1 to DF. If it has force screens, calculate DF based on screen DR separately, and add the two together.

Add 1 for these features: basic stealth, basic IR cloaking or basic emission cloaking.

Add 2 for these features: radical stealth (if vehicle does not have partial stealth), radical IR cloaking (if vehicle does not have basic IR cloaking) or radical emission cloaking (if vehicle does not have basic emission cloaking).

Other factors (such as vehicle volume and the benefits of FTL drives) affect DF as described on p. S93: when calculating volume, 27 cf = 1 cy.

SAMPLE VEHICLES 11

This section provides a short selection of vehicles from different time periods in a ready-to-use format. As well as being usable in adventures, these craft should give some insight into how to build other vehicles of their general class.

Abbreviations

Abbreviations are used to succinctly refer to particular locations (the body and the various subassemblies) or to particular facings (front, back, right, left, top, underside).

Locations: Body (Bo), Turret (Tu), Superstructure (Su), Open Mount (Om), Pod (Po), Gasbag (Gb), Mast (Ma), Wheels (Wh), Tracks (Tr), Halftracks (Ht), Skids (Skd), Skitracks (Ski), Wings (Wi), Rotors (Ro), GEV skirt (GEV), SEV sidewalls (SEV). Multiple examples are identified by a number, e.g., Tu2 is the second turret on a vehicle.

Facing: Front (F), Back (B), Right (R), Left (L), Underside (U), Top (T).

Armor: Chp: cheap, Std: standard, Exp: expensive, Adv: advanced.

Where no location is given for a component, assume it is in the body!

Roundship (TL3)

A roundship, or cog, is a medieval sailing ship. This particular one is a small example with single square-rigged mast, wide body, and two "castles" (raised superstructures) to fore and aft. Cogs were used interchangeably as warships and merchants. They often carried soldiers, but even warships were rarely armed.

Subassemblies and Body Features: Superstructure 1 (atop front of body), superstructure 2 (atop aft body), 40-foot mast. Flotation & hydrodynamic hull with mediocre lines. Flotation rating 137,940 lbs.

Propulsion: Sails. Fore-and-aft rig, 640 sf of cloth sails, average motive thrust 1,280 lbs.

Instruments and Electronics: TL3 Navigation instruments (Su2, HP 4).

Miscellaneous: Bilge pumps (two). External cradle for 2,000 lb. boat (HP 16).

Controls & Crew Stations: Primitive. "Steersman" runs maneuver controls from roomy crew station (Su2). "Navigator" runs navigation instruments from roomy crew station (Su2).

Occupancy: Long. *Passengers:* Six. *Crew:* Captain, steersman, navigator, two sailors. *Quarters:* Two cabins (Su2, HP 800 each). Two cabins (Su1, HP 800 each). Four bunks (HPs 150 each).

Cargo and Empty Space: 1,700 cf cargo space (Body). 10 cf cargo (Su2). Empty space (Su2 9.6 cf; Bo 96).

Volume: Su1 (1,000 cf). Su2 (1,100 cf), Bo (2,420 cf). 40' Mast (6.4 cf). *Areas:* Su1 600, Su2 800, Bo 1,200, Ma 21, Total area 2,621, Structural area 2,600.

Structure: TL3 medium frame, standard materials (wood).

Hit Points: Bo 1,800, Ma 42, Su1 900, Su2 1,200.

Armor: Bo: PD 3, DR 20 std. wood. Ma, Su1 and Su2: PD 3, DR 10 std. wood.

Surface Features: Waterproof.

Vision: Good for crew, Poor for passengers.

Statistics: Empty weight 95,002 lbs. Usual payload 36,400 lbs. Loaded weight 131,402 lbs. (65.7 tons). Volume 4,526.4 cf. Size modifier +6. Price $43,252.50. HT 8.

Water Performance: Can float. Hydrodynamic drag 517. Aquatic motive thrust 1,280 lbs. Speed 8 mph. wAccel 0.2 mph/s. wMR 0.05. wSR 4. wDecel 1 mph/s. Draft 3.7'.

Jeep (TL6)

This is a 4-wheel drive vehicle of the sort used by the U.S Army and others from WWII to the late '70s, and still in use in many areas today. By deleting payload, an open mount and weapon can easily fit in the cargo area without affecting performance.

Subassemblies: Off-road wheels (4 wheels).

Propulsion: TL6 40 kW wheeled all-wheel-drive drivetrain (HT 15).

Controls: Mechanical. *Crew stations:* "Driver" runs controls from normal exposed crew station (Bo).

Occupancy: Short. *Passengers:* Three. *Crew:* Driver. *Accommodations:* Normal exposed seat. Two cramped exposed seats.

Power Systems: TL6 40 kW standard gasoline engine (HP 19, uses 1.8 gph gasoline). Powers drivetrain. *Energy Bank:* TL6 2,000 kWs Lead-acid battery (HP 3). Auxiliary power for lights, radios, etc.

Fuel: 10 gal. fuel tank (HP 8, fire +1). 10 gal. gasoline (fire 12). 5.5 hours fuel.

Access, Cargo and Empty Space: 9 cf access, 20 cf cargo, 0.25 cf empty.

Volume: Body 90 cf, wheels 18 cf. *Surface Areas:* Body 125, wheels 50, total 175.

Structure: Light frame, cheap materials.

Hit Points: Bo 94, Wh 19 each.

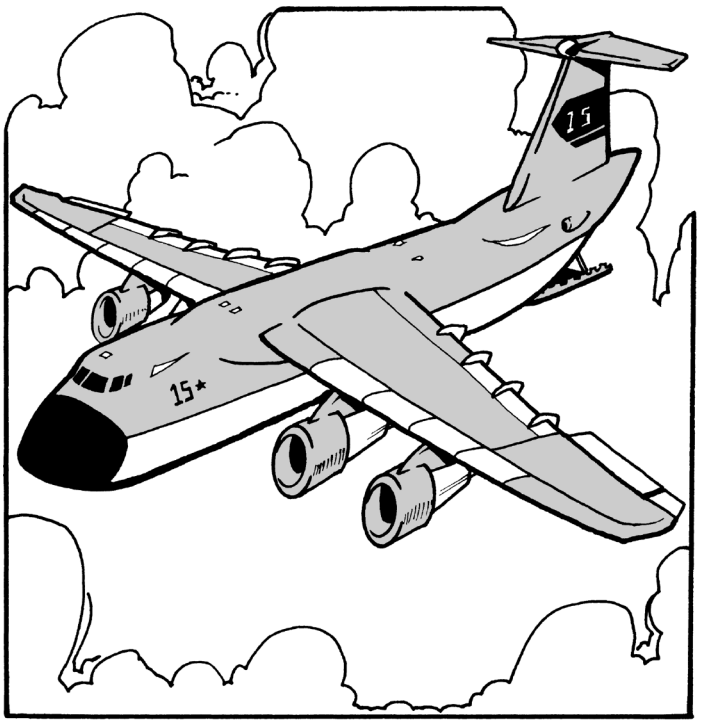
Armor: Bo and Wh: PD 3, DR 5 std. metal. Does not protect exposed seats!

Other: Hitch. *Details:* Headlights, no doors.

Statistics: Empty weight 2,199 lbs. Usual payload 800 lbs. Loaded weight 2,999 lbs. (1.5 tons). Volume 108 cf. Size modifier +3. Price $3,921.90. HT 11.

Ground Performance: Speed 80 mph. gAccel 4 mph/s. gDecel 10 mph/s. gMR 0.75. gSR 4. Moderate GP. 1/3 off-road speed.





Transport Aircraft (TL6)

This is a medium twin-engine cargo and passenger propeller airplane of a type used from the 1930s to the present.

Subassemblies: Retractable wheels (three wheels, retract into body and wings). Two STOL wings. Two pods (#1 and #2, on WiR and WiL).

Body Features: Fair streamlining.

Propulsion: Two late TL6 895 kW aerial propellers (Po1, Po2, 895 kW each) with total 5,370 lbs. motive thrust.

Instruments and Electronics: TL6 communicator, long range (100 mi., HP 10). TL6 navigation instruments (HP 4). Autopilot (HP 2).

Controls: Mechanical. Duplicate maneuver controls. *Crew stations:* "Pilot" runs controls, communicator, autopilot from roomy crew station. "Co-Pilot" runs duplicate controls from roomy crew station. "Navigator" runs navigation instruments from roomy crew station.

Occupancy: Short. *Passengers:* 14. *Crew:* Pilot, co-pilot, navigator. *Accommodations:* 14 roomy seats for passengers.

Power System: Two 895 kW TL6 HP gasoline engines (Po1, Po2, use 44.75 gph AvGas each, HP 100 each) power airscrews. TL6 3,600 kWs lead-acid battery (HP 4) powers communicator, lights.

Fuel: TL6 300 gal. light fuel tank (fire +2, HP 100). Two TL6 light 150 gal. fuel tanks (WiR, WiL, each HP 50, fire +2). 600 gallons aviation gas (fire 15) for 6.7 hours fuel.

Access, Cargo and Empty Space: 320 cf cargo space. 478.32 cf empty space. Extra 106.65 cf empty space (per wing).

Volume: Po1 and Po2 (each 54 cf). Bo (1,722 cf). Wings (172.2 cf each), wheels (86.1 cf). *Areas:* Body 1,000, wheels 125, wings 400 each, pods 100 each. Total area 2,125 sf.

Structure: Light frame, expensive materials.

Hit Points: Pods 75 each, body 750, wheels 63 each, wings 300 each.

Armor: Overall: PD 3, DR 5 exp. metal.

Vision: Fair.

Statistics: Empty weight 19,234.5 lbs. Usual payload 6,600 lbs. (cargo lightly loaded at 10 lbs. per cf). Loaded weight 29,734.5 lbs. (14.9 tons). Volume 2,266.4 cf. Size modifier +5. Price $339,380. HT 10.

Ground Performance: Top Speed 160 mph. gAccel 10 mph/s. gDecel 10 mph/s. gMR 0.25. gSR 3. Very high GP. No off-road speed.

Air Performance: Stall speed 45 mph, can fly. Aerial motive thrust 5,370 lbs. Aerodynamic drag 1,000. Speed 200 mph, aAccel 4 mph/s, takeoff run 51 yards, landing run 51 yards, aMR 3.5, aSR 3, aDecel 14 mph/s.

Family Car (TL7)

A mid-sized contemporary automobile.

Subassemblies: Standard wheels (4 wheels).

Propulsion: TL7 95 kW wheeled drivetrain (HP 14, 95 kW).

Instruments and Electronics: Communicator, medium rng. (30 mi), receive only (HP 1).

Controls: Mechanical. *Crew station:* "Driver" runs controls, communicator from roomy crew station.

Occupancy: Short. *Passengers:* Four. *Crew:* Driver. *Accommodations:* One roomy seat, three cramped seats. *Environmental Systems:* Environmental control, five people (HP 4, 1.25 kW). *Safety Systems:* Driver side airbag (HP 6).

Power Systems: 95 kW standard gasoline engine (HP 30, uses 3.8 gph gasoline). Powers drivetrain. Lead-acid battery, stores 2,000 kWs (HP 3). Powers lights, radios, environmental control, etc.

Fuel: Standard 15 gallon tank (HP 10, fire +0). 15 gallons gasoline (fire 11). 3.95 hours fuel for engine.

Access, Cargo and Empty Space: 13.45 cf access space, 20 cf cargo space (HP 40). 4.142 cf empty space.

Volumes: Body 195 cf, wheels 19.5 cf. *Surface Area:* Body 250, wheels 50, total 300.

Structure: Light, cheap materials.

Hit Points: Body 188, wheels 19 each.

Armor: Overall: PD 3, DR 5 chp. metal.

Details: Headlights, many windows, four doors.

Statistics: Empty weight 3,152.9 lbs. Usual payload 1,400 lbs. Loaded weight 4,642.9 lbs. (2.32 tons). Volume 214.5 cf. Size modifier +3. Price $9,990. HT 12.

Ground Performance: Top Speed 100 mph. gAccel 5 mph/s. gDecel 10 mph/s. gMR 0.75. gSR 4. High GP. 1/6 off-road speed.

Motorboat (TL7)

This is a lightweight motorboat with a gasoline engine, capable of carrying four people and a small quantity of cargo.

Subassemblies and Body Features: Flotation and hydrodynamic hull with average lines. Flotation rating 5,616 lbs.

Propulsion: Light screw propeller with 40 kW motive power (HP 7, 40 kW, motive thrust 480 lbs.).

Instruments and Electronics: Communicator with medium range (30 mi, HP 3).

Controls: Mechanical. *Crew stations:* "Helm" runs control, communicator from normal exposed crew station.

Occupancy: Short. *Passengers:* Three. *Crew:* Helmsman. *Accommodations:* Three normal exposed seats.

Power Plant: 40 kW standard gasoline engine (HP 17, uses 1.6 gph gasoline). Powers all systems.

Fuel: Standard 10 gallon tank (HP 8, fire +0). 10 gallons gasoline (fire 11). Provides 6.25 hours fuel for engine.

Access, Cargo and Empty Space: 5.7 cf access space, 10 cf cargo space. 7.06 cf empty space.

Volume: Body (108 cf). *Surface Area:* Body 150. Total area 150.

Structure: Light frame, cheap materials.

Hit Points: Body 113.

Armor: Overall: PD 3, DR 5 std. composite.

Surface Features: Waterproof. *Vision:* Good.

Details: Windscreen, no doors.

Statistics: Empty weight 1,392 lbs. Usual payload 1,000 lbs. Loaded weight 2,452 lbs. (1.225 tons). Volume 108 cf. Size modifier +3. Price $6,250. HT 12.

Water Performance: Can float. Hydrodynamic drag 18. Aquatic motive thrust 480 lbs. Top speed 18 mph. wAccel 4 mph/s. wMR 0.25. wSR 3. wDecel 2 mph/s [4 mph/s]. Draft 1.1'.

Motorcycle (TL7)

This is a large motorcycle, fast and reasonably powerful. The performance assumes it carries only one person.

Subassemblies: Standard wheels (2 wheels).

Propulsion: 30 kW wheeled drivetrain (HP 8, 30 kW).

Controls: Mechanical. *Crew stations:* Cycle crew station runs controls.

Occupancy: Short. *Passengers:* One. *Crew:* Driver. *Accommodations:* Cycle seat.

Power Plant: TL7 30 kW standard gasoline engine (HP 14, uses 1.2 gph gasoline). TL7 lead-acid battery, stores 1,000 kWs (HP 2) for lights, etc.

Fuel: Standard 5 gallon tank (HP 5, fire +0). 5 gallons gasoline (fire 11). 4.17 hours engine fuel.

Access, Cargo and Empty Space: 7.5 cf empty space.

Volume: Body 13.35 cf, wheels 1.335 cf. *Surface Area:* Body 40, wheels 8, total 48.

Structure: Cheap. *Armor:* None.

Hit Points: Body 60, wheels 12 each.

Statistics: Empty weight 722 lbs. Usual payload 400 lbs. Loaded weight 1,152 lbs. (0.58 tons). Volume 14.685 cf. Size modifier +1. Price $2,975. HT 12.

Ground Performance: Speed 115 mph. gAccel 5 mph/s. gDecel 10 mph/s. gMR 1.5. gSR 2. High GP. 1/6 off-road speed.

Main Battle Tank (TL7)

This is a modern, Western-design main battle tank like the German Leopard II or the U.S. Army's M1 Abrams.

Subassemblies: Tracks, turret (full rotation, on body), two open mounts (#1 and #2, limited rotation, on turret).

Body Features: Slope on body: front 60 degrees. Slope on turret: front 60 degrees, right 30 degrees, left 30 degrees.

Propulsion: Tracked drivetrain with 1,100 kW motive power (HP 125, 1,100 kW).

Weaponry: TL7 120mm tank gun (TuF, HP 125). 7.62mm GMPG (TuF, HP 3). 12.7mm HMG (Om1F, HP 8). 7.62mm GMPG (Om2F, HP 3). 40 × 120mm shots (Tu, HP 50). 1,000 × solid 12.7mm HMG shots (Tu, HP 10). 12,000 × 7.62mm shots (Tu, HP 17).

Weapon Accessories: Tank gun and turreted 7.62mm GMPG are linked. Anti-blast magazine for 120mm shots (Tu). Full stabilization for tank gun (Tu, HPs 27), 7.62mm GMPG (Tu, HP 1).

Instruments and Electronics: Two communicators, medium range (30 mi, Tu, HP 1 each) with scramblers. Light amplification (HP 1). Thermograph with 2 mi. range, scan 13 (Tu, HP 3). Military GPS (HP 2). Laser rangefinder, 5 mi. range (Tu, HP 3). Minicomputer, hardened, dedicated to Targeting program (Tu, HP 7, comp. 2, +2 Gunner skill).

Miscellaneous: Fire suppression system (HP 16).

Controls: Mechanical. *Crew stations:* "Driver" runs controls, light amp., one communicator from normal crew station. "Commander" runs GPS, thermograph, other communicator, 12.7mm HMG from normal crew station (Tu). "Gunner" runs 120mm gun, turret 7.62mm GMPG, computer, laser rangefinder from normal crew station (Tu). "Loader" runs 7.62mm GMPG in open mount from normal crew station (Tu).

Occupancy: Short. *Passengers:* None. *Crew:* Driver, Gunner, Loader, Commander. Loader loads 120mm gun when not firing GMPG. *Environmental Systems:* NBC Kit for four people (Tu, HP 10, 1 kW).

Power: 1,118 kW ruggedized standard gas turbine (HP 200, uses 67.08 gph diesel fuel). Powers all systems.

Fuel: Self-sealing 500 gallon tank (HP 125, fire -1). 500 gallons diesel fuel (fire 8). 7.45 hours fuel for power plant.

Access, Cargo and Empty Space: 157.88 cf access space. 27 cf cargo space (Bo). 20 cf cargo space (Tu). Empty space (Bo 68.12 cf; Tu 15.328 cf).

Volumes: Om1 (1.606 cf). Om 2 (0.352 cf). Tu (400 cf). Body (750 cf). Tr (450 cf). *Surface Area:* Om1 9, Om2 3, Tu 400, Bo 500, Tr 400. Total area 1,312. Structural area 1,300.

Structure: Extra-heavy.

Hit Points: Om1 18, Om2 6, Tu 2,400, Tr 1,200 each, Bo 3,000.

Structural Options: Heavy compartmentalization for body and turret. Improved suspension.

Body Armor: F PD 6, DR 1,680 exp. laminate. R,L,B: PD 4, DR 140 std. laminate. T, U: PD 4, DR 90 std. metal.

Turret Armor: F: PD 6, DR 1,500 exp. laminate. R,L: PD 5, DR 200 std. laminate. B: PD 4, DR 200 std. laminate. T: PD 4, DR 120 std. metal.

Tracks Armor: PD 4, DR 30 std. metal; tread skirts with extra DR 70 std. metal. Combined armor is PD 4, DR 100 if tread skirts successfully protect, PD 4, DR 30 if they do not.

Defensive Surface Features: Sealed.

Vision: Poor. *Details:* Headlights, no windows, hatches instead of doors.

Statistics: Empty weight 118,215.9 lbs. Usual payload 1,740 lbs. Loaded weight 125,885.9 lbs. (62.94 tons). Volume 1,601.96 cf. Size modifier +5. Price $2,125,543.30. HT 10.

Ground Performance: Speed 55 mph. gAccel 3 mph./s gDecel 20 mph/s. gMR 0.5. gSR 7. Low GP. 2/3 off-road speed.

Utility Helicopter (TL7)

A general-purpose transport helicopter. This kind will still be used in TL8 by civilian and military groups that can't afford newer hardware.

Subassemblies: Skids (two), TTR rotor.

Propulsion: 1,050 kW TTR helicopter drivetrain with 1,680 lbs. thrust, 10,500 lbs. lift (HP 30, 1,050 kW).

Instruments and Electronics: Communicator with long (300-mile) range (HP 4, 0.04 kW).

Controls: Mechanical. *Crew stations:* "Pilot" runs controls, communicator from normal crew station.

Occupancy: Short. *Passengers:* 13. *Crew:* Pilot. *Accommodations:* One normal seat. 12 cramped seats *Safety Systems:* Seat belts.

Power Plant: TL7 1,050 kW HP gas turbine (HP 50, uses 73.5 gph jet fuel). Powers drivetrain. TL7 3,600 kWs advanced battery (HP 2). Powers communicator.

Fuel: Light 220 gallon tank (HP 75, fire +1). 220 gallons jet fuel (fire 14). Three hours fuel for gas turbine.

Access, Cargo and Empty Space: 32.3 cf access space. 30 cf cargo space. 1.82 cf empty space.

Volumes: Bo (430 cf). Ro (8.6 cf). Skd (21.5 cf). *Areas:* Bo 400, Ro 81, Skd 50. Total area 531.

Structure: Light frame, standard materials.

Hit Points: Body 300, rotary wing 122, skids 38.

Structural Options: Folding rotors.

Armor: Overall PD 3, DR 5 std. metal.

Vision: Fair.

Statistics: Empty Weight 4,995.65 lbs. Usual payload 3,400 lbs. Loaded weight 9,825.65 lbs. (4.91 tons). Volume 460.1 cf. Size modifier +4. Price $207,688.75. HT 11.

Air Performance: Stall speed 0, can fly. Aerial motive thrust 1,680 lbs. Aerodynamic drag 531. Speed 155 mph. aAccel 2.5 mph/s. aMR 4, aSR 2, aDecel 16 mph/s.



V/STOL Fighter-Bomber (TL7)

This is a modern fighter-bomber much like the AV-8B Harrier II. It uses vectored thrust for vertical take off and landing capability. When fully loaded, it cannot take off vertically, but after dropping its hardpoint load, it can do so.

Subassemblies: Small wheels (three wheels, retract into body); two standard wings. *Body Features:* Very good streamlining.

Propulsion and Aerostatic Lift: Turbofan with 21,500 lbs. thrust and vectored thrust (135 cf, HP 175, uses 645 gph jet fuel).

Weaponry: TL7 25mm Gatling (BoF, HP 40, 6.4 kW). 300 × 25mm SAPHE (HP 15).

Instruments and Electronics: Communicator with long range (300 mi, HP 4, neg. power) and scrambler. IFF (HP 3). Digital vehicle camera (HP 2). HUDWAC (HP 3). Advanced bombsight (HP 3). Laser spot tracker (HP 4). Small computer, hardened, dedicated to Targeting program, complexity 1 (HP 1) with +2 skill program. Advanced radar detector (HP 4).

Miscellaneous Equipment: Refuelling probe (HP 18). Compact fire suppression system (HP 6).

Controls: Electronic. *Crew stations:* "Pilot" runs all systems from normal crew station.

Occupancy: Short. *Crew:* Pilot. *Environmental Systems:* 0.5 man-days limited lifesystem for one person (HP 10, 0.5 kW). *Safety Systems:* Ejection seat (HP 18).

Power: Turbofan delivers 215 kW, powers Gatling gun, electronics.

Fuel: Two 200 gallon ultralight self-sealing tanks (WiR, WiL, each HP 60, fire +1), 700 gal. ultralight self-sealing tank (HP 150, fire +1). 1,100 gallons jet fuel (fire 14). 1.7 hours fuel for engine.

Access, Cargo and Empty Space: 135 cf access space. Empty space (Bo 10.74 cf, WiR 14 cf, WiL 14 cf).

Volumes: Body (460 cf increased by streamlining and retractable wheels to 618.125 cf). Wings (44 cf). Wheels (30.9 cf). *Areas:* Body 500. Each wing 112.5. Wheels 60. Total area 810.

Structure: Heavy, very expensive.

Hit Points: Body 1,500, each wing 338, each wheel 120.

Armor: PD 3, DR 7 advanced metal (Bo, Wi, Wh)

Surface Features: Sealed.

Hardpoints: One body rated 1,000 lbs. two wing rated 2,000 lbs. each, two wing rated 1,000 lbs. each, two wing tip rated 200 lbs. each. Total hardpoint load 7,400 lbs.

Vision: Good.

Statistics: Empty Weight 13,270.5 lbs. Usual (internal) payload 200 lbs. Ammo and fuel: 7,390 lbs. Loaded weight 20,660.5 lbs. (10.33 tons), or 28,060.5 lbs. (14.03 tons) with hardpoints loaded. Volume 737.025 cf. Size modifier +4. Price $8,697,540. HT 12.

Ground Performance, Hardpoints Loaded: Top speed 345 mph. gAccel 20 mph/s. gDecel 10 mph/s. gMR 0.25. gSR 3. Extremely high GP. No off-road speed. (With hardpoints unloaded, it simply takes off!)

Air Performance, Hardpoints Unloaded: Static lift 21,500 lbs. Stall speed 0, can fly. Aerial motive thrust 21,500 lbs. Aerodynamic drag 145. Top speed 740 mph. aAccel 20 mph/s. aMR 7, aSR 4, aDecel 36 mph/s.

Air Performance, Hardpoints Loaded: Stall speed 50 mph, can fly. Aerial motive thrust 21,500 lbs. Aerodynamic drag 180. Top speed 740 mph. aAccel 15 mph/s. Takeoff run 31 yards, aMR 5, aSR 4, aDecel 20 mph/s, landing run 63 yards.

Scout Ship (TL10)

This is a small, fast starship suitable for a small group of survey scouts, patrol officers, or pirates. It is a highly-streamlined wingless lifting body equipped with vectored thrust and is lightly loaded to take off or land vertically. Its one turret is retractable and pops out from under the body. Larger starships will normally have anti-gravity systems, but the scout can thrust continuously at 1 g, providing its own gravity.

Subassemblies and Body Features: One pop turret (full rotation, under body). Retractable skids (3). Excellent streamlining. Lifting body.

Propulsion: Two TL10 100,000 lb. thrust super reactionless thrusters with vectored thrust (each HP 500, 50,000 kW). One 250-ton hypershunt hyperdrive (HP 150, 2,500 kW routine travel, 90,000,000 kWs to enter hyperspace).

Weaponry: One space combat laser (TuF, HP 125, Pow. 93,312 kW).

Weapon Accessories: Full stabilization for laser (Tu, HP 24). Universal mount for laser (Tu, HP 75).

Instruments and Electronics: Two communicators with long range (50,000 mi, HP 2, neg. kW) and two scramblers. Laser communicator with very long range (1,000,000 mi, Tu, HP 18, 1 kW). Radar with 4,000 mile range (Tu, HP 75, 1,000 kW, scan 32). PESA, 250 mi range, scan 25 (HP 18). Inertial Navigation System (HP 3, neg. power). IFF (HP 2). Two microframes each complexity 6 (HP 10 each, 0.2 kW). Two terminals (HP 4 each). 2 HUDWACs with pupil scanners. Med-res planetary survey array (HP 11, 0.5 kW).

Miscellaneous: Automed (HP 125, 0.1 kW). One 1-man airlock (HP 100). Full fire-suppression system (HP 16). Cargo ramp.

Controls: Computerized. *Crew stations:* Roomy. "Pilot" controls #1 computer terminal and controls from roomy crew station. "Systems Operator" controls #2 computer terminal from roomy crew station. Two G-seats, eight crashwebs.

Occupancy: Long. *Passengers:* 6. *Crew:* Pilot, co-pilot (doubles as mechanic). *Accommodations:* Four shared cabins (HP 600 each). *Environmental Systems:* TL10 full lifesystem for eight people (HP 100, 80 kW). 480 man-days provisions (HP 50).

Power Plant: TL10 fusion reactor with 200,000 kW output (HP 600, lasts 200 yrs.). Powers all systems except hyperdrive jump with 5,60x.2 kW excess for upgrades or to power hyperdrive.

Energy Bank: Rechargeable power cell stores 90,000,000 kWs (HP 100), powers hyperdrive good for one hyperspace entry. By shutting down weapons and drive, the power plant can recharge enough to make a single hyperdrive entry in just over 4.5 hours.

Access, Cargo and Empty Space: 4,280 cf access space, 270 cf cargo space (Bo, 270 cf). Empty space (Tu, 10.2 cf). Empty space (Bo 355.5 cf).

Volume: Pop Turret (180 cf). Body (13,608 cf). Retractable Skids (680.4 cf). *Surface Area:* Turret 200, body 4,000, skids 400. Total area 4,700 sf.

Structure: Light frame, very expensive materials.

Hit Points: Body 3,000, skids 250, turret 150.

Armor: PD 4, DR 100 exp. composite on body and on turret front, back, right, left, and top. PD 4, DR 10 exp. composite on skids.

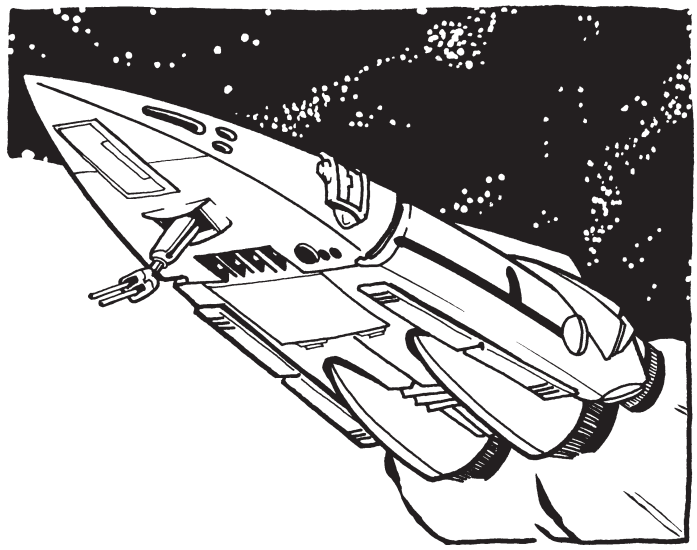
Surface Features: Sealed. Basic stealth.

Vision: Poor. *Details:* No windows, only outside doors are airlocks.

Statistics: Empty Weight 164,715 lbs. Usual payload 7,000 lbs. Loaded weight (with provisions) 172,675 lbs. (86.34 tons). Volume 14,468.4 cf. Size modifier +7. Price $14,531,580. HT 8.

Aerial Performance: Aerostatic lift 200,000 lbs., stall speed 0, can hover, motive thrust 200,000 lbs., aerodynamic drag 200, top air speed 2,740 mph, aAccel 26 mph/s, aMR 2, aSR 5, aDecel 9 mph/s.

Space Performance: sAccel 1.158 g, sDecel 1.158 g, sMR 1.158 g, FTL speed 0.2 parsecs per day.



VEHICLE ACTION 12

Thoth-Ra snarled in triumph. The American woman's insane flying car had shot down his wingman's Harrier. But now his own jet was coming from behind her, 12 o'clock high, and she was skimming low over the lake with no room to maneuver. Another second, and she'd be in his gun sights. Victory for the Elder Dark!

Morgan glanced at her rear-view mirror, frowned, and shoved her control stick forward –

"Die!" shrieked Thoth, thumbing his Gatling cannon's trigger.

– and Kitty Hawk slid into the lake and vanished!

"Heh," Morgan grinned. "Bet ***you*** *can't swim."*

This chapter covers vehicle movement. It contains rules for routine travel, plus two tactical movement systems: a basic system designed to use abstract movement, and an advanced system for detailed hex-grid movement. The detailed rules should only be used for short, intense encounters: chases, combat, races, or any time the GM decides dangerous maneuvers are needed to avoid accidents.

These rules sometimes refer to "control" rolls. This means a roll against whatever skill is used to steer and maneuver the vehicle, e.g., Driving or Pilot. These skills are summarized in the sidebar.

Routine Travel

Traveling from point A to point B uses the rules on pp. B187-188.

Long trips in vehicles not designed for long-term occupancy (i.e., lacking quarters, etc.) result in fatigue: 1 point of Fatigue per four hours if just serving as crew or passengers, double that if actually steering a vehicle, and four times that under any of the following circumstances: driving off-road, piloting an aircraft at low altitude (below 500 feet) without terrain-following radar, steering a watercraft or airship through bad weather.

Double fatigue if any of these conditions apply: characters have no seats, cramped seats or spaces, exposed spaces or seats in bad weather. Halve fatigue for roomy seats or spaces.

On the ground, GMs may require one vehicle operation skill roll per eight hours of travel on normal roads, per four hours of travel off-road or on bad or slippery roads or at night, or per two hours of travel in terrible weather conditions like blizzards or fog.

In the air, a roll is required on landing or takeoff, or per hour of travel at very low altitudes (under 500 feet) or per 10 minutes of flight below 100 feet in areas with tall buildings or power or telephone lines. Roll twice as often in bad weather. A roll should also be made when performing routine but somewhat dangerous maneuvers like acrobatics or mid-air refuelling.

On the water, a roll is required for each docking or undocking, when passing through narrow passages or rapids, when maneuvering near other vessels, per day during bad weather or iceberg-infested waters, or per hour during severe storms.

GMs may wish to apply modifiers for very dangerous situations. However, only a critical failure results in any danger unless the operator's Fatigue is 3 or less – than any failure may result in danger. If a potential danger occurs, then the GM should come up with a problem: ground vehicles may suffer collisions, get stuck, suffer flat tires, etc.; watercraft may run aground or strike other vessels, rocks or icebergs; low-flying aircraft may hit the ground, collide with power lines, strike birds, and so on. Any vehicle could have a malfunction of some sort.

Once the danger has been determined, allow a second vehicle operation roll to avoid it. A failed roll will usually only result in minor damage, but a critical failure brings a disaster. The effects will depend on the GM's whim, but may include a roll on the *Loss of Control* table, fire, or collision with a terrain feature, vehicle, building or pedestrian.

Basic Vehicle Movement

This is a simple system which is used with the Basic Combat system. Don't bother setting up a hex map and rolling for success each turn whenever the characters are out driving around the city! In particular, GMs should feel free to ignore many of these rules in the interest of speeding up play.

At the start of a vehicle combat, the GM simply decides what the range separating involved vehicles is. A driver can have his vehicle open or close the range by a distance (in yards) equal to half his top speed. Maneuvering is entirely abstract.

Vehicle Operation Skills

The skills used for steering vehicles are: Bicycling, Boating, Driving, Motorcycle, Piloting, Powerboat, Shiphandling and Teamster. Operation of an unfamiliar vehicle of a known type incurs a -2 *familiarity* penalty – see p. B43.

Bicycling **see p. B68**

This is required for any muscle-engined, wheeled vehicle light enough to be carried by its operator.

Boating **see p. B68**

This skill is used to control a floating vehicle no larger than 2,700 cf that is using oars, paddles or sails for propulsion, such as a canoe, rowboat or small sailboat. It defaults to Powerboat-3.

Driving **see pp. B68-69**

Driving skill is used when a vehicle (except a two-wheeler) is moving on the ground powered by anything except a muscle engine. Some specializations are listed below. For exotic vehicles, the GM may wish to come up with new specializations.

Driving (Automobile) is required for vehicles moving on three or more wheels, whose weight does not exceed 10,000 lbs. and which do not have railway wheels. It defaults to Heavy Wheeled at -2, to other Driving skills at -4.

Driving (Construction Equipment) is required for operating vehicles that weigh 4,000 lbs. or more while using construction equipment such as bulldozers, plows, cranes or the like. This includes farm tractors. It defaults to other Driving skills at -5.

Driving (Halftrack) is required for operating vehicles using halftrack or skitrack motive systems. It defaults to Tracked Vehicle at -2 or other Driving skills at -4.

Driving (Heavy Wheeled) is required for operating vehicles moving on three or more wheels, with a loaded weight of 10,000 lbs. or more, which do not use railway wheels. It defaults to Automobile at -2 and to other Driving skills at -4.

Driving (Hovercraft) is required for any vehicle operating as a hovercraft. It defaults to other Driving skills at -5.

Driving (Locomotive) is required for any vehicle using railway wheels or mag-lev. It defaults to other Driving skills at -5.

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Vehicle Operation Skills (Continued)

Driving (Mecha) is required for a vehicle using legs or a flexibody that isn't a battlesuit. It defaults to Exoskeleton or Battlesuit at -3 and to other Driving skills at -5.

Driving (Tracked) is required for vehicles moving on tracks. It defaults to Halftrack at -2 or other Driving skills at -4.

Motorcycle see p. B69

This skill is required for powered one- or two-wheeled vehicles or for two-wheelers with sidecars.

Piloting see p. B69

Piloting is used when the vehicle is flying. Its numerous specializations include:

Piloting (Aerospace): Use this for flying vehicles with a top air speed of 3,000 mph or more, as well as any vehicle making a winged flight to orbit or winged reentry. Defaults to High-Performance Airplane at -2, other Piloting at -4.

Piloting (Autogyro): Use this skill with wingless vehicles equipped with rotors but not helicopter drivetrains. It defaults to any helicopter at -3, any airplane at -4, others at -5.

Piloting (Contragravity): Use this skill for all vehicles flying primarily via contragravity lift or levitation. Defaults to Vertol at -3, others at -5.

Piloting (Flight Pack): Use this skill for aircraft with no stall speed and a single "external space" occupant. Defaults to Vertol at -4, others at -5.

Piloting (Glider): Use this skill for all unpowered vehicles flying with wings. Defaults to Light Airplane or Ultralight at -2, other Piloting at -4.

Piloting (Heavy Airplane): Use this for flying winged vehicles weighing over 20,000 lbs. with a top air speed no greater than 600 mph. Defaults to Light Airplane at -2, other Piloting at -4.

Piloting (Helicopter): Use this skill for all vehicles flying via helicopter drivetrains. Defaults to Autogyro at -2, Vertol at -4, other Piloting at -5.

Piloting (High-Performance Airplane): Use this for flying winged craft with an air speed greater than 600 mph. Defaults to Light or Heavy airplane at -2, other Piloting at -4.

Piloting (High-Performance Spacecraft): Use this skill for vehicles with at least 0.1 G sAccel that are maneuvering in space. It defaults to Low-Performance Spacecraft at -2, Aerospace at -4.

Piloting (Light Airplane): Use this for flying winged craft weighing less than 20,000 lbs. with top air speed that is no greater than 600 mph. Defaults to Glider, Ultralight, High-Performance or Heavy Airplane at -2, other Piloting at -4.

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Disabled Vehicles

A vehicle that is moving when it is disabled will crash unless the driver makes a control roll at -10 + the vehicle's SR.

On a failure, crash damage is 1d per 10 mph the vehicle was moving *per ton of vehicle mass (or fraction thereof).* Crash damage to the occupants is identical but is *not* multiplied by vehicle mass.

A vehicle disabled in the water will begin to sink and must be abandoned. A disabled aircraft can no longer fly, and will begin to crash. Make a roll against (Piloting-10) + aircraft's SR to guide it to a safe landing. Failure means crash damage, as above.

On a critical failure, the vehicle takes double damage from the crash (an air vehicle high in the air will be destroyed, and everyone killed).

Ramming and Collisions

A ram attempt is an attempt to crash into another vehicle (or pedestrian) to cause damage. The ramming vehicle must be fast enough to close with the other vehicle. Resolve a ram against an evading target as Quick Contest of vehicle operation skills (or DX, to run someone over). The winner chooses whether the target was hit, and if so, the type of collision (sideswipe, head-on, etc.) – then use the collision rules (p. 157) to calculate damage based on the type of collision and the GM's judgement of the net speed.

Advanced Vehicle Movement

This section describes rules for advanced movement on a hex grid or table top using counters or miniature figures. These rules are mainly designed for actions involving automobiles, tanks, helicopters, boats or other relatively slow vehicles that are occurring at reasonably close ranges. They are not applicable for space movement – see p. 164 instead. For high speed, long-range action between aircraft or spacecraft, we suggest using the abstracted *Dogfighting Combat* rules on p. 160 instead.

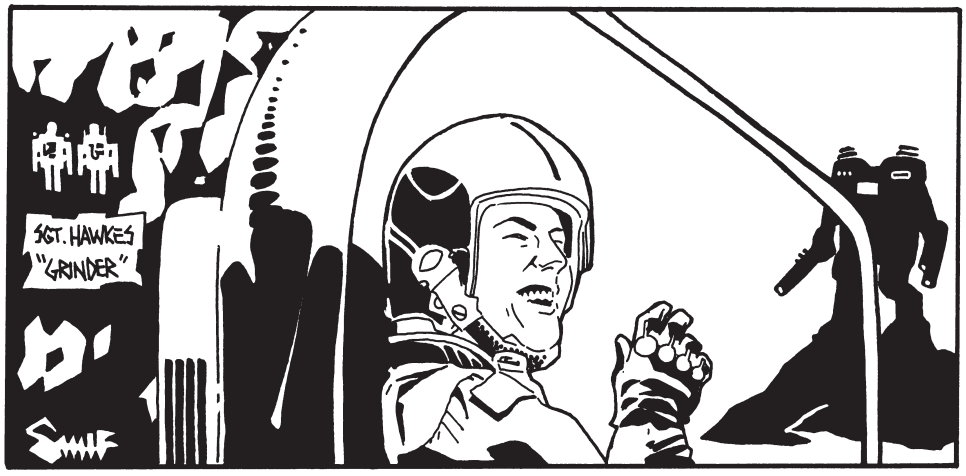
Tactical maneuvering is handled in much the same way as ***GURPS*** advanced combat, but with some very important differences. Obviously, if a vehicle is moving at 60 mph, it can race across a hex map with 1-yard hexes in less than a turn; therefore, we suggest a larger scale for vehicles: 5 yards to a hex if using a hex grid, 5 yards to an inch if not using such a grid. This has three advantages: first, the average person (Move 5) can still move 1 hex per turn. Second, it means that a vehicle moves 1 hex for every 10 mph – which is very convenient. Third, if you use a 1-inch hex, it happens to be the same scale as ***Car Wars.***

Vehicle Logs

If a vehicle is in combat, keep a vehicle log. Use a sheet of lined paper, and use one line for each turn. Each turn, record the vehicle's current speed, and for flying vehicles (or subs), keep track of altitude (or depth) as well. When a vehicle maneuvers, the log can also keep a record of its accumulated G-force (described under *Maneuvering,* p. 146).

Characters in Vehicles

A character operating a vehicle does not take normal maneuvers as such. He makes the appropriate "control" rolls (Driving, Powerboat, Piloting, etc.) as needed. If he is using a weapon, he attacks by making the appropriate weapon skill rolls (usually vs. Guns, Beam Weapons or Gunner skill). If he's fighting someone in the vehicle (wrestling for the wheel, etc.), it's resolved using normal combat rules.





A *control roll* is a roll against the vehicle operator's control skill: Driving, Boating, Piloting, and so on. It is made when trying to do something difficult with a vehicle. A successful roll allows the maneuver to be made or the hazard to be safely negotiated. Failure results in temporary loss of control of the vehicle. Control rolls are usually modified by the difficulty of whatever feat is being attempted, and by various control roll modifiers described in the sidebars.

Movement

Vehicles normally only move straight ahead in the direction they are facing, moving one five-yard hex per 10 mph of speed.

Their speed can be increased at the start of each turn by an amount no greater than the vehicle's acceleration rating (provided this does not increase speed above its top speed), kept steady, or decreased by an amount no greater than the vehicle's deceleration rating.

To change facing and thus the direction of forward movement, vehicles perform maneuvers. Maneuvers are rated for the G-force they require. If a maneuver requires no more Gs than the vehicle's MR, it is performed automatically. If it requires more Gs, then a *control roll* must be made against the vehicle controller's skill, modified by the G-force of the maneuver. Failing a control roll results in a loss of control, the severity depending on the degree of failure and how stable the vehicle is.

Aircraft and submarines move in three dimensions. If these vehicles are in use, keep a record of their altitude or depth, again in increments of 5 yards.

Vehicles and Facing

When using a hex grid, represent vehicles by multi-hex counters drawn at 1 inch to 15 feet or 5 yards. Vehicle counters are sometimes more than 1 hex in size. If using miniatures, cut cardboard bases of the appropriate size. Movement is controlled by the center-front hex of the vehicle, or if the vehicle is an even number of hexes wide, by the left or left center hex. Determine the distance moved as though this "controlling" hex were a 1-hex figure, and the rest of the vehicle follows. This is important for maneuvers! When turning the vehicle, it should pivot on this hex. Calculate drifts the same way: move the controlling hex left or right by that amount. Unlike characters, vehicles may face hex points as well as hex sides. Turning from a hex side to an adjacent hex point, or vice versa, is a 30° turn. Turning from hex side to adjacent hex side, or hex point to hex point, is a 60° turn. When a vehicle faces into a hex point, it will have two hexes immediately in front of it. Each time it moves forward 1 hex, a vehicle facing a hex point alternates moving into the left and right hexes.

Sequence of Action

When vehicles are being used, it is necessary to keep track of their current speed in mph. However, vehicles move on the normal turn of their *operator,* based on his Basic Speed. Vehicular weapons fire on the turn of their gunner (again, based on Speed), and other crew and passengers take their actions (such as firing personal weapons or activating equipment) on their respective turns. Consider software to have a Speed of (Complexity/4) + 4 for this purpose.

When it is a vehicle's turn to act, its driver decides on its acceleration or deceleration, and then moves it. Maneuvers may be made and weapons controlled by the driver may be fired at any time during movement.

Acceleration and Deceleration

Each player should keep track of the current speed in mph of any vehicle his character is operating. A vehicle's operator decides on whether to accelerate or decelerate at the start of his move, and applies the effects before moving. The options are to *maintain speed, accelerate* or *decelerate.*

Vehicle Operation Skills (Continued)

Piloting (Lightsail): Use this skill when piloting spacecraft propelled by a lightsail. Defaults to Low-Performance Spacecraft at -4.

Piloting (Lighter-than-Air): Use this if the vehicle is flying thanks mainly to the lift generated by lifting gas. It defaults to other Piloting skills at -5.

Piloting (Low-Performance Spacecraft): Use this skill for vehicles with less than 0.1 G sAccel maneuvering in space. Defaults to High-Performance Spacecraft at -2, Aerospace at -4.

Piloting (Ultralight): Use this skill for vehicles flying with wings that weigh less than 1,000 lbs. and with top speeds under 200 mph. Defaults to Glider or Light Airplane at -2, other airplanes at -4, non-airplanes at -5.

Piloting (Vertol): Use this skill for craft flying primarily due to lift engines, lift fans or vectored thrust, and which lack wings or rotors. Defaults to Contragravity-3, Helicopter-4, other Piloting-5.

Powerboat see p. B69

This skill is used to control a floating vehicle no larger than 2,700 cf using paddle wheels, hydrojets, screw propellers, airscrews, jet or rocket engines or reactionless thrusters for propulsion. Defaults to Boating-3.

Shiphandling/TL see p. CI161

This skill is used to operate a large floating vessel (over 2,700 cf) or any submersible. (The *Seamanship* skill, p. B57, is needed to *crew* such a vessel.) It has three specializations:

Shiphandling: Use this skill for surface watercraft propelled by sailing or by a combination of sails and oars.

Shiphandling (Steamer): Use this specialization for large watercraft propelled by powered propulsion systems.

Shiphandling (Submersible): This skill is used when operating any size of vehicle that is moving underwater.

Teamster see p. B47

This skill is required for driving any animal-drawn vehicle. With the exception of horses and mules, which use the same skill, each species of animal requires a different skill, defaulting to other species at -3.



Maintenance, Breakdowns and Repairs

Vehicles require regular maintenance to work properly. This may be as simple as scraping off rust or barnacles, or changing the oil, or as complex as dismantling the engine and running computerized stress tests on every part.

To find out how many hours a vehicle can safely operate between maintenance checkups, do the following:

Divide 20,000 by the square root of vehicle cost. The quotient is the *maintenance interval* in hours.

Example 1: Geronimo Flak's subcompact cost him $8,000. 20,000 divided by the square root of $8,000 is about 224 hours. So if Flak drives his car to and from work for 2 hours a day, it should get a checkup after about 4 months on the road.

Example 2: A jet fighter cost $15,000,000. It requires maintenance every 20,000/(square root of 15,000,000) = 5 hours, or about after each flight.

Vehicles built from living metal don't require maintenance.

Each maintenance checkup requires 4 hours and should be performed by someone with the appropriate Mechanic skill (see p. B54) at 9 or better and a tool kit or workshop. Vehicles that do not use mechanical parts (e.g., sailing ships, wagons) may require other skills.

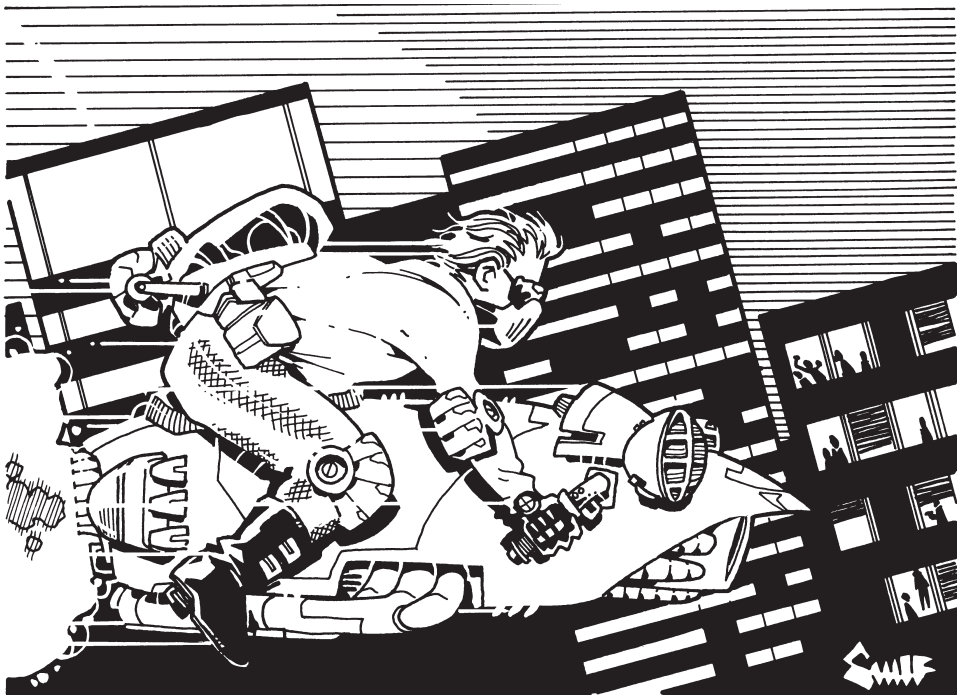
On vehicles that require frequent maintenance, the duties are often split between several people. On vehicles that operate continuously (like ships), this usually means that there is ongoing maintenance performed by the crew. Determine the man-hours of maintenance required per day using the formula 96/maintenance interval.

Example: A ship that requires a checkup every 5 hours actually needs 96/5 = 19.2 man-hours per day. This will usually be provided by two or three mechanics working shifts.

If a checkup is missed, roll against the Mechanic skill of the character who made the *last* checkup (use the average skill, if multiple mechanics were involved). Apply a -4 modifier per additional checkup missed after the first.

If that roll fails, then roll vs. the vehicle's Health. Failure means HT drops by 1, representing wear-and-tear. A critical failure has the same effect, and also means a serious breakdown. Pick something on the vehicle and have it break down. Often it will be the propulsion system or motive system (treat as a crippled wheel, track, or whatever). Breakdowns often occur during use, or when trying to start the engine. The GM decides when a breakdown occurs – this could be in the middle of an adventure. Note that even healthy ground vehicles can break down due to stress on their suspension and drive systems from routine travel. See *Ground Vehicle Breakdowns,* below.

If a vehicle has lost Health due to missing maintenance checkups, this loss is cumulative. Lost Health can be regained: treat regaining a point of Health as making a minor repair (see below).



Maintain Speed: The operator may elect to keep the vehicle at the same speed as it was going on the turn before.

Accelerate: The vehicle may increase its current speed by a number of mph up to its acceleration ("Accel") rating, provided that does not exceed its top speed.

Decelerate: Any vehicle can decelerate, reducing its current speed by its deceleration ("Decel") rating. The deceleration listed for all vehicles is the safe deceleration. It is possible to decelerate harder, but this requires a control roll. A vehicle on the ground may decelerate at up to four times its Decel rating. One in the air or water is limited to twice its Decel. See *Hazardous Deceleration* on p. 148 for the effects.

If the vehicle is flying it may also decide to climb or dive at this stage, which will also affect its current speed. See the rules for aerial movement on p. 155.

After acceleration and deceleration take place, record the current speed, and then move the vehicle.

Moving the Vehicle

A vehicle *must* move a number of 5-yard hexes equal to its mph/10 in the direction it is facing. Round fractions up to the nearest whole number.

Firing weapons and maneuvering take place during movement. If the vehicle interrupts its movement to maneuver or fire, make a note on its log how many hexes it has already moved, so that you will know how far it must continue to move after it has done so!

After moving a hex, a vehicle can maneuver. Unless a vehicle's speed is 10 mph or less, it may not make a new maneuver until it has moved at *at least* one 5-yard hex since its last maneuver.

Maneuvering

A deliberate change in vehicle direction is called a *maneuver.* These rules work with vehicles that have MR 0.25 or more. If the required G-force is much greater than MR, then the turning rules on p. B139 can be used instead. There are three main types of maneuvers: bends, drifts, and "stunts."

All maneuvers are rated for the Gs (gravities) the maneuver requires, in increments of one-quarter (0.25) G. Maneuvers at higher speeds or tighter angles generate greater G-force. If the G-force exceeds the vehicle's MR, the vehicle has made a hazardous maneuver: immediately after the maneuver is performed, a control roll is required! When a player character attempts a maneuver, the player should clearly tell the GM its type, angle and direction before the control roll is made.

The G required for a particular maneuver is found by consulting the *Maneuver G-Force Table* on p. 147.

If a vehicle makes multiple maneuvers in the same turn, G from one maneuver is added to the next maneuver's G. As G is cumulative, several small maneuvers can eventually be as hazardous as one big one. In situations where vehicles will do a lot of maneuvering, we suggest keeping a written record of a vehicle's accumulated G-force on the vehicle log. At the start of a new turn, accumulated Gs are reduced to zero again. Players of ***Car Wars*** may note that the way G accumulates is analogous to a car's "handling status," and MR to its Handling Class.

Here's what each maneuver involves:

Bend

This is a basic "turn" used to change the vehicle's facing and thus the direction it moves.

Bends have a direction (right or left) and an angle (up to 90°), e.g., "bend right 60°." One hex side to an adjacent hex side, or one hex point to an adjacent hex point is 60°; one hex side to an adjacent hex point, or vice versa, is 30°. When a vehicle makes a bend, pivot it in the direction of the bend.

A bend counts as one 5-yard hex of movement. When a bend occurs, move the vehicle 1 hex forward and then pivot it in the direction of the bend. This works using the facing rules described earlier: pivot around the center-front hex of the vehicle's *counter.* If using a hex grid, bends must be exactly 30°, 60° or 90°. Otherwise, bends can be any angle up to 90° – use a protractor to regulate them.

Drift

In a *drift,* the vehicle immediately moves 1 hex forward and then one 5-yard hex to either side *without* changing facing. The lateral part of the drift does not count as a hex of movement. Drifts are usually used to "change lanes" or avoid collisions.

A flying or submerged vehicle may drift up or down 5 yards instead of right or left.

Stunt

This covers any other kind of maneuver. Vehicles on the ground may perform a bootlegger reverse (p. 155) or T-stop (p. 156). Flying vehicles may perform rolls (p. 156).

Dodge

A Dodge isn't a maneuver. However, a vehicle can only Dodge if it performed at least one 15° or greater bend or two or more drifts on its most recent turn. (Note that a vehicle that is moving at 80 mph × MR or faster will be unable to make a Dodge without having to make a control roll.)

G-Force Table

The table below shows the G-force required for a bend or drift at different speeds. For example, at 40 mph, a 30° bend is 1 G. If the speed falls between two numbers, use the nearest, for instance, 1-4 mph is treated as 0 mph, while 5-9 mph is treated as 10 mph.

Maneuver G-Force Table

Speed	*Bend (Degrees)*						*Drift*
(mph)	*15*	*30*	*45*	*60*	*75*	*90*	
10	0	0.25	0.25	0.5	0.5	0.75	0
20	0.25	0.5	0.75	1	1.25	1.5	0
30	0.25	0.75	1	1.5	1.75	2.25	0
40	0.5	1	1.5	2	2.5	3	0.25
50	0.5	1.25	1.75	2.5	3	3.5	0.25
60	0.75	1.5	2.25	3	3.75	4.5	0.25
70	0.75	1.75	2.5	3.5	5	5.25	0.25
80	1	2	3	4	5	6	0.5
90	1	2.25	3.25	4.5	5.5	6.75	0.5
100	1.25	2.5	3.75	5	6.25	7.5	0.5
120	1.5	3	4.5	6	7.5	9	0.75
140	1.75	3.5	5.25	7	8.75	10.5	0.75
160	2	4	6	8	10	12	1
180	2.25	4.5	6.75	9	11.25	13.5	1
200	2.5	5	7.5	10	12.5	15	1.25
220	2.75	5.5	8.25	11	13.75	16.5	1.25
240	3	6	9	12	15	18	1.5

To find the G-force for drifts at higher speeds, multiply mph by 0.00625 and round to the nearest half or whole G.

For a bend, multiply by 0.0125 for 15°, 0.025 for 30°, 0.0375 for 45°, 0.05 for 60°, 0.0625 for 75° or 0.075 for 90° and round to the nearest whole G.

EXAMPLE

A limousine full of frothing Sons of the Outer Dark are trying to catch Captain Morgan, who is making a quick getaway in the Kitty Hawk. Morgan is going at 35 mph when she decides to make a 30° turn to get around a corner. This is a 30° bend maneuver. At 35 mph, we round up to 40 mph, so it counts as 1 G. Morgan's car has MR 1.5, so no control roll is needed. Morgan zips around a tight corner. However, if she makes any further maneuvers this turn, she will add the 1 G she has accumulated to her G rating. The thugs following her perform the same maneuver on their turn. They are going at 40 mph, which also requires 1 G. However, their car only has MR 0.75. After making the turn, but before continuing to move, their driver must make a control roll vs. his Driving (Automobile) skill. Failure means a loss of control.

Ground Vehicle Breakdowns

Early automotive vehicles (TL5 and pre-1930 TL6 vehicles) and heavy tracked vehicles like tanks are notorious for being less than mechanically-reliable. Even today, armored vehicles traveling long distances are likely to shed tracks or suffer damage to their suspensions. As such, armies prefer to ship tanks on wheeled transporters for long-distance travel. The same is probably true of vehicles with legs or flexibodies.

A *powered* ground vehicle that (a) doesn't use wheels, or (b) has HT less than 10, or (c) was built in the first half of TL6 must make a HT roll for every six hours of continuous travel.

Modifiers depend on how it is moving: +5 if on wheels, +3 if halftrack, skitrack or legs, +2 if on tracks or flexibody. If TL5: -6. If TL6 between circa 1900 and 1910, -4. If TL6 between circa 1910 and 1920, -2. If TL6 between circa 1920 and 1925, -1. If legs at TL7: -4. If legs or flexibody at TL8: -2.

If a roll fails, the vehicle's drivetrain or suspension system has been malfunctioned in some way: a blown tire, slipped track, etc. It will require 1d man-hours and a Mechanic roll to repair it.

If the roll is a critical failure, the malfunction is more serious – the vehicle's motive subassembly or drivetrain loses all its hit points and is effectively disabled until repaired. Also, the GM may rule that an accident of some sort takes place.

Repairing Damaged Vehicles

Repairing a damaged vehicle is normally a task for the Mechanic (vehicle type) skill.

If a body or subassembly has hit points remaining, fixing damage is usually a "minor repair." This requires a half-hour of work per attempt. Success restores one lost hit point times the amount the roll succeeded by (minium 1 hit). All normal modifiers for using the skill apply; see p. B54 for Mechanic skill modifiers. If a body or subassembly is down to 0 or fewer hits, fixing damage is a "major repair." The same amount of time is required and the same number of hit points are repaired, but all rolls are at an extra -2 modifier. The GM may require a set of spare parts (costing perhaps 10-60% of the vehicle's cost) to fix the damage.

If a vehicle part is damaged or crippled as a result of a hit to a particular hit location or a critical hit, this is a minor repair if it has hit points remaining or a major repair if it (or the hit location housing it) was reduced to 0 HP or knocked out as a result of a critical hit. Cost to repair will be 10-60% of the cost of the vehicle component. Success restores hit points as described above.

Hiring a Mechanic: If a character isn't capable of doing the work, he can hire someone to fix the damage. A typical mechanic's skill is 11 + 1d. At TL7+, mechanics charge about $20 per hour.



Crew Actions and Crew Stations

A vehicle crew member can only operate controls or other vehicle systems assigned to his crew station. A character can move to a new crew station (provided no one else is occupying it) but this takes at least two seconds. In a large vehicle – especially if the crew stations are in different locations – one option is to assume the average time in seconds is equal to the square of the Size Modifier of the vehicle.

A single crew station may have many different functions assigned to it: weapons, electronic systems, vehicle controls, and so on. A character can only fire one weapon or set of linked weapons at once, regardless of how many weapons the crew station controls. However, this can be combined with maneuvering the vehicle or operating electronics such as sensors, but performing any "multitask" function is more difficult: the GM may wish to impose a skill penalty if a character tries to do too many things at once.

Maintaining detection once an object has already been spotted, or leaving a communicator open to receive messages does not count: only tasks that actually require the character to do something. Simply looking in the direction one is driving or shooting doesn't count as a task, but attempting to spot hidden objects or keep an "all round" watch *does.* This is why vehicles sometimes have one person who does nothing but act as a lookout or observer – he's more likely to spot something than a person who is busy doing some other kind of task.

A suggested penalty is -4 on skill for any "secondary" tasks that the character isn't giving his full attention too – for instance, operating sensors or firing weapons while driving.

Continued on next page . . .

Control Rolls

As stated earlier, a control roll is required whenever a vehicle does something potentially dangerous.

Control Rolls for Maneuvers

A vehicle may be required to make a control roll because the G-force of a maneuver exceeded its MR, or because it performed a stunt, or both. Apply a skill modifier of -1 per 0.25 G the maneuver required in excess of MR. This G penalty *doubles* for vehicles with MR under 1 G, or quadruples if MR is under 0.5 G.

EXAMPLE

Junior Priest Thoth-Ra is driving the Sons of the Outer Dark's limo in hot pursuit of Captain Morgan. He has Driving (Automobile)-12. Their stock car has an MR of 0.75 G and Thoth has already made a 1 G maneuver – his 30° bend. G is now higher than MR, so a control roll is required. The penalty is -1 for exceeding MR by 0.25, doubled to -2 as Thoth's MR is less than 1 G. He has an effective skill of 10. Thoth-Ra rolls a 13 and fails, losing control. Morgan looks in the rear view mirror and grins: no slimy cultmobile can keep up with Kitty Hawk!

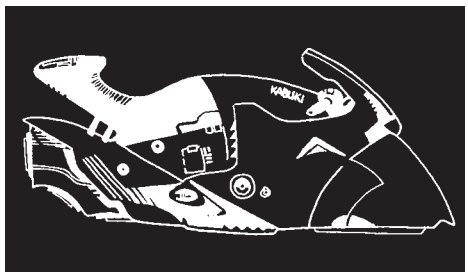
Hazard Control Rolls

A hazard is an outside event that forces a vehicle to make a control roll. Examples of a hazard are rapid deceleration, driving through debris, and taking crushing or explosion damage.

Most hazards require a control roll at some penalty to skill, though some have no penalty. There is always a penalty for speed if the vehicle is going over 10 mph: -1 per full (20 mph × appropriate MR) of vehicle speed. For instance, a vehicle on the ground with gMR 0.75 would be -1 on hazard rolls for every 15 mph of speed, while a fighter aircraft with aMR 8 would be at -1 per 160 mph of speed in the air. Encountering hazards can be very dangerous at high speeds! In addition, there is a modifier of -1 per 0.25 G the vehicle has accumulated in excess of its MR when it encountered the hazard. This G penalty is doubled for vehicles with MR under 1 G or quadrupled if MR is under 0.5 G.

Hazardous Deceleration: If a vehicle performs deceleration in excess of its *Decel* rating, it is a hazard. The skill roll is -1 for every full 5 mph/s of deceleration over the vehicle's Decel rating: that is, no extra penalty at 0-4 mph/s over, -1 to skill for 5-9 mph/s over, -2 for 10-14 mph/s over, etc. These penalties are doubled for vehicles with Decel under 10 mph/s, quadrupled for those with Decel under 5 mph/s.

Damage: Taking 5 or more points crushing or explosive damage per ton of vehicle mass from a single damage roll (or if a burst, the group's highest roll) is a hazard. The difficulty of the hazard depends on the ratio of the damage (*before subtracting DR*) to the mass of the vehicle:



Damage Hazard Table

Damage per Ton	*Difficulty of Hazard*
4 or less	Not a Hazard
5-9	0
10-19	-2
20-49	-4
50-99	-6
100-199	-8
200-499	-10
500 or more	-12

If the damage was caused by a collision, add +2 if the vehicle operator initiated the collision himself. Note that if two vehicles simultaneously try to ram, *both* operators are "initiating" the collision.

Failing a Control Roll

If a control roll fails, the vehicle has *lost control.* Take the amount the operator missed the roll by, subtract the vehicle's SR, and consult the appropriate *Loss of Control* table (there's one for loss of control on the ground, in the air, in water, and underwater). If a critical failure was rolled, treat it as a roll that missed by 10 if that is more than the actual amount it missed by. Effects depend on the type of maneuver being attempted, and whether the maneuver took place on the ground, in the air or in water. See p. 149 for ground movement, p. 150 for water movement, p. 151 for movement underwater and in the air. The operator must spend his next turn fighting for vehicle control; no maneuvers can be attempted until after he recovers control.

In addition, all vehicles suffer these effects:

Any vehicle that has lost control isn't a very stable firing platform. All aiming bonuses are lost, and all weapons fire is at a -1 per point the control roll was failed by until the operator regains control.

If it's important, any passengers or crew standing up in a vehicle when a control roll fails must make an immediate roll vs. DX (at a penalty equal to the amount failed by) or fall over. If they could conceivably fall out of the vehicle, or if they are clinging to the side or on deck, a failed DX roll means they fall off.

Loss of Control on the Ground

If a vehicle maneuvering on the ground (or an aircraft that is landing or taking off) fails a control roll, take the amount it failed by, subtract the vehicle's SR, and find the result on the table below:

Failure	*Result*
0 or less	Skid if caused by bend, Veer otherwise.
1 or 2	Spinout.*
3 or 4	Roll.
5 or more	Vault.



* If the vehicle has harnessed animals, or is moving using either legs, a flexibody, or 1 or 2 wheels, treat as a roll.

If multiple failures occur, then only the worst result is in effect at any one time. E.g., if a vehicle that is spinning makes a control roll to stop its spin and fails, any spinout or skid is ignored, but if the new result is "Roll," the vehicle stops spinning and goes into a roll.

Skid: The vehicle immediately moves one 5-yard hex in the direction it was moving *before* It made the bend, rather than in the direction it is now facing. Subtract 10 mph from the current speed. Tracked, halftracked and skitracked vehicles must make a HT+2 roll or shed a track.

Veer: The vehicle changes facing by 30°: roll randomly to see if it turns right or left. Tracked, halftracked and skitracked vehicles must make a HT+1 roll or shed a track.

Spinout: Any wheels or tires each take 1d damage per 20 mph (or fraction thereof) of speed the vehicle had – and the vehicle starts to spin, in the direction it was maneuvering, or a random direction if a hazard. From now on, the driver cannot make any maneuvers or voluntarily accelerate or decelerate. The vehicle moves straight ahead, but for every 5-yard hex it moves, it spins 1 hex side. This new facing doesn't affect the direction of movement: it remains traveling in the same direction it was going when it started to spin, regardless of its facing, until it stops spinning.

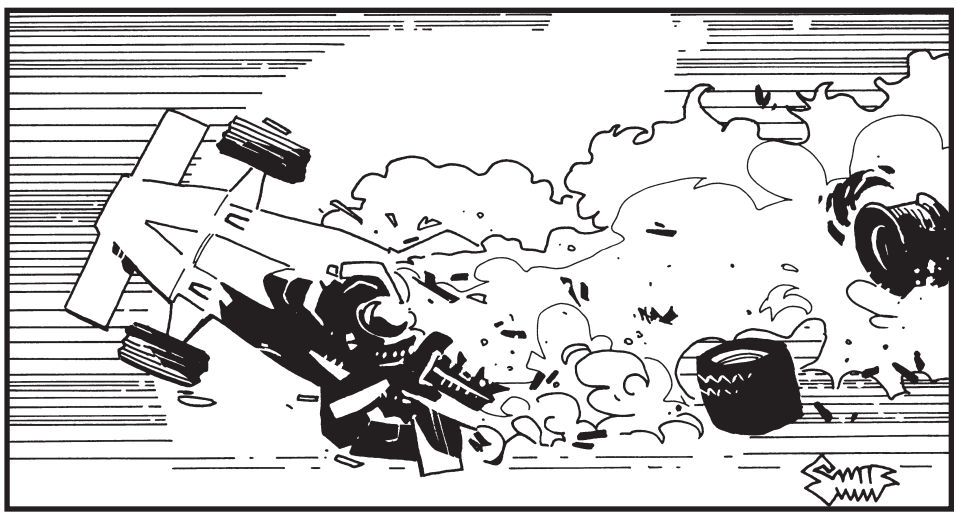
Each turn the vehicle begins while spinning, it decelerates by 20 mph. The spin stops automatically when the vehicle reaches 0 speed. Also, at the *start* of each turn, a driver can try to stop the vehicle from spinning: make a control roll at -4. If successful, the vehicle's facing corrects so it is moving in the direction it was moving before the spin occurred.

When the vehicle starts to spin, tracked, halftracked and skitracked vehicles must make a HT-2 roll or shed a track.

Roll: The vehicle turns 90° sideways and rolls in the direction it was facing before it turned sideways. Count each hex of rolling movement as 2 hexes of ordinary movement. At the end of any turn a vehicle is rolling, it takes 10d damage per ton it masses (so a 0.4 ton cycle would take 4d damage). This damage is rolled separately for each subassembly attached to the top, right, or left or bottom of the vehicle, and for the body. Damage to the body is resisted by the vehicle's top armor DR. Anyone strapped into cycle seats also takes this amount of damage; harnessed animals and anyone in a cycle seat and not strapped in are thrown out of the vehicle (see p. B135 for damage to harnessed animals).

The vehicle decelerates at 20 mph per turn and cannot be controlled until it stops rolling. Then roll 1d: on a 1-3, the vehicle is right way up and is once again drivable, otherwise it has overturned and is not. Vehicles with less than five legs or two or fewer wheels never end right way up! Vehicles that have two legs and those with flexibody motive systems can right themselves in two seconds. Otherwise, the vehicle must be physically lifted back into place, which may require the use of robot arms or a crane if it's too heavy for people to lift.

Vault: The vehicle leaps into the air, sails 1d vehicle lengths and crashes into the ground, taking damage to a random body side (1-2 = front, 3 = right, 4 = left, 5 = back, 6 = top). Treat impact with the ground as if it were a head-on collision (p. 158) with an immovable object at the vehicle's



Crew Actions and Crew Stations (Continued)

If the vehicle has computerized controls, a crew station with a computer terminal can control any maneuver controls, diving controls, weapons or electronic systems on the vehicle, provided they are not being controlled at the same time by a different crew station. Computerized crew stations can also monitor *but not control* input from a sensor or communicator being controlled by another crew station on the vehicle. Each terminal can emulate a specific system. Assigning several terminals to a single station allows it to do more. However, as with ordinary controls, a single person can only do so much at once! Installing different crew stations with their own terminals allows the work load to be shared. There are normally override codes to allow senior crew members to take control away from subordinates if they feel it is necessary to do so. Computer Hacking skill (p. B245) can be used to crack them. Characters attempting to perform multiple tasks using computerized controls suffer only half the usual penalty for doing multiple things at once. However, they still can't fire more than one weapon or set of linked weapons at a time.

Using Interface Controls: If the vehicle has neural interface systems (p. 64), each interfaced user can function as if he had any number of computer terminals without requiring a terminal. The penalties for multi-tasking are the same, but the +4 skill bonus that an interface provides helps cancel that.

Vehicle Statistics

Five vehicle statistics are very important for vehicle movement and maneuvering. They are:

Acceleration – rated in mph per second, this is the maximum number of mph that the vehicle can add to its speed per turn. Vehicles will have different values for ground, water, underwater, air, hovercraft, mag-lev and space movement: gAccel for ground, wAccel for water, uAccel for underwater, aAccel for air, hAccel for hover, mAccel for mag-lev and sAccel for space.

Safe Deceleration – this is the maximum velocity that the vehicle can safely subtract from its speed per turn, measured in mph per second. As above, vehicles will have different values for ground, water, underwater, air, hovercraft, mag-lev and space movement: gDecel for ground, wDecel for water, uDecel for underwater, aDecel for air, hDecel for hover and mDecel for mag-lev. For a spaceship, this is the same as sAccel.

Continued on next page . . .

Vehicle Statistics (Continued)

Top speed – this is the maximum speed in mph that the vehicle can accelerate to under its own power. Again, there are different values for each mode of movement. A Speed of 1, in game terms, equates with 2 mph. Note that vehicles in normal space have no top speed other than the speed of light.

MR – this is the vehicle's *maneuver rating.* It is measured in gravities, or G (often in increments of 0.25 G). A facing change (turn) is rated for the G-force that is used to perform it. MR is the maximum G the vehicle can safely perform. Vehicles will have different MR values for ground, water, underwater, air, hovercraft, mag-lev and space movement: gMR for ground, wMR for water, uMR for underwater, aMR for air, hMR for hover, mMR for mag-lev and sMR for space.

SR – the vehicle's *stability rating* is used when a control roll is failed: when a control roll is failed by an amount greater than stability rating, the vehicle is completely out of control, and suffers a disaster. Vehicles will have different SR values for ground, water, underwater, air, hovercraft and mag-lev movement: gSR for ground, wSR for water, uSR for underwater, aSR for air, hSR for hover and mSR for mag-lev.

Abstract Advanced Movement

This is the easiest way to quickly handle what happens if a party of foot soldiers are suddenly confronted by a main battle tank on the horizon, or two ships clash. Keep track of vehicle movement and spatial relationships with pencil and paper or in the GM's head, but use all the normal advanced rules. GMs will need to carefully describe cover, terrain, and so on, and describe, using dramatic license, what happens if someone fails a control roll: "You suffered a 6-yard skid? The Corvette jumps the curb and crashes into the hot dog stand. The owner throws himself aside as your car totals his cart, ketchup and hot dogs flying everywhere!"

Change of Top Speed

Sometimes, a vehicle's top speed will change. This can occur when a vehicle moves off-road, through bad terrain, or when damage occurs that lowers or eliminates its top speed. If the vehicle is presently moving faster than its new top speed, this has three effects:

First, the vehicle may not accelerate above its new top speed.

Second, the vehicle *must* decelerate each turn by *at least* 5 mph if on land, 2 mph if on water, or 1 mph if in the air. If the vehicle operator does not take action to decelerate, it will automatically decelerate by this amount.

Third, if an airborne vehicle has a stall speed, and its new top speed is below this, the vehicle is in trouble. It will eventually decelerate below its stall speed. Unless the vehicle can land before this happens, it will eventually stall and crash.



present speed. The vehicle then spins along the ground on the same side that took damage, unless this was the front or back, in which case roll randomly (1-2 = left, 3-4 = top, 5-6 = right). Treat this as a sideswipe collision (p. 158) with the ground, at the vehicle's former speed. Finally, the vehicle skids to a stop – still on its top or side – 1d vehicle lengths away.

Track Loss: If a tracked, halftracked or skitracked vehicle sheds a track, the vehicle's Top Ground Speed is zero until the track can be reattached. It can be repaired with a Mechanic roll and one man-hour's work per four tons of vehicle mass.

Whiplash: If a vehicle rolls or vaults, all occupants suffer whiplash – see p. 160.

Loss of Control in the Water

If a vehicle maneuvering on water, including a hovercraft or hydrofoil, fails a control roll, take the amount it failed by, subtract the vehicle's SR, and find the result on the table below:



Failure	*Result*
0 or less	Minor Swamping. If hazard, also Veers.
1 to 4	Major Swamping. If hazard, also Veers.
5 to 7	Capsize!
8+	Capsize! and Hull Stress.

Minor Swamping: The vehicle decelerates by 5 mph. In addition, if the vehicle is *dangerously overloaded,* roll 1d. On a roll of 6, the weight of water washing over the vessel pushes it under, and the vehicle sinks!

Major Swamping: The vehicle decelerates by 10 mph. Everyone not inside the vehicle or securely strapped down must make a DX, Boating or Shiphandling roll: failure means they are washed overboard! In addition, if the vehicle is *dangerously overloaded,* roll 1d. On a roll of 4-6, the weight of water washing over the vessel pushes it under, and the vehicle sinks!

Veer: The vehicle turns randomly 30° to the left or right.

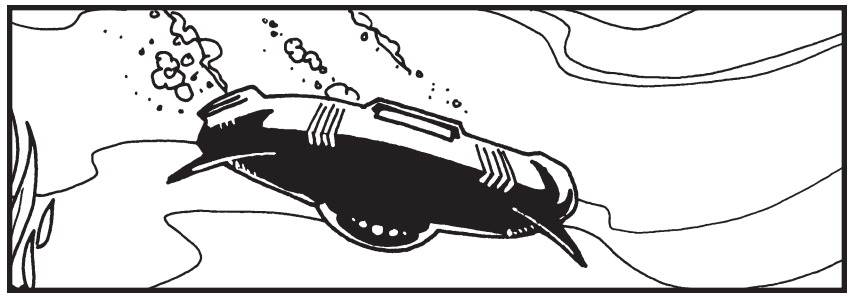
Capsize! The vessel capsizes! If it is dangerously overloaded, it automatically sinks. Otherwise, treat this exactly as a ground vehicle roll result, except damage is halved. Any material or people in the open and not secured to the vehicle are tossed overboard. A capsized vehicle will begin to take in water just as if it were disabled (see p. 186). Righting the vehicle is easy if it is submersible or has legs or a flexibody (this takes two seconds) or is light enough for the crew to lift up and push back over. Otherwise, doing so requires cranes or the like.

Hull Stress: As *Capsize!,* but the hull may also suffer damage. Roll vs. the vehicle's HT. Failure means the body takes damage equal to 0.5 points × the amount the roll failed by × *body* area. DR does not protect.

Loss of Control Underwater

If a vehicle maneuvering under water fails a control roll, take the amount it failed by, subtract the vehicle's SR, and find the result on the table below:

Failure	*Result*
0 or less	Minor Depth Change. If hazard, also Veers.
1 to 4	Major Depth Change. If hazard, also Veers.
5 or 6	Hull Stress.
7 or more	Major Hull Stress.



Minor Depth Change: The vehicle decelerates by 5 mph, and either gains or loses (roll randomly) 5 yards of depth. This may result in accidentally surfacing or hitting the bottom!

Major Depth Change: As above, but double effect.

Veer: The sub turns randomly 30° to the left or right.

Hull Stress: As *Major Depth Change,* but the hull creaks and groans. Roll vs. HT+5, with a -1 per 20% of crush depth the vessel is currently at. Failure means the hull takes 0.5 points damage × the amount the roll failed by × *body* area. DR does not protect.

Major Hull Stress: As above, but without the +5 to HT!

Loss of Control in the Air

If a flying vehicle, excluding hovercraft, fails a control roll, take the amount it failed by, subtract the vehicle's SR and find the result on the table below:

Failure	*Result*
0 or less	Energy Loss if caused by bend, Veer otherwise.
1 or 2	Severe Energy Loss if caused by bend, Veer and Energy Loss otherwise.
3 or 4	Tailspin.
5 or more	Disaster.

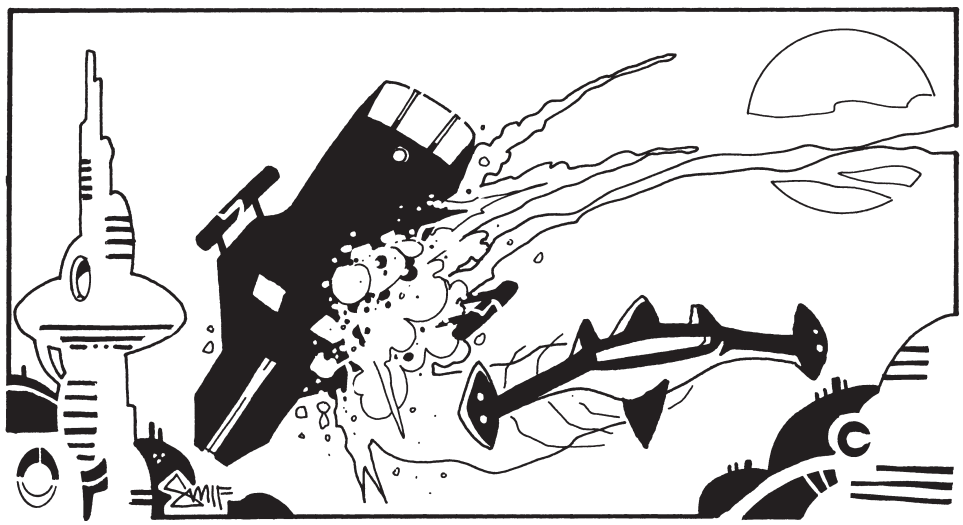
Energy Loss: The vehicle loses 5 yards of altitude. This may cause a crash into the ground if the vehicle is very low. In addition, the vehicle decelerates by 5 mph per 0.25 G of maneuver that was attempted. This may cause a stall (p. 156) if a winged aircraft or autogyro was flying very near its stall speed.

Veer: The vehicle veers 30° to right or left; roll randomly.

Severe Energy Loss: Same as *Energy Loss,* but double effect. There is a 1 in 6 chance that any propulsion system that uses fuel may stop working (jet engine flameout or propeller engine malfunction) – treat the propulsion system as disabled until it can be restarted, which requires a Piloting-4 roll each turn. A rotor loses 1d-1 × 10% of its original hit points due to rotor strain!

Tailspin: The vehicle begins to spiral down out of control. It must use 100% of its speed to dive each turn. Each turn, it will roll 180° and turn 30° in the direction of its present maneuver, and wings will suffer stress, losing 1d-1 × 10% of their original hit points. A gasbag collapses and loses that percentage of its lifting gas instead. A helicopter or autogyro loses 2d-2 × 10% of its rotor's original hit points due to rotor strain. The vehicle will spin automatically for the rest of this turn. Each turn after that, the pilot can try once per turn to pull out of the spin. Make a control roll using the same modifiers as a hazard (p. 152), at -5 to skill . . . the only effect of a failed roll is that the vehicle does not pull out.

Disaster: A wing breaks off, the rotor fails, the contra-grav units overload, etc. The aircraft is no longer flyable, and will plummet to the earth (see *Falling*, p. 157). A good time to eject (p. 161) or bail out! The airplane goes into a steep dive as above, and cannot pull out.



G-Forces and Realism

Realistically, most vehicles will be physically incapable of attempting maneuvers requiring more Gs than twice their MR.

The GM should feel free to impose this limit in very realistic campaigns, but not in more cinematic games.

Control Roll Modifiers – On the Ground

These conditions modify all control rolls made by ground vehicles.

Wheeled Vehicles only:

Poorly-maintained road . . . . . -1
Loose or gravel road . . . . . -1
Rain-slick road or runway . . . . . -2
Driving on ice (off or on the road) or packed snow . . . . . -3
Oil on road or runway . . . . . -3
Part or all of vehicle on the shoulder of the road . . . . . -1
Bad visibility . . . . . See below
Off-road, no off-road wheels . . . . . -2

Other Ground Vehicles:

Rain-slick road or runaway . . . . . -1
Ice (off or on the road) or packed snow . . . . . -2*
Oil on road or runway . . . . . -2
Bad visibility . . . . . See below

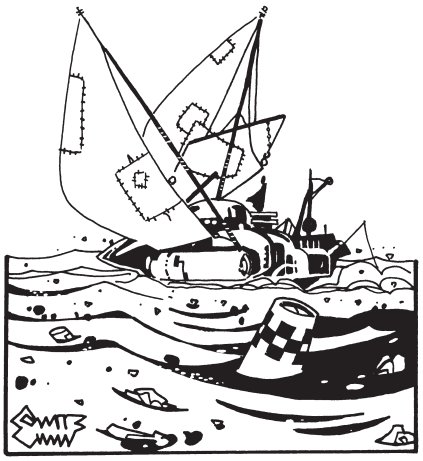
* No penalty for skid or skitrack vehicles.

Bad Visibility Control Roll Modifiers

At night, area well-lit . . . . . -2*
At night, poorly-lit back streets . . . . . -4*
At night, open country or unlit street . . . . . -6*
Total darkness . . . . . -10*
Rain or mist . . . . . -1**
Heavy rain or light snow . . . . . -2**
Driving through smoke screen . . . . . -3**
Dense fog or blizzard . . . . . -4**

* Ignore penalty if using headlights, Night Vision, light amplification, low-light TV, radar, ladar, infrared or thermograph. *Exception:* Night Vision, light amplification and low-light TV have no effect on *total* darkness!

** Ignore if using radar, ladar or thermograph. Halve penalty if using infrared.



Control Roll Modifiers – In the Water

These apply for vehicles that are moving *on* water. These do not include fully-submerged submarines but do include hydrofoils and hovercraft moving over water.

Calm water	No modifiers
Choppy seas	-1*
Rough seas	-2*
Stormy seas	-3*
Major storm	-6*
Bad Visibility	See p. 151 **

* Double all sea penalties for hydrofoils riding on their foils and for hovercraft.

** Only applicable if there is imminent danger of collision with other vehicles, rocks, etc.

Control Roll Modifiers – In the Air

High winds	-1 to -2*
Major storm	-4*
Bad Visibility	See p. 151 **

* Double penalty when close to the ground or maneuvering around mountains or tall buildings.

** Modifiers for visibility only apply when landing or taking off, or if maneuvering in close proximity (within 100 yards) to the ground, a terrain feature, a structure, or another vehicle.

Loss of Vehicle Operator

If a vehicle's operator is out of action in some way (killed, knocked out, falls out of the vehicle, abandons the controls) the effects depend on the type of vehicle.

If a wheeled vehicle with one or two wheels, or a walker with two or three legs, loses its driver, the vehicle will immediately go into a roll as if it had lost control.

If the operator of any other type of vehicle is lost, consult the *Loss of Control* table by rolling 1d+2 and subtracting the vehicle's SR as if the vehicle had lost control due to a hazard. Afterwards, if the vehicle hasn't suffered some sort of disaster like a roll or spin, water vehicles and animal-drawn or wind-powered ground vehicles continue to move ahead at current speed. Other ground vehicles decelerate by 5 mph each turn. Aircraft that are not lighter than air lose 5 yards of altitude and 5 mph of speed each turn, and if they drop below stall speed, they will stall. Lighter-than-air aircraft simply continue on ahead.

Leaping or Falling from a Moving Vehicle

If a character does this, calculate falling damage normally, and then add 1d damage for every 5 mph speed.

Using These Rules with Simplified Movement

The G-based maneuvering rules can be used without a hex map. For instance, if a pedestrian blunders in front of a PC's car, it's fine to simply tell the player "Make an IQ roll to spot him, O.K., now you need to make a 90° turn to avoid hitting him – do you want to risk it? Make the Driving roll," and then use the *Maneuvering* and *Control Rolls* rules and the amount the PC made his roll by to judge the character's success. For instance, if the driver barely made his roll, he avoided the pedestrian, but may have veered into other traffic, requiring further rolls to avoid difficulty. If he failed, the vehicle skidded before turning, and the PC ran the pedestrian over; and if the driver rolled a critical miss . . . it's time to consult the *Loss of Control* table!

Special Movement Rules

This section covers describes special situations vehicles may face while moving on the ground, in the air, or in water. It also covers collisions.

Movement On the Ground – Special Rules

These rules apply to vehicles with ground motive subassemblies moving on land, including aircraft taking off or landing on the ground. They also apply to hovercraft moving over ground.

Terrain and Off-Road Movement

The rules for ground movement assume the vehicle is traveling on a smooth surface such as a road, salt flat or runway. When moving off-road, the vehicle's mobility will depend on its motive system.

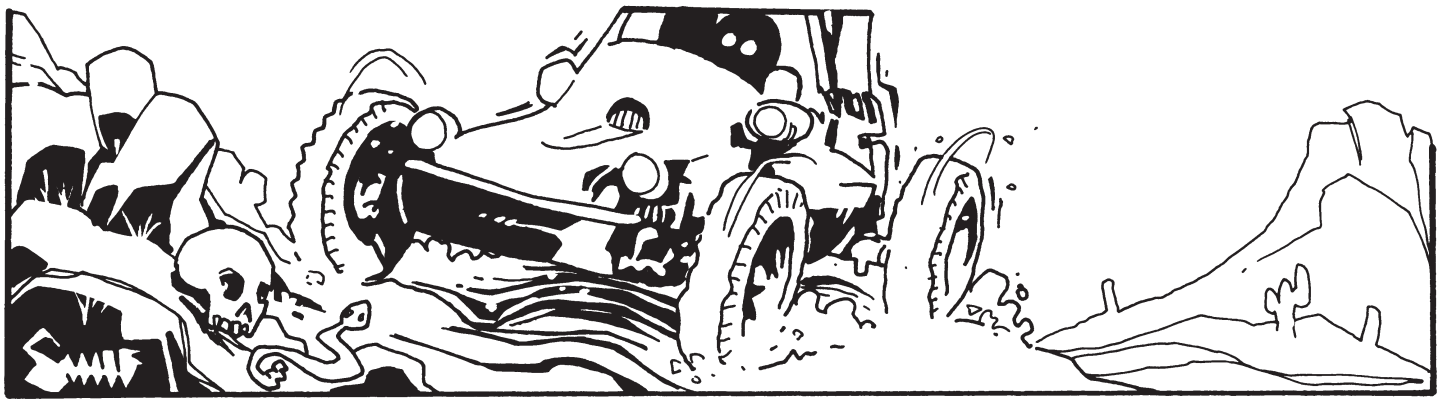
Off-Road Speed: Ground vehicles have an off-road speed. Use this fraction of top ground speed when the vehicle is off-road.

In addition, some types of terrain will further slow the vehicle down:

Hard: This is a paved road, salt flat, aircraft runway or the like. Vehicles use their normal top ground speed.

Open: This includes ordinary grass, dry earth or packed sand or muddy dirt roads. A vehicle uses its off-road speed.

Broken: This is rocky or very hilly terrain, broken up by gullies and ridges. It may be barren or covered with vegetation. A vehicle uses half its off-road speed unless it has legs or a flexibody, then it uses its full off-road speed.





Forest: This is terrain with thick vegetation – dense hedgerows, jungle or thick woods. Vehicles with a Size Modifier of +2 or less move at normal off-road speed. Most other vehicles move at half off-road speed. Exceptions: Vehicles with masts, unfolded wings or rotors with a Size Modifier of +2 or more have a Speed of 0. A vehicle that has a mass of 50 tons or more, no rotors, wings or masts, *and* front body DR 50 or better can simply crash through everything at normal off-road speed.

Quagmire: This includes mud, swamp, riverbanks, marsh, very soft sand, the sea bottom and deep snow. A vehicle uses its off-road speed, and off-road speed is halved in quagmire unless the vehicle has legs, a flexibody, or an extremely low ground pressure. Worse, a vehicle with high, very high or extremely high ground pressure may get stuck – make a Driving-4 roll every ten minutes (if high ground pressure), every minute (if very high) or every ten seconds (if extremely high) to avoid becoming stuck! If this happens, the vehicle cannot move. Extricating a stuck vehicle requires reversing, and takes a skill roll at an additional -5. One attempt may be made every three seconds, but failure by 5 or more means the vehicle is permanently stuck, until towed out.

Snow-covered or icy: Any of the above types of terrain, including forest, can be described as "snow-covered" or "icy." Vehicles move at 2/3 the listed speed unless they have skitrack or skid subassemblies, but vehicles with skitrack or skid subassemblies move at *double* their normal speed.

Slopes

A vehicle climbing a gradient experiences *gravitational deceleration* every turn: a deceleration of 1 mph/s per 4.5° of slope. After this deceleration reduces velocity to 0, the vehicle will gain reverse velocity, starting to move backwards. This does not count against a vehicle's gAccel or gDecel limits.

A vehicle going downhill gains *gravitational acceleration* every turn: an acceleration of 1 mph/s per 4.5° of slope. This does not count against a vehicle's gAccel or gDecel limits, and may increase the vehicle's speed beyond its normal top speed.

Obstacles: A 90° or greater slope is not a slope, it's an obstacle! A vehicle can scale a vertical obstacle whose height in feet is less than (vehicle Size Modifier + 1) ×2 feet if using legs or a flexibody, ×1 foot if using a tracked drivetrain, ×0.5 feet if using a halftrack drivetrain or if equipped with off-road wheels, and ×0.25 feet if using any other wheels, skitracks or skids.

A vehicle which hits an obstacle it cannot scale has had a collision (p. 157). Climbing an obstacle is a hazard.

Moving in Reverse

A ground vehicle with a powered motive system and a drivetrain (vehicles propelled by sails, airscrews, reaction engines and reactionless thrusters are excluded) can shift into reverse if its speed is 0. Wheeled vehicles can only reverse if they have at least 3 wheels. A vehicle traveling in reverse has a top speed of 20 mph or half its normal top speed, whichever is less. It can accelerate at half its normal rate. To shift to forward movement, it must decelerate back to 0 speed. All control rolls made while traveling in reverse are at -4, unless a set of rear-facing duplicate controls has been installed.

Riding Outside Vehicles

If the vehicle has a deck, there's room for one person per 9 square feet of deck space to stand on deck.

Even a vehicle without a top deck can carry additional passengers (not crew) who cling to the outside, but this is not very safe at high speeds. The maximum number of people who can safely cling to a vehicle is its surface area/20.

Characters standing on an open deck or clinging to the vehicle body will be flung off if it suffers a crash table result *(Failing a Control Roll* , p. 148), and may be shaken off whenever the vehicle makes any maneuver more violent than 0.5 g: have them make a ST roll at -2 per 0.5 G over 0.5 G. If clinging, failure means they fall off; if on an open deck, failure means they fall down (no effect if they are already prone), and failure by 4 or more means they fall off. If the vehicle makes a steep climb or dive, or rolls, ST rolls must be made at an extra -4 penalty to avoid falling off.

Anyone actually strapped to the vehicle (e.g., chained to a mast) won't fall off.

GLOC

High-G maneuvers and sudden acceleration or deceleration impose severe stress on the crew and passengers. If this is severe enough, the vehicle crew and passengers may lose consciousness. Pilots call this "gravity-induced loss of consciousness" or GLOC. If that happens to the operator, it could be very dangerous. Anyone subjected to sudden high-G maneuvers must make a G-modified HT roll; if it fails, he rolls on the *GLOC Effects* table (p. 155).

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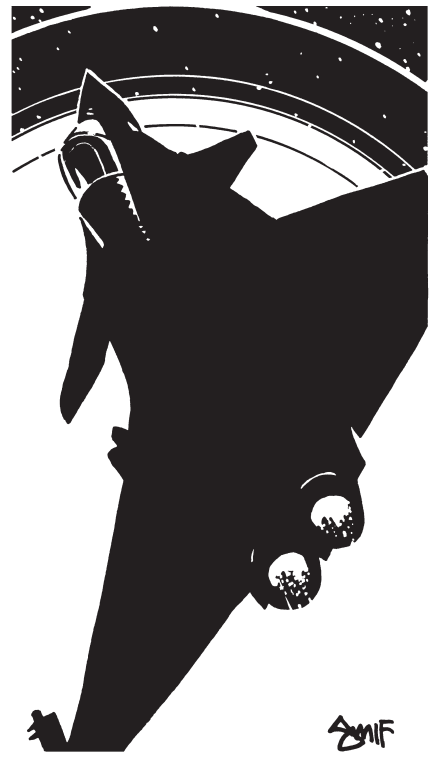
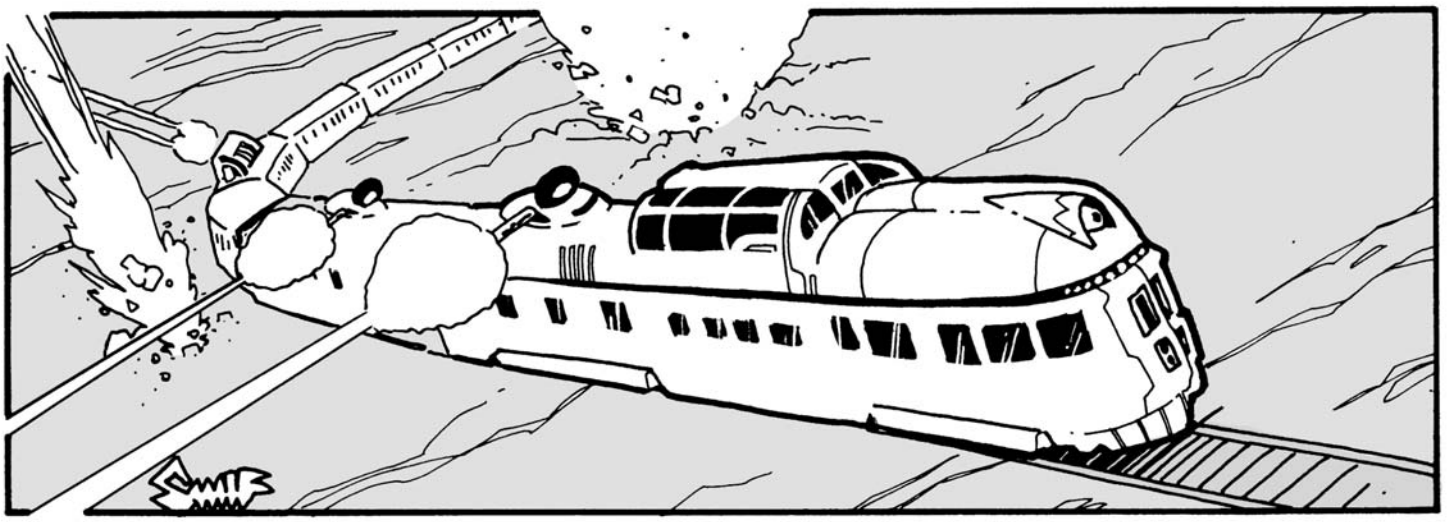




GLOC (Continued)

Maneuvers, acceleration and deceleration in space are already rated in G. For other accelerations or decelerations, G is 0.5 G per 10 mph/s added to or subtracted from speed. The higher the felt G-force, the more difficult the HT roll. Halve the *felt* G-force for *each* of the following that applies: wearing a G-suit (p. 204), seated in a G-seat (p. 79), seated in a womb tank (p. 79). Gravity webs (p. 79) and grav compensators (p. 80) reduce the *actual* experienced G-force, depending on TL; apply the effects of gravity compensators *before* modifying for felt G-force! Once effective G is known, consult the table below, rounding fractional G up:

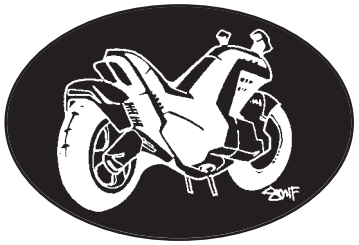
G-Modified HT Roll Table

Up to 2 g	No roll necessary
3 g	Roll HT
4 g	Roll HT-1
5 g	Roll HT-2
6 g	Roll HT-4
7 g	Roll HT-6
8 g	Roll HT-8
9 g	Roll HT-10

. . . and so on, rolling at an additional -2 HT for each extra G.

Modifiers: +5 for the Acceleration Tolerance advantage (see p. CI19), -3 for the Acceleration Weakness disadvantage (see p. CI79).

Each high-G maneuver is a new acceleration – roll again. Note that no repeated roll is required for *constant* acceleration or deceleration: the horizontal forces are less extreme. Do not roll again for constant acceleration unless it continues for more than an hour – than roll each hour, at 3 G less.



Railway Movement

A vehicle with railway wheels can only move on railway tracks, and must maneuver to follow the rails. Any skid, spin, roll, veer or vault will result in it jumping the tracks, effectively immobilizing the vehicle! The same applies to mag-lev vehicles moving on mag-lev rails.

Movement on or under Water – Special Rules

Only vehicles that can float (those with flotation hulls or submersible hulls) can move on water, although hovercraft can skim over the surface.

Running Aground

In shallow waters, any vessel except a hovercraft may run aground. This depends on the *draft* of the vessel – the distance between the vessel's water line and the bottom of the hull. Running aground is simple: if the vessel enters water whose depth is less than its draft, it has run aground. If a vessel runs aground on something sharp, like rocks or a reef, that is just equal to its draft, treat it as a sideswipe collision against the underside. If less than draft, it is a head-on collision.

To get free, the crew can jettison cargo or other stores, hoping to lower mass and raise draft. If successful in raising draft, roll 1d. On a 1-3, the vehicle is still stuck.

Currents

A vehicle on or under water and traveling with the flow of a river, stream or ocean current will add the current's speed to the vehicle's speed. Traveling against the current will subtract its speed, which may result in the vehicle moving backwards. Moving across a current will cause the vessel to drift sideways.

Ocean currents (such as the Gulf Stream) will average about 5 mph. A typical river current will be 5-10 mph depending on the river, though some may be more sluggish and rapids may be faster.

Dangerously-Overloaded Vessels

The best way to lose a ship or a boat is to overload it. Every year, hundreds of boats sink this way, either because their operators have taken a chance and loaded more people or cargo on the vessel than was advisable, or because the vessel has suffered flooding, taking on an extra weight of water as the result of a leak.

A vessel is considered *dangerously overloaded* if its current weight is 90% or more of its flotation rating.

Sinking

A dangerously-overloaded vessel can sink suddenly as a result of a *Swamping* or *Capsize!* loss of control result. In addition, a vessel will also sink if its weight exceeds its flotation rating. The usual way this happens to otherwise seaworthy vessels is through flooding caused by damage (see p. 186 in the *Combat* chapter).

A sinking vehicle goes nose down and vanishes beneath the surface of the water. It sinks 1 yard per turn. Eventually, it will hit the bottom, or if the water is deep enough, the hull will crack from water pressure. (See *Crush Depth,* p. 133).

Underwater Movement and Submarines

A vehicle with a submersible hull may swim underwater. Preparing a surfaced vessel with open hatches for diving requires 5 turns, plus 1 turn per 10 tons of surfaced mass.

Only certain types of power systems can operate in an underwater environment – see *Power Systems* (p. 81) and *Snorkels* (p. 84) for details.

A vehicle with a submersible hull has a crush depth. If a submarine exceeds its rated depth, its body may collapse under pressure, if it has any pressurized compartments. Roll vs. the vehicle's Health every minute, with a -1 per 20% below rated depth. Add +2 for heavy compartmentalization or +4 for total compartmentalization (p. 20).

A failed roll means the body takes damage equal to 0.1 hit points × its body surface area per point the roll failed by (minimum 1 hit). DR does not protect. On a critical failure, the hull suddenly buckles, and the vehicle is destroyed!

Flying Movement

Use these rules for any vehicle flying above the ground, with the exception of hovercraft and mag-lev (which travel only a few inches or feet off the ground).

Aircraft operate in three dimensions, and routinely change their altitude. This is not considered a maneuver, and is resolved any time during the vehicle's turn.

Climbing: Vehicles climb to gain altitude. A vehicle may devote a percentage of its speed to vertical movement; this amount is added to altitude; the rest is available for normal horizontal movement. For example, suppose an F-16 fighter has a current speed of 800 mph, enabling it to move 400 yards this turn. If the pilot devotes 80% of his move to vertical movement, he will gain 320 yards of altitude and move 80 yards horizontally.

Climbing vehicles decelerate due to gravity. A climbing vehicle suffers deceleration *at the end of its turn* equal to 20 mph times the percentage of its speed devoted to climbing, multiplied by local gravity, if not on Earth. For percentages expressed in increments of 10%, this means a loss of 2 mph per 10% of speed. For example, if our F-16 devoted 80% of its movement to climbing, it would decelerate by 80% of 20 = 16 mph.

A climb doesn't count as a maneuver, but if the vehicle climbed, it may not dive on the same or very next turn – it must fly level for one turn first. A vehicle may not devote more than 50% of move to a climb unless it climbed (any amount) on the previous turn. If a vehicle devoted more than 50% of its movement to a climb, it must devote at least 10% to a climb on the following turn. While climbing, the only maneuver that can be performed is a vertical roll (see p. 156).

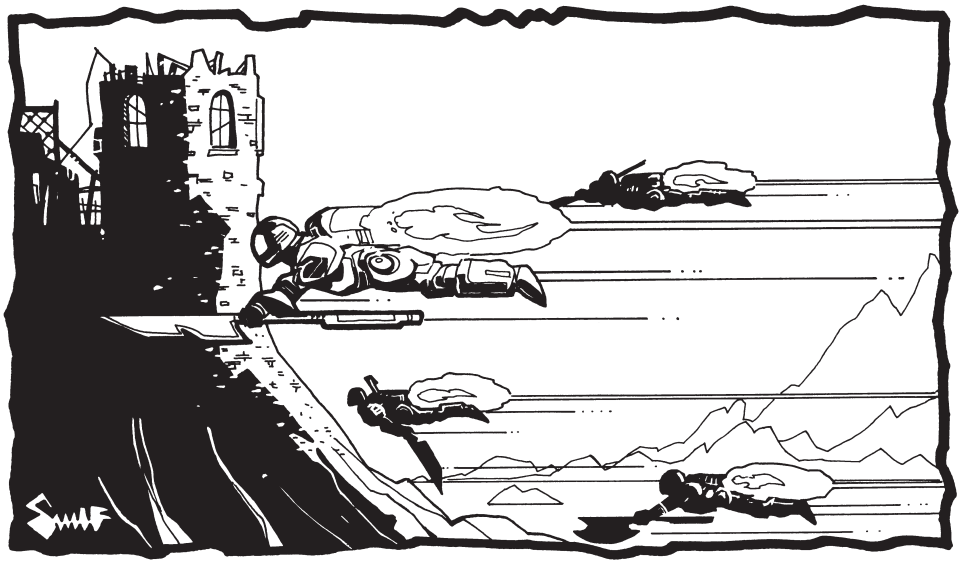
Diving: Vehicles lose altitude by diving. A vehicle may devote a percentage of its speed to vertical diving movement (but see below). This amount is subtracted from altitude; the rest is available for horizontal movement. For instance, if an aircraft with a speed of 1,000 mph (moving 500 yards/s) devoted 30% of its movement to a dive, it would lose 30% × 500 = 150 yards of forward movement and so move only 350 yards horizontally.

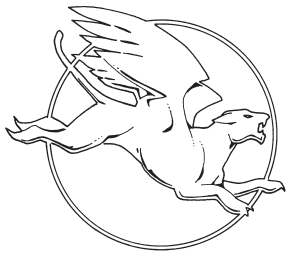
Diving vehicles accelerate due to gravity at the end of the turn in which they dive. A diving vehicle accelerates at 20 mph × the percentage of its speed devoted to diving (times the local gravity, if not on Earth).

A vehicle may only devote more than 50% of its speed to a dive if it dived on the previous turn. An aircraft may not dive and climb on the same turn. If a vehicle devoted up to 50% of its move to a dive, it may not climb on the following turn. If a vehicle devoted more than 50% of its move to a dive, it must devote at least 10% to a dive on a following turn.

Climbing, Diving and Combat: If an aircraft devoted *more than half* its speed to a climb, the aircraft's tail is pointed at the ground, and its nose at the sky – this will affect hit location and what weapons can be fired. If an aircraft devotes more than half its speed to diving, its nose is pointed at the ground and its tail at the sky, with obvious effects on hit location and what weapons can be fired.

Diving and Top Speed: A diving aircraft's speed may cause it to exceed its normal top speed; see *The Sound Barrier* (p. 159) for dangers of very high speed flight.





GLOC Effects

When a character fails his roll to deal with a high-G maneuver, look up the amount the roll failed by on this table:

1 – stunned 1d turns ("gray-out").
2 – unconscious 2d turns.
3 – unconscious 3d turns.
4 – unconscious 4d turns.
5 – unconscious 6d turns.
6 – unconscious 10d turns.

On all the results below, the victim is unconscious for 10d turns *and* suffers damage:

7,8 – 1d-3 damage.
9,10 – 1d-2 damage.
11,12 – 1d-1 damage.
13 – 1d damage.
14 – 1d+1 damage.
15 or more: 1d+2 damage.

If a character passes out or is stunned, treat it as loss of vehicle operator (p. 152), except that the pilot will eventually recover.

This table is similar to the one in ***GURPS Space,*** but the effects are based on the amount the roll failed by rather than the total G.

Extra Damage: Assess additional damage equal to 1d + the G-force if the character is caught wholly by surprise and thrown to the floor, against the side of the vehicle, etc.

Stunts

These are special maneuvers a vehicle can perform. A "stunt" is much like a bend or drift, but it differs in that a control roll is always required whether or not *G* exceeds MR, and the results of failure are usually greater than normal.

Bootlegger Reverse

A bootlegger (sometimes called a J-turn) is a controlled skid to reverse the vehicle's direction, effectively turning 180° and decelerating to 0. It can only be performed by a self-propelled (not animal-drawn) vehicle with four or more wheels, or a 50 cf or less two-wheeled vehicle whose driver is in a cycle seat (he uses his foot to control the skid).

The driver may not accelerate or decelerate on the turn he wants to make a bootlegger reverse, and the vehicle's current speed in mph may not exceed twice its gDecel in mph/s. While a vehicle is performing the bootlegger, no other actions can be performed – including maneuvers and weapon fire.

Continued on next page . . .



Stunts (Continued)

To perform a bootlegger, treat it exactly like a 90° bend. However, the vehicle takes 3d damage to each tire (or to its wheels, if it has no tires) and a control roll is automatically required even if the vehicle did not pull enough *G* to require one. This control roll is at an extra -1 to skill.

Failing a control roll for a bootlegger has the same effect as any other failed control roll: it will lead to the vehicle skidding, spinning or rolling.

If the control roll succeeds, the vehicle does *not* continue to move in the direction it is now facing. Instead, its next five yards of movement are a controlled skid in the direction it was going before it made the turn. Then it immediately rotates another 90° and decelerates to 0 speed, ending the turn facing the direction it originally came from.

T-Stop

A T-stop is a controlled skid that suddenly halts the vehicle. It can only be performed by a self-propelled (not animal-drawn) vehicle with four or more wheels, or a 50 cf or less two-wheeled vehicle whose driver is in a cycle seat (he uses his foot to control the skid).

The driver may not accelerate or decelerate on the turn he wants to make a T-stop, and the vehicle's current speed in mph may not exceed twice its gDecel in mph/s.

To perform a T-stop, treat it exactly as if it were a 90° bend. However, the vehicle takes 3d damage to each tire (or to its wheels, if it has no tires) and a control roll is automatically required, even if the vehicle did not pull enough *G* to require one.

Failing a control roll for a T-stop has the same effect as any other failed control roll: it will lead to the vehicle skidding, spinning or rolling. If the control roll succeeds, the vehicle turns 90° as planned, and also decelerates to 0 speed.

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Aircraft with Stall Speeds

A flying vehicle with non-zero stall speed (i.e., with wings or autogyro rotors) requires forward motion for lift.

Takeoff: The vehicle takes off by accelerating in a straight line along the ground using the ground movement rules until it exceeds its stall speed. It may then begin climbing.

Landing: Landing is the reverse of taking off. In order for a landing to count as a landing rather than a crash, the vehicle must be at under 10 yards altitude and traveling right-side-up in level flight. If it then decelerates to just below its stall speed, it lands instead of crashing or stalling. Now it just has to decelerate to 0 speed before going off the end of the runway! If the landing aircraft doesn't have a ground motive subassembly, it will crash instead of landing, but will take only half damage. *Exception:* Any aircraft can land in water without landing gear (of course, it will sink if it can't float).

Stalling: If its speed is at or below its stall speed, the vehicle's wings or rotor won't provide enough lift for the aircraft to stay in the air. If the aircraft meets landing parameters (see above), it lands. Otherwise, the aircraft *stalls.* This can also occur as the result of a failed control roll.

Stalls can be dangerous. For the rest of the turn the aircraft is stalling, it can't make any more maneuvers, and its weapons can't be fired. On the following turn, it levels out (if climbing) or (if not climbing) immediately goes into dive (roll 1d+2 × 10% for percentage of movement devoted to diving). While diving, the aircraft will accelerate, gaining speed. No other actions or maneuvers are possible (the aircraft can't accelerate, decelerate, maneuver, etc.) while this is occurring, and the aircraft cannot fire weapons. *Exception:* Any pilot can voluntarily put the aircraft into a steeper dive, if desired.

Pulling Out of a Stall: The aircraft will gain speed as it dives. Once the aircraft's dive results in it moving faster than its stall speed, the pilot can attempt to regain control at the start of each turn. Make a control roll, with a modifier of -1 per full (10 mph × aMR) vehicle speed. Success means the vehicle pulls out, failure means it does not.

Rolling: The pilot of a vehicle with wings or late TL7+ rotors may roll any time if he does not use a turn or drift maneuver in the same one-second turn. Rolls can be combined with climbing and diving. The aircraft inverts and is now flying upside down. If an aircraft if flying upside down, add 1 G to accumulated G for all maneuvers; it also loses 5 yards of altitude each second. A roll does not require a control roll.

Vertical Rolls: If the aircraft is in a steep dive or steep climb it can roll around its longitudinal axis quite easily. When it pulls out of the vertical, it can do so pointing in almost any direction the pilot wants, not just opposite to the previous direction of flight. This maneuver allows an aircraft to end up pointing in any direction when leaving a vertical climb or dive. This does not require a control roll.

Exotic Maneuvers: On a one-second turn scale, most aircraft maneuvers are simply combinations of other actions. For instance, an Immelmann turn could be a 50% climb, a 100% climb and vertical roll to reverse direction, a 50% climb and level flight.

Vehicles with Vectored Thrust or No Stall Speed

Flying vehicles with no stall speed *or* with vectored thrust systems have certain special abilities. If the vehicle does not use all of its acceleration to increase its speed, it may use any unused portion of it to maneuver with at any time during its turn, as follows:

Increase altitude by one yard (costs 2 mph/s acceleration).

Decrease altitude by one yard (costs 2 mph/s acceleration).

Drift one yard right or left while maintaining its facing (costs 2 mph/s acceleration).

Assist in making a maneuver, adding +0.25 to MR (costs 5 mph/s acceleration).

None of these actions in and of themselves require a control roll.

These vehicles may also climb and dive normally, and any late TL7+ air vehicle with an aMR of 0.25 or more can also roll.

A flying vehicle with *no* stall speed has certain additional abilities. It can take off and land vertically, or decelerate to zero speed and then hover in place. Once it has decelerated to 0 speed, the vehicle may move sideways or in reverse, although it has only half its usual MR (round down) while doing so. It can accelerate in reverse or sideways at half its usual rate. Its reverse speed may not exceed half its top speed or 150 mph, whichever is less.

Lighter-than-Air Flight

A vehicle is lighter than air if its combined lifting gas, levitation or contragravity lift (but *not* lift from other sources like rotors, lift engines or vectored thrust) exceeds its weight.

Lighter-than-air vehicles may, instead of using normal climbing rules, gain or lose up to 10 yards of altitude each turn as a result of manipulating ballast, or for contragrav, adjusting the weight. Updrafts and downdrafts have double their effect on lighter-than-air vehicles.

Taking Off and Landing: If the vehicle does not have contragravity or levitation, this can be difficult: the crew must cast off the mooring lines and drift up at 1-2 yards per turn. To land, the craft must slow to 10 mph or less speed and 0 altitude. Landing any faster is a crash. Or the crew can leap out (or lower lines to ground crew) and tie the craft down. This requires 1 person per 10,000 lbs. of loaded weight, or twice as many in bad weather.

Ballast: All vehicles that are lighter than air and don't use contragravity require occasional replacement of gas and ballast, since they use up both when maneuvering, climbing or diving. This limits operating range to one to five days, at the GM's option. In general, turbulent weather conditions will result in shorter range than good weather conditions, since ballast and gas must be constantly released to maintain good trim.

Free Flight: A lighter-than-air vehicle that has no acceleration or top speed drifts with the wind: it may not maneuver, but may gain or lose altitude if someone (or a remote system) is in control to release gas, drop ballast or manipulate contragravity controls.

Falling

When a large object like a vehicle is falling through an atmosphere, powered only by gravity, its speed increases as it falls to the ground. Assume a falling object's speed will increase by 20 mph per second until it reaches terminal velocity, after which it will continue to fall at that speed.

To find terminal velocity, calculate the speed of the vehicle using the aerial top speed rules in Chapter 10, but with an aerial motive thrust of one pound per pound of vehicle loaded weight, due to gravity.

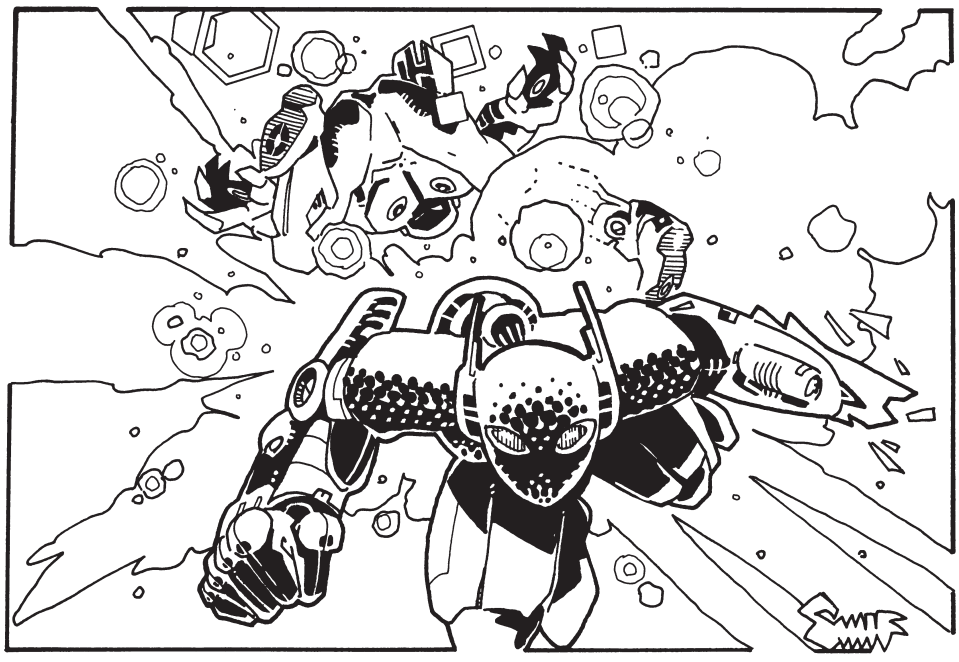
When a vehicle falls to the ground, treat it as if it had a collision (angle as appropriate) with the ground (or whatever else it hits!) at a speed based on its current speed.

Collisions

When a moving vehicle hits something, this is a collision.

Normally, a collision is automatic if two objects are on a collision course with each other. However, if one of the objects is much larger (its Size Modifier is three higher than that of the other) the smaller object can dodge, provided it or its operator is aware of the incoming object and free to move. Dodging is also possible in mid-air, underwater or space collisions, regardless of vehicle size. Make a normal Dodge roll, though PD doesn't help. A successful Dodge roll will move a dodging character the same distance as a Step maneuver; for vehicles, this is the same distance as a Drift maneuver. If this is far enough to avoid the collision, it doesn't take place. Otherwise, the character or vehicle didn't get far enough away!

All collision damage is *crushing.* Armor DR always protects against collision damage. However concussion and whiplash effects may damage living beings aboard a vehicle even if the armor is not penetrated. At high speeds, this can be fatal!





Stunts (Continued)

Look, Ma – Two Wheels!

Godfrey Daniels is racing the wrong way down a single-lane, one-way mountain highway with a sheer cliff on one side and a 1,000-foot drop on the other, pursued by a car full of gun-toting thugs. He rounds a bend and suddenly the road ahead is filled by a huge semi-truck! There's only three feet of clearance . . .

Is Godfrey doomed? In a realistic campaign, maybe. In a cinematic campaign, if someone is driving a vehicle with four or more wheels, he can tilt it *sideways* and drive on two wheels for the rest of the turn (a further roll is needed each turn), reducing the amount of space the vehicle takes up, enabling him to dodge incoming trucks, fit through narrow alleys, etc.

While a bootlegger is a controlled skid, this is a controlled *roll.* Treat it exactly like a Drift maneuver, except that a control roll is *always* required, and instead of drifting, the vehicle moves onto its side.

If "sideways tilt" control roll fails, *any* failure result, regardless of SR, is treated as a roll. This is a very dangerous maneuver!

The Chicken Coop

Chicken coops (fruit stalls, etc.) are always being hit by autos, at least in the movies.

Driving through such an obstacle isn't a hazard if the vehicle masses over 3 tons, but is a hazard with no modifier to the control roll otherwise. More importantly, the cloud of scattered feathers (hay, torn newspaper, etc.) imposes a -2 hazard on anyone following you!

The Narrow Passage

Sometimes, vehicles of any type may have to negotiate a very narrow passage. This can be used for flying through tunnels, driving between other vehicles and the like.

The GM should select a Size Modifier for the tunnel or passage based on how wide it is. A vehicle that has an equal or larger Size Modifier cannot fit through it. One with a smaller Size Modifier can, but it will be a tight fit. If a vehicle has wings or rotors, add 1 to its effective Size Modifier.

Continued on next page . . .

The Narrow Passage (Continued)

Make a hazard control roll. Normal penalties for speed apply. In addition, there is a penalty based on the difference between the vehicle's Size Modifier and the passage's:

Vehicle is one smaller: -4.

Vehicle is two smaller: -2.

Vehicle is three smaller: no modifier

Vehicle is four or more smaller: no roll needed.

Only one roll is normally needed. An additional roll should be required every minute or so, or whenever the vehicle makes a Dodge. Any Veer result leads to a sideswipe collision with whatever the vehicle is passing through (tunnel walls, other vehicles, etc.). Other results cause the usual effects (Roll, Spin, etc.), plus a head-on collision with the object.

Muscle Power and Fatigue

Individuals who are rowing or working muscle-engines will take fatigue based on their encumbrance, as if they were marching. That is, 1 point of Fatigue per hour if unencumbered, 2 points per hour if lightly-encumbered, and so on. For playability's sake, it is not necessary to recalculate vehicle performance until fatigue reduces Strength to 3. At that point, halve the speed and acceleration of any oar- or muscle-powered vehicle.

Sails and Wind

The maximum speed of sailing craft is determined by the wind speed and direction, the TL of the sails, and the size and number of the vehicle's masts. The GM determines wind speed and weather conditions – see p. B187-188. The basic movement rates given in the design rules assume the vehicle is *running with the wind on the quarter,* that is, behind and slightly to the right or left. For wind from other angles, use the rules below.

Wind on the Bow: The wind is coming from in front of the vessel. The vessel must move by tacking, i.e., zig-zagging back and forth. Speed is 10% of listed speed if a square rig, 20% if a full rig, or 30% if a fore-and-aft rig.

Wind on the Stern: The wind is directly behind the vessel. Speed is 80% of listed speed.

Wind Abeam: The wind is blowing to either side of the direction the vessel is facing. Speed is 50% of listed speed if a square rig, 80% of listed speed if a full rig, 90% of listed speed if a fore-and-aft rig.

At the GM's discretion, wind direction may change every few minutes, or remain steady.

Continued on next page . . .

A vehicle in a collision normally *inflicts* dice of damage equal to (its original body hit points × collision speed in mph)/200, rounded up to the nearest full die. The dice of damage it *takes* is usually based on what the other vehicle inflicts. If this is too high a number to roll, the GM can convert it into a more reasonable die spread before rolling, for example, 480 dice could be 6d × 80.

Rams: If the striking vehicle has a ram, it adds +1 per die in any head-on, T-bone or rear-end collision. If a ram-equipped vehicle is involved in a head-on collision, it takes one less point of damage per die.

If a pedestrian, creature, robot, etc. is struck, it inflicts damage like a vehicle based on its hit points (usually equal to HT, for a person) and its current speed. Impacting a person can damage a vehicle: if an average person (HT 10) is hit at 50 mph, he will inflict 10 × 50 / 200 = 2.5, rounded to 3d damage, to a vehicle! Similarly, an airplane striking a bird (1 hit point) at 1,000 mph can be in serious trouble, taking 5d damage!

The three things to determine in a collision are the type of collision, where a vehicle was hit and what the collision speed was.

A *head-on collision* occurs any time two vehicles moving within 30° of the opposite direction hit each other. Unless either vehicle is traveling in reverse, both will take damage to their front sides. Collision speed is the sum of the two vehicles' speeds.

A *rear-end collision* occurs any time two objects moving within 30° of the same direction hit each other. Collision speed is the speed of the faster-moving, or "striking," object minus that of the slower, "struck," object. Unless one object is going in reverse, the striking object will take damage to its front, and the struck object to its back. Calculate damage normally, except that the struck object cannot *inflict* more damage than the striking object.

A *T-bone collision* occurs when an object moving in one direction hits another in the side. Collision speed is based on the speed of the striking object – the one that hit the other vehicle in the side. Normally, the striking object will take damage to its front and the struck object to its side. A T-bone collision involving aircraft, spacecraft or submarines may also result in one vehicle striking another in the top or underside. Calculate T-bone damage normally, except that the struck object cannot do more dice of damage than the striking vehicle inflicted.

A *sideswipe* occurs when one vehicle drifts or skids into another object, so that both sides scrape against each other. Damage is to the striking sides of both objects. Collision speed is the sum of both speeds if they are going in different directions, or the speed of the faster object minus that of the slower if they are going in the same direction. A sideswipe involving submarines, spacecraft or aircraft may also result in one craft's top striking the other's underside. Calculate dice of damage normally, and then divide by 4, rounding down.



Special – Vehicles with Legs

A vehicle moving on legs can step over or stomp on an object that has a Size Modifier two or more less than its own; this is *instead of* colliding with it.

Stepping over the obstacle harmlessly evades it, while stomping on it may inflict damage. The victim can Dodge to avoid a stomp. Otherwise, a stomp does damage as per *Kicking* (p. 188), but at +1 damage per ton of vehicle weight (or fraction thereof). This doesn't count as an attack, but a vehicle can only stomp one target per two legs unless it is very large, in which case a single leg's stomp will cover (leg surface area/100) 1-yard hexes.

Note that if another vehicle initiates a ground collision with a walker large enough to stomp it, collision damage is applied to the walker's legs.



Collision Aftermath

A vehicle involved in a collision may require a hazard control roll (see p. 148) as a result of the impact damage from the collision. See *Overruns* (below) for an exception to this.

In a sideswipe, both objects will keep going in the same direction as before (assuming they survive the damage and the hazard rolls).

In a head-on collision, both objects will come to a dead stop unless one inflicts twice the damage of the other, in which case the object that did more damage continues moving, while the other object is knocked aside and (if a vehicle) must make a control roll at -4, modified by collision impact damage (see p. 148).

In a T-bone collision, both objects have their speeds cut in half unless the striking object inflicted twice the damage of the struck object, in which case its speed is unaffected, and the struck object (if a vehicle) is knocked aside and automatically suffers the worse result on the appropriate *Loss of Control* table – e.g., "Vault" for ground vehicles, or "Disaster" for air vehicles. *Exception:* If the striking object inflicts less than 5% of the struck object's hit points, it merely bounces off and comes to a stop, while the struck object continues on its way unobstructed.

In a rear-end collision, the two objects have their speeds averaged together unless the striking object inflicted twice the damage of the struck object, in which case its speed remains the same, and the struck object (if a vehicle) is knocked aside and must make a control roll at -4, modified by collision impact damage (see p. 148).

Overruns: If the striking object in a T-bone or rear-end collision, or either of the objects in a head-on collision, has a Size Modifier that is 3 or more greater than that of the other object, *and* inflicts twice the damage it suffers, it *runs right over* the other object! The object performing the overrun does additional damage to the object it is running over as if trampling (see p. B142), except that vehicles add a further die of damage for each additional ton of weight over 5 tons! Against another vehicle, this damage is applied to the top of the vehicle. The overrunning vehicle continues on with no loss of speed. There is no need to check for loss of control.

Hitting Buildings and Immovable Obstacles

If a vehicle or other moving object hits a stationary object like a wall, rock or iceberg that is too big to push aside, it inflicts its normal collision damage on it (like a T-bone) but it *takes* the same damage, up to a maximum of the damage it inflicted or the sum of the structure's HP and DR, whichever is less.

For the effects of damage on buildings, see *Damaging Buildings* on p. 166. If the vehicle can make a big enough breach in the structure, it can keep on going right through it – for breaches and building hit points, see p. 167.

But even if a vehicle crashes through, it decelerates immediately by [(HP + DR of barrier)/damage rolled] × pre-crash speed in mph, rounded to the nearest half or whole number. For example, suppose a tank moving at 20 mph hits a barrier with 66 hit points and inflicts 840 points of damage. The tank would decelerate by (66/840) × 20 = 1.56 mph, rounded up to 2 mph. In other words, it would crash through and hardly be slowed!

Immovable Objects: If a vehicle hits the ground, a hill or the like, it simply takes (its own body HP × collision speed in mph)/200 dice of damage. Reduce damage by -2 per die for collisions with water or -1 per die for collisions with snow, soft mud, etc.

Sails and Wind (Continued)

Sail Handling: A skilled crew may sail faster, by better handling the sails; conversely, poorly-skilled crews are unlikely to get the most out of their vessels. If more than one person is required to man the sails, use the average of the helmsman's Shiphandling skill and the average Seamanship skill of the sailing crew. One roll is allowed each minute in a tactical situation or race, every day for a long voyage. A critical success adds 10% to speed. A success allows normal speed. A failure slows speed by 10%. A critical failure slows speed by 20%.

Gales: While strong winds will blow a ship faster, there's always too much of a good thing. If wind speed is gale force or greater, roll vs. the average Seamanship skill of the sailors every ten minutes. For every point the roll fails by, the masts lose 10% of their *original* HT. In a severe gale, the crew may wish to step down the masts and stow the sails (this takes about 5 seconds per sf of sail area) and ride out the storm.

Staying on the Ground

Most aircraft can set their control surfaces to "spoil" lift. If the pilot of a winged vehicle wishes to travel at a ground or water speed that exceeds its stall speed, but does *not* wish to take off, he may do so. Keeping the plane on the ground requires a Piloting roll on any turn that the plane accelerates or maneuvers, and every turn on rough water or terrain.

The Sound Barrier

The speed of sound (Mach 1) is 760 mph at sea level, somewhat less as altitude increases. Aircraft moving at transonic speeds will experience increasing turbulence that acts to slow them down.

Vehicles that do not have Superior or better streamlining and which attempt to exceed Mach 1 (through diving, for instance) must make a HT roll on *every* turn that they exceed 650 mph, at -1 per 50 mph over that speed. Failure causes the aircraft to take 1d of damage per ton of mass (or fraction thereof) to its body, rotors, airscrews and wings. Armor does not protect against this damage. In addition, the aircraft will suffer a deceleration of 20 mph every turn and must make a Hazard roll to avoid losing control.



High Altitudes

At very high altitudes atmospheric pressure will decrease – see *Atmospheric Pressure* on p. 166.

On Earth, an unprotected human will have trouble breathing past 3,300 yards, and will also suffer from cold. If the vehicle lacks a lifesystem, double fatigue costs for any exertion between 3,300 and 5,000 yards. Past 5,000 yards, an oxygen mask (or life support) is needed and use the rules for freezing (p. B188). On alien worlds, multiply these numbers by the air pressure in Earth atmospheres at sea-level. If the aviators have only oxygen masks rather than limited or full life support, they only suffer from freezing.

Variable-Sweep Wings

An aircraft with variable-sweep wings can adjust its wing position. There are three basic positions: back-swept, mid-swept and out-swept.

A variable-sweep aircraft may have manual or automatic wing sweep. *Manual wing sweep* (as on a MiG-23) takes the pilot a combat action and two seconds to change wing position by one step (back to middle to front or vice versa) during which he cannot maneuver. *Automatic wing sweep* (as on an F-14 Tomcat) does not require a combat action, the wings take only one second to change position, and the pilot can maneuver freely while they are doing so.

The normal stall speed and top speed of the aircraft assume its wings are swept back; these are referred to as the "swept-back" speeds. Altering the sweep of the wings to the mid- or out-swept positions will change top and stall speed and increase aMR. In general, back-swept wings are used for high-speed dashes, mid-swept wings are used for maneuvers at moderate speeds, while out-swept wings are used for landings, takeoffs and low-speed maneuvers.

Back-Swept Wings: An aircraft can only sweep its wings back if its wings are in the middle position and it is moving faster than its swept-back stall speed. As stated, a variable-sweep aircraft with its wings swept back has normal top and stall speeds.

Mid-Swept Wings: If the aircraft has its wings in the back-swept or out-swept position and is currently moving at no more than two-thirds its swept-back top speed, the pilot may sweep its wings into the middle position. In this position, top speed and stall speed are only two-thirds of swept-back speed, and aMR is +0.5.

Out-Swept Wings: An aircraft with mid-swept wings and moving at half its swept-back top speed or less can move the wings to the "out-swept" position. In this position, top speed and stall speed are only half of swept-back speed, and aMR is +1.

Other Collision Rules

DR and Collisions: DR will always protect the vehicle, but the crew may get mashed up – see below.

Whiplash and Concussion: Any violent impact may jerk the crew and passengers around inside a vehicle, toss them through windscreens, or (at high velocities) result in broken necks even if they are securely strapped in. Assume that any collision in which the vehicle is brought to a halt, slowed by 20 mph or more, or spun out of control (but not one in which it pushes aside whatever it hit and keeps on going) does 1d-2 damage per 20 mph. This damage is not absorbed by armor (but the Toughness advantage does protect!) but can be reduced by safety devices and increased by lack of precaution. Double damage if not wearing safety belts! However, airbags, crashwebs and womb seats will protect against the damage.

If a person in a seat equipped with an airbag or crashweb suffers a crash at a collision speed of more than 20 mph, the airbag or crashweb automatically inflates. The airbag or crashweb reduces whiplash and concussion damage with an effective DR equal to its TL. However, the activated airbag or crashweb impedes vision and blocks movement (make a DX-2 roll each turn to get loose; until loose, you can't operate vehicular equipment), and TL7 airbags do 1d-3 cr. damage to the user as well. After a collision, TL7 airbags must be replaced at half cost, while TL8+ systems reset within 10 seconds. TL8+ crashwebs can also be voluntarily turned off by the vehicle operator, or have their crash speed reset from 20 mph to a higher speed. This takes 2 seconds (and is useful if contemplating ramming a vehicle).

If a person in a womb seat suffers whiplash or concussion, the womb seat reduces whiplash and concussion damage by an effective DR equal to *twice* its TL. This protection is cumulative with airbags and crashwebs.

Dogfighting Combat

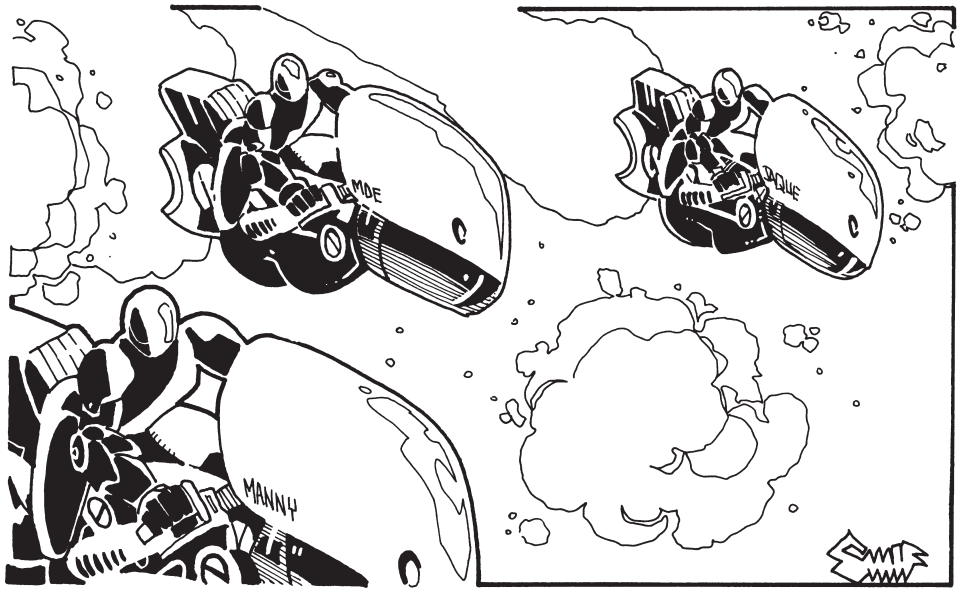
Aircraft speeds are so high that actually mapping out an aerial combat can be very difficult and time consuming. To simplify play, these "dogfight" rules can be used for purely aerial engagements between small numbers of aircraft. Note that while most of the rules in this book are very detailed, this system is intentionally abstract, and the GM should feel free to exercise dramatic license when using it!

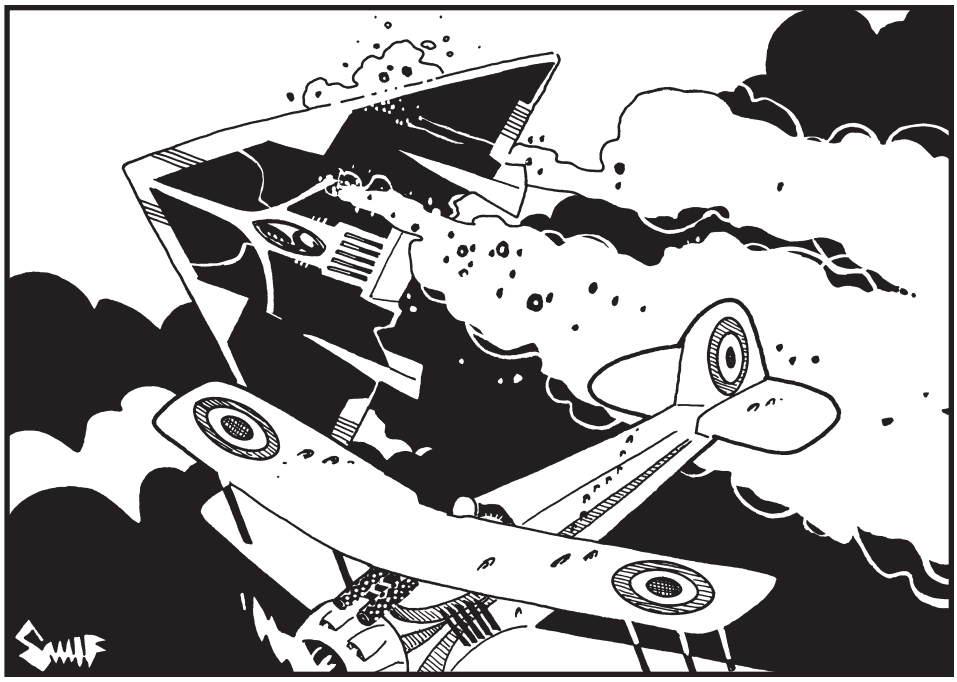
Dogfights consist of two phases: initial contact and the actual dogfight itself. They are divided into *rounds* of 10 seconds each.

Initial Contact

The GM decides on the range at which the encounter occurs, and on how quickly the aircraft are closing or passing. Range can be set at anything, while for simplicity, speed should be taken to be equal to one-third the sum of the aircraft's top speeds. Every 10 seconds, each aircraft gets a roll to spot the other – if it is within sensor or visual range – using the *Sighting and Detection* rules (see Chapter 13). As soon as one aircraft has detected the other, and regardless of whether it has been detected itself, proceed to the *The Dogfight* (below).

If there are multiple aircraft on either side, the range of the encounter is the same for all of them, and closing speed is calculated using the lowest speed in each group. If one enemy is detected, assume all of them are, by everyone in the group. This isn't realistic, but it is playable.





The Dogfight

A dogfight begins as soon as one aircraft has detected another and initiates air combat maneuvering. The 10-second rounds are still used. The dogfight consists of five steps: *Maneuvering Contest, Range Determination, Direct Fire, Guided Missile Fire* and *Detection.*

Step 1 – Maneuvering Contest

At the start of each round, the pilots roll a Quick Contest of Piloting skills. If one aircraft has not detected the other, its pilot does not roll and is assumed to automatically lose the contest; however, the first pilot must still roll versus his modified skill. Modifiers to each pilot's skill are:

+1 per 1 G *or fraction thereof* that the aMR of your vehicle exceeds that of your opponent's. A pilot does not have to use his full aMR – if he does, the acceleration may result in him passing out, with disastrous results (see the *GLOC* sidebar, p. 153).

+2 if you were closing on your opponent on the previous round and your opponent was retreating.

+2 if you have detected your opponent and he has not yet detected you.

+1 per *full* 5 mph/s by which your aAccel exceeds that of your opponent.

-1 per full 50 mph of stall speed. +2 if no stall speed!

A pilot who wins the contest by 5 or more, or via a critical success, selects his aspect from the *Aspect Table* below, and also chooses his opponent's aspect. The same applies to a pilot whose foe has not yet detected him and who makes his skill roll by 5 or more, or who rolls a critical success.

A pilot who wins the contest by 1-4 gets his opponent to choose one of the aspects on the *Aspect Table* – but may prohibit his opponent from taking *one* of these aspects (often "Closing: nose facing opponent.") if he wishes. The winner then chooses an aspect for his own aircraft from the table. The same applies to a pilot whose foe has not yet detected him and who makes his skill roll by 0-4.

If the contest is a tie, if both pilots fail their rolls, or if a pilot whose foe has not yet detected him fails his skill roll, aspect is determined randomly.

Aspect Table

1 – Retreating: your tail (back) facing opponent.
2 – Neutral: your left side facing opponent.
3 – Neutral: your right side facing opponent.
4 – Neutral: your top facing opponent.
6 – Neutral: your underside facing opponent.
6 – Closing: your nose (front) facing opponent.

EXAMPLE

Morgan is dogfighting an enemy Harrier jump jet. Her modified skill roll is 19, and she rolls a 10. The enemy pilot's modified skill is 15 and he rolls a 9. She has won the contest by 3. She tells her opponent, "Pick any aspect except closing." Her opponent decides on neutral, his left side facing Kitty Hawk. Morgan then selects closing, her nose facing the opponent.

Ejecting

Most TL7+ military aircraft, and some other vehicles, incorporate ejection seats as a means of escaping a doomed craft. TL7+ hypersonic craft and spacecraft are generally equipped with crew escape capsules instead.

A person strapped into an ejection seat can activate it in one second. This counts as his action for the turn; however, if one crewman is unconscious, another crewman can eject them both. Jettisoning an escape capsule also counts as action, usually on the part of the vehicle's commander, and ejects the entire crew.

In the case of an ejection seat, the seat's rocket blows the canopy off (or a portion of the roof, if no canopy). This compromises life support, NBC kits and waterproofing. In a flying vehicle, ejecting will also compromise aerodynamics – a control roll must be made if someone other than the pilot ejects (if the pilot ejects, the vehicle is out of control anyway. . .). In the case of an escape capsule, the vehicle is automatically disabled.

The GM should determine what will happen if someone tries to eject while underwater. Depending on depth and pressure, the ejection seat may pop the character out, or it may fail to clear the vehicle entirely. Escape capsules will always jettison underwater, but will immediately flood and sink unless they are sealed. In all cases, the vehicle will be flooded.

An ejection seat has only a 50% chance (1-3 on 1d) of working if the body or subassembly housing it is disabled. If not, the seat, canopy, etc., is stuck and the occupant can't get out. He can try a ST-6 or Mechanic-6 roll to unjam it each turn . . . this can get desperate if the craft is on fire or out of control. Escape capsules are more robust, and are only disabled with the body or subassembly if a 6 is rolled on 1d.

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Ejecting (Continued)

An ejection seat blasts the user and his seat out with an acceleration of about 16 gravities, boosting him 80 yards up in a single second. See *GLOC* (p. 153) for the HT roll needed to avoid passing out; a character in an ejection seat is treated as if he were in a G-seat, whether he is or not. An escape capsule is simply blown free of the vehicle, but at hypersonic speeds, this still requires the HT roll mentioned above!

In early-TL7 ejection seats (circa 1950-1970), the user must disentangle himself from his seat and deploy his own parachute, which takes 2 seconds per attempt and a successful Parachuting roll, and can only be attempted if the user is conscious. Since most people will pass out from 16-G acceleration, the seat is not very safe at low altitudes – the user may hit the ground before his chute can be opened. If this happens, or if he isn't strapped in when he ejects, the character suffers a fall from an altitude of 80 yards plus the altitude of the craft. If the user *does* manage to deploy a parachute in time, use the normal Parachuting skill rules (p. B48) to determine whether a safe landing was achieved.

This problem was solved by late-TL7 (post-1970s) "automatic" ejection seats, which automatically open a parachute 1 second later, whether the user is conscious or not. Such a seat is much safer at low altitudes and is the only type really practical for ejection from ground vehicles.

Vehicles with rotors cannot use normal ejection procedure, since anyone ejecting would be chopped up by the rotor! A typical rotor-ejection system ejects the user 25 yards downward (TL7) or sideways (TL8), whereupon the chute opens automatically. This is obviously of limited use at low altitudes, but can be better than nothing! Some helicopters use a system that blows the rotors off instead; this allows upward ejection, but automatically destroys the rotors.

Ejection capsules (late TL7) are an integral part of the vehicle, usually the cockpit. Capsule chutes always deploy automatically. Once the capsule is blown free of the vehicle, the vehicle is disabled; if the vehicle was moving faster than the speed of sound, or in space, assume that it disintegrates unless it can make a HT-6 roll.

Step 2 – Range Determination

Top speed played no part in determining the maneuvering contest, but now it comes into play! The GM determines the range (measured in yards) separating the opponents. This range is the same as it was on the previous round (if this is the first round, it is the initial encounter range), modified as follows:

Both aircraft are closing: The range decreases by 1d yards times the sum of their top speeds in mph. If range is reduced to zero or below, one aircraft may try to initiate a head-on collision. This can be avoided with Dodge roll.

One aircraft is closing and the other is neutral: The closing aircraft may reduce the range by any amount up to either five yards times his top speed in mph, or the actual range, whichever is *less.* If he can reduce the range to zero, he can choose to initiate a collision – the other aircraft gets a Dodge to avoid it, and if not, a T-bone collision occurs.

One aircraft is closing and the other is retreating: The faster aircraft may increase the range (if retreating) or reduce the range (if closing) by any amount up to five yards times the difference in top speeds in mph. Again, if he can reduce the range to zero, he can choose to initiate a collision – the other aircraft gets a Dodge to avoid it, and if not, a rear-end collision occurs.

In any of the above three cases, if the range drops below zero, reverse the facing of the two aircraft, with a range equal to the difference. Thus, if two aircraft were closing nose-to-nose and range dropped to -200 yards, the range would now be 200 yards and they would be facing tail-to-tail.

Both aircraft are neutral: Roll 1d. On a 1-3, range increases by 1d yards times the difference in speeds in mph; on a 4-6, range increases by 1d yards times the sum of their speeds. (Note that the random result allows for one aircraft flying inverted.)

One aircraft is retreating and the other is neutral: The retreating aircraft may increase the range by any amount up to either five yards times his top speed in mph, or the actual range, whichever is less.

Both aircraft are retreating: The range increases by 1d yards times the sum of their top speeds in mph.

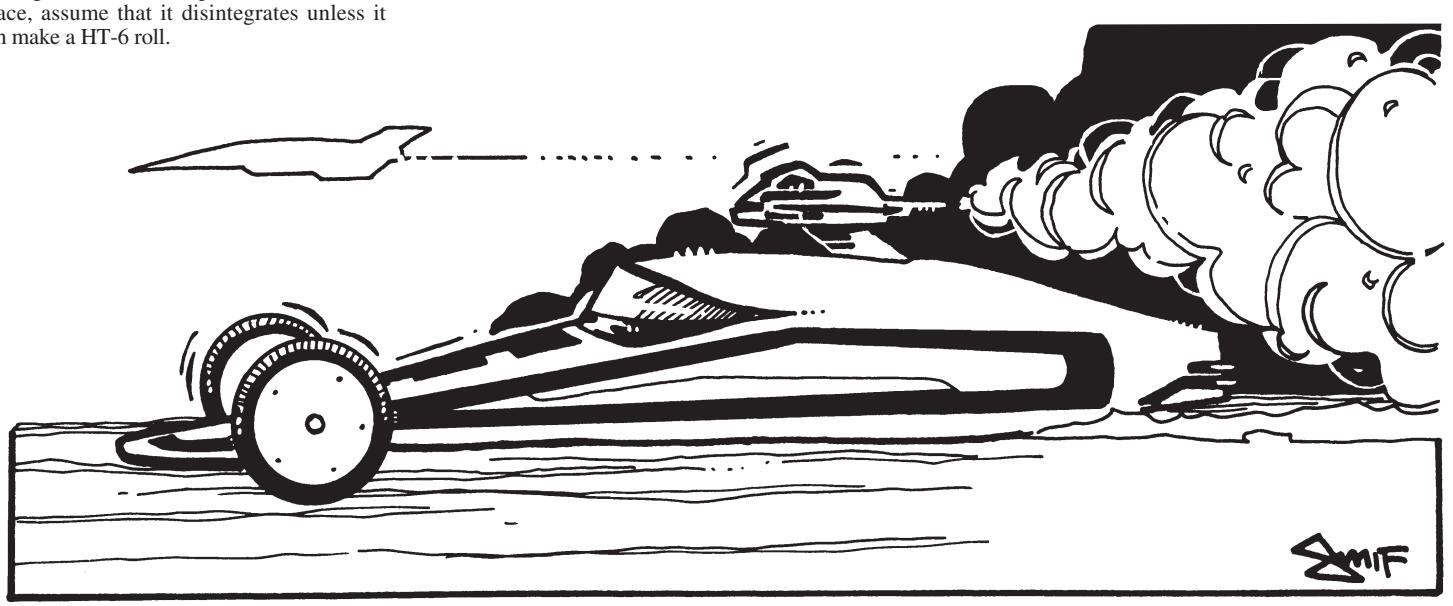
Keep a record of the range – it will set the range for the next turn.

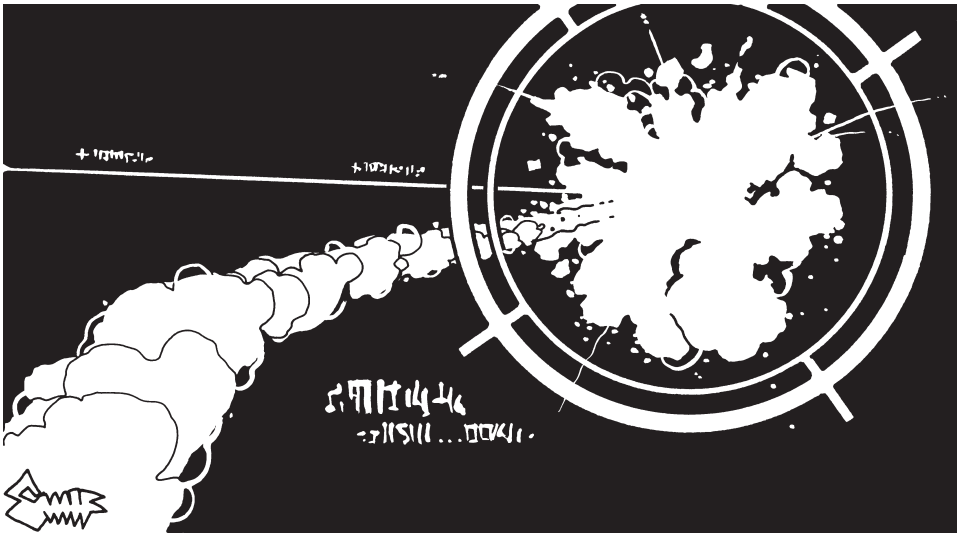
Step 3 – Direct Fire

Pilots who are closing on their opponents fire first, followed by those of neutral aircraft, followed by those in retreating aircraft. On a tie, the effects of fire are simultaneous; the GM can resolve the actual shooting in whatever order is desired. Note that an aircraft that has not yet detected its enemy cannot Dodge; as well, an aircraft cannot fire unless it has detected its enemy visually or with a targeting sensor (*Targeting via Sensors,* p. 171).

How a pilot's aircraft faces his opponent's determines what weapons he can fire, based on their normal arc of fire. How an opponent's aircraft faces him determines which side his weapons will hit. Weapons can only fire if the enemy is within range and arc of fire: most weapons on fighters can only fire if the front of the aircraft is facing the enemy. Resolve *one turn* of fire – most of the 10-second round was spent maneuvering.

Gun, beam and unguided missile fire is resolved using the normal ranged combat rules, but apply a -4 penalty on weapons *not* fired by the pilot into the forward arc. Calculate the Speed/Range modifier normally, except that Speed is assumed to be half the target aircraft's top speed (this represents an average of the changing speeds during maneuvering). A character can also designate some weapons for "point defense" fire – these will be reserved to shoot at incoming missiles, if any.





Step 4 – Guided Missile Fire

A guided missile can be fired in a dogfight if the range is no greater than 10 yards times the missile's Spd statistic, the target is within its arc of fire, and the missile does not use inertial, communicator, TV or wire guidance.

Note that a pilot who has not detected his enemy cannot fire at all. If he has detected his enemy, but not with a targeting sensor, he can only fire brilliant missiles. If he has detected enemy sensors or missiles, but not his enemy, he can Dodge or use decoys against those missiles, but cannot fire. *Exception:* Missiles with ARM guidance *can* be fired at an undetected foe whose radar or radio has been detected.

Resolve guided missile fire *after* gun or beam weapons fire (Step 3). All missile fire is simultaneous. Remember, some missiles have a minimum range: getting in close can prevent a missile shot.

If a missile requires a roll to track its target, make the roll. If the target can use countermeasures, give him one attempt to deploy them and see what happens. If the missile succeeds in its tracking roll and is not decoyed, assume it hits. If any target aircraft weapons are facing the firing aircraft and were dedicated to point defense, they can shoot at the missile. If not shot down, the missile will strike whatever aspect of the target the firing aircraft is facing. The target gets a Dodge roll to avoid this. If it succeeds, the missile will miss.

Step 5 – Detection

If one craft has not yet detected the other, it may now roll again for detection, as described in *Initial Contact* (and in Chapter 13). Detection rolls can also be made to spot missiles, etc. Note that if one aircraft is behind another, it may be out of its arc of vision (or that of its sensors), depending on how that craft is designed and crewed.

Ending the Dogfight

The dogfight ends when the enemy aircraft are destroyed (or surrender!), when both aircraft move out of maximum sensor range or voluntarily decide to stop fighting, or when fuel runs out (assume aircraft use up fuel at 1 percent of their maximum hourly rate per round of combat).

Multiple Aircraft Dogfights

These dogfight rules work best as a duel with two aircraft. Once the fight begins, break the aircraft up into one-on-one duels. If there are leftovers, they may form into "flights," ganging up as desired on single enemy aircraft. For maneuvering and range, a flight is treated as a single aircraft. Skill rolls are made against the average of all pilots' modified skills, and speed is based on the *lowest* of their top speeds.

Other Considerations

Range abstracts altitude for these purposes. If altitude over ground is important (e.g., when a character wants to bail out) the GM can select an altitude, or assume that the current altitude is 2d-1 yards times slowest aircraft's top speed in mph.

Traveling Dogfights

Sometimes, one vehicle is fairly close to an objective, while the other is trying to intercept it. The GM can rule that a certain number of rounds are needed for a dogfight to reach that destination.

If one aircraft must go in a certain direction, it will be at -3 in the maneuvering contest since, while it can lead the enemy the way it wants to go, it is still restricted. If the aircraft doesn't take that penalty, it doesn't get any closer to where it's going.

Dusting and Toasting

Vehicles with vectored thrust propulsion or rotors can do unpleasant things to people below them . . .

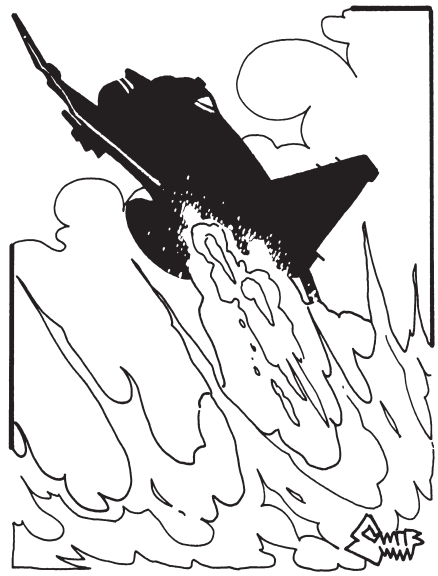
Dusting

A helicopter's rotors stir up dust and debris below it. The radius of this effect is equivalent to the linear dimension of the helicopter's Size Modifier. In the area immediately below a helicopter (the helicopter must be hovering at less than 10 yards altitude), the wash from its rotors will disperse smoke screens and dust clouds, blow papers and hats around, etc. Anyone in the open trying to concentrate on anything (firing weapons, etc.) will be at -1 on skill; for boats, treat it as a 30 mph wind.

Toasting

All reaction engines and TL9 reactionless thrusters have a dangerous exhaust. Anyone directly behind an operating engine of this type (this applies to anyone *below* the engine, if the vehicle is a vertol) will take 1d damage per 1,000 lbs. of thrust. Damage is quartered for every 2 yards of distance from the engine, except for a pion drive, which is treated as an energy beam with 1/2D range equal to dice of damage and Max range equal to three times 1/2D.

A hovering (0 speed) vehicle with a vectored thrust reaction engine may swivel its engines to toast someone directly beneath it with the exhaust. Treat this as a ranged attack with SS 20, Acc 0, and damage and range as above, using Piloting-4 instead of weapon skill.



Ground-to-Space Capability

To put something into orbit, it is necessary to fly at orbital velocity. For planets, this is 17,800 mph × the square root of (M/R) where M is its mass in Earth masses, and R is its radius in Earth radii. Escape velocity is 1.414 times the orbital velocity.

If air speed is higher than orbital velocity, a vehicle can fly into orbit. If top speed is lower, it can still reach orbit if it has a sAccel rating and its space propulsion system can operate for the necessary time; the required time (in seconds) is [orbital speed (in mph) - top speed (in mph)]/[21.8 × sAccel (G)]. This assumes the vehicle has a lift system that will operate at speed independent of the engine, such as wings or contragravity. If the engine must also lift the vehicle, subtract local gravity (G) from sAccel. Use the same procedure for reaching escape velocity, substituting it for the orbital velocity.

Space-to-Ground Capability

There are two steps involved in getting down from orbit: shedding orbital velocity and making a soft landing.

For a planet with no atmosphere, the only way to shed velocity is with a vehicle that has a sAccel rating. Use the same rules as for entering orbit, except that there is no need to worry about supplying lift. Once the vehicle has killed its orbital velocity, it lands safely if it can maintain a sAccel greater than the local gravity for at least 30 seconds.

For a world with an atmosphere, velocity can be shed as above, or alternatively via aerobraking. Time required to do this is equal to (orbital velocity - top air speed)/1,500 minutes. This maneuver requires a Piloting (Aerospace) roll to perform. A great deal of heat is generated: the vehicle takes (4 × minutes spent aerobraking) points of fire damage to the underside of its body, its wings, and any subassemblies mounted under the body or on the wings, and one-quarter that damage to other subassemblies. Standard ablative armor will burn off, but fireproof ablative armor or any other nonflammable armor survives intact. If the Piloting roll failed, multiply the damage to each location by the amount the roll failed by! On a critical failure, treat as a failure by 20.

After aerobraking, the vehicle can be assumed to be about 15,000 feet up and moving at its top air speed or terminal velocity. It makes a soft landing as a normal aircraft. This usually requires wings, contragravity, parachutes or lift engines; otherwise, refer to the rules for crashing.

Congested Areas

Use these rules if the GM rules the fight is taking place within or has traveled into a "congested area" like a city, canyon or sci-fi asteroid belt. A fight in a congested area is treated as a normal dogfight with two exceptions:

1) An aircraft that gets a critical failure on a Dodge or in the maneuvering contest is assumed to have had a head-on collision with a solid object at half its top speed – and is normally out of the fight.

2) A pilot can, before the Quick Contest, declare that he is making a "wild maneuver," such as a surprise swing between two narrowly-spaced buildings at high speed. A wild maneuver adds +2 to Piloting skill for the purpose of winning the maneuvering contest, but *any* failed Piloting skill roll results in a collision as described above, and a critical failure does double damage. Note that it is possible to lose the Quick Contest of Piloting without failing a Piloting skill roll.

At any time the GM can rule that the fight has left the congested area, or both pilots can mutually agree to do so.

Spacecraft Dogfights

In a space dogfight, treat the spacecraft as aircraft, except that top speed is assumed to be equal to 4,000 mph × sAccel (in G), sMR = sAccel, and the bonus for greater Accel is measured in 0.25 G increments instead of 5 mph/s increments.

Space Travel

In space, a vehicle that accelerates in one direction will retain its velocity until it cancels it by accelerating in the opposite direction. Changing the direction the vehicle is facing will not affect this.

The normal rules for maneuvering do not apply in space, since there is no friction, nor is top speed a factor (assuming the spacecraft does not approach the speed of light).

Long-Distance Space Travel

To determine the time required for a space voyage, decide how long the vehicle accelerates for and calculate the speed that gives it. Then divide that by two (to allow for deceleration). Trip time is the larger of the selected acceleration time, or (distance/speed).

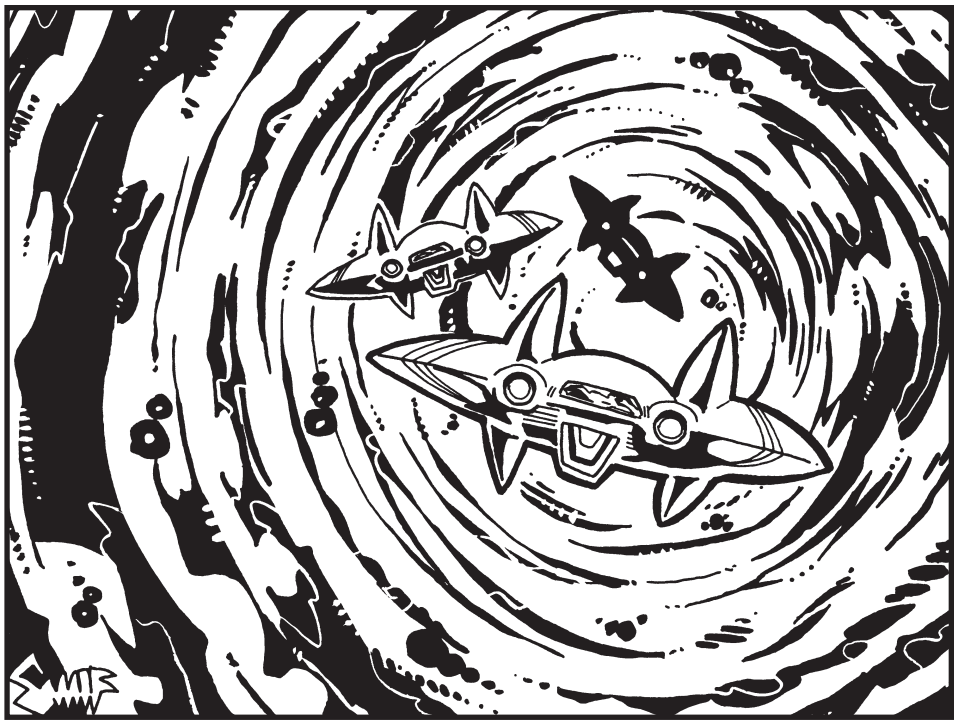
For reactionless drives where fuel consumption is unimportant, and assuming constant acceleration to a mid-point, followed by constant deceleration to slow down, the travel time (T) in hours is given by:

T = Square root of [0.0000508 × (D/A)]

where *D* is the distance in miles and *A* is the acceleration in G.

For simplicity, see the table below from ***GURPS Space*** for constant acceleration trips, where distances are measured in AU (astronomical units). An AU is the average distance from Earth to the Sun, about 93,000,000 miles.





Travel Times with Constant Acceleration Table

	Acceleration					
Distance	*0.0001 G*	*0.001 G*	*0.01 G*	*0.1 G*	*1 G*	*2 G*
0.2 AU	4.5 months	5.7 wks	1.8 wks	4 days	31 hrs	22 hrs
0.5 AU	7 months	9 wks	2.9 wks	6.3 days	2 days	34 hrs
1 AU	10 months	13 wks	4 wks	9 days	2.8 days	2 days
2 AU	14 months	4.5 months	6 wks	13 days	4.1 days	2.8 days
5 AU	23 months	7 months	9 wks	2.9 wks	6.3 days	4.5 days
10 AU	32 months	10 months	13 wks	4 wks	9 days	6.3 days
50 AU	5.5 yrs	23 months	7 months	9 wks	2.9 wks	2 wks
100 AU	7.8 yrs	32 months	10 months	13 wks	4 wks	2.9 wks

When time is of the essence, the duration (T) and distance (D) are both fixed, and the necessary acceleration in G (A) is given by:

$$A = (0.0000508 \times D)/(T \times T).$$

When a spacecraft travels this way for a fixed time (T) at an acceleration in G (A), the distance covered (D) is given by:

$$D = 19{,}700 \times A \times T \times T.$$

Advanced Hex-Grid Movement

For space movement on a hex grid when not using the simplified dogfight rules, it is suggested that either a rubber hex mat and a water-soluble marker or a sheet of plastic-covered hex paper and a grease pencil be used. This allows courses to be plotted and then rubbed off as necessary.

Movement: The following rules assume 5-yard hexes and 1-second turns; see below for more reasonable scales for space movement. Space movement is a three-step process:

Step 1: If the spacecraft was already moving, project the course the ship took on the previous turn forward the same distance and direction. Then move the vehicle to that hex.

Step 2: The pilot can *then* accelerate if he wishes, moving the vehicle a number of additional hexes equal to or less than its sAccel rating (in gravities).

Step 3: Record the ship's course by drawing a line from the hex it started in to the present hex it occupies. Erase the last turn's course. This line indicates the distance and direction the ship will have to move in Step 1 of its *next* turn.

Note that in all cases, the facing of the ship is irrelevant to its actual course.

Suggested Scale: Distances in space are great enough that the normal 1-second turn and 1-yard or 5-yard hexes are inappropriate for resolving space battles and chases.

A suggested scale for space combat is 1,000 miles (1,760,000 yards) per space hex and ten minutes per space combat round. This means that every G of space acceleration produces a velocity change of approximately 2 space hexes per space combat round. (Note that these numbers are rounded off in the interests of playability!) Remember: accelerating for a full 10 minute turn uses 10 minutes of fuel! These figures also make it easy to convert range and rate of fire statistics of weapons. See *Space Combat* in the *Combat* chapter for rules for fighting within a 10-minute space combat round and for the effects of space on weapon ranges.

Control Rolls for Airships and Large Watercraft

While an automobile can operate with only a single person manning the wheel, sailing vessels and airships require a team of aircrew or sailors in order to maneuver properly. Whenever a control roll is called for on a vessel with sailor or rigger crew members, average the skill of all sailors or riggers with that of the person manning the maneuver controls. Having less than the *necessary* crew will also modify control rolls:

Necessary crew under 3/4 strength . . . . . -1
Necessary crew under 1/2 strength . . . . . -2
Necessary crew under 1/4 strength . . . . . -3
If normal crew is 10 or more,
and only one person . . . . . -5

Battlesuits at Low Speed

If a battlesuit's top speed is no greater than twice its acceleration, then it can be treated as a human for movement purposes instead of as a vehicle! This can be more playable.

Extreme Environments

The vehicle rules assume vehicles will go into action on an Earth-like world: 1-G gravity, oxygen-nitrogen atmosphere with one atmosphere of pressure, and an Earth-like temperature range

But what about other planets, or extreme environments on Earth?

GURPS Space gives very detailed rules for the effects of alien environments on individuals. These rules expand on ***Space*** to cover vehicular operations.

Extreme Temperature

Engines and fuel tanks using gasoline or diesel fuel must be kept heated in very cold environments before they can start. Unless the engine was left running (using up fuel), increase the time to start by a factor of 20. Diesel-fuelled engines require heating at 20°F or lower; gasoline engines only at temperatures well below 0°.

At TL7+, insulation is good enough that any sealed vehicle with a life system can withstand any degree of cold, even that of an iceball world in interstellar space, as long as an energy bank or power plant can run the heater. Again, as long as power exists to run air conditioning, TL8+ vehicles with limited or full life systems and at least DR 70 armor can travel across deserts hot enough to melt lead.

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Extreme Environments (Continued)

High and Low Gravity

Even if a vehicle's body can remain intact and its passengers can breathe, gravity will still affect vehicle performance. A vehicle's loaded weight will change as gravity changes (multiplied by gravity). This will affect ground pressure, stall speed and lift, but *not* a vehicle's flotation, top speed, acceleration or deceleration, which actually depend on mass rather than weight.

Atmospheric Pressure

Air-breathing engines, and airscrews, ornithopter motors and helicopter drivetrains, are effectively useless in atmospheres with a pressure under one-half atmosphere (this includes extremely high altitudes on Earth). Vehicles cannot use them for power, lift or propulsion.

Atmospheric pressure will have an additional effect on the performance of most flying vehicles. Divide stall speed by atmospheric pressure. In vacuum or trace atmospheres, winged, or rotor flight is impossible, as is lift from lifting gas. However, all vehicles are treated as having "radical" streamlining due to the lack of air resistance.

Life Support

Life support is needed for people to function in a non-oxygen-nitrogen atmosphere, or in an oxygen-nitrogen atmosphere at below 0.5 atm or above 1.5 atm (1 atm = Earth air pressure). This includes underwater and at stratospheric or higher altitudes. Areas contaminated with chemical and biological weapons (or extreme pollution, volcanic ash, etc.) are also dangerous. In any of these environments, the occupants must be in internal seats (or battlesuits or quarters) with a limited or full life system, or the crew and passengers must wear appropriate protective gear. An NBC kit is also usable in a contaminated atmosphere where there is still atmospheric oxygen at sufficient pressure to breathe.

Leaks: In some atmospheres, leaks are a possibility even with good life support. Check for leaks once per week in areas contaminated by chemical or biological weapons, or mildly-corrosive atmospheres (e.g., high-oxygen or ammonia), once per day in hydrogen atmospheres or in corrosive atmospheres like chlorine or sulphur trioxide. In extreme temperatures, highly-corrosive atmospheres (like fluorine) or super-dense pressures, check once per hour! Also, check for a leak if a pressurized area of a vehicle is penetrated by an attack. A location (body, turret, etc.) that loses a large amount of hit points will automatically leak – see the *Combat* chapter.

Continued on next page . . .



Damaging Buildings

Vehicles will often crash into, out of or through buildings, or shoot at them. The *Collision* rules (p. 157) cover the damage a vehicle inflicts when it crashes into something. But what happens to the *building?*

Building Statistics

A building's ability to withstand damage depends on its type (framed or frameless), its DR, its hit points (HP) and its *breach capacity* (BC).

DR is the building's average damage resistance. It works just like normal DR.

Hit Points are the hit points of a single hex of wall. If damage equals or exceeds building hit points, it causes a 1-hex-wide hole – a *breach.* However, any damage from a single attack in excess of hit points "blows through" the building rather than inflicting any more damage *unless* the damage results from explosive concussion or a collision with a vehicle of Size Modifier +2 or greater. In this case, divide the penetrating damage by hit points to determine the total number of breaches inflicted on the building. There is no maximum if the damage was caused by an explosion; if caused by a collision, the maximum number of breaches is the Size Modifier of the colliding vehicle. New breaches are created alternately to the right and left of the original breach (and then upward or downward from it, if the building has additional stories above or below the breach). Keep track of the number of breaches that are formed in a building.

Breach Capacity is the number of breaches a building can take before collapsing into rubble. If damage to a single story exceeds breach capacity, that story and all stories above it will collapse.

Crashing Through Walls: If a vehicle drives into a building's wall, it does normal ram damage. If the vehicle has created as many breaches as its size modifier (minimum one breach) it crashes right into the building, and if still intact, can keep on driving out the other side (resolve another collision!).

Collapsing Buildings: A building whose breach capacity is exceeded takes three seconds to fall for every story tall it is. When the building collapses, everyone in it takes dice of damage equal to building (HP + DR)/4 per story of building height (it doesn't matter what story you are on: if you are on an upper story, you fall farther; if you are on a lower story, more weight crushes you). Anyone may make a DX roll to avoid damage (roll at -4 in a frameless building), with a +4 bonus for individuals in a basement. Anyone who survives will be trapped in the rubble, however. The building may also fall sideways, crushing vehicles or people outside. The GM should rule on this.

Fire: A building can be set on fire. Use the same rules as for vehicle fires (see *Fire and Explosion* on p. 184), with wooden buildings being more vulnerable. Fire damage to a building accumulates from turn to turn for the purpose of causing breaches.

EXAMPLE

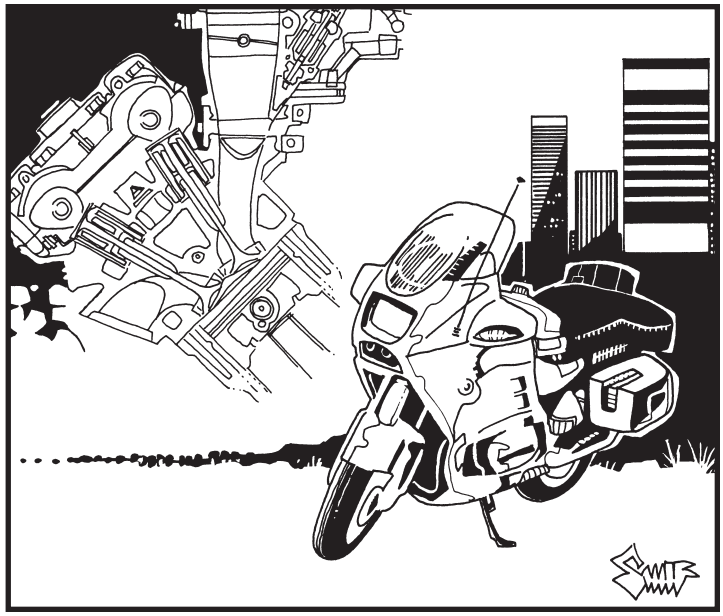
A meeting of the dastardly Sons of the Outer Dark is taking place in a well-guarded, heavy brick house (with DR 6, HP 60 and BC 12) in the mountains of Rumania. The house is so well guarded it would take a tank to break in. Morgan finds one, and after moving into range, opens fire with its 125mm gun. The first armor-piercing round whistles down range and does 600 points of crushing damage. The DR 6 stops only 3 hits (armor-piercing rounds, remember) and 597 hits penetrate into the house, but only 60 points of damage are inflicted, since the rest blows through. A single breach is inflicted.

As machine gun fire from the panicked guards rattles off the impenetrable tank armor, Morgan decides to load an HE shell. She fires. Direct hit! Kaboom! Compared to the AP round, it does only 240 points of damage. The armor DR is squared against HE (see p. 190), and stops 36 hits, leaving 204 points of damage. But since this is explosive damage, it inflicts 204 divided by 60 HP = 3 breaches! That was much better, she thinks. Three more shots and she'll reduce the house to rubble.

Unfortunately, black-market, ex-Red Army tanks aren't too reliable. Her next shot jams! Fluently cursing the Russian colonel who sold her this lemon, Morgan pauses to use the tank's machine gun to deal with a pesky cultist with a rocket launcher, then sets her face into a grim expression and orders the driver to accelerate. From within the building comes the sound of frenzied chanting, as the cult prepares to summon a demon.

The tank lumbers forward. As terrified Sons of the Outer Dark scamper out of the way, the armored behemoth crashes through the building's front door at 20 mph. With 2,400 body hit points, it inflicts 6d×40 crushing damage and scores 880 points of damage. The brick house's DR stops 6; the remaining 874 hits are inflicted on the building. That's 874/60 = 14 breaches, but the tank's Size Modifier is only +5, so it can inflict a maximum of 5. It crashes into the building, lurches, and drives on out the back, inflicting another 5 breaches. That's a total of 14. The building shudders, then collapses three seconds later, burying what's left of the cult and their demon under the debris.

Designing Buildings



There are two main types of buildings, framed and frameless.

A *frameless* building is supported by its walls, which are made quite strong to hold the structure up. Knocking large holes in a frameless building has a good chance of collapsing it. Frameless buildings are usually made of stone, concrete or brick, and are normally one to ten stories high.

A *framed* building is supported by a skeleton of wood or metal. Because the walls are not load-bearing, they can be very light: wood or even glass. While its easy to make holes in a framed building, a lot of breaches are needed to destroy it. Wooden-framed buildings tend to be 1-5 stories high, while glass-clad, steel-frame buildings normally range from 1 to 100 stories.

A *fortress* is a framed building with thick, armored walls. Combining the resilience of framed buildings with the thickness of frameless construction, fortresses are very hard to destroy!

DR and HP: This depends on the wall material. Typical DR and HP: wood (DR 4, HP 20), concrete (DR 4, HP 60), glass and steel (DR 5, HP 10), light brick (DR 6, HP 40), heavy brick (DR 6, HP 60), stone (DR 8, HP 90), thick stone (DR 8, HP 180), fortress (DR 100, HP 200).

Breach Capacity (BC): For *frameless* buildings, BC is equal to the building's length times its width (both in yards) divided by eight, regardless of height, with a minimum BC 1. For *framed* buildings or fortresses, BC equals the length times the width (also in yards) divided by four and multiplied by the number of stories it has.

Extreme Environments (Continued)

At each interval, roll 3 dice. Subtract 2 if the vehicle has heavy compartmentalization or 4 if total compartmentalization. In the case of damage that penetrates DR, roll at +6. Unless armor was penetrated, a high DR will reduce the chance of a leak as follows: DR 30-99 gives a -1, DR 100-299 give a -2, DR 300-999 gives a -3, DR 1,000 or more gives a -4. Use the vehicle's lowest DR, if it has more than one value. A modified roll of 14+ is a leak, a 17+ a fast leak, and an 18+ an explosive blowout. In a superdense atmosphere, any uncorrected leak will blow out at the next interval. Otherwise, add 3 to the next roll for a leak, or 6 for a fast leak.

Patching a leak is easy if it's detected. Corrosives can be detected by smell, but hydrogen or TL7+ biochemical weapons are odorless. If the vehicle has an NBC kit, its sensors will detect a leak on a roll of TL+4 or less. Chemscanners (see *Multiscanner* on p. 54) can also detect leaks.

Effects of a blowout depend on the type of gas. Chemical or biological weapons affect the occupants. Mild corrosives will cause 1d damage per minute until the vehicle is patched, and won't do controls or interior fittings any good, either. Severe corrosives, like chlorine or fluorine, will cause burning and poisoning – at least 3d damage every minute until patched – and will definitely damage electronics and fittings. Hydrogen has no effect on its own, but once it combines with oxygen in the vehicle, any spark will turn the vehicle into a fireball!

Patching a blowout or leak requires a minute, mechanic tools, and a Mechanic roll, at -4 for a blowout. Living metal bodies will automatically seal a leak within a few seconds of it occurring, so only a blowout is dangerous.

Radiation Protection

Radiation rules are given in ***GURPS Space,*** with a more detailed set in ***GURPS Grimoire.*** A vehicle with an enclosed body, and heavy armor (DR100+ laminate or metal) or a force screen, has a natural radiation protection factor (PF). This is based on the DR of the side facing the radiation (underside if going through a nuclear bomb crater, top if a nuke explodes overhead, etc.). Vehicles with sealed hulls get even better protection:

Radiation Shielding Table

Vehicle Protection	*Enclosed*	*Sealed*
DR under 100	1.5	2
DR 100-199	5	10
DR 200-399	50	100
DR 400-799	500	1,000
DR 800-1,599	5,000	10,000
DR 1,600-3,199	50,000	100,000

. . . and so on. Each doubling of DR increases PF by a factor of 10. Also, if the vehicle has superconducting armor on the side facing the radiation, and the radiation is primarily X-rays, UV or gamma rays, double its PF.

SIGHTING AND DETECTION 13

In any action situation, being able to find someone, or avoid being found, can be just as important as being able to fight him. Modern vehicles carry a wide array of detection and stealth systems. This chapter provides detailed rules for using them in adventures and combat.

Expanded Speed/Range Table

This table fills in the gaps on the Speed/Range table on p. B201. Use it for really long-range actions!

Speed/Range Table

Speed/Range Modifier	*Size Modifier*	*Linear Measurement – Size or Speed/Range (miles or mps)*	*(yards or yps)*
-25	+25	20	35,200
-26	+26	30	52,800
-27	+27	45	79,200
-28	+28	70	123,200
-29	+29	100	176,000
-30	+30	150	264,000
-31	+31	200	352,000
-32	+32	300	528,000
-33	+33	450	792,000
-34	+34	700	1.23 mil.
-35	+35	1,000	1.76 mil.
-36	+36	1,500	2.64 mil.
-37	+37	2,000	3.52 mil.
-38	+38	3,000	5.28 mil.
-39	+39	4,500	7.92 mil.
-40	+40	7,000	12.3 mil.
-41	+41	10,000	17.6 mil.
-42	+42	15,000	26.4 mil.
-43	+43	20,000	35.2 mil.
-44	+44	30,000	52.8 mil.
-45	+45	45,000	79.2 mil.
-46	+46	70,000	123 mil.
-47	+47	100,000	176 mil.
-48	+48	150,000	264 mil.
-49	+49	200,000	352 mil.
-50	+50	300,000	528 mil.
-51	+51	450,000	792 mil.
-52	+52	700,000	1.23 bil.
-53	+53	1 mil.	1.76 bil.

Abbreviations: mps = miles per second, yps = yards per second; mil. = million, bil. = billion. Speeds are usually expressed in mph: mps = mph/3,600 and yps = (approx.) mph/2.

Bearing

Successful sensor detection often gives a "bearing" on a contact. This is in relation to the vehicle. The GM can use "clock directions" to describe this; e.g., 12 o'clock is straight ahead, 3 o'clock is to the right, 6 o'clock is directly behind, 9 o'clock is to left, and so on. "High" is above the vehicle, "Low" is below it.

Electronic Sensing

These rules are used for electronic sensors: active and passive sonar, AESA and PESA, geophone, gravscanner, infrared and thermograph, ladar, MAD, multiscanner, and radar, including imaging and passive radar.

A character using an electronic sensor is a "sensor operator." A character can only use a sensor that is controlled by his crew station, but *can* use sensors while doing other things, like driving or firing a weapon.

Line-of-Sight Sensors

Line-of-sight (LOS) sensors require a direct line of sight to the target, who must also be in the sensors' arc of vision. They are subdivided into "active" sensors (those that emit some form of scanning energy, such as active sonar, radar, imaging radar, ladar, or AESA) and "passive" sensors (those that do not emit energy, such as vision, infrared, thermograph, passive radar or PESA). All LOS sensors are precise enough that the sensor can substitute for vision when navigating the vehicle, even in situations where vision is hampered (e.g., by darkness or bad visibility); however, LOS sensors are limited in two major ways:

(1) Arc of Vision: A LOS sensor can only detect targets in its arc of vision – that is, in the direction it is looking. Most sensors face forward, so they will use the arc of vision described on p. B115; if not, extrapolate the arc based on the side of the vehicle the sensor is pointing out of. Sensors on turrets or rotating open mounts will look in the direction their mount currently faces, but are treated as having "peripheral vision," since they can easily swing back and forth a few extra degrees. Turrets or open mounts containing nothing *but* sensors will rotate rapidly, scanning their entire 180° or 360° arc in a turn.

(2) Line of Sight: A LOS sensor requires a line of sight to an object in order to detect it. This line of sight is limited by the horizon (see below) and cannot pass through solid objects such as hills or structures.

Unless noted, sensor line of sight is not blocked by atmospheric conditions like clouds or fog, or by aerosols like smoke – but this is not always the case; see the modifiers for specific sensors in the sidebars.

Horizon: The distance at which a viewer can no longer see something because it has vanished behind the curvature of a planet or similar curved body is the *horizon.* LOS sensors cannot see over the horizon; neither can vision. Weapons fire is only possible over the horizon using guided missiles, torpedoes, or indirect fire.

A rough formula for determining the horizon in yards:

Horizon = Square root of [(D × 1,760 × H) + (H × H)].

Where *H* is the sum of object's and observer's heights, in yards above the local base level, and *D* is the planet's diameter in miles (Earth has a diameter of about 7,915 miles).

Indirect Sensors

These sensors consist of passive sonar, geophones, MAD, multiscanners and gravscanners. They do not require a direct line of sight to sense objects. They cannot be used for navigation on the ground, but may be adequate in space, in flight, in water or underwater. Indirect sensors do not suffer from arc-of-vision or line-of-sight restrictions. However, some sensors have their own unique limitations on what they can sense:

Geophones can only sense objects that are on or beneath the ground and *moving,* and only if the geophone itself is also stationary and on the ground.

Passive sonar can only detect objects if both sensor and object are floating or submerged in the same body of water. Moreover, a silent and motionless object can never be detected. However, an object moving or with a power plant (as opposed to energy bank) running is not silent! Note that some kinds of power plants, like nuclear reactors, are very difficult to shut off, while others, such as diesel engines, can be turned on or off rapidly.

MAD can only detect objects that are mainly ferrous metal (assume this means any object with TL6- metal armor, or any cheap or standard TL7 metal armor) or which radiate a very strong magnetic field: an object with an MHD or fusion power plant, or mag-lev, fusion rocket or fusion air-ram propulsion qualifies, as does any object that has just fired a charged particle beam, flamer or fusion gun, or an electromag gun such as a Gauss gun or railgun.

Gravscanners detect objects by their minute gravitational field. A target can only be distinguished enough from other objects (like buildings or rocks) if it is moving, or if it is using gravity-based technology (except for other gravscanners), including grav weapons, tractor beams, artificial gravity, grav compensators, deflector shields and contragravity lift.

Multiscanners must be set to radscanner, bioscanner or chemscanner mode. Radscanners only detect energy sources, bioscanners only detect life forms, and chemscanners must be set to detect a particular chemical compound. Furthermore, bio- and chemscanners only detect the nearest object in that category: known objects in a category can be screened out.

Sensor Rolls

If an important object is detectable by a sensor, the GM should make a skill roll to see if a NPC or PC notices it. Although sensor detection rolls take no "time," the GM decides how often new attempts are permitted in the case of a failed roll.

If several sensor operators on the same side can detect the same object, the GM may wish to roll only for the ones who have the best chance of detection, and skip the others, or use the "simple detection" system described below.

The interval at which sensor rolls are made is up to the GM, and should be adjusted to suit the tempo of the situation. For instance, in a tense combat situation fought in one-second turns, allow a roll every second; in a dogfight using 10-second rounds, roll every 10 seconds. In a more slowly-developing situation, like a long-range naval or air engagement, checking every minute, 10 minutes or even every hour may be more appropriate.

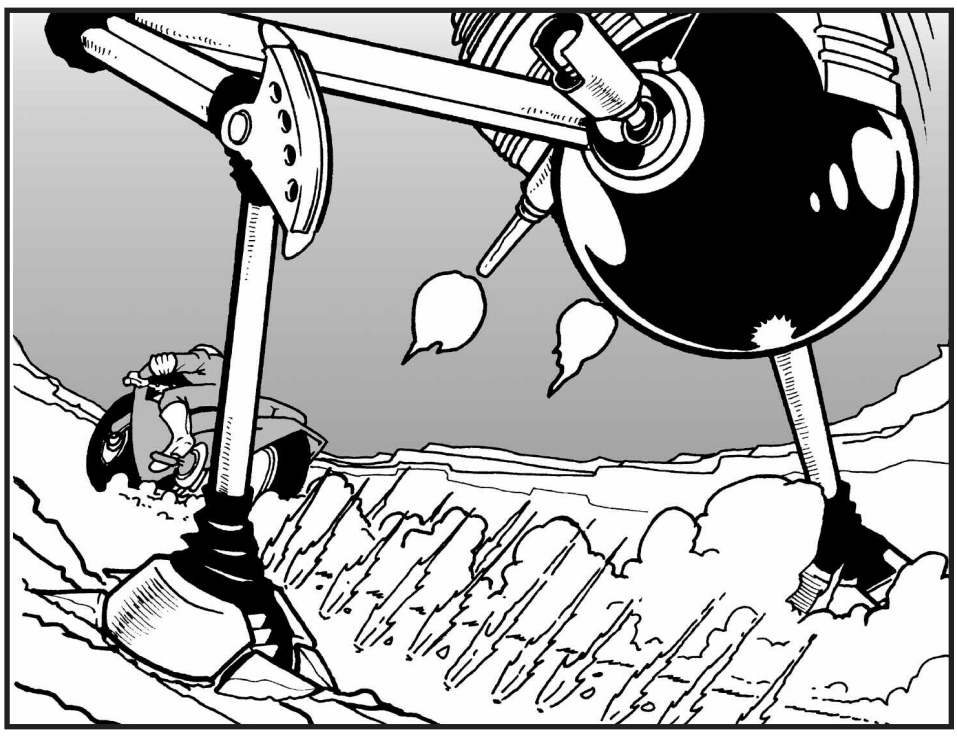
The GM always makes these "sensor rolls" secretly. Add together the sensor's Scan number and the object's Size, Speed/Range, Special, Prior Contact and Distraction modifiers, as well as each sensor's unique Sensor Modifiers (see sidebars of this chapter) to get a *Sensor Skill Modifier.*

Range is the maximum effective range of the sensor. As a general rule, the GM shouldn't bother calculating detection if an object is beyond the maximum range.

Scan is the Scan rating of the sensor. If using these rules with sensors from ***GURPS Robots*** or other ***GURPS*** books that don't give a "Scan" number, find their Scan by consulting the *Range to Scan Table* (p. 52).

Size Modifier: If using a LOS sensor, a bigger object is easier to detect. The Size Modifier is 0 for a normal-sized human, and vehicles will have been assigned their own Size Modifiers when they were designed. It is otherwise found using the *Size and Speed/Range Table* on p. B201. Indirect sensors *do not use* the Size Modifier in quite the same fashion – see the sidebar on each sensor.

Speed/Range Modifier is calculated exactly as on p. B201, except for one big difference: speed is *subtracted* from range instead of adding to it! A moving target is far more likely to be noticed by a sensor operator – in fact, many sensors have "moving target indicators" that flag moving objects.



Approximate Size

These rules refer to "approximate size." Here's a suggested breakdown of approximations the GM can use when describing sensor contacts; as long as the players also know what you mean, this should be reasonably clear while still leaving them in the dark about exactly how large or small that contact is:

Tiny (-2 or less), e.g., cat, baby, small missile.
Small (-1 to +2), e.g., dog, human, cycle or horse.
Medium (+3 to +6), e.g., car, tank or light plane.
Large (+7 to +10), e.g., house, ship or jumbo jet.
Huge (+11 or more) e.g., zeppelin, ocean liner, battleship.

Note that in the case of radar, read the Size Modifier *after* applying bonuses for radar reflectors, blip enhancers and stealth.

Signal Strength

Some sensors provide a "signal strength" instead of an approximate size. This is determined by the difficulty of the skill roll. If the skill modifier, excluding penalties for distraction, was -3 or worse, signal strength is "very weak." If -2 to +2, it is "weak." If it is +3 or better, it is "strong."

Active Sonar Modifiers

These modifiers are used for active sonar detection and for the attack roll of sonar-guided weapons:

Target Object has . . .

Basic Sound Baffling	-1 × (baffling's TL-4)
Radical Sound Baffling	-2 × (baffling's TL-4)

Object is in, or line of sight passes through . . .

Standard or dense atmosphere	-6
Thin atmosphere	-10
Very thin atmosphere	-15
Trace or vacuum atmosphere	no detection!
Light woods	-1
Dense woods or jungle	-2
The radius of a sonar decoy	-5

Detection gives a bearing and an approximate size, range and speed. Round range and speed to nearest 10 mph or 100 yards; e.g., "Medium contact 12 o'clock, range 2,000 yards, speed 40 mph."

Recognition means the object's general shape can also be discerned; e.g., "Contact is fish-like shape."

Identification is possible only if using imaging sonar. It provides exact size and a sharp image, though with no color or flat detail; e.g., "Contact is a sperm whale."

Infrared and Thermograph Modifiers

Aside from the horizon and solid objects, LOS is automatically blocked by 10 yards or more of hot smoke, water or blackout gas, or 50 yards or more of blizzard, dense forest or jungle.

Continued on next page . . .

Infrared and Thermograph Modifiers (Continued)

These modifiers are used by infrared and thermograph sensors, PESA operating in thermograph mode, and for the attack roll of IRH or IIRH weapons.

Object is . . .
Silhouetted against sky . . . . . +2

Object is using . . .
Basic IR or emission
cloaking . . . . . -1 × (cloak's TL-4)*
Radical IR or emission
cloaking . . . . . -2 × (cloak's TL-4)*
Using afterburner, fusion air-ram
or any kind of rocket engine . . . . . +2

Object is within, or line of sight passes through . . .
A body of water . . . . . -1 per yard
Blackout gas or hot smoke cloud -1 per yard
Blizzard. . . . . -1 per 5 yards
Falling rain and snow . . . . . -1 per 50 yards
Light woods . . . . . -1 per 50 yards
Dense woods or jungle . . . . . -1 per 5 yards

For IRH guidance missiles only . . .
Object has just launched a flare of equal or higher TL than the guided weapon . -5
Object using IR jammer . -1 × Jammer rating
Object using TL10+ deceptive jammer. . . . . -1 × Jammer rating
Missile is early-TL7 and is *not* aimed directly at the exhaust pipe of a jet or rocket engine, or the hot rear exhaust pipe of a gas or MHD turbine power plant . . . . . -7

A jammer or flare has *no effect* if it is of lower TL than the sensor it is trying to jam.

* Emission or IR cloaking has no effect if object is using an afterburner, fusion air-ram, or any kind of rocket engine.

Detection gives a bearing and approximate size, plus a temperature contrast: this reveals whether a power plant is running, or shows a warm, live body from something that isn't; e.g., "Medium-sized object, looks hot," or, "Small, warm object."

Recognition means the object's shape stands out; e.g., "A medium-sized ground vehicle with a turret," or, "Looks like a man."

Identification resolves a sharp *image;* e.g., "A tank – a Russian T72 by the shape of the turret," or, "A big man in combat armor holding pistol." Identification is only possible with a thermograph – the best that passive infrared can manage is recognition. Identification does not provide color or flat detail.

Passive Radar Modifiers

Passive radar, or PESAs in passive radar mode, are treated as thermographs (above), except that IR cloaking, IR jammers and hot smoke are ineffective against them, while they receive no bonus to detect vehicles using afterburners, fusion air-rams or rocket engines. PRH missiles or PEH missiles in PRH mode are treated as IIRH missiles, with the same modification noted above. Successful detection or recognition is as with passive infrared – that is, the best result is "recognition" – except that no temperature information is given. However, detection or better does mean that the user will be able to tell whether an object is metallic or nonmetallic.

Underwater, count every yard of depth as five yards of range to simulate convergence zones, inversion layers, marine life and other problems that make deep underwater detection difficult.

Special modifiers are given in the sidebars and are specific to each kind of sensor. For simplicity they can be ignored, but much of the flavor will be lost if this is done.

Prior Contact: Give a +4 bonus if the target is currently successfully detected either visually or by another sensor on the vehicle (or by an ally using Datalink to share sensor information), or if trying to "Improve Contact" as described under *Improving Contact* (p. 172).

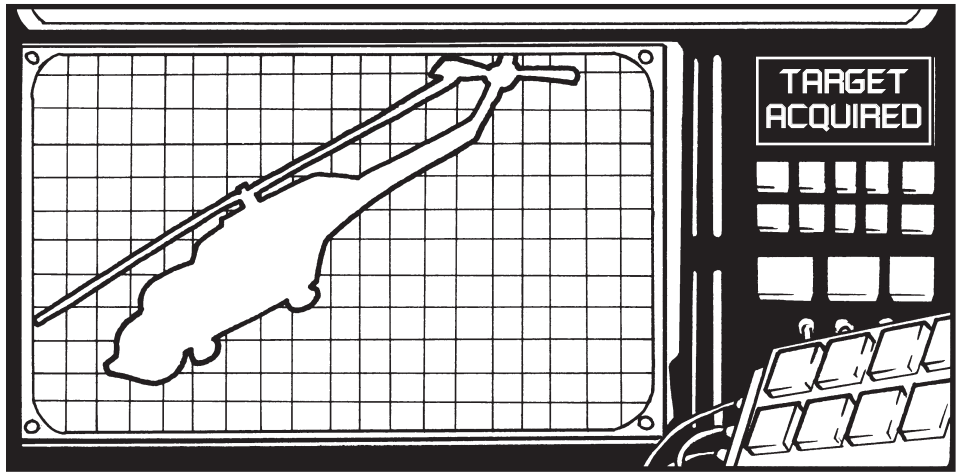
Distraction Modifier: The GM should impose a -4 penalty on any sensor operator who isn't giving his full attention to that particular sensor, e.g., also driving the vehicle, firing weapons or watching other sensors. This is the reason larger vehicles often assign a specialized sensor operator.

Total up all the modifiers. If they add up to -10 or worse, detection is impossible: the sensor just isn't good enough, regardless of operator skill. If +10 or better, the GM can choose to assume that detection is automatic, with the same result as a critical success (see below). Otherwise, roll vs. the operator's Electronics Operation (Sensor) skill and read the degree of success on the *Sensor Scan Table,* below, to find out whether or not detection occurs. For example, a success by 3 would mean "detection and recognition."

"Simple Detection" – It is possible to skip the die roll altogether to save time. This works well for NPCs. Simply take the sensor skill modifier without rolling and compare it to the table below. Negative modifiers become margins of failure, while positive ones are treated as margins of success; e.g., a -3 skill modifier would be treated as a failure by 3 – "No contact." This gives the same result as an average roll against skill 10.

Sensor Scan Table

Degree of Success	*Result*
Critical Failure	Contact error.
Failure by 3+	No contact.
Failure by 1-2	Detection – but may be spoofed.
Success by 0-2	Detection.
Success by 3-4	Detection and Recognition.
Success by 5+ or Critical Success	Detection, Recognition and Identification.

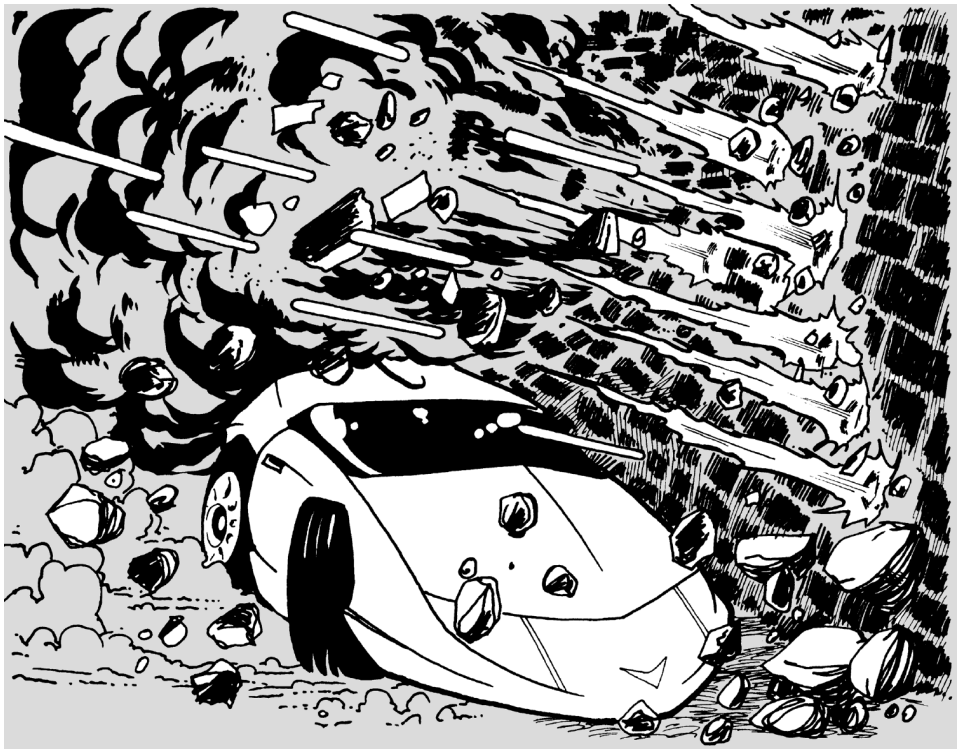


Contact Error: The operator has "detected" an object that isn't there, or has grossly misidentified one that is. This may be a malfunction in the sensor, or it may be the result of operator error. For instance, a building might be misidentified as a vehicle.

No Contact: The object is simply too small or too far away to detect. The GM should not usually check again for detection until the chance of success improves – the object moves close enough to reduce the range modifier, or other circumstances have changed. However, if the sensor operator knows for certain there is something out there – for example, it's firing at him, or he detected it before and then lost it when it ducked into cover – the GM can allow more frequent skill rolls, up to one every turn.

Detection: The object's existence has been discovered by the sensor operator. The GM should tell the player something is "out there," but detection alone provides very limited information: a bearing, and sometimes a range and speed. The exact effects depend on the sensor. For example, if an imaging radar detected Captain Morgan, the GM may describe her as, "Contact at six o'clock, small slow object, 2 miles away."

May Be Spoofed: Detection occurs normally, but the sensor may be spoofed *if* the object is using a deceptive jammer of TL equal to or higher than that of the sensor. Also, unless it was built at TL10+, a deceptive jammer can only affect a radar; other sensors cannot be spoofed. A "spoofed" sensor is receiving spurious information from the jammer. This is usually only important if attempting to



attack the object – while the sensor operator knows the object is there, he has also received several false targets along with it. For more on how to handle this, see *Spoofing,* below.

Recognition: More information is provided, generally enough to get some idea of what general category the object fits into. So an imaging radar getting a "recognition" result on Morgan would yield something like: "Contact at six o'clock, a walking humanoid shape, 2 miles away."

Identification: Provides a still higher level of information, usually enough to identify a specific type of vehicle or species, and often providing additional details, although most electronic sensors do not provide color or flat detail. Using imaging radar, we'd get, "Contact at six o' clock, female human in body armor carrying pistol, 2 miles away."

Passive infrared, non-imaging radars, active sonars and MADs are not usually sensitive enough to achieve identification: the best result normally possible is recognition.

Targeting via Sensors

A sensor is a "targeting" sensor if it can be used in place of normal vision when making ranged or melee attacks.

Only LOS sensors are classed as "targeting sensors." To be used as a targeting sensor, a radar or active sonar *must not* have been modified with the "no targeting" option (p. 51). A radar or active sonar with this option, or an indirect sensor, is too imprecise to use for targeting attacks.

To use a targeting sensor, it must have achieved "detection," as described above. Recognition or identification of a target isn't necessary – it's perfectly possible to shoot down a target before you can see it clearly.

Attacks made using targeting sensors in place of vision ignore penalties for darkness, bad visibility or invisibility (although some forms of magical or psionic invisibility may be effective against *all* sensors). In addition, if the targeting sensor is a ladar, radar, imaging radar or AESA, it gives a +2 bonus to hit. This bonus is not cumulative with that of laser rangefinders or sights – in fact, the targeting sensor is doing exactly what the laser would do.

There is one disadvantage of targeting sensors: if sensor detection was "spoofed" by a deceptive jammer or distortion jammer, any attack made on the "target" will automatically miss. See *Spoofing,* below.

Spoofing

If spoofing occurs, the sensor operator will know there is something there, but is receiving multiple fake targets. Spoofing can be ignored if no attack is made against the object, or the attack is directed visually or by another sensor. If using the spoofed sensor for targeting, though, there is a good chance that one of the false returns will be attacked by mistake.

Each turn, before ranged attacks are made, the player or GM controlling the jammer should record a number from one to six. This is the "true target." Then the attacker picks which contact he will shoot at. If he has multiple attacks, he can spread his fire among multiple targets, or gamble and pick a single one. After the attacks are announced, the true target is revealed; all the other attacks are assumed to have missed. If it's important (e.g., they were explosive warheads) assume they miss by one-tenth the total range or one yard, whichever is greater.

Radar and Imaging Radar Modifiers

Aside from the horizon and solid objects, LOS is automatically blocked by 5 yards or more of chaff or 50 yards or more of dense woods or jungle.

Apply these modifiers to radar and imaging radar sensors, to an AESA operating in either mode, and to the attack roll of active radar homing or semi-active radar homing weapons.

Object is . . .
Not silhouetted against sky . . . . . -4

Object is using . . .
Basic Stealth . . . . . -1 × (stealth's TL-4)
Radical Stealth . . . . . -2 × (stealth's TL-4)
TL7+ deceptive jammer . -1 × Jammer rating

Line of sight passes into or through . . .
A body of water . . . . . -2 per yard
Falling rain or snow . . . . . -1
Light woods . . . . . -1 per 50 yards
Dense woods or jungle . . . . . -1 per 5 yards
Radius of area jammer . . . -1 × Jammer rating
Chaff cloud
. . . .-5, or -2 per yard, whichever is worse

Chaff, deceptive jammers and area jammers have *no effect* if they are trying to jam higher-TL sensors. At the GM's option, a deceptive jammer may also have no effect on *lower*-TL sensors, if the owners forgot to program it to deal with "obsolete" threats!

Detection gives a bearing and approximate size, range and speed; e.g., "Medium contact at 12 o'clock, range 2,000 yards, speed 1,200 mph."

Recognition means the object's shape can be discerned somewhat; e.g., "Contact is medium, winged aircraft."

Identification is only possible with imaging radar. It provides exact size and a sharp image, but with no color or flat detail (so no markings are visible); e.g., "A sleek, delta-winged, single-engine fighter, maybe a Mirage 2000."

Ladar Modifiers

Aside from the horizon and solid objects, any prism or blackout gas cloud, 5 yards or more of chaff, dense fog or smoke, or 50 yards or more of cloud bank, mist, dense woods or jungle, automatically block ladar LOS.

These modifiers apply to ladar, to an AESA operating in ladar mode, and to active laser homing (ALH) weapons:

Object is . . .
Silhouetted against sky . . . . . +2

Object is using . . .
TL8+ Basic Stealth . . . . -1 × (stealth's TL-4)
TL8+ Radical Stealth . . -2 × (stealth's TL-4)
TL10+ deceptive jammer -1 × Jammer rating
Basic chameleon system . . -3 (-1 if moving)
Instant chameleon system . -6 (-3 if moving)
Intruder chameleon system -10 (-6 if moving)

Line of sight passes into or through . . .
A body of water -8 Scan (also reduces range)
Thick fog or smoke . . . . . -1 per yard
Mist, cloud bank, falling rain or snow
-1 per 5 yards
Light woods . . . . . -1 per 50 yards
Dense woods or jungle . . . . . -1 per 5 yards
TL8+ chaff cloud
. . . -5, or -2 per yard, whichever is worse
Prism cloud or blackout gas
. . . . . detection fails automatically!

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Ladar Modifiers (Continued)

Chaff, deceptive jammers and stealth have *no effect* on higher-TL ladar. At the GM's option, jammers may also have no effect on lower-TL sensors, if the owners forget to program it to deal with "primitive" threats!

Detection, Recognition and *Identification:* Same as for imaging radar (above).

Passive Sonar Detection

Apply these modifiers to passive sonar, active/passive sonar in passive mode, or passive sonar homing (PSH) weapons:

Object is . . .
Not in or under water . . . . . no detection

Object is using . . .
Basic Sound baffling . -1 × (baffling's TL-4)
Radical Sound baffling -2 × (baffling's TL-4)
Moving using any form of propulsion except a flexibody, reactionless thrusters or TL7+ hydrojets (including MHD tunnels)
. . . . +2 if ducted propellers, +4 otherwise

Line of sight passes into or through . . .
Radius of sonar decoy . . . . . -10

Sensor or PSH weapon is . . .
Not in or under water . . . . . no detection

Detection gives a signal strength and bearing only; e.g., "Strong, unknown contact at 3 o'clock low."

Recognition means the sensor operator has some idea of what it sounds like, if it is within his experience. Speed can be roughly estimated (round off to the nearest 20 mph). E.g., "Contact is submarine moving at 40 knots – you recognize the propeller noise."

Identification matches the exact sound. Range can also be estimated, rounded off to the nearest 10 miles. Note that it doesn't get much more precise than that, making passive sonar ineffective for rangefinding! E.g., "Contact identified as Russian Akula-class boat, 30 miles away."

Modern navies maintain extensive computer libraries of marine sonar readings to ease recognition and identification. If the user has a computer terminal and access to that sort of database, he can recognize objects outside his personal experience by matching the sonar data to it; the GM may require a Computer Operation roll to do this quickly.

MAD Modifiers

Apply Size Modifiers normally, but only if the object is mostly ferrous metal, or has ferrous metal armor, or uses mag-lev propulsion. An object's armor is ferrous if it is TL6- metal armor, TL7 cheap or standard metal armor, or TL8 cheap metal armor. Use these modifiers:

Object has . . .
Mag-lev propulsion or MHD (TL8+) hydrojets . . . . . .+4
Basic emission cloaking . . . . . -1 × (TL-4)
Radical emission cloaking . . . . . -2 × (TL-4)
Just fired electromag weapon (including Gauss and railgun), charged particle beam, flamer or fusion gun . . . . . +5**

Object has MHD or fusion power plant* that generates . . .
Under 1 kW . . . . . +1
1-10 kW . . . . . +2
11-100 kW . . . . . +3
101-1,000 kW . . . . . +4
1,001-10,000 kW . . . . . +5
. . . etc.

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Distortion Jammer Spoofing

A distortion jammer can be used to fill the enemy's screen with false targets, as above, or the jamming operator can be more insidious and set it to give "false recognition" readings. This fools the sensor into thinking it has achieved a "recognition" result on a vehicle that looks like something else, provided it is about the same size as the vehicle.

Maintaining and Breaking Contact

Once achieved, detection, recognition or identification is maintained without need for any die rolls until any of the following events occur that "break contact":

(1) The object moves out of line of sight or arc of vision, if that is a requirement (it isn't for indirect sensors). This is the easiest way to break contact.

(2) The object moves out of the maximum range of the sensor, if using an active sensor (this isn't a requirement for passive sensors).

(3) The object launches an *effective* decoy and the sensor operator fails a skill-4 roll. Effective decoys are:

Chaff of the same or higher TL as a sensor using radar, imaging radar, ladar or AESA.

A *flare* of the same or higher TL as a sensor using infrared, thermograph or passive radar (or a multi-mode sensor like a PESA using one of these modes).

A *sonar decoy* of the same or higher TL as a sensor using active or passive sonar.

Note that smoke, hot smoke, prism and blackout gas do not count as decoys, but a vehicle that hides in a thick enough cloud will block line of sight, automatically breaking contact.

Improving Contact and Dealing with Spoofing

A sensor operator who has detected an object but who has not achieved recognition or identification can try for it. This is treated exactly like a normal sensor skill roll, except that it gets the +4 prior contact bonus, and minimum success is the previous result. For instance ,if the previous result was "detection and recognition" and the sensor operator was hoping for "identification," even a roll of "no contact" or mere "detection" will still remain "detection and recognition."

If the sensor operator is aware that he has been spoofed, this same procedure can be used to get rid of the spoofing, with the minimum result being "detection – but may be spoofed."

Guided missiles and torpedoes cannot use this procedure after they have been launched.



Handing Off Contact

If an object has been detected by one sensor operator, other sensor operators on the same vehicle and who are in communication with him get a +4 on any sensor attempt. This also applies to visual sighting. The sensor does not have to be the same type. Detection can also be "handed off" in the exact same way between friendly vehicles, provided they have computers running Datalink programs that are in communication.



Vision: The Mk. 1 Eyeball

If the GM wishes, these sensor rules can also be used for Vision rolls: the human eye is basically a passive, line-of-sight sensor.

In unobstructed daylight on the ground, about 2,000 yards is the maximum spotting range for clear vision, with aerial objects being spotted at about twice that distance. The GM should generally rule that spotting of nearby objects in the open is automatic, but beyond about 200 yards, or when poor visibility, camouflage or obscuring terrain get in the way, the GM can require a roll to spot something.

Visual Line of Sight

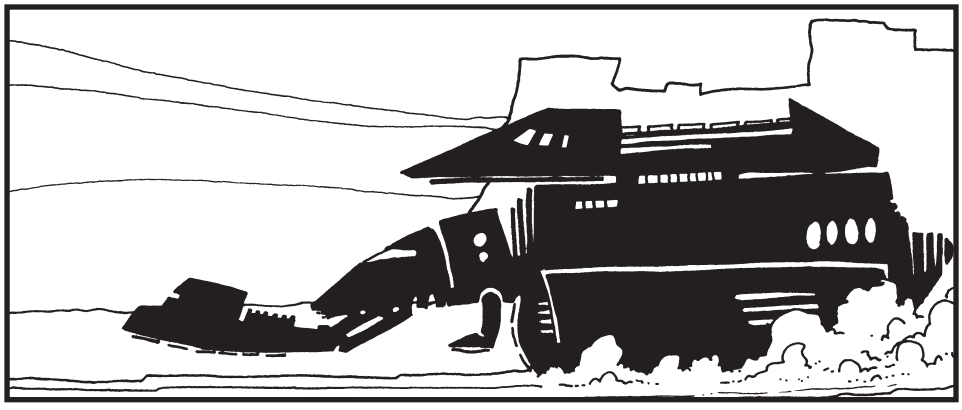
Aside from the horizon and solid objects, LOS can be assumed to be automatically blocked if an object is totally concealed within blackout gas, or 10 yards or more of thick smoke, or 50 yards or more of water, thick fog, snowstorm, cloud bank or dense forest or jungle, or 500 yards or more of mist or light woods.

Vision Sighting Rolls

Use the rules for *Electronic Sensing,* with two differences:

"Scan" is not used at all, although some vision systems like binoculars or low-light TVs provide a bonus to Vision rolls. If a system has a split Vision bonus, e.g., +2/+4, use the lower number if using vision to initially detect the object, or the higher number if attempting to "improve contact" or "hand off contact" (p. 172) and get a better view of a previously-detected object. This represents "zooming" to a higher magnification!

"Electronics Operation (Sensor) skill" is replaced by a Vision+10 roll: that is, IQ+10, modified by any advantages or disadvantages that affect normal vision, in particular Acute Vision, Alertness, and Bad Sight.



MAD Modifiers (Continued)

* Count fusion rockets and air-rams as power plants with kW = thrust/100.

** Optionally, use power plant table, based on weapon power requirement.

If an object is not ferrous or using maglev, MHD or fusion power plant or propulsion systems, and has not just fired a charged particle beam, flamer, electromag weapon or fusion gun, then it cannot be detected!

Detection: This gives the object's bearing and signal strength.

Recognition: The operator has some idea of what the MAD contact might be if it is within his experience ("a submarine" or "a fusion reactor"). He can also roughly estimate speed (round off to the nearest 20 mph). Magnetic flux sources will be identified as to their power requirement or power output, to within an order of magnitude.

Identification is not possible with a MAD if detecting metal objects. Magnetic flux sources will be identified as to their exact power requirement or power output.

Geophone Modifiers

Apply these modifiers when trying to detect an object by using a geophone:

Object is . . .

Not moving on the ground . . . . . no detection possible!

Walking or crawling slowly while successfully using Stealth skill . . -1 × amount the Stealth roll is made by

Tunnelling underground . . . . . +4

Object has . . .

Extremely low ground pressure . . . . . -2

Very low ground pressure . . . . . -1

Very high ground pressure . . . . . +1

Extremely high ground pressure . . . . . +2

Sensor is . . .

Not in contact with the ground . . . . . no detection possible!

Detection: Reveals the object's bearing, the signal strength and whether it is moving closer, holding position, or moving away; e.g., "Weak signal at 6 o'clock, closing."

Recognition: Also reveals its the ground propulsion system it is using, if any; e.g., "Signal sounds like a tracked vehicle."

Identification: Also reveals the mass of the object in pounds, and its approximate speed (to the nearest 10 mph).

Gravscanners

These modifiers apply when trying to detect an object using a gravscanner:

Object is using . . .

Contragrav propulsion or artificial gravity +4

Deflector screen up . . . . . +4

TL11+ basic emission cloaking . -1 × (TL-4)

TL11+ radical emission cloaking -2 × (TL-4)

TL12+ deceptive jammer -1 × Jammer rating

Gravity-ripple communicator . . . . . +2

Object has just fired . . .

Gravitic or gravity beam weapon, or is using a tractor or pressor beam . . . . . +5*

* Optionally, use the power plant table under *MAD Modifiers* (above), based on weapon power requirement.

Continued on next page . . .

Gravscanners (Continued)

Detection: Reveals the object's bearing, its approximate mass to the ton, and its speed to within 10 mph: "Two-ton object at 3 o'clock, moving at 50 mph." Also reveals whether any form of gravity-manipulation technology (anything that gives a bonus to detection) is in use.

Recognition: Reveals the object's range to within the nearest mile, and gives an idea of its approximate size. Reveals what kind of gravity manipulation technology is in use.

Identification: Reveals the exact weight of object in pounds and details (GM's option) of the gravity manipulation technology used.

Multiscanner Modifiers

Multiscanners – advanced, multi-mode sensors – may operate in one of three modes:

Chemscan: The scanner can detect specific chemical compounds or elements, e.g., TNT or steel. If that material is in range, a successful roll locates the largest, closest concentration. Known locations can be screened out. It may also analyze the exact chemical composition of an object detected by other means. This requires a second roll, at +2 to skill.

Bioscan: As above, but optimized to detect life forms, and much more precise. It can be set to detect specific life forms (e.g., humans), or for more general detection (e.g., "carbon-based life forms larger than rats"). If someone's genetic "fingerprint" is in a computer database on the vehicle, a bioscan can look for that person. As usual, a roll detects the largest, nearest object in the chosen category, and known life forms can be screened out.

Radscan: This can be tuned to function as an advanced radar/laser locator (p. 59), a radio direction finder (see p. 59) or energy scanner (treat as MAD, except that it can detect any kind of power plant, not just MHD or fusion). In any radscan mode, a multiscanner emits no scanning radiation.

When using the bioscan or chemscan functions, use these special modifiers:

Bioscanner vs. target concealed in vegetation . . . . . -1 per 10 yds of cover
Target underwater . . . -1 per 2 yards of water
Target behind a wall . . . . . -1 per 5 points of wall DR and HP
Bioscan vs. target in sealed vehicle/robot or wearing sealed armor . . . . . -1 per 5 points of armor DR
Chemscanning interior of sealed vehicle/robot . . . . . -1 per 5 points of armor DR
Object using TL10+ distortion jammer . . . . . -1 × Jammer rating
Target wearing a distort belt or a holodistort belt . . . . . -2 × (TL-9) of belt
Object has basic emission cloaking . . . . . -1 × (TL-4)
Object has radical emission cloaking . . . . . -2 × (TL-4)

Force Screens and Detection

Force screens block all active sensors (radar, sonar, ladar, multiscanners on chemscanner or bioscanner mode) trying to scan into the screen. Although the screened vehicle's location as a "blip" is detected normally, nothing else is. The force-screened vehicle can use its own sensors freely! Passive sensors are not affected.

Deflector screens do not interfere with detection. They do make a vehicle easier to spot with gravscanners.

In addition to the modifiers for Size and Speed/Range, use the *Vision Modifiers Table* below:

Vision Modifiers Table

Visibility:
Bad light . . . . . -1 to -9
Total darkness . . . . . fails automatically!

Vehicle has:
Poor view . . . . . -2 or more*
Fair view . . . . . -1*
Good view . . . . . no modifier

Line of sight passes into or through:
Blackout gas . . . . . totally blocked!
Dense smoke . . . . . -1 per yard
Dense forest or jungle . . . . . -1 per 5 yards
Cloud bank, thick fog, blizzard . . . . . -1 per 5 yards
Water . . . . . -1 per 5 yards
Light mist, open woods . . . . . -1 per 50 yards
Prism . . . . . -1

Object is a character. . .
Prone behind minimum cover, head down . . . . . -7
Any position, only head exposed . . . . . -5
Behind someone else . . . . . -4
Prone or crawling without cover . . . . . -4
Body half exposed . . . . . -3
Behind light cover . . . . . -2
Crouching/sitting/kneeling without cover . . . . . -2

Concealment (use only the "worst" modifier):
Object properly camouflaged . . . . . -2
Object has clashing camouflage or paint scheme . . . . . +2
Object using chameleon system . . . . . -3 (-1 if moving)
Object using instant chameleon system . . . . . -6 (-3 if moving)
Object using intruder chameleon system . . . . . -10 (-6 if moving)

Notes:

* The poor or fair view modifier is ignored if using a low-light TV or PESA for vision. Modifier may be worse than -2 at the GM's option: for many armored vehicles, it will -4, or even -8, forcing a person to stick his head out a hatch to get a good visual sighting.

Bad Light or Darkness: There is no penalty to see an object illuminated by a headlight, searchlight, etc., or by its own lights. As well, darkness modifiers do not apply if using light amplification or LLTV, and are halved if an object is silhouetted against something else, such as the moon or another light source.

Invisibility: An invisible object *cannot* be spotted visually, assuming it leaves no wake or impression! However, an invisible vehicle moving through water is relatively easy to spot, since it leaves an obvious wake – this might be a -3 to spot. One leaving tracks on the ground, hovering and creating a dust cloud, or flying and leaving a contrail could be spotted at a penalty from -1 to -10, depending on how obvious the signs were.



COMBAT 14

This chapter describes how the normal ***GURPS*** combat rules can be adapted to handle attacks made by or against vehicles. Most of these rules deal with ranged combat. For ramming procedures, see the *Vehicle Action* chapter. For hand-to-hand attacks (including those made by vehicles with arms) use the normal ***GURPS*** melee combat procedures. If a vehicle is the target, use these rules for determining hit location and damage.

Attacking

A fighter in a vehicle has three main choices: he can attack with a vehicle weapon (if he is manning it), fire a hand weapon (or toss a grenade) through an open hatch, door, window or gun port, or not fire at all.

A given weapon can only be used once per turn, firing a number of shots up to its normal RoF; a given character (or a given copy of the Gunner program) can only fire one weapon or set of linked weapons (p. 45) per turn. Any number of linked weapons may be fired simultaneously, as long as they are fired at the same target.

A character may normally only fire the weapons his crew station controls, although at TL8+, vehicles with computerized controls can reconfigure their control panels so that any gunner can fire any weapon from any crew station.

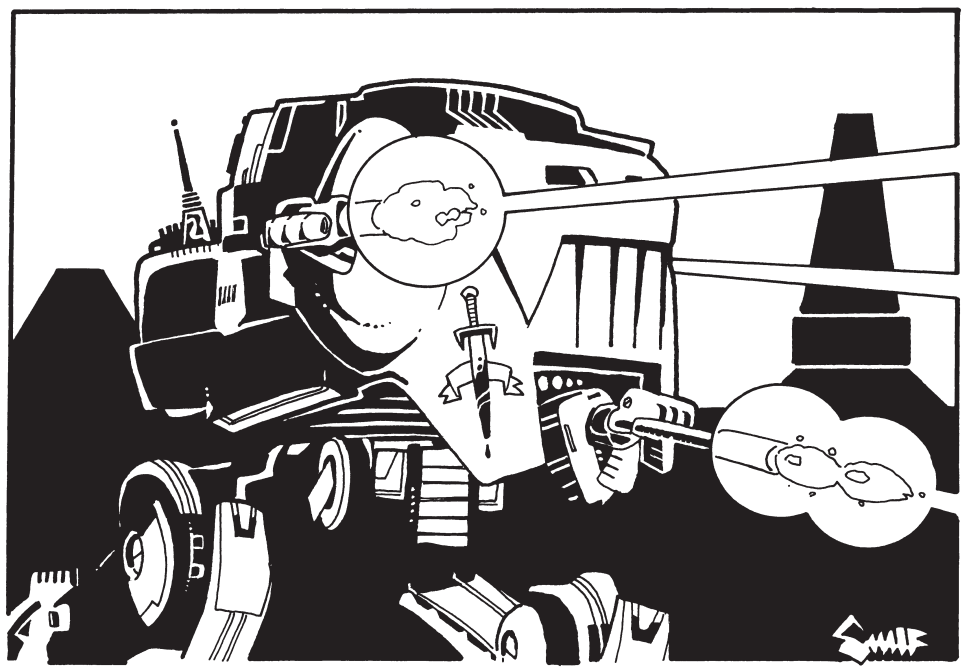
Some vehicles will have computers that can control vehicle weapons. Computers can control one weapon per copy of the Gunner program running.

A few ultra-tech vehicles have neural interface systems (these are described in the Chapter 4). Besides giving a +4 bonus to skill, these allow more than one weapon to be fired at once, at a -2 penalty per extra weapon or set of linked weapons fired (e.g., three extra weapons would be -6 on all four attacks).

The procedure for an attack follows normal ***GURPS*** rules. However, after a vehicle is hit and fails any defense rolls, determine damage location (p. 177) before rolling for damage and subtracting DR.

Arc of Fire

The target must be in the attacking weapon's arc of fire – this is limited by the way the weapon is mounted (see *Angle of Fire,* in the sidebar). If using counters, trace all lines of fire between the attacking counter and the target vehicle counter. For an attack made by a turreted weapon, use the center of the turret as the starting point; otherwise, use the middle of the edge of the counter on the side the weapon is installed.



Angle of Fire

A weapon can normally only fire in the direction it is facing, plus a few degrees off to either side ("angle off") and up (elevation) or down (depression). The exact arc of fire is described below, depending on where the weapon was installed:

In Body: The weapon can fire with a 15° angle off to right or left and a 15° elevation or depression.

In Wing or Pod, or on Hardpoint: The weapon can fire with a 15° angle off from the side it is attached to (thus, a weapon in a right wing can fire at 15° off to the right). The weapon also has a 15° elevation and depression.

In Superstructure or Fixed Open Mount: The weapon can fire with a 15° angle off to right or left. A weapon in a superstructure above the body can fire with up to 30° of elevation; one below the body can fire with up to 30° of depression.

In Turret or Rotating Open Mount: As for a superstructure, but it can be rotated to face any direction, effectively giving a 180° horizontal arc of fire for a limited turret or mount, or a 360° horizontal arc of fire for a full rotation turret or open mount.

In Arm: A weapon mounted in an arm can fire in any direction that the arm is pointing in.

In Leg: The weapon can point at whatever direction the leg points – but cannot be fired on any turn that the vehicle is moving! Furthermore, if the vehicle is standing, no more than half of the vehicle's legs can fire weapons at any one time!

See p. 45 for the effects that special mountings have on arcs of fire.

Bombs and torpedoes on hardpoints or in weapon bays will drop below the vehicle.

Gunner Specializations

The Gunner skill is required for all *vehicular* or *tripod-mounted* weapons. For hand-held weapons, see *Guns Specializations,* below.

Machine Gun – Firing bursts from conventional or electrothermal guns with bore sizes under 20mm.

Gauss Gun – Firing bursts from electromag or gravitic guns with bore sizes under 20mm.

Cannon – Firing conventional or electrothermal guns with bore sizes over 20mm that are neither low- nor very-low-powered.

Continued on next page . . .

Gunner Specializations (Continued)

Railgun – Firing electromag or gravitic guns with bore sizes over 20mm that are neither low- nor very-low-powered.

Grenade Launcher – Firing guns with bore sizes 20mm to 40mm that are low- or very-low-powered.

Mortar – Firing guns with bore sizes over 40mm that are low- or very-low-powered.

Flamethrower – Firing flamethrowers and liquid projectors.

Guided Missile – Firing guided missiles.

Torpedo – Firing torpedoes.

Rocket Launcher – Firing unguided missiles.

Beams – Firing beam weapons.

Bombs – Releasing bombs.



Guns Specializations

The Guns skill is required for all hand-held projectile weapons. Beam weapons use the Beam Weapons skill (see pp. UT124-125); TL3 to early TL5 handguns use the Black Powder Weapons skill (see pp. HT14-15):

Pistol – Firing a conventional or electrothermal gun with a pistol grip, a bore size under 20mm and a RoF of 3~ or less.

Rifle – Firing a rifled conventional or electrothermal gun with a shoulder stock, a bore size under 20mm, and a RoF of 1/2 to 3~, provided the gun is not low- or very-low-powered.

Musket – Firing an unrifled conventional or electrothermal gun with a shoulder stock, a bore size under 20mm and a RoF under 1/2, provided the gun is not low- or very-low-powered.

Shotgun – Firing a conventional or electrothermal gun with a shoulder stock and a bore size under 20mm which is low- or very-low-powered and has a RoF of no greater than 3~.

Light Automatic – Firing a conventional or electrothermal gun with a shoulder stock and bore size under 20mm in bursts with RoF 4 or more.

Machine Pistol – Firing a conventional or electrothermal gun with a pistol grip and bore size under 20mm in bursts with RoF 4 or more.

Needler – Firing an electromag or gravitic gun with a bore size under 20mm.

Grenade Launcher – Firing any hand-held gun with a bore size 20mm to 40mm that is low- or very-low-powered.

Flamethrower – Firing any hand-held flamethrower.

Light Antitank Weapon – Firing any hand-held missile launcher (unguided or guided).

Hand-Weapon Fire From Vehicles

The GM should use judgement to determine whether or not a particular character can fire hand-held weapons from within a vehicle. This depends on the layout of the vehicle – a character on a motorcycle can fire in almost any direction, while one in the back seat of a car has a more restricted field of fire.

If the driver of the vehicle is trying to use a personal weapon while driving, he has an extra -4 to hit.

A character inside an enclosed vehicle generally needs an open window, door or firing port. At high speeds in atmosphere (over 200 mph), the rush of air will make it difficult to fire out an open door or window.

Attack Rolls

An appropriate Guns, Beam Weapons or Gunner skill is required to fire any vehicular weapon. Control of all vehicular weapons must be assigned to specific gunner stations.

Use the normal ranged combat rules from the ***Basic Set,*** with the following modifications:

The *Vehicular Combat Modifiers* sidebar gives various special modifiers that apply only to vehicle combat.

Failed Control Roll: A failed control roll (p. 148) erases any accumulated aiming bonus. As well, any attack made from the vehicle is at a penalty equal to the amount by which the roll was failed until the vehicle operator has taken one full turn to regain control.

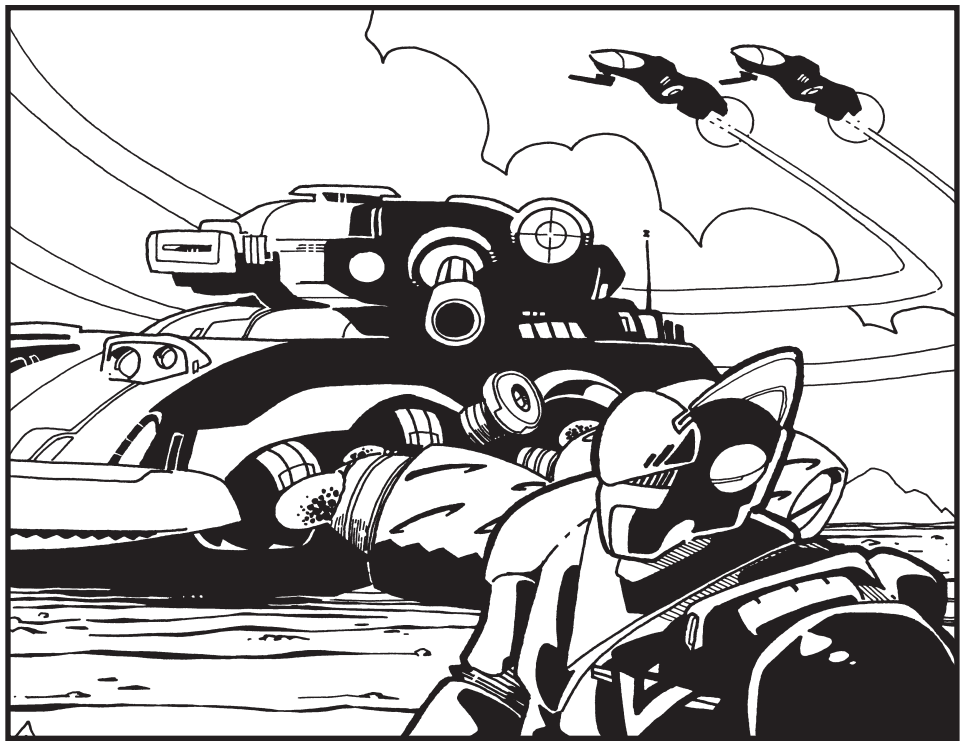
Guided Missiles and Torpedoes: These use special rules, and are described in their own section on p. 192.

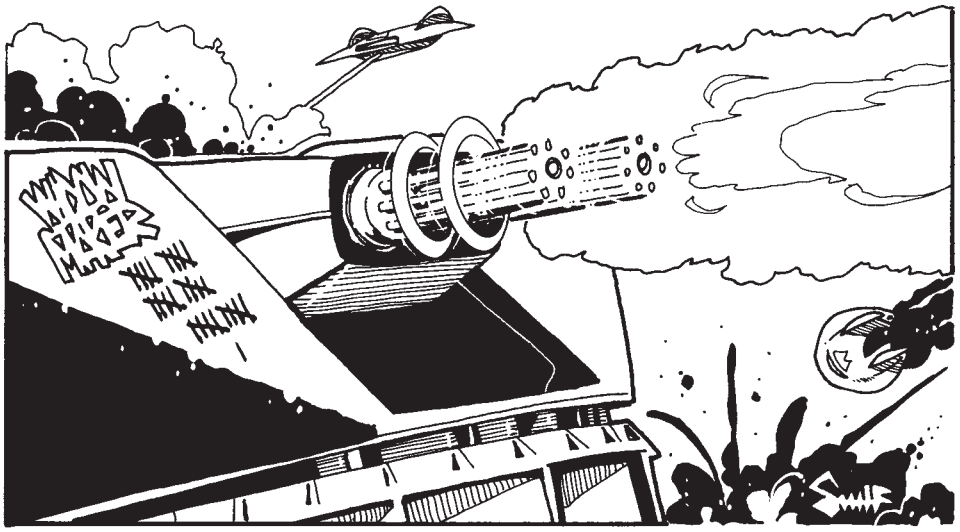
Beehive, Canister, Chainshot, ICM, SATNUC, Shotshell, Shrapnel and SICM: These rounds have special effects or restrictions that apply to their firing and hit probabilities – see the ammunition section on pp. 188-191 of this chapter.

Scattering: Normally a miss is just a miss. But if an attack can produce an explosion or carries submunitions, smoke, gas or other chemicals, it will go off somewhere – maybe close enough to do damage. Use the *Scattering* rule on p. B119, except that vehicular weapons will often scatter for a greater distance than thrown grenades. Take the amount the attack roll was missed or dodged by and look it up on the *Speed/Range* column on the *Size and Speed/Range Table,* p. B201. Read over to the adjacent *Linear Measurement* column. This gives the distance the attack missed by, to a maximum of 1/10 the range to the target (but always at least 1 yard). Then determine scatter direction, as per p. B119. For instance, a miss by 3 would be -3 on the speed/range column, and hence a miss by 7 yards.

If a target is flying, scatter can usually be ignored – unless the target was flying just above the ground and the attack came from above, a miss will normally pass harmlessly by. In populated areas, though, the GM may want to see where the shot landed . . . this can be important with explosive or chemical projectiles!

Critical Hits on Vehicles: For simplicity (and extra lethality!) the GM can assume that a critical hit simply allows no defense rolls and bypasses all DR. For more detail, use the *Vehicle Critical Hit Table* on p. 184.





Very High RoF: Machine guns and autocannon regularly have rates of fire of 20 or more, up to RoF 100 for miniguns and Gatlings! Moreover, multiple machine guns are often linked together, giving combined rates of fire in the hundreds. For identical, linked automatic weapons with a single or combined RoF of 20 or more, resolve fire using 20-round groups instead of normal 4-round groups, using the table below:

Roll Made By:	*-3*	*-2*	*-1*	*0-1*	*2-4*	*5+*
Number of Hits:	0	1	5	10	15	20

Thus if the roll needed to hit is 14, and a 12 is rolled, 15 rounds hit the target. If the RoF does not divide evenly by 20, either ignore the excess or calculate fire for it in groups of 4 (see p. B120).

If the target gets a PD or Dodge roll, this can also be simplified. Rather than rolling Defense against each shot, make one roll that applies to all shots in the entire 20-shot group.

Hit Location

An attacker can choose what part of a vehicle to attack. Different parts of the vehicle will have different reactions to major damage. In some instances, they may have different PD and DR values as well, in which case these are used instead of the vehicle's body PD and DR.

Random hit location is used when a part of the vehicle must be randomly targeted. It is suggested that random hit location be used for indirect fire or for any fire beyond 1/2D range.

In either case, use the table below. If a rolled location does not exist or could not be hit, treat the result as a body hit. If a result covers multiple locations (e.g., 5 is rolled but the vehicle has several small turrets or superstructures), roll randomly among them to determine which one was actually hit.

Hit Location Table

Random Location	*Hit Location*	*Hit Penalty*
3-5	A small turret, small gasbag or small superstructure.	-5
6, 8	An arm, pod or external mount.	-2
9, 11	The body.	0
7, 10	A large turret, large gasbag or large superstructure.	-1
12-14	A wing, GEV Skirt, SEV wall, leg, track, halftrack or skitrack.	-2
15-16	A mast, skid, wheel or rotor.	-4
17-18	A vital area.	-6



Note that the penalties are in addition to the vehicle's Size Modifier. Thus, a large turret on a vehicle with a +3 size modifier is actually at +2 to hit.

A "small" turret, superstructure or gasbag is one whose volume is under one-fifth the vehicle's total volume; a "large" one has a volume of at least one-fifth the total vehicle volume.

On a "vital area" hit, a vital area of the vehicle's body (e.g., the power system) is hit. Treat this as a body hit, but damage that exceeds the vehicle's DR is multiplied by 1.5.

If a subassembly is retracted, it cannot be hit. However, if the location it is retracted into is disabled (see below), it cannot be extended again, and is effectively disabled too.

Vehicular Combat Modifiers

Vehicles take the usual modifiers for ranged fire – see p. B201. In addition, apply the following:

Other Firing Modifiers

Target Position and Cover:

Shooting at rider on a saddle seat, on deck (unless prone) or someone wearing strap-on vehicle 0

Shooting at passenger/crewman in exposed seat, prone on deck or operating open mount weapon . . . . . -3

Shooting at passenger/crewman through a window . . . . . -4

Target has chameleon system:

Basic chameleon system . -3 (-1 if moving)

Instant chameleon system -6 (-3 if moving)

Intruder chameleon system . . . . . -10 (-6 if moving)

Target in a clump of light woods . . . . . -2

Target in dense forest or jungle . . . . . -4

Target in defilade . . . . . see p. 185

Vehicles with legs or flexibodies can drop prone, just like a human:

Prone without cover . . . . . -4

Prone with cover . . . . . -7

Targeting System:

Computer with Targeting program . . . . . +(Complexity+1)

Neural Interface . . . . . +4

Firing multiple weapons via neural interface . . . . . -2 per extra weapon

Targeting using active sonar . . . . . +1

Targeting using radar, ladar or AESA . . . . . +2

Weapons Fire From Moving Vehicles:

In space . . . . . no penalty

Good road or in the air . . . . . -1

Bad road or in the water . . . . . -3

Off-road or in rough waters . . . . . -4

A vehicle-mounted weapon will provide a bonus to hit (usable only to reduce this penalty) depending on how the weapon is mounted:

Firing vehicle has SR 5 or more . . . . . +1

Open mount . . . . . +1

Weapon installed in body, pod, superstructure, wings, arm or turret . . . . +2

Stabilized weapon . . . . . +1

Fully-stabilized weapon . . . . . +3

Failed control roll this turn: -1 × amount failed

Target flying, both it and firing vehicle are moving, and firing character is *not* the vehicle operator . . . . . -4

Weapon System:

Firing hand weapons from cramped seat/station . . . . . -2

Firing hand weapons while controlling a vehicle . . . . . -4

Indirect fire . . . . . see pp. 179-181

Dropping bombs . . . . . -15, modified by bombsight (p. 58)

Vehicle operator is firing a weapon that is built into body, wing or pod, or attached to a hardpoint . . . Gunner skill limited to relevant vehicle operation skill-3

Modifiers to SS Rating:

Cyberslave mount: *halves* base SS number

HUDWAC (TL7-8) . . . . . -2

HUDWAC (TL9+) . . . . . -5

Pupil scanner on HUDWAC . . . . . -2

Option: Loaders and Rate of Fire

Breechloading and muzzleloading weapons often require loaders. The listed rates of fire assume an average crew at full strength. If one or more loaders are required, the following modifications may be made:

Double the RoF (maximum RoF 1) if the gun crew's average skill is 16+ and the master gunner also has Leadership 15+ (e.g., a RoF of 1/8 would become 1/4).

Halve the RoF if the number of loaders is less than the number required, but not less than half the number (e.g., a RoF of 1/8 would become 1/16). A weapon with less than half the minimum number of loaders required cannot be reloaded.

Smoke from Black Powder

TL3 to TL5 guns use early "black powder" propellant charges. Firing them produces smoke that obscures the gun. As a rule of thumb, any good-size cannon produce smoke covering a 1 hex radius per 25mm of bore size centered on the gun's muzzle. Any fire through the cloud (in or out) is at -1. Further shots increase the density of the smoke to a maximum of -5. The smoke lasts for 300 seconds/wind speed in mph (max. 300 seconds). A moving vehicle will sail or drive out of its guns' smoke cloud, which can be good or bad.

Broadsides

An Age-of-Sail naval vessel often mounts scores of identical cannon which fire simultaneously at the same target. To ease play, it is suggested that the automatic fire rules be used to handle each group of identical cannon, with the effective RoF being equal to the number of shots in the broadside and the skill used being the average skill of the Gunners. Of course, the cannon will require their normal time to reload after firing. Rolling hit location, PD and damage for each individual shot can be tedious; therefore, roll once for each group of cannon shots, not for each shot.

Passive Defense

A hit vehicle gets a Passive Defense roll based on armor PD, unless the attack's damage was in the form of an explosion.

GURPS High-Tech, Second Edition introduced a rule in which *personal* armor PD is reduced by 1 per full 3d of damage an attack inflicts. This can optionally be applied to vehicle armor as well.

Dodging

A vehicle being attacked can dodge if, on its operator's last turn, it was moving evasively. A vehicle is considered to have been moving evasively if it made at least two drift maneuvers or a bend of 15° or more, or performed any kind of stunt. Many vehicles (such as ships) lack the maneuverability to perform this kind of maneuvering without serious risk of losing control – vehicles like this won't be doing much dodging! If not using advanced movement rules, assume that a vehicle with MR 1 or more can dodge, but one with less MR cannot. Most vehicles have a fairly low Dodge score:

Dodge = operator control skill/4.

The exceptions are any flying vehicle, or any vehicle currently using legs or a flexibody drivetrain for propulsion:

For vehicles flying or moving using a flexibody drivetrain or three or more legs, Dodge is **control skill/3.**

For vehicles moving on two legs, Dodge is **control skill/2.**

Round all fractions down: A Dodge of 2.75 is treated as 2, for instance. Combat Reflexes bonuses will increase Dodge normally. Passive Defense adds to Dodge normally when making defense rolls, but if the sum of PD and Dodge exceeds 14, treat it as 14.

EXAMPLE

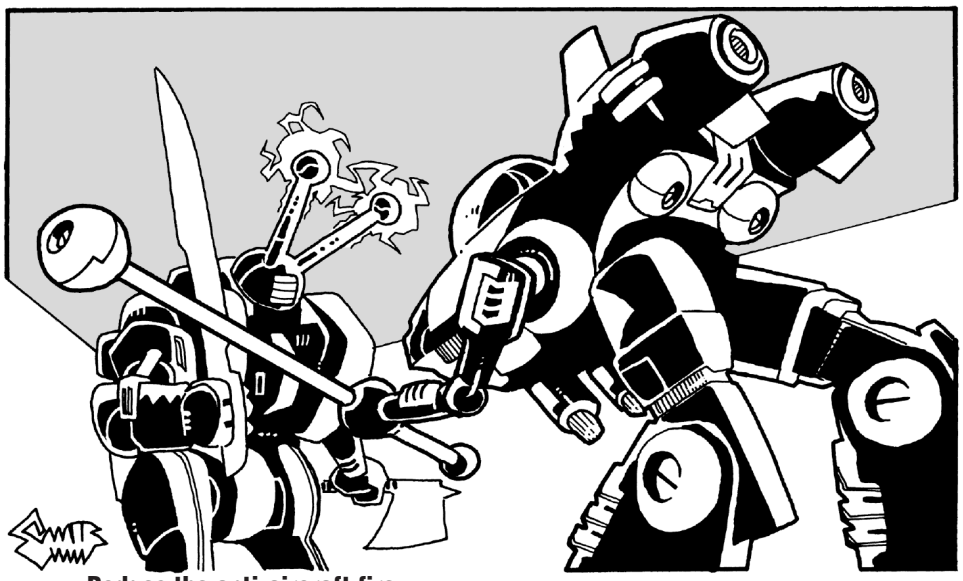
A few years before her Amazonian adventure, Captain Morgan is driving home from the White Sands air field when a terrorist rises from cover . . .

A glint of light off the barrel gives away the terrorist, so Morgan makes a quick bend maneuver in order to count as dodging when it's the sniper's turn to fire.

The sniper fires and hits with one shot. Morgan Dodges. Her motorcycle is neither flying nor moving on legs or a flexibody, so it has a standard Dodge: her control skill – Motorcycle – divided by 4, rounded down. Morgan has Motorcycle-15 so her basic Dodge is 3.75. Her Combat Reflexes add +1, for 4.75, rounded down to Dodge 4. The cycle's body has PD 0, so Dodge is not increased. Morgan needs a 4 or less to make her Defense roll. She rolls a 10 and takes a hit. The shot takes out her cycle's tire, and Morgan is thrown as the vehicle spins out of control.

Morgan survives the attack and returns to base safely to report the incident. The next day, the local squadron receives orders to strike the terrorist headquarters. While female pilots aren't supposed to fly combat missions, Morgan is a law unto herself: she "borrows" a fighter and joins in. While on a strafing run, her F-16 is hit by a burst of machine-gun fire. She made a pair of drifts a moment ago, so she may Dodge, and the hit location is the fighter's body, so its PD 3 will protect. She has Piloting-19 and the fighter is a flying vehicle, so her Dodge is Piloting/3 plus her Combat Reflexes bonus, giving her a Dodge of 6.33 + 1 for Combat Reflexes = 7.33, rounded to 7. She gets +3 for PD, giving her an active defense of 10. Morgan's player rolls an 8 and Morgan





Dodges the anti-aircraft fire.

Parrying

A vehicle with arms can use them to parry – just as if it were a human – either bare-handed or with a hand weapon. Note that striker arms can be used to parry "bare-handed," but cannot wield weapons. The normal restrictions on parrying apply (i.e., ranged attacks, except for thrown weapons, can't be parried). In addition, the user's skill or DX when parrying cannot exceed his vehicle operation skill.

Damage Effects

Damage is resisted by the vehicle's DR and subtracted from the hit points of the body or subassembly (the "hit location") that was hit.

A hit location that has lost 10% of its hit points (20% if the vehicle has heavy compartmentalization, 50% if total compartmentalization) is no longer sealed. This can have serious effects if it is in an airless or contaminated environment.

A hit location reduced to 0 hit points or less is disabled. Any components in a disabled location will stop working – see *Loss of Components,* p. 180. Also, if a wing, motive subassembly (wheel, tracks, legs, etc.) or rotor is crippled, it will immediately affect the vehicle's movement.

Option – HT Rolls: Instead of being disabled immediately, a location may take some time to stop working. For each such hit location that is at 0 or less hit points, roll against the vehicle's Health (not hit points) every turn; on a failed roll it is disabled, which means any component built into it ceases to function as well. A hit location that is destroyed immediately stops working.

If a body or subassembly is reduced to -1 × hit points, it must make a Health roll to avoid being destroyed, much like a human rolling to avoid death. The vehicle must roll once at -1 × hit points, and once more for every 5 hits of damage it is below that threshold. At -5 × hit points, a body or subassembly is automatically destroyed. At -10 × hit points, it is blown to bits or vaporized.

A location that is destroyed is disabled, and in addition cannot be repaired. Also, if a location is destroyed, all locations attached to it are effectively disabled. For example, if the body of an airplane were destroyed, its wings and wheels would be disabled.

Waterline Damage: When the body of a vehicle with a flotation or submersible hull is hit, keep a separate record of the points of damage inflicted by attacks from below the vehicle's waterline. Assume that any attack from below (like a torpedo or mine) or any explosion that takes place inside the vehicle's body is damage "below the waterline." This will be important for determining the effects of flooding, as described in the *Combat* chapter (see *Flooding* on p. 186).

Crippling Vehicles

Wings, rotors and motive subassemblies (wheels, tracks, halftracks, skitracks, skids, legs) have additional special effects – when they are disabled they are referred to as "crippled."

Wheels: If a vehicle has only one or two wheels, its top ground speed while using them drops to 0 when one wheel is crippled. If the vehicle was moving on the ground at the time, this is a -10 hazard.

If a vehicle has three wheels, its top ground speed drops to 0 when an attack cripples its front wheel or when both of its rear wheels are crippled. This is a -7 hazard if the vehicle is moving on the ground at the time. If the vehicle loses only one rear wheel, halve the vehicle's top ground speed; this is a -4 hazard.

If a vehicle has four or more wheels, its top ground speed drops by 10% whenever a wheel is lost; this is a -2 hazard. Its top ground speed is halved when it loses half or more of its wheels; if it loses all the wheels on *two corners* roll at -6 to avoid loss of control. Top ground speed drops to 0.

Indirect Fire

Indirect fire simply means that the gunner is firing projectiles in a ballistic arc. The target may be behind an obstacle – for instance, on the other side of a building or hill, or over the horizon – provided the weapon has the range to shoot over it. The second advantage of indirect fire is that it multiplies Max range by 2.5 (5 if a missile).

Indirect fire can be performed by any gun, any launcher firing unguided missiles, or any stone or bolt thrower, provided it has a high-angle or universal mount, as well as by any counterweight stone-thrower regardless of its mount. Even without special mounts, any of these weapons can use indirect fire if the vehicle itself is tilted up at a sharp angle, such as a tank climbing a slope (see *Elevated Positions,* p. 185).

A launcher firing a *guided* missile can only use indirect fire if the missile has inertial guidance: if this is the case, use the rules for inertial guidance missiles (p. 195) instead of these rules.

These rules are suitable for the quick resolution of indirect fire by a single vehicle firing individual rounds against a pinpoint target, such as an enemy vehicle, building or group of soldiers. This is the normal form of ranged combat used by warships firing guns. It may also be used by futuristic armored vehicles (as in ***Ogre***). For massed artillery bombardments directed from a central location, the GM should refer to pp. HT78-84.

To attempt indirect fire, either the gunner must be able to observe the target, or someone else who can observe the target must be in voice or data communication with the gunner or with a fire direction center that is in contact with the gunner.

Indirect fire is aimed at a specific *area* (which may be a patch of ground or water). A person, vehicle or structure that is in that area at the time the fire arrives will be affected by it.

If the gunner can't see the target, the observer will need to give the gunner map references – to do this, both will need to be using compatible maps (or devices like GPS, inertial navigation systems or computer navigation programs). Once the observer has spotted the target, he must relay firing coordinates to the gunner. This takes two seconds if they are Datalinked or next to each other in the same vehicle, or 2d+5 seconds if they must rely on radio or the like for communications. Note that in some cases, the observer may be distant, but on the same vehicle – e.g., on an observation post in the superstructure of a ship, while the gunner is in a turret elsewhere on the vessel.

Continued on next page . . .

Indirect Fire (Continued)

Once the gunner has firing coordinates – or can observe the target for himself – he can fire. Only aimed fire is allowed. Only range modifiers apply; since the attack is aimed at a set of coordinates, the size and speed modifiers are not important, nor is cover, concealment, smoke, or darkness a factor (except in preventing the gunner or observer from spotting the target hex).

Indirect fire is always treated as beyond 1/2D range, regardless of the actual range. Thus, there is *no* Accuracy bonus. Other modifiers:

Indirect Fire Modifiers:
Excellent/very bad maps . . . . . .+1/-1
Fire direction center
. . . . . .+2 at TL5, +3 at TL6, +4 at TL7+
Fire Direction program . . . . . .see p. 62
Firing weapon fixed and sited . . . . . .+2*
Relying on observer to see target 0**

* This means the firing vehicle has stopped moving and precisely fixed its own site in relation to the target. If it does so, it gets a +2 bonus to hit. Doing so takes 5 minutes at TL5-, 2 minutes at TL6, 1 minute at TL7+. If a vehicle has an inertial navigation system, it takes only 10 seconds. Usually, stopping is only an option for ground vehicles!

** This is increased by the amount that the observer makes a Forward Observer (p. B243, defaults to IQ-5) skill roll by, or decreased by the amount it fails by. See p. B243 for modifiers that apply to the Forward Observer skill roll.

Minimum Range: Indirect fire may not be performed at closer than one-tenth the indirect fire range (25% of normal maximum range); at closer ranges, use direct fire instead. If using missiles, minimum range is 1 yard times missile's Spd.

Effects of a Hit: If a hit is achieved, it means the round came in over the target hex. Air-burst rounds such as fused artillery shells and cluster munitions will then burst centered above this hex. Most other rounds will strike the hex from overhead. If there is a building, vehicle or person in the hex, the round will hit it, striking from above.

Explosive and Special damage from indirect fire is normal. Kinetic-type damage (Crushing and Impaling types) is halved, as if the attack had been made at or beyond the 1/2D range, regardless of actual range.

Misses: The likely result of rapid indirect fire is a miss – which may inflict damage anyway, since indirect fire is usually used to deliver explosives or submunitions. Use the *Scattering* rule (p. 176) to determine how far away the shot landed!

Correcting Fire: Once the first shot is fired, fire can be corrected, provided the fall of shot and any movement of the target is observed. This takes the same time as acquiring the original coordinates, i.e., 2 or 2d+5 seconds. To correct fire, roll again, but at a +4 bonus for the first shot or +8 for the second, with an added +2 for each subsequent shot at the same target; however, the total bonus for correcting fire cannot exceed the weapon's Accuracy.

Legs: If a vehicle has two legs and one is disabled, the effects are the same as when a human suffers a crippled leg. For vehicles with three or more legs, loss of legs reduces ground speed when walking or running. Divide speed by the number of legs, rounding up. That is the speed lost for each leg that is crippled. In addition, if all legs on one corner or side of a vehicle are lost, the vehicle falls down, and can only move on the ground by crawling.

Skids, Tracks, Halftracks or Skitracks: If the vehicle has two tracks or skids and either or both are crippled, its top ground speed drops to 0 and this is a -2 hazard. A tracked vehicle with four tracks suffers those effects only if it loses two or more tracks; if a single track is disabled, speed is halved rather than reduced to 0, and the hazard roll is at +2.

GEV Skirt or SEV Sidewalls: The vehicle's hover top speed is reduced to 0, and the vehicle is no longer hovering; its pilot must make a hazard roll to avoid losing control. If a GEV was hovering over water or mud and can't float, it may sink.

Mast: The mast comes crashing down. The vehicle loses area of sail equal to (total area of sail/original number of masts). This which will reduce its top speed and acceleration. When the mast comes down, anyone in the rigging will fall, and the mast will do dice of crushing damage to the top side of the vehicle equal to (original mast HP/10).

Wings or Rotors: If crippled, these no longer function. Damage to them is an immediate -5 hazard. For simplicity, assume a crippled rotor or wing (except a stub wing) means the vehicle is no longer flyable: it gains an effectively "infinite" stall speed and its aMR, aSR and top air speed are halved. For more detail, refer to *Aerial Performance* and recalculate the vehicle's stall speed and aMR as if the crippled subassembly no longer contributed to lift area or aMR. (Note also that a helicopter drivetrain can no longer contribute motive thrust or lift without rotors.) It is possible that the resulting performance change may cause a vehicle without a stall speed to gain one, and if the vehicle is flying slower than that, it will stall. If a vehicle has *no* functional wings or rotors and no other means of lift to cancel its weight, it stall speed becomes effectively "infinite."

General: If the body is disabled and the vehicle was moving on the ground, it will crash. If it was in the water, it will begin to sink. If it was flying when the body was disabled, the vehicle will lose control and begin to fall out of the sky.

All control rolls are made as explained in the *Vehicle Action* chapter.

Loss of Components

A component inside a disabled body or subassembly stops working, as does one disabled via the Advanced Damage System (p. 182). The effects are usually obvious – a gun that isn't working can't fire, loss of life support in a hostile environment means the crew must get into suits or start to suffocate, and so on. However, some components may have more critical effects:

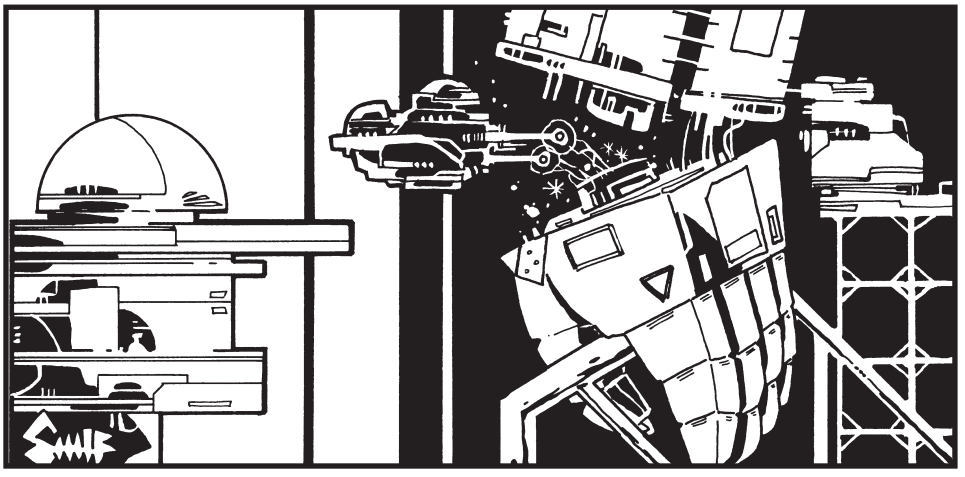
Disabling a propulsion system that is being used eliminates the motive power or motive thrust it produces, which will reduce its top speed and acceleration to zero using that system. If a vehicle has multiple propulsion systems (for instance a multi-engine jet aircraft), only a partial loss occurs – see *Partial Motive Power or Thrust Loss,* below.

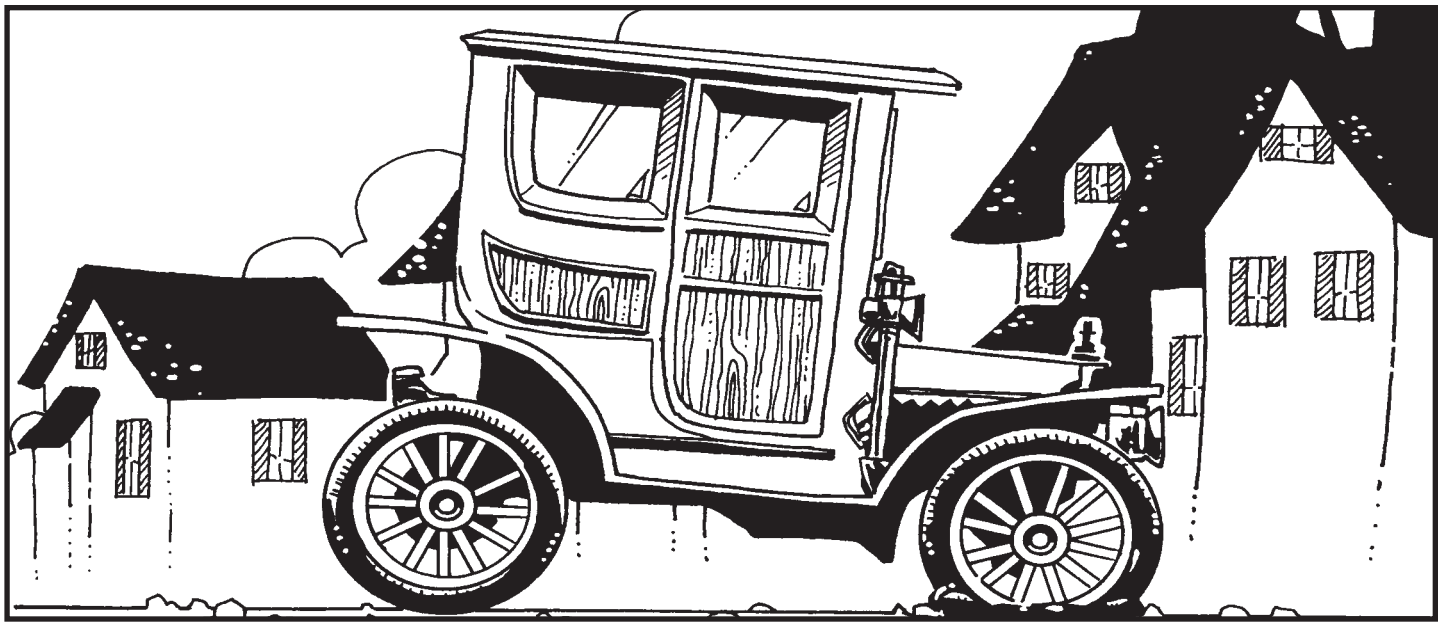
Disabling a location containing lifting gas, contragravity, a helicopter drivetrain, lift engines or fans, or a vectored thrust propulsion system will result in a loss of that system's lift. If the vehicle is flying, this may cause a crash if lift no longer exceeds vehicle weight and the vehicle cannot fly by other means (e.g., using wings or rotors).

Disabling a location containing a crew member's crew station means that he cannot do his job – a gunner cannot fire, a loader cannot load, etc. Disabling whatever location contains the maneuver controls means the vehicle can't be maneuvered.

Disabling a power system effectively disables all systems that require power. A vehicle may have back-up systems, but if they can't meet the entire power requirement, some things may have to be shut down. Of course, since the main power system is usually in the body, any damage (except a critical hit) that disables it has usually disabled the rest of the vehicle as well.

Disabling a fuel tank eliminates the fuel in it. If a power plant or reaction engine needs fuel and can't get it, it stops working too. In addition, check for fire – see *Fire and Explosion,* p. 184.





Partial Motive Power or Thrust Loss

A vehicle with multiple motive systems that work in concert to provide power or thrust, or one with multiple power systems used to drive such motive systems, will suffer a loss of top speed and acceleration if one or more of these systems is disabled. Instead of reworking vehicle performance from scratch, use this method to quickly re-evaluate vehicle performance:

Acceleration is usually a function of power or thrust ratios. To find the vehicle's new acceleration, multiply the vehicle's original acceleration by (remaining power or thrust / original power or thrust).

Ground or Air Speed is a function of the *square root* of applied power; therefore, find the square root of the above quotient, and multiply top speed by the result.

Water Speed is a function of the *cube root* of applied power; therefore, find the cube root of the above quotient, and multiply top speed by the result. See the table on p. 138, if necessary.

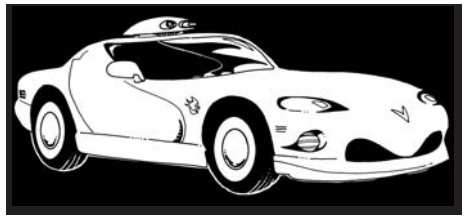
EXAMPLE

A WWII-era bomber has four aerial propellers powered by gasoline engines, each producing 5,000 lbs. thrust for a total of 20,000 lbs. One engine is disabled by enemy fire; as a result, the aircraft can now only power three of the propellers. The power quotient is 15,000/20,000 = 0.75, so aAccel and gAccel are 0.75 times normal. Top air and ground speeds are multiplied by the square root of 0.75, which we round to 0.86. If the top speed were 280 mph, it would drop to 241 mph.

The *Vehicle Action* chapter explains what happens when top speed drops below the current speed of the vehicle. (Basically, the vehicle *must* decelerate each turn.) Note that if top air speed is less than the aircraft's stall speed, the aircraft will eventually decelerate to below its stall speed, and will fall out of the air . . .

Quick Reference: Since this calculation can slow the game, use this table for vehicles with two to four systems of equal power or thrust:

Power or Thrust Quotient and Accel	*Water Speed*	*Air/Ground Speed*
3/4	0.90	0.86
2/3	0.87	0.81
1/2	0.79	0.70
1/3	0.69	0.57
1/4	0.62	0.50



Thus, a ship with two screw propellers of equal thrust that loses one would drop to 1/2 acceleration, but 0.7 times speed.

Shock, Knockback and Stunning

Damage to a vehicle never causes it to suffer shock, stunning or knockdown. However, a vehicle can suffer knockback. The number of hits required to knock a vehicle back 1 yard is equal to its (weight in pounds/20), rounded up. The operator of a vehicle that is knocked back must make a control roll to avoid a crash.

Indirect Fire with CLGP

If using cannon-launched guided projectiles against a target that is laser-illuminated (e.g., by a laser designator), indirect fire is at a +5 bonus to hit and range penalties are ignored.

Jamming Tracks

A tracked, halftracked or skitrack motive system is quite vulnerable to jammed running gear or a slipped track even if the tracks as a whole aren't wrecked. Any loss of at least 10% of a track's original hit points has a 2-in-6 chance of immediately crippling one track until the damage taken is repaired.

Damage Modifiers vs. Flesh for 10mm or Larger Rounds

A projectile of 10mm (.40 caliber) or larger size that inflicts crushing damage has a "projectile size damage modifier," as explained under *Bullet Size* on p. HT6. This will increase the damage the round does when it strikes flesh. *There is no similar increase in damage vs. vehicles or buildings.*

If at least 1 point of damage was inflicted after subtracting DR and modifying for armor divisor (p. 188), modify damage as follows:

If the round is between 10mm and 15mm (.40 to .60 caliber), multiply final damage by 1.5.

If the round is larger than 15mm, multiply final damage by 2.

(This multiplier takes place before any increases in damage that result from hitting a particular hit location.)

Example: a 12mm AP round doing 7d(2) damage hits a person in DR 40 armor and does 24 hits damage. The AP round's armor divisor reduces the effective DR to 20, so 4 points of damage penetrate. This is then divided by 2 (since it is an AP round), leaving only 2 hits of actual damage. However, since the round was between 10mm and 15mm, damage is multiplied by 1.5, to inflict 3 hits of damage on the target.

Damage to Wheels with Tires

An attack on a TL5+ light, standard or off-road wheel has a chance of hitting the tire instead of the wheel.

This chance is 50% (roll 1-3 on 1d) if the attack came from the sides and 100% if it came from below, front or rear.

If a tire is hit, use the tire's armor instead of the wheel's. This is normally PD 2, DR 2. Any damage penetrating its DR goes to the tire first rather than to the wheel. A tire's hit points are equal to the wheel's hit points, but are kept track of separately.

Destruction of the tire has identical effects to crippling the wheel, except that a tire can be easily replaced (in five minutes or so) if the vehicle is stationary on the ground. If damage to a tire exceeds its hit points, excess damage is applied to the wheel; its DR protects normally.

Melee Attacks Against Vehicles

If a person attacks a vehicle in melee, the GM may wish to forgo using the hit location table and simply allow the character to hit whatever part he wishes to and can logically reach.

Optional Combat Rules

These rules are designed to modify the combat procedures in the ***Basic Set*** to reflect conditions on the battlefield. By and large, they make combat less lethal by reducing the chance of NPCs scoring hits and allowing characters to avoid certain kinds of damage that otherwise hit automatically.

Dodging Explosions

If a person is caught within the radius of an explosion or similar area effect attack, he is normally hit automatically. However, the GM may allow a Dodge and Retreat (with the usual +3 bonus, but ignoring PD). Success means that person can dodge, leap, drop, dive or roll up to 1/5 Move (minimum 1 hex) away from the explosion. While this is often not enough to escape an explosion's radius, it may be enough to throw oneself into a trench or behind cover, which can absorb the blast!

Reduced Hit Probability

GURPS High Tech provides several subjective rules for reduced weapon accuracy, reflecting the fact that most soldiers do not aim and fire well when under stress. The same is true for vehicle crews.

To routinely reduce the lethality of vehicular weapons from "textbook" to "realistic" levels the GM may want to use this rule:

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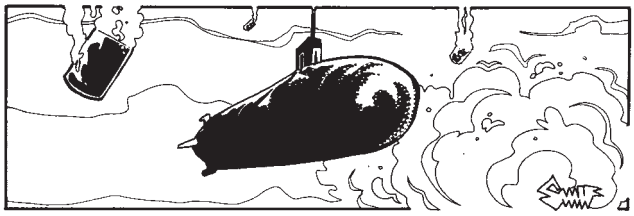
If a vehicle overturns and does not have either two or more legs or a flexibody, it can only right itself and move again if it has arms strong enough to lift itself upright. In any case, this requires two turns.



Injuries to Vehicle Occupants

If a location that is occupied by crew or passengers suffers an attack that does damage *after* DR, anyone in that location may be injured, either directly or as the result of fragments. Roll 1d per 100 points (or fraction thereof) of penetrating damage. On a 6, one random or GM-chosen occupant takes 50 hits or half the penetrating damage the location actually took, whichever is less.

Exception: If the attack's damage was greater than the location's original hit points, damage is inflicted on a 5-6, up to a maximum of whatever penetrating damage the location took or 100 hits.

Disabled Locations & Trapped Characters: If someone is within a body or subassembly location that is disabled or destroyed, they may be trapped. Roll 1d. On a roll of 5-6, the character is stuck in debris. One frantic roll to escape is allowed each turn, rolling vs. ST-7, or a more deliberate attempt can be made every ten seconds, rolling vs. ST-3. Failure inflicts 1d damage to the character: DR does not protect. A victim who is trapped cannot eject, but can always remain still. It is also possible for someone else to assist him (each person assisting can also roll) or slowly cut him loose using cutting tools. Roll vs. Mechanic skill every minute to do so without causing 1d damage.

Fire: If a character is in a location that is on fire, he takes normal fire damage each turn, as described on p. B129.

Advanced Damage System

In the advanced damage system, if the hit location roll results in a hit on any location that houses components (except for gas envelopes), a component inside that location can be damaged or disabled even if the location itself still has hit points remaining.

Roll 3d on the table below to determine what is damaged. Apply the damage that penetrated DR to vehicle components as directed on the table:

Component Damage Table

3 – *Fuel:* One fuel tank in the location hit is damaged. See also the *Fire and Explosion* sidebar, p. 184. Cascades to *Power.*

4 – *Passenger:* One person or robot who is a passenger in the hit location takes the damage. Cascades to *Cargo.*

5 – *Propulsion/Lift:* One propulsion system, lift engine or fan or contragravity component within the hit location takes the damage. Cascades to *Weaponry.*

6 – *Cargo:* If the vehicle has cargo space, the hit does damage to any stowed cargo (including stowed vehicles). If there is excess damage or no cargo, cascades to *No Special Effect.*

7 – *Equipment:* One item of miscellaneous equipment (items from the *Miscellaneous Equipment* or *Instruments and Electronics* chapters, including arm motors) or a life support system in the hit location takes the damage. Cascades to *Crew.*

8 – *Crew:* One person or robot serving as crew in the hit location takes the damage. Cascades to *Passenger.*

9 – *Power:* One power plant or energy bank in the body or subassembly hit takes the damage. Cascades to *Propulsion/Lift.*

10 – *Weaponry:* One weapon within the hit location takes the damage. Cascades to *Equipment.*

11 – *No Special Effect:* The hit passes through the vehicle, doing no damage except to the location's overall hit points. Apply any remaining damage to the armor on the opposite side of the vehicle. If any damage remains, the projectile (unless it was explosive) passes right through and continues on out that side, and may even strike another target outside the vehicle, if it is in the line of fire! See *Hitting the Wrong Target,* p. B118. If this occurs, apply only the remaining damage to that target.

12 – *Fuel:* As **3,** above.
13 – *Passenger:* As **4,** above.
14 – *Propulsion/Lift:* As **5,** above.
15 – *Cargo:* As **6,** above.
16 – *Equipment:* As **7,** above.
17 – *Crew:* As **8,** above.
18 – *Power:* As **9,** above.



If more than one character or component falls under the rolled category (e.g., the result is a "Weapon" hit and the vehicle has several different weapons) the GM may choose to roll randomly or select the most likely option. Any component that has *both* weight and volume can be hit.

If there are no undestroyed components or living beings of the rolled type *within the location that was hit,* do not reroll. Instead, damage "cascades" to the next category on the table, as shown.

If a character is hit, he suffers normal damage equal to the amount that penetrated DR. Personal armor and blow-through rules do apply.

If a component is hit, record damage against it.

Components and Damage

Components have their own DR that will absorb damage:

Component DR Table

Component Type	*DR*
Fragile Optics (e.g., recon camera)	1
Most Electronics (e.g., computers, sensors)	2
Fuel Tanks	3
Machinery (e.g., life system, power plant, miscellaneous equipment)	5
Weaponry	5
Energy Banks	5

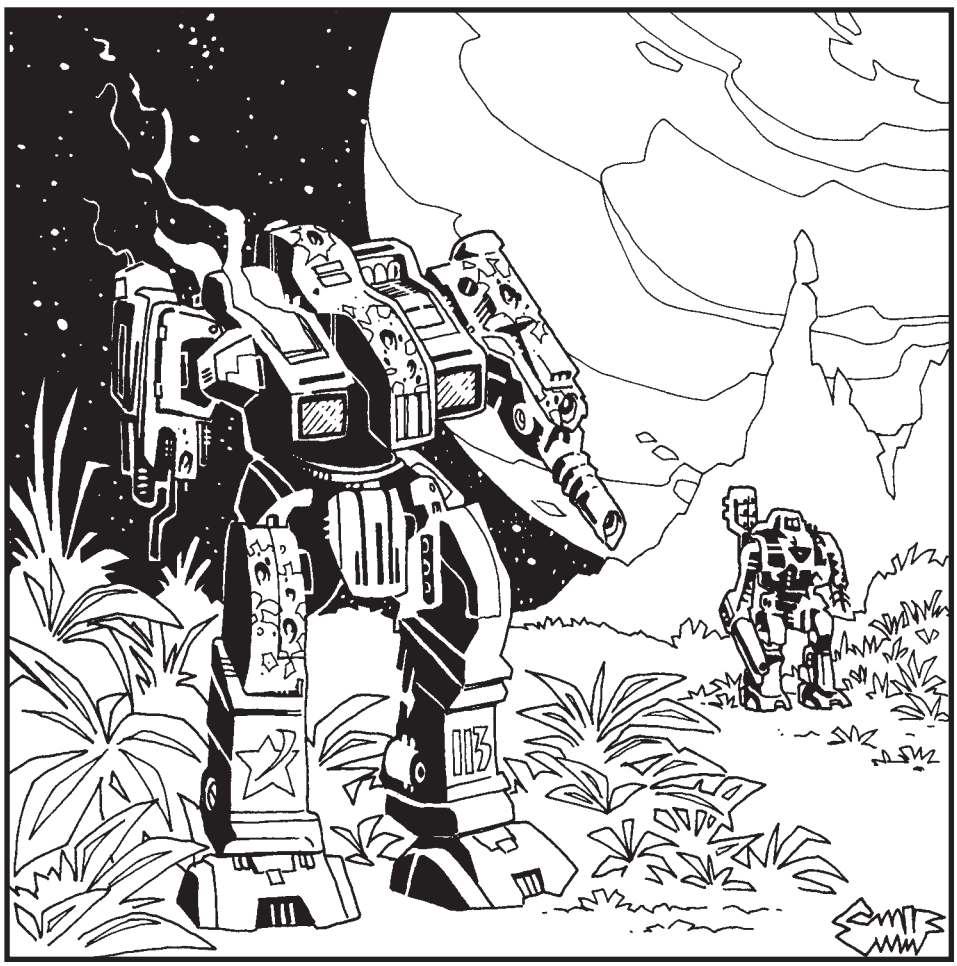
Most components (including cargo) have hit points equal to their surface area in sf, as calculated from their volume – see p. 18 and p. 20. Ruggedized components (p. 27) will have more hit points. Most components are disabled at 0 HP, destroyed at -5 × HP – see p. 180, *Loss of Components.*

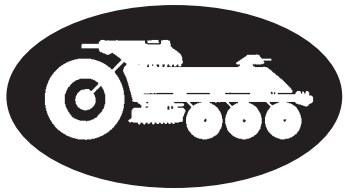
Fuel tanks and lifting gas are exceptions:

A fuel tank checks for *fire* (see p. 184) if damage *from a single damage roll* exceeds 10% of its current hit points; if reduced to 0 hit points, it bursts and all fuel is immediately lost. Also, it loses one gallon of fuel for every 10 points of damage inflicted, and unless self-sealing, will leak the same number of gallons each minute. Make a note of leakage in gallons per minute (gpm); multiple leaks are cumulative – add their gpm.

Hydrogen lifting gas checks for *fire* as above. Lifting gas does not lose hit points. Instead, it loses one pound of lift per 40 points of damage inflicted if hot air, per 11 points if helium, or per 10 points if hydrogen. As with fuel, further equal losses of lift will continue every minute.

If damage remains after destroying a component, eliminating an entire tank of fuel or gas, or killing a person or robot, or if damage blows through a person, damage cascades normally on the table.





Optional Combat Rules (Continued)

Unless an NPC is firing at someone in an ambush-type situation (e.g., an airplane sneaks up on another from behind) or has Combat Reflexes, add only half Accuracy bonus when aiming.

This also reflects the advantage that ace pilots used to make them aces: the best way to shoot accurately is to sneak up on someone and let him have it before the bullets start flying!

Optionally, this rule can also be applied to PCs. On the other hand, letting all PCs remain "cool" in a combat situation does allow them to perform more heroically – it's up to the GM.

Aiming Successive Groups

The *Aiming Successive Groups* rule (p. B121) allows automatic weapons to be used like a garden hose, aiming as they fire to get the full Accuracy bonus.

While this is a legitimate tactic in some situations, GMs may find that the interests of play balance are better served by reducing this bonus to *half* of Accuracy, rounding down, when firing under less-than-ideal circumstances. If the *Reduced Hit Probability* optional rule comes into play, this bonus should be further reduced, to one-quarter the Accuracy bonus. Professional soldiers are usually taught that automatic fire is far less accurate than single aimed shots; this rule makes it so.

Reserve the full Accuracy bonus for actual aimed fire, or for automatic fire on the firing range.

Defense of Occupants

If someone fires at a vehicle *occupant* (through an open window, for example) the target gets his normal Dodge roll, with the usual penalties for sitting down. *Exception:* If he is strapped in, or wearing a safety belt, he cannot dodge, although his armor PD will protect!

Anyone *on top of* a vehicle (e.g., someone standing on the deck of a ship or in the bed of a pick-up truck) may dodge normally to avoid attacks that might hit him. However, the GM may rule that he falls down if he fails the Dodge roll – and may wish to apply the same modifier to the Dodge roll as that for weapons fire from a moving vehicle.

A person doesn't get a defense roll (PD or Dodge) if the vehicle was hit and the result was a crew or passenger hit.

Armor and Explosive-Type Damage

PD never protects against explosions. However, vehicle armor is very effective against concussion damage from explosions. If a vehicle or structure has any armor except nonrigid or open-frame, the armor provides far more protection – *square* the DR! This does *not* apply against *direct hits* by shaped-charge (HEAT, HEDP) ammunition. It also does not apply to unsealed personal armor or battlesuits – the force is transmitted through to the person wearing it, and while the armor may not crack, the wearer is likely to be jelly from the concussion!

Fire and Explosion

A fire is one of the worst things that can happen to a vehicle. *Flame attacks* are especially likely to start fires. Flame attacks include explosions, shaped-charge damage, fragments from explosions, flamethrowers, API and "DU" kinetic-energy rounds, Molotov cocktails, lasers, flaming oil, napalm, nuclear explosions and flamers, as well as magical or super-powered fire, including walls of fire, flame jets, fireballs and anything else the GM thinks likely to start a fire.

There are several ways a vehicle can catch fire. These are:

Flame Attack: If a flame attack *penetrates* the DR of any type of vehicle body (or hits a vehicle with wood or plastic armor) the vehicle may catch fire. Roll 3d vs. the penetrating damage (or *any* damage, if it hits flammable armor) done by the flame attack. If the roll is equal to or less than the damage, the vehicle catches fire.

Fuel Tanks: Some types of fuel, like gasoline, have a *Fire* number, as described in Chapter 7 (see the table on p. 90). A check for fire must be made whenever any body or subassembly that contains a fuel tank takes damage greater than half its hit points from a single attack. If using the detailed damage system, a check for fire must *also* be made any time a fuel tank takes damage at least 10% of its hit points. Roll 3 dice. If the roll is less than or equal to the Fire number, the tank catches fire (add +4 to Fire number if the disabling attack was a flame attack).

Once a fuel tank catches fire, roll 3d vs. *half* the tank's Fire number every 10 seconds. "Success" means the fuel tank explodes. The vehicle takes 6d × 10 damage per gallon of hydrogen on board, 6d × 15 per gallon of gasoline, diesel or jet fuel, and 6d × 25 per gallon of flammable rocket fuel. If the vehicle has a self-sealing tank, only one-quarter damage is done – the rest of the energy is dissipated tearing the tank apart against the resistance of the seal.

Continued on next page . . .

Vehicle Critical Hit Table

Critical hits allow individual vehicle components to be damaged. If a vehicle takes a critical hit, the vehicle gets no defense roll.

3 – Triple damage; also, if there is a computer in that hit location and any damage penetrated DR, it is destroyed! (If multiple computers, the largest one is destroyed.)

4 – Double normal damage. Also, if the hit struck the body of a winged or rotary-winged vehicle, or one with a flotation hull, and did damage in excess of 5% of body hit points (minimum 1 hit) after DR, the rudder system is damaged. The vehicle's MR is halved, rounding down.

5 – Bypasses 90% of armor DR and does normal damage (i.e., divide armor's DR by 10). Also, whether any damage penetrated the vehicle or not, a sensor in the hit location (if any) is disabled.

6 – Normal damage; also, the vehicle's power plant, if any, is damaged. The vehicle's largest power plant is badly damaged and its power output is halved (if this result occurs a second time, the power plant stops working). This may reduce the vehicle's speed, if the vehicle cannot provide sufficient power to the propulsion system. If the vehicle has an energy bank but no working power plant, treat as #14, below.

7 – Normal damage; also, if the attack penetrated DR, or if the vehicle has a wooden structure, fire breaks out in the area hit! See the *Fire and Explosion* sidebar.

8 – Normal damage; also, if the vehicle has weapons in its body, one is struck in the barrel and disabled.

9-11 – Window hit: if the hit location has windows or a transparent canopy, one shot goes in through them, ignoring all but window DR (DR 1 for normal windows).

12 – Normal damage. Also, any one item of miscellaneous equipment in the location hit is disabled, GM's option.

13 – Bypasses 90% of DR and does normal damage (i.e., divide armor's DR by 10).

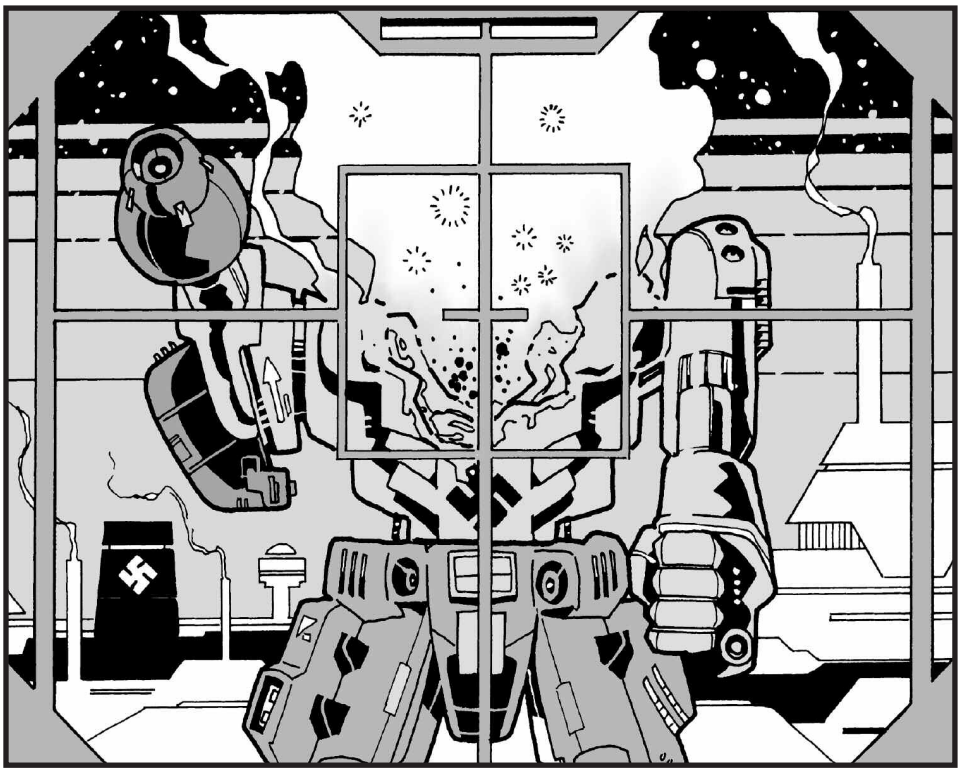
14 – If the vehicle has an energy bank in the location hit, half the maximum kWs of storage capacity (along with half the stored power) are lost. If the vehicle has no energy bank, treat as #6, above.

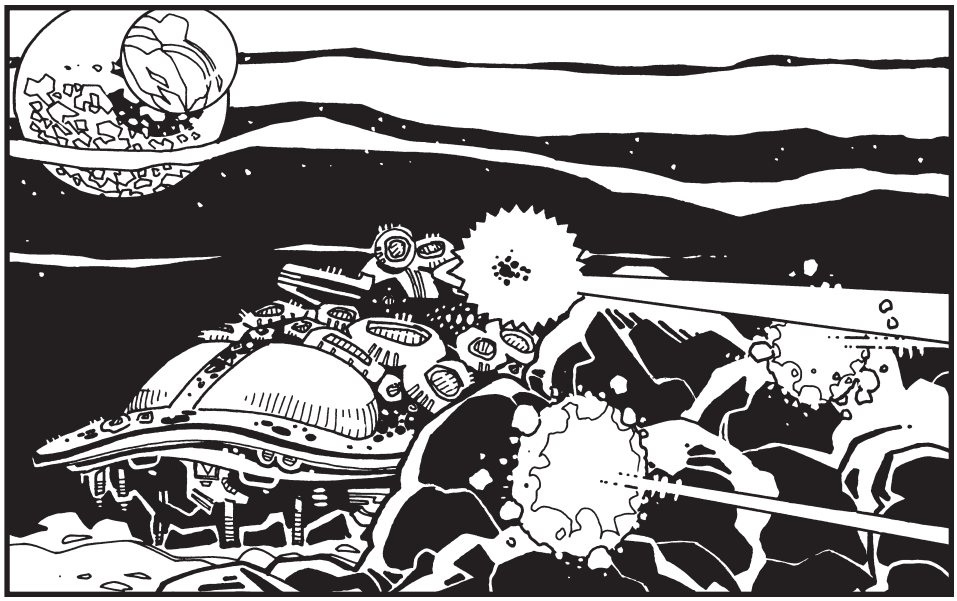
15 – Normal damage; also, if any damage penetrated armor and there is a communication or ECM system in the location hit, one such system is disabled.

16 – Double normal damage. Also, if the vehicle has a fuel tank in the location hit, check for fire, and it develops a leak. 1d% of the total fuel capacity leaks out immediately, plus (unless the tank is self-sealing) 1d% every minute.

17 – Triple normal damage.

18 – Double normal damage; if the location hit contains explosive ammunition and any damage penetrated, the ammunition explodes. See the *Ammunition Explosions* sidebar, p. 186. If no ammunition, treat as #3, above.





Special Situations

These rules describe several situations that can occur in vehicular combat.

Ground Combat

Defilade: Hiding Behind a Ridge

A vehicle on the ground is in defilade (sometimes called "hull-down") if its front side is partially concealed behind a hill, low ridge or building (flying vehicles with no stall speed, like helicopters, *can* also use defilade). Attacks can be made against any rotors, superstructures, open mounts or turrets atop the vehicle's body.

A vehicle in defilade can only fire into its forward arc with weapons mounted in or on turrets, rotors, open mounts or superstructures atop the vehicle body. This restriction does not apply to indirect fire.

A vehicle can also be completely concealed behind cover. For vehicles with turrets, this sometimes referred to as "turret-down." In this case, a crewman can still stick his head out a top hatch to see over the cover, and may fire personal weapons or weapons mounted atop the turret and next to the hatch.

Elevated Positions

Ground vehicles are often intentionally parked on slopes or earthworks to elevate their guns. This allows them to engage aircraft, and also allows indirect fire with direct-fire weapons. The effective elevation of weapons pointing up-slope is increased by the angle of the slope; the effective depression is reduced by the same amount. The effective elevation of weapons pointing down-slope is decreased by the angle of the slope; the effective depression is increased by the same amount. In addition, a weapon pointing up-slope may use indirect fire, even if it is not in a universal or high-angle mount, as long as the slope is 15° or steeper. All fire from elevated positions is at -3 unless the gunner uses a TL7+ Targeting program.

Anti-Aircraft and Aerial Combat

Elevation

Most vehicle weapon mounts cannot elevate or depress more than 15°. This will often mean that nearby targets above or below the vehicle cannot be engaged! Refer to *Angle of Fire* (p. 175) for details.

Strafing

Use these rules for aircraft attacking ground targets with automatic weapons (machine guns, autocannon, etc.) or salvos of unguided rockets when moving at speeds over 100 mph.

Most strafing runs take place at altitudes under 200 yards and at speeds just above stall speed. All the guns fired by a single gunner hit a single "beaten zone." The beaten zone is the area filled with bullets (or other rounds), and is 1 yard × the Speed/Range modifier in length, plus 1 yard per 200 mph of speed. It is 1 yard wide, or 2 yards wide for wing-mounted guns.

Fire and Explosion (Continued)

Every ten seconds that a fuel tank is on fire, fuel equal to 1d × 5% of its total fuel capacity is burned away. When all the fuel is gone, the tank is no longer on fire.

Lifting Gas: Any body or subassembly containing hydrogen lifting gas may catch fire if damaged. Treat them as fuel tanks with a Fire number of 17. Lifting gas – and lift – is lost at the same rate that fuel would be burned away, that is, 1d × 5% per 10 seconds.

Power Plant Hits: Damage to a power plant or reaction engine that uses flammable fuel may result in a fire. If using the detailed damage rules, and an attack disables the power plant or engine, roll three dice vs. the Fire number of fuel used. If equal to or less than the Fire number, the vehicle catches fire.

Effects of Fire: A vehicle on fire suffers 2d damage, plus another 2d every 10 seconds, ignoring DR. Fire damage is always applied to the location where the fire is taking place. The vehicle crew may be able to put the fire out by using fire extinguishers (see p. 65), diving into water, etc. If the vehicle has heavy compartmentalization, subtract 2 from fire damage. If it has total compartmentalization, subtract 4.

If a vehicle has a wooden structure, a fire does 3d damage instead of 2d.

Fire can spread or die. Every ten seconds, each fire may spawn another fire. This occurs if the fire did 8 or more hits of damage after modifiers. However, if an individual fire did less than 4 hits damage after modifiers, that fire dies. If a fire totally destroys a location, the fire there also dies.

Fire-Fighting: A vehicle can use fire extinguisher or fire suppression systems to put out the flames.

Fire *suppression* systems get a roll to put out a fire immediately, with an another roll allowed every ten seconds. Fire *extinguisher* systems do not roll immediately, but do roll every ten seconds. Regardless of the type or number of fire-fighting systems, make a single, separate roll for each fire raging in the vehicle, rolling against the systems' TL+2. *Modifiers:* -1 per separate fire going on at once, +1 per fire extinguisher or compact fire suppression system installed in the vehicle, +4 per full-sized fire suppression system installed.

Individuals with buckets or hand-held extinguishers can also attempt to put out fires, if they aren't doing anything else: each person can fight a maximum of one fire at a time. Roll 6 or less on 3d to put out a fire manually, or TL+2 or less (minimum 7 or less) if using an extinguisher. One roll is allowed every ten seconds but any roll of 17 or 18 means the fire fighter takes 2d burn damage. The DR of fireproof clothing will help against this damage.

Ammunition Explosions

If a body or subassembly that contains ammunition with explosive or submunition warheads, or any rockets, missiles or flamethrowers, loses at least 5% of its hit points, and each turn it is on fire, check for an explosion. If using the detailed damage system, any time a weapon or magazine containing any of the above is disabled, check for an explosion.

Roll 1d: An explosion occurs on a roll of 6, or on a 5-6 if the damage came from a flame weapon (see *Fire and Explosion,* above). If the ammunition is kept in an anti-blast magazine, roll 3d against its TL+6: on a success, the explosion does not damage the vehicle, but the ammunition is destroyed.

To determine the damage of an ammunition explosion, use the damage of 1d shots (or whatever's left) in the weapon or in any ready-to-use magazine. That's the force of the explosion. Damage from the explosion is applied immediately vs. the body or subassembly where the ammunition was stored. Vehicle DR does not protect!

Antimatter and Nuclear Power Plant Explosions

An antimatter fuel bay or power plant will explode on a roll of 16 or less if it or the vehicle location containing it is disabled or destroyed. Failsafes (p. 90) will reduce the chance of this catastrophic effect occurring. Damage from a fuel bay explosion is equivalent to a 12.5-kiloton nuclear blast per gram of fuel stored within it. If an antimatter power plant explodes, damage is 6d × 10,000 per kW of output per year of useful life left in the plant. All damage is explosive concussion damage. The area may also be contaminated by radiation – see ***GURPS Grimoire*** or ***GURPS Space*** for radiation rules.

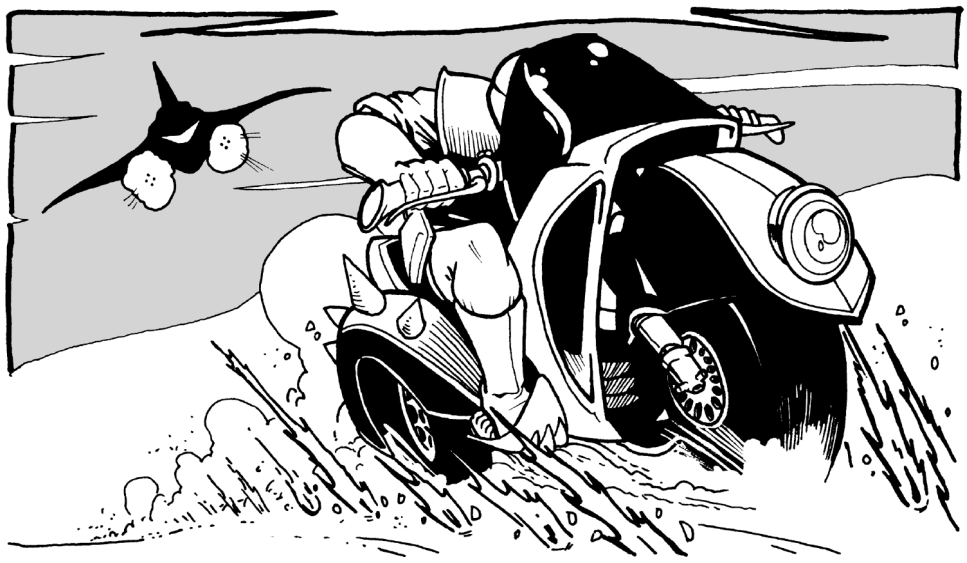
Nuclear power plants incorporate failsafes to keep bad things from happening should they break down. They work . . . most of the time. However, there is a 1 in 6 chance that a fission or fusion plant will undergo an energy release if disabled – this is not a nuclear blast, but a release of (possibly radioactive) steam or high-energy plasma contained within the system. Damage is 6d concussion per kW of output.

Any fission, fusion or antimatter power plant, and any antimatter fuel bay, can be rigged to self destruct. For an antimatter power plant or fuel bay, this is merely a matter of turning off the containment system, and damage is as described above. For a fission or fusion plant, a successful Engineering (Nuclear Weapons) skill roll is needed to cause a nuclear blast; damage is 6d × 100 per kW.

To see where the beaten zone is centered, roll against the firer's skill. All modifiers for range, Accuracy and targeting systems apply, but ignore modifiers for target size, speed and cover, since the target is an area of ground. Roll only once for all rounds fired, regardless of RoF.

On a critical success, the beaten zone is centered on the target hex. On a success, it is displaced from the target hex by one hex per 200 mph (or fraction thereof) of speed the plane is travelling at; roll direction randomly, but reroll any result that puts the zone behind the firing aircraft. On a failure, the center of the beaten zone is five yards × the Speed/Range modifier from the target, in a direction determined as above. On a critical failure, treat as a failure, except that *no* rounds will strike the target hex – and the GM should feel free to center the beaten zone on any friendly forces in front of the firing aircraft that are within 50 yards × the Speed/Range modifier.

One-third of the total number of rounds fired hit the center hex (center two hexes for wing-mounted guns) of the beaten zone. The remaining two-thirds are divided evenly among the other hexes in the zone, with leftover rounds being distributed by the GM to those hexes closest to the center. Anyone in the zone is attacked by automatic fire (use the table in the ***Basic Set***) with a skill of 9. The only modifiers that apply are target cover. Cannon shells may also have explosive warheads: apply concussion and check for fragmentation.



Naval Combat

Underwater Combat and Detection

Targets underwater are hard to spot visually and hard to hit unless guided weapons are used. The only reliable underwater sensors are normal vision (which may be adversely affected by the clarity of the water), sonar, MAD, gravscanners, multiscanners and ladar.

Weapon Ranges Underwater

Guns and *Missiles* fired underwater have 1/20 range – if fired from water into air or vice versa, count each hex underwater as 20 hexes of range.

Torpedoes function normally underwater.

Liquid Projectors flamethrowers are useless, but water cannon have 1/100 range underwater (minimum 1 hex).

Beam Weapons: The range of disintegrators is not affected. The range of stunners and screamers fired underwater is unimpaired. Lasers have 1/10 range; all other beam weapons have 1/100 range.

Explosions: Note that the increment for concussion damage from explosions is *tripled* underwater (see p. 190).

Flooding – Taking on Water

A floating vehicle that has been "holed" will leak. A vessel is holed if damage from an attack below the waterline (see p. 79) penetrated its DR and caused damage equal to or greater than (body hit points/10). Every minute, the vessel will take on pounds of water equal to the points of damage that caused that hole. However, after the first minute, roll 1d to see if the flooding has been stopped by internal, watertight bulkheads. If the vehicle has total compartmentalization, the flooding stops on a roll of 2-6. If it has heavy compartmentalization, the flooding stops on a roll of 3-6. Otherwise, the flooding stops only on a roll of 5-6.

Keep track of the weight of water that has flooded into the vehicle. If the weight of water that has been taken on is more than 25% of the vehicle's flotation rating, the vehicle is considered *badly flooded.* Many of its compartments are filled with water. Its top speed and acceleration are halved.

Worse, enough water may cause the vessel to sink! If the weight of water plus the vehicle's loaded weight is 90% of the flotation rating, the vehicle is *dangerously overloaded.* If the two together equal flotation rating, it will sink at 1 yard/second.

Water can be pumped out if the vehicle has pumps (most vehicles do – see *Bilge Pumps,* p. 66). Characters on relatively small vehicles (under 10,000 cf size) can also help bail out water with buckets, helmets or the like at a rate of about 100 lbs. of water per minute.

If a vessel that does not have a submersible hull sinks, everything in it is disabled. If a vehicle that has a submersible hull "sinks," it can still function (although it can no longer surface) until the weight of the *water alone* is greater than its flotation rating. Then all systems are deemed to have been flooded, and the vehicle is effectively disabled.

Escaping Sinking Vessels

If a vehicle sinks, everyone on deck or near a hatch may swim free, but anyone below decks is doomed unless they can breathe water and survive at whatever depth the ship sinks to. A ship of 10,000 or more cf may suck swimmers down with it: the danger radius around the vehicle is equal to (vehicle's total volume in cf/10,000) yards. Within this radius, a Swimming-5 roll is needed to survive. Modern submarines sometimes carry emergency aqualungs to allow the crew some form of escape in the event of fire or holing; however, below about 50 yards, water pressure makes escape very difficult – characters in a sunken submarine are advised to wait for rescue!

Space Combat

Distances are so vast in space combat that a ten-minute tactical turn is suggested, as described in the *Vehicle Action* chapter. These rules can also be used with a standard one-second turn, however.

Beam Weapons in Space Combat: The ranges given for most beam weapons assume atmospheric interference with the beam. In vacuum, the 1/2D and Max ranges are affected as follows:

X-ray or gamma-ray laser	×100
Rainbow or ultraviolet laser or neutral particle beam	×50
Laser, disruptor, flamer, fusion gun or antiparticle beam	×10
Charged particle beam	×0.01
Screamer or stunner	×0 (does not function)
All other beam types	×1

Guns in Space Combat: Max and 1/2D range are ignored – the projectiles will keep on going, and neither Acc nor damage are reduced past 1/2D range. Indirect fire is not allowed in space combat!

Launchers in Space Combat: Torpedoes are obviously useless in space. For missiles, see the *Space Combat Missiles* sidebar, p. 112.

RoF and Accuracy: If using an ordinary one-second turn, RoF and Accuracy are unaffected. Within a 10-minute turn, normal RoF considerations can be ignored. Assume each weapon will fire *once* every ten minutes at its normal rate of fire, or at RoF 1 if its RoF was less than one. The rest of the time is spent aiming. Because of this added aiming time, the Accuracy bonus which a weapon can add is not limited to the firer's skill! As a result, space combat weapons with high Accuracy may strike over many hundreds of miles and still hit their targets.

Defense in Space Combat: A spacecraft's Dodge is calculated as for a flying vehicle (see p. 178). A spacecraft is considered to be maneuvering evasively, allowing it to Dodge, if it used at least 0.1 g of space acceleration to change its course on its turn.



Nuclear Weapons

The rated damage for nuclear weapons, including micronukes, is explosive concussion damage, just like the explosion of a HE round.

The DR of unsealed personal armor does not protect against explosive concussion damage. However, vehicle DR or the DR of sealed personal armor protects with the *square* of its DR. This means that an exceedingly well-armored vehicle, such as an ***Ogre***-era cybertank, could conceivably survive a direct hit by a very small nuke!

However, concussion damage is not all there is to worry about. Nuclear weapons also produce *flash damage:* an intense pulse of heat radiation. Under normal atmospheric conditions, this is equal to 20% of the concussion damage (just divide the concussion damage by ten and double it); on an exceptionally clear day, use 30%, while on a hazy day, use only 6%. Thus, a micronuke that did 12d × 200 concussion damage would also do 12d × 40 flash damage. Armor DR is *not* squared against flash damage. Flash damage is also reduced more slowly by distance than concussion damage. Instead of quartering the damage every increment, divide the rolled flash damage by the *square* of the distance (in yards) to the point of detonation. For example, a nuke blast 20 yards away would do 1/400 the basic flash damage. Having a calculator is handy to determine the exact damage, but then again, people probably won't drop nukes all that often!

In most cases, the blast and heat from a nuclear weapon are so great that immediate radiation effects from the blast are secondary (anyone close enough to be killed by the radiation pulse will have been blown to bits or burned to death). If the GM wishes to bother, radiation equals one rad per point of flash damage inflicted *before* DR was subtracted.

However, if the fireball touched the ground (a "ground burst"), the cloud of radioactive fallout generated by the mushroom cloud is a serious threat to anyone downwind of or passing through the impact site.

In game terms, assume the contaminated "footprint" is an area 800 yards long and 200 yards wide drifting downwind for a 0.1 kiloton nuke. Double the length and width for each tenfold increase in yield! Anyone passing through the contaminated area soon after the detonation will be exposed to 100 rads of radiation per hour. This drops to 10 rads per hour about two days after the explosion and 1 rad per hour about two weeks after.

Rads accumulate over time. 200 rads will incapacitate someone and may lead to cancer or genetic damage several years later, 500 rads is often fatal, and 750 or more rads will usually kill swiftly. See ***GURPS Space*** or ***Grimoire*** for details. TL9+ weapons (using laser fusion or antimatter) can be designed to be relatively "clean" and will produce 1% the above rad dosages.

Vehicular Body Combat

Any vehicle can "slam" someone: use the *Collision* rules, p. 157. Vehicles designed in a more-or-less anthropomorphic way have other means of inflicting damage:

Fighting With Arms: Robotic arms can be used for brawling, or to wield weapons that are appropriately sized, using vehicle operation skill. A punch does thrust/crushing damage based on the arm's ST. Refer to p. B248 for a table that covers damage at very high Strengths!

Constriction: A vehicle with a flexibody drivetrain may be able to constrict other targets. This should only be possible if neither the attacker nor the subject is moving faster than speed 10 (20 mph), and the flexibody vehicle's volume is equal to or greater (but no more than ten times greater) than its victim's. A typical human is about 2-4 cf in volume. If allowed, this can be treated as a grapple attack with ST equal to [(flexibody drivetrain's motive power in kW)-(the vehicle's weight in tons)] × 80. Treat constriction as a Quick Contest of ST; the victim takes damage equal to the amount he lost by if he loses. If the target lacks a ST value, the Contest is vs. the target's HP instead.

Kicking: A vehicle with legs can kick anything next to it. A kick is resolved as a melee attack using the vehicle's control skill-2. Success does thrust+2 crushing damage, using the leg's effective ST: this is equal to [(leg drivetrain motive power in kW)-(vehicle mass in tons)] × 160, or to 2 × body hit points, whichever is *less,* divided by the number of legs. Legs can also do damage simply by stepping on things during movement. This is covered in the *Collision* rules (p. 157). Kicks have a reach of (leg surface area/20) + 1 hexes.

Super Strength vs. Vehicles

A super, dinosaur, dragon, atomic horror, robot or any other super-strong character, as well as a vehicle with arms, can use its physical abilities to damage a vehicle in ways beyond simply punching it. A successful grapple attack (roll the contest vs. the vehicle's Dodge rather than the operator's skill) allows a strong person to attempt one of the following:

Crush It: If the character is big enough, he can simply crush the vehicle. Use the *Constriction* rules above, pitting the character's ST against the vehicle's effective ST or HP.

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Ammunition – Special Rules

Many types of gun, launcher, bomb and mine ammunition have special combat effects. For actual descriptions of the technology behind these rounds or warheads, see the *Weaponry* chapter. This section provides details of their combat effects: for nuclear weapons and bursting-class ammunition (CHEM rounds, submunitions, etc.), see the appropriate sidebars on pp. 187-196; for all other ammunition types, see below.

Kinetic-Energy Class

These are projectiles that inflict damage through impact. They generally do crushing damage, though some small projectiles may do impaling damage instead.

Solid smallarm or cannon rounds do the ordinary damage described for guns in the ***Basic Set.***

Chainshot is a solid round that gets +2 to hit, and does double damage against masts & sails.

AP, APC, API, APCR, APDS, APFSDS and *APS* are all "armor-piercing" rounds of one sort or another that receive an armor divisor of (2) – that is, armor protects at half-normal DR, rounding down. Against flesh, divide any crushing damage that penetrates by 2 to get the actual damage done. Thus, it halves armor but also halves actual damage. Always round damage down! API rounds also counts as *flame attacks* for the purpose of starting fires.

APDU, APDSDU and *APFSDSDU* are depleted uranium armor-piercing rounds that get an armor divisor of (3): that is, armor protects at one-third normal DR, rounding down. Damage after penetration is divided by 2. Also, these rounds count as *flame attacks* for the purpose of starting fires.

APSHD, APDSHD and *APFSDSHD* are hyperdense armor-piercing rounds that get an armor divisor of (5): armor protects at one-fifth DR, rounding down. Damage after penetration is divided by 2.

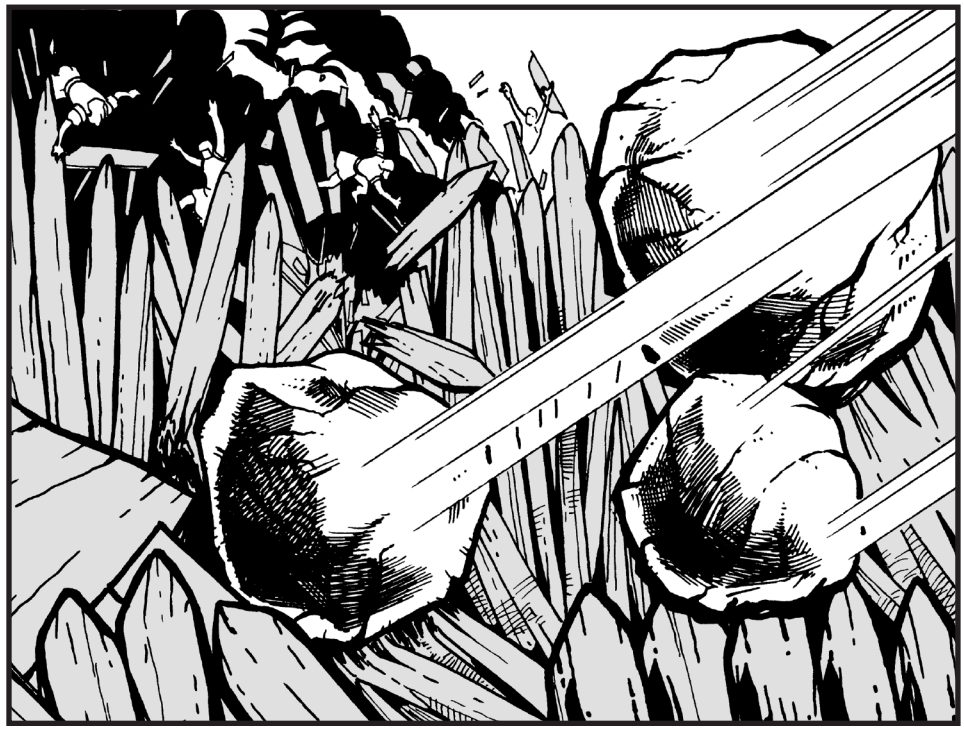
HP ("hollow point") rounds get a 0.5 armor divisor: DR protects at *double value*. As well, anything – even ordinary flesh – gives a minimum DR 1 against it. However, any damage that penetrates DR into flesh is multiplied by 1.5; this does not apply to inorganic objects like vehicles. See p. HT5 for additional rules on hollow point bullets.

Needles do impaling damage. The DR of most types of armor is *doubled* against them. The exception is the DR of nonrigid, open-weave armor, which is *not* doubled and which is limited to 2 versus needles.

Plastic bullets inflict ordinary crushing damage; their lower damage is reflected on the *Ammunition Table* (p. 112).

Baton rounds inflict normal crushing damage for the purpose of knockback, but *halve* actual damage after DR.

Superwire rounds do impaling damage, and armor protects at one-tenth normal DR (one-fifth DR for TL9+ laminate armor). Treat them like needles versus open-weave armor. Unlike many other armor-piercing rounds, damage is *not* reduced after penetration!





EXAMPLE

A 7d(2) damage AP round hits a person or vehicle with no armor. The damage rolled is 23 hits. This is halved to 11 hits. The person or vehicle takes 11 points of damage.

The same AP round hits a person or vehicle with DR 30 armor and does the same 23 hits damage. A normal solid round would bounce off – but the AP round has an armor divisor of (2), so the armor's effective DR is divided by 2, to DR 15. The result is that 8 points of damage penetrate. This is then divided by 2 again, leaving only 4 hits of actual damage.

These rules are based on the revised armor divisor guidelines presented in ***GURPS High-Tech,*** *Second Edition*. They supersede other rules for AP-type ammunition given elsewhere.

Kinetic-Energy Class – Multiple Projectile

Shotshell, canister, shrapnel and beehive are kinetic-energy rounds loaded with multiple, smaller kinetic-energy projectiles, such as pellets or darts.

Shotshell: Use the shotgun rules (p. B119).

Canister: These are multiple-projectile rounds that fire a cone of projectiles from the muzzle of the weapon (see below), like a giant shotgun.

Shrapnel: This is a high-tech form of canister: a thin-cased shell filled with bullets, with a small timed charge to burst it at the desired distance. It is aimed at a specific target hex. Roll to hit normally, as if firing an ordinary round; on a miss, check for scatter. After striking (or missing) the target hex, the round then explodes and sprays a cone of bullets in the direction it was travelling (see below).

Beehive: This is a shrapnel round loaded with finned darts (known as flechettes) instead of pellets. These darts get +6 to hit and do impaling damage. Otherwise, beehive works just like shrapnel (see below).

To resolve attacks with canister, shrapnel or beehive, either use the rules on p. HT19, or the following simplified system:

First, determine the point of dispersion (POD); everything in a cone in front of this point will be attacked. For canister, the POD is the muzzle of the firing weapon, and projectiles are sprayed in the direction the gun is pointing. For shrapnel or beehive, the POD is the hex where the shell landed, and projectiles are sprayed in a direction determined by drawing a straight line between the muzzle of the firing weapon and the POD.

Next, determine the area of effect. This is a cone 1 yard wide at the POD; it increases in width by 1 yard for every 10 yards of range, out to maximum range. Anything in that cone will be attacked, unless it is behind solid cover.

Finally, roll to hit every target in the cone. The attack roll is equal to 9 + (bore size of the weapon/20), plus the target's Size Modifier, minus the range modifier to the target. Use missile diameter/20 for missiles. Always count range from the POD. Flechettes from beehive roll at +6; the only other modifiers that apply to this roll are those for cover. The number of hits inflicted is determined using the table below:

Super Strength vs. Vehicles (Continued)

Throw It: If a character is strong enough to lift the vehicle, he can throw it. If a vehicle is thrown, it will "collide" with whatever it hit (this may be the ground). Its speed is equal to 2 mph times the maximum distance it could have been thrown (not the actual distance). All normal effects of collision (p. 157), including *Whiplash and Concussion,* apply.

Overturn It: This requires only half the ST needed to lift the vehicle, and can be done by several people combining to push it. (This is how rioters disable cars). A vehicle that is flipped over takes damage equal to a side-swipe collision with an immovable object (the ground) at 5 mph. Also, any overturned vehicle, except one with contragrav, two legs, or a flexibody, will be unable to move. (A thrown vehicle lands overturned on a roll of a 1-3 on 1d.)

Tear Open a Hatch: Roll a Quick Contest between the hatch or door's (HP+DR) and the user's ST. If the HP and DR of the hatch or door are unknown, assume that HP are equal to vehicle weight in tons (min. 10, max. 50 HP) and that DR is equal to the DR of the side the hatch or door is mounted on. One attempt can be made each turn. Success allows the character to enter the vehicle's crew or passenger compartment.

Bend a Gun Barrel: A gun barrel normally protrudes slightly from the body or turret. Bending it requires grabbing it, bracing oneself, and yanking hard. This normally requires at least one second per attempt. The ST roll is made at a penalty of -[10 + (weapon weight in lbs./100)]. A weapon with a bent barrel may not fire. The GM can rule that some weapons do not have barrels, or that the barrels of weapons that are concealed do not protrude.



Bursting Class – CHEM Rounds

Instead of damage, these have a radius of effect in yards and spray or scatter chemicals over that radius. The exact effect depends on the filler that was used in the particular round:

Smoke: Covers an area with dense chemical smoke. Smoke takes 5 seconds to fill the area, and lasts for about 300 seconds divided by wind speed in mph (max. 300 seconds). All visually-aimed attacks or sighting through chemical smoke will have at least a -5 penalty. Ladar suffers the same penalty. Note that other sensors, like infrared or radar, are unaffected. Smoke is ineffective underwater.

Hot Smoke: As above, but lasts half as long and penalizes infrared and thermograph sensors or aimed attacks as well as visual ones.

WP: "White Phosphorous" covers the area of effect with a "hot smoke" screen that forms instantly and also blocks infrared and thermograph detection, but only lasts half as long. As well, it scatters burning white phosphorous fragments. Treat as a fragmentation attack (p. B122) with the fragments having a maximum range of twice the radius of effect. Anyone hit by a WP fragment takes 1d damage each turn for the next 20 seconds; clothes will be set on fire, but armor protects normally unless DR is exceeded. A victim, or a friend, may try to scrape off the fragments: this requires a successful DX roll. If trying to remove them yourself, subtract any damage you actually took from the DX roll (unless you have High Pain Threshold)!

Note that WP cannot be extinguished with water and *will* still burn underwater. However, if a WP shell bursts underwater, the fragments will not disperse properly and it will not create smoke. WP does not work at all in a vacuum.

Prismatic Smoke: "Prism" is identical to normal smoke, except that the cloud forms immediately, and it impairs TL7-9 laser beams: lasers (including communicators, designators, rangefinders and ladar) cannot trace a line of sight into or through the cloud. Its effect on weapon lasers is described under *Lasers,* p. 196.

Blackout Gas: Creates a nearly opaque cloud of thick, inky-black smoke that covers the area of effect. Everyone in the cloud functions as though in complete darkness; any action requiring sight is at -10, or is impossible (see p. B92). Light amplification and visual aids like Low-Light TV are useless, but infrared, thermograph or PESA sensors reduce the penalty to -5, and active sensors (such a radar or sonar) are unaffected. However, lasers (except for X-ray and gamma-ray lasers) cannot penetrate the cloud. Characters without breathing gear must make a HT roll each round or take 1 point of damage, choking on the thick smoke.

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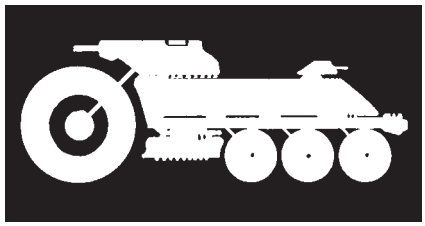

Multiple Projectile Hit Table

Success By	*# Hits*	*Success By*	*# Hits*
0-1	1	6	10
2	2	7	15
3	3	8	20
4	4	9	30
5	7	10	45

. . . and so on, following the same progression.

Explosive-Concussion Class

This is ammunition that does explosive concussion damage through a chemical explosive filler.

Concussion damage works using the rules on p. B121: the explosion affects not just the target which was hit, but everything in a 2-yard radius, at full damage. PD does not protect, but damage is quartered every *additional* 2 yards from the centre of the explosion. As stated in ***High-Tech,*** this applies only to small explosions. Damage is quartered every *4* yards from the explosion if damage is 6d × 20 or more, every *8* yards if 6d × 200 or more, every *16* yards if 6d × 2,000 or more, and so on – each tenfold increase in force doubling the increment. These range increments are *tripled* underwater!

A *crucial* addition to the ***Basic Set*** rules on concussion damage applies when dealing with vehicles and structures: the DR of non-living targets (like vehicles or robots) and the DR of any character in sealed or pressurized armor is *squared* against concussion damage. However, if an explosive round goes off in *direct* contact with flesh (that is, the target doesn't have *any* armor) damage is doubled.

Some, but not all, rounds in this class also do fragmentation damage, as described on pp. B121-122. If it occurs, fragmentation damage is listed in square brackets following concussion damage, and is always cutting; e.g., 6d [2d] is 6d of concussion and 2d fragmentation.

Optional Rule – Fragmentation Damage vs. Large Targets: Large objects may be hit with multiple fragments. An object will be attacked once for each +1 Size Modifier over 0. Thus, for an object with a Size Modifier of +4 (a typical tank or fighter airplane), *four* fragment attacks are made against it – roll vs. PD individually for each of them.

HE and *LE* ("high explosive" and "low explosive") rounds, warheads, bombs and mines use these rules without modification. Note that their explosive damage is not affected by the weapon's 1/2D range.

HEC: These "high explosive concussion" rounds do concussion damage as HE, but do no fragmentation damage.

SAPLE and *SAPHE:* These "semi-armor-piercing explosive" rounds do crushing damage just like a solid projectile, except they have a (0.5) armor divisor – armor DR is doubled against them, and even unarmored flesh has at least DR 1. However, if any crushing damage penetrates DR, the round is assumed to have gone through the target's armor and exploded inside. It then does the same damage as an HE or LE round, but DR does not protect against the concussion and fragmentation damage. If the crushing damage failed to penetrate, the round exploded against the outside of the armor: DR protects fully against the concussion and fragmentation damage (and vehicle or sealed DR is squared). Concussion damage vs. a living target who takes a direct hit is doubled; moreover, if the round penetrated the character's DR (or damaged an unarmored person), it will explode *inside* flesh, and damage is multiplied by five! These rounds can also be used as normal LE or HE, simply by firing them at nearby structures or the ground to produce area concussion and fragmentation effects.





APEX: This "armor-piercing explosive" round functions exactly like SAPHE, except that armor DR is halved vs. the crushing damage.

HEDC: This "high explosive depth charge" round must be set for a specific depth when loaded, and will explode only after reaching that depth. If a submarine (or anything else underwater) is caught in the blast radius, it will take concussion damage. Remember that the range increment is *tripled* underwater!

HEPF: This "high explosive proximity-fused" round works like an HE round, but if it is fired and misses by 4 or less, use the *Scattering* rules (p. 176), even against flying targets, to see how close to the target the round passed. If the round came within 10 yards, it will explode, detonating at that distance from the target. Check to see if the target (or anything else) is within range of concussion and fragmentation damage. When used in indirect fire against surface targets, HEPF is normally set to burst several yards above the ground, spraying fragments: quarter the concussion damage but double the fragmentation distance to 10 yards × dice of damage, and only overhead cover gives protection against it!

These rules do not quite reflect the way late TL7 air-to-air missiles (AAMs) work. These AAMs use an "annular blast fragmentation" (ABF) warhead – a shaped explosive that projects its blast and fragments in a lethal cone ahead of the weapon, triggered by a proximity fuse. An ABF warhead is treated like ordinary HEPF. It spews fragments only in a 60° forward cone, but fragment damage is doubled.

HESH: If a "high explosive squash head" round strikes, treat it exactly like an HE round with two exceptions: it does no fragmentation damage, and if it scores a direct hit and fails to penetrate armor DR, 10% of the damage (one point per 10 points of HESH damage) will still bypass DR and inflict damage anyway! Internal component DR (and personal body armor) protects normally against this damage.

Shaped-Charge Class

These are specially-shaped explosive charges built to penetrate armor.

HEAT: A near miss by a HEAT round has much the same effect as a near miss by an HE round, except there is no major fragmentation. On a direct hit, the damage is treated differently: the DR of any target that is *directly* struck protects at only one-tenth its normal value; HEAT has a (10) armor divisor. This is a big difference from armor DR being squared vs. concussion damage!

However, a HEAT warhead fired at a soft target may not detonate. Roll 3d vs. armor DR+3. (In the case of nonrigid armor, use only half its DR. This is an enhancement to the rule in ***Ultra-Tech.***) If the roll fails, the weapon doesn't go off. Instead, it inflicts one-sixth its normal damage as crushing damage, and has no armor divisor. For instance, a shaped-charge warhead that would have done 6d×4(10) damage now does 4d of ordinary crushing damage.

Laminate armor is specially designed to disrupt the jet produced by HEAT attacks. This armor protects with *twice* its DR against direct hits from HEAT rounds. (Since this doubled DR is then divided by 10, this effectively means that laminate armor gets one-fifth DR vs. HEAT.)

Damage from HEAT rounds counts as flame damage for setting fires. Note that unlike some AP-type rounds with armor divisors, the HEAT round does full damage after penetrating armor.

HEDP: This is a "dual purpose" round with the effect of HEAT, but only a (5) armor divisor. In addition, it inflicts fragmentation damage (p. B121); this damage is noted in square brackets after the HEDP's normal damage. Unlike HEAT, it always explodes, even against soft targets.

Bursting Class – CHEM Rounds (Continued)

Poison Gas: These include nerve gas, tear gas, etc. Anyone in the area who is not wearing sealed armor or inside a life-system- or NBC-kit-equipped vehicle will be exposed to the gas. The duration of the gas cloud depends on the type:

Tear Gas: See B132.

Mustard Gas: See B132.

Nerve Gas: This lethal gas causes the nervous system to malfunction, resulting in death. It is a contact agent – actually a fine liquid aerosol spray rather than a true gas – and a gas mask alone does not protect. Only being inside a sealed vehicle with a NBC kit or life system, or wearing an airtight suit, will prevent exposure. Each turn, anyone exposed to nerve gas takes 1 hit of damage, or 2 hits if not wearing a gas mask. He must also make a HT-4 roll each turn (unless wearing airtight armor); if it is failed, he will be paralyzed for (30-HT) minutes, and take 4d of damage if not given an antidote within five minutes.

Persistent Nerve Gas: As nerve gas, but coats vegetation, structures, vehicles and the ground, and does not dissipate for several days. Rain or snow may help clear it up more quickly.

Pesticides and Herbicides: These kill insects (pesticides) or vegetation (herbicides). They may be species-specific or generic. Some types are toxic (treat as tear gas if inhaled, with long term effects being up to the GM), others are theoretically harmless.

Sleep Gas (TL8): For every turn spent in a sleep gas cloud without holding his breath, an unprotected character must roll HT-4. If he misses the roll, his ST goes to 0 and he falls asleep. If he makes the roll, he takes 1 point of fatigue. If fatigue drops to 0, he falls asleep. If he leaves the cloud, he may regain lost ST normally. Those who fall asleep remain so as long as they continue to breathe the gas, and for at least 30-HT minutes after that. When that time is up, the victim must roll HT each minute to awaken. He may be awakened normally by a successful First Aid roll.

Bioagents (TL6): These contaminate the area of effect with whatever germ or virus they were loaded with. Any unprotected person in or entering the area must check for infection (pp. B133-134) as if exposed. The contamination usually remains for days or longer; rain or snow may help clear it up more quickly.



Bursting Class – Submunitions

These rounds can only be fired indirectly (p. 179) or dropped as bombs. They have no damage listed on the *Ammunition Table* in Chapter 9. Instead, they have a burst radius in yards; the effect within the radius depends on the munition:

ICM: These automatically inflict 2d concussion damage and 4d cutting fragmentation damage to everything within the burst radius, and one-quarter that damage to anyone within twice the radius! At TL8, double concussion damage. At TL9+, triple concussion damage.

Also, roll 3d for each being, structure or vehicle within the burst radius: on a roll of (5 + Size Modifier) or less, the target is directly hit by a bomblet. The bomblet's shaped-charge warhead adds a (10) armor divisor to the concussion damage: use the rules for HEAT direct hits. Concussion and fragmentation damage for direct hits is unchanged.

Overhead cover (e.g., being in a forest) gives a 50% chance (a roll of 1-3 on 1d) of completely protecting against fragments, halves the concussion damage, and gives a -3 to the roll for a direct hit. Being inside a solid building (unless standing next to a glass window, etc.) will protect completely if the building holds up.

SICM: These "Smart ICM" burst open in the air and release (bore size/40, rounding fractions up) homing submunitions. These descend slowly, swinging around as they scan below them using their own sensors to look for targets. Each submunition will select one vehicle-sized target (anything with Size Modifier +1 or more). If there are more viable targets than submunitions, randomly determine which of the vehicles are attacked by which submunitions. If there are fewer, divide the attacks evenly among them, randomly determining which vehicles receive additional attacks.

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Unguided Missiles

These weapons – such as rockets – differ from ordinary guns in that they have Endurance (End) and Speed (Spd) statistics.

If used in direct fire, they are treated as guns out to their 1/2D range. If their Endurance is *2 seconds or more,* they will take more than one turn to reach their target if it is beyond 1/2D range, preventing them from accurately striking fast-moving targets at this distance. In this case, a successful attack roll means they hit the hex the target was in *when the missile was fired,* while a miss scatters normally.

If used for indirect fire, treat them exactly like guns, with the capability to fire out to 5 times their maximum range.

Guided Missiles

A missile must be launched in the general direction of its intended target. It may be successfully launched at any target that is outside its minimum range. A single gunner can only fire and control one wire-guided or TV-guided missile at a time. Any number of other missiles (provided they are linked) may be fired at once. Different rules apply for launching and guiding different types of missiles, as described below.

Wire-, TV- and Communicator-Guided Missiles

To fire, the gunner must have detected or visually sighted the target. The gunner's vehicle may not be moving if using a wire-guided weapon. A missile that is not mounted to face forward or backward may only be launched in atmosphere if the vehicle is moving slower than 100 mph (40 mph if moving underwater). There are no other requirements.

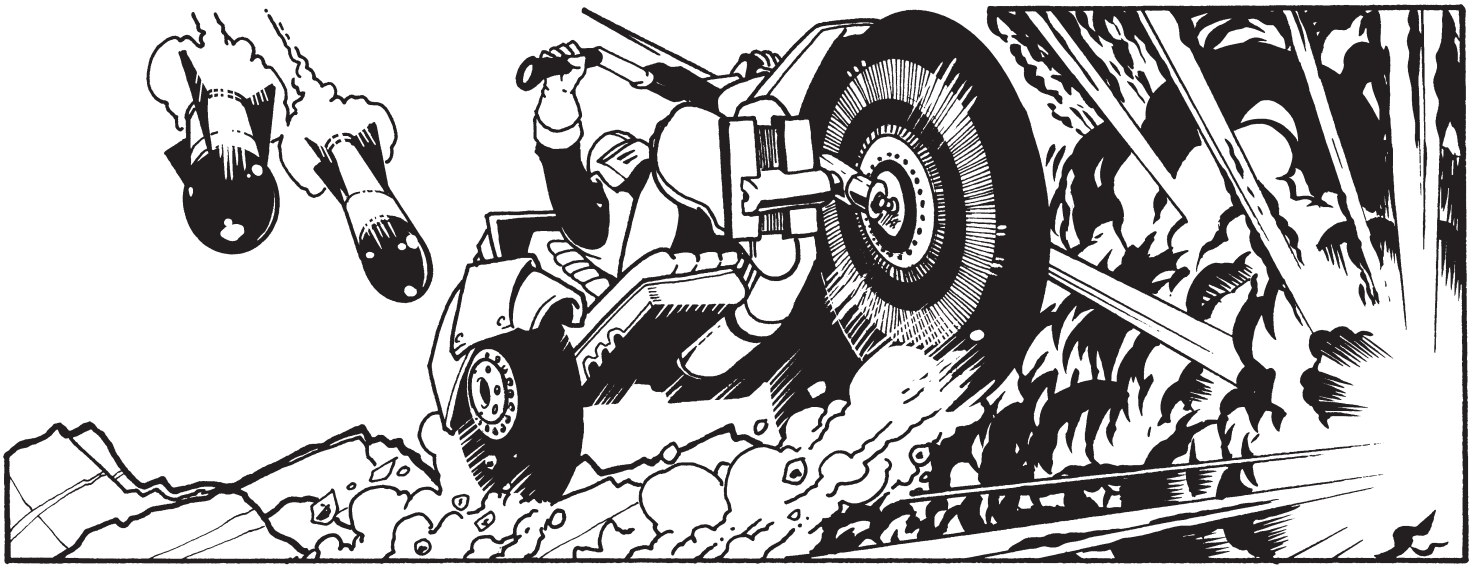
Launching requires an attack maneuver. To launch a missile, the gunner rolls versus his Gunner (Guided Missile) skill at +4. Failure means the missile was incorrectly launched and will automatically crash on its first turn of flight.

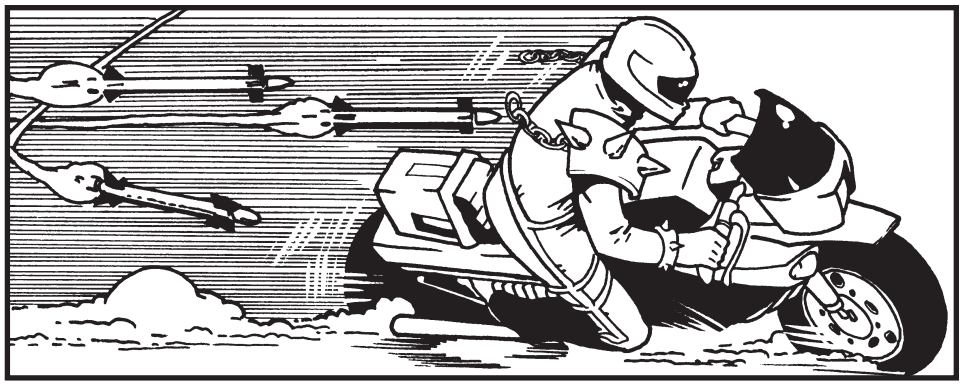
Each turn a missile is in flight, check to see if it can track its target. Whether a missile can track its target depends on its guidance system (see below). If the criteria for tracking a target are not fulfilled, the missile will either crash or plow ahead without maneuvering, depending on the guidance system. Here's how the different systems track targets:

Wire-Guided (WG): The missile will track its target as long as its gunner can see (or detect with sensors) the target and does nothing but remain at his crew station and continue to take Aim maneuvers to steer the missile. Neither the gunner nor the firing vehicle may move or dodge. If these criteria aren't fulfilled, the missile will crash. The gunner must also make periodic skill rolls vs. his Gunner (Guided Missile) skill to keep the missile steady: roll every turn for early TL7 missiles, every 5 turns for later missiles (but at least once during its flight). A failed roll means the missile is off course; roll at -3 to avoid a crash on the next turn, with success bringing the missile back on track.

Communicator-Guided (CG): As for WG, above, except that the communicator must be in communication with the weapon, and the firing vehicle (but not the controlling gunner) can move or dodge. All usual communication restrictions apply: laser communicators must have a line of sight, radios can be jammed, etc. If communication is lost, the weapon will crash or self-destruct.

TV-Guided (TVG): Use the same rules as for WG, except that the firing vehicle need not remain stationary, and since the missile has a camera in its nose that feeds a picture to the launcher, the gunner does not have to directly see or detect the target: he can watch it through the missile's camera. Only one successful skill roll is needed to fly the missile – roll on the first turn of flight.





If a WG, CG or TVG missile can track its target, it will move toward it at its listed *Speed.* A missile must be steered to keep its target in front of it. To do so, the gunner may cause it to change direction by up to 30° each turn, climb or dive. A missile can only move for a number of seconds equal to its *Endurance.* After this is exceeded, it will self-destruct.

If the missile reaches its target, see *Striking the Target* on p. 195.

Homing Missiles

A homing missile must "lock on" to its target before it can be launched. This requires an Aim maneuver by the gunner. If using identical missiles against the same target, make only one attempt for all the missiles; if a die roll is needed, roll only once: the missiles will either all lock-on or all fail.

The procedure required for lock-on depends on the type of missile guidance. Resolve the attempt as a roll against the gunner's Electronics Operation (Sensors) skill + the missile's skill. Apply target Range and Size (but not Speed) modifiers as described on p. B201, and additional modifiers depending on the type of missile guidance as follows:

Active Ladar Homing (ALH) uses the *Ladar Modifiers,* p. 171.

Active Radar Homing (ARH) uses the *Radar and Imaging Radar Modifiers,* p. 171.

Active Sonar Homing (ASH) uses the *Active Sonar Modifiers,* p. 169.

Anti-Radiation Missile Homing (ARM) can only lock onto a target that is using a radar, radio or active radar jammer that is in line of sight and within a distance of up to twice the radar, radio or jammer's range. Subtract the target radar, radio, or radar jammer's (TL-6) × 2 from the chance of success.

Infrared Homing (IRH) and *Imaging Infrared Homing (IIRH)* use the *Infrared and Thermograph Modifiers,* p. 169.

Multiscanner Homing (MH) can be used as either bioscanner, radscanner or chemscanner homing: decide before rolling for lock-on. All three options can be tried for lock-on in a single turn if one fails. A radscanner can only lock onto a target that is emitting some form of radiation (including radio or radar), while a bioscanner can only lock onto living targets. Use the *Multiscanner Modifiers,* p. 174.

Neutrino Homing (NH) gets a +4 if the target has an operating radiothermal, nuclear, fission, fusion or antimatter power plant, rocket or air-ram, or has a force screen up, and subtracts (TL-9) if the target uses basic emission cloaking or twice that if the target has radical emission cloaking.

Optical Homing (OH) uses the modifiers for visual sighting rolls (p. 174), ignoring the penalties for bad light.

Passive Electromagnetic Homing (PEH) can be used as either OH, IIRH, ARM or PRH. All four options can be tried for lock-on; decide on the order before rolling. The first one to succeed is used.

Passive Sonar Homing (PSH) uses the *Passive Sonar Detection* modifiers, p. 172.

Passive Radar Homing (PRH) uses the *Passive Radar Modifiers,* p. 170.

Semi-Active Laser Homing (SALH): The missile cannot lock onto the target unless it is illuminated by an allied laser – see sidebar, p. 196.

Semi-Active Radar Homing (SARH): The missile cannot lock onto the target unless it is illuminated by an allied radar or imaging radar – see sidebar, p. 196.

One lock-on attempt can be attempted each second. (If using the 10-second dogfighting rounds or 10-minute space combat turns, still allow only one attempt per round or turn.)

Lock-On Table

Die Roll	*Result*
Critical failure	False lock-on
Failure by 3 or more	No lock-on
Failure by 1 or 2	Lock-on, detection*, but may be spoofed
Success by 0 to 2	Lock on, detection*
Success by 3 or 4	Lock-on, recognition*
Success by 5 or more	Lock-on, identification*

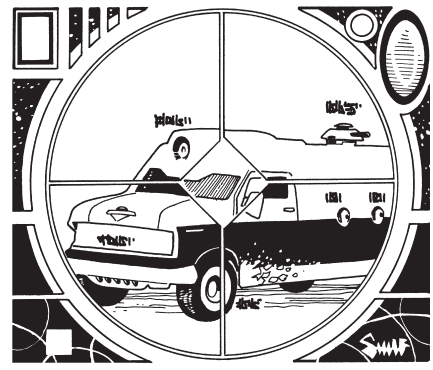
Bursting Class – Submunitions (Continued)

Once a submunition has selected a target, it explodes in mid-air. The explosive shapes the submunition's metal into something known as an *explosively-forged fragment* (EFP). The EFP is a chunk of dense metal that shoots downward at an extremely high velocity, hopefully penetrating the roof of the target vehicle.

To determine whether the fragment hits, roll 3d vs. (warhead's TL + target's Size Modifier). If the target is protected by IR Cloaking, subtract that from the chance to hit. Thick overhead cover, like a forest, gives a -3 to the roll. The attack is assumed to come from above. The target gets normal defense rolls. A successful hit does 6d×2(5) at TL8 or 6d×3(5) at TL9+. The (5) indicates that armor DR protects at one-fifth normal value, thanks to the density and extremely high velocity of the fragment.

If there are no viable targets, a SICM submunition will land somewhere within the burst radius and turn into a land mine, with its sensor facing upward. Anything with a Size Modifier of +1 or more that passes over the munition will detonate it, causing the EFP to fire *upward* into the bottom of the object. If a vehicle drives over a SICM, don't bother to roll to hit – assume the mine's fragment hits automatically. The GM should determine the chance of driving over a SICM projectile, depending on where it lands.

SATNUC: These "SATuration NUclear Clusters" use the rules for SICM (above), but a SATNUC submunition inflicts 6d×2,000 explosive damage! Unlike SICM rounds, SATNUCs that miss or fail to find targets will still explode. The heat and concussion from this pattern of multiple, exploding micronukes inflicts 6d×200 damage to everything within the burst radius of the round, and 6d×20 damage to everything within twice its burst radius. The burst radius of a SATNUC strike is contaminated with at least 50 rads/day (10 rads per day within twice the radius). See ***GURPS Grimoire*** or ***GURPS Space*** for radiation rules.



Bursting Class – Special Types

Starshell: Fired into the air, these flares illuminate 100 times the radius shown for a normal CHEM round with light equivalent to daylight. They burn for 5 minutes. Fired at ground targets, they illuminate only ten times the radius shown, but may start fires if in contact with flammable material, or do 2d of burn damage to anyone directly hit. If set off suddenly, anyone within 15 yards looking at the burst without anti-glare goggles must make a HT roll or be blinded for (20-HT) seconds – roll at +3 if 5+ yards away, and at -3 at night. At TL11+, starshells use high-performance aerostats to remain airborne for ten times as long (provided this technology exists in the campaign).

Chaff (TL6) bursts into a cloud of conductive strips designed to reflect radar signals, which produces a huge, diffuse target that can distract incoming missiles or give the vehicle something to hide behind – see the *Sighting and Detection* chapter for the effect: in general, a -10 penalty on radar detection, but only effective vs. radar of the same or lower TL. Area of effect is five times that of a CHEM round. It disperses in (150/wind speed in mph) seconds (max. 150 seconds). Air-launched chaff will also drift downward at about 5 yards/turn.

Flare (TL7) a hot decoy, usually launched from a discharger, that is used to jam infrared and passive radar homing missiles. An infrared or imaging infrared homing missile is -5 to its attack roll if the vehicle has launched a flare of equal or higher TL than the guided weapon. A passive radar homing missile is at -3 under the same circumstances.

Napalm: The napalm mix splashes out over the same radius as a CHEM round. Everything in the inner half of the radius is affected automatically; napalm is capable of penetrating into earthworks and bunkers – anything short of fully-enclosed cover is no protection. In the outer half of the radius, roll 3d for each target: a target is hit by the splash on a roll of (5 + Size Modifier) or less; at this distance, cover will protect. Napalm sticks to whatever it hits, and continues to burn for at least a minute (60 turns)! It cannot be extinguished by anything less than complete immersion in water or burial under lots of earth (which won't help the victim). Napalm does not require oxygen to burn. Dropped on water, it will float (still burning): it is necessary to dive underwater and swim out of range to escape it.

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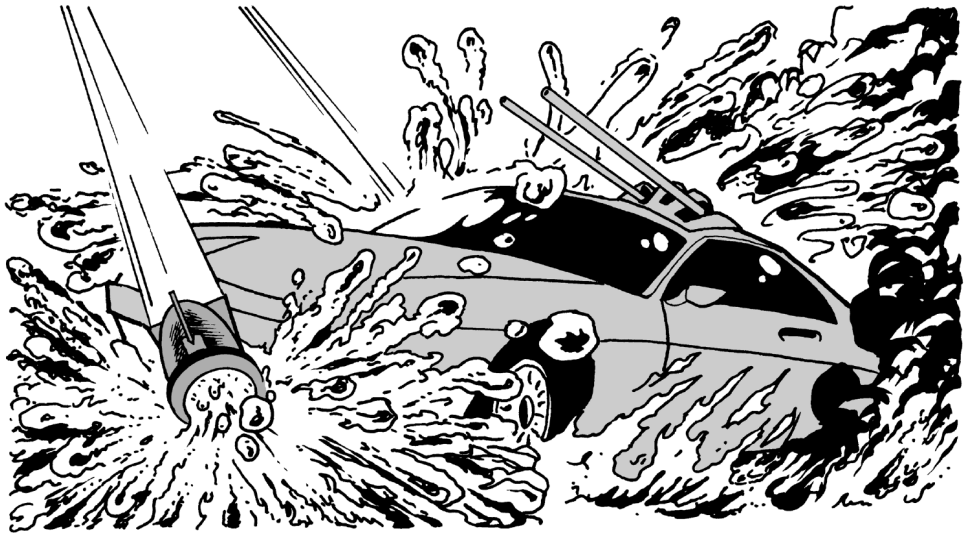

False Lock-On: The gunner thinks he has locked the missile on target. It is locked onto *some*thing (GM's option) in its arc of vision – but not the correct target! It will chase that object once launched.

No Lock-On: The missile's seeker head has not yet acquired a valid target. Another attempt can be made next turn (next round in a dogfight) – it is often a good idea to move closer first!

Lock-On: If the lock-on roll succeeded, the missile cues the gunner that it is ready to be launched. The missile can then be fired – see *Launching Homing Missiles*, below.

Lock-On, May Be Spoofed: The missile cues the gunner that it is ready to be launched. The missile will work normally unless the target has an operating deceptive or IR jammer effective against that type and TL of missile. If so, everything will seem fine, but when launched, the missile will go off course and automatically miss.

* *Detection, Recognition and Identification* – If using an IIRH, OH or PRH weapon, or a PEH weapon using one of these modes, the weapon also transmits an image of the target to the gunner's console as if passive infrared (IIRH), passive radar (PEH) or low-light TV (OH) had detected, recognized or identified the target. The missile ceases to transmit imagery when it is fired. It is possible not to fire and simply keep using a missile as a sensor; some gunners in the Gulf War used their IIRH Mavericks this way.

Launching Homing Missiles: A homing missile must have a lock-on to launch. Launching a locked-on homing missile is an attack. A missile that is not mounted to face forward or backward may only be launched in atmosphere if the vehicle is moving slower than 100 mph (40 mph if moving underwater). To launch, the gunner rolls vs. his Gunner skill at +4. Failure means the missile was incorrectly launched and will crash on its first turn of flight.

Once launched, the missile moves toward the target at its listed Speed. A missile will always try to keep its target in front of it, in the arc of vision (see p. B115) of its guidance system. To do so, it may change direction by up to 30° each turn, climb or dive. A missile can only move for a number of seconds equal to its Endurance. After this is exceeded, it will self-destruct. The missile retains its lock-on and tracks the target unless any of the following occur:

1. The target moves out of arc of vision or line of sight of the missile, e.g., behind a hill. This automatically breaks lock-on.

2. The target launches a decoy effective against that type of missile, unless the missile successfully rolls vs. its skill with a penalty equal to the TL of the decoy. A decoy is effective only if its TL is equal to or higher than the TL of the missile guidance, and is of the proper type: IRH, PRH and IIRH guidance are decoyed by flares, ARH and ALH guidance by chaff, ASH and PSH by sonar decoys. Whether and how PEH can be decoyed depends on the system it is using to home with.

3. The missile is an ARM, and the target radar or area jammer shuts off before the ARM strikes. In this case, the ARM will cease to home, but will head for the emitter's last known location if it makes a successful roll against its skill rating: it ceases to function as a homing missile, and is now treated as an inertial guidance missile (p. 195).

4. The missile is NH, and the reactor, force screen, etc., it was homing in on shuts off before it strikes. In this case, the NH missile will cease to home, but will head for the target's last known location as if it were an IG missile. Use the rules for ARMs (#3, above).

5. The missile uses semi-active radar homing (SARH), and the target is no longer illuminated by the radar used to achieve lock-on. Note that, since most radars point forward, a moving aircraft guiding SARH missiles with its own radar will generally have to keep its nose pointed at the target and will not be able to turn away, climb or dive without losing control of its missile.

6. The missile uses semi-active laser homing (SALH), and the target is no longer illuminated by a laser designator.

If a missile successfully tracks and reaches it target, see *Striking the Target* on p. 195.

Using Brilliant Missiles

A brilliant missile must be *programmed* with its course and target before it can be fired.

Its *course* is the distance and bearing that it will fly before activating its terminal homing system. Distance can be up to 90% of its range. Bearing may be any direction; late TL7+ missiles can also be programmed to fly in a particular pattern, e.g., a dog-leg or zig-zag.

Targets are the specific targets it will try to attack. At TL7, this category must be fairly general (e.g., biggest surface vehicle, or biggest building, for instance). At TL8+ it may be detailed, e.g., a specific type of vehicle or building, or a series of prioritized categories (typically summarized as "biggest intact enemy vehicle, from a database of known enemy vehicles"). Weapons given narrow target parameters will attack only applicable targets; those with broad parameters may attack friendly as well as enemy targets, although they can be pre-programmed to ignore targets with friendly IFF (p. 57).

Programming takes 10 seconds at TL7 and two seconds at TL8+; multiple, identical weapons can be programmed (for the same course and target) simultaneously.

Launching requires an attack maneuver. A missile that is not mounted to face forward or backward may only be launched in atmosphere if the vehicle is moving slower than 100 mph (40 mph if moving underwater). To launch a missile, the gunner rolls vs. his Gunner skill at +4. Failure means the missile was incorrectly launched or programmed and will automatically crash on its first turn of flight.

Once launched, the missile moves on its preset course at its listed Speed to the point where it was programmed to turn on its "terminal" guidance system. It then selects the nearest target in its arc of vision which matches its programmed target parameters. If there are no targets that match, it will continue to cruise straight ahead until it finds one or flies for more turns than its Endurance (in which case it crashes). Once it has found a target, it will turn on its terminal guidance system and attempt to lock-on as a homing guidance missile (see above), rolling versus every target in its arc of vision, starting with the nearest. Until it succeeds, it will fly straight, making a new series of lock-on roll each turn. Once it has locked onto a target, it functions like a normal homing missile.

Using Inertial Guidance (IG) Missiles

Before launch, the gunner must preset the weapon with the distance and direction it is to travel, up to a maximum distance equal to its *Max* statistic. If the weapon is to strike a surface target (on the ground or water), the weapon must also be preset with the target's map coordinates. For obvious reasons, inertial guidance weapons are most effective against fixed targets like buildings! Finally, the gunner decides whether the weapon will follow a relatively flat, direct trajectory or an arching, indirect trajectory. If used indirectly, the weapon's endurance is multiplied by five, but its accuracy will be reduced.

TL6 and early TL7 IG weapons must be programmed *before* the weapon is loaded into the launcher. This takes at least several minutes. Late TL7 and any TL8+ IG weapons can be programmed in advance *or* at the time of firing, by a computer or a person using a computer terminal. Programming takes ten turns at TL7 but only one turn at TL8+. Multiple, identical weapons can be programmed simultaneously, provided they are given identical programming.

Once launched, the missile automatically flies toward the pre-programmed target area at its full speed. When it gets there, roll to see if the missile has hit: use the gunner's skill and apply the Size Modifier of the target area (maximum +10), with a -10 penalty if fired indirectly. On a failed roll, the missile scatters (see p. 176). The GM may apply additional modifiers based on the accuracy of the maps that were used to program the missile.

If the roll was successful, see *Striking the Target,* below.

Striking the Target

No attack roll is needed, since the missile is guided. A missile normally strikes the side of the target facing the direction the missile approached from (but see *Pop Up,* in the sidebar on p. 197).

Bursting Class – Special Types (Continued)

Treat napalm as normal flame damage: 1d-1 per turn (see p. B130). In addition, napalm burns up the oxygen in its immediate area, threatening even those protected against the flame with asphyxiation: make a HT roll each turn or take 1 hit of damage, unless in an airtight environment or wearing airtight armor. A vehicle drenched with napalm had better have life support!

Super-Napalm: This is like napalm with a burn duration of only ten seconds, but does 5d damage at TL9 or 6d at TL10+.

FASCAM (Field Artillery Scatterable Mines): This dispenses a cluster of small, pressure-sensitive anti-armor mines. It must be fired indirectly or dropped as a bomb. Any vehicle moving on the ground through the area where the mines land must make a roll versus (Size Modifier + 3) every 5 yards; "success" means that it has hit a mine. Each mine does 6d(10) × (TL-6) damage, treating the mine as a HEAT round attacking from below the vehicle.

Tangler: This round expands out into a net of sticky strands. The area of effect is one-quarter that of a normal chemical round, but anyone directly struck or in the area of effect may be trapped! Victims of a tangler round have an extra Dodge roll to evade the strands before they close, but neither armor PD nor DR protects against being hit by tanglers, as they simply wrap around armor as well as the person wearing it.

A person who is trapped gets one Quick Contest of Strength per minute to break the strands; the strands' ST is equal to half the bore size of the tangler round. Alternatively, if the victim is fully-clothed, an Escape-3 roll (one try every 10 minutes) will let him wriggle out of his clothes and escape. Any failed attempt to break free or wriggle out results in the strands constricting, causing 1 point of damage. Any rigid armor with DR 2+ protects totally against the constriction damage. The PD of deflectors (p. 93) *is* effective against tangler strands.

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Bursting Class – Special Types (Continued)

Ten hits from intense heat, such as a laser or flamer, will free the victim, but he will also take full damage from the weapon if he isn't otherwise protected. The threads are too tightly wound around the victim, as well as too sticky, to be cut off. The easy way to remove tangler strands is with anti-tangler aerosol spray. A can costs $100, weights 2 lbs., and treats 25 captives at one per turn. A "dose" of this spray costs $4, for the purpose of filling a CHEM round.

If one is hit by multiple tangler rounds, each additional round adds half its ST to the ST of the strands, and gives -1 to any Escape attempt. The strands lose their constricting ability after 24 hours, then lose ST at a rate of 1 per 2 hours.

Illuminating Targets

Semi-active laser homing (SALH) weapons and semi-active radar homing (SARH) weapons can only be fired at a target that is "illuminated" or "painted" by a target-designating beam. This beam is a laser in the case of SALH weapons and a radar for SARH weapons.

The target-designating beam may come from the firing vehicle, or from another source – for instance, an aircraft may fire a laser-guided missile at a target that is illuminated by an infantryman with a hand-held laser designator.

Laser illumination for SALH may be provided by a laser designator (p. 58) or any ladar (p. 51) except one modified with the "no targeting" option.

Radar illumination for SARH may be provided by any radar except one modified with the "no targeting" option. The radar must have detected the target, as described in the detection rules. Early TL7 radars can only guide missiles toward one target at a time; to engage multiple targets, multiple radars are needed.

Continued on next page . . .

Rolls for hit location, defense and damage proceed normally; however, PD is treated as 0 against guided missiles.

A successful Dodge roll means the missile missed. If it was attacking a surface target or had a proximity warhead, it may still explode: use the *Scatter* rules (p. 176) to determine how far away the missile exploded – it still might do damage to the target or something else important. In the air or in space, a dodged missile will fly past the target and continue on until it runs out of fuel or hits something.

Exception: Missiles with bursting-type warheads detonate *over* the target area rather than striking it. Thus, a Dodge will often have no effect unless the missile scatters by a distance greater than its radius of effect.

A missile can also be shot down – see the sidebar, *Detecting and Shooting at Missiles,* p. 197, for details.

Unguided Torpedoes

Once launched, these must move straight ahead at full speed for a number of turns equal to their Endurance. A target will be hit if it gets in the way. GMs should require Vision or sensor rolls to spot torpedoes in time to take evasive action. A submerged vehicle can only effectively launch an unguided torpedo at a surface vessel if it is within 30 yards of the surface, or if it is presently climbing.

Guided Torpedoes

Guided torpedoes are treated exactly as guided missiles, except for some additional restrictions on how they are launched. Any vehicle presently in or under water can launch a torpedo, as can an aircraft flying low over water. A torpedo may not be launched on a turn in which a vehicle performed a 1 g or harder maneuver. A torpedo that is not mounted to face forward or backward can only be launched if the vehicle is moving slower than 40 mph. Also, air-launching a torpedo requires a Gunner (Torpedo) skill roll to drop it properly, with a -1 per 50 mph of speed or 25 yards of altitude. Failure means the torpedo was improperly launched and sinks. At TL7, guided torpedoes dropped by aircraft are delivered by parachute, which gives +4 to skill. Some missiles may also deliver torpedoes.

Beam Weapons – Damage Effects

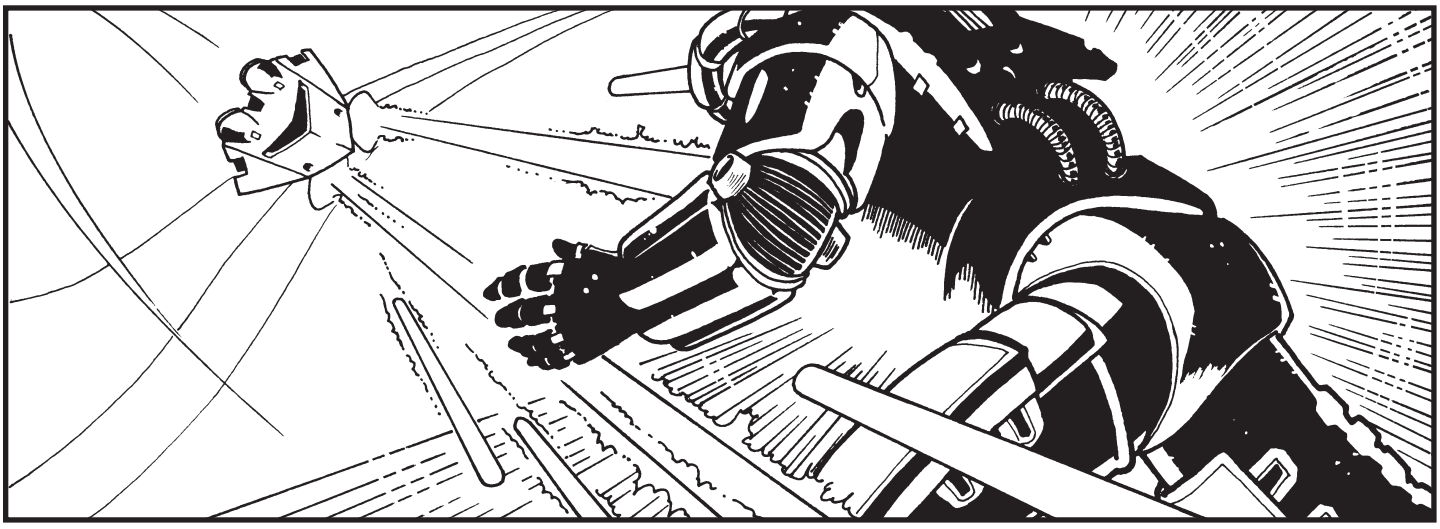
Most types of energy beam have special rules pertaining to how they do damage:

Lasers (TL8): These do impaling damage. In rain or fog, lasers do half damage. Damage is also halved for *every* (1/2D range/5) hexes of smoke (or fraction thereof) they cross. Lasers cannot penetrate Blackout gas or Prism clouds at all. Lasers fired at RoF 4 or higher use the special laser automatic fire rules described under *Damage from a Burst,* p. B120.

Disruptors (TL8): Damage versus living things is *tripled* rather than doubled after DR. The same applies to brick or wood. Microwaves also interfere with electronics: double damage after DR is applied to any electronic component (sensors, radio, etc.) hit. However, targets with metal or laminate armor always get PD 8 versus maser attacks: metal reflects microwaves!

Blasters and Particle Beams (TL8): These inflict impaling damage, and the radiation produced can also disable electronics – the extra damage from impaling not only applies to living beings, but also to electronic components and robots.

Flamers (TL9): A flamer can be used much like a flamethrower, attacking more than one target as long as they are all in the same arc of fire, as described for area weapons (p. B121). When used this way, divide the dice of damage by the number of targets. If the targets are more than one



hex apart, 1d of damage is lost for each extra hex separating them. The wash of superhot plasma from a flamer easily penetrates non-sealed armor: it gets only 1/2 DR against the attack. It also *melts* armor. For every 10 points of damage done before subtracting DR, armor loses 1 DR on the location hit. (If the armor is ablative, this is in addition to any DR lost to ablation). A sealed suit (or machine) becomes unsealed after losing 20% or more of its original DR on a particular side. Paper, cloth and wood automatically ignite if hit by a flamer discharge. Flammable plastics and such catch fire if their DR is exceeded.

Screamers (TL9): If damage from a screamer attack is more than double that listed for any limb, it is completely torn off. Any hit to a living being's head requires a roll against HT, or the target's eardrums will be shattered, causing deafness until the eardrums are replaced. Completely sealed armor is the only way to avoid this, but if the armor's DR was exceeded by the screamer, the character will be vulnerable. Any armor hit by a screamer loses 1 DR at the location hit for every 4 dice of damage the screamer inflicts. Screamers are useless in the absence of air or water to conduct the sound. Screamers that do 18d or more damage produce a wide wave of concentrated sonic energy. If the roll to hit misses by only 1 or 2, the target is caught by the edge of the beam and takes 1/4 damage.

Stunners (TL9): Use the rules for stunners on p. B119, except the HT modifier when rolling to resist may range from 0 to -10, depending on the power of the stunner. This HT modifier is always at +3 past 1/2D range, e.g., HT-8 would become HT-5.

Paralysis Beams (TL10): These weapons affect the nervous system of living things, causing instant paralysis if the target fails a HT roll, or a -2 to DX and a -1 to IQ (and all related skills) if it succeeds, with the effects lasting for 30-HT minutes. A paralyzed target is conscious of everything going on around him, but cannot move at all (though psi powers, super skills and magic spells that require no motions to activate can still be used). Living beings in sealed armor are unaffected. A p-beam that hits an unshielded robot, computer or other electronic device knocks it out on a roll of 1-2 on 1d. A computer is only fully shielded if it has both radiation shielding and is hardened (see p. 61): if it only has one of these features, it is still knocked out on a roll of 1. With the exception of electronic systems, a paralysis beam has no effect on unliving things, and may be ineffective against members of certain nonhuman races as well (GM's discretion).

Military Paralysis Beams (TL10): As paralysis beams, except instead of giving total protection, sealed armor simply gives a +4 to HT to resist. Military paralysis beams have double the chance of knocking out unshielded robots or electronics. They affect organic beings behind sealed armor or shielded robots as if they were unprotected beings hit by a non-military paralysis beam. (Exception: they will not affect a sealed or shielded target behind DR 200 or more armor.)

X-ray Lasers (TL10): These function like lasers, except DR protects at one-half normal value against X-ray beams. Furthermore, the X-ray laser's damage is not reduced by smoke, fog, or Prism.

Fusion Beams (TL12): These do explosive concussion damage equal to the weapon's base damage to anyone within 2 yards of the target hit, with damage quartered every 2 yards beyond that. Vehicle and sealed armor DR is squared against this "back-blast" as it is vs. normal explosive concussion damage, but not against a direct hit from the beam.

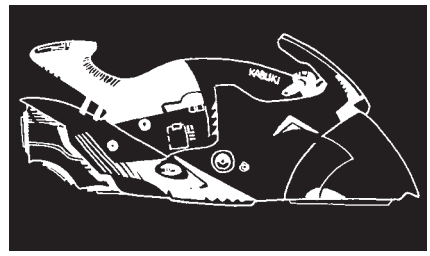
Gravity Beams (TL12): Against a gravity beam, armor PD does not protect and DR gives only 1/100 normal value! As "force beams" or "kinetic stunners," they do crushing damage, but the full damage is only used when calculating knockback – actual damage is halved. For example, if 16 points of damage were rolled, a man would suffer 2 hexes of knockback, but only take 8 hits damage. Damage inflicted by this setting is a wide bruise covering much of the target's body!

Pulsars or Antiparticle Beams (TL12): These do impaling damage, and armor DR protects at half value. They also do explosive concussion damage equal to half the weapon's damage to anyone who is within 2 yards, quartered every 2 yards beyond that. This concussion damage works the same way as an HE round, as described under *Explosive-Concussion Class,* p. 190. In addition, a direct hit inflicts 10 rads of radiation times the damage that was rolled before DR; the target's radiation protection factor, if any, will protect normally. A miss by 1 inflicts half radiation damage!

Grasers (TL14): These function like lasers, except DR protects at one-fifth normal value! Like X-ray lasers, atmospheric conditions and countermeasures have no effect.

Disintegrators (TL15): The weapon's sights allow for normal direct fire, but indirect fire is possible (using the indirect fire rules) to "shoot through" walls, hills, etc. Against a disintegrator, sealed armor and force fields protect at 1/100 DR; unsealed armor and deflectors do not protect at all. The beam's only weakness is that it will not penetrate a nuclear damper field. The energy produced by the disintegration beam also causes an explosion that may damage nearby objects: treat as normal concussion damage radiating from wherever the beam struck. Damage is equal to the listed damage, but with no armor divisor, and treated as if it were a normal concussion explosive (like a HEC round). DR protects normally against this explosion.

Displacers (TL16): Everything in the area of effect will be sucked in unless it is either on the edge and can make a Dodge roll or is too big to fit (i.e., its smallest dimension exceeds the diameter of the area of effect). Use the scatter rules on p. 176 to determine the effects of a miss! Where something goes when it is sucked in depends on the GM. Usually it is far away . . . interstellar space, another time or dimension, the heart of a sun, etc. We suggest that PCs and important NPCs go some place interesting but survivable; anyone else can be assumed to have vanished forever.



Illuminating Targets (Continued)

In order to guide the weapon, the illuminating radar or laser must be constantly active and aimed at the target. If the radar or laser is jammed, ceases to operate, or is not pointed at the target, the attack will automatically miss. Note that many vehicle radars and lasers are mounted in fixed positions (e.g., facing forward). In such a case, training the laser or radar requires the vehicle to continually point itself at the target.

Exotic Missile Abilities

Pop-Up: When fired at a vehicle on the ground, or a building, a missile with pop-up capability (indicated by a small "p" next to the missile's guidance notation; e.g., ALHp means an ALH missile with pop-up) can either strike the side of the vehicle or building it would normally hit, or it can rise to attack the top or deck of the vehicle or building, where (in theory) the armor is usually weaker. This must be decided before the missile is fired.

Evasive: Any TL8+ brilliant missile can be programmed with an "evasive" course; this halves effective speed and thus range. If the missile is attacked (see below), it gets a Dodge roll equal to its skill/2 (no PD modifiers) to avoid the attack.

Bus Missiles: These missiles are treated as if they have IG, but carry warheads with their own guidance systems. They will release them one turn before impact, or if indirectly fired, as the missile descends. Each weapon then rolls to attack separately.

Detecting and Shooting at Missiles

A missile can be fired at, provided it has been detected. A missile's size modifier can be determined from its volume using the *Size Modifier* table (p. 26). Ten points of damage is enough to knock any missile off course or cause its fuel tanks to explode; ignore smaller amounts of damage. If this happens, the missile crashes somewhere along its flight path. The GM will have to decide if collateral damage results from debris, fuel or warhead explosions. Nuclear warheads will not usually explode, and may even be recovered for later use. Some missiles or torpedoes have "stealth," equivalent to Basic Stealth. This makes them harder to detect and intercept.

VEHICLES IN THE CAMPAIGN 15

A battered Kitty Hawk landed beside Cassidy's hanger. Morgan jumped out. She seemed tired but unhurt, and inordinately pleased with herself. They hugged quickly, then pulled apart.

"Armageddon postponed, Captain?" Cassidy asked.

"The cause of light triumphs again," Morgan sighed, leaning back against the hood. "She of the Seven Eyes is in the trunk."

"But you got tagged," Cassidy observed. He pointed to a huge dent near the front fender. "What did that, a 25mm cannon round?"

"You should see the other guys." Morgan grinned evilly. "Harriers zip, Kitty Hawk two. But speaking of repairs . . ."

This chapter covers the role of vehicles in the campaign. It deals both with issues that concern PCs (such as obtaining and legally operating vehicles, designing new ones and personal vehicular equipment), and those that concern GMs (such as tech paradigms and alternative vehicular technologies).

Using GURPS Vehicles

What can you do with ***GURPS Vehicles?*** That depends on the worldbook you use it with. Obviously, it can be used as a source for vehicles and vehicle combat for historical, fantasy, modern-day or futuristic adventures. In addition:

GURPS Time Travel

When characters are adventuring in the past, the GM can use this book to create period transportation. Furthermore, using the ***Basic Set*** rules for building up tech levels, characters stranded in an earlier time can try to construct their own non-historical vehicles. As well, the rules for "parachronic conveyers" (p. 40) are suitable for use in ***GURPS Time Travel's*** *Infinite Worlds* background.

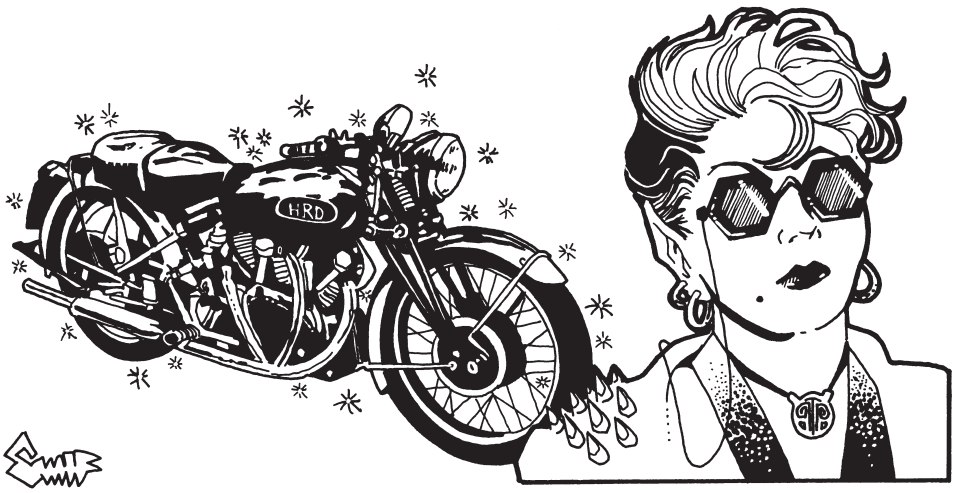
GURPS Magic

The GM can use ***Vehicles*** to create exotic enchanted craft such as demonic war machines powered by soulburners, flying ships drawn by gryphons or boats rowed by zombie oarsmen.

In a modern-day "mana-punk" campaign, or a weird science one like ***GURPS IOU,*** spell-powered motorbikes and autos can be easily created using these rules.

GURPS Espionage

What's an espionage game without car chases and exotic vehicles? These rules allow the design of "spymobiles" with everything from mutable license plates to oil jets.



Sensitive and Secret Technology

When PCs wish to build vehicles, GMs should feel free to classify as "sensitive technology" any item whose manufacturing process is classified and unavailable to ordinary citizens. Examples at TL6 would be most kinds of radar, advanced bomb sights and proximity fuses. At TL7, examples of sensitive technology include most ECM and stealth systems, fission power plants, advanced sensors, laminate armor and some guided missiles.

Characters will usually be unable to purchase sensitive equipment commercially, and stealing it, or the plans or machines used to build it, may be the focus of an adventure.

The actual manufacturing blueprints of many military (and some civilian) *vehicles* are also classified, even if the vehicle itself is for sale. Even though none of its components may be classified in and of themselves, designing the vehicle is still a long and expensive process. However, possession of the engineering drawings enables the vehicle to be easily "reverse engineered." After France embargoed sales of advanced jets to Israel, Israeli agents stole the blueprints of the French Mirage 5 fighter. Later, Israel produced its own Mirage 5 clone, the Nesher.

Making Lemons

If a vehicle is poorly maintained (or very used) it may have various bugs. Also, some vehicles are just designed badly. Some sample flaws are given below. Pick a few that can apply to the vehicle, or make some up.

Minor Bugs

Hangar Queen: Reduce the time the vehicle can run between maintenance checkups (p. 146) by 10-60%.

Low Mileage: Add 10%-30% to the fuel consumption of the vehicle's power plant.

Complex Controls: The vehicle's controls are very complex. Anyone new to the vehicle will be at an extra -1 to skill beyond the usual -2 for unfamiliarity with the vehicle type. Default use is at an *extra* -2 penalty. This is common on military jets.

Continued on next page . . .

GURPS Space and Cyberpunk

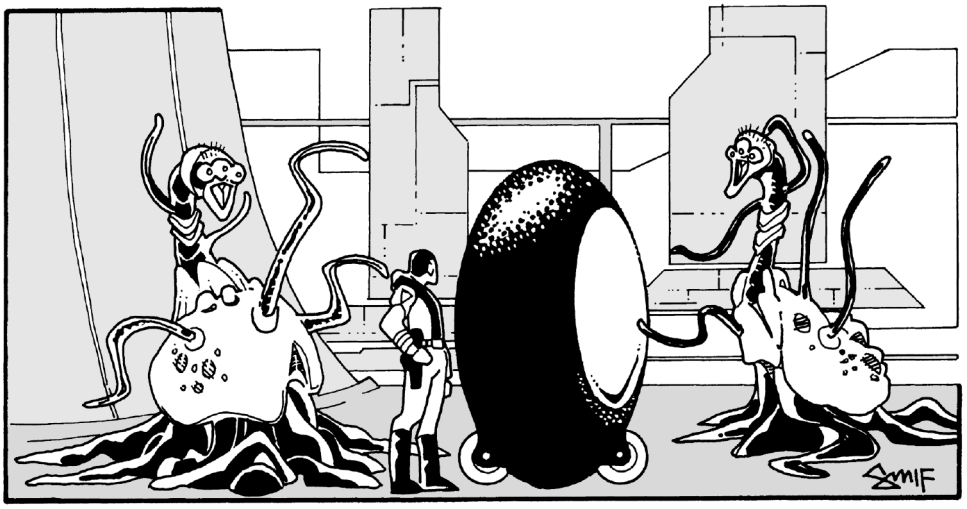
Who knows what vehicles will be built in the future? This book lets you answer that question for your own campaign, creating anything from spaceships to anti-grav cycles.

GURPS Supers

Gadgeteers can use these rules to build personalized super-vehicles with a wide array of exotic abilities. When it comes time for your super to face down a tank or a fighter plane, you'll find full rules for designing and fighting them.

GURPS Robots

The new ***Vehicles*** system is compatible with ***GURPS Robots,*** and gadgets and rules from both can be freely used with either. See the sidebar on p. 201 for notes on this.



Acquiring Vehicles

This section deals with buying, building and purchasing vehicles.

Other Production Costs

At TL6 and up, the base price of vehicles assumes they are built from pre-existing blueprints and mass-produced in a factory. This does not apply to all vehicles, however:

A *limited-production* vehicle is not built on a mass-production line. In many cases, demand does not warrant the expense of setting up a mass-production line, so vehicles are built individually. Examples include some luxury limousines and yachts, most racing vehicles, and many large ships. Double the vehicle's cost, although the GM may adjust the price further upward if demand exceeds supply.

A *home-built* vehicle is constructed by the purchaser from existing blueprints or a kit. Since the PCs are doing the labor, they only have to pay for parts: the cost is usually 20% of the base cost. For the time required, see *Building Vehicles,* below.

A *prototype* vehicle is a new design. See *Building Vehicles* for details on how to create new designs and build prototypes.

Getting Vehicles Cheap

There are various ways to get a vehicle at less than its listed price. Some options:

Loans: In any civilized culture from ancient Rome to the far future, bank or credit financing is usually available to let people purchase commercial vehicles. A typical scheme may be a down payment of 10-20% the base price, then *monthly* payments of 1% for 12 years, or 2% for 6 years. This assumes a reliable credit risk – preliminary credit checks of some sort are usual to determine if the buyer is reliable. Typical adventurers or "just starting out" merchants may have to make a larger down payment, or pay more interest – meaning the monthly payments may be 2-4 times as high! Tracing people who default on vehicle loans is often a lucrative business.

Used Vehicles: Used vehicles, weapons or equipment are often available. Besides private vehicles, a large portion of the world's arms sales are in reconditioned equipment. Availability is up to the GM. Typically, used prices are 10% to 50% of list, depending on quality and obsolescence: the low end is likely to be damaged, malfunction-prone or one TL obsolete. A vehicle can also be built with a mix of new and old equipment: decide which components are "used" and reduce the vehicle's cost appropriately by deducting a percentage of that component's cost from the total.

Making Lemons (Continued)

Unstable: Reduce SR by 1. (This is very common in air and water vehicles.)

Vulnerable Fuel Tanks: Tanks are poorly placed in the vehicle. Add +1 to the chance of any fire starting.

Shoddy Armor: Due to poor quality control on the armor, reduce DR by 10% (minimum DR 1) on one or more sides of the vehicle.

Poor Handling: Impose a -1 penalty on all control rolls.

Slow: The vehicle's speed is disappointing. Subtract 10%-20% from its top speed.

Restricted Visibility: The vehicle operator's vision is totally obscured in one or more directions (usually to the rear).

Malfunction-Prone Weapons: Drop the Malf. number of weapons by one step, e.g., from Ver. to Crit or from Crit. to 16. Or decide the firing of a weapon has a 1 in 6 chance of causing vibration or overheating that disables another fragile system.

Inferior Sensors: One or more sensors have their Scan reduced by 1d/2 points.

Temperamental Electronics: An electronic system (e.g., inertial navigation system, computer, radar, etc.) is very sensitive. On any given day, roll 1d. On a 1-2 it's "down" and just won't work without several hours of tinkering.

High Stall Speed: This applies only to vehicles with wings, or to autogyros. Add 10-30% to the vehicle's stall speed.

Major Bugs

Failure-Prone Power Plant: The power plant has a tendency to fail under stress. Any time the vehicle attempts a maneuver that is greater than its MR, roll 1d. On a 6, the power plant dies (is effectively disabled) for 3d seconds.

Structural Weakness: Reduce HT by 1d.

Very Unstable: Reduce SR by 2 (minimum SR 0). Note that SR 0 means any failed control roll will lead to a crash table result!

Very Poor Handling: Impose a -2 penalty on all control rolls.

Unsafe: A vital safety system (e.g., a fire extinguisher or ejection seat) has a 50% chance of not working when used, or fuel tank Fire number is increased.

Leaks: Watercraft takes in 1d lbs. of water per 1,000 lbs. of flotation per hour at sea, or a sealed hull loses integrity after 3d hours in a hostile environment.

Sticky Controls: Any time the vehicle attempts to exceed its MR during a stressful situation, roll 1d. On a 6, the controls freeze up, and the vehicle's MR drops to 0. Each turn, roll 1d. On a 1, the controls unfreeze.

Weak Brakes: Any time the vehicle attempts to exceed its safe deceleration during a stressful situation, roll 1d. On a 6, the brakes fail, halving the vehicle's safe deceleration rating. Repair requires four hours.

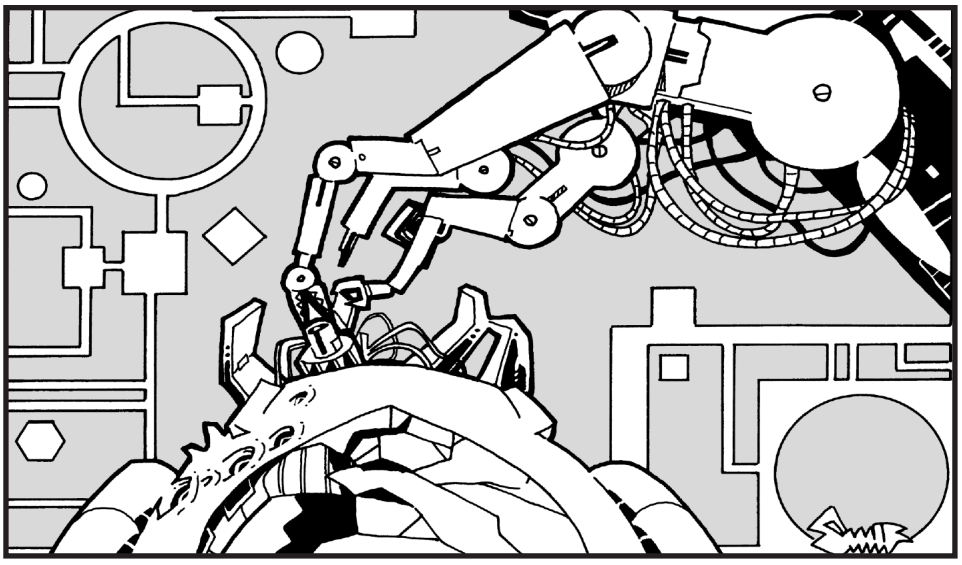
Black-Market Weapons

Most of the weapons suitable for vehicles are highly illegal: with the "Legality Class" system used in some ***GURPS*** worldbooks, every weapon in this book except water cannon, stunners, and oil jets would be Legality 0, and those exceptions would be Legality 1. Moreover, some weapons are more illegal than others: a black-market arms dealer will sell a "Legality 0" machine gun or anti-tank rocket launcher at anything from 50% to 500% the list price (depending on supply and demand), but finding a 105mm tank gun or radar-homing air-to-air missile is more difficult!

As a rule of thumb, any weapon weighing 150 lbs. or less *and* costing under $50,000 is likely to be available on the black market. Anything heavier or more expensive is likely to be available only to governments (or maybe government-sponsored mercenary units) in all but the most anarchistic or libertarian societies. Obsolete material is an exception: heavy weapons one or more TL old may be available in limited quantities, although finding ammunition, spare parts or operating manuals may be problematic.

Salvage

Salvage means removing a component from one vehicle to sell or install in another vehicle. A salvage attempt usually takes one minute per 100 lbs. (or fraction thereof) the item weighs, and requires a skill roll just like a repair attempt, but at +3. Success salvages the item. Failure does 1d damage to it.



Salvage: If the PCs are building their own vehicle, the cost can be further reduced by using salvaged components. If the PCs already have a source of parts (e.g., they are cannibalizing a vehicle they own to build a new one) just subtract the cost of the parts that are transferred into it from the cost of the vehicle. If they are looking for parts by rooting through junkyards, old battlefields, etc., make a Scrounging roll and reduce the vehicle's parts cost by 10% × the amount it succeeds by (maximum 50%). The GM may assign penalties to the roll if the vehicle's parts are state-of-the-art, exotic or illegal components.

Stolen Vehicles: Stolen commercial vehicles are usually available at 1% to 5% of list price. Finding a car fence in a modern city is fairly easy: a Streetwise+2 roll is all that's needed. (A critical failure means the character meets an undercover cop.) At higher TLs, it may be just as easy to find fences for futuristic craft like vertol or contragrav fliers. Finding a source to provide stolen or black-market military vehicles or weapons is more difficult, and should require an actual adventure rather than a die roll.



Legal Considerations

Operating a vehicle in civilized areas is usually circumscribed by law. Roads have speed limits and channel traffic in certain directions; aircraft must file flight plans and follow the directions of air traffic controllers, and so on. These laws will vary greatly by era and region, and degree to which they are enforced: in ancient Rome, no wheeled transit was allowed in the city by daylight hours; in today's Rome, drivers do as they please. Violating national borders in a vehicle may result in anything from a stern warning to a missile attack.

In populated regions, all but the simplest vehicles require a license to operate. GMs can probably assume that anyone without the Youth disadvantage *and* who has an appropriate vehicle operation skill for a civilian-type vehicle also has the license. This may not be true of characters who have disadvantages like Dead Broke (if there is a license fee!) or Zeroed. In addition, licenses are not always transferable between countries, and sometimes not even between regions of the same country. Some vehicles may be prohibited to all but the military or government groups.

Penalties for operating a vehicle without a license may range from a light fine to a severe sentence, depending on the jurisdiction. A character operating a vehicle without a license may also be suspected of having stolen the vehicle.

From TL4 on, commercial vehicle operators are often expected to have insurance, and from TL7 on, so are most owners of any kind of powered private vehicle. Insurance premiums will amount to *at least* 2% of the vehicle's cost per year, often higher, but will be sufficient to pay for the vehicle if it is lost due to accidents, acts of god, or crime. Insurance for commercial cargoes may cost extra, and may have to be arranged on a per-trip basis, based on the value of the goods carried.

Renting Vehicles

Civilian vehicles costing under $50,000 are usual available for rent; more expensive vehicles may be chartered, which is similar, except that the vehicle comes with an operator.

Vehicle rental typically costs about 0.1% of purchase price per day for rent and insurance fees. Limousines or chartered craft also requiring hiring the driver (and crew, if any), which will substantially increase cost – see the ***Basic Set*** for rules on hiring. TL7+ rental companies usually require the borrower's credit card number for security; lower-TL rentals often require a deposit of at least 1% of the vehicle's value.

Building Vehicles

Characters may wish to design their own vehicles, or have them built to order. Use the *New Inventions* rules on p. B186, with these changes. The skill required for most vehicles is Engineering.

The *conception roll* is at -15 if the vehicle is a truly new invention, or -10 if it is simply a variation on another vehicle (like a new model of car or airplane today). In the conception stage, the player will design the vehicle using the vehicle construction rules. Failure at this stage requires additional tries; critical failure means a flaw in the design (equivalent to a "flawed theory") that escapes scrutiny – the designer *thinks* it's fine, but it's not! Success or critical failure leads to the *working model* stage, giving a set of rough blueprints that can be used to build a prototype vehicle.

The *working model* roll is made with the same modifier as the conception roll. Assembling the prototype requires appropriate parts and machine tools, and a big enough workshop, dock or hangar to hold the assembled vehicle. For each attempt, an amount of money must be spent equal to the base price of the vehicle. This may be reduced by using salvage (see *Salvage,* p. 200).

To build the working model requires a minimum of one week per 6,750 cf of vehicle size or fraction thereof; roll at the end of that time. Lack of proper testing and work facilities will impose a penalty, which is up to the GM: trying to build an early biplane aircraft in a TL6 bicycle shop is perfectly possible (-1 to skill); building a jet fighter isn't really feasible (-20, if the GM feels very kind).

As described on p. B187, a success creates a working model, a failure means more work is needed (roll again in 1 week, regardless of vehicle size), while a critical failure causes an accident of some sort and probably causes damage equal to the cost of parts and tools.

If the working model roll succeeds, the result is a usable vehicle; but unless it was a critical success, the vehicle will probably have some non-fatal bugs in it. Success by 3 or more means a design with 1d/2 minor bugs. Success by only 0-2 means 1d minor bugs and 1d/2 major bugs.

The GM should decide the nature of each bug. A minor bug is something that is annoying but not critical. A major bug is something potentially crippling, like the engine failing whenever the vehicle performs a high-G maneuver. See *Making Lemons,* p. 198, for examples.

Once the prototype is built, a test pilot or crew should take it through its paces. During each week of testing, the GM rolls secretly against the vehicle operator's skill-3 (or the average skill-3, if a test *crew*). A critical success finds all the remaining bugs. A success finds one bug, if any remain to be discovered; roll randomly. A failure means either that no minor bugs show up, or that an unfixed major bug reveals itself by causing an accident. A critical failure means that no information is gained and the vehicle has an accident, regardless of whether it has bugs; alternatively, nothing untoward happens, but one bug is chosen that won't be detected by *any* amount of testing, and that bug will be carried into production!

If an accident results, the GM should come up with a problem (related to a major bug, if the vehicle has one). If NPCs are testing the prototype, decide how badly it was damaged and whether they survived. If PCs are aboard, play out the result using the *Vehicle Action* and *Combat* rules – a control roll may be needed to safely bring the vehicle home, a Mechanic roll could be necessary to jury-rig repairs, bad weather may complicate the situation, the GM may rule that the



Fatigue and Magic

GMs may wish to use some of the technological spells from ***GURPS Grimoire*** when enchanting vehicles.

Energy Spells

The rules for fatigue in relation to Energy Spells given in ***GURPS Grimoire*** are incorrect. The actual relationship is:

1 kWh = 10 fatigue.

Fatigue stored in power cells = (kWs/360). Fatigue stored in a particular type of power cell will vary by TL. At TL8 it is:

A cell = 0.1 Fatigue.
B cell = 1 Fatigue.
C cell = 10 Fatigue.
D cell = 100 Fatigue.
E cell = 1000 Fatigue.

At higher TLs, increase TL8 fatigue costs by 50% per extra TL. Thus, a TL9 D cell stores 150 Fatigue, a TL10 D cell stores 200 Fatigue, and so on.

As well:

1 megawatt = (approximately) 2.8 fatigue per second.

1,000 horsepower = (approximately) 2 fatigue per second.

These corrections will affect the examples given for the Lend Power, Conduct Power and Draw Power spells.



GURPS Robots and GURPS Vehicles

The ***Robots*** design system is intended as a simpler but more specialized version of the ***Vehicles*** system. Designs using either book can be freely used in the same campaign, but both books can be integrated to create more complex machines. Here's how to build a robot or cyborg using the combination:

Design Concept: Start with p. RO7 for ideas on a robot design concept. Then flip to ***Vehicles*** and use these rules to build the robot, with the following alterations:

Weapons: At the point in the design process where weaponry is added, also refer to *Contact Weaponry and Jaws* on p. RO20 and consider installing these close-combat weapons. Note that a "head" in ***Robots*** is the same as a "turret."

Ranged weapons can be drawn from both ***Vehicles*** and ***Robots.*** Those in ***Robots*** (pp. RO22-24) have ammunition and power included with the weapon: calculate *their* volume based on this loaded weight rather than using the empty weight. Do not install any weapons in the robot that require loaders!

Continued on next page . . .

GURPS Robots and GURPS Vehicles (Continued)

Instruments and Electronics: At this stage of the design process, refer to ***Robots*** and use the *Robot Brains* (pp. RO9-11), *Sensors* (pp. RO11-14) and *Communicators* (pp. RO14-16) rules to design these robot components rather than using the equivalent ***Vehicles*** rules for computers, sensors and communicators. Place them in body, superstructure, turret, arm, leg or pod locations. If building a cyborg, see p. RO52 for cyborg installation rules.

Miscellaneous Equipment: If the robot has arms, use the more detailed arm motor rules on pp. RO16-17 instead of those in ***Vehicles.*** One arm motor must be placed in each arm. In addition to the miscellaneous equipment described in ***Vehicles,*** any accessories from ***Robots*** (pp. RO28-33) can be added to the design as well.

Crew Positions: Normally, the robot will be unmanned, but crew positions (to give it a manual control option) or passenger capacity can be added if desired.

Structure: Make sure the robot has the robotic structure option!

Surface Features: After other surface features are added, refer to the *Biomorphics* (pp. RO43-45) and *Other Surface Features* (p. RO45) rules and add any of these features.

Statistics and Performance: Calculate this entirely using the ***Vehicles*** rules, with the exception of HT. Then go back and determine the robot's attributes using the rules on p. RO46. Then refer to p. RO50 to calculate the point cost of the robot's movement capabilities and its model point cost.

Programs and Characters: Refer to ***Robots,*** Chapters 2 and 5, for rules on programming the brain and the robot as a character.

Combat and Actions: If a vehicle with a robotic brain is involved, feel free to use either the ***Robots*** rules or the much more complex rules in ***Vehicles.*** If the latter, we suggest adding these sections from ***Robots:*** *Robots with Multiple Arms* (p. RO94), *Melee and Close Combat* (p. RO96), *Dodging* (p. RO96, used instead of normal Dodge rules while under robot brain control), *Other Hazards and Robots* (p. RO97), *Damaged and Destroyed Brains* (p. RO98), *Shock, Knockback and Stunning* (p. RO99), *Repairs to Robot Brains* (p. RO99) and *Robot Critical Hits* (pp. RO99-100).

Vehicle and Robot Differences

Here's a list of the major simplifications made in ***Robots*** and how they correspond to the more detailed ***Vehicles*** design system:

Power and Propulsion: Robot drivetrain, aquatic propulsion and power plant systems are the same as equivalent vehicle systems but without access space.

Continued on next page . . .

vehicle is out of control, on fire, lost, etc. Failing to successfully deal with the problem may result in a collision, crash, explosion, being stranded in the wilderness or any other consequences the GM thinks fit the circumstances.

For each bug that shows up in testing, the design team can decide whether to fix it or to try to accept it. Fixing it requires a redesign of part of the vehicle. This takes one week and an Engineering roll, at -3 if a minor bug or -6 if a major bug. It costs 1% of the cost of the vehicle (minor) or 5% (major). Success fixes the bug; critical success does so and halves the cost. Failure means another try is required (taking an extra week and more money), while critical failure means the bug can't be fixed, or worse, the designer *thinks* its fixed when it isn't (or the fix causes another, unknown problem).

Testing and quality control can continue until the design team is satisfied or gives up!

Hiring Other People

The rules above apply mostly to fictional, inventor-type gadgeteers. If the characters go to an ordinary corporation and want to order a custom-built design, the conception time is ten times as long (roll every ten days), the workshop time takes a minimum of six months, regardless of how long it would actually take, and everything costs ten times as much. The GM will have to decide how skilled the corporation's designers are, but unless it's a fly-by-night outfit, a skill of 18 to 20 is likely.

Production

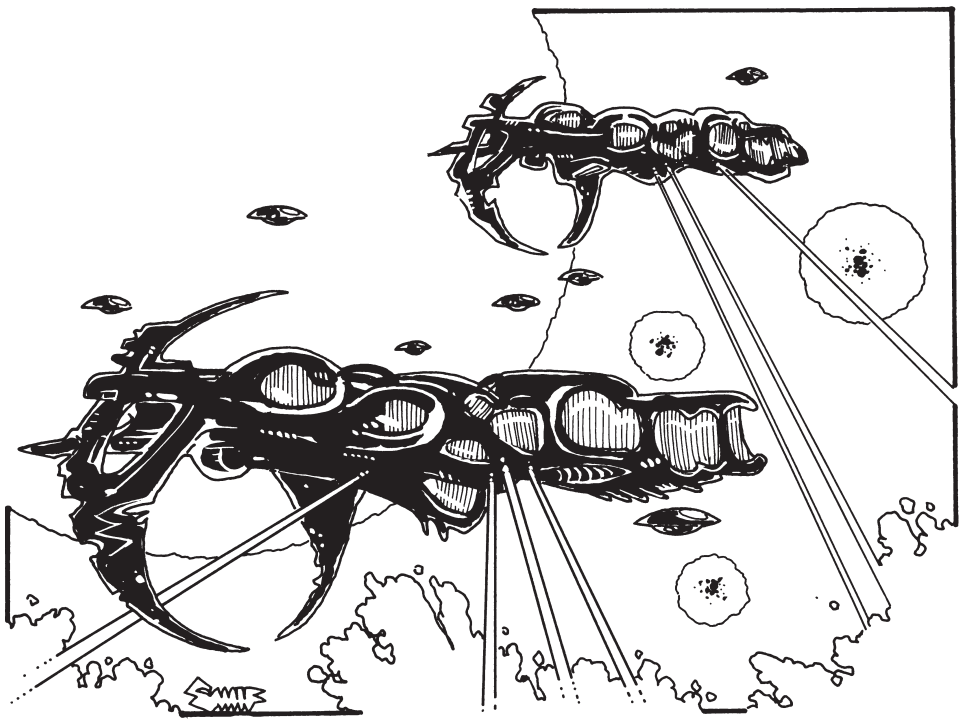
Once a working model is built, no die roll is required to build a copy of it; however, it still takes one week per 6,750 cf (or fraction) of vehicle size to build a copy. For a rush job, doubling the price will halve the time, and tripling the price will cut the time to 1/3. Quadrupling the price will cut the time to one-quarter, but getting NPC workers to do a job that quickly will usually require a reaction roll of Very Good or better.

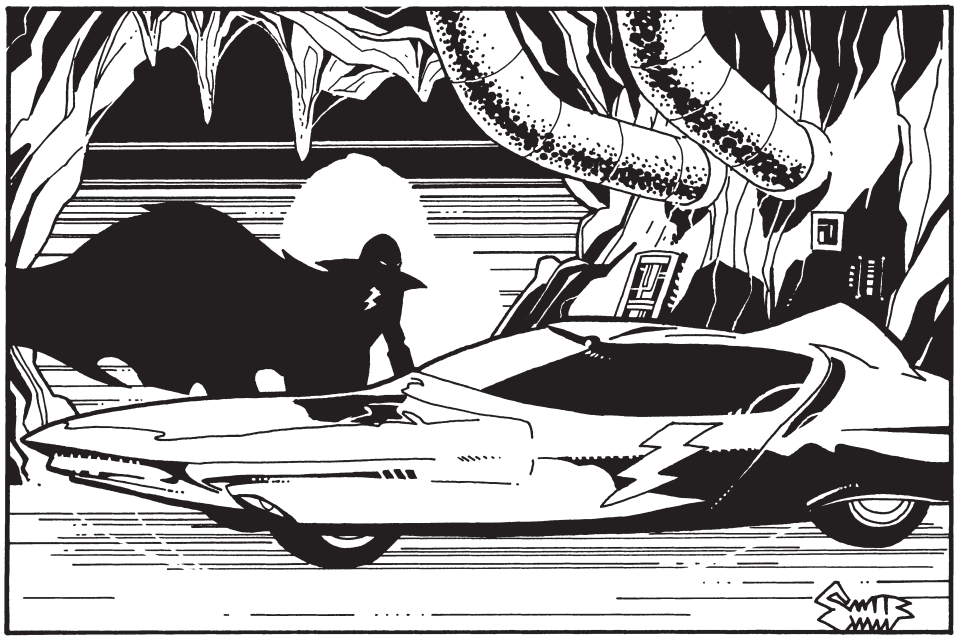
The cost of each production vehicle is 20% of the list price for parts alone, or 100% of the list price including labor.

Mass Production: This option is available at TL6+. Setting up a mass-production line costs 20 times the list price of the vehicle. (It also takes up space equal to 100 × the volume of the vehicle.) Each line can turn out one vehicle in one-seventh the time it took to build a prototype. The cost is 20% of the list price for parts or 50% of the list price including labor. Note that this saving is usually kept by the company as profit.

Refitting

Cost of refitting new components into an existing vehicle is the cost of the equipment, plus an extra 30% for the modification job. There must be empty space available, or components that can be removed to make room. Characters with access to a workshop of the appropriate size and sophistication can make skill rolls (usually against Mechanic, Armoury or Electronics Operation, as appropriate) to install equipment without paying the extra 30%. However, a failure may result in a faulty installation, and a critical failure will damage other vehicle parts in the process.





Super-Vehicles

GURPS Supers GMs may allow characters to purchase ultra-tech or heavily-armed vehicles as gadgets. When using the gadget-purchasing rules to buy large vehicles, the GM can decide that individual components count as separate gadgets. If a PC wants a sports car, he just has to pay the cash and buy the car. If he wants to use his gadgeteer abilities to modify it with a TL9 MHD turbine power plant, TL10 armor and a TL9 Gatling laser under the hood, these count as three gadgets, each of which should be researched and paid for separately.

A super vehicle can have special powers. Imagine a demonic motorcycle with Shadow Form and Body of Fire, or an Elizabethan galleon with Flight! Particularly in-genre are Body of Air, Body of Fire, Bouncing, Clinging, Chameleon, Insubstantiality, Invisibility, Flight, Hyperflight, Matter Surfing, Regeneration, Shrinking, Super Jump, Tunneling, Unaging and Walk (drive) on Air or Liquid. At the GM's option, vehicles can also have disadvantages to pay off their advantages, e.g. Terminally Ill (it's going to break down *soon*), Enemy (someone wants it back) or Weirdness Magnet. The source of a vehicle's powers may be some weird gadget built into it, an enchantment, or the same odd processes that produce superheroes ("After a tire was bitten by a radioactive hare, the ordinary VW Rabbit mutated into Fluffy the Bouncing Bunnymobile.").

Enchanted Vehicles

The GM will have to arbitrate the exact effects of spells cast on vehicles. For most Regular spells, it will be important to know how many "hexes" a vehicle takes up. Since a "hex" is a 3' circle, and magical effects are assumed to extend 4 yards (12') up (as per p. M11), each "hex" corresponds to a volume of roughly 85 cf. So to place a regular spell on a vehicle, determine its "size in hexes" by dividing its volume in cf by 85, then multiply the spell's fatigue cost by the quotient. The same multiplier is applied to the energy cost of enchantments. When the cost of a spell or enchantment depends on weight, simply use the vehicle's loaded weight.

Example 1: To enchant a 200-cf subcompact car with Walk on Air (500 energy; see p. M35) would cost (200/85) × 500 = 1176 energy.

Example 2: To enchant a 500-lb. motorcycle with Invisibility (500 energy per 50 lbs.; see p. M58) would cost (500/50) × 500 = 5000 energy.

The energy cost to activate a vehicular enchantment is normally paid by the vehicle operator, a Power enchantment or a dedicated Powerstone. Alternatively, the vehicle can be enchanted with Draw Power (p. G101) and powered by conventional power supplies (see p. 201 to convert kWs to fatigue).

For armor enchantments, multiply the energy cost by (surface area being armored/25). When cast on vehicle locations with DR 20 or more armor, the *Fortify* spell will increase DR on a percentage basis instead of adding a flat bonus: 50 energy gives +5%, 200 gives +10%, 800 gives +15%, 3,000 gives +20% and 8,000 gives +25%.

GURPS Robots and GURPS Vehicles (Continued)

Wheels and Wheeled Drivetrains: Robot wheels are the same as vehicle off-road wheels with all-wheel drive.

Rotors and Helicopter Drivetrains: The robot systems are all coaxial (CAR) drivetrains and rotors.

Fuel Tanks: The tanks included in ***Robots*** have been simplified by combining the weight of the tank and fuel and also by rounding off the weight of hydrogen fuel.

Jets and Rockets: Chemical rockets in ***Robots*** are simplifications of more complex designs in ***Vehicles.*** Use the ***Robots*** rockets in ***Vehicles*** if desired!

Wings: Robot wings are the same as "standard" vehicle wings.

Structure: Robot structures have the "robotic" structure option built in, which is why they cost twice as much!

Armor: The robot armor types are identical to the "advanced" ***Vehicles*** versions.

Camouflage and Threat Protection: Robot stealth and IR cloaking are identical to the "basic" ***Vehicles*** versions.

Sensor Scans: Radars, ladars, sonars, xadars and scanners in ***Robots*** don't have a Scan rating. To use the advanced sensor rules with them, determine their Scan rating by referring to the table on p. 52.

Flotation and Water Speed: The ***Vehicles*** rules use a more realistic system, better suited to larger craft. If desired, this more complex system can be adopted for robots built entirely with ***Robots*** rules. Just find the aquatic motive thrust as given in ***Vehicles*** and then use the *Water Performance* section of the ***Vehicles*** rules to recalculate the flotation and top speed statistics.

Empty Weight, Acceleration, Deceleration, MR, SR, Off-Road: These stats do not appear in ***Robots.*** Calculate them for robots using the ***Vehicles*** guidelines. Or continue using the simplified rules beginning on p. RO93.

Personal Equipment

Some items useful for vehicle crews:

Life Jacket (TL6): An inflatable life jacket prevents a person from drowning, but cuts swimming Move in half. Laws often require watercraft to carry enough life jackets for crew and passengers. 6 lbs., 0.2 cf if stowed. $10 at TL6-, $50 at TL7+.

Parachute (TL6): These become available after World War I. They are used when people bail out of aircraft (see p. B48). They are normally worn by military aircraft crew who do not have ejection seats and by paratroopers. Trying to get out of an aircraft takes 25-DX seconds if a person isn't in an open or external seat. Once out, a person will normally fall for at least 80 yards before the chute can open and significantly slow his fall. A parachutist will then descend at approximately 5 yards per second, drifting with the wind until he reaches the ground. An open parachute is +4 to hit and has 50 hit points, but can only be damaged by proximity explosions or flamethrowers. 30 lbs., 1.5 cf. $100 at TL6, $400 at TL7+. Weight and price includes harness, main chute and one reserve chute.

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Personal Equipment (Continued)

Contragrav Chute (TL12): This is a contragravity device that cancels 99% of weight, allowing the wearer to drift gently down. It is very easy to use (+4 to Parachuting skill). 20 lbs., $2,500. See p. UT116 for details on its operation.

G-Suit (TL7): This is a flight suit with a G-meter linked to bladders filled with compressed air. They inflate to apply pressure to the lower body and legs during high-G maneuvers, preventing blood from retreating from the brain. This halves the felt G-forces experienced by the wearer, although it has no effect on the *actual* G-force of the maneuver. A G-suit's capabilities can also be added to a vacc suit or any kind of full-body armor. 10 lbs., $1,000.

Portable Fire Extinguisher (TL6): A chemical extinguisher. A character using it can put out fires (see *Fire and Explosion,* p. 184) as if using a vehicular fire extinguisher, but at -2 to success. It can spray for 20 seconds before needing a refill. 20 lbs., 2 cf. $30 at TL6, $150 at TL7+.

Skyhook Harness (TL7): This is the most common means of "no-landing extraction" (using an aircraft to pick up things on the ground without landing). It consists of a harness worn by a person or attached to a bundle of cargo, a prepackaged, one-use helium balloon and a long coil of cable. One end of the cable is attached to the balloon, the other to the wearer's harness. The balloon inflates and bobs up to a height of 200-300 yards, carrying the cable with it. The cable can then be snagged by an aircraft with a skyhook (p. 67). The procedure is very simple, and requires a roll against No-Landing Extraction skill (p. B243) at +5, or against IQ-1. The harness is 40 lbs., 0.8 cf and $400.

Vacc Suit (TL7): A space suit, protecting the wearer against vacuum, unbreathable atmospheres, extreme temperatures and so on. A typical vacc suit takes a minute to put on (only 5 seconds to don the helmet if the rest of the suit is already on). It contains 5 minutes of air, and is PD 0, DR 1 (the helmet is tougher, with PD 2, DR 3). Real-world, TL7 suits are customized to individual astronauts, and cost hundreds of thousands of dollars each. A "mass-produced," TL8 vacc suit is $1,000, 10 lbs.; cost (but not weight) halves at TL9 and again at TL10+. See pp. S49 and UT25 for details.

Air Tanks (TL7): Vacc suits and diving gear are often worn with an air tank. A basic 12-hour tank is 36.5 lbs. and $400. Alternatively, a more sophisticated system using some recycling can be purchased – use the rules for limited lifesystems (p. 77) to determine weight and cost.

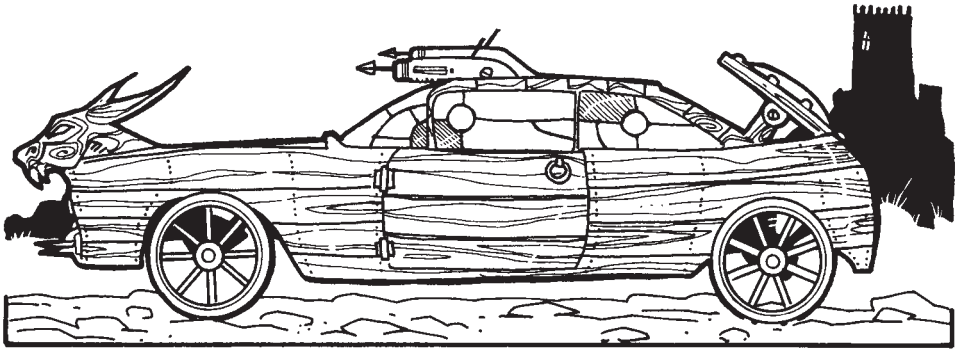


Vehicle Quality – Cheap, Fine and Very Fine Vehicles

An entire vehicle may be defined as being "cheaply made," at one-half cost. This gives a permanent -1 HT, and means that *twice* the vehicle's unmodified cost is used when calculating maintenance interval (see p. 146).

An entire vehicle may also be defined as being "finely made," for 4 × cost. This gives a permanent +1 HT, and means that only *one-quarter* the unmodified cost of the vehicle is used when calculating maintenance interval.

Finally, at 20 × cost, an entire vehicle may be "very finely made," which gives +2 HT and means that only *1/20* unmodified cost is used when calculating maintenance interval!



Campaign Technology

Most of this book is about vehicle design and the availability of various technologies at different tech levels. However, the concept of a "tech level" is primarily a convenience that relates to Earth history and the standard ***GURPS Space*** future. The GM should feel free to reassign technologies to tech levels to suit the campaign he is running. For example:

Hard Science

In this background, a lot of the props of space opera become unavailable, since they violate what appear to be fundamental laws of physics (such as the conservation of energy!). In a hard-science campaign, the GM should consider banning some or all of these technologies: reactionless thrusters; hyperdrives, jump drives and warp drives; gravity-manipulation technology, including contragravity, deflectors, artificial gravity, grav compensators, gravity webs, gravitic guns, tractor and pressor beams, and gravity beams; force screens; psionic and magical technology; teleportation, time travel, stasis fields and dimension travel; all FTL technology; nuclear dampers; disintegrator and displacer weapons.

Anachronistic Fantasy

In this sort of campaign, pre-Industrial and Renaissance gadgeteers or "techno-mages" are capable of building strangely sophisticated vehicles, such as metal riding beasts and muscle- or magically-powered winged flyers. While the overall TL will be 2-4, certain devices appear at this TL that would not otherwise appear, including: aerial sails; ornithopter drivetrains, leg drivetrains and arm motors (all at double TL7 weight, cost and volume); hot air lifting gas; and turret, leg, arm, gasbag and wing subassemblies. Magical power plants may also be available.

Feel free to add to the list of allowable anachronisms but remember – this is not a serious assessment of the difficulties of making primitive vehicles! The devices suggested are chosen for their period appeal, not their feasibility, which is why ornithopters are available at TL2-4 but helicopters are not. These rules are intended, for example, to let a madcap Renaissance techno-mage build a giant mechanical riding bird, not to add machine guns and jet fighters to fantasy worlds.

Steampunk

In this type of campaign, the overall technology is late TL5, but the mechanical visions of H.G. Wells and Jules Verne have come to life. These higher-tech devices should be available: ornithopter drivetrains, leg drivetrains and arm motors (all at double TL7 weight, cost and volume); leg, arm, and wing subassemblies; and time machines.

Cyberpunk

In "cyberpunk" campaigns with an otherwise general TL of 8 these systems may be available at the GM's option: any neural interface device, sentient computers, biomechanical structures, living metal structures.

CHAPTER 8 STARSHIPS

The ship-design system presented here gives the GM the tools he needs to create ships customized for his campaign. Before using it, the GM should decide which technologies exist (see Chapter 2) and determine which components are (and *aren't*) standard for his campaign. Everything here is a suggestion; costs and efficiencies can be varied to change campaign balance or to provide interesting distinctions between worlds. For instance, contragravity – given here as TL12-13 – could have been invented at TL9-10 in the GM's universe, or not exist at all. The warp drives of Salusia may be 10% more massive than those listed here, but 20% faster . . . and repairable only by Salusian engineers. And so on.



Units and Abbreviations

cDR: A measure of spaceship Damage Resistance. One point of cDR equals DR 100.

cf: A cubic foot. Hull size and cargo capacity are measured in cubic feet.

cHP: A measure of hull hit points. One cHP equals 100 hit points.

Gravity (G): A measure of acceleration equal to the surface gravity of Earth, or 9.8 meters per second per second (about 21.9 mph per second). Earth gravity is "1 G."

ksf: A measure of hull or turret surface area equal to 1,000 square feet.

M$: A "megabuck" or "megacredit"; one million $.

MW: A megawatt, a unit of power. Used for power requirements or power output. Equal to 1,000 kilowatts (kW).

MWs: Megawatt-second, a unit of energy equal to the output of a 1-MW plant for 1 second. Used to describe the amount of energy held by energy banks.

Space (Spc).: A unit of 500 cf; a convenient measure of internal volume.

Ton: A measure of mass and weight; 2,000 pounds.

A "k" following a number indicates thousands, an "M" indicates millions, and a "G" indicates billions (be careful not to mistake it for G for "gravity"!). Thus, "16k" means 16,000, "25M" means 25 million, and "7G" means seven billion (but "7 Gs" means seven gravities).

Suggested Hull Sizes

What one background may call a "destroyer" another may refer to as a "battleship" – terminology is up to the GM. Here are a few suggestions:

Lifeboat	5,000-10,000 cf
Fighter	5,000-20,000 cf
Shuttle	5,000-50,000 cf
Scout	20,000-100,000 cf
Light Freighter	50,000-500,000 cf
Patrol Boat, Corvette	100,000 cf+
Destroyer/Frigate	500,000 cf+
Passenger Liner	500,000 cf+
Bulk Freighter	1 million cf+
Cruiser	2 million cf+
Colony Ship	.5 million cf+
Battleship	20 million cf+
Carrier	50 million cf+
Dreadnought	100 million cf+

How Big Is My Hull?

A ship's actual dimensions can vary greatly. For a rough idea of the hull's length, look up its Size Modifier in the Size column on the table on p. B201. This assumes a fairly average cylindrical ship, or a collection of disks, pods, and cylinders. Length may be 1.5 to 3 times that if it is long and skinny, dartlike, or a flattened disk or wedge. Diameter will be 2/3 that if the ship is ovoid or spherical.

Designing a Ship

First, come up with a general concept and mission for the ship. Who's building it and for what purpose? Is it an interplanetary craft or a starship? A merchantman or a warship? The ship should fit the GM's assumptions about technology in his universe, such as which space drives are available and which superscience technologies exist, if any. This system can also be used for space stations and satellites; just read "ship" as "station" and do not install a space drive.

Next, decide on the ship's TL. This design system allows ships to be built at TL8 and up.

EXAMPLE: The GM wants to design a fast interstellar freighter suitable for a party of adventurous space merchants or smugglers. The ship is built to carry passengers and cargo from one star system to another, and can be operated by a small crew. The superscience technologies used are hyperdrive, reactionless thrusters, and artificial gravity. The GM decides the ship is built at TL10: the "*Tanstaafl*-class star freighter."

Design Sequence

The following is a step-by-step spacecraft design process. Calculations are simple and can easily be done on scrap paper. A calculator is useful but not essential. Before beginning, refer to *Units and Abbreviations* (sidebar) for the terminology used in this design system.

Step 1: Design the hull and record its characteristics.
Step 2: Designate turrets.
Step 3: Select armor tonnage. Calculate its cost, cDR, and PD.
Step 4: Consider sensor masking features.
Step 5: Determine internal spaces.
Step 6: Estimate mass.
Step 7: Fill all internal spaces with component systems.
Step 8: Calculate basic statistics.
Step 9: Calculate performance.
Step 10: Finalize design.

As design choices are made, keep a running total of the ship's mass (in tons) and cost (in M$).



Step 1 – Hull Design

The hull is the frame of the ship. A hull is more than a shell. It comes with decks, cables, stress bracing, etc.

Select a standard hull volume from those listed on the table below. See the *How Big is My Hull?* (p. 108) for an approximation of ship dimensions.

Decide whether the ship is *streamlined* (SL) or *unstreamlined* (USL). Streamlined ships are sleek lifting bodies (often dart-, teardrop-, wedge-, or disk-shaped) and may fly within a planetary atmosphere. Unstreamlined ships cannot make a safe atmospheric reentry without contragravity (if it exists). They may be cylindrical, spherical, or just about any other shape.

Based on the hull's volume, note hull area (in ksf), structural mass (in tons, varies with TL), hull cost (in M$, varies with streamlining), Size Modifier, and Maximum Turrets (the maximum number of weapons turrets that can be added).

Hull Table

Hull	Area	Structural Mass (tons)					Cost (M$)		Size	Max
Volume	(ksf)	TL8	TL9	TL10	TL11	TL12+	USL	SL	Mod.	Tur.
5,000	2	4	3	2	1.5	1.0	0.1	0.24	+6	0
10,000	3	6	4.5	3	2.2	1.5	0.15	0.36	+6	1
20,000	5	10	7.5	5	3.8	2.5	0.25	0.6	+7	1
50,000	10	20	15	10	7.5	5	0.5	1.2	+8	2
100,000	15	30	22	15	11	7.5	0.75	1.8	+8	3
200,000	25	50	38	25	19	12	1.2	3	+9	5
500,000	40	80	60	40	30	20	2	4.8	+10	8
1,000,000	60	120	90	60	45	30	3	7.2	+10	12
2,000,000	100	200	150	100	75	50	5	12	+11	20
5,000,000	170	340	260	170	130	85	8.5	20	+12	34
10,000,000	280	560	420	280	210	140	14	34	+12	56
20,000,000	440	880	660	440	330	220	22	53	+13	88
50,000,000	810	1.6k	1.2k	810	600	400	40	97	+14	160
100,000,000	1.3k	2.6k	2k	1.3k	980	650	65	160	+14	260
200,000,000	2k	4k	3k	2k	1.5k	1k	100	240	+15	400
500,000,000	3.8k	7.6k	5.7k	3.8k	2.8k	1.9k	190	460	+16	760
1,000,000,000	6k	12k	9k	6k	4.5k	3k	300	720	+16	1,200
2,000,000,000	10k	20k	15k	10k	7.5k	5k	500	1.2k	+17	2,000
5,000,000,000	18k	36k	27k	18k	14k	9k	900	2.2k	+18	3,600
10 billion	28k	56k	42k	28k	21k	14k	1.4k	3.4k	+18	5,600
100 billion	130k	260k	190k	130k	95k	65k	6.5k	16k	+20	26k
1 trillion	600k	1.2M	900k	600k	450k	300k	30k	72k	+22	120k
10 trillion	2.8M	5.6M	4.2M	2.8M	2.1M	1.4M	140k	340k	+24	560k

EXAMPLE: We choose a modest 200,000 cf hull, perhaps 100 yards long (see *How Big is My Hull?,* p. 108). We want *Tanstaafl* to take off and land on a planet; so since contragravity is unavailable, we decide she is streamlined. The area of a 200,000 cf SL hull is 25 ksf, structural mass is 25 tons at TL10, and cost is $3 million. The ship can have up to 5 turrets.

Step 2 – Turrets

Turrets are rotating superstructures attached to the hull, normally used to mount weapons. A hull can have as many *small* turrets as its Max Turrets value (from the *Hull Table,* above). It can always have fewer turrets, or none at all.

There are three basic sizes of turret: *small* (available in single-, double-, triple-, and quad-mount versions), *medium* (in single, double, or triple mounts), and *large* (single mounts only). Each medium turret counts as 4 small ones; each large turret counts as 10 small ones. Turrets must be streamlined if the hull is streamlined.

Hull Options

Compartmentalization

Compartmentalization is the degree to which the interior of a ship is divided into "compartments" that can be sealed to prevent the spread of fire or toxic gases, or to keep a hole from depressurizing the entire ship. It comes in three levels:

Standard: Most walls and doors are DR 6, 20 hit points; pressure walls and doors, where encountered, are DR 12, 40 hit points. This is the default: no extra mass or cost.

Heavy: Most walls and doors are DR 8, 30 hit points. Pressure walls and doors are more common and are DR 16, 50 hit points. This adds 10% to the hull's structural mass and costs M$0.01 per ton of extra mass added.

Total: Every door is a pressure door unless the designer specifies otherwise. All walls and doors are DR 16, 50 hit points. This adds 20% to the hull's structural mass and costs M$0.01 per ton of extra mass added.

Other Hull Options

Biomechanical Hull: What if the ship were alive? Some cultures may take animals or plants (especially spacefaring life forms) and genetically or cybernetically modify them into ships. A living ship may get sick or have a mind of its own, but it can also heal hull damage naturally (1% of cHP per day on a successful HT roll). Multiply hull cost by 1.5. A biomechanical ship rarely has more than cDR 1-2 armor. For a different, more organic look at living starships, see ***GURPS Bio-Tech.***

Living Metal Hull: At TL13+, a hull can use nanotech "living metal," packed with active self-repair nanomachines. It heals 1% of cHP per hour. Double hull cost.

Robotic Ship: For a ship run completely by an AI, with no crew, double hull cost (cumulative with the above modifiers) to include built-in servos that let the robot maintain itself, etc.



Buying a Ship

The outright purchase of a starship is likely to be beyond the means of even a Filthy Rich character. However, several PCs may pool their wealth for a down payment on a ship; the Ship Owner advantage (pp. 46-47) is one way to handle this. As well, PCs who will have no home but their ship may use *all* of their starting money (not just 20%) to buy that ship. For more information, see *Finances* (p. 113).

Buying It Used

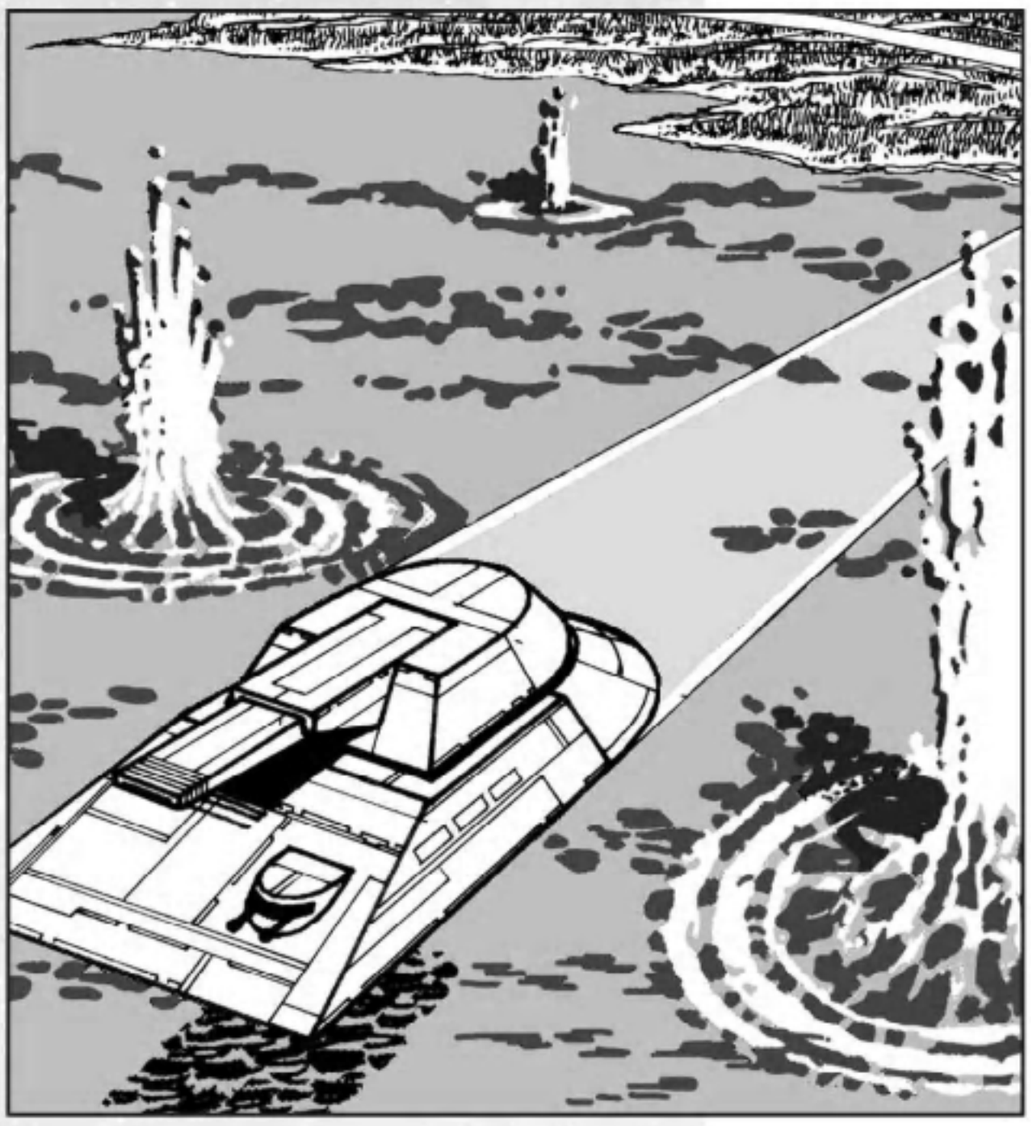
In a culture where star travel is common, used ships will be common. As with used cars in the 20th century, let the buyer beware! Most used-ship salesmen have high Acting and Fast-Talk skills. A roll on Shipbuilding (Starship), or an appropriate Engineer or Mechanic skill, may be required to detect hidden flaws. Then the buyer must decide whether to walk away or to bargain the price down.

Availability of used ships is entirely up to the GM. An apparent bargain on a used ship is a great way to start an adventure.

Typically, used ship prices might be around 90% of new for a modern ship in good shape, 50-80% for a battered but spaceworthy ship of modern design, 30-40% for an obsolete or nonstandard ship in good shape, and 10-20% for an obsolete or nonstandard ship with no guarantees.

Outdated military ships are often available at surprisingly low prices; many navies consider a ship "outdated" as soon as somebody can build a better one. These are more likely to have hidden damage. In some jurisdictions, military ships must be disarmed before they are sold. In others, they come with weapons intact.

And some used ships are *stolen* . . .



Turret Table

Turret Size	Structural Mass (tons) TL8	TL9	TL10	TL11	TL12	Cost (M$) USL	SL
Single Small	0.8	0.6	0.4	0.3	0.2	0.02	0.048
Double Small	1.2	0.9	0.6	0.45	0.3	0.03	0.072
Triple Small	1.6	1.2	0.8	0.6	0.4	0.04	0.096
Quad Small	2	1.5	1	0.75	0.5	0.05	0.12
Single Medium	4	3	2	1.5	1	0.1	0.24
Double Medium	6	4.5	3	2.2	1.5	0.15	0.36
Triple Medium	8	6	4	3	2	0.2	0.48
Single Large	20	15	10	7.5	5	0.5	1.2

Record the combined mass (which varies with TL) and cost (which varies with streamlining) of all turrets installed.

EXAMPLE: *Tanstaafl*'s 200,000 cf hull can have a maximum of 5 small turrets (*or* one medium and one small). Since she is not a warship, we give her only two quad small turrets. At TL10 and for a streamlined hull, their combined mass is 2 tons, combined cost is M$0.24.

Step 3 – Armor and Screens

Armor

Ships are armored to protect against radiation, micrometeors, harsh atmospheres, and enemy weapons. Adding heavy armor will slow a ship down (due to the extra mass) but make it more "survivable."

Computing Total Area

Calculate the ship's total surface area. This is the hull area (see *Hull Table,* p. 109) plus 1 ksf per small turret, 4 ksf per medium turret, or 10 ksf per large turret.

EXAMPLE: To *Tanstaafl*'s 25 ksf hull area, we add 1 ksf for each of her small turrets, giving a total area of 27 ksf.

Choosing Armor cDR

Spaceship armor is rated in *cDR* (multiples of DR 100). A streamlined ship *must* have at least cDR 1. An unstreamlined ship may have cDR 0, but most civilian vessels have cDR 1-2 regardless. Ships likely to face enemy fire (warships, pirate vessels, etc.) may be better armored, or may rely on high agility, defensive weapons, or countermeasures.

To decide how much armor a ship needs, think like those who commissioned it. What kinds of threats did they expect it to face? Take a look at the damage inflicted by ship's weaponry (see pp. 142-143), take a guess at the kinds of weapons the ship is likely to face, and buy reasonable protection against those weapons. Enough armor to protect from the maximum damage of those weapons will usually add too much mass (and be boring from a gaming perspective . . .); instead, choose a cDR in the neighborhood of the weapons' *average* damage roll. This will make the ship "survivable" against a few hits.

If force screens exist (see below), their cDR is additive with that of armor. Bear this in mind when selecting armor cDR. A warship could get by with light armor if it had a heavy force screen.

EXAMPLE: *Tanstaafl* is a streamlined civilian vessel, so we choose cDR 1.

Armor Mass and Cost

Armor Mass: Multiply the ship's total area (in ksf) by the chosen cDR and by the Mass (in tons) shown on the *Armor Table* for the ship's TL. This gives the armor mass.

Armor Cost: Multiply armor mass by M$0.012 to get armor cost.

Passive Defense (PD): Armor PD is 0 if cDR is 0, or 4 if cDR is 1+.

Armor Table

TL	TL8	TL9	TL10	TL11	TL12	TL13+
Mass	12.5	7.5	5	3	2	1.25

EXAMPLE: *Tanstaafl*'s armor mass is 27 (total area in ksf) × 1 (cDR) × 5 (mass at TL10) = 135 tons. Cost is 135 (tons) × M$0.012 = M$1.62. PD is 4.

Option: Separate Turret/Hull cDR

Turrets can have different armor from the hull. To do this, work out hull armor using only the hull's area and turret armor using only the turrets' area. In some settings, turrets are designed with lighter armor than the hull itself (saving a bit of weight). For a quick way to design this kind of ship, just add *half* the total turret area to the ship's hull area and armor the combined area normally; this gives the turrets exactly half the hull's cDR.

Force Screens

At TL11+, superscience force screens may be available. These give the effect of armor – while the power is on. A force screen is assumed to consist of an external screen generator grid connected to the ship's power plant. When activated, it projects an energy barrier around the ship that absorbs or deflects incoming attacks. See Chapter 5 for descriptions of how force screens work, and Chapter 2 for advice on how their exact effects can be adjusted to fit a campaign.

To add a force screen to a ship, follow these steps:

Screen cDR: Select the screen's cDR, using the same guidelines for choosing armor cDR.

Screen Power, Mass, and Cost: To get the screen's power requirement in megawatts (MW), multiply its cDR by the ship's total surface area (in ksf). To get its mass (in tons), multiply the power requirement by the Mass shown on the *Force Screen Table.* To get its cost (in M$), multiply mass by 2.5 for "expensive" screens (per ***GURPS Vehicles***) – or by 0.25 for "cheap" screens (for settings where screens are common).

Force Screen Table

TL	11	12	13	14	15+
Mass	0.4	0.2	0.1	0.05	0.025

EXAMPLE: Suppose *Tanstaafl* was TL11, force screens were available, and we chose one with cDR 3. It would require 3 × 27 (area) = 81 MW, mass 81 (power) × 0.4 (TL11) = 32.4 tons, and cost (assuming "cheap" screens) 32.4 (mass) × 0.25 = M$8.1.

Step 4 – Sensor Masking

A vessel may optionally be given *stealth* to make it harder to detect with active sensors (like radar), and *emission cloaking* to be mask it from passive sensors (like infrared). Each feature comes in two levels: *basic* and *radical;* a vessel may not have both basic and radical versions of the same feature. At TL10+, a ship may also be made invisible to the naked eye by installing an *intruder chameleon system.*



Standard Designs

Most starships are built to order from existing hull plans. If your requirements are neither outlandish nor locally illegal, you can probably find plans for an appropriate ship; a set of plans would be about a 1-gig database, $1,000+. Or the shipyard may offer use of *their* standard plans, at a discount. It is up to the GM whether to provide standard plans. The more common space travel is in your universe, the greater will be the variety of plans available.

Buyers may specify reasonable variations from the plans on armor, surface features, compartmentalization, weapons, and non-vital interior components. Changes in hull size or drives should add to the cost, at the GM's discretion.

Usual time to build a ship at a Class V port is hull volume/1,000 days, with a minimum of 6 months. Doubling the price will halve the time (and minimum). Tripling the price cuts the time by two-thirds (minimum 2 months). Four times the price, and a reaction roll of Very Good or better (using influence or bribery, as necessary), cuts the time to the actual minimum, volume/4,000 days, with a six-week minimum and work around the clock. Military shipyards on a war footing use this speed. Special items may take extra time to install. Anything not available locally must be imported.

Smaller shipyards also take longer. A Class IV port will take twice as long on any hull over 200,000 cf and three times as long on anything over 1M cf (if they will handle it at all). A Class III port isn't really equipped for shipbuilding at all. It can build a ship of up to 10,000 cf, but takes four times as long. It can't build larger ships.

The price for a ship built to standard plans is simply the sum of the prices of all its systems and components.

Custom-Building

If plans are not available, it will take a month to draw up complete plans (regardless of ship size – although a very complex design may take more time, at the GM's option). The fee for this is usually $1 per ton of final empty mass, with a minimum of $10,000. Triple this if the designer will not have the right to sell the plans as "standard" after he finishes.

PCs with Shipbuilding (Starship) skill at the appropriate TL can prepare their own plans. A shipbuilding program will help! The GM makes a single skill roll. A failure wastes the month, but they can start over. A critical failure produces a plan that is so subtly flawed that the builders won't notice . . . but the GM can provide a catastrophe when the ship is first flown.

An advantage of custom-built ships is that nobody can tell from the outside exactly what they are like. A successful roll on Shipbuilding (Starship) skill will allow a determination of capacity, a good guess about power plant, and a wild guess about weaponry (turrets are obvious; their contents aren't!).

Refitting and Repairs

A used ship may not suit the buyer's exact needs, and will require refitting. A ship that takes damage will require repair. Either situation requires a shipyard (see p. 171). Within the guidelines given there, the GM judges whether the yard can do the required work.

Cost of refitting is the cost of all new equipment added, plus 30%. Old equipment may have some salvage value, especially if the PCs are good negotiators.

Cost of repairs is the cost of all equipment destroyed, plus 10%, plus half the cost of damaged but not destroyed items.

In terms of cHP, it takes 50 man-hours of work and a roll against Mechanic skill to repair one cHP of damage; all normal modifiers apply (see p. B54). Treat this as a "minor" repair if the hull or turret has not actually been disabled (which occurs at 0 or less hit points), "major" otherwise (an extra -2 penalty). Hiring a mechanic costs at least $20 per person per hour. Repairs can be rushed – see *Heroic Performance* (p. 49) for details.

Time for extensive repairs or refitting is generally equal to half the time it would take that shipyard to build a ship of mass equal to the mass of gear being replaced or installed. This may be modified by extra payments, as described under *Standard Designs* (p. 111) – and, of course, by the GM's judgment.

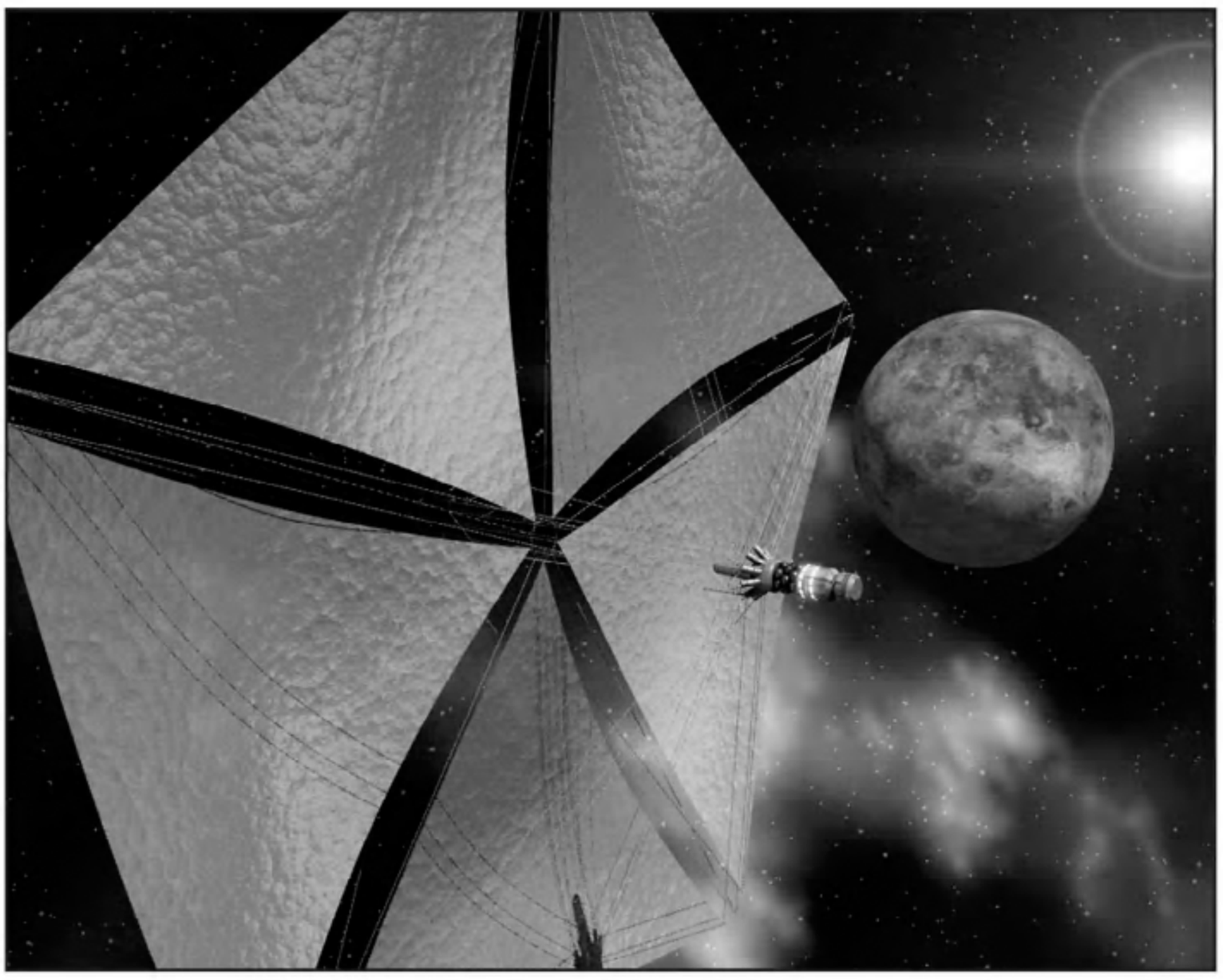
Basic emission cloaking subtracts (TL-4) from rolls to detect the ship with a passive sensor scan, while basic stealth subtracts (TL-4) from active sensor scans. Radical cloaking or stealth doubles this penalty to -2 × (TL-4). Intruder chameleon systems give -10 to spot the ship visually (-6 if it is moving).

Mass and Cost: If the ship one of these features, calculate its mass by multiplying the number shown on the *Sensor Masking Table* by the ship's total surface area (see *Armor and Screens,* p. 110). Find cost by multiplying mass by M$ 0.3 if basic, M$1.5 if radical, or M$1.33 if intruder.

Sensor Masking Table

Feature	TL8	TL9	TL10	TL11	TL12+
Basic Stealth	0.5	0.25	0.25	0.25	0.25
Radical Stealth	1	0.5	0.5	0.5	0.5
Basic Emission Cloaking	1	0.5	0.25	0.25	0.25
Radical Emission Cloaking	2	1	0.5	0.5	0.5
Intruder Chameleon	–	–	0.3	0.15	0.075

EXAMPLE: We decide *Tanstaafl* has no sensor masking. But suppose it had basic stealth. It would mass 27 (area) × 0.25 (TL10) = 6.75 tons, cost 6.75 × 0.3 = M$2.025, and at TL10, give a -6 penalty to active sensor scans to detect the ship.



Step 5 – Internal Spaces

Hull spaces are a measure of usable internal volume. An unstreamlined ship has spaces equal to hull volume divided by 500. A streamlined ship has spaces equal to hull volume divided by 625. If the ship has turrets, hull space is reduced by 1 space per small turret, 2 spaces per medium turret, and 20 spaces per large turret.

Turrets have their own internal spaces, however. Each small turret has one space per mount (i.e., 1 to 4 spaces). Each medium turret has 10 spaces per mount. Each large turret has 100 spaces.

EXAMPLE: *Tanstaafl* has a streamlined 200,000 cf hull; 200,000/625 = 320 spaces. Subtracting 2 for her two small turrets gives the ship 318 hull spaces. Two small quad turrets give the ship 8 turret spaces.

Step 6 – Hull Mass and Estimated Mass

Hull Mass: Add together *hull, turret, armor, force screen, and sensor masking mass,* as calculated in Steps 1-4. Record the total as the *Hull Mass.*

Estimated Mass: A working approximation of the ship's final mass. It is useful when deciding what components to place in the hull; it will be ignored after the ship is designed. Feel free to set whatever value seems correct. A good estimate is [(sum of hull and turret spaces) × 5] + Hull Mass, but the multiplier for hull and turret spaces can be varied up or down from 5 if much of the ship is likely to be devoted to systems with a higher or lower average mass (see *Step 7 – Systems,* below).

EXAMPLE: *Tanstaafl*'s Hull Mass is 25 tons (hull) + 2 tons (turrets) + 135 tons (armor) = 162 tons. Estimated Mass is [318 (hull spaces) + 8 (turret spaces)] × 5 tons + 162 tons (Hull Mass) = 1,792 tons.

Step 7 – Systems

A "system" is a set of components grouped together in modular fashion, like a bridge or a hyperdrive. Each system is rated for the *spaces* it takes up. Select systems whose total spaces are sufficient to fill the ship's hull spaces. Weapons, cargo, magazines, and sensors may also be placed in turret spaces. Keep a running total of remaining space; when it's gone, no more systems can be installed inside the hull.

Every ship should have bridge or cockpit, sensor, and power systems Others are more-or-less optional, although life support, drives, and quarters should be installed in nearly all vessels.

Where systems are available at different TLs, the TL is given after the name; e.g., "Super Thruster/10" means a TL10 super thruster. If no TL is given, assume the system is available at TL8+. Systems are also rated for other statistics:

Spc: The spaces the system takes up.

Mass: The system's mass in tons.

Cost: The system's price is millions (M$).

Pow.: The power consumption in megawatts (MW). If this entry is omitted, the system requires no power. If listed as "Neg.," it is negligible – as long as the ship has a working power plant, sufficient power is available.

In some cases, a system is partially designed by the ship's builder: select a size in spaces, which then determines mass, cost, and power. Some systems have additional statistics, like thrust, power output, and fuel consumption; see the individual description for details.

Bridge

All ships require at least one bridge component. Large ships often add a second one (frequently of smaller size) as backup.

Small Bridge: A rudimentary bridge system. Includes a small airlock (not necessarily in the bridge, but usually nearby), two control consoles, a computer, and communication and navigation systems, plus life support (air and heat) for two man-days (TL8), three man-days (TL9), or four man-days (TL10+).

Medium Bridge: A typical bridge system for an average freighter or small warship, designed with four bridge consoles and doubly redundant avionic and computer systems, plus life support for four man-days (TL8), six man-days (TL9), or eight man-days (TL10+).

Large Bridge: A more advanced bridge system. It has work space for ten crew (not all stations need be manned, though), better computers, and triply redundant avionics, plus life support for 10 man-days (TL8), 15 man-days (TL9), or 20 man-days (TL10+).

Finances

In most human societies, only the sleaziest seller expects to be paid in cash. Indeed, offering a cash payment will probably amaze a legitimate seller. Ships are just too expensive. The customary way to buy a ship is to finance it through a bank (or a moneylender). The bank pays the seller when the ship is delivered, the buyer gets the ship, and the buyer makes payments to the bank for a long, long time. A very wealthy seller, or a government, may "carry the note" itself.

All rates are negotiable, and depend on local economic conditions, the apparent wealth, honesty, and importance of the buyer, the need and greed of the seller, and the negotiating skill of the players themselves. Typically, a down payment of 10-20% is required (directly to the seller). If the ship is new, half this payment is made on order (nonrefundable, of course) and the rest on delivery.

Interest rates on the balance typically range from 8% to 16%. GMs inclined toward realism may work out actual amortization tables. A quick-and-dirty replacement: At 8% compound interest, pay 1% of the amount financed, every month, for 12 years. At 12%, pay 1.5% of the amount financed, every month, for 9 years. At 16%, pay 2% of the amount financed, every month, for 6 years. These payments include principal and interest; at the end of the period, the ship is paid off.

Example: A ship costs M$11. The down payment is M$1; the remaining M$10 is financed at 8%, with a payment of 1% ($100,000) every month. The ship will be paid off in 12 years.

The bank will require you to keep the ship insured, and may attempt to set other limits on your use of it, to protect their huge investment.

Buyers who come into money can always pay off the remaining principal amount (this is where an amortization table will come in really handy).

Buyers who default on their payments may have the ship repossessed. This can get interesting, especially if there isn't anywhere much to run. Defaulters are favorite targets for bounty hunters. Some moneylenders take more direct measures (hidden programs in the ship's computer, or even hidden bombs) to insure that they get paid on time.

Now . . . how will the proud owners earn the money to make those payments? That's what the campaign is all about . . .

Getting a Ship Without Buying It

In many campaigns, a prime goal of the PCs will be to get – or keep – their own starship.

They can be members of a military or other government service which assigns them a ship. Of course, the service will also assign them specific duties, unless they are special agents or assigned to detached duty.

They can be employed by a corporation that provides a ship. Again, however, most adventuring will be limited to that which serves the company's purposes (usually pursuit of profit).

If they join a pirate or other criminal gang, they may be supplied a vessel and allowed some measure of freedom. But they must give the organization a healthy cut of any profits, and will have to make themselves available for special services from time to time. The latter will usually be dangerous and always be illegal.

PCs can be free traders or work as crew on a ship owned by an NPC. Owners will rarely allow the PCs to take the ship off on profitless adventuring, but some might allow PCs a say in the ship's next destination or purpose.

The PCs could steal a ship. This might be one they've purchased but are unable to meet payments on, one they've leased, or one they've hijacked. This should be played out as an adventure. If FTL communications exist, those who steal a ship might find it difficult to get far enough away to evade capture. And some rental companies, as well as those to whom ship payments are due, take precautions. The engines (or life support!) may be rigged to shut down after a certain period of time. If the computer is sentient, it may become a dangerous opponent if the ship is stolen. It should require high skill to deactivate such precautionary measures.

Adventurers might be fortunate enough to find a ship that they can claim as salvage, either adrift in space or abandoned on a planet. This is also best played out as an adventure.

The PCs might accept a very dangerous job with a ship as the payment. This might be a freelance mission for an intelligence agency or the military, a private firm, or even a criminal organization. Or perhaps for that very rich NPC who needs a favor: "Rescue my daughter from the Death Planet and this ship is yours!"

Or the group can get along without a ship, by buying (or working) whatever passage they need. They might also put down a deposit and *lease* a ship. Some major starports might have rent-a-ship centers. They must return the ship in time or suffer penalties (financial at least; worse if they've kept the ship overtime without a valid reason).

Cockpit: A one-person cockpit designed for short-range spacecraft like fighters and shuttlecraft. It includes a control console, an ejection seat, a computer, and communication and navigation systems. Unlike a bridge, there is no room to stand up and walk around, nor is an airlock included: access is through a hinged canopy or a hatch. A cockpit includes life support (air and heat) for two man-days (TL8), three man-days (TL9), or four man-days (TL10+), plus 40 cubic feet of extra space usable for personal cargo or later upgrades to the system. Two-seater spacecraft should have two cockpit systems.

Bridge Table

System	Spc.	Mass	Cost	Pow.
Cockpit/8	0.5	2.5	1.1	neg.
Cockpit/9	0.5	1.4	0.66	neg.
Cockpit/10+	0.5	0.9	0.4*	neg.
Small Bridge/8	1	2.9	1	neg.
Small Bridge/9	1	1.8	0.56	neg.
Small Bridge/10+	1	1.3	0.3*	neg.
Medium Bridge/8	2	5.7	2.1	neg.
Medium Bridge/9	2	3.6	1.1	neg.
Medium Bridge/10+	2	2.6	0.6*	neg.
Large Bridge/8	4	9	3.2	neg.
Large Bridge/9	4	5.8	1.7	neg.
Large Bridge/10+	4	4.4	0.9*	neg.

* At TL10+, a bridge or cockpit computer may be upgraded to *sentient* status (see p. 66). This adds M$0.5 to cost for a cockpit or small bridge, M$1 for a medium bridge, and M$1.5 for a large bridge.

EXAMPLE: We select a medium bridge for *Tanstaafl;* 316 hull spaces remain.



Sensors

Sensors enable a ship to see where it is going and detect other spacecraft. Every mobile ship requires at least one sensor system for navigation. No ship requires more than one, but ships often install extras as backup in case of damage.

Basic Sensors: A set of active and passive electromagnetic sensors adequate for most vessels.

Enhanced Sensors: A set of more expensive, longer-ranged sensors suitable for warships or scout ships.

Advanced Sensors: A longer-ranged (but bulkier) version of enhanced sensors.

FTL Sensors: Available in some settings, usually only those with warp drive. FTL sensors send out an active pulse that can reach maximum range and return more or less instantly.

Sensor Options: Add-on systems include *planetary survey* sensors (allow use of Planetology skill from orbit) and *astronomical* sensors (to gather precise astronomical data). At the GM's option, *special sensors* for detecting FTL-related phenomena may exist (see p. 40).

Sensors are rated with a Scan value. This is the skill modifier when making sensor scans with active sensors/passive sensors/radscanner. See *Sensors* (p. 123).

Sensors Table

Component	Spc.	Mass	Cost	Pow.	Scan
Basic Sensors/8	1	12	4.6	0.5	32/31/–
Basic Sensors/9	1	12	3	0.75	33/32/28
Basic Sensors/10	1	11	2.4	1.5	35/34/30
Basic Sensors/11+	1	11	2.1	3.4	37/36/33
Enhanced Sensors/8	1	12	23	1	34/33/–
Enhanced Sensors/9	1	12	15	1.5	35/34/30
Enhanced Sensors/10	1	11	12	3	37/36/32
Enhanced Sensors/11+	1	11	11	6.8	39/38/35
Advanced Sensors/9	4	52	31	6.8	39/36/33
Advanced Sensors/10	4	39	28	15	41/38/36
Advanced Sensors/11+	4	39	28	30	43/40/39
If FTL Sensor	×2	×2	×20	×2	+32/0/0
Add-ons:					
Astronomical/8+	neg.	0.1	0.5	neg.	–/–/–
Planetary Survey/8	neg.	0.12	0.25	neg.	–/–/–
Planetary Survey/9+	neg.	0.06	0.12	neg.	–/–/–
Special Sensor/10+	neg.	0.1	1	neg.	–/–/–

EXAMPLE: We give *Tanstaafl* a Basic Sensors/10 system; 315 hull spaces remain.

Drive, FTL

FTL drives enable faster-than-light travel under the ship's own power. Three examples are provided in this system; for descriptions of how they work, see Chapter 2. Feel free to further customize their statistics in accordance with the guidelines in that chapter.

Hyperdrive: Lets the ship enter hyperspace. The number of drive spaces and the TL determine the drive's "hypershunt rating"; a ship's hypershunt rating must equal or exceed its mass to enter hyperspace. The GM should decide if faster travel is possible if hypershunt capacity exceeds the ship's mass; in some campaigns it is. Otherwise, hyperdrive speed is fixed and an overpowered drive is only useful when you need to carry an especially heavy cargo. Determine how many spaces of hyperdrive are needed by dividing Estimated Mass by 400 (TL10) or 800 (TL11+), rounding up. This should be sufficient for FTL travel at the base hyperdrive speed set by the GM (e.g., 0.2 pc/day). If extra speed is possible, the ship's actual speed will be (hypershunt capacity/loaded mass) times the base speed.

Jump Drive: Allows the ship to perform an FTL jump from one special "jump point" to another. The drive is rated for "jump capacity" based on its TL and the number of drive spaces installed. If the ship masses more than total jump capacity, it cannot jump. Determine how many spaces of jump drive are needed by dividing Estimated Mass by 1,000 (TL10) or 2,000 (TL11+), rounding up.

Warp Drive: Enables the ship to move at FTL speeds in normal space. The drive is rated for "warp thrust," determined by its TL and the number of spaces of warp drive installed. The speed of the ship under warp drive will be its (warp thrust/loaded mass) in parsecs per time period. The time period is normally "per day," but the GM can adjust warp speed to fit the campaign by changing the time increment to weeks, hours, minutes, or even seconds! To determine how many warp drive spaces are needed for a given speed, divide the ship's Estimated Mass by 80 (TL10) or 160 (TL11+) and multiply by the desired multiple of the base speed.

Warp drive is generally more effective than hyperdrive or jump drive. In a universe where multiple stardrives exist, the GM may wish to have warp drive systems appear two TLs later; i.e., at TL12-14 instead of TL10-12.

Jump drive and hyperdrive have a very high power consumption to jump or to "skip" into hyperspace (see below). This extra energy should be provided by installing energy banks (pp. 127-128).

STL Colony Ships

If FTL drives have not yet been discovered, man can still reach the stars in slower-than-light colony ships. These vessels are typically massive, designed to carry hundreds or thousands of colonists. Since it will be years before they reach their destination, STL colony ships are designed in one of three ways:

Sleeper ships. Colonists are frozen in suspended animation (p. 91). This is the most economical method, as more colonists and supplies can be contained in a ship. Such ships might be computer-controlled, with hundreds or thousands of freeze tubes, holds full of the equipment the colonists will need, and shuttlecraft to get them down to their new home. The down side is that suspended animation may not be feasible, and probably requires at least TL9 technology.

Generation ships. The original "colonists" will raise children and die aboard their ship as it slowly makes its way across the void. It will be a later generation that actually colonizes the new world. Hence the name "generation ship."

Genebank ships. The "colonists" are frozen sex cells, or even genetic codes stored only as information. Sophisticated biotechnology and robotics are required at the end of the voyage to convert them to a human population. If braintapes (p. 90) and forced-growth technology (p. 89) are available, the task is a little easier, since the ship doesn't need to raise and educate a batch of infants before settlement begins.

Any of these ships might reduce the *shipboard* time that elapses if it could travel near the speed of light (see p. 27). Doing this will usually require reactionless thrusters, though. Even so, trips would take many years.

Ethnic, religious, or cultural minorities might choose to leave the solar system as colonists. And some colonists will leave Earth involuntarily. Colony worlds might also be the Botany Bays of the future, where criminals or social undesirables are sent. Either way, the colonists on a generation ship can never go home.

An adventure could involve a party that discovers a lost generation ship drifting in space. Boarding it, they might encounter an entire self-contained world which the descendants of the original colonists believe to be their planet.

The invention of practical FTL stardrives makes slow colony ships obsolete. However, if many such missions were sent out, there may be hundreds of scattered human worlds in the galaxy – or the remains of those that failed.

Auxiliary Craft

An auxiliary is any craft that is carried aboard a larger one. This can include escape pods, lifeboats, shuttles, space fighters, the captain's gig, and a variety of special-purpose craft, with or without FTL capability. Here is a sample design:

Lifeboat (TL10)

Carried to allow the mother ship to be abandoned in case of catastrophe. Most are not capable of interstellar travel – they will merely allow the passengers to survive until help arrives. A typical lifeboat is the Tri-Tachyon Short-Haul, capable of carrying 30 passengers for three days or so. It is a streamlined lifting body, capable of landing on most planets.

Hull: 5,000 cf SL Hull. 8 spaces. cDR 1.
Systems (Spaces): Small Bridge/10 (1), Basic Sensors/10 (1), Standard Thruster/10 (1), Fission Power/10 (1.5), Fission Core/10 (0.5), Passenger Seats/10 (2), Cargo Hold (1).
Statistics: EMass 22.3 tons. LMass 26.3 tons. Total Cost $M3.412. Scan 35/34/30. cHP 30. Hull Size Modifier +6. cSM -4.
Performance: sAccel 0.3 G. Air speed 547 mph.

Consumables

Fuel and Reaction Mass

Antimatter: Fuel for an antimatter power plant (lasts 2.5 years at TL11, 5 years at TL12+), per MW of output: $1,000 at TL11, $500 at TL12, $250 at TL13+. Price per ton: $100 billion at TL9, $10 billion at TL10, $1 billion at TL11, $500 million at TL12, $250 million at TL13+.

Argon: $170/ton.

Cadmium: $24,000/ton.

Fissionables: A two-year fuel supply of fissionables (e.g., uranium rods) for a fission reactor, per MW of output: $80,000 at TL8, $8,000 at TL9+.

Hydrogen: $350/ton.

Hydrogen/Oxygen Fuel: $95/ton.

Nuclear Pellets: $25,000/ton at TL8, $2,500/ton at TL9, $500/ton at TL10+.

Water: $20/ton (may be free on some planets, more expensive on others).

Food

For ships without total life support, 2 lbs., 0.04 cf, and $6 per man-day. A full cargo space of supplies (12,500 man-days) is 12.5 tons and $75,000.

At the GM's option, some FTL drives use reaction mass or other consumables (see *Drive, Maneuver,* p. 116, for examples). If so, assign a mass and cost for the consumable and a consumption in tons per space of drive. Consumption is per jump or skip (if jump drive or hyperdrive) or per time period (if warp drive).

Once you know how many spaces of FTL drive are being installed, consult the *FTL Drive Table.* Rating, power, mass, and cost are given *per space.* Rating is the drive's hypershunt capacity, jump capacity, or warp thrust rating, measured in tons.

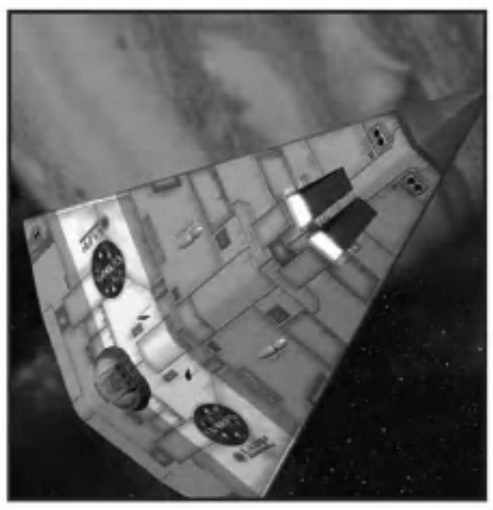
FTL Drive Table

System	Rating	Pow.	Mass	Cost
Hyperdrive/10	400	4*	4	0.16
Hyperdrive/11	800	8*	4	0.32
Hyperdrive/12+	800	8*	4	0.032
Jump Drive/10	1,000	**	4	0.14
Jump Drive/11	2,000	**	4	0.28
Jump Drive/12+	2,000	**	4	0.028
Warp Drive/10	80	8	4	0.04
Warp Drive/11	160	16	4	0.08
Warp Drive/12+	160	16	4	0.008

* To enter hyperspace also requires 360 MW of power *times the hypershunt rating* for *one second.*

** A jump requires 3,600 MW *times the jump capacity* for *one second.*

EXAMPLES: *Tanstaafl* uses a Hyperdrive/10 for FTL travel. We divide 1,792 (her estimated mass) by 400 (hypershunt rating of a TL10 hyperdrive) to find we need 4.48 spaces, which we round up to 5. A 5-space Hyperdrive/10 has a hypershunt capacity of 2,000 tons, masses 20 tons, requires 20 MW power, and costs M$0.8. In addition, to skip into hyperspace requires 360 MW × 2,000 (hypershunt capacity) = 720,000 MW! This power is only needed for one second, though. She has 310 hull spaces left.



Warp Cores

Warp drives require a single "warp core" system *in addition to* the drive itself. Install one warp core (provides no thrust) per warp drive system, regardless of size:

System	Spc.	Mass	Cost
Warp Core/10	0.5	2	0.02
Warp Core/11	0.25	1	0.02
Warp Core/12+	0.25	1	0.002

Drive, Maneuver

A maneuver drive propels the ship through normal space at slower-than-light speeds. A ship will need a maneuver drive if it has no FTL drive or if its FTL drive has significant limitations (such as not functioning close to a planet's gravity).

There are many different kinds of maneuver drives to choose from, but most campaigns will have only a few types in common use at any given TL. Maneuver drives fall into two broad categories, *reaction drives* and *reactionless drives,* each with many subtypes. See Chapter 2 for technological descriptions of each type.

If the ship needs a maneuver drive, select one from the options available in the campaign and refer to the appropriate table below to determine its statistics. Each is rated for its thrust (in tons) and (if a reaction drive) its reaction mass consumption.

A ship's acceleration in gravities is (thrust of maneuver drive/loaded mass). To determine how many spaces of maneuver drive are needed, divide the ship's Estimated Mass by the thrust shown on the table, multiply by the desired acceleration in Gs, and round off.

Reaction Drives Table

System	Thrust	Mass	Cost	Pow.	Consumption
Chemical Fuel					
Chemical Rocket/8	330	4	0.2	0	2,300HO
Fission Drive					
Fission Drive/8	27	4	0.8	0	94H
Ion Drives					
Slow Ion Drive/8	0.004	4	0.4	0.64	0.0039A
Fast Ion Drive/8	0.02	4	0.8	26	0.0023C
Fast Ion Drive/9	0.02	4	0.4	26	0.0023C
Nuclear Pulse Drives					
Nuclear Pulse/8	100	4	0.8	0	35N
Nuclear Pulse/9	100	4	0.4	0	35N
Fusion Drives					
Slow Fusion/9	0.08	4	0.8	0	0.024H
Slow Fusion/10	0.4	4	0.8	0	0.12H
Fast Fusion/10	13	4	0.8	0	22W
Optimized Fusion/9	0.0013	4	0.8	0	0.000003H
Optimized Fusion/10	0.013	4	0.8	0	0.00003H
Bussard Ramjet/9	0.000013	4	1.6	0	none
Bussard Ramjet/10	0.00013	4	1.6	0	none
Antimatter Drives					
Slow AM Thermal/9	16	4	0.8	0	2.7W*
Fast AM Thermal/9	200	4	0.8	0	85W**
AM Pion Drive/9	0.004	4	0.8	0	0.000000034H***
AM Pion Drive/10	0.02	4	0.8	0	0.00000017H***
Light Sails†					
Light Sail/8	0.037	50	50	0	0
Light Sail/9	0.63	50	50	0	0
Superscience Drives					
Fusion Rocket/9	80	4	0.8	0	14W
Fusion Rocket/10	160	4	0.8	0	27W
Antimatter Rocket/10	200	4	0.8	0	17W**
Super Bussard Ramjet/10	6.5	4	3.2	0	none
Total-conversion Drive/??	††	††	††	††	††

Thrust, mass, cost, power, and consumption (in tons per hour) are *per space* of drive. Half-space drives are possible.

Notes:

* Plus 0.00000035 tons antimatter per space per hour.

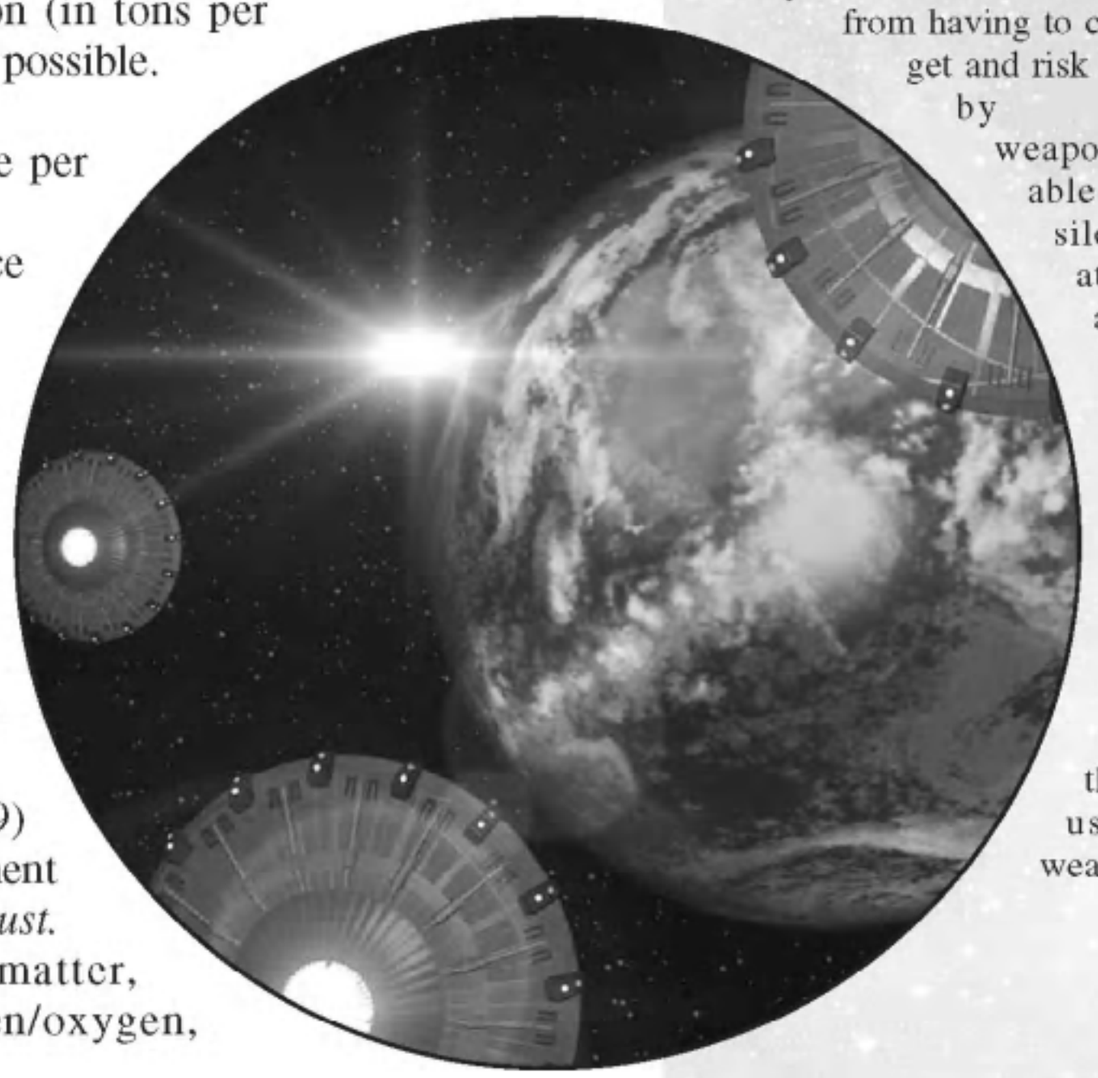
** Plus 0.000000034 tons antimatter per space per hour.

*** Plus an equal tonnage of antimatter.

† A light sail may not be larger than two spaces at TL8 or 1.5 spaces at TL9+. Thrust assumes a 1 AU distance from a star with the luminosity of the sun. Divide thrust by the square of the distance (e.g., at 3 AU, thrust is 1/9 that listed) and multiply it by the luminosity ratio if a different star. Sail area is 15 square miles/space at TL8, 240 square miles/space at TL9+.

†† Treat as a reactionless thruster (pp. 28-29) of the same TL, but replace the power requirement with a fuel requirement of 0.00012H *per ton of thrust.*

Abbreviations: A = argon, AM = antimatter, C = cadmium, H = hydrogen, HO = hydrogen/oxygen, N = nuclear pellets, W = water.



Missile Warheads

Missiles can be given one of the following warheads:

Kinetic (TL8): The basic space-missile warhead, this is simply a dense rod that smashes into the target. A kinetic missile relies on the high relative speed gained from its own motor or from the launching ship's maneuvering. If reactionless thrusters are not available, kinetic weapons get *most* of their speed from the launching ship's maneuvering; their own drives are used mainly for steering. Use the base cost on p. 127.

Nuclear (TL8): A fission, fusion, or antimatter explosive (the latter are not strictly nuclear, but possess equivalent effects). Nuclear weapons are usually fused for proximity bursts. Typical yields are in the 10-kiloton range (light warhead) or 1-megaton range (heavy warhead). Most nuclear weapons give a "one hit, one kill" capability to even small ships, unless very heavy armor is available. At TL8, add M$0.042 per light missile or M$0.064 per heavy missile. Halve this extra cost at TL9-14; halve it again at TL15+.

X-ray Laser (TL9): These warheads detonate a small nuclear weapon to energize an X-ray laser beam – in fact, this is the only way that such weapons can be built in the foreseeable future. The warhead consists of a nuclear bomb, an array of beam-generating laser rods, and a targeting system. Instead of physically intercepting the target, the missile stands off at a distance of several hundred miles, orients itself on the target, and detonates. The nuclear blast destroys the missile but also pumps energy into the laser array; as the rods vaporize, they produce powerful X-ray laser beams directed at the target. X-ray laser warheads thus free missiles from having to close on their target and risk being shot down by point-defense weapons. Only available for heavy missiles; add M$0.11 at TL9, M$0.064 at TL10, or M$0.041 at TL11+.

Nuclear and X-ray laser warheads may be very hard to find (LC -1) if law, treaty, or doctrine strictly controls the availability or use of nuclear weapons in space.

Airlocks

An *airlock* is a room with a heavy door at either end. One door leads to space; the other leads to the ship. An airlock allows people to enter or leave the ship in space without decompressing the whole ship. Airlocks are designed so that both doors can't be opened at once. Typically, they have the same PD as the ship's hull and half the DR. Controls are automatic, and can be operated either at the lock or from the bridge; there is also a manual lever for emergencies.

Standard airlock doors are designed so that a ship can mate airlocks directly with a station, or so that an auxiliary can mate directly with a larger ship. Docking requires a Piloting roll by the pilot of any craft that is actively maneuvering. The larger craft will *usually* hold its course as the smaller one docks (only the pilot of the smaller craft rolls), but if both vessels are maneuvering, both pilots must roll.

Airlocks may also be located between compartments of a ship, for extra safety or to separate compartments with different atmospheres; see *Pressure Doors* (p. 119).

A ship is assumed to have one airlock per bridge installed, but may acquire more by installing entry modules (p. 128).



Passage Tubes

A *passage tube* is a flexible tube that connects the airlocks of two ships in space. It holds pressure, allowing the occupants to travel between the ships without vacc suits. Usually 100 feet long and about 8 feet in diameter; hooks to standard fittings around exterior airlocks. Takes about an hour to unstow and rig in free fall (30 minutes with two or more working), which requires a Mechanic (Starships) roll.

Reactionless and Grav Drives Table

System	Thrust	Mass	Cost	Pow.
Standard Thruster/9	4	4	0.2	4
Super Thruster/9	10	4	1	10
Standard Thruster/10	8	4	0.16	8
Super Thruster/10	20	4	0.8	20
Standard Thruster/11+	80	4	0.16	8
Super Thruster/11+	200	4	0.8	20
Mega Thruster/13+	4,000	4	32	400
Grav Drive/12	4,000	4	0.8	8
Grav Drive/13+	8,000	4	0.16	16

Thrust, mass, cost, and power are *per space* of drive.

EXAMPLE: Looking at the TL10 maneuver drives available in the campaign, we decide that TL10 super thrusters suit *Tanstaafl*'s needs. Thrust is 20 tons per space and we want an acceleration of 1 G, so drive spaces required are [1,792 (Estimated Mass)/20 (thrust)] × 1 (Gs) = 89.6, rounded to 90. The Super Thruster/10 therefore masses 90 × 4 = 360 tons, costs 90 × 0.8 = M$72, uses 90 × 20 = 1,800 MW, and develops 90 × 20 = 1,800 tons of thrust. She has 220 hull spaces left.

Power Cores

Fission drives must also possess a fission power core. Slow and fast fusion drives and Bussard ramjets (but *not* superscience drives) must also possess a fusion power core. Antimatter pion drives built at TL9-12 must also possess an antimatter power core. These power cores must be of the same TL as the drive. See *Power Cores* (p. 121) for statistics.

Reaction Mass/Fuel Tanks

A ship that uses a reaction drive requires tanks. Each one-space tank system is an ultra-light, self-sealing tank (or shielded storage compartment) with appropriate feed or pump mechanisms.

To determine how many hours a particular reaction drive will operate on a full tank, divide the tons of reaction mass that one space of tank can carry (see below) by the total consumption of the drive (see *Reaction Drive Table,* p. 117). To increase the drive's endurance, add additional tankage.

Antimatter Bays: Antimatter requires special storage arrangements. These are functionally identical to fuel tanks, but substantially heavier. Antimatter bunkers are rated for the number of tons of antimatter they can contain per space. Antimatter storage capability is speculative; the standard antimatter bay assumes that antimatter remains very difficult to store; the high-capacity bay assumes that a more efficient system is found (perhaps a gravitic system).

Mass of Reaction Mass/Fuel

Argon	7.7 tons/space
Cadmium	110 tons/space
Hydrogen	1 ton/space
Hydrogen/Oxygen fuel	3.5 tons/space
Nuclear pellets	12 tons/space
Water	15 tons/space
Antimatter (TL9)	0.0001* tons/space
Antimatter (TL10)	0.00025* tons/space
Antimatter (TL11)	0.0005* tons/space
Antimatter (TL12)	0.001* tons/space
Antimatter (TL13+)	0.002* tons/space

* A "high-capacity" antimatter bay stores ten times the tonnage of antimatter per space, but is more expensive (see below). The TL at which high-capacity antimatter bays appear is up to the GM.

EXAMPLE: What if *Tanstaafl* had a three-space nuclear pulse drive instead of her reactionless thrusters? Three nuclear pulse drives have a combined fuel consumption of 105 tons of pellets per hour. A tank holds 12 tons of pellets per space; 12 divided by 105 gives us 0.11 hours per space. If we wanted *Tanstaafl* to thrust for a day, we'd need 24 hours/0.11 hours = 218 spaces of tankage, filling most of the hull!

Reaction Mass/Fuel Tank Table

System	Mass	Cost
Tank	0.025	0.17
Antimatter Bay	25	0.5
Hi-Cap. Antimatter Bay	25	10

Mass and cost are *per space* of *empty* tank or bay. Half-spaces are possible, storing half as much reaction mass or fuel.

Gravity Generation

Space is a zero-g environment, but humans are physically and mentally accustomed to living in a gravity field. A ship or station designed for lengthy occupation by humans (or other races with similar needs) should be given some form of gravity.

Spin Gravity: This system simulates gravity by mechanically spinning a portion of the ship. An outer spinning hull may surround a stationary inner hull, or spinning cages may be installed. A spin-gravity section should have a spin radius of at least 100 yards per G. To contain this, a ship needs a volume of at least [8 × spin radius (in yards) cubed] cf if unstreamlined, or [1,000 × spin radius (in yards) cubed] cf if streamlined. Going part-way to the center of rotation will reduce gravity proportionally; living quarters will usually be located where gravity is closest to the home gravity of the occupants.

Spin gravity does not behave quite like real gravity – if you move in the direction of the spin, gravity increases; if you move in the reverse direction, gravity drops. Individuals unused to spin gravity are at -2 DX. Double this when jumping, throwing, or using low-speed missile weapons like bows; halve it in an extremely large spin-gravity habitat (10 times the above radius). Each week, a HT roll should be made to adapt to this environment and eliminate the penalties. Those with the G-Experience advantage (p. CI25) halve all penalties; those with the Motion Sickness disadvantage (p. CI82) double all penalties and get no HT roll to adapt.

Artificial Gravity: This system uses superscience to generate gravity. The field in the ship can be adjusted (via controls in quarters, bridge, or engine room) from 0 to 3 Gs in all or in part of the ship. One artificial gravity component is needed per 100,000 cf (at TL10) or 500,000 cf (at TL11+) of hull volume.

Gravity Systems Table

System	Spc.	Mass	Cost	Pow.
Spin Gravity	1*	2*	0.1*	0.1*
Artificial Gravity/10	1**	30**	0.1**	†
Artificial Gravity/11+	1***	18***	0.1***	†

* Per 20 yards (or fraction) of spin-section radius. Note that the ship will not be able to turn without turning off spin gravity first: the spinning segment acts as a gyroscope. Counter-rotating segments can eliminate this effect, but require extra moving parts and heavy hull reinforcement: multiply listed mass by 2, cost by 5. Space and power are unchanged.

** Per 100,000 cf or fraction of hull volume.

*** Per 500,000 cf or fraction of hull volume.

† Requires 0.037 MW *per 1,000 cf of hull volume.*

EXAMPLE: *Tanstaafl* will use an Artificial Gravity/10 system. As the ship is 200,000 cf in size, the system requires 2 spaces, masses 60 tons, costs M$0.2, and uses 7.4 MW. She has 218 spaces left.

Pressure Doors

Spaceships have internal pressure doors so that a single hole won't depressurize the whole ship. Those with standard compartmentalization (p. 109) have pressure doors only at strategic points (1 in 6 chance if unknown), those with heavy compartmentalization have significantly more (3 in 6), and those with total compartmentalization replace *all* internal doors with pressure doors.

Standard pressure doors are actually a set of *two* heavy hatches with a small compartment between them, forming an airlock (see p. 118); pumping is provided by the life-support system. Single sliding doors are used in some settings; these are compact and easier to open against a pressure differential, but they only work while the ship has power (there will be a manual lock – "dog" – and lever in case of power loss, but access is often difficult; see below).

If the pressure on both sides is the same, paired hatches take one second per hatch to negotiate. Sliding doors take only a second while the power is on, but it takes an extra 5 seconds to undog and open a sliding door manually, or to close and dog an open one. It also takes 5 seconds to undog it partially and listen for escaping air.

All pressure doors have indicators that show the air pressure on the other side, but these have been known to malfunction. A sign of a true spacer is the cautious way he opens pressure doors at all times. If there is air on one side of a pressure door and vacuum on the other, a manual override must be tripped before it can be opened.

In the case of double hatches, opening the first hatch from the vacuum side or second hatch from the pressurized side is easy; the pressure difference helps push it open. Roll DX-2 (or Free Fall-3 in micro- or zero gravity) to avoid being sucked through (or *blown out* from the vacuum side). With one hatch open, the airlock limits air loss to the small volume between hatches (unless it has been sabotaged!); this air will escape in 1 second. Opening the other hatch against the pressure difference is difficult; roll ST-6, but two people can combine ST for the attempt.

In the case of sliding doors, the constant air flow makes things more difficult. Roll as above to avoid being sucked out, but at DX-4 or Free Fall-6. If this roll is made, fully opening the door takes 1d+5 seconds. Others nearby may also have to roll. Unless overridden, a failsafe mechanism will automatically close the door if air is rushing through it. This takes 1 second, and anyone in the doorway must roll DX-4 or Free Fall-6 to avoid being caught.

Continued on next page . . .

Pressure Doors
(Continued)

If a pressure door fails (*both* hatches in an airlock), the compartment starts to depressurize. This means no more than 10% of the ship if compartmentalization is total, no more than 20% if heavy, but up to 50% of the ship if standard. It takes only about 20 seconds for a large compartment to empty to vacuum.

If any kind of pressure door is stuck open, a ST+2 roll and 1d+5 seconds are required to push it closed and dog it tight. Two people may combine ST for this. If the door won't close, fleeing to a further compartment will make the job easier, but the door leading to another compartment will probably have to be manually opened first! Air flows less quickly out of each compartment in series, giving a +2 to any door-closing attempt for each extra compartment in the way. Closing any door from the vacuum side is suicide unless you have your own air supply!



Contragravity

This superscience technology allows the ship to "screen" itself from some or all of the gravitational pull of a planet or other body. In practice, this means its weight is reduced to zero for takeoff or landing; thus, only a small amount of thrust is needed. Note that since *mass* is unaffected, the ship's space performance will be unchanged.

A ship with sufficient CG lift can hover in midair, or float gently up or down into orbit. To do this, it needs enough CG lift to neutralize its *weight* under the local gravity field. A half-space light contragravity (LCG) system can neutralize up to 1,000 tons. A one-space heavy contragravity (HCG) system can neutralize up to 5,000 tons. In both cases, this is weight under local gravity – a ship on a 2 G world will need twice as much CG!

If the GM wishes to make contragravity less effective, simply reduce the weight it can neutralize.

Contragravity Table

System	Spc.	Mass	Cost	Pow.
Light Contragravity/12	0.5	1	0.05	2
Heavy Contragravity/12	1	5	0.25	10
Light Contragravity/13+	0.5	0.5	0.01	2
Heavy Contragravity/13+	1	2.5	0.05	10

Tractor and Pressor Beams

These devices can generate a gravity field at a distance, pulling objects toward or pushing them away from the ship.

Tractor Beam (TL11): Each tractor beam system generates a ST 10,000 attractive force. Multiple systems can work together.

Pressor Beam (TL12): Similar to a tractor beam, but generates a ST 10,000 repulsive force.

Combination Beam (TL12): Usable as either a tractor beam or a pressor beam, but not as both simultaneously.

Tractor and Pressor Beams Table

Type	Spc.	Mass	Cost	Pow.
Tractor Beam	1	11	0.025	10
Pressor Beam	1	11	0.025	10
Combination Beam	1	11	0.028	10

Power Plant

Any ship needs a power source. Power is measured in *megawatts* (MW). As a comparison, the Niagara Falls power plant produces some 500 MW.

Add up the power requirements (in MW) of all systems installed so far. If the ship has both an FTL drive and a maneuver drive, use whichever power requirement is *higher.* That is how much power is needed to operate the ship; other requirements are typically trivial by comparison. An exception is any ship that will carry a lot of passengers (like a cruise ship or colony ship); large quantities of habitat modules (pp. 124-125), life support (p. 124), and passenger quarters (p. 123) use significant power. When designing a ship like that, install *all* other systems first, then come back here at the end of Step 7 and install a suitable power plant.

There is no need to provide power for hyperskips or jumps, or for beam or railgun weapons – these get their energy from energy banks (p. 26). However, the output of the power plant will determine how rapidly an energy bank can be restored.

Select a power plant from the table below (see *Power Plants,* p. 26, for descriptions) and install one with sufficient output to provide the required power.

Power Plant Table

System	Output	Mass	Cost	End.
Fission Power/8	2	4	0.8	2
Fission Power/9	8	4	0.32	2
Fission Power/10	8	4	0.16	2
Fusion Power/9	8	4	1.6	200
Fusion Power/10	40	4	0.4	200
Fusion Power/11	40	4	0.2	200
Antimatter Power/11	80	4	0.16	2.5
Antimatter Power/12	160	4	0.16	5
Antimatter Power/13	160	4	0.16	5
Total Conversion/14	400	4	0.24	infinite
Cosmic/16	800	4	0.016	infinite

Output, mass, and cost are *per space* of power plant. Power plants may also be taken in half-space increments with half the listed output, mass, and cost.

End.: The operating endurance of the plant, in years. Fission and antimatter plants can be refueled; fusion plants *cannot* be refueled.

EXAMPLE: *Tanstaafl*'s sensors use 1.5 MW, her maneuver drive needs 1,800 MW, her FTL drive requires 20 MW, and her artificial gravity uses 7.4 MW. We won't use the FTL drive and maneuver drive simultaneously, so the effective power requirement is 1,808.9 MW. We choose a 45.5-space Fusion Power/10 system, providing 1,820 MW, giving us 11.1 MW extra capacity. It masses 182 tons and costs M$18.2. *Tanstaafl* has 172.5 hull spaces left.

Power Core Systems

For each TL8-12 power plant installed (*regardless* of size), also install *one* "power core" system of the same type. It contains vital engineering room control space and, at TL8-10, core life support machinery. Note that TL13+ power plants do not require power cores.

Power Core Table

System	Spc.	Mass	Cost	Note
Fission Core/8	1	4	0.61	For Fission Power/8
Fission Core/9	0.5	1.3	0.09	For Fission Power/
Fission Core/10	0.5	0.9	0.03	For Fission Power/10
Fusion Core/9	2.5	11	5	For Fusion Power/9
Fusion Core/10	0.5	1.4	0.31	For Fusion Power/10
Fusion Core/11	0.5	1	0.15	For Fusion Power/11
Antimatter Core/9	2.5	10.4	2.01	For Antimatter Power/9
Antimatter Core/10	.05	2.2	0.41	For Antimatter Power/10
Antimatter Core/11	0.5	2	0.28	For Antimatter Power/11
Antimatter Core/12	0.5	0.5	0.14	For Antimatter Power/12

EXAMPLE: *Tanstaafl* has a Fusion Power/10 power plant, so it needs a single Fusion Core/10 system. *Tanstaafl* has 172 hull spaces left.

Solar Panels

Solar panels are an alternative to reactors, producing power from starlight. Solar panels are assumed to produce their rated power in vacuum at light levels equal to those 1 AU from Sol. This varies with stellar luminosity and with the square of the distance to the star (e.g., doubling the distance cuts output by a factor of 4), so solar power is almost useless to ships at the edge of a system with a Sol-sized star. Around another star, multiply output by the relative luminosity.

System	Mass	Cost	Output	Area
Solar Panel/8	12	1.44	1.9	48 ksf
Solar Panel/9	12	1.8	4.8	60 ksf
Solar Panel/10	12	2.4	6.4	80 ksf
Solar Panel/11	12	2.88	7.7	96 ksf
Solar Panel/12+	12	4	9.6	120 ksf

Bridge Systems

The heart of a bridge is its crew stations. Each station is a seat facing a console that consists of a computer terminal and various multifunctional displays. In most ships, these can be reconfigured to enable any station to perform any bridge crew function – pilot, navigator, communications, gunner, sensors, etc. – although the GM can rule that this is not possible in a particular ship design. A bridge also includes the following systems (singular in a cockpit or small bridge, doubled in a medium bridge, tripled in a large bridge):

Computer: A hardened mainframe computer, Complexity TL-4. The bridge crew stations have terminals that can access this computer; handheld models carried by crew and desktop models installed in staterooms can also interface with the computer if the proper passwords are known. See *Computers* (p. 64) for detailed rules.

Navigation Electronics: Precision navigation and inertial navigation systems that allow accurate normal-space navigation. Special systems for FTL navigation (if required) are subsumed in any FTL drive.

Flight Recorder: A tough "black box" flight recorder (like those on modern aircraft) that records voice transmissions and instrument readouts. It is designed to survive a crash.

Advanced Radar/Laser Detector: This sensor can detect and locate any operating radar or ladar sensor (such as an AESA) within twice that sensor's range. For this reason, a ship that wants to avoid detection will turn off its active sensors and rely solely on its passive sensor arrays (PESA).

Fire-suppression System: Automatic fire and explosion extinguishers that use nontoxic inert gas to smother fires within microseconds.

Ejection Seats: Cockpit systems (only) include an ejection seat. If the ship is likely to crash, the seat can blast the occupant out in less than a second – depressurizing the ship in the process – and (in atmosphere) deploy a parachute. A successful Parachuting skill roll is needed to land without injury.

Communications

Shipboard communications systems work much like the communicators described in Chapter 4, but have greater range and flexibility. Each bridge or cockpit system has the following equipment, installed one per cockpit or small bridge, two per medium bridge, three per large bridge:

Radio Communicator: A basic multi-frequency broadcast communicator capable of sending and receiving radio signals over great distances. Transmissions may be scrambled (encrypted), but will be received by all radios within range.

Microwave Communicator: A tight-beam directional communicator. The signal can only be picked up by microwave receivers within a 20° cone around the beam.

Laser Communicator: Encodes the signal onto a modulated laser beam; only another lasercom can receive its signal, and only if directly in the path of the beam. This makes transmissions secure, but the laser communicator can only be used to talk to a receiver whose precise location is known – no broad-band transmissions are possible. Clouds will block a laser beam, though, so ship-to-surface communication can be difficult.

IFF Transponder: This sends out an automatic identification code (via communicator). Civilian systems are factory-sealed – they can be switched off and on, but the signal can't be altered; military systems can be reprogrammed to give false identities. Of course, a ship that claims to be a 50,000 cf scout but appears on radar as a 50,000,000 cf cruiser would attract suspicion . . . but the cruiser could get away with claiming to be a bulk transport.

Communication Range Table

TL	Radio	Laser	Microwave
8	1 mil.	0.2 mil.	1 mil.
9	10 mil.	2 mil.	10 mil.
10+	50 mil.	10 mil.	50 mil.

Communicator ranges are in *millions* of miles.

FTL Radio

Availability and stats of this item are *entirely* up to the GM, depending on what has been decided for communications in the campaign (see p. 35). An FTL radio might be built into every bridge as a standard system (no extra cost) . . . or be the size of a city. If FTL radio is available, then small, self-powered *distress beacons* will also be available. GMs who want FTL radio but who do not want to make up a new system can assume that a ship's stardrive contains the "booster circuits" necessary to convert a normal signal into an FTL signal.

Mass, cost, output, and area are *per space* of solar panels. Panels are assumed to be retractable; it takes about 10 seconds to deploy a panel or retract it. Panels are very fragile, and would be destroyed almost instantly during combat. They will not survive acceleration greater than 0.1 G. Space dust and debris will also damage the panels if the ship is moving very rapidly. Thus, panels are rarely deployed under any of these conditions.

Crew and Passengers

Typical crew requirements are given below, but note that these are *averages;* actual requirements can vary a great deal. Military ships will have larger crews, to allow for multiple shifts and to replace losses in combat. Transports often run with a bare minimum of crew to save money. A civilian yacht might not have anyone with these titles, but somebody needs to do the job. Ships with minimal crews call for talented crewmen, since several jobs are doubled up.

In general, crew should have a skill level of at least 12 in the skill(s) appropriate to their positions. Good computers can make up for a lot, though (especially at high TLs); a luxury yacht may be capable of interstellar travel even though nobody aboard knows anything about piloting, astrogation, or the engine room!

If the GM feels a ship is under-crewed, he should assess penalties to appropriate skill rolls, especially in stress situations when one spacer has to be in three places at once.



Command: At least one captain, plus one command officer per 5-10 non-command crew. The officer who supervises engineers will usually be an engineer himself; the same goes for other specialties. On small ships, the commander may double as the pilot or gunner.

Engineering: Take the square root of the sum of the tonnage of the power plant and drives, divide by 60 and round down.

Gunners: On average, one for each turret. Hull weapons may be grouped into batteries of identical weapons which can be controlled by a single gunner; a gunner can also divide his time between several different batteries (using only one per turn). A weapon cannot be fired in combat unless it has an operator. However, this may be a gunner, a non-gunner operating at default, or a computer.

Life Support: One full-time life-support tech if there are over 20 people aboard; one more for every full 100 people added. On small ships, engineering deals with life support.

Maintenance & Damage Control: One full-time mechanic (who should have Vacc Suit skill) if there are over 10 people aboard; one more for every full 50 people or 200,000 cf of ship, whichever is *more.*

Medical Officer: One full-time medic if there are more than 20 people aboard (or 10 for over a month), plus another medic or assistant per additional 50 people aboard. A ship should have at least one medic per surgery (p. 129). Automeds (p. 96) can replace medics.

Passenger Service: A passenger ship will have crew whose job is to look after the passengers. As a rule, there will be at least one such crewman for every full 50 cargo or steerage passengers, 20 standard passengers, 10 first-class passengers, or 2 luxury passengers.

Pilot: At least one, unless the ship is being trusted to a piloting computer. All but the smallest military ships will have a specialist astrogator. On very small ships, the pilot usually runs the sensors.

Service: One full-time service person – cook, yeoman, morale officer, etc. – if there are over 20 people aboard; one more for every 50 people added.

Specialists: Large ships, especially military vessels, will have full-time officers and specialists for communications, sensors, etc. There may also be landing teams, security staff, science crew, cargo specialists, etc.

Optional Crew: Entertainers of various sorts will be found on luxury liners – sometimes more entertainers than passengers. They may or may not have any actual "crew" skills. *Marines* and *fighter pilots* aren't really ship crew at all. Marines usually get steerage accommodations; fighter jocks usually have the equivalent of standard quarters.

Multiple Shifts: Most military and some civilian ships carry three times as many crew so that they can operate around the clock (in three 8-hour shifts).

Backup Crew: Extra crew members may be carried in freeze tubes, to be awakened in an emergency. This is especially common on military vessels.

Quarters

Every manned ship or station designed for long-term operation requires quarters of some sort. Ships intended to operate for less than a day, like fighters, lifeboats, or shuttles, can omit quarters – the crew just remain seated. Install enough quarters for the estimated crew and passengers. Standard passengers and most crew often endure double-occupancy; first-class passengers and officers should have rooms of their own.

Quarters are not strictly necessary for long voyages – if there is sufficient life-support capacity, cargo space can be used and passengers carried as "steerage" in the hold. This is uncomfortable (and somewhat unsanitary), and is usually resorted to only in emergencies or when shipping refugees, slaves, or animals.

Bunk Room: A room with 5 bunk beds (each with a small locker), intercom, controls for light and temperature, and shared sanitary facilities.

Cabin: A furnished room capable of housing one or two people. Contains bed, chairs, desk, closet, and a toilet, sink, and shower. There is also an intercom and controls for light and temperature.

Luxury Cabin: A furnished room with fittings superior to those of an ordinary cabin. Can house one or two people.

Freeze Tubes: Available at TL9+. Each space contains 10 suspended-animation capsules, each capable of holding one person. See *Suspended Animation* (p. 91) for rules.

Passenger Seating: Ships designed for short-term operations, like shuttlecraft, may install passenger seating instead of quarters. Each space devoted to passenger seating provides 15 seats. The system's built-in air supply also provides 15 man-days of life support at TL8, 22.5 man-days at TL9, or 30 man-days at TL10+.

Quarters Table

System	Spc.	Mass	Cost	Pow.
Bunk Room	1	0.5	0.0005	neg.
Cabin	1	1	0.003	neg.
Luxury Cabin	2	2	0.01	neg.
Freeze Tube/9*	1	5	0.55	neg.
Passenger Seats/8	1	1.4	0.009	0.0075
Passenger Seats/9	1	1.4	0.012	0.0075
Passenger Seats/10	1	1.4	0.016	0.0075

* Also available in half-space versions: 5 tubes, half mass and cost.

EXAMPLE: We decide *Tanstaafl*'s the crew will consist of a captain, a pilot, an operations officer, two gunners (one per turret), and two engineers. We install 7 cabins for the crew (if we decide we need more crew, they can double up) and 8 for passengers. We also add a half-space of freeze tubes (5 tubes) just in case we want to carry extra passengers in cold sleep. This leaves 156.5 spaces.

Sensors

Each sensor system includes an array of two or three standard sensor types: AESA, PESA, and (at TL9+) a radscanner. In some campaigns, these sensors may have different limitations or capabilities. As a default, here is what they do:

Active Electromagnetic Sensor Array (AESA): A multi-mode sensor that works as a radar, imaging radar, and ladar. In radar mode, it detects objects within its range and shows them as "blips" with inexact size and shape. In imaging radar or ladar mode, it has only half its range but better resolution: objects appear as actual silhouettes, permitting identification of known ships and exact determination of size. In any mode, it will also function as a rangefinder, feeding targeting data to weapons consoles.

Passive Electromagnetic Sensor Array (PESA): An array of infrared thermal imaging and low-light telescopic sensors. A PESA gives the bridge crew a visual picture of objects within its sensor range.

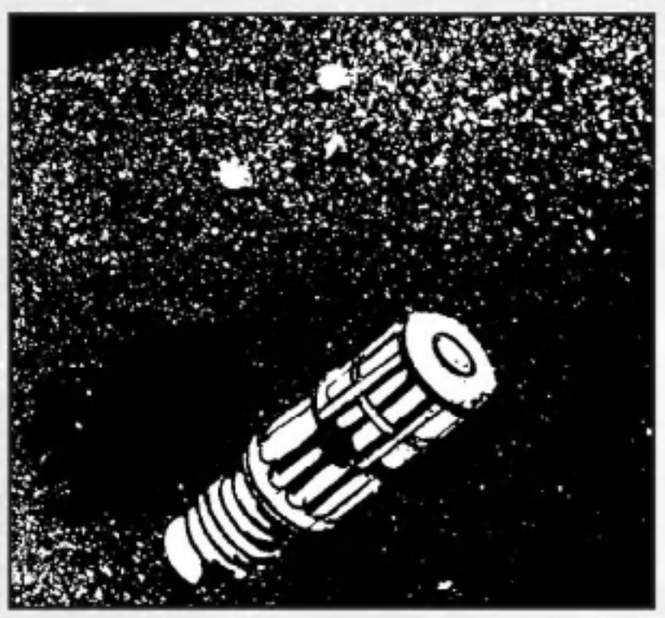
Radscanner: This is a multifunctional energy scanner that can detect and scan for various types of radiation, such as radio, neutrino, or radar emissions. It can detect the neutrinos emitted by power plants – this is a good way to tell a scout ship from a dreadnought . . . It is capable of detecting radiation from all directions simultaneously.

Detection Range

To determine the range at which an object can be easily detected with PESA or AESA, look up the sum (Scan + object's Size Modifier + 10) in the *Size* column of the *Size and Speed/Range Table* on p. B201; the number in the adjacent *Linear Measurement* column is the range.

Sensor Masking: When using AESA to look for an object with stealth, subtract (TL-4) for partial stealth or (TL-4) × 2 for radical stealth from the total before calculating the detection range.

When using PESA to look for an object with emission cloaking, subtract (TL-4) for partial cloaking or (TL-4) × 2 for radical cloaking from the total before calculating the detection range.



Using Tractor Beams

These beams use gravity control to exert an attractive force over a distance, pulling the target to the beam generator or vice versa. They are normally used for cargo handling, small-craft recovery, and minesweeping; ingenious spacers find other uses for them. Use of even one tractor beam gives a +1 bonus to Piloting skill for a micro- or zero-gravity rendezvous, but a critical failure on any tractor beam use tears the beam generator out of the mounting.

Tractor beams have ST 10,000 per module; multiple modules can combine their strength. Each can exert 100 tons of thrust on an object in space, or lift 100 tons in a 1-G gravity field. They are not long-ranged: effective strength is halved every 100 yards. Double this distance at each TL above 11. Tractor-beam operation is a P/E Professional skill, defaulting to Gunner (Beams)-2 or DX-4. In space combat, a tractor beam can be used as a beam weapon at point-blank range; it has sAcc -7. A hit will immobilize a vehicle with equal or less thrust (it cannot maneuver, and may be docked with against its will).

Pressor Beams (TL12+): Pressor beams are exactly like TL12 tractor beams, except that they work in reverse, pushing instead of pulling (assume they can impart 100 tons of thrust). They improve at higher TLs, always having the same cost and weight as a tractor beam. They are less versatile, but have their uses. In space combat, they are treated as tractor beams, but a hit instead forces ships out to short range or deflects missiles.

Combination Beams (TL12): These can work as either tractor or pressor beams, but not both at once.



Life Support

A manned ship should have at least one space of life support if it is intended to operate for more than a couple of days. Thus, short-range shuttles or fighters do not need life support.

Life-support systems are rated for the number of people they can support per space of system. Two types are available:

Full systems provide air, heat, and water, but not food – which should be carried as cargo for long voyages.

Total systems *do* provide food; they include hydroponics or food vats of some kind.

When deciding how many spaces of life support are needed, it is safe to count two people per cabin or luxury cabin and five people per bunk room. Life support is not required for passengers in freeze tubes. Excess life-support capacity allows extra passengers to be carried in "steerage" (see explanation under *Quarters,* above).

A life-support system can be overloaded if necessary. Roll 3d after each day overloading, at +1 per full 10% by which the number of people aboard exceeds system capacity. On an adjusted roll of 13 or more, the system begins to break down, losing 10% of its *current* capacity for each point by which the roll was missed. A Mechanic (Life Support) roll can be attempted once per day; if it succeeds, it will restore 10% of *full* capacity. But note that once the life-support system begins to fail, the effect snowballs. If the ship remains overloaded, life support will eventually reach 0% and fail. At that point, all the oxygen in the air will be used up within a few hours, and everyone will die. Those in cold sleep are unaffected if life support fails . . . as long as the power stays on.

Life-Support Table

System	Mass	Cost	Pow.	Capacity
Full Life Support/8	5	0.01	0.2	20 people
Total Life Support/8	2.5	0.005	0.05	5 people
Full Life Support/9	5	0.025	0.5	50 people
Total Life Support/9	2.4	0.012	0.12	12 people
Full Life Support/10	10	0.05	1	100 people
Total Life Support/10	5	0.025	0.25	25 people
Full Life Support/11+	5	0.25	0.05	500 people
Total Life Support/11+	2.5	0.12	0.012	125 people

Mass, cost, power, and capacity are *per space* of life support. Life support may be taken in half-space increments if desired. Power requirements for life support are usually relatively slight; if a ship lacks sufficient leftover power output to manage them, go back and add a few more spaces of power plant.

EXAMPLE: With 15 cabins (a potential 30 people), we decide to install 1.5 spaces of Total Life Support/10 (good for 37 people, which is useful emergency capacity). This requires 1.5 spaces, 7.5 tons, M$0.0375, and 0.375 MW. *Tanstaafl* has 155 spaces left.

Habitat Modules

Colony ships and space stations may contain large urban or green areas. Each module described below is about the size of a city block and includes lighting, temperature control, and air circulation.

Farm: An acre or so of open space with a few buildings devoted to agriculture and food processing. Up to 10 people or robots can work it efficiently; each worker can grow sufficient food to feed 10 people. Using crop rotation, the farm can act as total life support (see above) for about 100 people.

Factory: A large industrial park containing warehouses and robotic factories, capable of operating efficiently with a few dozen workers or robots.

Housing: One or more apartment buildings or a few dozen houses, plus surrounding grounds, walkways, etc., providing long-term accommodation for up to 100 people in conditions much more "open" than quarters.

Park: A landscaped green space, possibly with entertainment or exercise facilities (pools, stream, playgrounds, etc.). In a pinch, it can provide camp grounds for about 100 people.

Plaza: A mall or concourse area with a dozen or so medium-sized establishments, plus substantial open space for several hundred people to congregate around them.



Habitat Modules Table

System	Spaces	Mass	Cost	Pow.
Farm	10,000	20,000	0.5	0
Factory	10,000	50,000	10	10
Housing	10,000	40,000	1	0.1
Park	10,000	20,000	0.2	0
Plaza	10,000	30,000	1	0.1

Weapons

If space conflict is ongoing or likely, ships may be armed. In some cultures, only naval or Patrol vessels (and criminals) will be equipped with weaponry. In others, yachts and traders may legally mount weapons to defend against pirates . . . or the competition.

Weapons are grouped into three broad categories: *beam weapons, guns,* and *missiles.* For simplicity, beams and guns have been classed as *light* (Lt., occupying 1 space), *medium* (Md., 10 spaces), *heavy* (Hv., 100 spaces), *extra heavy* (EHv., 1,000 spaces), *super-heavy* (SHv., 10,000 spaces), and *ultra-heavy* (UHv, 100,000 spaces). GMs should feel free to extrapolate intermediate-sized or even larger weaponry.

Weapons can either be placed in hull mounts ("fixed" weaponry installed in hull spaces) or built into turrets. A *small turret* can mount one (single), two (double), three (triple), or four (quad) light weapons or missile bays. A *medium turret* can mount one (single), two (double), or three (triple) medium weapons. A *large turret* can mount one heavy weapon. Larger weapons can only be installed in hull mounts.

Option: Weapons and Surface Area

Realistically, a significant limit on hull weaponry is surface area (too many holes in the hull affect structural integrity). Each weapon mounted in the hull requires a certain amount of hull area; this "area requirement" is shown on the table below. Total area requirements for all hull-mounted weapons cannot exceed the ship's hull area minus the surface area of any turrets.

Weapon Types

Missile Bay: A launch bay capable of firing one missile per space-combat turn. Missiles deliver a great deal of damage (especially if given nuclear warheads), but are expensive on a per-shot basis, and can also be shot down. Each missile bay can hold up to 8 heavy *or* 40 light missiles.

Railgun: An electromagnetic "mass driver" that accelerates projectiles to high speeds. It does great damage, but its slugs move at a crawl compared to energy beams, which limits their effectiveness to close-range engagements or firing at non-maneuvering targets like space stations. At longer ranges, a ship will usually be somewhere else before the shot reaches it.

Laser: A space-combat laser fires high-energy pulses of coherent light, usually in the ultraviolet frequency. Lasers are quite accurate and reasonably long-ranged, but have extreme power consumption relative to their armor-penetrating ability.

Particle Beam: P-beam weapons fire focused beams of neutral subatomic particles moving at speeds approaching light speed. They are somewhat less accurate and more power-hungry than lasers, but deliver a more energetic punch: a hit inflicts both physical and radiation damage. Also known as a *NPAW* (neutral particle accelerator weapon) or *blaster.*

Teleport Projectors

The standard teleport projector consists of a room containing a number of platforms, each about a yard across, or perhaps a single large cargo platform. As a default, maximum range of a projector is assumed to be 10,000 miles. Conservation-of-energy issues related to teleportation are assumed to have been solved: an orbiting spaceship can teleport someone up from a planet below, or vice versa, if it has proper coordinates; excess energy goes into hyperspace or is otherwise dealt with.

The GM should decide if a teleport projector is a send-only device or if it can also snatch objects and teleport them *to* the projector. Other limitations can be applied by the GM as well. For example, a 'port could cause dizziness (HT roll to avoid -2 ST and DX for 20-HT seconds after teleporting), or teleportation might not work in a gravity well. One common limitation is that it cannot penetrate a force screen.

A teleport projector requires exact destination or pickup coordinates, usually supplied by shipboard sensors. Setting the coordinates and activating the machine takes 10 seconds and a roll vs. Electronics Operation (Teleportation), at -1 per 1,000 miles of range and +4 if teleporting from one teleport projector to another, cooperating projector. Failure when transporting someone out means the coordinates are a little off (GM's option – this could mean a few yards or a few *hundred* yards); failure when trying to pick someone up means the projector fails to lock on (try again after 10 seconds). Critical failure results in some sort of disaster, which may be annoying, gruesome, or just strange.

Compatibility with GURPS Vehicles

GURPS Vehicles offers a complete design system suitable for all types of vehicles, including starships, but it is also time consuming and complex. To make ***Space*** more accessible, this chapter presents a modular design system that allows one to construct ships from standard-sized hulls and components. All structures and components were created using the rules in ***Vehicles,*** *Second Edition* (with the addition of some new drives and habitat modules). Final weight in pounds, area in square feet, and cost in dollars were converted to tons, thousands of square feet (ksf), and millions of dollars (M$). Power is given in megawatts (1 MW = 1,000 kW), energy in megawatt-seconds. Volume was simplified by using components grouped into 500-cubic-foot ("one-space") system modules, often with some added empty space to give round numbers. Experienced GMs may use ***Vehicles*** to design their own systems or to create custom-built designs.

Vehicles can be used to extend the hull table to include nonstandard hull designs. Standardized hulls were built as vehicle bodies in multiples of 500 cubic feet, using medium frames and standard materials. Streamlined hulls used the "lifting body" and "very good streamlining" features. Turrets were built as full-rotation turret subassemblies with medium frames and standard materials. Basic landing gear was subsumed in streamlining to keep things simple.

The armor formula assumes "expensive metal" armor, and converts numbers to tons and M$. Other armor types are possible, as described in ***Vehicles.*** Briefly, "advanced" armor multiplies *final* weight by 0.6 and *final* cost by 2, while "standard" armor multiplies *final* weight by 1.6 and *final* cost by 0.5.

Ships designed with ***Vehicles*** can be used with the ***Space*** system fairly easily. Calculate cDR by dividing DR by 100, cHP by dividing hit points by 100, etc. Several simplifications were made to streamline ***Vehicles*** to fit this book: most numbers were rounded to two significant figures, while power requirements under 0.05 MW were treated as negligible on the scale ships were built at.



X-Ray Laser: A laser that operates at X-ray frequencies. It has more penetrating ability and greater range than ordinary (UV) lasers.

Antiparticle Beam: A particle beam weapon that accelerates antimatter particles. When the antiparticles impact the target, both they and an equal quantity of matter are annihilated, producing additional radiation and explosive damage. Also called an *APAW* (antimatter particle accelerator weapon) or *pulsar.*

Disintegrator: A superscience weapon that destroys matter on the subatomic level – with explosive results. The "rubber science" details are up to the GM. Although listed as TL15, GMs could easily have it appear at an earlier TL (anywhere from TL12 to TL14). Also called a *matter disruptor* or *disruption beam.*

Combat statistics for all these weapons are found in Chapter 9 (see p. 142).

Weapons Table

Weapon	Area Req.	Spaces	Mass	Cost*	Power
Missile Bay	0.2	1	1	0.003	0
Lt. Railgun/8	0.2	1	3.3	2.5	20
Md. Railgun/8	0.5	10	33	25	660
Hv. Railgun/8	1.5	100	330	250	2,000
Lt. Laser/8	0.2	1	5	0.9	100
Md. Laser/8	0.5	10	50	9	1,000
Hv. Laser/8	1.5	100	500	90	10,000
EHv. Laser/8	5	1,000	5,000	900	100,000
SHv. Laser/8	15	10,000	50,000	9,000	1,000,000
UHv. Laser/8	50	100,000	500,000	90,000	10,000,000
Lt. P-Beam/8**	0.2	1	5	0.9	290
Md. P-Beam/8**	0.5	10	50	9	2,900
Hv. P-Beam/8**	1.5	100	500	90	29,000
EHv. P-Beam/8**	5	1,000	5,000	900	290,000
SHv. P-Beam/8**	15	10,000	50,000	9,000	2,900,000
UHv. P-Beam/8**	50	100,000	500,000	90,000	29,000,000
Lt. X-Ray Laser/10	0.2	1	5	0.6	400
Md. X-Ray Laser/10	0.5	10	50	6	4,000
Hv. X-Ray Laser/10	1.5	100	500	60	40,000
EHv. X-Ray Laser/10	5	1,000	5,000	600	400,000
SHv. X-Ray Laser/10	15	10,000	50,000	6,000	4,000,000
UHv. X-Ray Laser/10	50	100,000	500,000	60,000	40,000,000
Lt. APAW/12	0.2	1	5	7	1,400
Md. APAW/12	0.5	10	50	70	14,000
Hv. APAW/12	1.5	100	500	700	140,000
EHv. APAW/12	5	1,000	5,000	7,000	1,400,000
SHv. APAW/12	15	10,000	50,000	70,000	14,000,000
UHv. APAW/12	50	100,000	500,000	700,000	140,000,000
Lt. Dis.Beam/15	0.2	1	5	3.2	1,000
Md. Dis.Beam/15	0.5	10	50	32	10,000
Hv. Dis.Beam/15	1.5	100	500	320	100,000
EHv. Dis.Beam/15	5	1,000	5,000	3,200	1,000,000
SHv. Dis.Beam/15	15	10,000	50,000	32,000	10,000,000
UHv. Dis.Beam/15	50	100,000	500,000	320,000	100,000,000

* *Halve* the cost of beams and guns (but not missile bays) one TL after they first appear; halve it again two or more TLs later.

** P-beams may be given the same options as hand blasters (see p. 82); "tight-beam" and "plasma" are the most practical.

All weapons include dedicated targeting computers running Complexity 4 targeting programs as a "backup" system. More sophisticated programs may be run from the bridge computers.

EXAMPLE: We decide to give *Tanstaafl* eight light lasers, four in each quad turret. Since we are at TL10 but lasers are TL8, they will cost only ¼ as much. They occupy all of our turret spaces, but we still have 155 hull spaces left.

Ammunition

Missile bays and railguns require ammunition.

Missile Bay Ammunition

Missile Type	Mass	Cost
Reaction Drive		
Lt. Missile/8	0.3	0.044
Lt. Missile/9	0.27	0.03
Lt. Missile/10	0.2	0.032
Lt. Missile/11	0.2	0.03
Hv. Missile/8	1.4	0.068
Hv. Missile/9	1.4	0.054
Hv. Missile/10	0.9	0.12
Hv. Missile/11	0.9	0.12
Reactionless Drive		
Lt. Missile/9	0.3	0.035
Lt. Missile/10	0.2	0.036
Lt. Missile/11	0.15	0.023
Hv. Missile/9	1.5	0.2
Hv. Missile/10	1	0.18
Hv. Missile/11	0.9	0.2
Grav Drive		
Lt. Missile/12	0.15	0.024
Lt. Missile/13	0.15	0.016
Hv. Missile/12	0.9	0.18
Hv. Missile/13	0.8	0.15

The drive technology used will determine mass and cost; for combat performance, see the *Missile Table* (p. 143). If both reaction drives and reactionless drives exist, each has its own advantages at TL9-10. At TL11, reactionless is better, while at TL12+, grav drives are superior. Cost assumes conventional "kinetic-kill" warheads; for other options, see *Missile Warheads* (p. 117).

Mass and cost are *per missile;* the missile takes up space in a missile bay. Extra missiles can be carried as cargo. Missile ammunition will not be accessible during combat, but can be reloaded into missile bays between battles (this takes about one man-hour per eight heavy or 20 light missiles). Stored as cargo, each light missile takes up about 6 cf (83 per cargo space), and each heavy missile takes up 30 cf (16 per space).

Railgun Ammunition

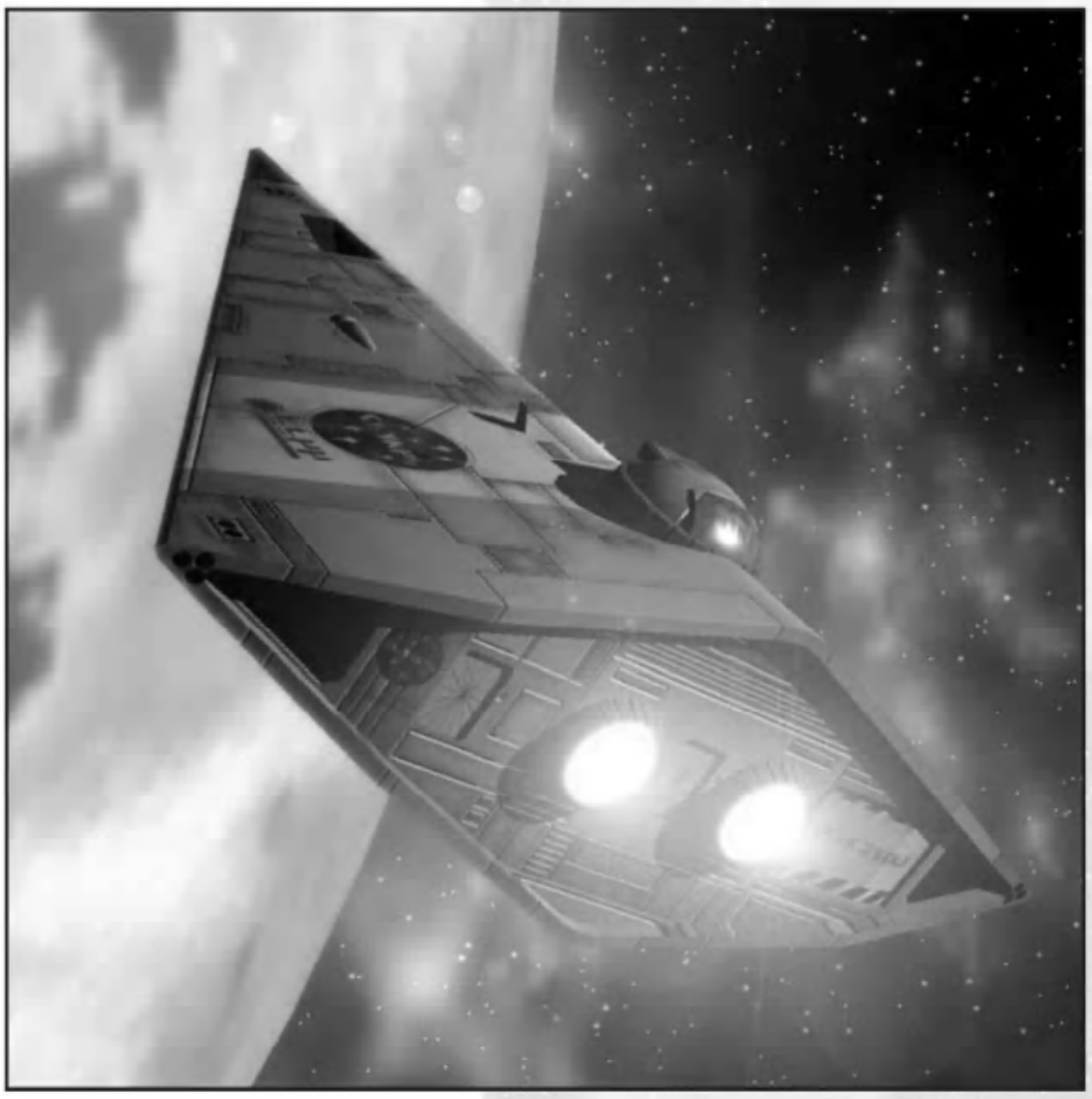
Magazine for	Shots	Mass	Cost
Lt. Railgun/8+	450	16	4.6
Md. Railgun/8+	45	16	4.6
Hv. Railgun/8+	5	16	4.6

Shots, mass, and cost are *per space.* Railgun ammunition consists of dense tungsten or depleted-uranium projectiles at TL10-, hyperdense projectiles at TL11+.

Energy Banks

A rechargeable energy bank is used to provide energy to systems whose transitory power requirements far outstrip the capacity of ordinary power plants: hyperdrives (when making a hyperskip), jump drives (when making a jump), and beams and railguns (when firing). Ships with any of these systems should be built with energy banks.

Stardrive Energy: To determine how much energy is required for jump drives or hyperdrives, find the "jump" or "skip" energy requirement of the stardrive (see pp. 115-116). Multiply this by the number of jumps or skips that can be made before recharging (usually one, but sometimes more). This gives the energy required in megawatt-seconds (MWs).



Light Sail Operations

A light sail is basically a large, ultra-thin steerable mirror that lets a ship use light for propulsion. The ship maneuvers by tilting the sail, with stellar gravity assisting in course changes.

Light sails are very fragile. When furled, a light sail provides no thrust, but is safely inside the ship. When unfurled, a light sail is large enough that it can automatically be hit in combat – but unless using a nuclear warhead, this will have little effect. By directing fire against shroud lines (cSM 0), the sail can be cut away. This requires 10 cHP damage per space of light sail. An unfurled light sail is not protected by ship cDR.

It takes an hour to unfurl or furl a light sail; a successful Piloting (Light Sail) roll can cut this to 15 minutes. A ship with an unfurled light sail cannot use any other kind of thrust or come within 200 miles of any world with an atmosphere without destroying the sail.



Beam/Gun Energy: The simplest way to determine beam weapon energy is to add up the megawatts of power required for *all* beam weapons and multiply this by the number of turns that the ship can sustain the barrage. This gives the megawatt-seconds of energy required. (This also makes record-keeping easier, as a simple "number of shots" can be recorded.)

After the total energy requirement in MWs is known, divide this by the energy stored in a single bank to find the number of spaces of energy bank needed. Round up to the nearest half or whole number. If the rounding up results in extra MWs of storage, just convert it into additional weapon shots.

Energy Bank Table

TL	Mass	Cost	Storage
8	25	5	450,000/45,000
9	25	5	675,000/67,500
10	25	5	900,000/90,000
11	25	5	1,125,000/112,500
12	25	5	1,350,000/135,000
13	25	5	1,575,000/157,500
14	25	5	1,800,000/180,000
15	25	5	2,025,000/202,500
16	25	5	2,250,000/225,000

Mass, cost, and energy storage (in MWs) are *per space* of energy bank. Energy banks are also available in half-space increments. Two numbers are given for energy storage: the higher one is for superscience power cells, the lower one is for energy storage using advanced room-temperature superconductor loops.

If using a power plant to recharge an energy bank, each MW allocated to this purpose recharges one MWs of stored energy per second. The ship can be designed with excess capacity for use in recharging, or it can simply shut down some power-using systems (e.g., the main drive) to divert power to this task.

EXAMPLE: The *Tanstaafl* requires 720,000 MWs for its hyperdrive, and we decide we only need one hyperskip between recharges, so 720,000 MWs it is. She also has eight light lasers that use a total of 800 MW. Taking a look at the table for energy banks, we see that at TL10, a single energy bank provides 900,000 MWs per space. After subtracting 720,000 MWs, that leaves 180,000 MWs, and with that we could power the eight lasers for a total of 225 turns. This seems like more than enough. We install a single-space energy bank: it will provide enough energy for one hyperskip and 225 laser shots. She has 154 hull spaces left.

Accessories

Automed Bay: This system contains a number of automeds (p. 96): two at TL9, three at TL10, five at TL11+.

Chrysalis Bay: Contains three chrysalis machines (p. 91).

Complete Workshop: A workshop with tools and spare parts for using all of Armoury, Electronics, Engineer, or Mechanic skill. Up to three people can use it at once; gives +2 skill.

Entry Module: An entry module consists of a passage tube (p. 118) and either a four-person (small module) or eight-person (large module) airlock (p. 118).

Hall, Bar, or Conference Room: A large room with tables. Usable as a restaurant, bar, conference room, etc. It can hold up to 50 people (smaller lounges and conference rooms are included in stateroom volume) and includes furnishings.

Lab: An equipment-filled laboratory designed for a specific Scientific skill (pp. B59-62). It gives a +2 bonus in situations where using lab equipment is helpful but not necessary, or no bonus in situations where a laboratory *is* necessary.

Spacedock Hangar: A pressurized hangar bay designed to house smaller craft within the ship. Its airlock doors or landing pad elevators open into space, but the hangar is sealed off and possesses air pumps that allow it to be evacuated or filled with air in a matter of minutes. Each space provides sufficient hangar facilities for storing 250 cf of vehicles (e.g., to carry a 5,000 cf shuttle would require 20 spaces of spacedock). The volume of the spacedock system can be divided up among several smaller hangars, if desired.

Surgery: A well-equipped surgery, including an operating table (fully gyrostabilized for shipboard use) that allows one person to be operated on at a time.

Teleport Projector: A sophisticated teleportation chamber. The basic model can be designed to transport either six people or 250 cf of cargo instantaneously through space; see *Teleport Projectors* (p. 125) for details. Multi-space projectors can be either separate projectors or larger models – decide when the ship is being designed. The device has a default TL of 15, but as it is superscience technology, the GM can make it available at a lower TL, if desired.

Vehicle Bay: A snug conformal bay designed to house one *specific* model of ship or vehicle. To enter the craft, one uses a door (or slide, or whatever) that leads directly into the craft; the craft exits through a small set of hangar doors. The spaces required for a vehicle bay are equal to the craft's volume in cf times 0.0021. (Round fractional sizes up to the nearest half or whole space.)

Accessories Table

System	Spc.	Mass	Cost	Pow.
Automed Bay/9	0.5	0.6	0.1	neg.
Automed Bay/10	0.5	0.75	0.15	neg.
Automed Bay/11	0.5	1	0.25	neg.
Chrysalis Bay/13	0.5	1.6	0.45	neg.
Complete Workshop	2.5	15	0.06	neg.
Entry Module, Small	0.5	2	0.007	neg.
Entry Module, Large	1	3	0.011	neg.
Hall, etc.	10	0.2	0.03	neg.
Lab	2	10	1	neg.
Spacedock	var.	1*	0.005*	
Surgery	0.5	0.14	0.05	neg.
Teleport Projector/15	1	12	30	
Vehicle Bay	var.	0.5*	0.003*	

* Mass and cost are paid only once, regardless of the number of spaces making up the spacedock or vehicle bay, and represent the mass and cost of the hangar doors and air pump.

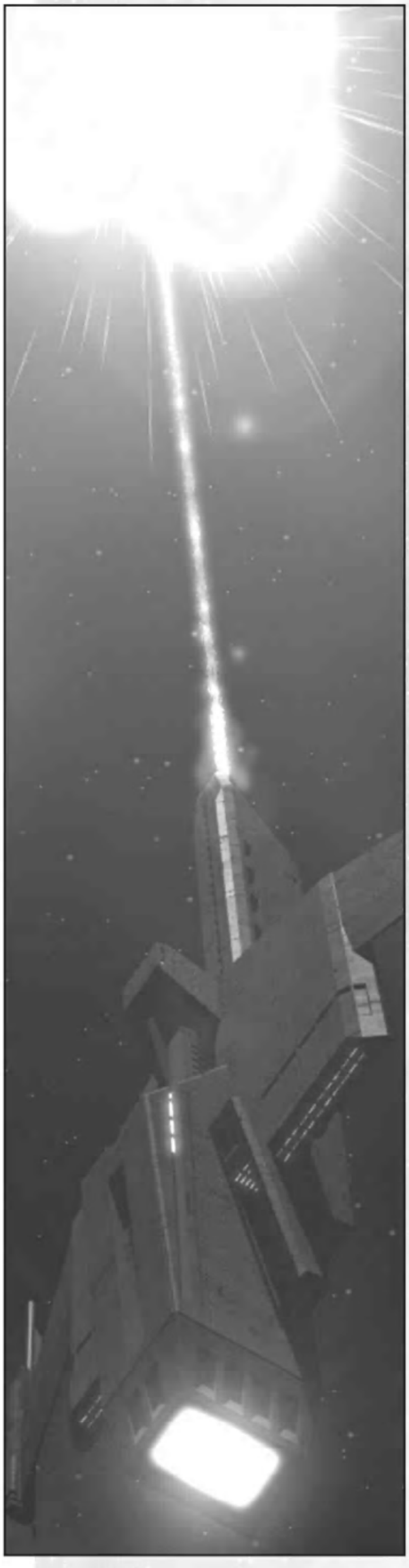
EXAMPLE: As the ship does not have a medic, we decide to install an Automed Bay/10. We also add a Small Entry Module. *Tanstaafl* has 153 hull spaces left.

Cargo Capacity

Any leftover space in the vehicle may either be left as "empty space" or designated as a cargo hold. Each space of cargo hold has room for 500 cf of cargo. Necessary cargo doors or ramps are included. Multiple spaces of cargo can either represent a single large hold or a number of smaller holds – decide which. Holds in ½-space increments (250 cf) may also be installed.

An empty cargo hold has no mass or cost.

EXAMPLE: We decide that *Tanstaafl*'s 153 remaining hull spaces are two cargo holds: one 150-space cargo hold and one three-space "ship's locker" to store crew and passenger personal gear.



Ground-to-Space & Space-to-Ground Performance

Escape!

A ship with an acceleration greater than the local surface gravity can blast straight up and escape. The time required to escape is 19 minutes/(sAccel - planet's surface gravity); both sAccel and gravity are in Gs. Contragravity negates some or all of the subtraction for the planet's gravity (e.g., a 1-G contragrav system could cancel up to 1 G of gravity).

Takeoff

Below TL13 or so, the best way for a ship to take off directly from the surface when its sAccel is less than the planetary gravity is to *fly* into space. This requires a streamlined ship, which must accelerate to orbital velocity. For planets, this is 17,800 mph × the square root of (M/R), where M is the planet's mass in Earth masses and R is its radius in Earth radii.

If a ship's rated air speed is higher than orbital velocity, it can fly into orbit in under an hour without experiencing any difficulties. If lower, it can still reach orbit if it has a space acceleration that can operate for long enough before running out of fuel:

Time to Orbit (in seconds) = [Orbital Speed (in mph) - Air Speed (in mph)]/[21.8 × sAccel (G)].

A streamlined ship with reactionless thrusters (which operate as long as there is power) will rarely have any trouble accelerating into orbit – it's just a matter of time.

Escape velocity (the speed needed to leave orbit) is 1.414 times the orbital velocity. Use the same formula to see if a ship can reach it, substituting escape velocity for the orbital velocity.

Assisted Takeoff

There are other ways to get a ship into the air: laser launch, catapults, "beanstalks," or skyhook systems. All require very extensive launch facilities. They might be suitable for merchants on regular routes, or for shuttles to non-landing starships, but not for explorers.

Landing

If a ship can take off from a world, it can land there. It is also possible to land "dead-stick," with no power at all, simply gliding in and decelerating. This gives a -4 to Piloting rolls.

Step 8 – Statistics

Total Empty Mass (EMass): Add together the mass of the hull, turrets, armor, screens, surface features, and all installed systems. This is the ship's *empty mass.* Do *not* include the mass of ammunition, fuel, or reaction mass.

Total Loaded Mass (LMass): This is equal to EMass plus these additions:

- The mass of cargo carried. If exact numbers are unknown, assume five tons per space of hold (i.e., about 20 lbs./cf), which allows for cargo holds that are not fully packed, container mass, etc. A density of 12-18 tons per space of hold is reasonable if hauling dense, heavy loads, but acceleration will be much lower.
- The mass of occupants. Assume 0.1 ton per person. As a rule of thumb, this can be simplified to 1.5 tons per passenger seat system, 0.5 tons per space of bunk room, 0.2 tons per cabin or luxury cabin, and 2 tons per space of freeze tubes.
- *Half* the mass of fuel or reaction mass (pp. 118-119). This is because the tank will be partially used during the flight. Calculating LMass using a half-tank is a reasonably accurate way of approximating more complex rocket equations.
- The mass of ammunition (p. 127).
- The mass of ships or other vehicles carried in spacedocks or vehicle bays.

Total Cost: Add together the cost of the hull, turrets, armor, screens, surface features, and all installed systems to get the ship's cost.

Size Modifier (SM): See the Size Modifier column in the *Hull Table* (p. 109).

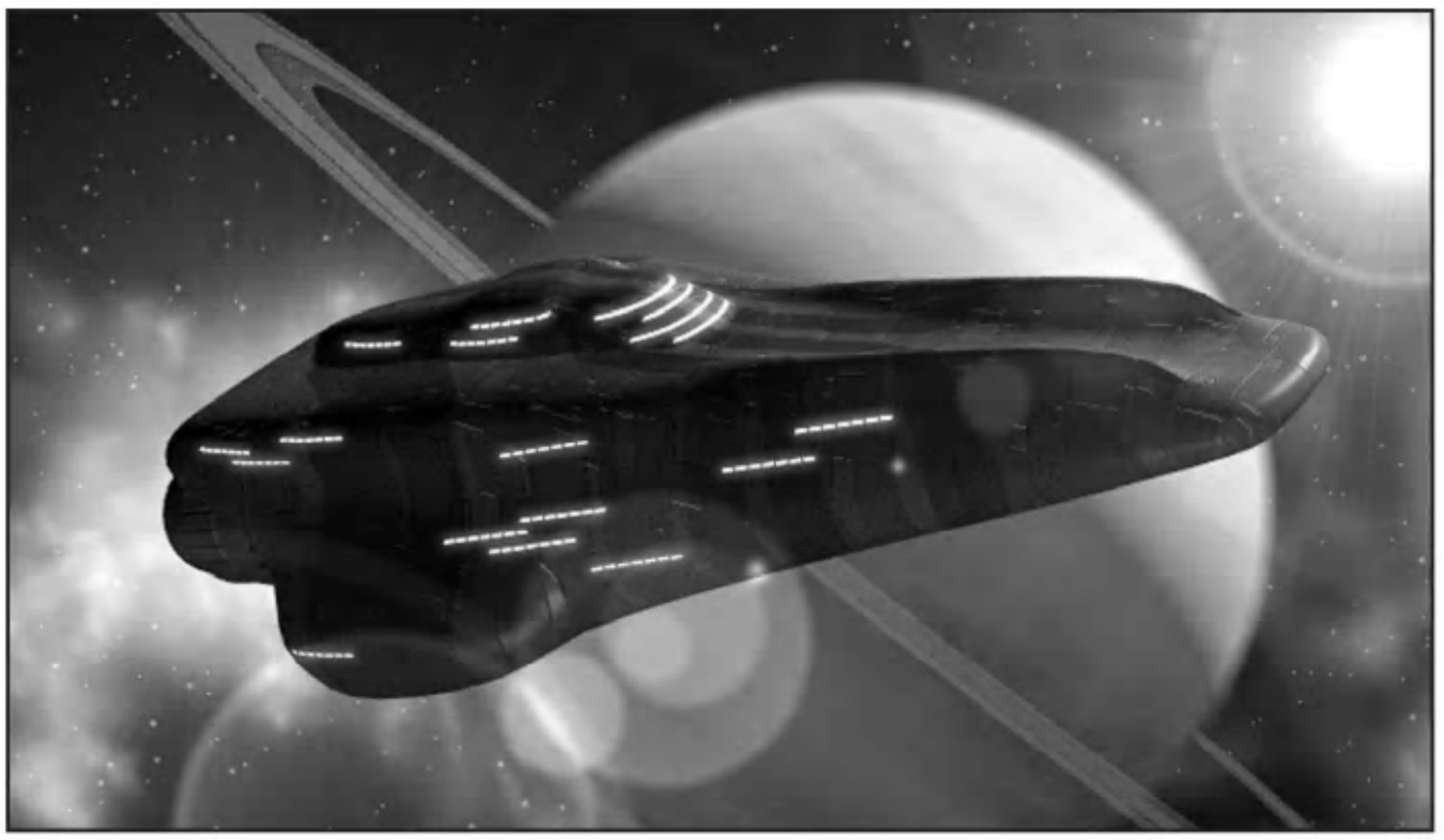
cSM: Used in the space combat system, this is (Size Modifier-10).

ASig: This is the ship's active sensor signature. It is equal to cSM, minus (TL-4) if ship has partial stealth or 2 × (TL-4) if it has radical stealth. Add +6 to ASig if a light sail is unfurled.

PSig: This is the ship's passive sensor signature. It is equal to cSM, minus (TL-4) if ship has partial emission cloaking or 2 × (TL-4) if it has radical emission cloaking.

Hull cHP: One cHP is equal to 100 hit points. A hull's (or turret's) cHP are equal to its area in ksf times 15.

EXAMPLE: *Tanstaafl*'s hull mass was 162 tons and the mass of all its systems is 728.25 tons, so it has EMass 890.25 tons. For loaded mass, we add 765 tons for cargo (153 spaces × 5 tons) and 4 tons for occupants (15 cabins and a half-space of freeze tubes), giving LMass 1,659.25 tons. *Tanstaafl*'s total cost is M$106.5195. Her Size Modifier is +9. Her cSM is (+9 - 10) = -1. Her ASig and PSig are also -1. She has Hull cHP 375 (hull area 25 ksf × 15).



Step 9 – Performance

Space Acceleration (sAccel): This measures how rapidly the ship can accelerate (including its ability to decelerate and maneuver). A ship's sAccel in Gs is equal to the tons of thrust provided by all maneuver drive systems that will be used simultaneously divided by the ship's LMass in tons.

Burn Endurance: For reaction-drive ships only. Measured in hours, this is the mass of fuel or reaction mass in tanks (in tons) divided by the drive's fuel or reaction mass consumption (in tons/hour).

FTL Performance: If the ship has an FTL drive, calculate its performance capabilities based on the ship's LMass and FTL drive rating (see *Drive, FTL,* p. 115).

Top Air Speed. A streamlined ship, or one with contragravity, may fly in atmosphere. If so, calculate the ship's drag as equal her total surface area (in ksf) × 200. Her top air speed in mph for normal cruising (i.e., not when accelerating into or out of orbit) is the square root of [15,000,000 × (thrust/drag)].

EXAMPLE: *Tanstaafl*'s maneuver drive has 1,800 tons of thrust. Dividing that by her LMass (1,659.25 tons), we get sAccel 1.08 G. Her hyperdrive's hypershunt capacity is 2,000 tons, which is more than enough to carry her into hyperspace (and which optionally multiplies base FTL speed by 2,000/1,659.25 = 1.2). As she is streamlined, she has a top air speed. Her drag is 5,400 (27 ksf × 200), her thrust 1,800 tons, so air speed is the square root of [15,000,000 × (1,800/5,400)] = 2,236 mph.

Option: Variable-Mass Performance

GMs may wish to calculate multiple sets of performance figures for ships whose mass can change dramatically; e.g., with near-empty vs. full cargo holds or spacedocks.

Step 10 – Finalization

The ship design is now complete. A new ship is usually categorized by size and function; e.g., "heavy cruiser" or "tramp freighter." A *class name* for the first ship of her type to fly is also assigned. Later ships generally follow the same theme; e.g., all battleships in the *Ares* class are named after human (or alien) war gods.



Creating Deck Plans

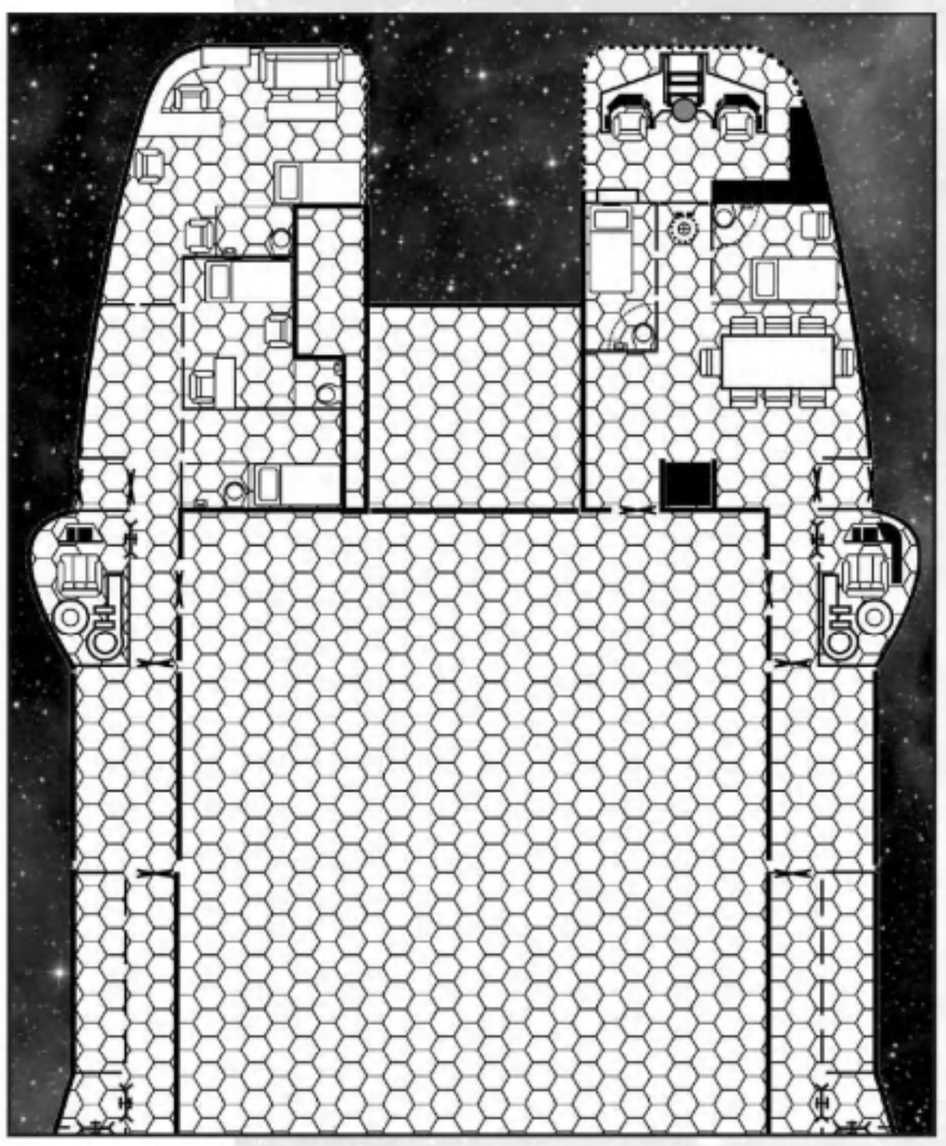
Ship designs can be used to create deck plans to facilitate boarding actions, hijackings, and other adventures. ***GURPS*** uses a one-yard hexagonal grid for maps. Assuming headroom of about 8-9 feet and some room under the decks (about 25% of each space), a space can be represented by six hexes. GMs should feel free to swap space around a bit for aesthetic effect.

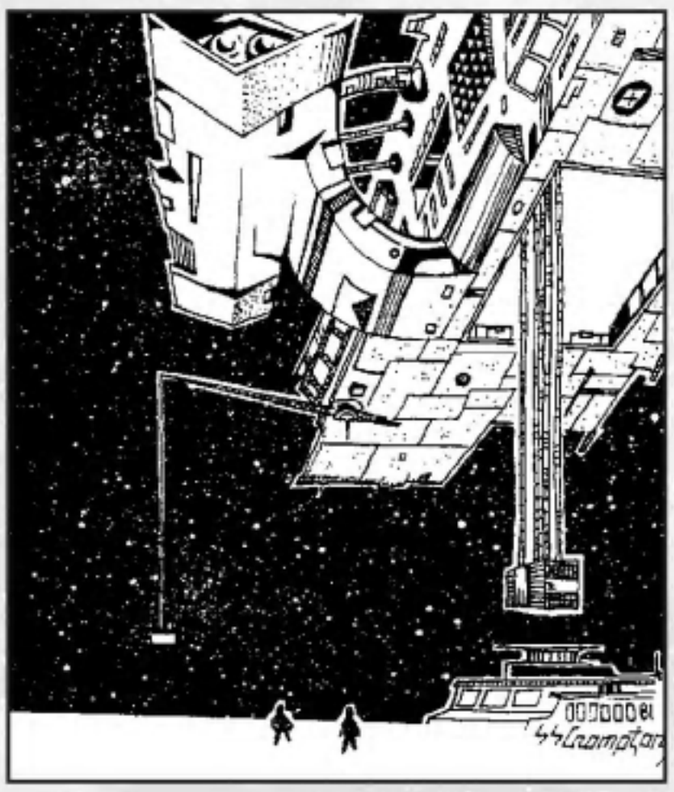
Traveling

Speeds with Maneuver Drives

The fastest way to get anywhere is to accelerate halfway there, turn the ship around, and decelerate the rest of the way – especially if using reactionless thrusters. If the drive is a reaction drive, this uses reaction mass for the whole trip, so the drive must be able to accelerate for that long. One can save by traveling more slowly, by accelerating only part of the way, or by using a transfer orbit (see sidebar).

The distance separating two planets in a star system may be as short as the difference between their distances from their star or as long as the sum of those distances, depending on their orbital positions. For a rough average approximation, the GM can assume the distance between two worlds is equal to distance from their star to the world that is furthest from the star. For this information, see *Orbit Locations* (p. 153). A moon's distance from its primary varies considerably; ours is about 0.0026 AUs away. Some travel times for constant-acceleration trips. Distances are given in AU (1 AU = 93,000,000 miles, the distance from Earth to the sun):





Interplanetary Travel with Low-Endurance Reaction Drives

Lower-TL space games may have extremely limited reaction drives – limited enough that the type of travel described under *Speeds with Maneuver Drives* (p. 131) is inappropriate because there are more fuel-efficient routes. The *most* fuel-efficient route between two planets is called a "Hohmann transfer orbit." Hohmann transfer orbits are only available at certain times, though, with a predictable separation between them; the "frequency" row on the table below indicates how often a transfer orbit is available between Earth and some popular destinations in the near solar system (or vice versa).

For most of the time a ship is in a Hohmann transfer orbit, it is coasting (and thus not using fuel), but to complete a given orbit requires acceleration for as many hours as the "impulse" number on the table divided by the ship's sAccel in Gs. This includes the thrust required to enter or leave low orbit (except in the case of Jupiter, where the numbers reflect a trip to or from one of its major moons). The table also shows the total travel time required using such an orbit.

Destination

	Moon	Mercury	Venus
Frequency	80 min.	4 mon.	17 mon.
Impulse	0.11	0.53	0.25
Time	5 days	110 days	170 days

	Mars	Jupiter
Frequency	26 mon.	13 mon.
Impulse	0.22	0.6
Time	260 days	3.1 years

Distance (AU) Acceleration

AU	0.0001 G	0.001 G	0.01 G	0.1 G	1 G	2 G
0.1	3.1 mon	1 mon	9 days	68 hrs	22 hrs	16 hrs
0.2	4.5 mon	5.7 wks	1.8 wks	4 days	31 hrs	22 hrs
0.5	7 mon	9 wks	2.9 wks	6.3 days	2 days	34 hrs
1	10 mon	13 wks	1 mon	9 days	2.8 days	2 days
2	14 mon	4.5 mon	6 wks	13 days	4.1 days	2.8 days
5	23 mon	7 mon	9 wks	2.9 wks	6.3 days	4.5 days
10	32 mon	10 mon	13 wks	1 mon	9 days	6.3 days
50	5.5 yrs	23 mon	7 mon	9 wks	2.9 wks	2 wks
100	7.8 yrs	32 mon	10 mon	13 wks	1 mon	2.9 wks

Or use this formula: Time (in hours) = 68 × [square root of (D/A)]; D is the distance in AU, A is acceleration in Gs.

Example: Tanstaafl's hyperdrive (see *Stardrive Performance,* below) gets her to within 0.1 AU of a planet. With her maneuver drive, she can reach 1.08 G. Assuming she takes it easy with a steady 1 G, she can reach her destination in 22 hrs.

Trips with Reaction Drives

If using a reaction drive, the usual method is to boost up to a reasonably high speed, then coast the rest of the way: a short burn at the start of the trip, and a short one at the end.

The maximum speed a ship can reach using reaction drives (its delta-vee) is (*very approximately*) its sAccel (in Gs) × its Burn Endurance (in hours) × 3,600 × 21.9 mph (which simplifies to 78,840 mph × Burn Endurance per G). As the ship's crew will usually want to use half its reaction mass to slow down and come to a stop at its destination, the effective delta-vee is half that: 39,420 mph × Burn Endurance per G. To get a delta-vee in "AU per hour" divide by 93,000,000.

The total length of a full-thrust trip will be roughly Burn Endurance plus [distance (miles)/delta-vee (mph)] hours.

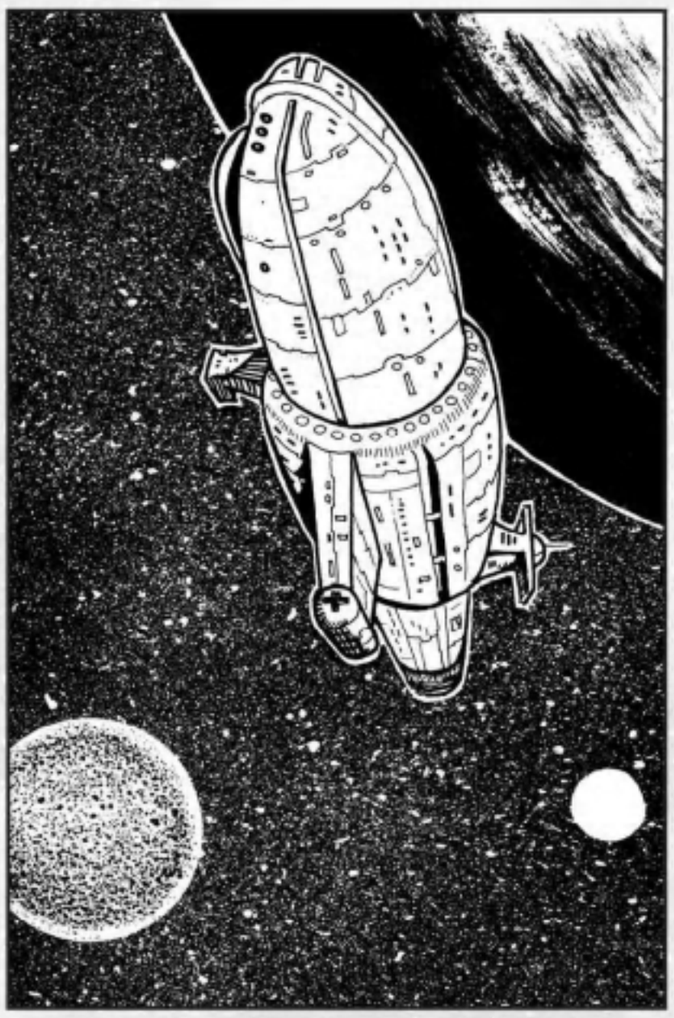
To convert AU distances to miles, multiply by 93,000,000.

Example: A ship with a 0.2 G sAccel and Burn Endurance of 4 hours can achieve a round-trip delta-vee of 31,536 mph. To travel 1 AU (say, a typical Earth to Venus voyage) would take 4 + (93,000,000/31,536) = 2,953 hours.

Stardrive Performance

The GM should work out the mechanics of stardrive operation using the guidelines in Chapter 2. For example, in *Tanstaafl*'s universe, travel is by hyperdrive. Drives use the standard rules for energy requirements; how often a ship can skip depends on how fast it can recharge its energy banks. Travel through hyperspace is 0.2 parsecs per day. Astrogation is "modified straight-line" (p. 34), with a -1 to Astrogation rolls for each full parsec. There are no FTL sensors; ships usually come out of hyperspace and look around every couple of parsecs to avoid getting lost. Hurried skips give a penalty to the roll: -1 for 30 minutes, -2 for 10 minutes, -3 for a minute, -4 for a skip without preparation. If an astrogator gets a critical failure, the ships may mis-skip dramatically, sometimes by many parsecs, often burning out its drive in the process. An ordinary failure may put a ship a parsec or so off course.

Hyperdrive in this setting has the following limitations: Ships can enter hyperspace anywhere as long as they are in vacuum and zero gravity (i.e., orbit); ships can't leave hyperspace within (approximately) 0.5 AU of a stellar mass or 0.1 AU of a planetary mass. Accuracy is within 100 AU per parsec, so a ship often skips into a system, takes a new sighting, then skips again to get closer. An Astrogation roll is required to get "just close enough but not too close" to a target world. For a short in-system jump, an astrogator who tries to cut it fine and fails will be bounced and appear 3d AU away from the target. If he has energy, he can skip again; otherwise, he'll have to wait for a recharge, or give up and go in on maneuver drives. In any case, maneuver drives are needed for the final 0.1 AU approach.



Detecting Worlds

If FTL travel is possible, then the procedure for investigating a new system will nearly always be the same: jump in, look around, take notes, and get the word home. However, things may differ at lower TLs, or in settings without FTL travel.

Beginning at late TL7, *large* planets (like gas giants) can be detected indirectly from many parsecs away, provided they are both reasonably close to their star and quite massive. At TL8, astronomical techniques improve to allow detection of Earth-sized planets from several parsecs distant.

Long-range observations can reveal roughly how massive a planet is – whether it is a tiny rockball, an Earth-sized planet, or a huge gas giant. They can also show how far the planet is from its star and what its orbit is like, which gives a rough idea of whether it is too hot, too cold, or just right for life as we know it. Use of radio telescopes can determine whether it is pumping out electromagnetic signals. At TL8+, interferometry can even reveal details about atmospheric composition from several parsecs away (NASA's Terrestrial Planet Finder project claims a range of 15 pc).

At interstellar distances – unless *really good* FTL sensors are available – everything else is a mystery. To find out more, someone may want to visit the system and take a look, or at least send an unmanned probe. This may be a government job (Survey Service), or private enterprise. Or colonists may do their own world-hunting.

No matter how good your sensors and robots are, though, someone will have to "prove" a planet habitable by landing on it. This is always a chance for adventure.

Stardrive Options

Once the drive type has been chosen, the GM may customize his system. These decisions are important; they provide much of the campaign's flavor.

Drive Reliability

Decide how much attention the engines need. They may be so reliable that a yacht owner need only order a checkup every few years – or so finicky that a specialist with a Scots accent has to roll against Engineering (Stardrive) at -4 after every use just to get them working again.

Drive Speed

Decide how fast the drive can go. This decision depends on how large an area the campaign covers and how fast you want the ships to get there.

Hyperdrives and warp drives can be given a speed in parsecs per day (or hour, or second . . .). For hyperdrives, there may also be a limit to the time or distance a ship can stay in hyperspace without emerging into normal space. Each separate trip is called a "skip," and the ship must wait a GM-set time between skips. For instance, maximum skip might be one parsec. If this is almost instantaneous, but the ship requires a day to recharge its energy banks, then effective speed is one parsec per day.

For jump drives, "speed" depends entirely on how far away the chosen jump point is through normal space. The important factors are endurance (which affects how *often* a ship can jump, with respect to refueling or maintenance) and normal-space time from one jump exit to the next entrance.

The following chart provides sample figures for distance, time and speed.

Speed	Alpha Centauri (1.3 pc)	Canopus (30 pc)	Across our galactic arm (2,000 pc)	To Sagittarian Arm (3,500 pc)	Galactic core (10,000 pc)
0.02 pc/dy	65 days	50 mon	270 yrs	480 yrs	14 cty
0.2 pc/dy	6.5 days	5 mon	27 yrs	48 yrs	1.4 cty
0.5 pc/dy	2.6 days	2 mon	11 yrs	19 yrs	55 yrs
1.5 pc/dy	21 hrs	3 wks	4 yrs	6 yrs	18 yrs
2.5 pc/dy	12 hrs	2 wks	2 yrs	4 yrs	11 yrs
7 pc/dy	4.5 hrs	4 days	9 mon	1.4 yrs	4 yrs
10 pc/dy	3.1 hrs	3 days	7 mon	1 yr	3 yrs
1 pc/hr	78 min	30 hrs	2.7 mon	4.8 mon	1 yr
4 pc/hr	19 min	8 hrs	3 wks	1 mon	3.4 mon
12 pc/hr	6.5 min	3 hrs	1 wk	1.5 wks	1 mon
20 pc/hr	4 min	1.5 hrs	4 days	1 wk	3 wks
1 pc/min	1.3 min	30 min	1.4 days	2.4 days	7 days
0.5 pc/sec	2.6 sec	1 min	1 hr	1.75 hrs	5.5 hrs

For instance, if your campaign centers around a galactic arm and you want the journey across it to take a year, then your starships should travel about 5 parsecs per day. At this speed, it will take two years to reach the Sagittarian Arm, and six years to reach the center of our Milky Way galaxy. Very long trips take longer, of course. Other galaxies in our group are some 700 kiloparsecs apart; the next group of 20-50 galaxies is about 1,500 kiloparsecs away.

Comparative Speed

With warp drives, ships will probably have different speeds, depending on mass and thrust. This can also be true with hyperdrives. Alternatively, all travel in hyperspace is automatically (for instance) at 0.2 parsecs/day – a drive is either powerful enough to boost a given mass into hyperspace or it isn't, with no middle ground.

Chapter 8 shows the relationship between mass and speed for each drive. With jump drives, point-to-point speed is likely to be the same for any ship, though one ship can still have better *maneuver* drives than another.

Maximum Range

How far can a ship go at a time? Ships which have to refuel often, or which require lengthy calculations before "going FTL," may have limits on the distance traveled before another jump or calculation is necessary. Possibilities:

Unlimited: The ship can go any distance, perhaps limited only by acquiring enough energy or suitable engines.

Great distances: A ship can travel a large number of parsecs (chosen by the GM) at a time. In fact, ships might not be capable of going small distances.

Small distances: A ship's maximum travel range is small relative to the distance between stars. For example, if the longest convenient trip is 2 parsecs without stopping, interstellar borders will be fairly easy to guard.

The distance traveled may also depend on other factors. For instance, very large ships might be able to jump farther than small ones (or vice versa) for reasons inherent in the drive system.

Effects on the Campaign: If ships can travel undetected through hyperspace for long distances, then interstellar nations cannot defend their borders – a hostile ship might warp in at any time. If ships can only travel short distances in FTL, or jump points are required and are easy to defend, then interstellar borders and border patrols become feasible. If the stops between voyage segments are long while energy banks are recharged, refueling is needed, or lengthy calculations are made, then borders become likely.

Fuel Consumption

Starships vary wildly in the amount of fuel they need. Sublight reaction drives need reaction mass (see pp. 118-119). Warp drives and hyperdrives must run continuously while the ship is in FTL mode. Jump drives operate for moments only, when jumping, but power requirements at that moment might be enormous. Drives consume either fuel or power from a separate power plant. And power plants don't create their power from nothing – they have fuel requirements of their own, although in some cases these are subsumed into the basic design ("a fusion plant has internal fuel for 200 years").

Some fuels are plentiful. A ship which uses hydrogen as reaction mass might dive through the outer atmosphere of a gas giant to "scoop" what it needs. A total-conversion power plant could burn *any* matter as fuel. Most restricted are ships which require processed or manufactured fuels, such as radioactives or antimatter; such ships must refuel at fueling stations or carry their own fuel-processing equipment.

A further possibility is that FTL drives require some crystal, rare earth, or other scarce material which wears out or is used up. Or they might require something that can be manufactured only at great difficulty or expense – like antimatter.

Effects on the Campaign: Availability of fuel will affect any strategic plans, military or otherwise. Ships must carry fuel or the means to get it. Starships with bad fuel economy must refuel frequently. Refueling points become strategically important, interstellar borders naturally expand around such points, and exploration depends on the location of new fuel sources. If hydrogen is the fuel, gas giants and cool stars become important specks of galactic real estate; for other fuels, other star or world types will dominate. A campaign where fuel is limited or expensive will be similar to the oil embargo situation of the 1970s, while limited fuel and bad endurance resembles the WWI strategic naval situation. When fuel is expensive, merchants will prefer to deal in low-weight, high-profit goods.

If fuel is free or ships are very fuel-efficient, travel becomes cheap. Conquerors might exile entire planetary populations, while merchants can afford to trade in bulky goods such as rice. If travel is both cheap and fast, tourism becomes an industry and the stars become melting pots of peoples and customs.

Campaign Scope and FTL Travel

The *scope* of a space campaign is the distance the characters can traverse regularly. This is tied closely to the type of space travel available to them. Possibilities include:

A single star system. Either there is no FTL travel or the adventurers don't have access to it.

A dozen star systems. The fastest travel is 0.1 parsec per day. (Unless habitable worlds are rare – see p. 31.)

All systems within a selected range of a homeworld. There are 150 stars within 10 parsecs of Sol, and 500 stars within 15 parsecs. This implies travel speeds of 0.2 to 2 pc per day.

A galactic arm, or part of one. A playable speed might be 2-30 pc per day.

A galaxy, or several galaxies. Instantaneous travel (stargates, for instance), or speeds of hundreds of pc per day.

If the campaign is based on a specific story or series, the scope is already defined. But even if the local civilization spans a galactic arm, the PCs may be concerned only with a few sectors on the frontier. Limiting the scope is easier for the beginning GM; the campaign can always be expanded later.

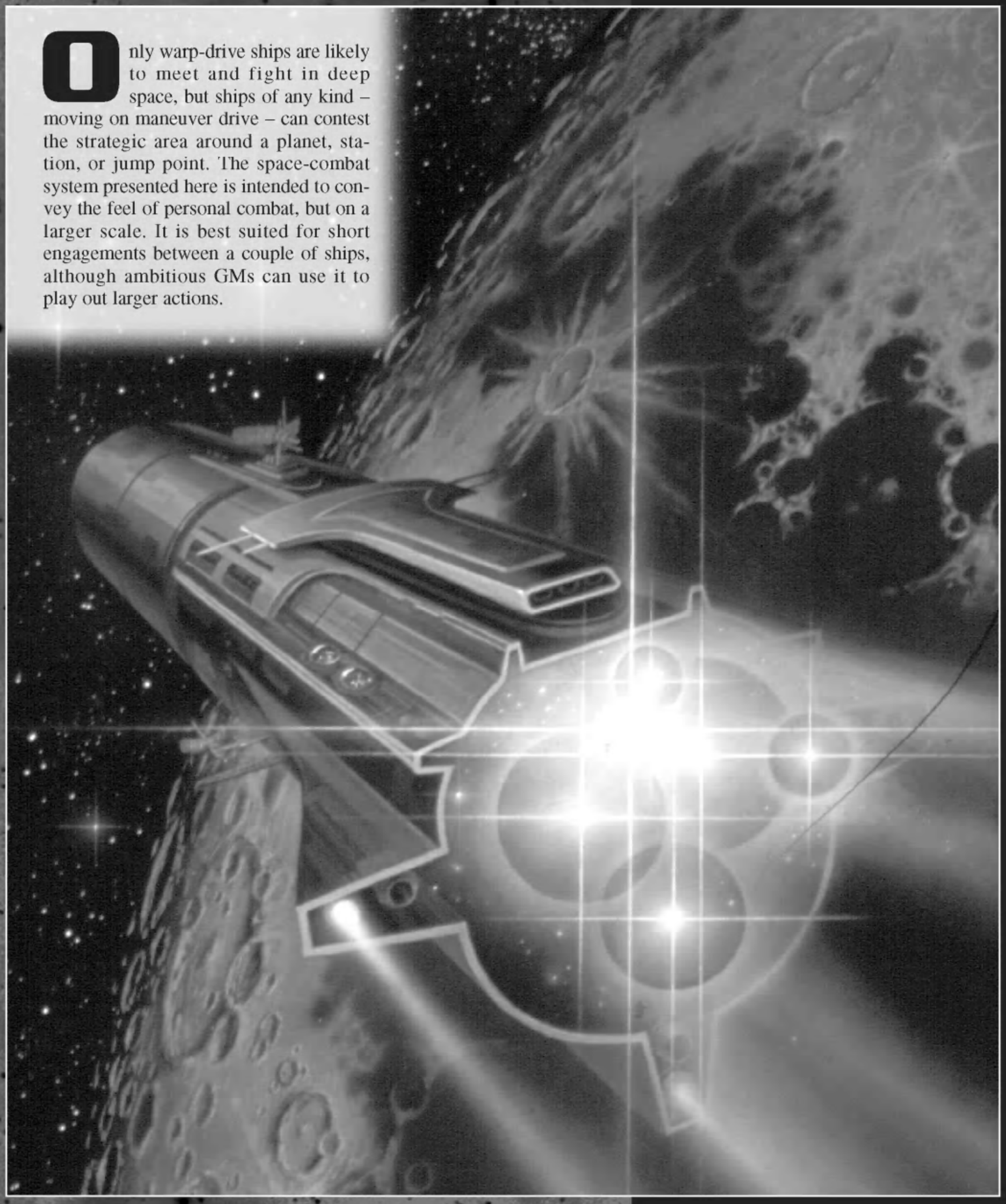


Speed vs. Acceleration

These rules give warp and hyperdrive FTL starships a *cruising speed* rather than an acceleration rating. The assumption, made both for playability and to conform with most fiction, is that there is *something* – an FTL friction factor, to give it a name – that requires hyperdrive or warp ships to constantly use energy to maintain speed. If this is true – and it is *much* easier to play if it is – then starships simply have a cruising speed (which can be "pushed" for a maximum speed) just as 20th-century automobiles do.

CHAPTER 9 SPACE COMBAT

Only warp-drive ships are likely to meet and fight in deep space, but ships of any kind – moving on maneuver drive – can contest the strategic area around a planet, station, or jump point. The space-combat system presented here is intended to convey the feel of personal combat, but on a larger scale. It is best suited for short engagements between a couple of ships, although ambitious GMs can use it to play out larger actions.



The Engagement

Before any combat involving spacecraft can occur, the opposing forces must have maneuvered, by accident or design, into the same general area of space (typically within a light second of each other – about 186,000 miles). Ships may blunder into each other by accident, may be deliberately looking for a fight, or may be attacking a defended point or patrolling a particular area. The GM should then determine whether combat can occur, based on their relative velocities and planned dispositions. He should also decide whether any celestial bodies or other interesting features exist in the combat zone to complicate the issue.

Initiative

Prior to the start of the engagement, each side's leader (the captain, if only one vessel is involved; the squadron leader or admiral in the case of multiple vessels) rolls 1d and adds the applicable modifiers from the *Initiative Table* (p. 141).

If they tie, both sides detect each other at roughly the same time and have an equal amount of time to prepare. If one side wins, it achieves *partial surprise.* If one side wins by five or more, it achieves *complete surprise.*

Partial Surprise

Partial surprise means that one side has detected the other a few moments before being itself detected. An engagement is unavoidable, but one side is more prepared for it. The side that was surprised may only choose Drift or Hold Course maneuvers, and suffers -4 (-2 for people with Combat Reflexes) on all attack and maneuver rolls. Partial surprise ends at the start of a surprised ship's *second* turn.

Complete Surprise

This means that one side has detected the enemy some *minutes* before being itself detected. If PCs achieve complete surprise, the GM should describe the enemy forces to them in terms of size and appearance.

If the side with surprise chooses battle, it has time to achieve a high speed and thus get among the enemy unexpectedly, or to stand off and launch missiles from a distance, or both. The enemy may take no maneuver other than Drift or Hold Course, suffers -6 (-3 for people with Combat Reflexes) on all attack and maneuver rolls, and may not fire weapons except against incoming missiles. At the start of the enemy's *second* turn, complete surprise ends, but the enemy is still off balance and suffers the effects of partial surprise, which lasts until the start of the enemy's third turn.

Alternatively, some or all of the ships on the side with surprise may break contact instead of attacking, avoiding the combat. However, if all forces retreat, it means abandoning any planet or station they were defending. In the case of a total retreat, no battle occurs, but the GM should consider the courses of both sides and decide whether or not a battle may take place hours later, elsewhere. If further action seems likely, roll initiative again; the GM may give the side that achieved complete surprise a bonus if its commanders made better plans based on their initial contact with their enemy.

Finally, a side with complete surprise may pull back but stay in fleeting sensor contact with the enemy vessels, perhaps hoping to be led to a base or the like; see *Shadowing and Detection* (sidebar).

Shadowing and Detection

A force that has completely surprised its opponents may choose to stay just on the edge of sensor range, shadowing the enemy. To do so, make another initiative roll every hour or so the shadowing takes place; the shadowing force get a +3 bonus. If they retain "complete surprise," they can continue to shadow the enemy. Of course, their opponents may eventually activate an FTL drive, arrive at a base, or even split into several groups, forcing the pursuers to split up or otherwise take action.

If "complete surprise" ever drops to "partial surprise" or worse, the shadowing force has been detected and a battle may occur.

It may or may not be possible to shadow ships moving in hyperspace or at warp speeds; an appropriate FTL drive is necessary, and FTL sensors may be required (GM's option).

Formations

A number of friendly vessels may be declared "in close formation." Designate one as the formation leader. Vessels in formation must take the same maneuver as the formation leader. If the formation leader fails at an Attack Run, Break Off, or Pursuit maneuver, they must take the same maneuver, but automatically fail also. If the formation leader succeeds at one of these maneuvers and a vessel in formation with it fails, that vessel has dropped out of formation.

As long as the ships remain in formation, they are automatically at short range to each other and to any vessel that it is at short range to any one of them.

Ships declare that they are breaking off formation at the start of the maneuvering phase of their turn. Formations may be freely designated before a battle begins. Ships may only join a formation during a battle if both they and the formation leader take the Form Up maneuver.



Space Combat Turns

Space combat is fought in *space combat turns,* each representing perhaps 10 seconds of engagement time. Space combat turns are the final dramatic moments of an engagement that may have involved several minutes or even hours of slow positional maneuvering before the ships entered weapons range and started shooting.

In space combat, each vessel takes its turn in sequence until they have all had a turn, then they start over – just like in personal combat.

The turn sequence – the order in which individual vessels take their turns – is up to the GM. The suggested method is that the side that lost the initiative roll (if both sides tied, roll a die) picks one of the *enemy's* vessels to go first and that vessel takes its turn. Then the other side picks one of its opponent's vessels to take its turn. Keep alternating back and forth until all vessels have taken turns or one side runs out of vessels. If the latter occurs, the remaining vessels take their turns in whatever order their leader wishes.

After everyone has acted, 10 seconds have passed. Begin a new turn, with surviving vessels acting in the exact same order as before. To facilitate record keeping, the GM should record the order in which individual vessels take their first turn (assign the first vessel the number 1, the second vessel the number 2, etc.).

Reaction Mass and Combat

A ship that uses a reaction drive must have sufficient reaction mass to maneuver in order to do anything but Drift. This is rarely a problem, as one space combat turn is 1/360 of an hour, but GMs may wish to take this into account for vessels which are low on reaction mass at the start of a fight, or which have very high consumptions (endurance under one hour).



Action Within the Turn

On a vessel's turn, the following activities take place:

1. **Maneuvering.** The captain picks a space maneuver. Any Contests of Skill that maneuver requires are resolved.
2. **Missile Attack.** Missiles the vessel launched on its *last* turn – and which were not shot down – attack their targets.
3. **Beam and Gun Fire.** The vessel's gunners may fire railguns and beam weapons.
4. **Missile Launch.** The vessel's gunners may launch missiles (which will reach their targets on the vessel's *next* turn).
5. **Other Actions.** The vessel's crew may perform other actions (repairs, moving about the ship, etc.).

After this, the active part of the vessel's turn is over and the next vessel in the sequence takes its turn. However, the maneuver the vessel chose is considered to remain in effect until the start of its next turn.

Space Maneuvers

Each captain starts a space combat turn by choosing any *one* of the following maneuvers. The maneuver a captain chooses will also affect his vessel's defenses if it is attacked before its next turn. Movement is wholly abstract: no game board is required.

Surprised vessels may only perform Drift or Hold Course maneuvers. A crippled or otherwise non-maneuverable vessel (space station, out of fuel, etc.) is limited to the Drift maneuver.

Speed Modifiers: Some maneuvers give a bonus to the "faster" ship. If both ships use maneuver drives, "faster" means "higher sAccel"; if both use warp drives, it means "higher warp speed." Where maneuvers require a Quick Contest of Piloting, the following modifier applies to the faster ship's pilot (use only the highest): +3 if faster, +6 if at least *twice* as fast, +7 if at least *five* times as fast, +10 if *ten* or more times as fast. If using warp drive and the other vessel is using only maneuver drive, a +10 modifier always applies.

Retaining Advantaged Status

One ship may become Advantaged over another as the result of an Attack Run maneuver, in which case it remains Advantaged until the start of its own next turn, regardless of the maneuvers taken by the enemy vessel. After that, it is no longer Advantaged until it regains that status through another successful Attack Run maneuver. A ship cannot be Advantaged against more than one opponent at a time unless those opponents are in the same formation. If a situation occurs where a ship would be Advantaged against a second opponent that isn't in the same formation, its commander must choose which ship he wishes to retain Advantage over.

Cinematic Rules

Hugging the Enemy

In some settings, small, maneuverable ships have a significant advantage over larger vessels. To simulate this, the GM may adopt the following rule:

A ship that has gained Advantage over a larger ship through an Attack Run maneuver may, *if the target has a Size Modifier eight or more greater than its own,* declare itself to be "hugging" the larger vessel – in effect, proceeding in close and using it as terrain. While doing so, it is considered at point-blank range rather than at short range; moreover, none of the bigger ship's hull weapons will be able to bear on the smaller ship (or ships, if all are in formation), and no more than two of its turrets may do so. Any shot fired at the smaller craft from a *different* vessel has a 50% chance (1-3 on 1d) of hitting the larger vessel it was hugging instead.

These effects persist only until the smaller vessel's next turn. To continue hugging its target, the smaller vessel must regain Advantaged status each turn through successful Attack Run maneuvers.

Dramatic Escape

In congested or hazardous environments, such as close to a star or black hole, within a strangely dense asteroid belt, or perhaps fighting in and around a large space station, a ship that chooses Break Off may attempt to elude pursuit by risking destruction and daring its pursuers to do the same.

The pilot of the ship attempting to Break Off describes the action, then negotiates the difficulty of the maneuver and the consequences of failure with the GM. Consequences may include damage, being caught in a gravity well . . . even instant destruction. A Piloting roll is then required to see if the maneuver succeeds – or fails, which means ship suffers the consequences.

Should the ship succeed, any opponent who wishes to pursue it (see *Pursuit,* p. 137) must not only win a Quick Contest of Piloting skills as usual, but must also dare the same maneuver, with all the same risks. Only by succeeding at *both* will the pursuing ship catch up with its fleeing target.

Attack Run

Choose a target (e.g., an enemy ship, space station, or ground installation). You attempt to close to short range (or to maintain that range, if it was already short) and place your ship in an optimum firing position. An Attack Run maneuver may not be performed on the first turn of an engagement unless your side has achieved complete surprise. You may only make attack runs against an installation on a world with an atmosphere if your ship has contragravity or streamlining.

If your target is incapable of maneuver, your Attack Run is automatically a critical success: you are at short range and are "Advantaged" against it. (An Advantaged ship has maneuvered into an especially good firing position relative to that particular target.) Otherwise, your target must decide whether to engage you or to evade. If his last maneuver was an Attack Run or Ram against *you,* he *must* engage; if it was Evasive Action or Break Off, he *must* evade.

If the target chooses to engage, the respective pilots roll a Quick Contest of Piloting skills. The pilot with the faster ship adds speed modifiers (p. 135). If either pilot is Advantaged against his opponent, he adds +4. The target's pilot subtracts any surprise penalties (if surprised). If either pilot wins the Quick Contest by four or more, or via a critical success, he is Advantaged vs. his opponent. Otherwise, win or lose, the two ships are now at short range. Exception: If you both get critical failures, you *collide!*

If the target chooses to evade, a Quick Contest of Piloting skills also takes place. The faster ship's pilot adds speed modifiers. You receive a +4 if you were at short range to the target on your previous turn, and another +4 if you were Advantaged against him. Your target receives a +4 if his last maneuver was Evasive Action. If you win, you are both at short range; if you win by four or more, or via a critical success, you are also Advantaged. If you tie or lose, your Attack Run fails and you are at long range.

See also *Hugging the Enemy* (sidebar).



Break Off

This maneuver represents an attempt to disengage from the battle. If a ship chooses a Break Off maneuver, it is assumed to have left the combat zone at the start of its *next* turn, if it has not lost maneuverability before then. However, any enemy ships that successfully perform an Attack Run or Pursuit against it before then will escape with it. This forms a second engagement that begins immediately, some distance from the first.

You may not choose Break Off if your ship's last maneuver was Attack Run or Ram.

See also *Dramatic Escape* (sidebar).

Drift

A vessel taking the Drift "maneuver" is not using its maneuver drive or warp drive, and is making no effort to avoid enemy fire. Depending on its actions on prior turns, it may still be moving or it could be stationary. This is what most orbital space facilities do *every* turn. It is also a useful option for cinematic starship captains who want to "play dead."

Evasive Action

You are maneuvering cunningly or violently, attempting to avoid enemy fire and to prevent enemy ships from closing. Evasive Action gives your pilot a +4 in any Quick Contest to evade ships that make Attack Runs against your vessel. It also gives your ship a favorable combat modifier against enemy fire.

Form Up

Your ship is maneuvering to establish a close formation with other vessels, or to incorporate another ship into an existing formation. See *Formations* (p. 134).

Hold Course

Your ship flies in a reasonably straight line, with only limited maneuvering. This is an option in a battle if you wish to keep your distance but not perform violent maneuvers. It is also a prerequisite for docking two ships, and for recovering small craft. With some kinds of FTL drive, it may be necessary to Hold Course for a given number of turns prior to engaging the drive. Finally, the GM may rule that a ship must Hold Course for a certain number of turns in order to do something; e.g., pass a blockade, land, or take off.

Docking: To dock (i.e., enter a spacedock or vehicle bay, or match courses and mate airlocks), both vessels must take the Hold Course maneuver and indicate that they are docking. The actual attempt comes at the end of the *second* ship's turn. Each pilot must make a Piloting skill roll. Failure means another turn is required; critical failure means a collision (see *Collision and Ramming Damage,* p. 140). It may be possible for a daredevil pilot to dock with a ship doing something other than a Hold Course maneuver, but the GM should apply a -4 or worse penalty.

Pursuit

You are attempting to follow a particular ship that is trying to flee the combat zone. Choose a target ship whose current maneuver is Break Off. You cannot pursue a ship that is faster than your own! If your ship is equal in speed or faster, your pursuit is successful if your pilot wins a Quick Contest of Piloting skills with the other ship's pilot. Add speed modifiers (p. 135); add an extra +4 if you were at short range to the target on your last turn, or +6 if you were Advantaged against it.

If you lose, your opponent will escape when he breaks off. If you win, your opponent breaks off from the main engagement, but you (and any other ships that have successfully pursued) follow him, starting a new engagement.

Ram

You attempt to ram a vessel or other target. To attempt this maneuver, you must select a specific target that you were at short range to on your previous turn. You may not attempt to ram a target that is Advantaged against you.

Your ramming attempt is *automatically successful* if your target is taking the Drift maneuver. Otherwise, your opponent must decide whether to accept the collision or to attempt to evade it. If he wishes to accept the collision, you ram each other automatically.

If your target wishes to evade, your pilot rolls a Quick Contest of Piloting skills against your target's pilot. The faster ship adds any speed modifier. You are at -4 *unless* you are presently Advantaged against this target. Your opponent gets +4 if his last maneuver was Break Off or Evasive Action. If you win the Quick Contest, your ram is successful. If you fail by 1-4, your ram just missed but is treated as a successful Attack Run (you are at short range to your opponent). If you fail by 5 or more, you did not even get near the target, and will be at long range.

If a ram succeeds, you smash into the enemy ship, doing collision damage in the missile attack phase of your *current* turn.

Selective Targeting

A gunner can choose to selectively target individual turrets or systems. When doing so, use the cSM of the turret or system rather than the cSM of the ship itself.

Turrets

Small Turrets: cSM -6 if single or double, cSM -5 if triple or quad.

Medium Turrets: cSM -4 if single or double, cSM -3 if triple.

Large Turrets: cSM -2.

Turrets have 15 cHP (small turret), 60 cHP (medium turret), or 150 cHP (large turret).

Ship Systems

Gunners may be able to aim at individual systems within a hull, provided the system is externally visible (e.g., a weapon, maneuver drive, or space dock) or shows up well on sensors (e.g., a power plant), or the gunner has knowledge of the target's internal layout. GMs may allow other systems to be targeted if they occupy 25% or more of the vessel (e.g., tanks, if a ship is mostly reaction mass tankage). Substitute the system's cSM for the vessel's. The cSM of a system depends on its size in spaces:

Spaces	cSM
0.5	-7
1-2	-6
3-6	-5
7-20	-4
21-60	-3
61-200	-2
201-600	-1
601-2,000	0
Etc.	Etc.

An attack on a system damages both the ship's hull cHP *and* the cHP of the system.

Assume that one space of system is destroyed per full [(hull cHP/hull volume) × 500] points of cDAM inflicted. Systems may degrade as they are damaged, or the GM may rule that the entire system must be knocked out to have effect, depending on the desired complexity level.

Alternatively, calculate individual component hit points using ***GURPS Vehicles*** and divide by 100 to get cHP.

If shooting at light sails, see *Light Sail Operations* (p. 127).



Asteroids!

In some scenarios, especially cinematic ones, the heroes may need to destroy asteroids. As a rule of thumb, a stony asteroid D yards across has a mass of (D cubed) tons, and has (D squared) cHP and a cDR of (D/10). Double all figures for a nickel-iron asteroid; reduce them by 50% or more for a snowball or cometary nucleus. See pp. 160-162 for more on asteroids.



Groundfire

If the battle is taking place close to a planet, moon, or asteroid, vessels in orbit may direct fire down onto it, or vice versa.

If the body has more that a trace atmosphere, beam weapons firing in either direction may have trouble penetrating the atmosphere. "Realistic" X-ray lasers, antiparticle beams, and neutral particle beams cannot fire through an atmosphere. This means that missile bays, lasers, railguns, and disintegrators are best suited for orbital bombardment.

Firing to or from space, light and medium lasers and disintegrators can only hit targets at short range. Heavy or larger weapons can engage targets at long range. Missiles and railguns can fire from long range if attacking from space to ground, but only from short range if firing from ground to space.

GMs may decide that clouds block fire on a particular target. This depends on climate and weather, but may occur occasionally on planets with standard atmospheres, often for dense atmospheres, and perpetually for very dense or superdense atmospheres. Radar can see through clouds, but passive and ladar sensors cannot, making precise identification of targets problematic without someone on the ground (requires Forward Observer skill, p. B234; the GM may assess penalties for observers unfamiliar with orbital bombardment). Clouds provide a cDR vs. laser fire of twice the planet's atmospheric pressure measured in atmospheres; e.g., cDR 2 on Earth.

Range

Range is an abstract measure of how far apart two ships (or formations) are. It may be *point-blank, short,* or *long.*

*Your vessel is at **point-blank** range to an object if:*

- It is a missile (except an X-ray laser type) that is targeted on your vessel.
- It is docking with you.
- It, or its opponent, is "hugging the enemy" (p. 136).

*Your vessel is at **short range** to an object if:*

- You just successfully performed an Attack Run against that object, or a vessel that it is in formation with. You remain at short range until your next turn.
- It just successfully performed an attack run (or barely failed a ram) against you (or a vessel you are in formation with). You remain at short range until its next turn.
- It is a missile (except one with an X-ray laser warhead) targeted on a vessel you are in formation with.
- It is a missile with an X-ray laser warhead targeted on your vessel.

*Your vessel is at **long** range to an object if:*

- None of the above apply.

Missile Attack

If the ship fired any missiles during its *previous* turn, and they were not intercepted, we now see if they hit. In the case of a nuclear missile, the firer must decide whether to try for proximity or impact detonation before rolling to hit. Any attempt to aim at specific locations must also be indicated (see *Selective Targeting,* p. 137).

Automatic Hit: If the target is drifting (crippled or incapable of maneuver), the missile always gets a critical hit.

Automatic Miss: If the target's current maneuver is Break Off or Evasive Action, it may be impossible for a slow missile to catch it! Compare the missile's performance (see *Missile Table,* p. 143) to the target's. The missile misses if the target is equally fast, or faster, in terms of sAccel. If the firing ship took an Attack Run or Hold Course maneuver on the turn it launched, adds it sAccel to that of the missile for this purpose.

Otherwise, the missile's firer (or the GM) makes an attack roll: 3d against the missile's Skill value (see *Missile Table* on p. 143), with modifiers from the *Missile Attack Table* (p. 144).

A successful roll means that the missile hit the target (or exploded nearby, if a proximity blast) – see *Damage* (p. 140). A failed roll means the missile overshot (or malfunctioned). It can be assumed to have run out of fuel or self-destructed. A critical failure may have no further effect, or it may mean that the missile accidentally locked onto a friendly vessel, if that seems remotely plausible to the GM (if so, resolve it next turn).

Rams

Ram damage is also resolved in this phase – see *Damage* (p. 140). No attack roll is necessary, as the maneuvering determined whether or not the rammer was on target.

Beam and Gun Fire

After a captain has chosen his vessel's maneuver and resolved any Quick Contests or missile attacks, some or all of his beam and gun weapons may be fired.

Resolve the vessel's fire one gunner at time, with the gunner's character using his skill to determine the results. (On ships with NPC gunners and PC officers, the GM may have the PCs make tactical decisions and let the players roll for the NPCs.)

A single gunner can control all the weapons in one turret, or fire any number of *identical* hull-mounted weapons. However, he must fire all weapons at the same target (or at the same salvo of missiles). Each Gunner program running can replace one gunner.

The target must be specified before rolling to hit, along with any selective targeting (see p. 137). Most guns and beams can fire at targets at any range (for some exceptions, see *Groundfire,* p. 138), but firing at targets that are at point-blank or short range is easier. Guns or beams installed in the hull cannot shoot at an enemy ship that is presently Advantaged over the firing vessel. And if an enemy has left the battle through Break Off or Pursuit, it cannot be fired at by vessels still in the original battle, and vice versa.

Each gunner may make one attack roll per turn. When one gunner fires multiple identical weapons, only one roll to hit and one damage roll are made, but if the attack hits, damage that penetrates cDR is multiplied by the number of weapons fired. Thus, four lasers in a quad mount do four times damage after cDR; a battery of 100 particle beams does 100 times damage after cDR. If 2+ weapons are fired like this, a miss by 1 or 2 means that *half* the weapons firing still hit; if 10+ weapons fire, a miss by 3 or 4 means *1 in 10* hit (round down). E.g., if an attack with 26 lasers misses by 3, two lasers hit and the damage (after cDR) would be multiplied by 2, not by 26.

Battery Anti-missile Fire: Battery fire can be used when firing at clouds of identical incoming missiles. Don't roll damage; if the battery hits, it kills as many missiles as there are guns in the battery (up to the number fired at).

Note on Shots: Beams and guns are usually limited in the number of shots they can fire before draining a ship's energy banks or running out of ammunition, as described in Chapter 8. Many ships are built with enough energy for dozens or even hundreds of shots – if so, there is no real need to keep track during a battle. For ships whose number of shots is significantly limited, GMs can track expenditure; assume that one well-aimed shot is being fired per weapon per turn.

Rolling to Hit

To hit, the gunner rolls 3d against his effective Gunner skill; see the *Beam and Gun Modifiers Table* (p. 143) for applicable modifiers.

Success means that the target is hit – see *Damage* (p. 140). Critical success does *double damage.* Critical failure means the weapon malfunctions, except for very reliable weapons (roll 3d again: only on a second critical failure does it malfunction).

Missile Launch

A vessel may launch one missile per missile bay on its turn, subject to ammunition limitations (you can't fire missiles from an empty bay), and provided it is not suffering complete surprise.

The type of missile and its target must be specified at launch ("We are firing six heavy X-ray laser missiles at the *Argument of Kings.*"). Decisions are made by the bay's gunners. The target may be any ship in the same engagement, but missile bays installed in the hull cannot launch missiles against an enemy ship that is presently Advantaged over the launching vessel. Different missile bays can engage different targets. If necessary, make a note of which missiles are targeted at which target.

Missiles launched *this* turn will not impact their targets until the missile attack phase of the firing ship's *next* turn. This gives the target (and perhaps other vessels in its formation) time to shoot at them. Exception: Missiles fired at targets at point-blank range impact their targets *immediately after being fired.* Use the same rules as for longer-ranged fire, but resolve the attacks immediately.

Kinetic-kill missiles launched on the first turn of battle by ships (not stations) that have achieved surprise against an opponent will do extra damage; it is assumed that ships (and missiles) have time to accelerate to higher speeds. This bonus increases if the missiles possess reactionless or grav drives, as such missiles have no fuel limitations and can accelerate for longer.

Ammunition: Unlike beam or gun weapons, missile bays typically carry only a limited number of shots, and may contain even fewer shots of a specific missile type; moreover, individual missiles cost many thousands of credits each. GMs should track missile expenditure carefully.

Other Space Combat Systems

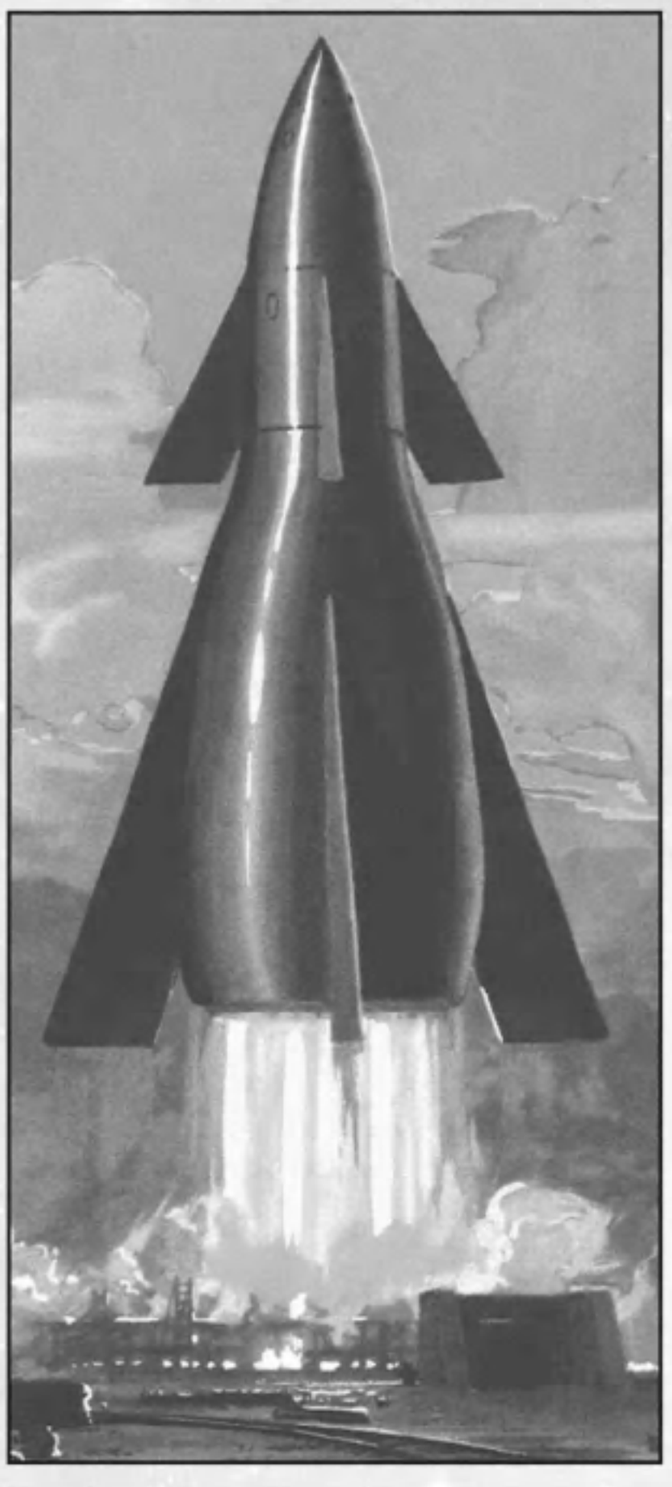
Alternative methods of resolving space combat can be found in several ***GURPS*** books:

Abstract Space Combat System (pp. CII100-106). A simpler system. To use it with ***Space,*** *Third Edition* ships, convert ship size in cubic feet to cubic yards (divide by 27) and derive DF and FP values as described on pp. CII100-101.

Space Opera Combat System (pp. CII106-111). A cinematic system relying heavily on GM fiat. Attempts to convey the heroic flavor of space-opera battles.

GURPS Vehicles, *Second Edition* (pp. VE164-165, 187) includes an outline for a complex system for resolving battles on a hex grid.

GURPS Traveller (pp. GT163-174). Another hex grid-based system, optimized for the ***Traveller*** setting. GMs who wish to use ***Traveller*** ships with this system should derive appropriate cSM, ASig, and PSig values using the rules in Chapter 8, and convert ***Traveller*** weaponry to cDAM and sAcc values using the guidelines in these sidebars. Change the time scale from 10 seconds to one minute and double the damage of ramming and kinetic-kill weapons (with a longer time scale, there is more time to build up higher speeds).



GURPS Weapon Statistics

Here are ordinary ***GURPS*** statistics for the guns and beam weapons used in ***Space.***

SS: 30.

Damage: Multiply cDAM by 100 to get ordinary damage. If using the table on p. VE125 to calculate damage for extremely powerful beam weapons (output over 1,000,000 kJ), substitute [10 × (cube root of O)] for (square root of O).

1/2D Range and **Acc:** 1/2D range in yards (*Max* range for disintegrators) in atmosphere is given below. Acc follows in parentheses.

Railguns: Lt.: 12,000 (19). Md.: 36,000 (19). Hv.: 120,000 (19).

Lasers (UV): Lt.: 110,000 (29). Md.: 340,000 (32). Hv.: 1,100,000 (35). EHv.: 3,400,000 (38). SHv.: 11,000,000 (41). UHv.: 33,000,000 (44).

Particle Beams: Lt.: 46,000 (27). Md.: 140,000 (29). Hv.: 460,000 (33). EHv.: 1,400,000 (35). SHv.: 4,600,000 (39). UHv.: 14,000,000 (41).

X-ray Lasers: Lt.: 230,000 (31). Md.: 730,000 (34). Hv.: 2,300,000 (37). EHv.: 7,300,000 (40). SHv.: 23,000,000 (43). UHv.: 73,000,000 (46).

Antiparticle Beams: Lt.: 90,000 (28). Md.: 280,000 (31). Hv.: 900,000 (34). EHv.: 2,800,000 (37). SHv.: 9,000,000 (40). UHv.: 28,000,000 (43).

Disintegrators: Lt.: 250,000 (31). Md.: 790,000 (34). Hv.: 2,500,000 (37). EHv.: 7,900,000 (40). SHv.: 25,000,000 (43). UHv.: 79,000,000 (46).

Max Range: For beam weapons other than disintegrators, this is three times ½D range. For railguns, it is twice ½D range.

Deriving sAcc

sAcc is a number that combines the weapon's Accuracy bonus, a range modifier, and modifiers for aiming and computer programs into one, easy-to-use value. GMs who wish to convert other ***GURPS Vehicles***-built weapons to this system can determine sAcc as follows:

sAcc = (Acc/2) - 17.

Acc/2 is half the weapon's Accuracy (using the *Reduced Hit Probability* rule, pp. VE182-183).

The -17 derives from the sum of these modifiers:

+3 for aiming for 3 seconds.

+5 for a Targeting program with Complexity 4.

+10 to account for the difference between cSM and Size Modifier.

-35, the Speed/Range modifier for 1,000 miles.

Damage

If a beam, gun, or missile attack succeeds, then the target has been hit and the firer should make a damage roll. (Exception: no damage roll is made when shooting at missiles. *Any* hit from a standard weapon will destroy a missile.) Damage dice are determined by the weapon's cDAM; see the *Beam and Gun Weapons Table* (p. 142) or *Missile Table* (p. 143), as appropriate. Note that some weapons suffer from reduced damage at long range.

Subtract the target's combined armor and force screen cDR (modified by the weapon's armor divisor, if any). If damage penetrates armor and screens, the excess hits are taken as damage. Apply damage against the target's hit points – normally the hull's hit points, unless the attack was specifically aimed at a turret.

Force screens may be overloaded by damage. If damage fails to penetrate a force screen but exceeds half the screen's cDR, the screen gains one energy level. If damage penetrates, the screen gains two energy levels. After a screen has gained eight energy levels, it collapses and cannot be raised again during the battle. (Screens may work differently in some settings.)

Force screens may be turned off in order to shed energy levels; this must be done on the ship's own turn. If so, every turn the screen is deactivated removes one energy level. GMs may allow engineers to make a heroic effort (see p. 49) to shed more energy: a successful Electronics Operation (Force Shields) roll will shed twice as much energy, but any failure will disable the screen.

Collision and Ramming Damage: If a ship collides with its target accidentally (due to a critical failure during a docking attempt or Attack Run), it inflicts cDAM equal to 1d(5) times *smaller* ship's cHP. If the collision is due to a deliberate attempt to a ram, multiply this damage by the amount by which the ramming ship won the Quick Contest of Skills (maximum 10). If both ships agreed to ram, or if the ram succeeded due to a critical success, multiply damage by 10. Note that *both* ships take ramming damage!

Damage Effects

All damage effects described below occur immediately after the damage occurs.

Major Damage: Each time cumulative damage to a ship's hull reaches a full multiple of 10% of its original cHP, roll 3d on the *Major Damage Table* (p. 144) and apply the result. This results in specific damage effects, like disabled drives.

A hull or turret reduced to 0 or fewer cHP is *disabled.* One reduced to -5 × its original cHP is *destroyed.* This has additional effects, as follows:

Hull Disabled: The spacecraft is crippled, out of power, and leaking air. A crippled vessel cannot take any maneuver but Drift, and can use neither FTL drives nor shipboard systems like sensors, computers, communicators, or weapons. However, piloted spacecraft (such as lifeboats or fighters) can still be launched.

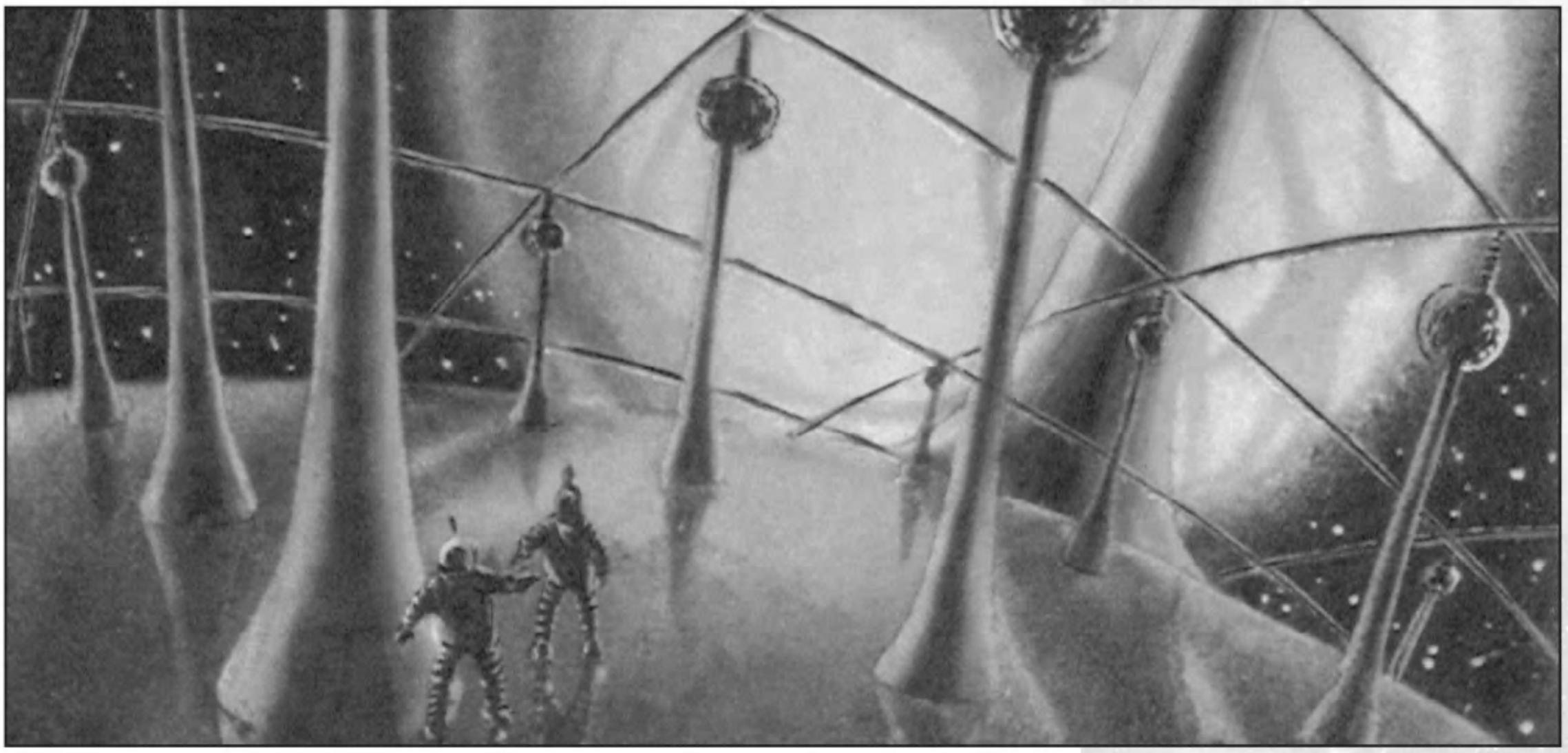
Hull Destroyed: The spacecraft loses structural integrity. At the GM's discretion, it may break up or even explode, and the crew may be killed or be trapped in wreckage.

Turret Disabled: Weapons and other systems built into that turret no longer function.

Turret Destroyed: As above, but the systems cannot be repaired – they must be replaced at full cost. Any crew in the turret take 5d damage (personal DR does not protect against this).

Ending the Battle

In an abstract system, ending an engagement must be at the discretion of the GM. Assuming neither side agrees to stop fighting, the battle ends when one side is crippled or when its ships have broken off. GMs should be sympathetic to clever PC ploys to escape a hopeless battle! The GM may also rule that after breaking off, a new battle will begin a few minutes, hours, or days later, after the forces have had time to regroup, repair, and make new plans. This might also be the case if, for instance, the forces met at high speed and passed through each other while firing!



TABLES

Initiative Table

Each side's captain (or squadron leader, if several ships) rolls 1d and adds:

+1 if he has a higher Tactics skill than the opposing commander, or +2 if skill is five or more higher. (Substitute Strategy skill if commanding 10 or more vessels.)

+1 if he has a higher IQ than his opponent.

+1 if his side has a ship whose sensors have a Scan bonus *higher* than any Scan bonus possessed by the enemy, or +2 if that bonus is five or more higher.*

+1 if his side has a sensor operator on duty who has a higher Electronics Operation (Sensors) skill than any sensor op on duty on the other side, or +2 if skill is five or more higher.

+1 if all vessels on his side have lower ASigs than the lowest ASig possessed by any of the enemy vessels.

+1 if all vessels on his side have lower PSigs than the lowest PSig possessed by any of the enemy vessels.

+1 if his side's slowest vessel is still faster than the enemy's slowest vessel, or +2 if it is also faster than the enemy's *fastest* vessel. For most ships, "fastest" means highest sAccel.

+1 or +2 if fighting in a busy region of space that is more familiar to his side than it is to the enemy. This includes dense asteroid belts, the space around a gas giant, the space junk- and satellite-filled orbits around a high-tech planet, etc.

+2 if the other side is broadcasting its position on open traffic-control frequencies. Civilian ships may be required by law to do this, which gives raiders a big advantage . . .

+1 to +3 if he possesses accurate intelligence on the enemy's intentions or predicted course and uses it to set an ambush (for example, laying in wait concealed behind asteroids), or if the GM decides that his side has a particularly clever plan.

* When comparing Scan bonuses for initiative, the PESA (passive) Scan number is normally used. Either side may indicate that it has turned on AESA (active sensors) *before* the engagement, however. If so, use the higher AESA Scan rating. Active sensors make it harder to be surprised, but they also make it nearly impossible to achieve surprise: If the side using AESA would have gained partial surprise, it is instead treated as a tied result; complete surprise is reduced to partial surprise.

Missile Performance

sAccel is based on the missile's sustained thrust. In order to produce the listed performance figures, reaction-drive missiles were assumed to need 30+ seconds' thrust; reactionless- and grav-drive missiles were assumed to require 20+ minutes' thrust (hence their ability to build up high speeds in the opening portion of the battle, if one side has the advantage of surprise). If converting ***GURPS Space,*** *Third Edition* missiles to the ***Traveller*** hex-grid system, only reactionless- or grav-drive missiles have the endurance to maneuver on the scale of that system. Light missiles have three turns' endurance, heavy missiles have four turns' endurance.

cSM is the missile's Size Modifier-10.

Skill was determined using the appropriate missile guidance system from ***GURPS Vehicles,*** with a -10 modifier (the difference between cSM and Size Modifier). Some missile designs may be operator-guided (for example, the missiles in ***GURPS Traveller***); in that case, Skill is 0 and the attack roll is against the gunner's Gunner (Guided Missile) skill.

Kinetic missile damage is an abstraction, since relative velocities will vary constantly through an engagement. It is based on the speed the missile could achieve in 10 seconds and assumes an armor-piercing depleted-uranium warhead.

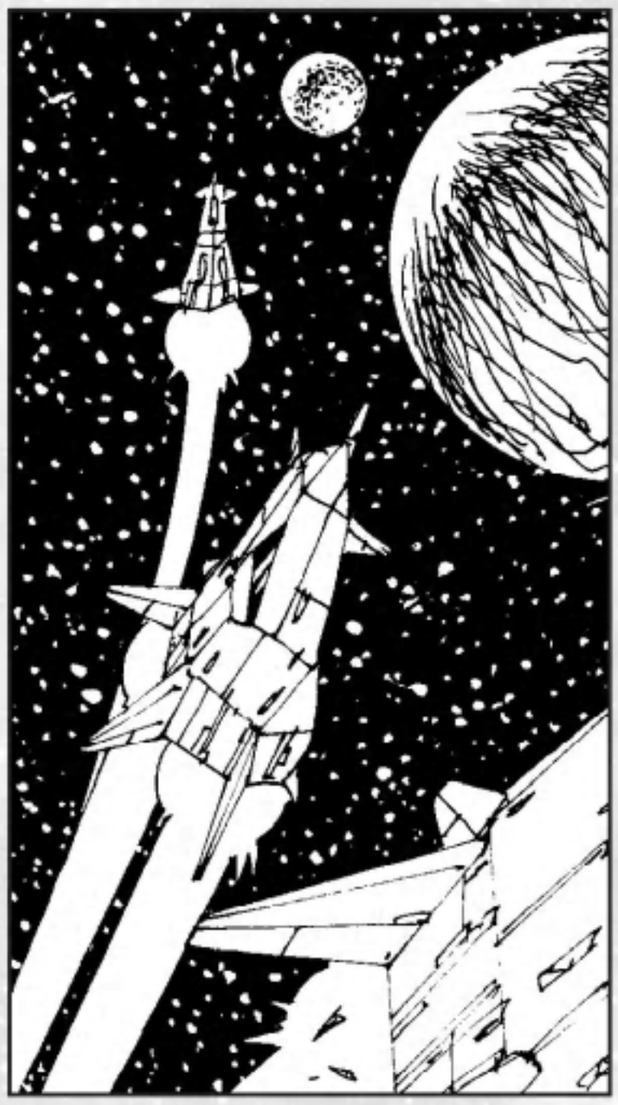
X-ray laser missile damage assumes a sub-kiloton yield nuclear bomb used to pump a 1 gigajoule energy beam.

Missiles were generally designed with DR 50 (cDR 0).

Covert Operations

Spies, smugglers, and special operators may wish to land covertly on an inhabited planet. A ship coming in for a landing will be at least as visible and audible as a large meteor due to the flare of reentry and the sonic booms as it decelerates from orbital speed. Of course, a vessel that possesses contragravity may be more stealthy!

If the planet is TL5-, the best solution is to come down in a secluded area (such as over the ocean or wilderness) a few hundred miles from any known habitation. With luck, no one will be there to see the ship. Making a landing during bad weather can further reduce this chance.



On TL6+ planets, the situation is made more difficult by the all-weather active and passive ground- and space-based sensor arrays routinely used for traffic control and planetary defense. Eluding them requires a combination of careful navigation (to avoid areas of extensive sensor coverage), good planning, and sensor-masking technology. Even so, the sensor arrays of major ultra-tech worlds may be all but impenetrable – at TL8+, a smuggler may only have a chance on frontier worlds.

Continued on next page . . .

Beam and Gun Weapons Table

Weapon	TL	Malf	sAcc	cDAM*
Railguns				
Light	8	ver.	-8	4d+1(3)†
Medium	8	ver.	-8	6d+2(3)†
Heavy	8	ver.	-8	9d×3(3)†
Lasers				
Light	8	ver.	-3	1d
Medium	8	ver.	-1	4d-1
Heavy	8	ver.	0	4d×2
Extra Heavy	8	ver.	+2	6d×3
Super Heavy	8	ver.	+3	8d×5
Ultra Heavy	8	ver.	+5	6d×15
Particle Beams				
Light	8	crit.	-4	6d
Medium	8	crit.	-3	6d×3
Heavy	8	crit.	-1	6d×6
Extra Heavy	8	crit.	0	6d×15
Super Heavy	8	crit.	+2	6d×30
Ultra Heavy	8	crit.	+3	6d×80
Tight-beam Particle Beams				
Light	8	crit.	-4	2d(4)
Medium	8	crit.	-3	6d(4)
Heavy	8	crit.	-1	6d×2(4)
Extra Heavy	8	crit.	0	6d×5(4)
Super Heavy	8	crit.	+2	6d×10(4)
Ultra Heavy	8	crit.	+3	8d×20(4)
X-ray Lasers				
Light	10	ver.	-2	2d(2)
Medium	10	ver.	0	6d-1(2)
Heavy	10	ver.	+1	6d×2(2)
Extra Heavy	10	ver.	+3	5d×5(2)
Super Heavy	10	ver.	+4	6d×9(2)
Ultra Heavy	10	ver.	+6	6d×20(2)
Antiparticle Beams (APAWs)				
Light	12	ver.	-3	3d×5(2)
Medium	12	ver.	-2	7d×5(2)
Heavy	12	ver.	0	5d×15(2)
Extra Heavy	12	ver.	+1	8d×20(2)
Super Heavy	12	ver.	+3	6d×60(2)
Ultra Heavy	12	ver.	+4	8d×100(2)
Disintegrators				
Light	15	crit.	-2	2d+1(100)
Medium	15	crit.	0	6d-1(100)
Heavy	15	crit.	+1	6d×2(100)
Extra Heavy	15	crit.	+3	5d×5(100)
Super Heavy	15	crit.	+4	6d×9(100)
Ultra Heavy	15	crit.	+6	6d×20(100)

TL: The tech level at which the weapon is introduced.

Malf: The likelihood of a malfunction on a critical failure. "Crit." means a malfunction occurs on any critical failure; "ver." means that it must be verified by a second roll, and only on another critical failure does it occur. Particle-beam Malf. goes from crit. to ver. at TL10+. If a malfunction occurs, an Armoury roll is needed to fix it (one crewman may attempt this each turn).

sAcc: The space-combat Accuracy value.

cDAM: Damage dice. A parenthetical number after damage is an armor divisor; e.g., 2d(2) means cDR is divided by two against that attack. Multiply cDAM by 100 to convert it to ordinary damage.

* If a weapon is designed at a TL higher than the one at which it was introduced, add +1 per die per TL for the first three TLs after it appears. E.g., a TL9 light particle beam would inflict 6d+6, while a TL11+ heavy railgun would dish out (9d+27)×3(3)!

† TL11+ railguns fire *hyperdense* ammunition. Change armor divisor from (3) to (5).

Beam and Gun Modifiers Table

Roll 3d against Gunner skill, with these modifiers:

Weapon: sAcc modifier (see *Beam and Gun Weapons Table,* above).

Target Size: Add the target's cSM. For objects for which cSM has not been calculated, cSM equals Size Modifier-10.

Range: +4 if target is at short range, or +10 if target is at point-blank range.

Target took Evasive Action maneuver: -2.

Target took Drift maneuver: +4 (+8 if firing railgun).

Firer Partially Surprised: -4 (-2 if gunner has Combat Reflexes).

Firer Completely Surprised: May only fire at missiles targeted on his ship, and does so at -6 (-3 if Combat Reflexes).

Targeting Program: A +5 Targeting program is built into a dedicated computer incorporated into each weapon system. If a better Targeting program is being run on the ship's computer, add its (bonus-5).

Missile Table

Missile	sAccel	cSM	Skill	Kinetic	Nuclear	X-ray
Reaction Drive						
Lt./8	6	-10	14	7d(3)	spcl.	–
Hv./8	9	-9	17	6d×3(3)	spcl.	–
Lt./9	9	-10	15	8d(3)	spcl.	–
Hv./9	12	-9	18/11	7d×3(3)	spcl.	5d×2(2)
Lt./10	12	-10	16	5d×2(3)	spcl.	–
Hv./10	20	-9	18/12	6d×9(3)	spcl.	(5d+5)×2(2)
Lt./11	14	-10	17	6d×2(5)	spcl.	–
Hv./11	25	-9	19/13	7d×8(5)	spcl.	(5d+10)×2(2)
Reactionless Drive						
Lt./9	0.5	-10	15	2d(3)	spcl.	–
Hv./9	0.5	-9	18/11	5d(3)	spcl.	5d×2(2)
Lt./10	2	-10	16	4d(3)	spcl.	–
Hv./10	2	-9	18/12	4d×4(3)	spcl.	(5d+5)×2(2)
Lt./11	17	-10	17	6d×2(5)	spcl.	–
Hv./11	25	-9	19/13	5d×10(5)	spcl.	(5d+10)×2(2)
Grav Drive						
Lt./12	350	-10	17	6d×10(5)	spcl.	–
Hv./12	500	-9	19/13	6d×40(5)	spcl.	(5d+10)×2(2)
Lt./13	700	-10	17	4d×20(5)	spcl.	–
Hv./13	1,000	-9	19/13	6d×60(5)	spcl.	(5d+10)×2(2)

sAccel: Missile's acceleration in Gs. Used to determine whether a missile can catch a target that is taking evasive action or breaking off.

cSM: Space-combat Size Modifier. Used when the missile is being shot at.

Skill: Abstract measure of missile's guidance system quality. Roll against this number to determine if the missile hits its target. Number after / applies if using an X-ray laser warhead.

Kinetic: cDAM with a kinetic-kill warhead. Damage is *halved* if fired at a target at point-blank range, *doubled* if fired at long range. If fired by a ship (not a station or other immobile vessel) with the advantage of surprise, damage is increased: if partial surprise, ×2 for reaction-drive missiles and ×5 for reactionless- or grav-drive missiles; if complete surprise, ×3 for reaction-drive missiles and ×10 for reactionless- or grav-drive missiles.

Covert Operations (Continued)

Full details of planetary defenses are beyond the scope of this book, but for a quick and dirty rule for penetrating them, use the following:

1. If there are vessels in space near the world, the intruder must first achieve *complete surprise* against them, per p. 134. If it does this, it can slip past. If it fails, those vessels can intercept the intruder and can alert the planet's defenses, if any. If this happens, the intruder must either give up and try to break off, or abandon stealth and fight its way through. (If the planet's navy is alerted and has established patrols through the system, the GM may require two rolls to penetrate!)

2. If the intruder successfully eludes the planet's space patrol, it can attempt to evade orbital and ground sensors or watchers. For *each ship* trying to land undetected, roll against the captain's Tactics skill, with the modifiers below. Critical success means the ship can come down wherever it pleases without detection, and can fly about at will (the GM may require a further roll each hour). Success means the ship successfully avoids detection while in the upper atmosphere, but will be detected unless it chooses to land somewhere far from any habitation. Failure by 1 or 2 is treated as a success, except that the ship's trajectory was briefly tracked (visually or on sensors) and someone has a rough idea of where it is to within a few hundred miles. Failure by 3+ means the ship was detected while still in the air or in orbit. Depending on the planet's defenses and attitude, the ship may be ignored, or traffic control or a naval base may verbally challenge it, launch ships or aircraft to intercept it, or open fire with planetary or orbital weapons.

Modifiers to the captain's Tactics roll:

Alertness: +4 if the authorities are not very alert (typical of a sleepy frontier planet or complacent inner world); +2 if the planet is somewhat alert (usually the case if there is a navy or Patrol base present); no modifier if the planet is on high alert to the danger of intruders (e.g., a navy or Patrol base on a war footing or making a special effort to deal with smugglers or spies).

Piloting Skill: +1 if the ship's pilot has skill 15+, or +2 if he has skill 20+.



Continued on next page . . .

Covert Operations (Continued)

Ship's ASig or PSig: Use the *higher* of the two values. If this is negative, add it to the captain's skill. If positive, subtract it from skill. E.g., a ship with ASig -6 would give +6 to Tactics; one with ASig +2 would give -2.

Starport Type: Subtract the starport class (p. 171) from skill.

Sensor TL: Subtract 2 × (TL-6) of the starport or planetary-defense sensors. If planet is TL5-, *add* +2.

Population: Add the (10 - Population Rating) (p. 166). E.g., a world with PR 7 would give a +3 bonus.

Contragravity: Ships with contragravity get +4 unless sensors can detect CG emanations (likely at TL11+).

Knowledge: If the captain has details of the planet's sensor systems and any weaknesses, blind spots, or pass codes, or even holidays when the defenders may be less alert, etc., the GM may assign a +1 to +5 bonus. Having bridge crew aboard who have previously made a run through this planet's defenses without being detected should give +2 or +3. But if planetary defenses have been warned to expect intruders at a particular time or place, the GM can apply a -1 to -5 penalty!

Good Planning: The basic Tactics roll simulates good planning, knowledge of sensors, and the use of night, weather, and terrain to mask approaches. The GM can give bonuses for good ideas (or penalties for bad ones). For example, a smuggling run might be timed to coincide with a heavy meteor shower. The ship glides in, its entry path mimicking a meteor's trajectory, using engines to level out only at the last moment, when it is below the clouds and hopefully masked by terrain from any ground-based sensor systems. This might give a +5 or better bonus . . . if meteor showers are common in that system at that time of year, and if the locals have no reason to suspect such a trick. This is most effective if the ship is relatively small (PSig and ASig total 0 or less). A "large meteor" might well be blasted out of space without any warning at all by planetary defense systems designed to protect against asteroids!

3. Taking Off. For ships attempting to take off without being detected, the GM can reverse the above procedure. Obviously, some tricks will not work (e.g., pretending to be a meteor).

Nuclear: cDAM with a nuclear warhead is 6d×200,000 with a light missile or 6d×20,000,000 with a heavy missile. If nuclear attack is a proximity explosion, divide damage by 10,000. cDR protects at a higher value than normal against explosions (impact or proximity): square it and multiply by 100 to get effective cDR (e.g., cDR 5 would protect as cDR 2,500 vs. explosions).

X-ray: cDAM with an X-ray laser warhead.

Missile Attack Table

Roll 3d vs. the missile's Skill, with these modifiers:

Target's Sensor Signature: Add the *higher* of target's ASig and PSig.

Relative Speed: -4 if the missile is no faster than the target, or slower; -2 if the missile is faster than the target, but less than twice as fast.

Target took Evasive Action maneuver: -2.

Proximity Blast (nuclear missiles only): +6.

Major Damage Table

3 – Energy bank damaged: lose 50% of stored energy. If target has no energy bank, treat as #12.

4 – Force screen damaged: halve its DR. If target has no force screen, treat as #13.

5 – FTL drive knocked out (if warp drive, halve its speed instead).* If target has no FTL drive, treat as #14.

6 – Cargo damage: 25% of cargo is lost.

7 – Roll 1d: on 1-3, one sensor is knocked out; on 4-6, one computer is knocked out.

8 – One accessory or gravity system (e.g., automeds, lab, freeze tubes, tractor beam, teleport projector, artificial/spin gravity, or contragravity) is knocked out. Roll randomly, or GM assigns.*

9 – Power loss: -50% power output from highest-output plant.

10 – Weapon damaged: largest turret or other weapon disabled (GM's option).* If target has no weapons, treat as #6.

11 – No special effect.

12 – Tankage shattered: 25% of fuel or reaction mass lost. If target has no tanks, treat as #14.

13 – 1d passengers injured: 5d damage each, ignore DR.*

14 – Maneuver drive damaged: halve sAccel.* If target has no maneuver drive, treat as #9.

15 – Spacedock or vehicle bay damaged: door cannot be opened/shut.* If target has no docks or bays, treat as #6.

16 – Bridge or cockpit knocked out. Ship is crippled unless it has an extra bridge.*

17 – Life support damaged: loses 10% of original capacity.*

18 – Power plant knocked out: lose highest-output plant.* If power plant is antimatter, roll 3d: on a 16 or less, the ship blows up and everything nearby takes damage as per a proximity nuclear blast from a light missile.

* One-third of the crew in that area (engineers if drive or power plant, gunners if turret, medics if surgery, stewards if passenger compartment, etc.) are badly injured and out of action, minimum one character. If PCs or major NPCs are present, roll 1d: on a 5-6, 5d damage is suffered (ignore DR).

Any time the damage result could describe more than one system (e.g., "drive" when the ship has two different drives), roll randomly to see which one is affected. With some FTL drives, it will be impossible to enter FTL until the drive is fully operational. With other drives, the ship is simply slowed.

Loss of power may force systems to shut down – see Chapter 8 for system power requirements. Loss of computers prevents the use of software (p. 66). Loss of *all* sensors means that no weapons except missiles can be used.

If crew or passenger injuries result from a particle beam, antiparticle beam, or nuclear missile, 10 rads × damage rolled may also be suffered (GM's option).

5 BASIC MECHA DESIGN







This chapter provides a step-by-step system for creating mecha. More options appear in Chapter 6, but it's best to become familiar with these rules first.

Mecha design requires some simple calculations, so you'll need a calculator with a square root key and some scratch paper.

PART I, "STEP 0" – CONCEPT

What is the mecha built to *do?* What's its role in the campaign? What's its TL (normally 8-12)? Here are several possibilities:

Military Mecha

Scout Mecha: Designed to find the enemy and return safely, it needs a high speed (often 60-120 mph), good sensors, an advanced comsuite and superior ECM and stealth. Weaponry should be sufficient to deal with enemy scouts or battlesuits, plus missiles in case a bigger foe is met. Armor rarely exceeds 25% of total weight. To make it hard to spot and cheap to lose, it should be small and light. Typical weight: 3,000-30,000 lbs.

Light Battle Mecha: The walking equivalent of a light tank, similar to a main battle mecha (below), but smaller. Its main advantage is that is easier to ship by aircraft or spaceship, which makes it useful for rapid-deployment forces like marines or space mercenaries. It is also cheap, and therefore attractive for organizations or governments on a budget, or those that value numbers above quality. Typical weight: 10,000-60,000 lbs.

Artillery Mecha: Built for indirect fire support rather than mecha vs. mecha duels, a typical artillery mecha has heavy missile launchers, mortars or big autocannon, but only minimal armor and low speed. Typical weight: 40,000-120,000 lbs.

Main Battle Mecha: A walking tank, built to fight enemy armored vehicles. It should have a speed of 40-60 mph and a main weapon powerful enough to punch through its expected opposition's armor. Secondary weapons to shoot at missiles and infantry are also important. From half to two-thirds of its total weight should be armor! Typical weight: 60,000-200,000 lbs.

Super Battle Mecha: A towering engine of destruction, standing many stories tall, this is an ultimate weapon that can single-handedly conquer or save the world! Super battle mecha are normally experimental designs or artifacts one or more TLs above the norm, and are so powerful that only another super mecha can defeat them. They are built like main battle mecha, but feature advanced options like force fields, exotic weapons, overload boosters or teleportation. Two cockpits are common, since a single pilot might be overwhelmed by the multitude of weapons and other systems. Typical weight: 200,000-20,000,000 lbs.

Space Combat Mecha: These are thruster-equipped mecha optimized for space battles. Putting legs on a space fighter is justified if huge space installations housing terrestrial environments exist, like L-5 colonies, hollow asteroids or domed cities. The mecha fights its way past defending spaceships, then battles "on foot" once inside. Space combat designs use rockets with extra thruster fuel (or rely on reactionless thrusters that don't *need* fuel). Laser and particle beam weapons are often preferred, thanks to their superior range in vacuum.

Command Mecha: A combat leader is sometimes issued an upgraded version of the mecha his subordinates use. In a realistic setting, a command mecha has superior communications and navigation gear, and sometimes a bit more speed or ECM. In a cinematic campaign, it's often bigger and better armed as well.

Police Mecha

Built to deal with criminals who use mecha, robots or super powers. Often, they have weapons that can fire non-lethal ammo; e.g., grenade launchers with tear gas. Missiles are rarely carried. To avoid straining civilian budgets, the price should be kept down, which means avoiding expensive options and minimizing ECM, stealth, et cetera. Armor shouldn't exceed DR 100. Typical weight: 2,000-20,000 lbs.



Civilian Mecha

Gladiator Mecha: In the coliseums of the future, armored machines duel for the prize! A gladiator mecha can be a custom design, but is often a surplus military or police machine. Any size is possible, but since it fights in a close-range arena duel, long-range weapons or sensors and expensive ECM systems should be avoided or stripped out. If the rules ban ranged weaponry, don't stint on adding giant swords and the like!

Labor Mecha: These are multi-purpose construction machines, strong but slow, with the simplest sensors and electronics. In some backgrounds, combat mecha will have evolved from them; in others, the reverse is true. Armor depends on the environment they are built for, but rarely exceeds DR 30. Armed and better-armored "combat engineering" mecha can also exist. Typical weight: 2,000-120,000 lbs.

Utility or Sports Mecha: A jeep or truck with legs! Most have four or more legs and no arms, and are designed to carry people and cargo over very rough terrain. They have few sensors and weapons, but add extra seats and cargo space. Armor is normally under DR 20. Suggested weight: 2,000 lbs. or more.

Other Possibilities

Don't let these examples limit what you build! How about "safari mecha" that resemble mechanical beasts, to be used by game wardens, hunters and poachers? Some additional concepts that recur in mecha design also deserve mention:

Species Compatibility: A mecha with the same number and type of limbs as its pilot (two arms and two legs for humans) is "species-compatible." A species-compatible mecha has superior performance, since it can be piloted almost instinctively.

Flight-Capable and Jump-Capable Mecha: Many mecha are strictly earthbound vehicles, but an equal number supplement their legs with thrusters, such as jets or rockets. A flight-capable mecha is one that has enough thrust to fly in earth-like gravity, or which possesses wings. At TL8-10, this is difficult to achieve without sacrificing other components (usually armor) to save weight. As a result, many mecha compromise by being only *jump-capable.* Their thrusters are not powerful enough for free flight in earth-like gravity, but they can boost the length of a normal jump. A jump-capable mecha can often fly in space, although it can't reach orbit on its own.

Battlesuits and various exotic concepts such as *Transformable Mecha* are detailed in the next chapter.

EXAMPLE: *Let's create a sample mecha. We decide it's a TL9 light battle mecha, and it's going to be flight-capable and species-compatible. We call it Seraph Delta.*

Design Tip: Target Weight

A mecha's actual weight will be determined at the end of the design process, and is the sum of the weight of all components, structures and surface features. This means that some performance figures, like speed, won't be known until the end of the design sequence.

To get an idea of how effective a mecha is *while building it,* pick a *target weight* to work toward. This makes it easy to estimate how fast the mecha will be on the ground, how much thrust it will need to fly and what kind of systems should go into it.

A target weight should be in pounds (an even number, like 20,000 lbs., is good) – use the typical weights for the various mecha concepts as guidelines. Divide target weight by 2,000 for a target mass in tons, which is needed for some decisions.

When using a target weight, keep a tally of the growing weight of the mecha as components and other systems are added to it. This allows you to ensure that the actual weight will be at least fairly close to the target weight.

Target weight *is* strictly optional. It's okay to design the mecha with no idea what the final weight will be, or to deviate from your target weight during the design process.

EXAMPLE: *Seraph Delta's target weight is 50,000 lbs. (25 tons).*

PART II – BODY AND SUBASSEMBLIES

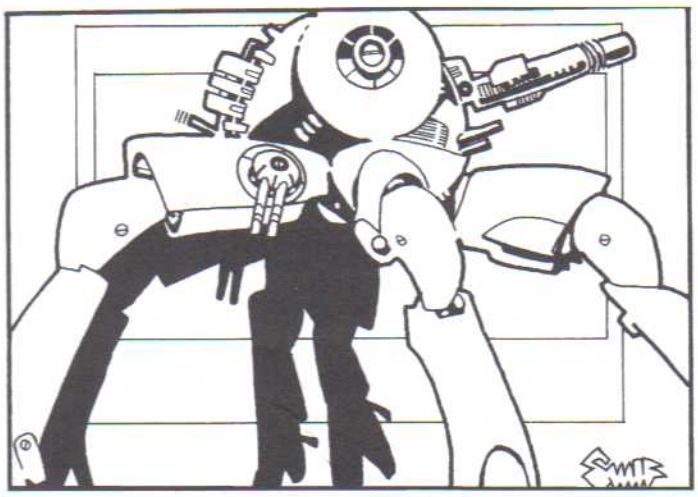
A mecha has a main *body* (the torso on a humanoid machine), with attached *subassemblies,* such as arms or legs.

Step 1 – Choose Subassemblies

Select the subassemblies that are attached to the mecha.

Legs: Decide how many legs the mecha has – at least two. Each is a separate subassembly. Three or four legs mean less maneuverability but more speed and stability. Further legs don't increase speed, but do make the mecha harder to cripple. A human-designed mecha that is species-compatible has two legs.

Arms: Decide how many arms the mecha has. Any number is possible, including none, but two are needed for a human species-compatible machine. An arm may be either a *manipulator arm* (one with a hand) or a cheaper, lighter *striker arm* (with no hand). Arms are assumed to be attached to the sides of the body, just like human arms. Other locations are possible; e.g., a tail would be an arm attached to the back of the body – it could reach into rear or side hexes, but not front hexes.



Turret: Decide whether the mecha has *no turret,* a *limited turret* (same degree of rotation as a human head), or a *full turret* (that can rotate 360°). A turret is assumed to be atop the mecha's body; on a humanoid mecha, it's a head. Multi-turret designs are possible, but are beyond the scope of this book; see ***GURPS Vehicles*** instead.

Pods: Decide whether the mecha has fixed (non-detachable) pods and if so, how many and where they are attached. A mecha can normally attach up to two pods to the back or top of the body. Pods can also go on wings, provided each wing has the same number of pods. They are generally used to house components (normally thrusters, fuel or launchers) outside the torso in order to make the mecha's body smaller or remove the risk of volatile fuel or explosive ammunition detonating inside it!

Wings and Wheels: A few mecha designs use these. See *Transformable Mecha* (p. 100-103), in the next chapter.

EXAMPLE: *We choose two legs, two manipulator arms and a limited turret.*

Step 2 – Streamlined Mecha

A mecha that will be flight-capable can benefit from streamlining, giving it a sleek body shape. Streamlining increases cost and overall volume, but improves flight speed.

Decide if a mecha will be streamlined, and if so whether it has "fair," "good," "superior" or "radical" streamlining. The better the streamlining, the greater the expense but the faster the mecha will fly. A vehicle with legs, arms, or turrets can't have superior or radical streamlining unless it is going to be transformable.

PART III – COMPONENTS

A component is an individual system – such as a cockpit, weapon or power plant – which is placed inside the body or a subassembly. The next several steps in the design sequence cover various components. As each component is selected for the mecha, record its basic description and statistics, which may be fixed or determined by a formula. The statistics are:

TL: The TL of the component. *Note:* The TLs given match the ***GURPS Space*** TL scheme. GMs should feel free to adjust the TLs of *specific* mecha components to suit the campaign setting!

Weight ("Wt."): Measured in pounds (lbs.).

Cost: In dollars ($).

Volume ("Vol.") and *Location:* Each component has its own volume in cubic feet (cf) and must be noted as occupying the body or a specific subassembly. Some components *must* go in certain locations (e.g., arm motors in arms).

Power Requirement ("Pow."): In kilowatts (kW). "Neg." means "negligible" – it requires too little power to worry about, as long as the mecha has some sort of power supply.

EXAMPLE: *"TL8 heavy laser cannon (6,000 lbs., 30 cf in body, $1,200,000, 300,000 kW)." This means a component called a "heavy laser cannon," built at TL8, weighing 6,000 lbs., occupying 30 cf in the body location, costing $1,200,000 and using 300,000 kW of power.*

Step 3 – Leg Drivetrain

A mecha with legs requires a leg drivetrain: the electric motors or mechanical transmission needed to move its legs.

Select the leg drivetrain's *motive power,* which is rated in kilowatts. Any motive power can be chosen, but the greater it is in relation to the mecha's final weight, the faster the mecha can run. Some typical ranges of motive powers:

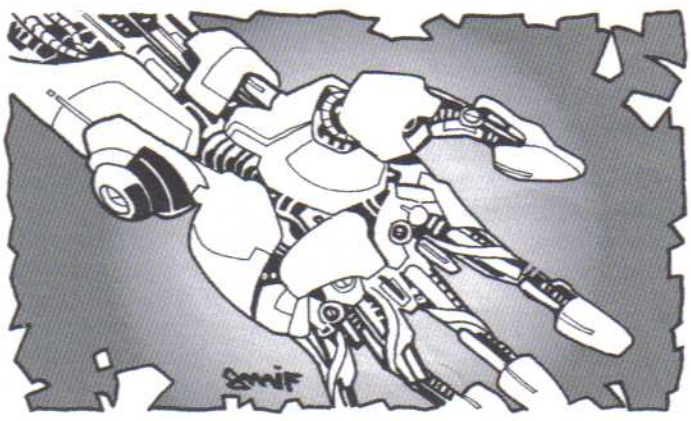
Scout or light battle mecha . . . . . .100-500 kW
Main battle mecha . . . . . .500-2,500 kW
Super mecha . . . . . .2,500-25,000 kW

If you are using a target weight and have an exact speed in mind, you can use this formula to find the motive power required:

2 legs: Power (kW) = {[speed (in mph)/8] squared} × loaded mass (tons).

3 legs: Power (kW) = {[speed (in mph)/10] squared} × loaded mass (tons).

4+ legs: Power (kW) = {[speed (in mph)/12] squared} × loaded mass (tons).



EXAMPLE: *A speed of 56 mph sounds good: with 2 legs and 25 tons, this requires (56/8) squared × 25 = 1,225 kW.*

Now determine the drivetrain's statistics using the table below:

Leg Drivetrain Weight Table

TL	*Weight in lbs. if motive power is:*	
	under 5 kW	*5 kW or more*
8	60×kW	(6×kW) + 270
9	40×kW	(4×kW) + 180
10	30×kW	(3×kW) + 135
11	20×kW	(2×kW) + 90
12+	15×kW	(1×kW) + 70

Weight: Calculate the weight of the power plant as shown on the table, based on kW of motive power. There are two columns, one for motive powers under 5 kW, the other for higher powers.

Volume and Location: A drivetrain has one leg motor located in each leg. The volume of each leg motor in cubic feet is drivetrain weight divided by 100 if two legs, by 150 if three legs, or by 200 if four legs. If more than four legs, each leg motor's volume is drivetrain weight divided by (50 × number of legs).

Cost: The cost of the entire drivetrain is $200 times drivetrain weight if two legs, $100 times weight if three legs, or $50 times weight if four or more legs. Two or three legs require more expensive gyro-stabilizing and control systems!

Power Requirement: This is identical to motive power.

EXAMPLE: *A TL9 drivetrain with 1,225 kW motive power weighs (4 × 1,225 kW) + 180 = 5,080 lbs. Since the mecha has two legs, the volume is 5,080/100 = 50.8 cf per leg. The entire drivetrain costs 5,080 × $200 = $1,016,000. It uses 1,225 kW. If we were writing this on a record sheet, we'd record:*

Leg Drivetrain: TL9 with 1,225 kW motive power (5,080 lbs., 50.8 cf in each leg, $1,016,000, 1,225 kW).

Step 4 – Arm Motors

If the mecha has no arms, go to Step 5. Otherwise, pick the strength (ST) for each arm. This is usually the same for each arm, but can vary. Some suggested strengths:

Scout mecha . . . . . .ST 50-500
Light battle mecha . . . . . .ST 100-1,000
Main battle mecha . . . . . .ST 1,000-10,000
Super battle mecha . . . . . .ST 5,000+

Target weight/25 (with a minimum ST 20) also gives good values. In supers or fantasy campaigns, a cap of ST 100-300 is a good idea, to balance mecha with supers or dragons. At ST 70+, a mecha's punch does about 1 + (ST/10) dice crushing damage.

An arm motor can have one or more of these options:

Cheap: The arm motor uses less-advanced technology, making it cheaper but heavier.

Flexible: A tentacle-like arm which can reach in any direction. Common on monstrous alien mecha!

Rocket Arm: An arm with this option can launch its fist as a ranged attack. (This option cannot be combined with a striker arm.) See *Using Arms* (p. 46).

Each arm requires an arm motor component. The arm motor's weight depends on that arm's ST and options.

Determine each individual arm motor's weight, volume and cost using this table:

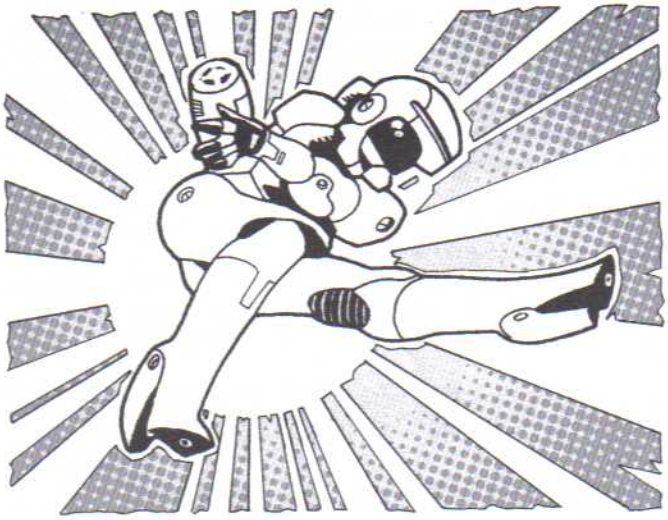
Arm Motor Table

TL of Arm	*Weight*	*Vol.*	*Cost*
TL8 Arm	0.2	0.004	$400
TL9 Arm	0.15	0.003	$300
TL10 Arm	0.1	0.002	$200
TL11 Arm	0.075	0.0015	$150
TL12+ Arm	0.05	0.001	$100
Type of Arm			
Manipulator	×1	×1	×1
Striker	×0.5	×0.5	×0.2
Options			
Cheap	×2	×2	×0.5
Flexible	×2	×2	×2
Rocket Arm	×1.5	×1.5	×4

Weight, Volume and Cost: This is per point of ST. Apply modifiers for arm type and options; all are cumulative. E.g., a TL9 striker arm motor with ST 200 and the cheap option weighs $200 \times 0.15 \times 0.5 \times 2 = 30$ lbs.

Location: An arm motor must be placed in the arm it operates.

Power: Arms require ST/200 kW of power.



EXAMPLE: *We give each of Seraph Delta's arms ST 4,000 and the cheap option. Each arm motor weighs 4,000 × 0.15 × 2 = 1,200 lbs., takes up 4,000 × 0.003 × 2 = 24 cf, costs 4,000 × $300 × 0.5 = $600,000 and uses 4,000/200 kW = 20 kW. One motor goes in the right arm, one in the left arm.*

As we are using a target weight, we'll keep a running total of accumulated weight. With the drivetrain plus the arm motors, this is now 7,480 lbs.

Step 5 – Thrusters

Jump- or flight-capable mecha have thrusters of some sort: jets, rockets, fans or reactionless thrusters. Skip this step and go on to Step 6 if the mecha isn't jump or flight capable.

Thrusters are rated for *motive thrust* in pounds. If not using a target weight, a good thrust is 20-50 lbs. per kW of leg drivetrain's motive power. To ensure a mecha is flight-capable, thrust must exceed weight; 1.1 to 1.5 times target weight is good. Jump-capable mecha, or those that can only fly in space, usually have thrusts of 50-100% of their target weight.

All thrusters incorporate thrust-vectoring systems (which is why they weigh 50% more than their ***Vehicles*** equivalents).

A mecha can have several smaller thrusters instead of one big one; this is mostly useful if the thrusters are spread around the mecha, in different locations. Their thrust is additive.

A brief description of the various types of thrusters:

Turbofans are jet engines. They are heavier than rockets and need an oxygen atmosphere to work, but use less fuel. If the mecha won't need to fly in space, they're a good choice.

Ducted fans are high-performance propellers, the blades of which are entirely shrouded within a cowling. They only work in an atmosphere. They require no fuel, only power.

Chemical Rockets are powerful but have very high fuel consumption. If the mecha is only designed to use its thrusters for a few seconds at a time, they are a good choice.

Fusion Rockets (TL9+) have an integral micro-fusion reactor that heats reaction mass and expels it to produce thrust. They work anywhere and don't use too much fuel. At TL9, they are probably the best choice, but they're very expensive!

Fusion Air-Rams (TL9+) use a fan to suck air into the rocket, which is heated by a fusion reaction and expelled to generate thrust. They require no fuel at all, but only function in an atmosphere – although it does not have to be a *breathable* one!

Reactionless Thrusters (TL9+) transform energy into thrust by means unknown to 20th-century science. They don't use fuel, only power. In some settings, they may not exist!

Fusion Ram-Rockets (TL10+) are fusion air-rams that can also function as fusion rockets in airless environments.

To install a thruster, select the type and motive thrust. Then calculate its statistics using the table below:

Thruster Table

TL and Type	*Weight (lbs.)*	*Cost*	*Fuel*
TL8+ Turbofan	(0.15×thrust) + 150	$50	0.015J gph
TL8+ Ducted Fan	(0.15×thrust) + 6.75*	$40	none
TL8+ Chemical Rocket	0.015×thrust	$25	1.1R gph
TL9+ Super Turbofan	(0.12×thrust) + 5	$50	0.03J gph
TL9 Fusion Rocket	(0.075×thrust) + 75	$100	0.02W gph
TL9 Fusion Air-Ram	(0.15×thrust) + 150	$100	1 yr.
TL9 Reactionless	1.5× thrust	$25	none
TL10+ Fusion Rocket	(0.0375×thrust) + 37.5	$100	0.02W gph
TL10+ Fusion Air-Ram	(0.075×thrust) + 75	$100	2.5 yr.
TL10 Reactionless	0.75×thrust	$20	none
TL10 Super Reactionless	0.3×thrust	$100	none
TL10+ Fusion Ram-Rocket	(0.09×thrust) + 90	$200	2.5 yr.#
TL11+ Reactionless	0.075×thrust	$20	none
TL11+ Super Reactionless	0.03×thrust	$100	none
TL13+ Mega Reactionless	0.0015×thrust	$4,000	none

* 1.5 × thrust if under 20 lbs. thrust.

0.02W when operating in an airless environment.

Weight: Calculate the weight (in lbs.) of the thruster as shown on the table, based on its thrust.

Volume and Location: This is weight/50 cf for most systems, or weight/100 for ducted fans. Thrusters may go in a body, leg, pod or wing.

Cost: Multiply the thruster's *weight* as found above by the "cost" number on the table to get its cost. For reactionless thrusters only, treat costs less than $500 as $500.

Fuel: "None" means the thruster requires no fuel (although it will require *power* – see below). "1 yr." or "2.5 yr." means the thruster can operate for that many years on its reactor. A number followed by "gph" is the *gallons per hour* of liquid fuel or reaction mass consumed per pound of thrust; multiply gph by thrust to find it. J indicates jet fuel is consumed, R is chemical rocket

fuel, W is water reaction mass. (Recording a consumption in *gallons per second* is a good idea, if the mecha only uses the thrusters occasionally. To find gallons per second, divide gph by 3,600; round to two places.)

Power: The only thrusters that need power are ducted fans and reactionless thrusters. Ducted fans need 0.25 kW per pound of thrust. TL9 or TL10 reactionless thrusters need 0.5 kW per pound of thrust; TL11+ need 0.05 kW per pound of thrust.

EXAMPLE: *Seraph Delta is to be flight-capable. With a 50,000-lb. target weight, it needs over 50,000 lbs. thrust. We choose 51,000 lbs. and produce it with a TL9 fusion rocket. It weighs (0.075 × 51,000) + 75 = 3,900 lbs., takes up 3,900/50 = 78 cf and costs 3,900 × $100 = $390,000. It uses 0.02 × 51,000 = 1,020 gallons per hour water. We put it in the body. Total weight is now 11,380 lbs.*

Step 6 – Cockpit

Every drivable mecha requires a cockpit. Most mecha have only one cockpit, but multi-cockpit designs are possible – they allow the crew to do several things at once, like engage several targets with different weapons. Computerized controls allow command of individual systems to be redistributed each turn.

Standard Features

A basic cockpit includes these standard features:

Compact Fire Suppression System: This is an automatic chemical fire extinguisher with outlets throughout the mecha.

Computer: A minicomputer and terminal, with fiber-optic hardening to protect against radiation and electromagnetic pulse. Its Complexity equals the mecha's TL-5.

Crew Station and Controls: A padded pilot seat surrounded by a bank of computerized controls.

Head-Up Display (HUD): A holographic data display with a pupil scanner that tracks the pilot's eye movements and trains weapons and sensors wherever he looks. At TL9+, the pilot is usually surrounded by a 3-D display – if desired, this display can even "edit out" the surrounding cockpit walls so that the pilot and his controls seem to be floating in space.

Lifesystem: At TL8-10, this is a limited-duration life support system that performs climate control and waste relief functions, and has a 24 man-hour supply of air. At TL11+, it is replaced by a system with indefinite duration. This system is only viable for *sealed* mecha (see p. 89); unsealed mecha should take the "No Lifesystem" downgrade (below).

The weight of a cockpit also includes 200 lbs. per occupant. The actual weight may differ, of course, but this is a playable average that takes into account personal armor or clothing.

Upgrades

A cockpit can be further customized by adding various upgrades. Unless noted, an option can only be taken once per cockpit. The upgrades are:

Ejection Seat: A rocket escape system that blasts the occupant out of the mecha, then deploys a parachute to land him safely. See *Ejecting* (p. 58).

Extra Air: This option adds 12 man-hours of air. It can be taken several times, if desired.

Extra Passenger Seat: A mecha cockpit can be fitted with one or more extra seats for passengers. At TL8-10, remember to divide the man-hours of air by the number of occupants! For extra *crew*, add another cockpit.

Genius Computer: This upgrades computer Complexity by 1, but *greatly* increases cost.

Womb Tank: This is a gel-filled fluid bath that provides superior protection against shocks and acceleration.

Downgrades

A cockpit can also have downgrades, which will reduce weight, volume and cost, but eliminate certain capabilities:

Dumb Computer: A cheaper but less effective computer. Reduce computer Complexity by 1. This may not be taken if the cockpit has the "genius computer" upgrade.

No Extinguisher: The mecha lacks an automatic fire suppression system. A good option for cannon-fodder mecha!

No Lifesystem: Removing the lifesystem saves quite a bit of weight and space, but it means that the occupants can only breath if there is a breathable atmosphere outside, or if they wear their own air supply, such as a vacc suit and air tank.

Cockpit Statistics

The weight, volume, cost and power requirements of a cockpit depend on its TL and the upgrades or downgrades it has. A cockpit may be located in the mecha's body or turret.

Cockpit Table

Type	*TL*	*Weight*	*Volume*	*Cost*	*Power*
Basic Cockpit	8	590	24.7	$80,100	0.5
Basic Cockpit	9	460	22.4	$41,100	0.5
Basic Cockpit	10	370	21.2	$21,850	0.5
Basic Cockpit	11+	340	21.2	$21,850	0.1
Upgrades					
Ejection Seat	–	100*	5*	$50,000*	0
Extra Air	8	75	1.5	$250	0
Extra Air	9	50	1	$250	0
Extra Air	10	25	0.5	$250	0
Extra Seat	8-10	220	20	$100	0.5
Extra Seat	11+	250	31	$600	0.1
Genius Computer	8	–	–	$450,000	neg.
Genius Computer	9	–	–	$225,000	neg.
Genius Computer	10+	–	–	$112,500	neg.
Womb Tank	8	200*	4*	$10,000*	neg.
Downgrades					
Dumb Computer	8	–	–	-$60,000	–
Dumb Computer	9	–	–	-$30,000	–
Dumb Computer	10+	–	–	-$15,000	–
No Extinguisher	–	-50	-1	-$500	–
No lifesystem	8	-150	-3	-$500	-0.5*
No lifesystem	9	-100	-2	-$500	-0.5*
No lifesystem	10	-50	-1	-$500	-0.5*
No lifesystem	11+	-20*	-1*	-$500*	-0.1*

* If mecha has extra seats, this is *per occupant.*



EXAMPLE: *Seraph Delta has a TL9 cockpit in the body (460 lbs., 22.4 cf, $41,100, 0.5 kW). We add an ejection seat option for an extra 100 lbs., 5 cf and $50,000. Total weight is now 11,940 lbs.*

Step 7 – Built-In Weapons

Combat mecha usually devote up to 10% of target weight to built-in weaponry, but any size arsenal is possible.

Mecha, especially those with manipulator arms, may supplement any built-in weapons with external armament: giant hand-held guns or modular weapon pods bolted onto hardpoints. This way, a weapon load can be tailored for the mission and takes up no internal space, allowing a smaller, lighter machine. However, external weapons are also vulnerable to damage, less accurate and compromise any stealth systems while attached.

Some mecha rely mostly on their built-in weaponry, while others rely on external weapons or a mix of both. Decide if the mecha will have any built-in weapons. If so, add them now, as described below. If not, go on to Step 9. (External weapons aren't part of the mecha design – they are covered after the mecha is built.)

A wide variety of built-in weaponry is available. For ranged weapons, refer to *Ranged Weapons* (p. 65). For melee weapons, refer to *Built-in Contact Weapons* (p. 68). Decide what weapons the mecha will have, and record each one's statistics:

Weight, Volume, Cost and Power are shown on the appropriate weapon tables.

Location: A ranged weapon can be located in the body or in an arm, turret, pod, wing or leg – although firing leg-mounted weapons is awkward. In general, putting weapons in arms or turrets gives a better arc of fire, while putting them in the body means they are less likely to be knocked out of action.

If a ranged weapon goes in the body or a turret, decide which way it faces: forward (F), right (R), left (L), up (U), down (D) or backward (B). Weapons in arms and legs face the way the limb points.

A built-in contact weapon can normally only go in an arm. However, claws and talons may go on legs, and jaws in a turret.

Note: Weapons in an arm can't be used if the pilot is using a hand-held weapon at the same time. Mecha that rely on external hand-held weapons often have no weapons in manipulator arms.

Ammunition is required for built-in guns and launchers. See the weapon tables on pp. 67-68 to find the weight per shot (WPS), volume per shot (VPS) and cost per shot (CPS). Multiply this by the desired number of shots carried to find ammunition weight, volume and cost. Ammunition must go in the same location as the weapon that uses it. If multiple, identical weapons are in the same location, they can share ammunition.

EXAMPLE: *We give Seraph Delta about 1/10 its target weight in weapons: four TL9 med. missile launchers (total 500 lbs., 10 cf in F Body, $16,400) for punch, and a TL9 md. rainbow laser in each arm (each is 1,800 lbs., 36 cf, $130,000, 259,200 kW). The launchers require ammunition. We choose 2 shots each: 8 med. missiles (total 400 lbs., 8 cf in body, $65,600). This is 4,500 lbs. of armament. Total weight is now 16,440 lbs.*

Step 8 – Weapon Accessories

Built-in weapons can be modified with various accessories. Decide if the mecha has any of them, and work out their statistics.

Links: A group of ranged weapons can be electronically linked together, enabling one person to aim and fire some or all weapons in the group at a single target in a single turn. Weapons can only be linked if they face in the same direction. Launchers can only be linked with other launchers. Weapons may be cross-linked to allow different combinations of weapons to be fired. Links cost $50 per set of weapons in the link. Links don't have a "location," since they have no volume.

Casemate Mount: This is a swivel system that can be added to any weapon built into the *body*. It gives that weapon a much wider arc of fire (45° to either side). It weighs 0.5 lbs. per pound of empty weapon weight, takes up 0.5 cf per cf of weapon volume, and costs $1 per pound of empty weapon weight. A casemate must be located in the body with the weapon it upgrades.

Anti-Blast Magazine: A useful option for ammunition that can do explosive damage, such as missiles, grenades or exploding cannon shells. It encloses the ammunition in a specially-built ammo box, designed to prevent damage from an ammo explosion by vectoring the blast harmlessly out of the mecha. It is 25 lbs. and $250 per cf (or fraction thereof) of ammo protected. It has no volume.

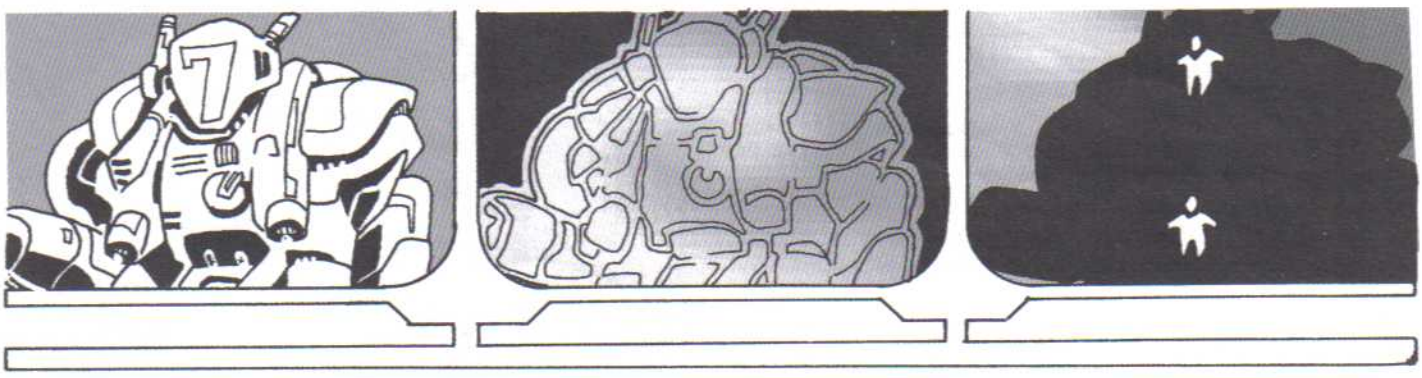
EXAMPLE: *We decide the launchers are linked together (for $50) as are the lasers ($50). The 8 cf of ammo has an anti-blast magazine: 200 lbs. and $2,000. Total weight: 16,640 lbs.*

Step 9 – Sensors

On the futuristic battlefield, a mecha's electronic sensors are nearly as important as its weaponry! Almost all mecha have sensors, though if they are lost (or not installed), the pilot can still see out through a vision slit, canopy or faceplate.

There are two types of sensor array:

Passive Electromagnetic Sensor Array (PESA): This is the mecha pilot's electronic "eyes." It can switch between telescopic day or night vision and high-resolution infrared thermograph



mode. Telescopic vision can be blocked by smoke, and thermographs by special "hot smoke" or infrared cloaking. So mecha often have an . . .

Active Electromagnetic Sensor Array (AESA): This is a multimode active sensor array that can switch between radar and laser imaging (ladar) functions. It gives more precise ranging information than a PESA, and when used for targeting adds a +2 bonus to hit in combat. There are ways of jamming or fooling an AESA using stealth or ECM, but its big disadvantage is that its use can be detected – this can be crucial in a hide-and-seek battle!

Most mecha designs have PESAs alone, or both AESA and PESA systems. To determine a sensor's statistics, decide on its type (PESA or AESA) and range in miles. Civilian and police mecha usually mount sensors with ranges of 1-5 miles, while ranges of 5-50 miles are typical of military mecha. Mecha built for air and space combat often have even longer ranges!

Use the table below to find each system's statistics:

Sensor Table

Type	*Weight*	*Volume*	*Cost*	*Power*
TL8 AESA	3	0.06	$5,000	0.25
TL9 AESA	1.5	0.03	$2,500	0.25
TL10 AESA	0.75	0.015	$1,250	0.25
TL11+ AESA	0.375	0.0075	$625	0.25
TL8 PESA	4	0.08	$16,000	neg.
TL9 PESA	2	0.04	$8,000	neg.
TL10 PESA	1	0.02	$4,000	neg.
TL11+ PESA	0.5	0.01	$2,000	neg.

Multiply the range of the sensor in miles by the numbers shown on the table. This gives the weight, volume, cost and (if AESA) power requirement. *Exception:* If a sensor has over 125 miles range, multiply its cost by only 100 + (range/5).

Location: A sensor is usually located in a turret, but can go in any body or subassembly except wheels. When it is installed, decide which direction it is facing, just like a weapon.

Sensors can only look in one direction, so it is useful to either place sensors in a rotating turret or install multiple sensors of the same type facing in different directions. A turret with one sensor facing forward and one facing backward gives effective 360° coverage. (Multiple sensors of the same type facing the *same* direction give no extra benefit, but are useful as backups.)

Magnification: PESAs are also rated for their power of telescopic magnification; e.g., 20× is a 20-power scope. This equals their range in miles or 1×, whichever is better.

EXAMPLE: *We decide Seraph Delta will have a 100-mile range PESA (which is 200 lbs., 4 cf, $800,000, 100× magnification) and a 200-mile range AESA (300 lbs., 6 cf, $350,000, 50 kW). Both systems are in the turret facing forward. Total weight is now 17,140 lbs.*

Step 10 – Comsuites

Almost all mecha have comsuites, which incorporate communication and navigation systems as well as sensors that detect radar and laser emissions. There are three main types. For rules, see *Using Comsuites* (p. 47).

Mini Comsuite (TL8+): This is a scrambled, medium-range radio, a military GPS system for satellite-aided navigation, and a radar/laser detector. Used by small or cheap mecha.

Basic Comsuite (TL8+): A mini-comsuite plus a laser communicator and "IFF" (Identify Friend or Foe) transponder. This is the standard type of mecha comsuite.

Advanced Comsuite (TL8+): A scrambled, long-range radio, laser communicator, IFF, military GPS system, inertial navigation system and advanced radar/laser detector. Mostly used by command, scout, ranger, air or space combat designs.



A mecha will normally only have one comsuite. Decide what type of comsuite – if any – a mecha has, and record its statistics:

Comsuite Table

Type	*TL*	*Wt.*	*Volume*	*Cost*	*Power*
Mini Comsuite	8	3.75	0.075	$2,275	neg.
Mini Comsuite	9	2.25	0.045	$1,175	neg.
Mini Comsuite	10+	2	0.04	$1,000	neg.
Basic Comsuite	8	19	0.38	$5,775	0.1
Basic Comsuite	9	12.5	0.25	$3,425	0.1
Basic Comsuite	10+	9.5	0.19	$2,625	0.1
Advanced Comsuite	8	62	1.24	$32,600	0.14
Advanced Comsuite	9	41	0.82	$17,550	0.14
Advanced Comsuite	10+	36	0.72	$17,275	0.14

The table shows the weight, volume, cost and power requirement of comsuites at various tech levels. They can be located in any body or subassembly except wheels.

EXAMPLE: *We give Seraph Delta a TL9 advanced comsuite (41 lbs., 0.82 cf, $17,550, 0.14 kW) and place it in the body. Total weight is now 17,181 lbs.*

Step 11 – Electronic Countermeasures (ECM)

These systems are designed primarily to decoy enemy homing missiles. For detailed rules, see *Homing Missiles* (p. 53).

Infrared Jammer (IRJ): This system emits thermal radiation to distract and confuse infrared homing missiles of the same or lower TL. It has no effect on sensors. Its "jam" rating is subtracted from the chance of these missiles hitting the mecha. At TL10+, a deceptive jammer (see below) can also jam homing missiles, so IRJs are generally no longer used.

Deceptive Jammer (DJ): A deceptive jammer detects an incoming sensor pulse, then fools the sensor by mimicking the signal and sending it back in an altered form. They make the mecha harder to track using radar (at TL8-9); those built at TL10+ use "distortion field" technology which works vs. any sensors and against infrared homing missiles.

Area Jammer (AJ): Broadcasts static that interferes with all radar scans and radio use (friend or foe), over a radius of five miles times its jamming bonus. However, the jamming field itself can be detected by an AESA (using its radar) or a comsuite that is in line of sight of it.

Dischargers: A launcher box for various decoy or concealment munitions. It is used to fire smoke, flares (to confuse infrared homing missiles), chaff (to confuse radars) and hot smoke (to block a PESA's infrared sensors). A decoy discharger can fire one shot per turn; mecha sometimes mount several dischargers. Decide what each discharger is loaded with and how many reloads, if any, it has.

ECM Table

Type	*TL*	*Weight*	*Volume*	*Cost*	*Power*
Infrared Jammer	8	20#	0.4#	$40,000#	0.25#
Infrared Jammer	9+	10#	0.2#	$20,000#	0.25#
Deceptive Jammer	8	40#	0.8#	$40,000#	4#
Deceptive Jammer	9	20#	0.4#	$20,000#	2#
Distortion Jammer	10	10#	0.2#	$10,000#	1#
Distortion Jammer	11+	5#	0.1#	$5,000#	0.5#
Area Jammer	8	20#	0.4#	$4,000#	100#
Area Jammer	9	10#	0.2#	$2,000#	50#
Area Jammer	10+	5#	0.1#	$1,000#	25#
Decoy Discharger (loaded)	8+	20	1	$100	0
each reload	8+	10	0.5	$20*	0

For a jam rating of 2. For a more potent jammer, multiply wt., vol., cost and power by ×2 (jam 4), ×5 (jam 6), ×10 (jam 8), ×20 (jam 10), ×50 (jam 12), ×100 (jam 14) or ×200 (jam 16).

* Reloads available are smoke, hot smoke, chaff or flare. Smoke is only $10; all others are $20.

ECM can go in any location except wheels.

EXAMPLE: *We give Seraph Delta a decoy discharger with a chaff decoy plus 3 chaff, 8 flare and 4 hot smoke reloads (170 lbs., 8.5 cf in turret, $400). Total weight is now 17,351 lbs.*

Step 12 – Power Systems

Any mecha whose components have a power requirement requires a *power system:* a power plant or energy bank.

A *power plant,* like a reactor, produces power constantly. It has a power output in kilowatts (kW), and may require fuel.

An *energy bank,* such as a battery or power cell, stores a finite amount of energy, which is drained as it is used. It is rated for the number of kilowatt-seconds (kWs) of energy it stores. One kWs provides one kW of power for one second.

Power plants are better for the long haul, while energy banks permit greater outputs for shorter periods. A mecha will usually have both, combining the benefits.

Examine the power requirements of all components on the mecha that require more than negligible power, then decide which will be met by power plants and which by energy banks. Most mecha designs will run any beam or electromag weapons (which require huge amounts of power) off of energy banks and everything else off of a power plant. However, it *is* possible to run a mecha entirely off one or the other system.

EXAMPLE: *Seraph Delta's power requirement is 1,225 kW for the drivetrain, 40 kW for the arm motors, 518,400 kW for the lasers, 50 kW for the AESA, 0.14 kW for the comsuite and 0.5 kW for the cockpit for 519,715.64 kW.*

We decide the 518,400 kW for the lasers is be met by an energy bank; the other 1,315.64 kW will be met by a power plant.

Power Plants

If the mecha has a power plant, decide on its output in kilowatts (kW) – the amount of power it produces. The output should equal or exceed the power requirements of all systems it powers. If it exceeds their power requirements, the excess energy can be used to recharge the energy bank or to power any external gear, such as hand-held or hardpoint-mounted weapons.

A mecha will sometimes have multiple power plants (possibly of different types). These can either add their output together or be designated as backup systems that only work when the main system goes down. A backup system will not use up fuel or deplete its endurance when it is not in use.

Several different types of power plant are available. Decide which type the mecha will use. In some settings, only certain types may be available – this is up to the GM.

Steam (TL5-6) – See p. 109.

Ceramic Internal Combustion Engines (TL8) are advanced versions of modern-day, high-performance diesel, Sterling or Wankel rotary engines. They are cheap and low-tech, but require a lot of fuel. They only function in an oxygen atmosphere, making them useless in space, underwater or on some alien worlds.

Gas Turbines (TL8) are the same as the turbine engines that are used on helicopters and some tanks today. They are lighter but more expensive than ceramic engines. They also only work in an oxygen atmosphere.

Nuclear Power Units (NPUs) (TL8) are compact but expensive, high-performance "radiothermal generators" that convert the heat produced by a decaying radioisotope into energy. They operate for months or years. At TL9+, an NPU can also represent a micro-fusion unit, such as a hydrogen-injection fission/fusion torch being used to drive a high-tech steam engine, or even a "cold-fusion" device, depending on the background technology.

Fission Reactors (TL8) produce power by splitting atoms. The fuel rods in the reactor will last for years.

Fusion Reactors (TL9) generate energy by hot thermonuclear fusion. They are more efficient than NPUs, and their internal hydrogen fuel supply lasts for centuries.

Antimatter Reactors (TL11) produce energy through the mutual annihilation of matter and antimatter. Again, an internal fuel supply provides power for years.

Total Conversion Power Plants (TL14) produce power by directly converting matter into energy. They use trivial amounts of normal matter for fuel, which provides power indefinitely.

The most efficient (if not cheapest) choice for a power plant varies with TL and output, depending on what is available:

TL8: A gas turbine – if being limited to working in an oxygen atmosphere and the high fuel consumption are acceptable. Otherwise, use an NPU to 950 kW, then pick a fission reactor.

TL9: As above, but after 23,750 kW, a fusion reactor is the optimum choice.

TL10: An NPU is best up to 2,468 kW, then fusion.

TL11: An NPU is best up to 9,910 kW, fusion to 20,000 kW, then an antimatter reactor.

TL12: An NPU is best to 13,273 kW, then antimatter.

TL13: An NPU up to 5 kW, then antimatter.

TL14+: An NPU up to 5 kW, then total conversion.

Select the type of power plant and its output, and work out its weight, volume, cost and fuel usage, as shown below:

Power Plant Table

Type	*Weight if output is:*			
	under 5kW	*5kW or more*	*Cost*	*Fuel*
TL8+ Ceramic Engine	4×kW	(2×kW) + 10	$12	0.03 gph
TL8+ Gas Turbine	4×kW	(1×kW) + 15	$30	0.055 gph
TL8 Nuclear Power Unit	no	(8×kW) + 200	$200	0.5 yr
TL9 Nuclear Power Unit	12×kW	(2×kW) + 50	$200	1 yr
TL10 Nuclear Power Unit	6×kW	(1×kW) + 25	$200	2 yr
TL11 Nuclear Power Unit	4×kW	(0.4×kW)+18	$200	5 yr
TL12+ Nuclear Power Unit	2×kW	(0.2×kW)+9	$200	10 yr
TL8 Fission Reactor	no	(4×kW) + 4,000	$100	2 yr
TL9 Fission Reactor	no	(1×kW) + 1,000	$40	2 yr
TL10+ Fission Reactor	no	(1×kW) + 1,000	$20	2 yr
TL9 Fusion Reactor	no	(1×kW) + 20,000	$200	200 yr
TL10 Fusion Reactor	no	(0.2×kW) + 2,000	$50	200 yr
TL11+ Fusion Reactor	no	(0.2×kW) + 2,000	$25	200 yr
TL11 Antimatter Reactor	no	(0.1×kW) + 4,000	$20	2.5 yr
TL12 Antimatter Reactor	no	(0.05×kW) + 2,000	$20	5 yr
TL13+ Antimatter Reactor	no	0.05×kW	$20	30 yr
TL14+ Total Conversion	no	0.02×kW	$30	infinite

Weight: Calculate the weight of the power plant as shown on the table, based on output. There are two columns, one for power plants with outputs under 5 kW, the other for larger power plants. A "no" in the "under 5 kW" column means a power plant of that type cannot be built with less than 5 kW output.

Volume and Location: Divide weight by 50 to find volume in cf, except for NPUs. For these denser power plants, divide by 100. The power plant goes in the mecha's body.

Cost: This is the cost per pound of power plant weight. There is an extra added cost for the reactor core of fission, fusion and some antimatter plants:

TL8 fission $200,000
TL9 fission $40,000
TL9 fusion $1,000,000
TL10 fusion or TL11 antimatter $200,000
TL11 fusion or TL12 antimatter $100,000

All power plants except gas turbines and ceramic engines have a minimum cost of $20,000. If the cost works out less than this minimum, raise it to the minimum cost.

Fuel: This determines how long the power plant can operate for. If a number followed by "gph" is given, operating the power plant requires that number of gallons per hour of diesel fuel per kW of output. If a number followed by "yr" is given, the power plant does not require a fuel tank. Instead, it operates for that number of *years*, using an internal isotope, hydrogen or antimatter fuel supply, after which a major overhaul is required. "Infinite" means the power plant can operate indefinitely.

EXAMPLE: *We need a 1,315.64 kW power plant. We decide upon an even 1,500 kW; the rest can recharge our energy bank. The lightest weight for a 1,500 kW output plant up to TL9 would be a gas turbine, but that requires fuel and air. We decide to choose the next-lightest option, a TL9 fission reactor.*

It weighs (1 lb. × 1,500 kW) + 1,000 = 2,500 lbs., takes up 2,500/50 = 50 cf in the body and costs $40 × weight = $100,000, plus $40,000 for the reactor core = $140,000. It lasts 2 years. Total weight is now 19,851 lbs.

Energy Banks

An energy bank stores electrical energy. A mecha may have one instead of a power plant – or it may have both. If the power plant output fails to equal or exceed the total power requirement of all systems, the mecha *must* have an energy bank.

An energy bank stores energy, measured in kilowatt-seconds (kWs) – one kilowatt of power for one second. A kWs of stored energy provides the same power as a 1 kW power plant – but only for a second. Thus, if a mecha had an energy bank holding 360,000 kWs, and it had systems that required 10,000 kW, the energy bank could power those systems for 360,000/10,000 = 36 seconds.

To design an energy bank, decide how many kWs of energy it will store. The best way to do this is to multiply the power requirements of the systems the energy bank powers by the seconds it is intended to power them for (1 hour = 3,600 seconds).

Decide what kind of energy bank is used:

Advanced Batteries represent various contemporary and projected battery technologies. In some early- to mid-TL8 campaigns, power cells may not be available, only batteries.

Rechargeable Power Cells are either sophisticated superconductor loops or highly-advanced flywheel designs. They can be recharged. A power cell storing 90,000 kWs × (TL-6) is the equivalent of a rechargeable "E cell" from ***GURPS Space.***

Non-rechargeable Power Cells are volatile electrochemical, nuclear-thermal or exotic-fuel batteries. They can't be reused once drained – remove the cells and install new ones at full cost. A power cell storing 180,000 kWs × (TL-6) is the same as an "E cell" from ***GURPS Space.***

Find the weight, volume and cost using the following table:

Energy Bank Design Table

Type	*Weight*
TL8+ Advanced Battery	0.001
TL8 Rechargeable Power Cell	0.00011
TL9 Rechargeable Power Cell	0.000074
TL10 Rechargeable Power Cell	0.000056
TL11 Rechargeable Power Cell	0.000044
TL12 Rechargeable Power Cell	0.000037
TL13 Rechargeable Power Cell	0.000032
TL14 Rechargeable Power Cell	0.000028
TL15 Rechargeable Power Cell	0.000025
TL16 Rechargeable Power Cell	0.000022

Non-rechargeable power cells have exactly *half* the weight of rechargeable cells.

Weight: Multiply the weight given on the table by the energy stored (in kWs) to find the weight (lbs.). If the weight is over 1 lb., round fractions up to the nearest whole number.

Volume and Location: To find volume, divide weight by 100 if a power cell or by 50 if a TL8+ battery. Energy banks can go in the body or any subassembly except wheels.

Cost: Multiply weight by $30 if an advanced battery or $100 if a power cell to find the actual cost.

EXAMPLE: *Seraph Delta's energy bank is designed to power its lasers, which require 259,200 kW each. We decide we want to be able to each laser for 30 seconds before draining the energy bank. This requires 2 × 30 s. × 259,200 kW = 15,552,000 kWs. A 15,552,000 kWs energy bank using TL9 rechargeable power cells weighs 0.000074 × 15,552,000 = 1,150.848 lbs., rounded to 1,151 lbs. It takes 1,151/100 cf = 11.51 cf, and costs 1,151 × $100 = $115,100. We put it in the body. Total weight is now 21,002 lbs.*

Step 13 – Fuel and Fuel Tanks

Mecha with fuel consumptions (in gallons) for power plants or thrusters must install a fuel tank.

To design a fuel tank, decide on its capacity in gallons, what type of fuel it holds and its location. A mecha can draw upon fuel from tanks in different locations, if desired.

The best way to select capacity is to multiply the gallons per hour of fuel the power plant or thruster consumes by the desired endurance in hours. Six or more hours is a typical endurance for a power plant, but fuel-thirsty thrusters are sometimes only given a few hours (or even minutes) of fuel.

There are four types of fuel tank; decide which is used:

Standard tanks are the cheapest kind.

Light tanks have reduced weight but greater risk of fire if they carry flammable fuel.

Self-sealing tanks prevent leakage and reduce risk of fire, but are heavier and more expensive.

Light self-sealing tanks combine the virtues and flaws of light and self-sealing tanks.

If the mecha uses different kinds of fuel (e.g., one for thrusters and one for a power plant), install separate tanks. They can be in different locations in the mecha. In game terms, a mecha cannot have more than one fuel tank that uses the same fuel in a given location (it might have more in reality, but they are treated in play as if they were a single tank).

Work out each tank's statistics using the table below, and also determine the weight and cost of the fuel itself (there's no extra volume, since the fuel is in the tank).

Fuel Tank and Fuel Table

Type	*Weight*	*Vol.*	*Cost*	*Fire*
Standard Tank	0.5	0.15	$5	-2
Light Tank	0.25	0.15	$10	-1
Self-sealing Tank	1	0.15	$10	-3
Light Self-sealing Tank	0.5	0.15	$20	-2
Fuels				
Diesel fuel	6	–	$1.2	9
Jet Fuel	6.5	–	$3	13
Rocket Fuel	10	–	$2	13
Water	8.5	–	–	–

Weight: The table shows the weight per gallon.

Volume and Location: The table shows the volume per gallon. Fuel tanks can be located in any body or subassembly except wheels, but usually only go in the body, pods, legs or wings.

Cost: The table shows the cost per gallon. Note that water is free on an Earth-like planet. In space – or in a desert civilization – it may be more expensive, perhaps $1 a gallon.

Fire: Some fuel types have a "Fire" number. This is the chance on 3d that the fuel will catch fire if the tank is badly damaged. It is modified by the type of tank used.

Endurance: Record how many hours the fuel will power the power plant or thrusters for. This is the gallons of fuel carried divided by the consumption in gallons per hour.

EXAMPLE: *Seraph Delta requires fuel (water) for its fusion rocket, which uses 1,020 gph of water. Its power plant does not require fuel. We decide that Seraph Delta is designed only for fairly short "hops" rather than long-range flight – and we don't want to have too much weight. We give it 20 minutes of fuel, or 340 gallons. We use two light, 170-gallon tanks, putting one in each leg. Each is 42.5 lbs., 25.5 cf, and $1,700. 340 gallons of water is 8.5 × 340 = 2,890 lbs. and is free. Total weight is now 23,977 lbs.*

Step 14 – Cargo Space

Mecha may have cargo storage space. Most mecha (and almost all battlesuits) *don't* have cargo space, but some have space for extra ammunition, provisions or the like. A few mecha types have large cargo bays – a mining mecha might have space for ore, or an assault transport may carry troops and cargo.

Each space is rated for its location in the vehicle and its volume in cubic feet. Cargo spaces can be located in the body or any subassembly except wheels, and can be in different locations.

Cargo spaces have no weight in and of themselves, but their cargo will weigh something; decide on a *usual payload* of between 20 and 50 lbs. per cf of cargo carried.

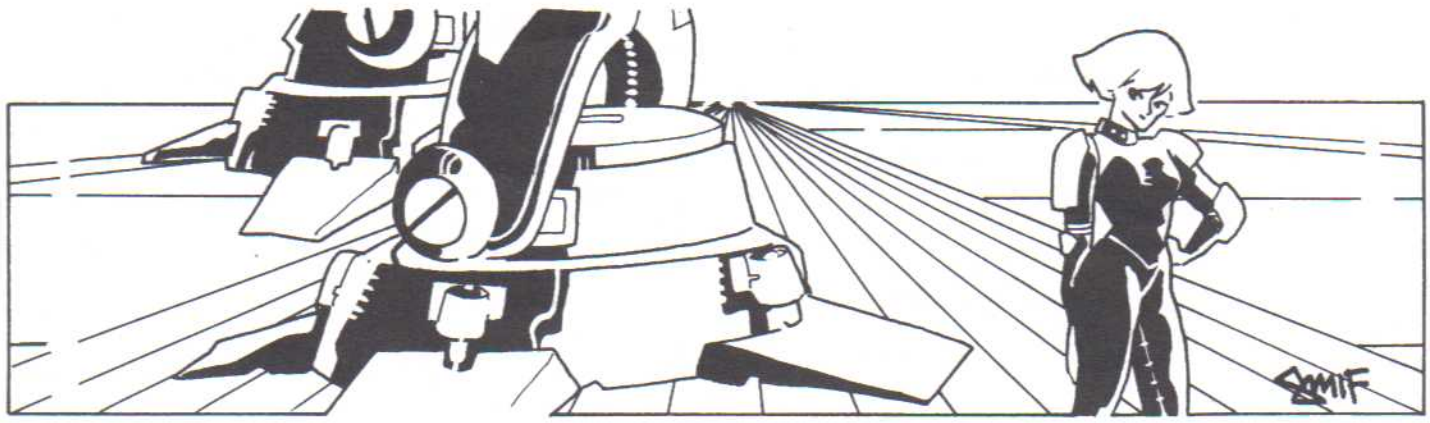
EXAMPLE: *Seraph Delta has no cargo space.*

Step 15 – Access Space

Mecha (except those with battlesuit systems) are designed with extra access space to allow mechanics to maintain their power plants, drivetrains and thrusters.

For each drivetrain, thruster or power plant that occupies a location (but *not* for energy banks), add extra cf of *access space* equal to its volume. This is effectively a component with volume but no cost or weight. *Exception:* Thrusters in pods do not require access space.

EXAMPLE: *Seraph Delta requires 50.8 cf access space in each leg (for its leg drivetrain) and 128 cf in the body (for its fusion rocket and fission reactor).*



PART IV – VOLUME AND STRUCTURE

The components are now selected, so now the mecha's internal structure can be designed and the components installed within it.

Step 16 – Body and Subassembly Volumes

Find the volume of the body and each individual subassembly, in the order listed; skip subassemblies the mecha doesn't have.

A note on body proportions: a humanoid shape that matches human proportions should have a body about 5 to 20 times the volume of its arms or head-turret, and legs that are each about one-third the body's volume. However, many mecha do not have humanoid proportions – anime-inspired designs often have small arms and head, but oversized legs.

Arm, Pod and Turret Volume

Add up the volume of all components located in each individual turret, pod or arm. For example, if a turret has a 0.2 cf AESA and a 5 cf laser cannon, it has volume of 5.2 cf.

Extra empty space can be added to an arm, pod or turret to "even out" the volume. For example, if one arm has less volume than the other, but you want the arms to be identical in size, a few cf of space could be added to the smaller arm so they match.

Empty space also allows for later modifications and, more importantly, can be used to make the subassembly larger and thus heavier and tougher. Arms often have very low volumes if weapons aren't installed in them; adding lots of "empty space" to the arms is common.

EXAMPLE: *Seraph Delta's turret houses the AESA, PESA and decoy discharger, for 18.5 cf. We add 1.5 cf empty space for an even 20 cf. The right arm houses its arm motor (24 cf) and a laser (36 cf) for 60 cf. The left arm is the same.*

Body Volume

Calculate the total volume of all components located in the body, in the same way as for a turret, pod or arm.

If a turret is attached, one extra component will take up space in the body: the *turret rotation space*. This space, for the turret's socket, is 0.1 cf times a limited-rotation turret's volume, or 0.2 cf times a full-rotation turret's volume.

As with arms or turrets, empty space can also be added to a body. This may be required: the body *must* have a volume greater than that of any single arm, pod or turret directly attached to it. If necessary, add empty space to the body to meet this minimum volume requirement!

If the body is streamlined, its final volume will be increased. Multiply the combined volume of all its components (including turret rotation and empty space) by 1.1 if the streamlining is "fair," by 1.2 if it is "good," by 1.3 if it is "superior" or by 1.4 if it is "radical."

EXAMPLE: *Seraph Delta's body houses the fusion rocket (78 cf), four medium launchers (10 cf), eight medium missiles (8 cf), the comsuite (0.82 cf), cockpit (27.4 cf), fission reactor (50 cf), energy bank (11.51 cf) and access space for the rocket and reactor (128 cf). The turret rotation space for a 20 cf limited turret is 2 cf. Adding everything up gives us a volume of 315.73 cf. We add 4.27 cf of empty space to make the body an even 320 cf. Seraph Delta isn't streamlined. Had it been given "fair" streamlining, for example, its "body volume" of 320 cf would be been multiplied by 1.1 to become 352 cf.*

Leg Volume

Add up the total volume of all components located in each individual leg subassembly, in the same way as was done for arms, to get the volume of each leg.

Extra empty space can also be added to legs. This may be required: all legs must have the *same* volume. In addition, to support the mecha, the combined volume of all its legs must be *at least* 0.6 × body volume. Since all legs must be the same volume, this means a two-legged mecha needs legs whose volume equals 0.3 × body volume. If volume is less than this, add more space to the legs to make up the difference.

Note that legs do not take up space within the body – the reference to body volume only refers to the size of the leg.

EXAMPLE: *Seraph Delta's right leg houses its leg motor (50.8 cf), fuel tank (25.5 cf) and access space (50.8 cf), for a total of 127.1 cf. We add 0.9 cf to even it out to 128 cf. Its left leg is the same. With two legs, each leg must be at least 96 cf in volume (0.3 × body volume); this is no problem.*

Wheel and Wing Volume

This only applies if the mecha has wheels or wings – see p. 101, in Chapter 6.

Step 17 – Surface Area

Each body or subassembly is rated for its surface area ("area"). Area is an approximation of the body's or subassembly's area in square feet, and is used to calculate the mecha's structural weight, cost, hit points and other attributes.

Calculate the surface area individually for the body and for each subassembly by looking up the body or subassembly's volume in the "volume" column and reading the surface area from the "area" column directly to the right of it. If a value falls between two numbers, use the lower.

Area Table

Volume	*Area*	*Volume*	*Area*	*Volume*	*Area*	*Volume*	*Area*
To 0.029	0.5	3.3-3.5	14	25-31	60	3,376-6,080	2,000
0.03-0.06	1	3.6-3.9	15	32-44	75	6,081-8,495	2,500
0.07-0.12	1.5	4.0-4.3	16	45-68	100	8,496-11,180	3,000
0.13-0.19	2	4.4-4.7	17	69-95	125	11,181-17,185	4,000
0.2-0.26	2.5	4.8-5.1	18	96-125	150	17,186-24,110	5,000
0.27-0.3	3	5.2-5.6	19	126-157	175	24,111-35,650	6,500
0.4-0.5	4	5.7-6.0	20	158-188	200	35,651-48,650	8,000
0.6-0.75	5	6.1-6.5	21	189-268	250	48,651-68,025	10,000
0.8-1.0	6	6.6-7.0	22	269-353	300	68,026-89,440	12,000
1.1-1.25	7	7.1-7.4	23	354-543	400	89,441-125,000	15,000
1.3-1.5	8	7.5-8.0	24	544-759	500	125,001-192,420	20,000
1.6-1.8	9	8.1-8.4	25	760-1,000	600	192,421-268,960	25,000
1.9-2.2	10	8.5-9.5	27	1,001-1,540	800	268,961-353,450	30,000
2.3-2.5	11	9.6-11	30	1,541-2,150	1,000	353,451-544,335	40,000
2.6-2.8	12	12-17	40	2,151-2,830	1,200	544,336-760,610	50,000
2.9-3.2	13	18-24	50	2,831-3,375	1,500	760,611-1,000,000	60,000

Note on Wings: As these are wider than usual, their surface area is doubled after it is calculated.

For larger surface areas use this formula:

Surface area = [(cube root of volume) squared] × 6.

Round to nearest 10,000 sf.

(If desired, the formula can be used for *all* volumes, replacing the "rounded off" surface areas given above.)

Total Surface Area: Once the surface area of the body and each subassembly is known, find the *total area* by summing these areas.

EXAMPLE: *We use the table above to calculate surface areas based on volumes, then add them together to get the total area. We record turret 50, each arm 100, body 300, each leg 175. Total area 900.*

Step 18 – Structure

After surface area is calculated, the mecha's internal skeleton and frame – its structure – must be designed.

Choose the mecha's *frame strength* and *materials:*

Frame Strength: The heavier the frame, the stronger and tougher the mecha, but the more its structure weighs and costs. Choose either a light, medium, heavy or extra-heavy frame.

Materials: This determines the quality of materials used: choose either cheap, standard, expensive, very expensive or advanced. Better materials mean less weight but much higher cost.

Some other design decisions also affect the mecha's structural cost, as shown under *Other Modifiers.* Some of these are only available in Chapter 6, *Advanced Mecha Design.*

Refer to the table below to find the structural weight and cost of the mecha:



Mecha Structure Table

Feature	*Weight*	*Cost*
TL8 structure	4	$50
TL9 structure	3	$50
TL10 structure	2	$50
TL11 structure	1.5	$50
TL12+ structure	1	$50
Frame Strength		
Light	×0.5	×0.5
Medium	×1	×1
Heavy	×1.5	×2
Extra-Heavy	×2	×5
Materials		
Cheap	×1.5	×0.5
Standard	×1	×1
Expensive	×0.75	×2
Very Expensive	×0.5	×5
Advanced	×0.375	×10
Other Modifiers		
If streamlined:		
Fair streamlining	×1	×1.2
Good streamlining	×1	×1.5
Superior streamlining	×1	×3
Radical streamlining	×1	×10
If mecha has wings	×1	×10
If biomechanical	×1	×1.5
If living metal	×1	×2
If transformable:		
with two configurations	×1.2	×2
with three configurations	×1.4	×3
with four configurations	×1.6	×4

Weight: Determine the structural weight as follows: Multiply the mecha's total surface area by the basic weight shown for its TL and then by every applicable multiplier in the *Weight* column.

Cost: Determine the structural cost as follows: Multiply the mecha's total surface area by the basic cost shown for the mecha's TL and then by every applicable multiplier in the *Cost* column.

EXAMPLE: *We choose a heavy frame strength, then reduce weight but increase cost by using very expensive materials. The structural weight is 900 (total area) × 3 (TL9 structure) × 1.5 (heavy) × 0.5 (very expensive) = 2,025 lbs. The structural cost is 900 (total area) × $50 × 2 (heavy) × 5 (very expensive) = $450,000. Total weight is now 26,002 lbs.*

Step 19 – Hit Points (HP)

Once the mecha's structure has been determined, find the hit points for the mecha's body and for each subassembly as follows:

Body . . . . . .the body's area × 1.5.
Each Turret, Pod, Leg or Wing . . . . . .its area × 1.5.
Each Arm . . . . . .its area × 3.
Wheels . . . . . .each wheel position on the subassembly has its own hit points equal to the area × 3 / number of wheel positions.

Divide HP by 2 for a light frame; multiply by 2 for a heavy frame or 4 for an extra-heavy frame. Round HP up to the nearest whole number, with a minimum of one hit point.

EXAMPLE: *The body has 300 × 1.5 × 2 (heavy frame) = 900 hit points. The turret 50 × 1.5 × 2 = 150 hit points. Each arm has 100 × 3 × 2 = 600 hit points. Each leg has 175 × 1.5 × 2 = 525 hit points.*

PART V – SURFACE FEATURES

Surface features are layered atop the mecha's structure, and include things like armor, environmental protection and stealth coatings. Surface features have a weight and cost, but not a volume or power consumption.

Step 20 – Environmental Protection

A mecha whose cockpit or battlesuit system has a lifesystem or NBC filter must be sealed. A mecha without a lifesystem may be waterproofed or it can be given no environmental protection.

Waterproof: Waterproofing a mecha insures that it will not leak if floating or suffer corrosion from salt water, but does not protect it from the effects of corrosive atmospheres or extreme pressures. A mecha that is sealed is automatically waterproof.

Sealed: The mecha's body is totally sealed and its components are protected against corrosion, the effects of sudden pressure changes and high or low temperatures.

Self-Sealing: As sealed, except the mecha's interior has a layer of plasteel, armor gel, micromachines, et cetera which automatically seals any puncture within a second. Mecha with advanced biomechanical or living metal structures (see p. 103) are self-sealing for free.

Sealing and Waterproofing Table

Type	*TL*	*Weight*	*Cost*
Waterproof	0	–	$2
Sealed	8	–	$20
Sealed	9+	–	$10
Self-Sealing	9+	0.1	$50

Multiply weight and cost by the mecha's total surface area.

EXAMPLE: *We decide Seraph Delta is sealed, which costs total area 900 × $10 = $9,000.*

Step 21 – Defensive Surface Features

These protect the mecha from detection or various threats. Unless noted otherwise, they can be combined. Sensor, vision and attack roll modifiers for infrared cloaking, stealth and chameleon systems can be found in the *Sensor Modifiers* sidebar on p. 49.

Infrared Cloaking: This disguises the mecha's heat profile and masks engine emissions, making it harder to spot with infrared sensors (e.g., a PESA using thermograph mode) or to attack using IR-homing missiles. Two levels of infrared cloaking exist: "basic" and the superior "radical" (which can't be combined).

Stealth: A mecha with a stealth surface is covered with radar-absorbent materials and has a shape that is designed to make it harder to detect with radar or AESA. As with IR cloaking, it comes in "basic" and "radical" versions that can't be combined.

Chameleon Systems: These systems give the mecha sensor-equipped skin that automatically alters its appearance to blend in with any background (instant chameleon) or to make the mecha virtually invisible (intruder chameleon). The automatic camouflage feature can also be manually controlled, allowing the pilot to electronically "paint" the mecha with whatever color scheme or markings are desired, or to give the mecha a mirrored skin with PD 6 vs. laser (but not x-laser) fire.

Thermal Superconductor Armor: This superconducting layer doubles any armor DR the mecha has vs. shaped-charge explosive warheads, lasers, x-ray lasers, disruptors, flamers or any heat-based attack.

Defensive Surface Features Table

Type	*TL*	*Weight*	*Cost*	*Power*
Basic Stealth or IR Cloaking	8	1	$150	0
Basic Stealth or IR Cloaking	9+	0.5	$75	0
Radical Stealth or IR Cloaking	8	2	$1,500	0
Radical Stealth or IR Cloaking	9+	1	$750	0
Instant Chameleon	9	0.5	$100	neg.
Instant Chameleon	10	0.25	$50	neg.
Instant Chameleon	11+	0.125	$25	neg.
Intruder Chameleon	10	0.6	$400	neg.
Intruder Chameleon	11	0.3	$200	neg.
Intruder Chameleon	12+	0.15	$100	neg.
Thermal Superconductor Armor	11	0.25	$250	0
Thermal Superconductor Armor	12	0.125	$125	0
Thermal Superconductor Armor	13+	0.0625	$62.5	0

Multiply weight and cost by the mecha's total surface area.

EXAMPLE: *We decide Seraph Delta has basic stealth and radical IR cloaking. Basic stealth is 0.5 × 900 = 450 lbs. and costs $75 × 900 = $67,500. Radical IR cloaking is 1 × 900 = 900 lbs. and costs 900 × $750 = $675,000. Total weight is now 27,352 lbs.*

Step 22 – Armor

This is a mecha's armored skin or hull. It's the last thing that needs to go on the mecha. Armor is rated for its Damage Resistance (DR), the location it covers and the armor material.

If using a target weight, it's a good idea to subtract the total weight of components, features and structures installed so far to find out how much weight is available for armor, then use most or all of the entire remaining target weight for armor. *Exception:* If the mecha is going to carry external hardpoints onto which modular weapons or other equipment can be hung, leave some weight for whatever hardpoint load is desired!

There are several types of armor:

Metal represents steel or other alloys, with more exotic materials (e.g., "durasteel") coming into use at higher TLs. No special rules apply to its DR.

Laminate is similar to the "chobham" armor developed for modern main battle tanks: it is a sandwich of metal, synthetic and ceramic materials. While expensive, it gives greater DR for its weight than equivalent-quality metal armor. Its effective DR is also doubled against the deadly shaped-charge ("HEAT") warheads used by the missiles in ***GURPS Mecha.***

Ablative armor is ultra-light, plastic-ceramic composite armor designed to chip or be melted away ("ablate") in a manner that carries away part of the energy of the attack. While very light, even low-powered weapons like infantry small arms can peel away ablative armor: every 10 points of damage the attack causes (*before* DR) blows away 1 point of DR.

Fireproof Ablative armor is also available, since ordinary ablative armor is flammable.

For the body and each subassembly, decide what type of armor is going to cover it: metal, laminate, ablative or fireproof ablative. Then calculate its statistics as follows:

Weight and DR of Armor: Multiply the body or subassembly's area by the number shown on the *Armor Table* for that type and TL to find the weight per point of DR. Then multiply by desired DR to find the armor's actual weight. Do the same for each location armored. To give the entire mecha the same DR, simply use its total surface area.

An alternative way to install armor is to decide how many pounds of armor a location is going to have. Then find the DR it has by dividing the armor's weight by the surface area of the armored location(s) and again by the number shown on the table below for that TL and type of armor. Whatever works best!

If building a battle mecha, it's a good idea to make sure the body's armor is capable of *almost* stopping an average-damage hit from the mecha's own main beam or gun!

Armor Table

Type	*TL8*	*TL9*	*TL10*	*TL11*	*TL12*	*TL13+*
Metal	0.15	0.1	0.06	0.04	0.025	0.015
Laminate	0.1	0.06	0.04	0.025	0.015	0.01
Ablative	0.03	0.02	0.012	0.008	0.005	0.003

Cost: An armor's cost is its weight multiplied by $20 if metal, $100 if laminate, $8 if ablative or $16 if fireproof ablative.

EXAMPLE: *So far we have used up 27,352 lbs., so we have 22,648 lbs. before hitting our target weight of 50,000 lbs. We aren't going to give Seraph Delta hardpoints, so we allot it all to armor. We decide that the body should have the best armor, to protect the vital power plant and cockpit. We armor the body with DR 600 laminate, which weighs 0.06 × 300 (its area) × DR 600 = 10,800 lbs. It costs $100 × 10,800 = $1,080,000. We armor the rest of the mecha (total area 600) with only DR 340 laminate. This weighs 0.06 × 600 (area) × DR 340 = 12,240 lbs., and costs $1,224,000. Total weight is now 50,392 lbs., a bit over target weight, but not enough to matter.*

Passive Defense

PD is determined by the DR of the outer layer of armor: PD 1 if DR 1, PD 2 if DR 2-4, PD 3 if DR 5-15, PD 4 if DR 16+.

EXAMPLE: *All locations are PD 4.*

Step 23 – Hardpoints (Optional)

Some mecha are built with *hardpoints:* reinforced points on their exterior to which missiles or modular equipment pods containing weapons, fuel or electronics can be bolted.

Decide if the mecha has hardpoints and if so, how many and where they are placed. Mecha with arms can mount one hardpoint on each arm (on the shoulder). Mecha with wings can also mount hardpoints under the wings, usually no more than three per wing. Mecha may also mount one or two hardpoints on their back.

Since hardpoints add weight, mecha designs often include only a single hardpoint, often on the back or shoulder.

Each hardpoint is rated for its individual *load capacity* in lbs. This is the maximum weight of equipment it can carry. Within these limits, a hardpoint can be loaded with *one* equipment pod or from 1 to 10 missiles (see p. 94).

Select the load capacity of each hardpoint, subject to this limit: the *combined* load capacity of *all* hardpoints placed on a specific location (wing, arm, body, et cetera) may not exceed 20 lbs. per hit point that location has. *Each* hardpoint weighs 0.05 lbs. and costs $0.1 *per pound of load capacity.* If the mecha is designed to be flight-capable while carrying its full hardpoint load, and doesn't have wings, the target weight of the mecha plus the combined load capacity of all hardpoints should be *less* than the mecha's thrust.

Rules for equipment pods and missiles on hardpoints are found in *Appendix 2* (p. 94).

PART VI – STATISTICS

At this point, everything that the mecha needs has been installed. Now we find out what it can do!

Loaded Weight: This is the "combat-ready weight" of the mecha. Add up the total weight of everything that went into the mecha, including cargo load. If weight was kept track of to meet a target weight, this has already been done. If it isn't close enough to the target weight, add or remove some armor.

Empty Weight: This is mainly used when transporting the mecha. To get empty weight, take the loaded weight and subtract the weight of the mecha's ammunition, fuel (but not fuel tanks) and the usual cargo load. If the mecha has a cockpit, also subtract 200 lbs. (plus 200 lbs. per extra seat) for occupants. If it has a battlesuit system, subtract the pilot weight.

Loaded Mass in Tons: This is used in some performance calculations. Divide loaded weight by 2,000 to get it. Round decimals to two places. (You can also do this for empty weight.)

EXAMPLE: *Seraph Delta's Loaded Weight totals 50,392 lbs. For Empty Weight, we take the loaded weight and subtract 400 lbs. of ammunition, 2,890 lbs. of water and 200 lbs. for the occupant, which leaves a 46,902 lbs. empty weight. For Loaded Mass in Tons, we divide the loaded weight by 2,000 and get 25.196, rounded to 25.20 tons.*

Mecha Volume: Add up the volumes of the body and all subassemblies. This is the mecha volume. (If the mecha is to be carried in a ***GURPS Space*** starship, divide volume by 27 to find the volume in cubic yards.)

EXAMPLE: *The body and subassemblies total 716 cf.*

Size Modifiers: Compare the mecha volume to the table below to find the Size Modifier. The mecha's volume will probably fall between two entries on the table; use the higher one to find the Size Modifier.

Size Modifier

Volume	*Modifier*	*Volume*	*Modifier*
0.1	-4	3,000	+5
0.3	-3	10,000	+6
1	-2	30,000	+7
3	-1	100,000	+8
10	+0	300,000	+9
30	+1	1,000,000	+10
100	+2	3,000,000	+11
300	+3	10,000,000	+12
1,000	+4	etc.	etc.

Do the same for each subassembly, but using its own volume. A subassembly's Size Modifiers are used if it is specifically targeted. Subtract 2 from the Size Modifier of any turret atop the body.

EXAMPLE: *A volume of 716 cf gives it a +4 Size Modifier. The 60 cf arms are each +2, the 20 cf turret is -1 (thanks to the modifier) and the 128 cf legs are each +3.*

Price: Add up the cost of everything except fuel and ammunition to find out how much the mecha costs. This is its price when purchased new.

EXAMPLE: *Total cost is $7,907,550. To bring this into perspective, a modern (late-TL7) main battle tank averages about $1-2 million, while a modern jet fighter is about $20,000,000.*

Health: This measures structural robustness. The heavier a mecha is compared to its structural strength, the more strain it puts on its systems and the lower its HT will be. A mecha can have a low Health but many hit points. Structural HT is calculated as follows:

Structural HT = (200 × Body HP/Lwt.) + 5.

Where *Body HP* are the mecha's body hit points and *Lwt.* is its loaded weight.

The maximum allowed structural HT is 12 or the mecha's TL, whichever is greater. Round HT to the nearest whole number.

EXAMPLE: *Seraph Delta's HT is [(200 × 900 body hit points) / 50,392] + 5 = 8.57, rounded to HT 9.*

Dimensions (Optional)

These formulae give a rough idea of how big the mecha is. These are approximations, and can be fudged considerably if desired!

Height: For a two-legged mecha, its *height* can be found as follows: find the square roots of the body area, the turret area and the area of each leg, add them all together and then divide this sum by 4.5. For a mecha with three or more legs, use the same formula, but only count the first two legs and divide the sum by 6, not 4.5.

Length: If the mecha has two legs, this is about 1/3 its height. If three or more legs, it is the square root of (body area/6).

Width: This is about 1/3 its length if 3+ legs, or equal to length if two legs – although with arms and legs spread out, it can take up a much larger area.

If a two-legged transformable mecha folds its legs, it swaps height and length. If a mecha has streamlining, it will be 50% longer but about 2/3 as wide.

EXAMPLE: *Seraph Delta's body area is 300, its legs are 175 each and turret area is 50. The square roots are 17.3, 13.2, 13.2 and 7.1, for a total of 50.8. Dividing by 4.5, we get a height of 11.3 yards. Its length and width are 3.8 yards.*

Strength and Reach

Mecha with arms or drivetrains have a ST attribute. This is split into two categories: Body ST and Arm ST.

Body ST is used when the mecha is pulling or kicking, for calculating encumbrance when moving on foot, or when the mecha slams into someone. It is normally twice body hit points, but it can't exceed (leg drivetrain motive power in kW - mecha weight in tons) × 80, nor can it be less than half body HP.

Arm ST is the ST of each individual arm. It is based on the arm motor's ST, but may not safely exceed four times the arm's hit points. If it *does*, the mecha has a "split arm ST," with a safe and a maximum ST value. If the mecha exceeds it safe ST (while punching, lifting, striking, et cetera), a HT+2 roll is required each second, with failure causing the loss of half the arm's current hit points and critical failure disabling the arm (it drops to 0 hit points).

Arm Reach in yards equals *half* the square root of the arm's surface area, rounding to nearest whole number. This may differ from arm to arm.

Thrust/Swing Damage may also vary if arms have different ST. See p. CI10 for ST over 20. A handy formula that works for ST 100+: thrust damage (dice) = (ST/10) + 1; swing damage (dice) = (ST/10) + 3; round fractions down. If the mecha has a split arm ST, calculate damage for the safe ST.

EXAMPLE: *Seraph Delta's body ST is twice its body hit points, or ST 1,800, well under the maximum for motive power. Its arm motors are ST 4,000, but safe ST is only 4 × 600 (arm HP) = ST 2,400. With surface area 100, each arm has reach 5 and does 241d thr and 243d sw damage.*

PART VII – PERFORMANCE

Mecha performance statistics are divided into ground, air and space performances. Advanced-design mecha with multiple configurations or which can combine or split up may have several sets of performance statistics.

A mecha whose power system doesn't require air and which is sealed can also walk along the bottom of a body of water.

Ground Performance

A mecha with legs and a leg drivetrain has a ground performance.

Ground Speed

This is the top speed the mecha can reach, measured in mph. Take the motive power of the drivetrain in kW, divide this by design mass in tons and find the square root of the quotient. Multiply the result by the motive system *speed factor* (see below) to get ground speed.

Speed Factor Table

Motive System	*Speed Factor*
Two legs	8
Three legs	10
Four or more legs	12

If speed works out to 50 mph or more, add an extra 5% to top speed if "fair" streamlining or 10% if "good" or better streamlining.

Round all speeds to the nearest 5 mph, unless they are below 20 mph; then round to the nearest mph.

EXAMPLE: *To find Seraph Delta's ground speed, we start with its leg drivetrain's 1,225 kW motive power and divide by 25.20 tons to get 48.61, the square root of which is 6.972. We then multiply by speed factor 8 (two legs) for 55.78 mph, which rounds to 55 mph.*

Ground Maneuver Rating and Stability Rating

Ground Maneuver Rating (gMR) is the maximum *safe* "g" (gravities) the mecha can pull while maneuvering on the ground. *Ground Stability Rating* (gSR) is a measure of how stable the mecha is. Both are determined using the table below:

gMR/gSR Table

Type of Motive System	*Mecha's Body Volume (cf)*									
	30 or less		*31 to 100*		*101 to 300*		*301 to 3,000*		*3001 or more*	
	gMR	*gSR*	*gMR*	*gSR*	*gMR*	*gSR*	*gMR*	*gSR*	*gMR*	*gSR*
2 Legs	2.75	1	2.25	1	1.75	2	1.25	2	0.75	2
3 Legs	2.25	2	1.75	2	1.25	3	1	3	0.75	3
4+ Legs	1.5	3	1.25	3	1	4	0.75	4	0.75	4

Add 0.25 to leg gMR for species-compatible mecha (one with the same number and type of limbs as the pilot).

EXAMPLE: *Seraph Delta's 320 cf body volume is 301-3,000 cf, so with 2 legs it has gMR 1.25. With a human pilot, this is increased for being species-compatible to gMR 1.5. It has gSR 2.*

Ground Move and Enhanced Move

A mecha's ground Move is the number of yards it can move per turn, exactly the same as a character's Move score. It is normally half its ground speed in mph, rounding fractions down. However, if this would give a Move greater than 10 × gMR, the mecha has a split Move. Its normal Move is 10 × gMR, rounding fractions down; its *enhanced Move* is equal to half ground speed. The mecha can only use the higher "enhanced Move" when sprinting in a relatively straight line.

EXAMPLE: *Seraph Delta's ground speed is 55 mph, which would give it Move 27. However, it has gMR 1.5. Since 10 × 1.5 = 15, Seraph Delta has a split ground Move of 15/27.*

Boosted Jumps

Mecha with thrusters or contragravity may use them to boost their jumping distance, even if they lack sufficient lift to fly. Record the mecha as "jump-capable." See *Jumping Mecha,* p. 43).

EXAMPLE: *Seraph Delta is jump-capable.*

Aerial Performance

A mecha with an aerial performance is flight-capable. To be flight-capable, the mecha requires both thrusters and a lift *in excess of its weight.* A mecha's lift is the thrust of all its thrusters in pounds, plus any lift from contragravity.

When a mecha's lift exceeds its weight, it can *hover.* This means it can take off or land vertically and fly sideways or backwards!

EXAMPLE: *Seraph Delta's thrust of 51,000 lbs. gives 51,000 lbs. lift. As this is greater than its loaded weight of 50,392 lbs., it is capable of flight and can hover.*

Effective Motive Thrust and Lift ST

Effective motive thrust is the amount of thrust the mecha can use to propel itself while flying. It is equal to the total thrust from all thrusters *minus* the mecha's *effective weight.* Effective weight is the mecha's loaded weight minus any contragravity lift; treat negative weight as zero.

Lift ST: This is equal to the mecha's effective motive thrust/15 or twice body HP, whichever is *less.* Use it instead of Body ST when calculating the encumbrance of flying mecha.

EXAMPLE: *Seraph Delta's effective thrust is its rocket's 51,000 lbs. minus its loaded weight of 50,392 lbs. = 608 lbs. It has lift ST 40.*

Aerodynamic Drag and Air Speed

Aerodynamic drag is used to determine a mecha's top air speed. Use this formula:

Aerodynamic Drag = Sa/Sl.

Sa is the total surface area of the vehicle.

Sl depends on streamlining: 1 if no streamlining, 2 if fair, 3 if good, 10 if superior or 40 if radical streamlining.

Note: Superior or radical streamlining only counts if a mecha either lacks arms, turrets, wheels and legs, or has transformed into a configuration in which they are folded. Otherwise, downgrade effective streamlining to "good."

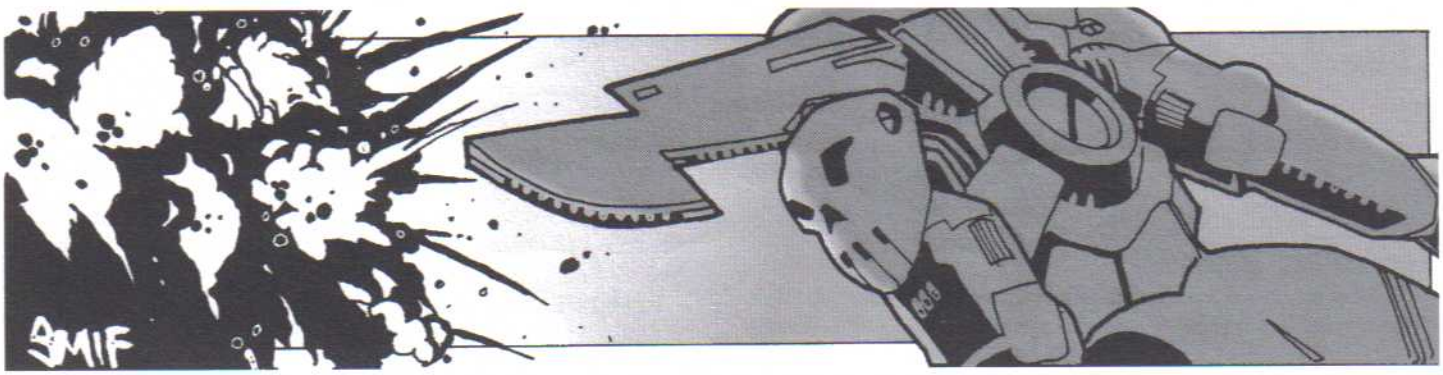
Air Speed is the mecha's maximum atmospheric flight speed in mph. To find it use the following formula:

Top speed = Square root of [(Emt/Adr) × 7,500].

Emt is effective motive thrust.

Adr is aerodynamic drag.

Round the result to the nearest 5 mph if over 20 mph, otherwise to the nearest mph. If the vehicle does not have effective superior or radical streamlining (see note for aerodynamic drag) and speed exceeds 600 mph, treat it as 600 mph.



EXAMPLE: *Seraph Delta's Emt. is 608 lbs. Its aerodynamic drag (Adr) is its total surface area of 900. So its top air speed is the square root of [(608/900) × 7,500] = 71.2 mph, rounded to 70 mph.*

Aerial Maneuver Rating

Aerial maneuver rating (aMR) is the maximum safe g (gravities) the mecha can pull while maneuvering in flight. Use this formula:

aMR = (TL + 1 - Size Modifier)/2.

Minimum aMR is 0.125.

EXAMPLE: *Seraph Delta can hover. As it is TL9 with a +4 Size Modifier, its aMR is (9 + 1 - 4)/2 = aMR 3.*

Aerial Stability Rating

This depends on total volume: 3 if under 100 cf, 4 if 100-999 cf, 5 if 1,000-9,999 cf, and so on.

EXAMPLE: *Seraph Delta's aSR is 4.*

Flying Move and Enhanced Move

This is the number of yards the mecha can move per turn when flying. It is exactly the same as a character's Move score. Flying Move is half air speed in mph, rounding down. However, if this would give a Move greater than 10 × aMR, the mecha has a split Move. Its normal Move is 10 × aMR; its *enhanced Move* is equal to half air speed. The mecha can only use the higher Move when flying in a relatively straight line.

EXAMPLE: *An air speed of 70 mph gives a flying move of 35. Since Seraph Delta has aMR 3 and 35 is more than 10 × aMR, the mecha has a split flying Move of 30/35.*

Space Performance

A mecha with a rocket, ram-rocket or reactionless thruster may maneuver in space, but its crew requires some means of breathing, like vacc suits or a lifesystem. Its power system can only function in space if it does not require air. If a mecha meets both requirements, it is "space-capable" and has a space performance, with one statistic: space acceleration.

EXAMPLE: *Seraph Delta is space-capable.*

Space Acceleration

Space acceleration (sAccel) is measured in gravities (*g*). Total the motive thrust of all rockets, ram-rockets or reactionless thrusters used together and divide by loaded weight to find the sAccel in *g*. Round to two decimal places.

(To find acceleration in yards per second per second, multiply sAccel by 10.)

sAccel also doubles as *space maneuver rating* (sMR).

EXAMPLE: *Seraph Delta has a motive thrust of 51,000 lbs. / 50,392 lbs. = sAccel 1.01 g.*

APPENDICES

These appendices describe additional equipment that can be added to a mecha after it is designed: hand-held weapons, equipment pods for hardpoints and computer software, as well as notes on using ***Mecha*** with ***GURPS Space.***

Hand-held weapons and equipment pods or missiles on hardpoints count as encumbrance (see p. 42); if the total weight of hand-held weapons and hardpoint loads exceeds twice the mecha's Body or Lift ST, it will reduce the mecha's performance. Note that a mecha cannot fly if its encumbrance exceeds 15×Lift ST.

Appendix 1: Hand-Held Ranged Weapons

Mecha with manipulator arms often carry giant-sized rifles, bazookas or pistols. These are slung on the back when not in use. To design a hand-held ranged weapon, follow these steps:

Decide if the weapon is a *pistol* which can be used by one manipulator arm or a *rifle* that needs two manipulator arms to use.

Pick a ranged weapon from the weapon tables on pp. 66-68.

Decide if the weapon will be armored or not. Most mecha weapons are armored pistols or rifles, which are heavier but more robust. Some police mecha or battlesuits carry unarmored weapons, though, when weight is more important than survival.

A hand-held weapon has the same statistics as a built-in version, except its Cost, Weight, Acc and SS are modified, and it has Hit Points, PD, DR, loaded weight, shots, magazine weight and ST.

SS and Acc: Pistols are -2 to SS and -5 to Acc. Rifles are -2 to Acc if guns or launchers, -1 if beams.

Cost: If the weapon is armored, add $5 times the *original* empty weight to the cost to cover the armor.

HP: Find the surface area of the weapon based on its volume, using the *Area Table* (p. 87). Its hit points equal 1.5 times its area. Also calculate its Size Modifier (see p. 90), in case it is shot at.

PD and DR: All weapons have PD 3. If the weapon is armored, its DR is 5 + [(Wt./Area)/A], where *Wt.* is the weight from the weapon table, *Area* is its surface area and *A* is 0.6 at TL8, 0.4 at TL9, 0.24 at TL10, 0.16 at TL11, 0.1 at TL12, or 0.06 at TL13+. Unarmored weapons are DR 5.

Unloaded Weight: If weapon is armored, multiply weight on the weapon table by 1.25 if a pistol or 1.5 if a rifle. If the weapon is unarmored, multiply rifle weight (only) by 1.2.

Shots: Decide how many shots a magazine holds.

Magazine Weight (MWt.): Find the weight of a loaded magazine by multiplying WPS by number of shots and then by 1.4 (for the magazine itself). Except for launchers, MWt. should not exceed the empty weight of the weapon, and is usually much less. Find Magazine Cost (MCost) by multiplying CPS by number of shots. Magazines can be stowed as cargo: volume is MWt./50.

Energy Cells: If the weapon has a Pow. requirement, it will need energy. If the mecha has a power plant with unused output

equal to or less than the Pow. requirement, or has an energy bank, the Pow. can be met by plugging it into the mecha – a cable connection is assumed to come with the weapon. Alternatively, the weapon can be given integral power cells:

Required # of C cells = [(Pow./RoF) × Shots]/P

where *Pow.* and *RoF* are taken from the weapon tables, *Shots* is the number of shots the weapon is to have and *P* is the kWs of energy stored in a C cell: 3,600 at TL8, 5,400 at TL9, 7,200 at TL10, 9,000 at TL11, 10,800 at TL12, 12,600 at TL13, 14,400 at TL14, 16,200 at TL15 and 18,000 at TL16.

It can be more efficient to use larger or smaller cells. If the number of cells is 0.1 or less, use a single B cell. Likewise, one D cell can replace 10 C cells; one E cell can replace 100.

Record energy cells after the number of shots, e.g., if the weapon has 20 shots on an E cell, this is written 20/E.

Loaded Weight (LWt.): Add the MWt. to the new unloaded weight of the weapon, plus 0.05 lbs. per B cell, 0.5 lbs. per C cell, 5 lbs. per D cell or 20 lbs. per E cell. This is the LWt.

Recoil and ST: Recoil is ignored for mecha, whose stabilized arms act as shock absorbers. ST requirement is (LWt./8)+5 if a rifle or (LWt./4)+5 if a pistol, multiplied as stated.

The weapon is now complete. It can be used by any mecha.

Appendix 2: Equipment Pods

Here's how to design equipment pods for a mecha's hardpoints. (An equipment pod is *not* the same as a pod subassembly!) As with mecha, it's useful to design with a target weight in mind – in this case, the load capacity of the hardpoint the equipment pod is being built for.

1. Select the components to be installed in it. These may be ranged weapons, ammunition, sensors, ECM, comsuites, fuel tanks, energy banks, cargo or empty space. Fuel and energy can be transferred through the hardpoint to and from the mecha, so equipment pods with extra fuel or power are common.

If components in the pod require power, this can be provided by the mecha (if it has excess power plant output or an energy bank) or by building an energy bank (p. 85) into the equipment pod.

2. Add up the volume of all components in the pod. Use the *Surface Area Table* (p. 87) to find the pod's area. Refer to the *Structure Table* (p. 88), select a frame strength and material cost, then find the pod's structural weight and cost.

3. Go to the *Armor Table* on p. 90 and add whatever armor is deemed necessary for the pod. Find the pod's hit points using the table on p. 88, treating it as a body.

4. Record the pod's total weight, cost, PD, DR, HP and volume. Calculate its Size Modifier (see p. 90) in case it is shot at.

Equipment pods housing sensors or weapons always face forward. Hardpoint loads can be jettisoned by the mecha pilot at any time (as a Ready maneuver). Bolting on a new equipment pod (or missile) takes about five minutes and a Mechanic roll.

Missiles on Hardpoints

A hardpoint can also mount loose missiles. It may be loaded with one or more identical missiles whose combined weight is no greater than its load capacity and whose individual WPS is no less than 1/10 capacity. Treat this as a missile launcher with RoF 1, but it takes about 5 minutes to reload. It's possible to shoot at a missile while it's sitting on a hardpoint – use the rules for *Shooting at Missiles* (p. 54).

Appendix 3: Software

Computers generally run programs. Like a computer, software is rated for its Complexity. This is usually abbreviated "C" – e.g., a C2 program is Complexity 2. See *Using Computers* (p. 46) for how many programs can be run at once.

A computer can only run a program if the software's Complexity and TL are equal to or less than its own. While a mecha's computer can run the entire gamut of software (e.g., see p. VE62 or p. CII17ff), a mecha will usually just run the most complex Targeting program it can install, plus a Datalink to keep it in touch with any allies.

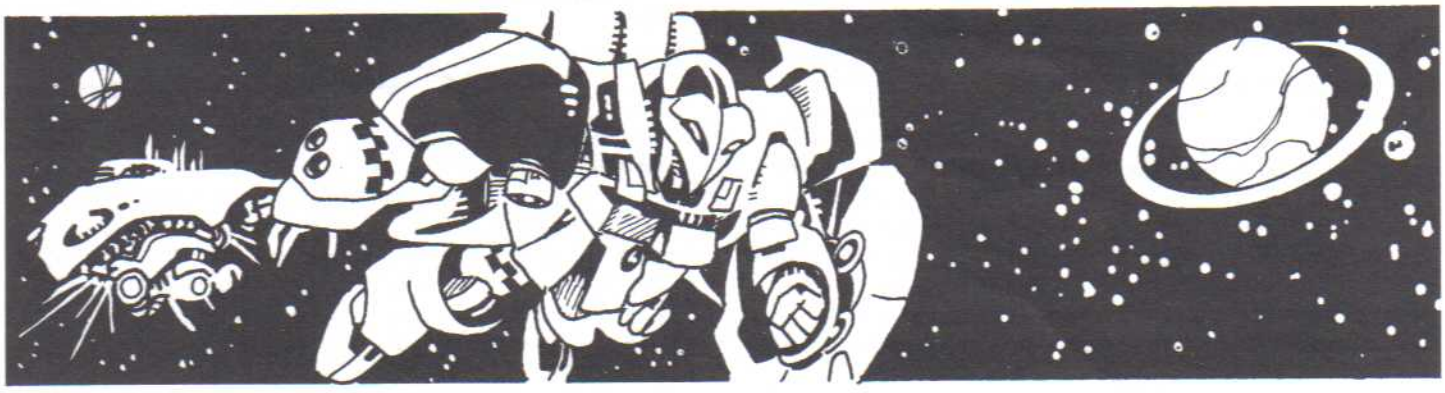
Datalink: This program enables a computer to link (via communicator) with external computer networks or with another electronic device – such as a computer in another mecha, vehicle, or building – and share information. Using a Datalink also permits communicators to send text and images as well as voice. C1, $400 at TL8, $200 at TL9, $100 at TL10+.

Targeting: Each Targeting program adds to a Gunner skill – e.g., Gunner (Machine Gun) – for a single weapon or set of linked weapons. If more than one gunner is firing at a time, multiple programs must be run. A Complexity 1 program gives a +2 to skill and costs $1,000. Each time an additional +1 to skill is added, increase Complexity by one and double the cost. Halve the cost at TL9 and again at TL10+.

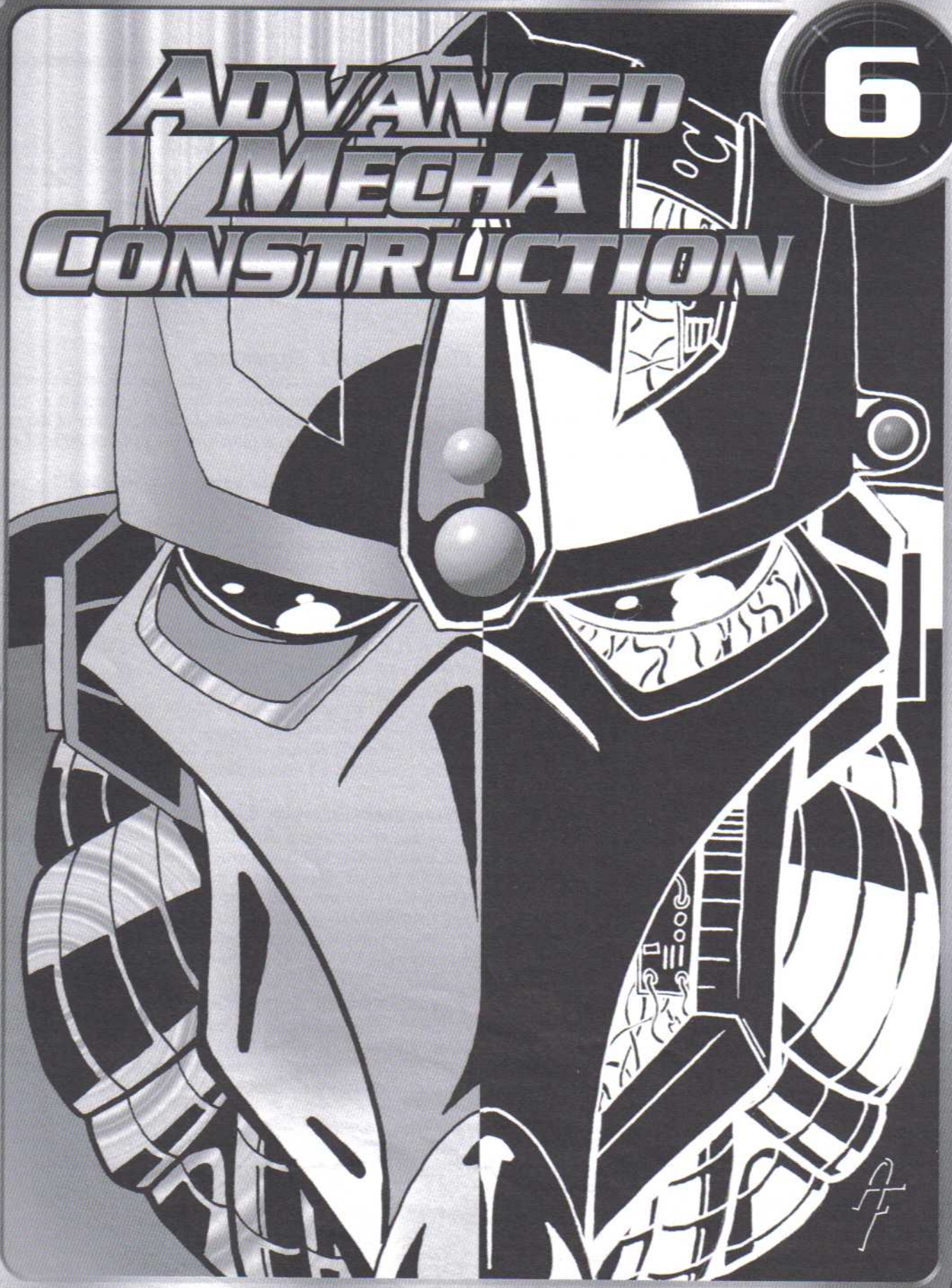
EXAMPLE: *Seraph Delta's computer has Complexity 4. We install a +5 Targeting program (C4, $4,000) and Datalink (C1, $200).*

Appendix 4: Mecha and GURPS Space

GMs with ***GURPS Space*** may wish use the abstract combat system presented there to resolve battles between mecha and spaceships. See p. CII100 for firepower (FP) and defense factor (DF) conversions.



6 Advanced Mecha Construction



This chapter is a grab-bag of optional rules for mecha design. It's up to the GM which, if any, are available.

BATTLESUITS

A battlesuit is a mecha that has a *battlesuit system* instead of a cockpit. The pilot's arms and legs extend into the suit's limbs (see *Wearing Battlesuits,* below).

A battlesuit is designed to carry only a single person, and must have the same basic shape as the intended wearer.

Most battlesuits are fairly light-weight, with a suggested target weight under 4,000 lbs. This is more a matter of practicality than a general rule. Where small size is not critical, it is better to build a mecha with a cockpit.

There are many possible types of battlesuits, including:

Infantry Battlesuit: Built to enable one trooper to carry the same heavy weapons as an infantry squad, while protecting him with armor and ECM against small-arms fire, radiation, chemicals and artillery barrages. The suit usually has DR 100 to 200. Typical weight: 500-2,000 lbs., including wearer.

Ranger, Scout and Command Battlesuits: These are specialized infantry suits. Ranger suits emphasize speed, electronic countermeasures and stealth. Scout suits have superior sensors, more speed and often extra thruster fuel. Command suits have better comsuites and often superior speed.

Light Battlesuit: A suit specialized for close-range combat, small enough to easily move within buildings, vehicles and spaceships. They are used by shipboard marines, commandoes, SWAT teams, superheroes and pirates, and are usually DR 70-150. Typical weight: 400 to 500 lbs.

Super Battlesuit: One worn by a superhero or villain. Super battlesuits are usually light-weight, but use very high technology – often two or more TLs above the norm. Some are totally unarmed, relying only on high-strength arm motors, while others bristle with exotic weaponry; most fly.

Powered Exoskeleton: A non-combat battlesuit, also called an "exosuit" or "power loader." They perform manual labor, exploration, rescue and construction tasks. The bare-bones design consists of leg and arm motors, battlesuit system, power supply and the suit's structure. The suit often has no armor or open-frame armor, but some "armored exosuits" are built for operations in very hostile environments. Typical weight: 200-2,000 lbs.

Battlesuit Design

A battlesuit is built like any mecha, with these exceptions:

Target Weight: It's a good idea to aim for a weight between 250 and 5,000 lbs. (including the pilot). Heavier designs should generally be built as cockpit-equipped mecha.

Step 1 – Choose Subassemblies: Battlesuits must be species-compatible, with the same number of arm or leg subassemblies as the intended wearer.

Step 6 – Cockpit: Instead of installing a cockpit, give the mecha a *battlesuit system* and, possibly, battlesuit upgrades. It can only have one battlesuit system.

Step 16 – Volumes: Unless you are designing a *master-slave battlesuit*, the volume of the suit's body cannot exceed the *pilot weight*/10.

Step 20 – Environmental Protection: A battlesuit can only be sealed if it either has a turret or is a master-slave design (p. 96) with the pilot in the body.

Battlesuit System

A *battlesuit system* consists of space for the suit's operator, plus the suit's control system. Decide on the suit's "pilot weight." This is the maximum weight of the wearer of the suit; with minor adjustments, a pilot with as little as 80% of that weight can also use it.

Weight: The system, including pilot, weighs 1.2 × pilot weight (in lbs.).

Volume and Location: The system must occupy certain locations, where it takes up volume. It requires pilot weight/100 cf in the body, pilot weight/1,000 cf in each arm, pilot weight/400 in each leg. If a turret is installed, the battlesuit system requires pilot weight/400 in the turret.

Cost: The battlesuit system costs $3,000 + (pilot weight × $20) at TL8. This drops to $1,500 + (pilot weight × $10) at TL9, or $750 + (pilot weight × $5) at TL10+.

Power: Negligible.

A Normal battlesuit torso should be small enough that its pilot's limbs will extend into the suit's limbs. Unless it's a master-slave model, design the suit so that the volume of the mecha's *body* doesn't exceed pilot weight/10 cf.

Master-Slave Battlesuits

Instead of occupying the turret, body, arms and legs of the suit, the pilot may be placed entirely inside its body or turret. He controls the suit using small, interior "master" arms or legs which sense the user's attempted movement and transmit signals that control the external "slave" limbs.

This system has the same weight and cost as above, but takes up pilot weight/50 cf in either the body or the turret.

Battlesuit Upgrades

Unlike a mecha cockpit, the basic battlesuit system does not come with anything except basic controls, padding and a head-up display. Life support and other features are entirely optional. For more details, see Chapter 3, *Mecha in Action.*



The following upgrades can be added to a battlesuit:

No Faceplate: The mecha has no vulnerable visor. The pilot relies on sensors (usually a PESA, p. 47) to see out.

Suit Computer: A battlesuit system includes built-in dedicated computers for feedback control, but the suit may also be given a general-purpose computer to run software (such as a Targeting program). This upgrade gives the suit a voice-controlled personal computer with a Complexity of TL-6, but hardened to resist radiation and electromagnetic pulse.

NBC Kit: This allows the battlesuit to filter out air pollution and *n*uclear, *b*iological and *c*hemical (whence NBC) contaminants from otherwise breathable air. It also contains sensors that automatically detect radiation or known forms of contamination. Only usable on suits that will be sealed.

Limited Lifesystem: Taking this upgrade adds a life support system equivalent to that in a mecha cockpit. A standard suit limited lifesystem has six hours of air, but extra air can be added. Only usable on suits that will be sealed.

Full Lifesystem: Available at TL11+, this provides *indefinite* air via a small molecular recycling plant.

Extra Air: This option adds 6 extra man-hours of air.

Provisions: A suit can be equipped with a concentrated food and water supply in a handy helmet-mounted dispenser. The provisions can be consumed "hands-free" without taking off the helmet. The suit must have a turret or be a master-slave design.

Quick Access: This allows a battlesuit to be removed or put on in seconds rather than minutes; see *Suiting Up*, p. 41.

Trauma Maintenance: This adds a medical system to the suit. It uses a biomedical sensor to monitor the wearer's vital signs, and transmits that data to a superior officer on request, via comsuite. The user can also call it up on a HUD. The data adds +2 to Diagnosis rolls made for the wearer. The system also includes an auto-injector and 10 doses of drugs. The user can manually trigger it, or it can be preset to inject a specific drug if vital signs warrant it; e.g., a painkiller if injured or a stimulant if fatigued. This might also be remotely controlled by a superior officer. It could also be loaded with non-medical drugs; e.g., to trigger berserker rage. It has its own power supply (works for a year on an A cell) to make it independent of suit power loss. See ***GURPS Ultra-Tech*** for drugs.

Battlesuit Upgrades

Description	*TL*	*Wt.*	*Volume*	*Cost*	*Pow.*
No Faceplate	8+	–	–	–	–
Suit Computer	8	6	0.12	$5,000	neg.
Suit Computer	9	3	0.06	$2,500	neg.
Suit Computer	10+	1.5	0.03	$1,250	neg.
NBC Kit	8	10	0.2	$2,000	0.25
NBC Kit	9+	5	0.1	$1,000	0.25
Limited Lifesystem	8	37.5	0.75	$125	0.5
Limited Lifesystem	9	25	0.5	$125	0.5
Limited Lifesystem	10+	12.5	0.25	$125	0.5
Full Lifesystem	11+	20	1	$500	0.1
Extra Air	8	37.5	0.75	$125	–
Extra Air	9	25	0.5	$125	–
Extra Air	10+	12.5	0.25	$125	–
Provisions	8+	12	0.24	$6	–
if full lifesystem:	11+	2	0.04	$6	–
Quick Access	8+	–	–	$500	–
Trauma Maintenance	8	–	–	$2,000	–
Trauma Maintenance	9	–	–	$1,000	–
Trauma Maintenance	10+	–	–	$500	–

Weight, Volume, Location, Cost and *Power* are shown on the table above. Extra air is per *six hours* of air it provides; extra provisions are per day's food and drink.

Upgrades must be located in the body, except for computers, provisions and NBC Kits, which may go in the body or turret.

Battlesuit Performance

These differences apply to battlesuits:

Skill Required: A battlesuit over 50 cf in size uses Driving (Mecha). If 50 cf or below in size, it uses Battlesuit skill *unless* it meets the criteria for Exoskeleton skill: this means it must have no built-in weapons *and* any body armor must be either entirely open-frame or less than DR 30.

Handling Modifier: A battlesuit much larger than its operator is harder to control, due to the difference in size between the user's limbs and those of the suit. If the suit's Size Modifier is 3 or more greater than its pilot's, subtract (difference-2) from the wearer's effective Battlesuit skill. This is one reason why large mecha use cockpits and not battlesuit systems.

NEURAL INTERFACES

In some backgrounds, mecha may use a *neural interface* that links the pilot's nervous system with the mecha controls. This lets the user control the mecha or any of its systems mentally, as if it were part of his body. Neural interfaces often figure as an important part of a mecha story – for instance, they can explain why a 14-year-old can climb into a mecha cockpit and pilot it with little or no training.

An interface adds +4 to the user's skill when maneuvering the mecha, firing its weapons or using its electronic systems. A neural interface in a "species compatible" mecha gives a *further* +1 bonus to Driving and Piloting (but not Battlesuit) skill. There are several types of interface systems, differing in detail:

Surgical Neural Interface (TL8): The user's body is surgically linked to the mecha's controls. He can't come out! Installing a pilot takes surgery which requires a week's recovery. It takes half as long (and costs half as much) to remove a user.

Interface Web (TL9): Using this system requires the user to remove clothing, attach interface wires with electrode disks to all areas of the body and don a special crown or helmet. This takes 15 seconds. The user's body is then "put to sleep" and his nervous system synchronized with the mecha, taking three more seconds. He is then ready to control it. To leave the web takes the same amount of time: three seconds to shut down the interface and wake up, and 15 seconds to remove the connections (in an emergency, they can be ripped out in two seconds, but the interface can't be used again until repaired).

Auto-Interface Web (TL9): As above, but automated, cybernetic cables whip about the user like snakes, removing clothing and attaching themselves, which takes only three seconds, plus another three seconds to synchronize. The detachment procedure is just as swift.

Socket Interface (TL10): The mecha comes with a cable jack that plugs into the skull socket of anyone with an implanted neural interface (see *Interface Jack*, p. CI26). It takes two seconds to connect or disconnect the jack.

Neural Interface Helmet (TL10): A compact neural interface helmet is built into the mecha's cockpit or into the turret of a battlesuit. The user is connected when he puts the helmet on,

which takes two seconds. In a battlesuit, the helmet is part of the suit's helmet and connection occurs after a second of disorientation.

Induction Field (TL10): The user simply enters the mecha, turns on the system and is interfaced. No surgery, implants or helmets are required.

A neural interface is added immediately after the cockpit or battlesuit system is installed.

Neural Interface Table

Type	*TL*	*Wt.*	*Vol.*	*Cost*	*Power*
Surgical Interface	8	20	0.4	$10,000	neg.
Interface Web	9	25	0.5	$20,000	neg.
Auto-Interface Web	9	50	1	$40,000	neg.
Socket Interface	10	0	0	$500*	neg.
Neural Interface Helmet	10	3	0.06	$10,500	neg.
Induction Field	10	25	0.5	$50,000	neg.

* User needs an interface jack implant; the operation is $50,000, and it takes two weeks to recover (see p. CI26).

Weight, Volume, Cost and *Power* are per cockpit or battlesuit system. Halve cost one TL after the system appears and halve it again two or more TLs after it appears. The system must be located in the same location as the cockpit. In a battlesuit, it *must* go in the body if a surgical interface, interface web or auto-interface web, or in the turret if a neural interface helmet.

The TL shown is only a guideline: the GM can rule that interface systems appear at higher or lower TLs than those listed.

Interface Options

Any interface type can be built with one or more of these options. In some backgrounds, *all* neural interfaces will automatically have one or more of these options. For instance, if the GM wants interfaces to be rare and dangerous, they can all have feedback loops. Unless noted, these options don't affect cost, weight or volume. However, the GM may rule that hostile, weaker or feedback loop interfaces are half cost, or available a TL or two earlier.

Interface-Only: The mecha cannot be turned on and operated *except* by a neural interface – it lacks physical controls, or they must be used in conjunction with the 'face.

Interface Lock: This an interface that is programmed to only accept a user who has a specific genetic (or maybe personality or brainwave) pattern, or which requires a specific advantage (e.g., Intuition or Magery) to use. Some locks are attuned to one or more individuals (e.g., the mecha's creator), while others recognize family gene-lines. The "user list" can be hard-wired into the system (making it impossible to change); otherwise, any interfaced user can alter the lock's parameters. An interface lock is usually combined with "interface-only."

Hostile Interface: Using the interface to control this particular mecha is a disturbing or insanity-inducing experience. Make a Fright Check at -5 when the interface is first activated, and roll again every minute it is used. Users with the Interface Talent advantage (p. 34) need only make a Fright Check once, at no penalty, the first time they interface with that particular mecha.

Feedback Loop: The interface bonds the user so tightly with the mecha that he suffers injury if the mecha is damaged. For every full (mecha body HP/10) hit points the mecha loses, the user also loses 1 hit. If the interface is telepathic (see below), this occurs even if he's interfaced but *outside* the mecha! However, the interface is more sensitive: the user gets an extra +1 bonus to skill.

Weaker Interface: Instead of +4 to skill, it gives only +1, +2 or +3 to skill. If you like neural interfaces but want them to be less of a factor in the game, use this option.

Telepathic Interface: This device fits the mecha with psychotronic circuits that enable a telepath to control it. It is also typically fitted with interface lock. When inside the mecha and interfaced, the telepath gains the same effect as a neural interface, except that instead of a +4 skill bonus, the bonus is his Telecontrol skill/4, rounded down. Moreover, when outside the mecha, the psi can remotely operate the mecha at up to his normal Telepathy range! Doing so requires total concentration. Treat the psi as if he were on board, piloting the mecha through a neural interface, except that he gains no skill bonus from the interface and any skill he is using via the mecha (Pilot, Gunner, et cetera) cannot exceed his Telecontrol skill. A telepathic interface is 5× more expensive (100× if a socket interface).

EXOTIC WEAPONS

Nuclear Missiles (TL8)

Nukes are the ultimate weapon that a realistic mecha can carry. In some armies, even battlesuit troopers may be issued them. In others, they are "doomsday" devices, under strict control.

A medium or heavy missile (at TL8+) or light missile (at TL10+) may have a tactical nuclear warhead. A one-kiloton yield warhead does 12d×2,000,000 damage. For every 128 yards from the impact site, divide concussion damage by 4. Add $36,000 to CPS.

A heavy missile (at TL8+) or medium missile (at TL11+) may have a strategic nuclear warhead. A 100-kiloton nuke does 12d×200,000,000 concussion damage. For every 512 yards from the impact point, divide the damage by 4. Add $48,000 to CPS.

The additional ammo cost is halved at TL9-14 and halved again at TL15+.

Nuclear warheads produce radiation and (if the fireball touches the ground) radioactive fallout; see p. CII145 for details, or improvise the effects! Anyone in a sealed vehicle or suit will be fairly safe, but the GM can impose lingering deaths on unprotected victims.

Omni-Beam Projector (TL9)

This is a weapon that combines multiple beam weapons into one unit. It can only use one beam type at a time, but its user can decide which to fire before attacking. An omni-beam is lighter than buying multiple individual weapons, but more expensive.

To build an omni-beam, select at least two specific beam weapons; e.g., heavy x-ray laser and light flamer. Plasmablades, forceblades and plasmafausts can also be chosen. Each is a "subcomponent weapon." The omni-beam's weight is the weight of the heaviest subcomponent weapon (or one of them, if all are equal weight) plus 20% the weight of the other subcomponent weapons. The same applies to volume. The cost is *twice* the *combined cost* of all weapons! The power consumption and combat statistics are based on the weapon mode being used.

In combat, the user can decide which beam to use before attacking. Switching doesn't require a maneuver unless a plasma or force blade is chosen, in which case a Ready maneuver is required to turn it on, though no time is needed to deactivate it. While a forceblade is on, it can be used to parry, but using a different beam deactivates it; another Ready maneuver is required before it can be used to attack or parry again.

Combiner Beams (TL9)

A beam weapon can be built whose components are split evenly between two (or more) mecha. It can only be used when the mecha are in physical contact to establish a power connection. The advantage is that mecha can carry weapons too large for them to handle individually. The pilots of mecha with combiner beam weapons are often siblings, perhaps twins; the weapon symbolizes their fraternal bonds.

A power connection is achieved by physical contact between the mecha – usually by linking hands. The beam forms as a power discharge from both mecha and combines into a single beam. Only aimed attacks can be made with a combiner beam, and neither mecha may move on the turn they attack.

To make an attack, each gunner must roll to hit. Use the *least* successful roll to determine whether the beam hits. Results of critical failures apply to both mecha. The energy drain from firing the weapon is split evenly between the mecha.

Combiner beams can also be used if the mecha are designed to *combine* together (p. 106). In that case, it is simply treated as an ordinary weapon, without the restrictions given above, and only one attack roll is made, by the combined mecha's gunner.

To build a combiner beam weapon, decide what beam weapon will be installed. Choose how many parts, usually two, the weapon will have. The weight, volume, cost and power of each component is equal to that of the original divided by the number of parts. One component is installed in each mecha. There is no extra cost.

Wave Projector (TL9)

This option modifies a beam weapon to generate a fan-shaped wave of energy. In realistic campaigns, only flamer or plasma beams can be so modified. In cinematic games, any beam can be.

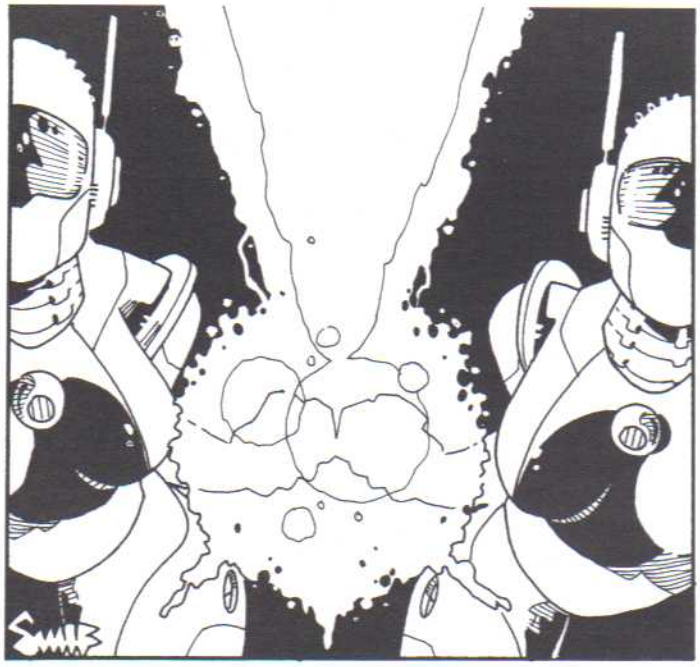
The area of effect starts out one hex wide, and its width increases by one hex to the right and left for each hex of distance until it reaches the fan's maximum width. Targets within the fan-shaped area are not hit automatically; the attacker must roll to hit (or miss) each individual target in the area. If the weapon has RoF 2+, it can fire multiple energy waves in a turn.

The weapon has a fan with a maximum width of one yard per +10% to weight, volume, cost and power. However, the energy wave projector has one-quarter the weapon's normal range.

This option is recommended for creating cinematic "main guns" for colossal super-mecha. Just take a big particle beam or flamer and augment it with a 100-hex-wide energy wave; the weapon will be about 10 times larger than normal, but will be very effective against massed enemies . . . or cities!

Baroque Weapons (TL9)

These are science-fantasy weapons that super mecha might use in over-the-top campaigns, or in fantasy or steampunk settings. The TL is arbitrary – feel free to adjust it up or down to fit the campaign.



Lightning Cannon: This weapon flings lightning bolts! Metal armor provides only PD 0, DR 1. If any damage penetrates the DR of a machine (like a mecha, robot or vehicle), it must roll 3d vs. its HT. Failure means its electrical systems short out, instantly disabling it for minutes equal to the amount failed by.

Wind Cannon: Fires a blast of air with the concentrated force of a hurricane! No attack roll is needed. It covers a cone-shaped area of effect, starting one hex in front of the weapon and extending out one hex in either direction for each hex of range. The attack *automatically* hits everyone in that cone unless they can use a retreating dodge to escape the area of effect. A wind cannon's damage counts as a hand-to-hand crushing blow for causing knockback. Even though full damage is counted for knockback purposes, the actual damage inflicted is only 1 point for every yard the subject is knocked back.

Power Lens: This device acts as an amplifier for the power of a mecha pilot who can use jet or missile spells or super powers. To design it, choose *one* spell or super power it can magnify (e.g., Fireball spell) and the amplification (e.g., ×10). If the pilot uses that spell or ability from within the mecha, damage and range are multiplied by the amplification.

Vibro-Cannon: This hideous weapon causes the target to vibrate rapidly! Neither PD nor DR of armor protects against it. Instead, subtract 1 from the damage for every full 1,000 lbs. the target weighs, as larger things are harder to vibrate. Deflectors and force shields protect fully, and force screens protect at one-tenth their normal DR. Optionally, a vibro-cannon may rely on sonic vibrations or musical notes; such weapons will not work in vacuum.

Flamers (p. 66) also make good baroque weapons.

Creating Baroque Weapons

Lightning Cannon: Use any TL9+ blaster or particle beam, but change Type to Cr. and give it half damage and range.

Wind Cannon: Use any flamer or plasma weapon with RoF 1, but change Type to Cr. and divide range by 10.

Power Lenses: These are 2.5 lbs., take up 0.05 cf, cost $1,000 and require 1 kW, all multiplied by the *square* of the amplification.

Vibro-Cannon: Use any flamer or plasma weapon, but change Type to Cr., and give it 1/5 normal damage and range.

OTHER ADVANCED COMPONENTS

Contragravity (TL12)

Contragravity (CG) is a means of artificially "screening" a mecha against a planet's gravity field, negating some or all of its weight. Not all backgrounds will have CG, since if it exists, there is little justification for giving a vehicle legs. However, many cinematic mecha designs use CG anyway!

If the mecha has contragravity, decide how many pounds of lift the CG generator provides. In order to fly, the lift should exceed the mecha's expected final weight. This lift is cumulative with the vectored thrust of a thruster – e.g., a 10,000-lb. mecha could fly with 4,000 lbs. of CG lift and 6,000 lbs. of thrust.

Note that CG cannot *propel* the mecha, only lift it, but a CG generator is more efficient than thrusters for this purpose. A mix of CG and thrusters is a very cost-effective design option. A CG mecha usually uses TL11+ reactionless thrusters (p. 80), but other types are fine. It's also possible to use *no* thrusters – the mecha would be able to jump long distances, or drift in the wind. Weight, volume and cost of a CG generator depend on TL:

Contragravity Table

TL	*Weight*	*Cost*	*Power*
12	(Lift/1,000) + 20	$(Lift/40) + $2,500	Lift/1,000 kW
13+	(Lift/2,000) + 10	$(Lift/200) + $500	Lift/1,000 kW

Weight, Cost and *Power* are based on the generator's pounds of lift. *Volume* is weight/50 cf.

Location: Contragrav generators may go in the body or in pods.

Personal Teleporter (TL16)

Some ultra-tech mecha are equipped with devices that allow them to teleport! These warp space around the mecha: it can vanish and reappear instantly at its destination, without crossing the intervening space. In some settings, these devices are TL12-15.

A personal teleporter is a component, rated for its jump capacity. The jump capacity must be equal to or greater than the mecha's loaded weight for it to function. It's a good idea to keep to a target weight when designing teleporting mecha!

Choose the jump capacity (minimum is 2,000 lbs.) and then determine the teleporter's statistics as follows:

Weight is 0.008 lbs. per *pound* of jump capacity.

Volume and Location: Volume is weight/50 cf. It can be located in the body or in any subassembly except wheels.

Cost is $7 per pound of jump capacity.

Power is 18,000 kW per pound of jump capacity, required for 1 second (i.e., 18,000 kWs of energy).

Making a teleport uses the same amount of energy regardless of the distance traveled, which can be almost infinite; however, the greater the distance, the more difficult the navigational problem. Roll vs. Piloting (Teleportation) to teleport without a problem. Some teleporters require a simple skill-10 roll without any other modifiers, regardless of distance; an alternative is to base the penalty on range:

Personal Teleporter Modifiers Table

Range	*Modifier*	*Range*	*Modifier*
1 mile	+2	1,000 miles	-1
10 miles	+1	10,000 miles	-2
100 miles	0	100,000 miles	-3

. . . and so on. If a range is between two numbers, use the higher to determine the modifier. If under one mile, treat as one mile.

Failure means the mecha misses its destination (by at least 100 yards or 10% of the distance teleported, whichever is greater) *and* the teleporter burns out. It will take a few hours of tinkering and an Electronics Operation roll to get it working again. Critical failure causes total destruction of the teleporter as well as stranding the mecha somewhere very far away – maybe in an entirely different dimension!

The teleporter circuits must always cool down after a jump, requiring at least one hour before further jumps are possible.

Space-Fold Drive (TL10?): More common in anime than hyperdrive, treat this as a teleporter, except it is used at -10 unless both the starting point and destination are in space.

TRANSFORMABLE MECHA

A transformable mecha mechanically alters its shape, shifting subassemblies and components like a Chinese puzzle.

Mecha usually transform for one of three reasons: to optimize their mobility for a specific environment (for instance, retracting legs and extending wheels while on smooth ground), to disguise the mecha as something it isn't, or to fold into a compact shape that is more easily stowed as cargo.

While at first glance this seems implausible, a lot of real-world vehicles "transform." As an airplane leaves the hangar of an aircraft carrier, for instance, it unfolds its wings, cruises down the runway and then, after leaping into the air, retracts its undercarriage – having completed a "transformation" from a wheeled ground vehicle into a streamlined aircraft. Some combat aircraft can further "transform" themselves by using variable-geometry wings, folding them back to reduce drag for high-speed flight, or forward for low-speed maneuvering.

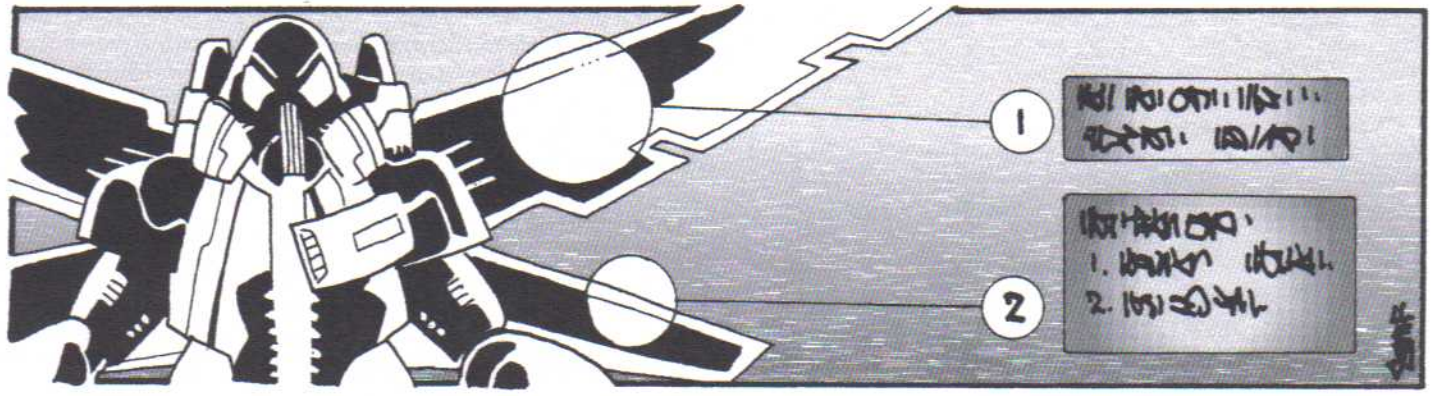
In a sense, mecha transformations are just wilder extrapolations of this: folding arms, turret and legs flush with the body during flight for better streamlining, or shifting wings or wheels out of the way when the mecha needs to fight on the ground.

Designing Transformable Mecha

A transformable mecha is built just like any other mecha, except for these additions to the design process:

At Step 1 – Wheel and Wing Subassemblies

A transformable mecha can be built with wings, wheels or both – subassemblies that would be awkward on an ordinary walking vehicle, but which can be folded out for use when they become necessary.



Wheels: Decide if the mecha has wheels. A transformable wheeled mecha can fold up its legs and unfold its wheels to go faster over smooth terrain like a paved road. If a mecha has wheels, decide how many wheel positions the subassembly has: two, three, or any even number over three. Unlike arms or legs, all are considered part of a *single* subassembly.

Wings: Decide if the mecha has wings. A winged mecha can fly faster (and with less thrust) than a wingless design. However, wings severely hamper a mecha's ground maneuverability until folded away. A winged mecha needs *two* wing subassemblies.

At Step 3 – Wheeled Drivetrain

If a mecha has a wheeled subassembly, it should be built with a wheeled drivetrain: a transmission or electric motor that transmits power to turn the wheels.

Select the wheeled drivetrain's motive power in kW. A mecha that can race along at about the same speed as a car or motorbike needs 30-40 kW per ton of target weight. If you have an exact speed in mind, the motive power needed to reach it, *per ton of target weight,* is kW = (speed in mph/16) squared.

A wheeled drivetrain's statistics are calculated as follows:

Weight: If the motive power is less than 5 kW, the drivetrain weighs 7.5 lbs. per kW. If the motive power is 5 kW or more, the drivetrain weighs 30 lbs. + (1.5 lbs. per kW).

Volume and Location: Volume is weight/50 cf, located in the body.

Cost: Cost is $20 × weight.

Power requirement is zero if the leg drivetrain's motive power is higher, as the wheels aren't used when the legs are. Otherwise, use the difference between the wheeled and leg drivetrains' motive power to find the additional power requirement.

Note that mecha drivetrains are assumed to use all-wheel drive.

At Step 5 – Thrusters

A mecha that has wings can fly with *considerably* less thrust than its weight, as long as its wings are unfolded. However, if its thrust doesn't exceed its weight, it will behave like an ordinary plane, unable to hover in mid-air or make vertical landings or takeoffs.

At Step 16 – Volume of Wings and Wheels

Determine the volume of any wings or wheels the mecha has *after* determining body volume.

Wings: Each wing has the volume of any components placed in it. However, minimum wing volume is 0.1 × body volume and both wings must have the same volume. Add empty space as necessary to fill out the required minimum volume or even-out the wings.

Wheels: If the mecha has wheels, the entire wheeled subassembly has a volume of 0.1 × body volume. This contains no components; the entire volume is filled with the wheels and suspension.

At Step 17 – Area of Wings and Wheels

If the mecha has wings or wheels, their area must also be calculated. Because wings are wider and flatter than other subassemblies, their surface area is doubled after it is calculated. Thus, a 20 cf wing would have area 100, not 50.

Wings and wheels add to total and structural surface area.

At Step 18 – Structure

In addition to choosing frame strength and materials, decide how many *configurations* the mecha has, and what they are. A mecha may have two, three or four configurations. The more it has, the more versatile, expensive and massive the mecha will be – see the *Mecha Structure Table,* p. 88.

Each configuration consists of a name (make this up!) and a list of which subassemblies are *folded.* A folded subassembly is one that is folded flush against the body.

Example: We decide a mecha with a turret, two arms, two legs and two wings has two configurations: "walker," in which its two wings are folded, and "flyer," in which its arms and legs are folded.

Some special considerations apply to what combinations of subassemblies can be folded in a configuration:

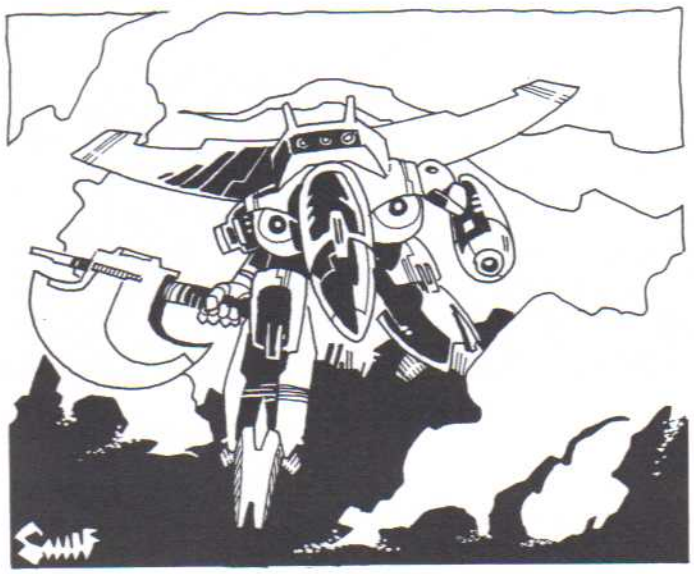
Legs: A configuration can fold some, none or all legs, but configurations with only one unfolded leg are not allowed.

Wheels and Legs: A configuration with unfolded wheels *must* fold all legs, and vice versa. A configuration with all subassemblies but wheels folded can be disguised as a car, truck or cycle, depending on its size and number of wheels.

Wings: Both wings must be folded at once. A mecha moving on the ground in a configuration that has unfolded wings suffers a severe MR penalty. If arms and legs are folded, a mecha with unfolded wings can pass as an ordinary airplane. If folding wings have pods attached to them, the pods must also fold.

Transformable Battlesuits: The wearer of a battlesuit occupies the arms, legs and turret as well as the body. For this reason, a battlesuit's configuration must have all of its limbs and turret folded or unfolded at once. (This rule does not apply to master-slave suit designs, where the wearer is in the body.)

Other Considerations: The more subassemblies that are folded, the more compact the mecha will be. In addition, folding subassemblies reduces aerodynamic drag; this means the more



subassemblies (other than wings) that a flight-capable configuration folds, the faster it will be able to fly! On the other hand, a folded arm, leg or turret housing weapons or sensors is less effective, as its arc of fire or vision becomes fixed.

Example 1: The Stormhawk (p. 73) has two arms, a turret, two wings and two legs. We decide it has three configurations, which we label "raptor," "plane" and "humanoid."

"Raptor" – No subassemblies folded. Lets the mecha switch quickly between moving on the ground and in the air without having to take time to transform; useful for combat near the ground.

"Plane" – Legs, arms and turret folded. This greatly reduces drag, allowing high-speed flight, but it can't move on the ground. The mecha can also disguise itself as an airplane.

"Humanoid" – Wings folded. With them out of the way, the mecha can't fly like an airplane, but it can maneuver properly on the ground and takes up less space in a hangar.

Example 2: The Kamen Panzer battlesuit (p. 73) has a turret, two arms, two legs and wheels. We decide it has two configurations, "cycle" and "humanoid."

"Humanoid" – Wheels folded, to make it species-compatible.

"Cycle" – Turret, arms and legs folded. The mecha can now race along on wheels and disguise itself as a cycle.

Performance

A different set of performance figures must be worked out for each configuration. Space performance will not change, but air and ground performance can vary greatly depending on which subassemblies are folded. The normal performance rules are modified by the effects of configuration as follows:

Ground Performance for Transformable Mecha

A configuration that has folded all ground motive subassemblies (i.e., legs or wheels) has no ground performance.

Ground Speed: Use the normal rules if the configuration has unfolded legs, basing speed factor on the number of legs unfolded. If the configuration has unfolded wheels, use the usual formula but substitute the wheeled drivetrain's motive power for the leg drivetrain's and use a speed factor of 16.

gMR and gSR: A configuration with unfolded legs uses the table on p. 92 based on its number of unfolded legs. However, if it has *unfolded wings,* its gMR cannot exceed 0.5. Also, a folded limb doesn't count toward species compatibility – e.g., a human-piloted mecha must have exactly two unfolded arms and two unfolded legs to get that gMR bonus.

A configuration with unfolded wheels uses a completely different table to find gMR and gSR:

Wheeled gMR/gSR Table

Type of Motive System	*Mecha's Body Volume (cf)* 30 or less		31 to 100		101 to 300		301 to 3,000		3001 or more	
	gMR	*gSR*	*gMR*	*gSR*	*gMR*	*gSR*	*gMR*	*gSR*	*gMR*	*gSR*
2 wheels	1.75	2	1.5	2	0.75	2	0.5	2	0.25	2
3 wheels	1.5	2	1.25	3	1	3	0.5	4	0.25	4
4-6 wheels	1.25	3	1	4	1	4	0.75	4	0.25	4
8+ wheels	1	3	0.75	3	0.5	4	0.5	5	0.25	5

There is no species compatibility bonus if moving on wheels. If the mecha has unfolded wings, gMR cannot exceed 0.5.

Ground Move: This is found normally, based on the configuration's top speed and gMR.

Air Performance for Transformable Mecha

A configuration with both unfolded wings and thrusters may be able to fly even if its lift does not exceed its weight.

Effective Motive Thrust: If the configuration has unfolded wings, effective motive thrust now equals the combined thrust of all thrusters. (That is, effective weight is no longer subtracted from motive thrust.)

Aerodynamic Drag and Aerial Top Speed: If the configuration has *any* folded subassemblies subtract *half their area* from surface area before calculating the configuration's aerodynamic drag. Then calculate top speed normally, based on the configuration's effective motive thrust and aerodynamic drag.

Aerial Maneuver Rating: If the configuration has unfolded wings, a different formula is used to determine its aMR:

aMR = (Whp/Lwt.) × (TL+1) × 30.

Where *Whp* is the sum of both wings' hit points, *Lwt.* is loaded weight in pounds and *TL* is the tech level of the wings. Round to the nearest half or whole number.

Aerial Stability Rating: Calculate aSR normally, but add +1 if the mecha has unfolded wings (unless it also has radical stealth).

Flight Move: Calculate Move normally, based on the configuration's top speed and aMR.

Stall Speed: A configuration with unfolded wings will have a *stall speed* if the sum of its thrust and contragrav lift is less than its weight. The configuration must be able to reach stall speed in order for its wings to provide enough lift to fly. Once it is airborne, it cannot fly slower than this stall speed without stalling, which means it will lose control and start to fall out of the air.

Stall speed depends on the configuration's *lift area.* This is found by adding the entire combined surface area of both its wings to 10% of the area of the body. Use lift area and the formula below to calculate stall speed:

Stall Speed = [(Lwt. - Lift)/Lift Area] × Sl × 2 mph.

Where *Lwt.* is loaded weight in pounds, *Lift* is equal to the sum of contragravity lift and vectored thrust and *Sl* is 1 if no or "fair" streamlining, 1.05 if "good" streamlining, 1.15 if "superior" or 1.3 if "radical." Round stall speed to the nearest 5 mph.

Other Configuration Effects

In addition to altering performance, the new configuration may restrict how certain subassemblies or components function:

Using Arms, Turret and Legs: When folded away, these subassemblies can't move or rotate. Each folded subassembly – including the turret – is locked into *one* facing, which must be chosen when the mecha is designed. Any ranged sensors or weapons that are mounted in a folded subassembly still work, but they can now only fire or look in the direction the subassembly is pointed. Melee weapons in folded subassemblies cannot be used at all.

Using Hand-Held Weapons: A hand-held ranged weapon that was held by an arm that was folded during the transformation is still held, but is locked into the same facing as the arm, and may only fire in that direction. A hand-held melee weapon held by a folded arm cannot be used.

Auto Disguise: A mecha with wheels unfolded and all other subassemblies folded can be mistaken for a wheeled vehicle: a dirt bike (two wheels), powered trike (three wheels), car or van (four wheels) or truck (six or more wheels). A folded turret forms part of a cab. A mecha whose wheels and turret were unfolded might be mistaken for an armored car.

Battlesuit Systems: When a battlesuit (except a master-slave design) folds arms, legs and turret, the suit's body opens up to form a cycle seat and the wearer find himself riding it. He is completely outside its structure and armor. When it transforms back into a species-compatible configuration, the mecha instantly enfolds the rider in the process, who is now wearing the battlesuit again.

Activating a Transformation

Transformation between configurations can be initiated by the mecha pilot at the start of any turn, and takes two seconds to complete. On the first turn, the mecha is assumed to be in the configuration it was in before transforming; on the second, it is in the configuration it is transforming into. At the start of its third turn, it has fully transformed.

In the two seconds a mecha is transforming, it can move, but cannot jump, attack or change facing or direction. A transformation can't be aborted once started! A transforming mecha can use active defenses normally, but some configurations will prevent some defenses; e.g., a configuration with an MR under 1 cannot dodge, and one with no arms can't parry.

EXOTIC STRUCTURAL OPTIONS

These options can be added in *Step 18 – Structure.*

Biomechanical Structure (TL9): A mecha with this option is a living (though non-intelligent) entity, although it may also have non-living components grafted onto it. The mecha is self-maintaining and heals 1 hit point per day for its body and each subassembly on a successful HT roll. However, it can also become infected with diseases (GM's option). This option multiplies the *structural cost* of the mecha by 1.5.

Living Metal Structure (TL13): This gives the mecha a structure built of living metal, a nanotech material that is capable of regeneration. The tiny "nanobots" contained within the living metal structure repair damage to the mecha at 1 hit point per hour (as long as it isn't utterly destroyed). They also perform routine maintenance and repair other components. If the mecha has ablated or damaged armor, this also regenerates at the same rate. A living metal structure enables the mecha to dispense with regular internal and external doors – it "opens" a hole to allow access, then seals it afterwards. A living metal structure cannot be combined with a biomechanical structure. Double the *structural cost* of the mecha.

Foot Rollers (TL8)

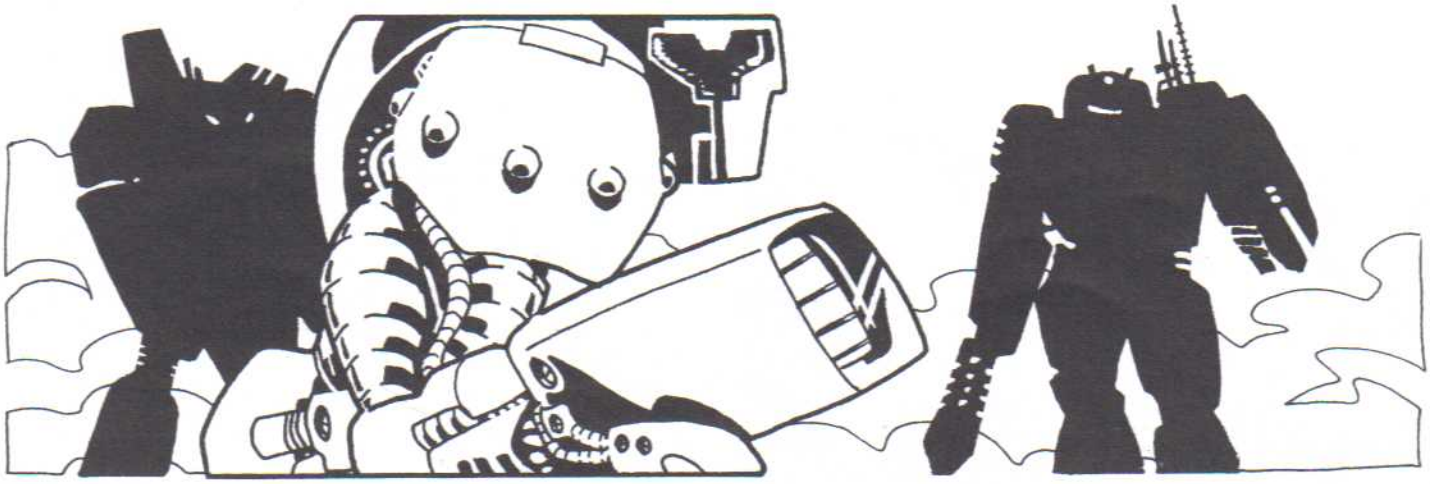
Legs can be fitted with small, semi-retractable rollers in their feet, allowing the mecha to move swiftly over smooth ground as if on roller skates. Foot rollers are added after Step 18, once the mecha's structural weight and cost have been calculated.

Weight: 0.05 × (combined leg area of mecha/total area of mecha) × mecha structural weight.

Cost: $100 times their weight.

Weight and cost are for *all* the mecha's rollers; there is no significant increase in volume.

Using Foot Rollers: A mecha pilot can decide to extend and use them at the start of any turn that the mecha is walking on flat, hard-surfaced ground, such as a floor or paved road. Using foot rollers modifies ground performance with legs: +20 mph ground speed, +10 to enhanced Move, -1 gSR. A mecha's Dodge when using foot rollers drops to Battlesuit/3 or Driving (Mecha)/3.



ARMOR OPTIONS

Armor and Facing

On some mecha designs, extra DR is added that protects a particular face of a body or turret, rather than the entire location. The faces are front, back, right, left, top and (except on a turret) the underside. Use only one-sixth the normal surface area of the location to calculate such armor's weight and cost. The armor will only protect against attacks from that direction.

Open-Frame Armor

Any kind of armor can be an open framework, much like a roll cage. This is common on labor mecha and exosuits. It protects normally vs. collisions, falls, rolls or swinging melee attacks, but has only a 2-in-6 chance of protecting vs. thrusting attacks, beams, arrows, bullets or other small missiles. It has no effect at all against flamer or flamethrower attacks or explosive concussion damage. Open-frame armor has 1/5 normal weight; as cost is based on weight, this will make it cheaper.

A mecha with open-frame armor cannot also be streamlined, waterproof or sealed.

Cheesecake Armor

Battlesuits may be built with "cutaway panels" on the arms, legs and torso. Ostensibly, this is to reduce the weight of the suit. Actually, it is used in gladiator or superhero battlesuits to provide a better view of the wearer's physique!

Cheesecake armor on body, arm or leg subassemblies weighs half as much. Its PD is -1 and its DR has only a 50% chance of protecting vs. an attack. Cheesecake armor on the arms or legs always protect against damage to hands or feet.

A suit using cheesecake armor cannot be sealed or waterproof, and may not have life support unless it has a deflector screen.

Compound Armor

It is possible to layer a body or subassembly with different types of armor: for example, metal armor with an additional layer of ablative armor underneath. Layered armor DR is added together, but keep track of the individual DRs of the layers because of their special characteristics. E.g., if DR 25 laminate armor is layered over DR 20 metal armor, the laminate DR is doubled against shaped-charge attacks, but the metal armor's DR is not.

If ablative armor is layered under other armor and is destroyed, the armor atop it will also be destroyed!

Exo-Armor Husk

An exo-armor husk is a second, outer layer of armor that is attached to the mecha by explosive bolts. In an emergency, it can be blasted off to reduce weight. This is useful for situations where speed is more important than protection – e.g., racing to the rescue, pursuing an arch-enemy or making a quick getaway.

Buy it exactly like a second layer of armor covering the entire mecha, but add 10% to its weight (which will increase its cost by 10% as well).

Calculate two sets of DR and PD: one with and one without exo-armor. When the mecha is complete, calculate two sets of weight and mass figures: one with the exo-armor husk's weight included and one excluding it. Do the same for any performance calculation in which the mecha's weight or mass is important.

Using Exo-Armor Husks: Normally, the mecha functions using the "with exo-armor" statistics. However, at the start of any turn, the pilot can jettison the exo-armor. Switch to the "without exo-armor" sets of statistics for PD, DR and performance. An exo-armor husk that has been ejected is considered destroyed. A new husk can be added at 50% of the cost of the original, since the connections, et cetera are still there.

Defensive surface features like stealth do not function until the exo-armor is ejected. (Optionally, the mecha's defensive surface features may be attached to the exo-armor husk. Add their weight to the husk; this weight will be shed when the husk is ejected, but the defensive features will be gone too.)

EXOTIC SURFACE FEATURES

Psibernetic Web (TL9)

A mecha can only be given this option if it has a neural interface system. A psibernetic web covers the mecha with a surface web of psi-reactive material, enabling it to function as an extension of the user's body with respect to psionic powers.



Design: This is a surface feature, like a stealth system. It consists of two parts. First, the neural interface system of the mecha is 5 times more expensive (100 times more if a socket interface), unless the mecha already has a telepathic interface. Second, the psibernetic web itself weighs one pound per sf of the mecha's surface area and costs $1,000 times the mecha's area. These costs halve at TL10 and again at TL11+.

Use: For purpose of psionic abilities, the mecha's body is treated as the pilot's; so if a psi power requires a touch, contact with the mecha is enough for it to work. It also means (for instance) that a Mind Sword blow that hits a psibernetic mecha's leg effectively strikes the pilot's leg. (Areas that don't match the pilot's body, like wings, are treated as touching his torso.) This can also extend to magical attacks hitting the mecha, if they affect the mind or soul.

Some psi skills that normally affect only the user's body now affect the mecha. This is the result of the self-image of the wearer and mecha becoming one. Only a few skills are affected, but the results are dramatic!

Energy and PK Shield: The shield covers the entire mecha. Also, if the mecha has 10 or more body hit points, the shield is stronger: it provides DR equal to the mecha's (body hit points/10) rounded down *per level of Power!*

Levitation: The entire mecha levitates. Instead of getting an ordinary +10 bonus to PK Power for purposes of levitation, add a bonus (p-5), where *p* is the minimum PK Power needed to levitate the mecha's weight. Thus, Power 5 or more can levitate the mecha. Higher Power allows faster flight.

Healing: The user can heal the mecha as if it were his own body. Another psionic healer touching the mecha can heal the mecha or the user as desired.

Surge and Dampen: The psibernetic web makes the mecha immune to these two psionic attacks.

Photokinesis: If the pilot uses this to blur himself or turn invisible, it affects the entire mecha.

Aspect: The entire mecha radiates the Aspect.

Mind Sword: This ability can only be used from within the mecha if it has a manipulator arm, but the mind sword's reach is now twice the reach of the mecha's arm. Damage is the same, but since it can reach through DR, this isn't much of a problem – the reach should allow the mecha-piloting psi to slice into a non-psibernetic mecha's cockpit to affect the enemy pilot (whose Mind Shield will protect normally).

Autoteleport and Combat Teleport: The entire mecha teleports with the pilot!

Skills listed here that are not in the ***Basic Set*** are described in ***GURPS Psionics.*** *Note:* Astral Projection is *not* affected – the mecha always remains behind!

Force Fields

These systems allow the mecha to generate one or more types of protective force field around it. Force field grids are added as part of a mecha's surface features, just before armor is installed. The mecha *must* have a power plant with enough excess power left over to run the screen, or have an energy bank the field can drain energy from. Since the power requirement of a force field is based on surface area, which won't be known until *after* power systems are installed, it is a good idea to run the force field off an energy bank rather than a power plant.

Deflector Screen (TL11): This adds to a mecha's passive defense, warping space to deflect energy beams and physical projectiles. It is visible as a faint shimmer around the mecha. It can also keep out rain, wind and atmospheric contaminants. It gives PD 8 (not cumulative with other PD).

Force Shield (TL11): Only available if the mecha has arms, this is a deflector field in the shape of a shield. It has PD 6 (cumulative with other PD, to a maximum of PD 8) and only protects the front of the mecha. It also be allows a Block defense at Force Shield skill/2.

Force Screen (TL12): Surrounds the mecha with a barrier that provides damage resistance (DR). It does not increase PD, but may be used with deflectors. Its DR is always applied before armor DR. Force screens don't hamper the mecha's own fire.

A force screen can be overloaded by a powerful attack. If the damage from a single hit (or total burst damage from an automatic-fire laser) exceeds *half* the screen's DR, the force screen *gains* an "energy level"; if the damage *exceeds* the force screen's DR, it gains two energy levels. The screen will often glow, climbing up the spectrum from red to violet as it gains energy levels. Upon gaining eight levels, it overloads, and the generator melts and is destroyed.

A force screen sheds one energy level every 10 seconds, radiating energy in the form of neutrinos and visible light. It cannot be turned off safely until it has shed all accumulated energy levels. If turned off prematurely, the shield generator overloads and is destroyed.

Force screens do not block slow-moving objects (under a few yards per second), so one *can* (slowly) walk through a screen. They can't be penetrated by active sensors (such as radar or ladar), although the presence of the field can be detected.

Force Field Grid Table

Type	*TL*	*Weight*	*Cost*	*Power*
Deflector	11	0.1	$250	3.6
Deflector	12	0.05	$125	3.6
Deflector	13+	0.025	$112.5	1.8
Force Screen	12	0.004	$5	0.01
Force Screen	13	0.002	$2.5	0.01
Force Screen	14	0.001	$1.25	0.01
Force Screen	15+	0.0005	$0.625	0.01

Multiply weight, cost and power requirement by the mecha's total surface area. For force screens, also multiply weight, cost and power by the desired *damage resistance* of the screen. Thus, a screen with DR 1,000 has 1,000 times the listed weight, cost and power requirement per sf. Minimum force screen DR is 100.

Force shields have half the weight, cost and power of deflectors. They must be designated as built into an arm.

OVERLOAD BOOSTERS (TL10)

An *overload booster* is a system that allows all propulsion, energy weapon and force field systems to perform at far greater than normal efficiency for a brief period of time – at the cost of eventually burning them out!

Design: Add this system after the mecha has been totally designed but before price has been calculated. Its cost equals the combined cost of all leg drivetrains, arm motors, thrusters, beam weapons, built-in contact *energy* weapons (plasmafausts, forceblades, et cetera), power plants, energy banks and force fields. The system has no weight, volume or power consumption, nor does it have an actual "location."

Use: The overload booster can be activated at the start of any turn, with the following effects:

1. The mecha's Arm ST is doubled.
2. The mecha's MR, speed, Move and (if using ***GURPS Vehicles***) acceleration scores are increased by 50%.
3. The damage of all built-in beam and contact energy weapons (plasmafausts, plasmablades, forceblades, et cetera) doubles!
4. The DR of any force screens the mecha has doubles. Deflector or force shield PD is +1.
5. The mecha begins to hum with power. In over-the-top style games, it may glow with energy.

The overload booster can be operated for as long as desired. However, each turn it is in use, roll 1d. On a 6, total overload occurs. Circuit breakers pop, sparks fly and the mecha loses its

bonuses. Worse, until the mecha has been repaired, it takes these penalties:

1. The mecha's Arm ST is 2/3 normal.

2. The mecha's MR, speed, Move and acceleration scores are decreased to 2/3 normal.

3. All beam weapons and contact energy weapons cease to function.

4. All force screens and deflectors cease to function.

5. The overload booster will not work.

The damage can be repaired by shutting down the mecha and replacing blown circuits, black boxes, et cetera. No actual physical damage was taken, so this requires Electronics Operation skill; roll every 4 hours to get things working properly again.

Empathic Overload Booster (TL11)

This is a specialized version of the overload booster, designed to convert emotional energy into raw power. The mecha psychically synchronizes with its crew and temporarily exceeds its normal operating parameters in extreme circumstances. It is only suitable for over-the-top campaigns! A good, cinematic example of this kind of booster can be seen in the anime *Iczer One*.

Design: An empathic overload booster can be added to any mecha with a neural interface system. It costs the same as an *overload booster* (above), plus an extra $1,000,000. A mecha can have both empathic and regular overload boosters – their effects, if used together, are *cumulative*.

Use: The device can be triggered if any of the mecha's crew can couple a powerful emotion, like love, with a burning need for more power. Simple fear of one's own death is not enough to trigger it – what is required is something like an urgent desire to protect or avenge a loved one. The GM decides whether a character's feelings are strong enough to trigger it. If so, roll vs. the user's Will-4 see if it is triggered, with a +2 bonus for characters with Empathy and a +2 if Dependents or a Sense of Duty are involved.

Success: If the Will roll succeeds, the user successfully synchronizes with the empathic booster. The mecha glows with power as the booster channels and amplifies the pilot's emotional energy, supercharging the mecha's energy systems exactly like an overload booster (p. 105). Unlike an overload booster, the effects endure for the length of the crisis and there is no damage to the mecha afterward!

Failure: If the Will roll fails, the character can't try again until the situation produces even *more* emotional angst (which is at the GM's discretion).

Example: Akiko, pilot of the empathic booster-equipped Zephyr Knight, is fighting her way into an enemy fortress when a half-dozen foes arrive and bar the way! Only two minutes remain before her lover, Sho, is due to be executed by the renegade mercenary, Colonel Vulture. Akiko's player tells the GM she thinks the Zephyr Knight's empathic booster will trigger, due to her fear Sho will die if she doesn't trash these new foes quickly. The GM agrees and allows Akiko a Will roll.

Akiko has a Will of 13, which would give her a 9 or less. Her Sense of Duty to Sho adds +2, for an 11. Unfortunately, she rolls a 12! Her mecha gets no boost. She fights on anyway, but arrives a few seconds too late, and Sho is dead! Sobbing over his broken body, Akiko spots Colonel Vulture trying to slink away in his own mecha. She wipes her eyes and cries out that Sho will be avenged! The GM allows another Will roll – this time Akiko succeeds. The vengeful Zephyr Knight glows with power and Akiko accelerates at super-boosted speed toward her prey.

COMBINING MECHA

It's possible for two or more mecha to combine to form a single machine. Such designs are complex, since multiple sets of performance statistics are required for them when they are separated, plus an additional set when they are combined.

Core/Shell Mecha

This is the simplest type of combining mecha, and the only one recommended for realistic campaigns. A smaller "core" mecha is built *within* a larger mecha "shell." The core contains the mecha pilot, enabling him to escape or fight on in a smaller mecha after the outer shell has been crippled or destroyed.

The Core

Build the core first as either a battlesuit or a drivable mecha, using the normal design rules. Some core designs omit arms and legs, and propel themselves entirely through thrusters. These flying "escape pods" can be armed, and will have an aerial performance but no ground performance.

The Shell

After the core is finished, build the larger shell. It is built like a normal mecha with several exceptions:

1. The shell may not have a battlesuit system and does not *require* a cockpit, since the core mecha's cockpit or battlesuit system controls the shell.

2. The shell may omit power systems if desired, using the core mecha's power system. Alternatively, the power produced by the core mecha can be used *as well as* any power system in the shell. While the core is inside the shell, its power need only be used to provide the core's cockpit power requirement – all other power can be diverted to the shell's systems.

3. The shell mecha requires weight and volume in its *body* for the core mecha and connections. The "core system" (with mecha) is 1.2 lbs. per pound of core mecha loaded weight, takes up volume equal to the core mecha's volume and costs $3,000 + ($20×core mecha loaded weight). Cost halves at TL9 and again at TL10+.

4. When the core mecha is inside the shell mecha, the combination is referred to as the "combined mecha." The combined mecha is controlled by the core's pilot (and any other core mecha crew). The only systems the core can use while inside the shell are its power systems and controls. If the core and shell separate, the shell can function on its own if it has a power system and has a manned cockpit or is remotely piloted by the core mecha (see below).

If the shell can function independently of the core, it will also need a second set of performance statistics, minus the weight of the core and with any changes that might be required due to the loss of the core systems.

Core/Shell Mecha in Play

Damage to the combined mecha affects only the shell, not the core, with one exception: if an explosion or fire does damage that penetrates the DR of the shell's body, one-quarter of



that penetrating damage is also inflicted on the body of the core mecha. The core's DR protects against this damage, however.

The core can separate from the shell (or its wreck) at any time. This takes two seconds and splits the mecha into independent shell and core; a hatch slides open, magnetic bolts are released and out pops the core. Once independent, the core's statistics are those of the original core mecha design. The core and shell may rejoin into a combined mecha. This requires contact and takes two seconds.

Remote Control: The shell can be remotely operated if the core remains in communicator contact with it and runs a Datalink program. As the systems for controlling the shell are already in place, no other hardware or software is required. However, if the pilot wishes to control *both* core and shell at once, all of his mecha-related skills will be at a -2 penalty.

Super Combining Mecha

A group of mecha (called "sub-mecha") can be designed to combine into a single, larger mecha (called the "combined mecha). To design such a mecha, follow the steps below:

First, choose the combined mecha's subassemblies as if you were designing a normal mecha. Next, design each of the sub-mecha using the standard rules, but observing the following restrictions:

1. Each sub-mecha will be assigned either to one of the combined mecha's subassemblies or to its body. Any number of mecha can be assigned to a given limb, but at least one must be assigned to the body, and none can be assigned to wheels or wings.

2. Any subassembly that does not have at least one mecha assigned to it (*including* wheels and wings) must have a subassembly of the appropriate type assigned to it from one of the sub-mecha that forms the *body;* e.g., if the combined mecha has a turret and no sub-mecha are assigned to it, the turret of one of the mecha forming the body must be assigned as the combined mecha's turret.

3. Each sub-mecha must have a transformable structure (see p. 88), and one of its configurations must be set aside as its "combiner configuration." This configuration must have *all* of its subassemblies folded, unless that subassembly has been assigned as one of the combined mecha's subassemblies. The system necessary to combine the mecha is integral to the mecha's transforming structure.

Find the volume of each of the combined mecha's subassemblies by adding together the total volumes of all sub-mecha assigned to that subassembly. If a sub-mecha's subassembly is assigned as one of the combined mecha's subassemblies, use its volume instead. All of the mecha's legs must have the same volume, and their total volume must be at least 60% of the body's. Likewise, its wheeled subassembly and each of its wings must have at least 10% of the body's volume. If these conditions aren't met, redesign the sub-mecha which make up the legs or provide the wings and wheels.

Combined Performance

Use these rules when the mecha have combined:

Combined Statistics: The *combined* mecha's empty and loaded weight and mass are equal to the sum of the respective statistics of *all* sub-mecha. The same is true of combined volume, which is used to find a combined Size Modifier. *Don't* work out a combined HT, however. Calculate dimensions by plugging the volumes of the combined mecha into the applicable formulae on p. 91. The combined mecha's Arm ST is found by adding together the ST of every body and arm of the sub-mecha assigned to the arm in question.

Combined Ground Performance: The combined mecha's effective motive power is found by adding together the motive powers of every drivetrain found in the mecha's legs, plus 0.002 kW × the total ST of every arm motor found in the leg. Calculate ground performance using this motive power and the combined mass. Streamlining is the *lowest* among all the sub-mecha forming the combined mecha. gMR and gSR are based on the *combined* body volume.

Combined Aerial Performance: This is also based on the new combined statistics. Motive thrust and contragrav lift from *all* the combined mecha are additive. Aerodynamic drag is calculated individually for each of the sub-mecha, then added together.

Combined Space Performance: This is based on the combined weight of the mecha and the total thrust of all space propulsion systems.

Stealth, IR Cloaking and Chameleon Systems: If the mecha in the combination have different levels of any of these systems, the *least* effective system is used; e.g., if one sub-mecha has basic stealth, one has radical stealth and one has none, the combined mecha has no stealth.

Transforming: The sub-mecha cannot transform once combined.

Super Combining Mecha in Play

Combining: All the mecha in a combination must move into contact to combine. If flying, the GM can require skill rolls to avoid collisions! Combining requires activating various physical, magnetic or nano-locking systems and takes two turns, during which the mecha can do nothing else. Combining is impossible if any of the sub-mecha has a disabled body. A core/shell mecha must be joined together before it can form its part in a combination.

Control: The combined mecha is piloted by *one* of the sub-mecha, designed when the mecha is built. The other crews, if any, may operate ranged weapons, communications, ECM or sensors allocated to them by the command pilot. Note that it is possible for some mecha in the combination to be unmanned: they simply become non-functional when they are not combined.

Combat: The attacker decides which combined mecha location to target. If a location contains multiple sub-mecha, determine randomly which sub-mecha is hit; damage is resisted by that sub-mecha's body DR and is applied to its body hit points. If the *body* of any sub-mecha is disabled, the combination breaks up.

Separating: Any of the involved mecha pilots can choose to break up the combination. This takes one turn. After separation, the mecha end up adjacent one another.

Energy and Fuel: These can be transferred between mecha while connected (fuel is limited to 190 gallons/minute).

EXOTIC TECHNOLOGIES

These rules drastically modify the way mecha are built. Decide whether they will be used before the design is started.

Energy Exosuits (TL12+)

At very high tech levels, a battlesuit can be made largely of energy fields rather than matter. A suit like this has a small physical connection to the wearer – a belt or harness – while its remaining components are composed entirely of energy and remain insubstantial when not in use.

Energy exosuits appear in several comics and novels. The most detailed descriptions are in Fred Saberhagen's *Berserker Man* and Greg Bear's *Hardfought.*

An energy exosuit is built exactly like a normal battlesuit except:

1. It cannot have any weapon that requires ammunition.
2. It cannot have any thruster or power plant that requires fuel or reaction mass.
3. It cannot have any cargo.
4. It has an "energy structure." There is no extra cost (but see below), but divide structural weight by 10.
5. It cannot have any armor, which is why it is an "energy exosuit" rather than a battlesuit!
6. It *must* have a deflector field generator (p. 105), which provides the "web" that holds the suit together. It usually has a force screen as well, to protect the wearer.

The energy exosuit is generated by a "harness." The harness is built after the mecha has been built and its weight and price statistics determined. Decide which of two styles the mecha uses:

Basic Harness: This consists of bands round the chest, ankles, neck and wrists that generate the field. Each band is packed with sophisticated circuitry. If the suit has a neural interface system, it may have no controls. Otherwise, it has an on/off control on the belt. The harness weighs 2% of the loaded weight of the mecha, with most of the weight in the belt. It costs 10 times the battlesuit's cost.

Compact Harness: As above, but requires only one set of connection points – e.g., pair of wrist bracers or a belt – to generate the field. Harness weight is 1% of the battlesuit's weight, harness cost is 20 times the battlesuit's cost.

The harness' weight does not add to the suit's weight; the harness *becomes* the suit when it is activated.

Only light clothing like swimwear, a body stocking or a superhero costume can be worn under the harness. (This also includes skintight armor, like the biosuit on p. UT26.)



Using Energy Exosuits

Activating an energy suit involves putting on the harness and turning on the deflector field. After this is done, the suit forms around the user. It looks just like a battlesuit of whatever size was constructed, except that it is made of shimmering fields of gauzy, not-quite-solid energy. To remove the suit, reverse the process.

Putting on or removing a harness takes one-quarter the time normally required to do the same with a battlesuit. The harness does nothing when not activated. It has DR 5, and damage suffered by it is doubled and applied to the body hit points of the suit.

Anachronistic Mecha

What if Victorian inventors had developed mecha? They're just the thing for fighting Little Wars in the Colonies, don't you know? Or perhaps these Land Juggernauts could be the answer to H.G. Wells' Martians, created with salvaged Tripod technology. For a step even farther into the past, wizard-gadgeteers in a medieval realm might also build their own mecha!

TL: Assume the mecha has TL8 components, unless noted below.

Advanced Mecha: All advanced components and rules are "in genre" except socket interfaces, nukes and perhaps force fields. Redefine the TL to match that of the campaign.

Enchantments on Mecha: The GM must arbitrate the effects. If the energy cost is based on size in hexes, multiply cost by (mecha volume/85), with a minimum of 1. When energy depends on weight, use loaded weight. For armor enchantments, multiply energy cost by (area being armored/25). When *Fortify* is cast on a location with DR 20+, each +1 to DR instead adds 5% to DR. See also ***GURPS Grimoire*** for useful "technomagic" spells!

Drivetrains: Use rules for TL9 drivetrains, but quadruple the weight and divide cost by 5.

Arm Motors: Use rules for TL8 arm motors, but double the weight, volume and cost.

Thrusters: Either these aren't available at all, or assume that TL10 reactionless thrusters are invented at a much lower TL . . .

Cockpits: The mecha is controlled by levers, pedals, et cetera. The cockpit has no HUD, computer or fire extinguisher. It weighs 370 lbs., takes up 23 cf, costs $150 and requires 0.5 kW.

In a Victorian setting, life support lasts only half as long (12 hours, plus 6 hours per extra air upgrade). In a medieval setting, always take the "no lifesystem" downgrade. The only other upgrade or downgrade that can be taken is "extra seats." Lifesystem and extra air upgrades or downgrades cost $50.

Battlesuits can't have *any* upgrades except for provisions or (in Victorian settings) a half-duration lifesystem.

Weaponry: Medieval mecha may have built-in claws or talons (but not monomolecular versions), the baroque weapons on p. 99, or carry giant medieval weapons (p. 110). Victorian mecha can also use TL5 weaponry. The rotary cannon is a Gatling-style gun operated by a hand crank. The 12-pounder is an antique smoothbore firing cannon balls; it may be possible to find one in a junkyard. The 105mm and 254mm are "modern" shell-firing cannon of the sort used by the Royal Navy.

Victorian Cannon Table

Name	*Damage*	*SS*	*Acc*	*1/2D*	*Max*	*Weight*	*Volume*	*RoF*	*WPS*	*VPS*	*CPS*	*Loaders*	*Cost*
12-pounder	Cr. 6d×6	30	6	550	2,400	2,500	50	1/60	19	0.13	$3.8	5	$9,200
37mm Rotary	Cr. 6d×3	20	12	560	3,400	350	7	var*	2.8	0.019	$0.56	0	$1,400
105mm Naval	Cr. 6d×8(0.5)	30	13	950	4,600	3,000	60	1/9	43	0.43	$26	2	$8,000
254mm Naval	Cr. 6d×19(0.5)	30	15	1,500	6,100	12,000	240	1/42	610	6.1	$180	6	$31,000

* RoF for the 37mm rotary cannon depends on the skill of the gunner turning the crank: it is (DX+Skill)/4.

The 105mm and 254mm guns fire shells that do crushing damage (but armor protects at *double* DR against them) and then explode for 6d×5[10d] if 105mm or 6d×64[12d] if 254mm. If the crushing damage penetrates armor, DR does not protect vs. the explosion!

Loaders: Some weapons require *loaders*. These don't require cockpit seats – instead, they must be given *standing room* in the same location as the weapon. Allow 20 cf and 200 lbs. (including the occupant) per loader.

Sensors, Comsuites, ECM: Skip these systems – the crew look out portholes, use hand-held telescopes, wave flags, et cetera. PESAs (at TL8) are optionally available as improved telescopes; they have only a DLTV setting, and are 1/10 cost.

Power Plants: These use magic or, in Victorian campaigns, steam power!

Steam Engines can be TL5 steam engines or experimental, early-TL6 steam turbines. Either works only in a breathable atmosphere. A steam engine can be shut down to conserve fuel, but starting it again requires five minutes plus one minute per 10 kW of power to "build up a head of steam."

Mana engines transform local mana (magical energy) into electrical power. They do not require fuel, but do not function in no-mana areas. Their creation requires a variant of the Powerstone spell (prerequisite: Power spell) and costs 100 energy per kW of power output.

The statistics are shown on the table below:

Anachronistic Engine Table

Type	*Weight if output is*		*Cost*	*Fuel*
	under 5kW	*5kW or more*		
TL1-4 Mana Engine	50×kW	(25×kW) + 125	$20*	none
TL5-7 Mana Engine	10×kW	(5×kW) + 25	$50*	none
TL8+ Mana Engine	2×kW	(1×kW) + 5	$50*	none
TL5 Steam Engine	100×kW	(50×kW)+250	$0.8	0.05C
TL6 Steam Turbine	125×kW	(25×kW)+500	$1	0.04C

* Minimum cost is $1,000, regardless of weight. This *doesn't* include the cost of the enchantment. In a "common magic" setting, add an additional $25 per energy point to cost.

Weight: Calculate the weight of the power plant as shown on the table above, based on output.

Cost: This is the cost per pound of power plant weight.

Fuel: "C" indicates the engine runs on coal; this is the amount of coal burned per hour, in cubic feet.

Volume and Location: Volume is weight/50 cf. It can be located in the body, a pod or wings.

Energy Banks: Use clockwork (weight is 0.25 lbs. per kWs, volume is wt./50 cf, cost is $20 per lb.) or, if Victorian, early batteries (weight is 0.03 lbs. per kWs, volume is wt./200 cf, cost is $0.25 per lb.).

Fuel Tanks: Steam power needs a coal bunker rated for the cubic feet of coal it can store. Its empty weight, volume and cost are 6 lbs., 1.2 cf, and $1 per cf of storage. It should go in the body. The coal itself is 50 lbs. and $1 per cf.

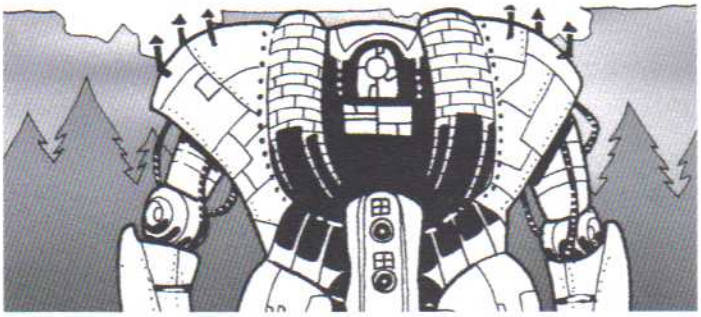
Structure: Multiply the *weight* of a TL8 structure by 3 if Victorian or 4.5 if medieval, but divide its *cost* by five.

Defensive Surface Features: These are unavailable.

Armor: Only metal armor, and this is riveted iron or steel. Use the normal metal armor rules (p. 89), but with a weight of 0.7 if medieval or 0.6 if Victorian, and a cost of $6 per lb.

Some cheap mecha may use wooden armor instead of metal! Wooden armor has a weight of 1 lb. but costs only $0.25 per pound. It is flammable and its PD cannot exceed 3.

Performance: This is calculated normally, but there is a penalty of -0.25 to gMR and -0.5 to aMR due to the mecha's lack of computerized controls.



NON-MECHA

A mecha campaign can simply involve walking machines slugging it out with each other, but it may also feature other types of vehicles. ***GURPS Mecha*** *can* be used to build non-mecha vehicles. For example, a fighter can be easily built: design a mecha with thrusters but no arms and legs, or a winged mecha that isn't transformable. For a "drop ship" or "assault boat," do the same but add enough cargo space to carry several mecha or battlesuits. For a full treatment of vehicles like cars, tanks and starships, see ***GURPS Vehicles,*** *Second Edition.*

Drop Capsules

A drop capsule is a reentry capsule protected by an ablative heat shield, allowing a single mecha to be dropped from a ship in low orbit. Reentry is automatic: after a series of braking parachutes have reduced descent speed, it breaks up a mile or so above the surface and the mecha is landed via parachute or jump jets. Assume that a capsule is 100 lbs. 1.6 cf and $1,250 per cubic foot of cargo it can carry. Determine its Size Modifier based on its volume. The capsule has DR 100 fireproof ablative armor.

Stealth Capsule: This is a drop capsule equipped with extra decoys and stealth systems, giving a -5 penalty on any roll to detect it and PD 5 vs. any incoming homing missiles. It is 150 lbs., 2.5 cf and $5,000 per cubic foot of cargo it can carry.

HAND WEAPONS AND SHIELDS

These can be used by any mecha with manipulator arms. As with hand-held ranged weapons, these are not "part" of the mecha, and when carried count toward encumbrance, not loaded weight.

Mecha-Sized Medieval Weapons

Wielded by a mecha's powerful arm motors, even ancient melee or thrown weapons can be devastatingly effective. Better still, they don't use up great amounts of power or require ammunition.

To build a mecha-sized medieval weapon, refer to the *Ancient/Medieval Hand Weapon Table* on p. B206 and select a weapon. Decide on the *Weight Multiple* (WM) of the weapon; i.e., how many times heavier than a human-sized weapon the mecha-sized weapon will be (e.g., a "20× broadsword"). The suggested WM is (Arm ST of the mecha arm that will use the weapon/normal Min ST of the weapon). See p. B206 for Min ST; if no Min ST is listed, treat Min ST as 5.

Modify the weapon's statistics as follows:

Type: This remains the same.

Damage: Multiply any damage bonus (e.g., sw+2) shown under *Damage* by the WM. If there is no damage bonus, then *add* a damage bonus equal to WM/2. If there is a damage *penalty,* like sw-2, add WM/(2 + absolute value of damage penalty) to it. The absolute value of a damage penalty is that number with its minus sign removed. Round fractions down.

For instance, suppose a weapon had a WM of 120×. If it did sw+2 damage, like a bastard sword, its giant form would do sw+240 damage! If it did sw damage, like a shortsword, it would swing+60 damage. If it did sw-2 damage, like a large knife, its damage would be sw-2 + [120/(2+2)] = sw+28.

Reach: Multiply the Reach by the *square root* of the WM, rounding to the nearest whole number.

Cost, Weight and Min ST: Multiply these by the WM.

Note: These rules can also be used to create hand weapons for giant-sized races. Simply substitute racial average ST for Arm ST.

Ultra-Tech Edged Weapons

Giant Vibroblades (TL8): Any edged hand weapon may have a vibroblade. This adds +1d damage and, more importantly, an armor divisor of (5). It costs an extra $200 (if knife), $400 (if sword) or $1,000 (if other weapon), *multiplied by the weapon's Weight Multiple.* It is powered by a number of B cells equal to its WM, for (60 minutes/original unmultiplied weight). In some anime, vibroblades are called "heat blades" – the vibrations may make the blade glow red hot, hence the name.

Giant Monomolecular Blades (TL9): This is an edged weapon with a monomolecular wire along its edge, giving +1d additional cutting damage and an armor divisor of (10). Any swung cutting weapon (but not thrusting or impaling weapons) can be made in a monowire version. It increases cost by the Weight Multiplier × $500 for knives, × $1,000 for one-handed swords or × $1,500 for larger cutting weapons, including two-handed swords. Monowire weapons cannot be vibroblades.

Giant Force Swords (TL11): These energy blades are described on p. B50; use Force Sword skill. A force sword does 4d(5) impaling or 8d(5) cutting damage. It is $3,000 and 2 lbs. for a normal-size sword with Reach 1-2. Larger versions for big mecha are possible: doubling the weight and cost adds +1 reach, +2d(5) impaling damage and +4d(5) cutting damage. In some cinematic settings, earlier types of energy swords may be built at TL9 or TL10. They are identical, except these "plasma swords" or "beam sabers" do only 3/4 damage at TL10 or 1/2 damage if built at TL9.

Shields

Mecha often carry large shields, especially in cinematic campaigns. A *mecha shield* is customized to the individual mecha. A mecha can only carry a single shield. Only an arm whose strength is at least equal to the *body's* surface area can carry a shield big enough to provide a PD bonus for a mecha.

Designing a Shield

Decide whether the shield is going to be a buckler or a small, medium or large shield. A shield's surface area is 10% of the body area of the mecha it is intended for if a buckler, 20% if a small shield, 30% if a medium shield or 40% if a large shield.

Calculate the shield's hit points as its surface area × 15, then go to *Step 22 – Armor* and give the shield its DR as if it were a subassembly. Add 20% to the armor's weight and cost to find the shield's total weight and cost. The shield's final weight should always be less than three times the ST of the mecha arm intended to carry the shield.

The shield's Passive Defense is not based on its DR. Instead, it is 1 if a buckler, 2 if small, 3 if medium or 4 if large.

A shield's *damage* score is equal to its DR and its hit points, in that order, separated by a slash; see sidebar, p. B120. Thus, a shield with DR 50 and 120 hit points would be rated as "50/120." After you have recorded the shield's damage score, ignore its DR and hit points – the damage score subsumes both of these functions.

A shield may be given a single hardpoint (treated as an arm hardpoint); its capacity can't exceed 20 lbs. × the shield's hits (i.e., the second number in its damage score).

Using a Shield

A mecha shield is used exactly like a normal shield. It can be ready or stowed on the back. It is suggested that the *Damage to Shields* optional rule always be used, to reflect the fact that firepower can easily tear a light shield to bits.

An arm that has folded away (see *Transformable Mecha,* p.100-103) cannot have a ready shield – before folding, the shield should be stowed on the back or it will be dropped.

The cost of repairing one point of damage to a mecha shield is equal to (shield's cost/shield's original hit points).

Using Other Mecha's Shields: A mecha's shield is customized to the mecha it is built for. If a mecha's shield is used by a different mecha than the one it is designed for, its relative size may provide more or less PD. Divide the surface area of the shield by the surface area of the new mecha's body and multiply by ten. This is the PD the shield provides, up to a maximum of PD 4. Round fractions down! If PD works out to 0, the shield is too small to adequately protect the mecha. If the shield's PD is 4, the shield is treated as a "large shield" for purposes of skill penalties while using it. Otherwise there is no skill penalty, regardless of its size.

Shields Designed For Humans: A battlesuit may use a shield built for humans, but the shield may not be large enough to do much good. Subtract the Size Modifier of the battlesuit from the shield's PD! If this results in a PD of 0 or less, the shield is useless.


MECHA IN ACTION
3

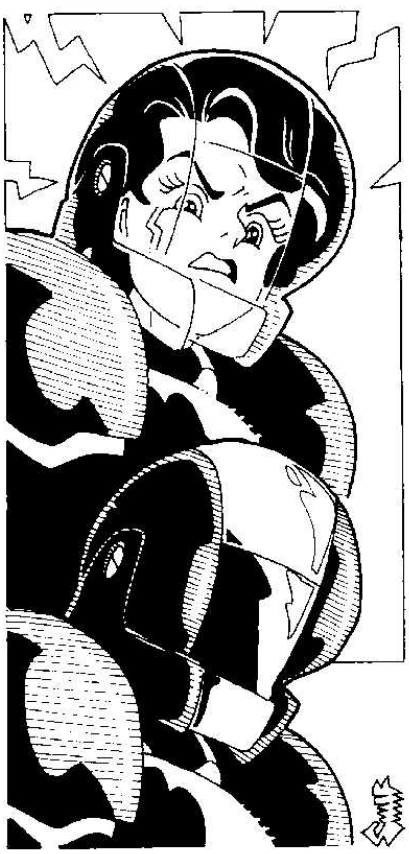
Battlesuit Faceplates

A battlesuit with an armored turret has a transparent faceplate. This lets the wearer use his own vision, even if no sensors are installed.

Anti-Glare: A battlesuit user can be blinded by sudden bright flashes, so the faceplate is designed to polarize to protect the user against blinding light. If desired, the user can hide his features by always keeping the plate tinted or mirrored.

Visor: The faceplate has a hinged visor, and can be opened or closed in one turn, exposing the wearer's face to the world. (Someone can also force it open by grappling the head and making a ST-20 roll.) If the visor is open, the suit loses its armor PD and DR on the front of location 5 (face), is no longer sealed or air-tight, and its sensor, HUD, computer targeting and anti-glare functions will not work. However, opening the visor does let the wearer talk without a comsuite, eat or drink, kiss someone, feel the wind on his face or use his sense of smell . . .

Suits with No Faceplates: A battlesuit with the "no faceplate" option has no visor – it can't be forced open, but the user is dependent on a PESA for vision; if it stops working, he can't see out.



There are two main types of mecha: drivable mecha, which have cockpits, and battlesuits, which have battlesuit systems. A rule referring simply to "mecha" applies to either type.

INSIDE YOUR MECHA

In the Cockpit

A drivable mecha's cockpit consists of a seat, computerized controls and various integral electronic, life support and safety systems.

Access: This is either through a hatch or via an aircraft-style cockpit canopy, depending on the design. If a mecha is three or more yards tall, it is difficult or impossible for a normal person to climb aboard from ground level unaided. Mecha hangars come with step ladders, gantries, slides or other devices, or the mecha assumes a kneeling position when parked

Control: A pilot usually uses joysticks and foot pedals to control legs, arms and any thrusters; firing controls are also placed on the control sticks. A computerized gyro-stabilization system keeps the mecha balanced. Some designs supplement or replace ordinary controls with neural interfaces (see p. 97). Instrument, targeting and sensor data are shown on multi-functional displays controlled by a computer terminal.

HUDs: Vital data is superimposed on a "head-up display" over the pilot's field of view or projected onto his helmet. At TL9+, the pilot is surrounded in a holographic virtual reality display. The HUD adds +1 to Electronics Operation skills for mecha sensor or communication systems, and gives an extra +1 to Free Fall and Piloting skill. It also lowers weapon SS numbers – see *Ranged Combat Modifiers*, p. 50.

The View: A mecha cockpit has either a transparent canopy or armored view ports. In battle, a blast shield slides down to protect them, and the pilot's only "natural" view is through a small optical periscope or tiny vision slit (-2 to Vision rolls). For better vision, a television camera is built into PESA sensors – see *Sensors*, p. 47.

Hearing and Speech: All cockpits include an external microphone and speaker, so the pilot can hear things or talk with people outside the mecha. The speaker volume can be cranked up, enabling the pilot to be heard over the noise of a battlefield.

Wearing Battlesuits

A battlesuit must fit like a glove for its kinesthetic control system to function. This puts some limits on who can fit inside a particular suit and what the operator can wear.

Pilot Weight: A battlesuit is rated for its *pilot weight*, which determines how large a person can wear that particular suit. A wearer will only fit into a suit if his own weight and that of any armor or clothing is no greater than the suit's *pilot weight* rating, nor less than 80% of it.

Fitting: Even if a person fits into the correct pilot weight range, a battlesuit system must still be refitted each time a different person uses it. (The one exception is if the new user is of the same sex and has exactly the same height and weight.) Adjusting a suit to a new user takes two hours and requires a successful Armoury (Mecha)+2 roll. Failure means two more hours are required; critical failure damages the suit, requiring minor repairs using Mechanic skill before it can be used again.

Clothing: A person wearing a battlesuit may not wear clothing any heavier than a skin-tight outfit like a body stocking or briefs. Some types of ultra-tech

armor are described as skin-tight, and these can be worn with a suit. Their DR will protect the pilot, but not the suit, from any damage that penetrates. There is one exception to these restrictions: if a suit has no armor at all, or has only open-frame armor, the user can wear any armor or clothing compatible with the pilot weight.

Suiting Up: A battlesuit is generally designed with a hatch or clamshell hinge at its waist. This allows the wearer to open it up, step into the legs and pull on or squirm into the rest of the suit. The helmet may be attached, or it may be screwed on separately. A battlesuit takes four minutes to put on and two to remove. Much of this time is spent screwing or locking fastenings securely into place and checking out systems like power or life support. Some suits have a "quick access" option. Via superior ergonomics or technology, these take only (30 - Battlesuit skill) *seconds* to put on, or half that to remove.

Control: A battlesuit isn't driven, it's *worn.* In a normal suit, the wearer's limbs extend fully or partially into the arms and legs. When the pilot tries to move his limbs, sensors in the suit detect the attempt and the suit's arm or leg motors copy the intended motion while amplifying its force. Learning to control this requires considerable effort, which is the main reason that the suit requires a special skill.

Controls for other systems, such as thrusters or sensors, may be located within suit gloves, on the suit arms or within the helmet. A battlesuit helmet includes the same head-up display (HUD) a mecha cockpit has. Helmet controls are operated by using neck or jaw muscles, voice control or even by sensing eye movements as the user stares at a menu on the HUD. Some suits may also use a direct neural interface.



MECHA AND MOVEMENT

A mecha is maneuvered very simply: the pilot chooses any normal basic or advanced combat maneuver and the mecha follows that maneuver, just as if it were a person. Thus, a mecha can take a Move maneuver, aim or make a snap shot, feint in hand-to-hand combat or even enter close combat with another mecha.

Mecha use the normal movement rules for humans, with the modifications described below; flying mecha use the rules for flying animals described in the ***Basic Set.*** Transformable mecha can alter their configuration and with it their performance; see pp. 100-103.

Sometimes, mecha pilots must make a *control roll.* This is a roll against the skill used to control the mecha, usually Driving (Mecha) or Battlesuit.

General Movement Rules

Order of Action

A mecha pilot uses his own Move score, rather than that of the mecha, to determine when his mecha acts in a turn.

Move Score

A mecha's Move score is equal to its basic Move modified by Encumbrance. A mecha uses its Move score exactly like a character, with one exception. Its Move attribute may be a split score, e.g., 10/15. If so, the first (lower) Move is used normally, while the second (higher) "enhanced Move" is used only when sprinting in a more-or-less straight line.

Besides Move, mecha have two statistics that humans lack:

Staging Combat

Mecha have high speeds and their weapons have very long ranges. For this reason, GMs may wish to avoid using a hex map for combat unless the fight comes down to close quarters. We recommend "abstract advanced movement," in which spatial relationships are kept track of in the GM's head or on a large-scale map, but which uses all normal movement rules.

To prevent the game from turning into a turkey shoot, the GM should carefully describe terrain, structures and distances. Be sure to include features that can block line of sight, provide cover, and so on:

"Okay, your PESA shows two Seraph Deltas have just crossed the ridgeline 1,900 yards away."

"Yikes! Do I see anything nearby for cover?"

"A stone farmhouse 40 yards away to your right, and those light woods you came out of are still 10 yards behind you."

"I sprint for the building at Move 30, firing my Gauss gun at the lead Seraph . . ."

Fast Movement and Encumbrance

To better reflect the effect of encumbrance on very fast movement (Move 10+), the penalties to Speed and Move for various encumbrance levels become . . .

Light: Move × 0.8, round down.

Medium: Move × 0.6, but minimum Move 7.

Heavy: Move × 0.4, but minimum Move 6.

Extra-Heavy: Move × 0.2, but minimum Move 5.

Example: A mecha has Move 22 but medium encumbrance. Its Move becomes 13.2, rounded to 13.

Traveling by Mecha

Use the mecha's top speed in mph, modified by encumbrance as above, to determine how fast it can travel.

Actual "cruising" rates should be about 60% of this top speed. See *Terrain* (p. 58) for the effects of terrain on movement speed.

Walking

Walking and running are not at all like moving on wheels. A running mecha, like a running human, moves by tossing its center of gravity off the ground while kicking backwards. A mecha going much faster than 20 mph does so by making a series of leaps.

This means that a mecha moving at 40 mph will only touch the ground every 10 yards or so. It will skip blithely over 20-foot ditches, minefields and the like without even having to use thrusters. So what happens when a 40-ton mecha marches down the street?

Very little. A mecha is generally fairly light for its size, and the soles of its feet are like snowshoes, disproportionately large. The ground pressure exerted by most mecha is not much more than twice that of a human being. A mecha won't normally punch holes in the pavement with its feet.

However, the full weight of the mecha *will* come down on any imperfection in the terrain. A mecha's footprint may only be half an inch deep on soft ground, but twigs, branches, anthills, rises in the ground and enemy infantry will be flattened.

Step

GMs may wish to use the *Increased Step for High Move* rules (p. CI172) for mecha.

gMR is the mecha's *ground maneuver rating*, a measure of the maximum g-force a mecha can safely use during a maneuver on the ground. It is normally used only when attempting to turn while traveling at high speed. Flight-capable mecha also have an aMR (*aerial MR*) statistic, used when the mecha is flying.

SR is the mecha's *stability rating*. If a control roll fails by more than gSR (on the ground) or aSR (if flying), the pilot loses control. A walking mecha falls over, "colliding" with the ground at a speed equal to its height plus the distance it moved this turn (both in yards). A flyer spirals out of control; the mecha can do nothing but dive downward at its present speed + 10 yards/turn until the pilot can recover (a Piloting-5 roll).

Encumbrance and Move

Rather than recalculate a mecha's statistics whenever it carries something, as is done in ***GURPS Vehicles***, GMs should use the standard encumbrance rules with mecha. If the mecha is moving on two or three legs, use the rules on p. B76. Otherwise, treat it as a beast if moving on the ground (p. B145) or a flyer if airborne (p. B139). See also p. CI14 for detailed encumbrance rules.

When calculating encumbrance, use the mecha's *Lift ST* if it is flying or *Body ST* if it is moving on the ground.

Encumbrance subtracts from both normal and enhanced Move.

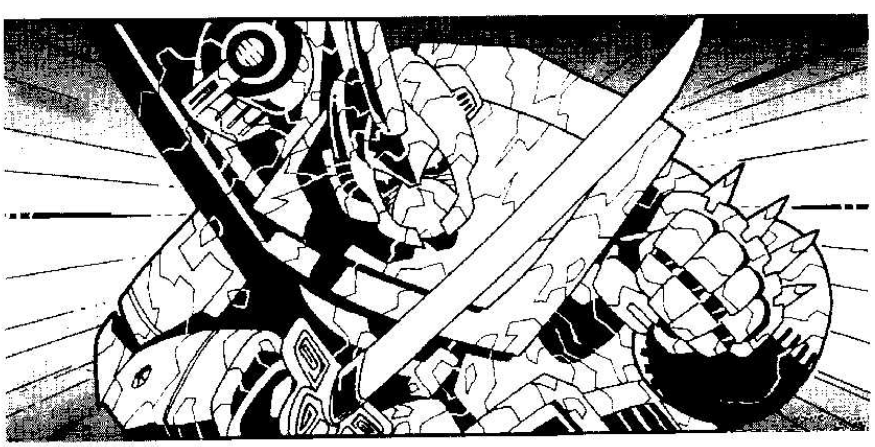
Multi-Hex Mecha

Most large mecha occupy multiple hexes. Use the rules for multi-hex animals on p. B141.

Move Maneuvers

A mecha uses a Move maneuver just like a human. Remember, it's possible to move and fire ranged weapons at the same time! (See p. B117.) A mecha with legs can move across just about any terrain a human can, moving at full speed either on or off road. See *Terrain*, p. 58, and p. B107 for rules for movement points and crossing rough terrain.

Enhanced Move and Sprinting: Some mecha have a split Move score, with a normal and enhanced Move. The mecha can only use an enhanced Move while sprinting (p. B108). Instead of a +1 yard bonus, the sprinting mecha uses its higher enhanced Move. (A mecha without an enhanced Move can sprint normally.) GMs may allow a sprinting mecha to change facing, but if so, use the *Turning Radius* rules on p. B139; the maximum g-force a mecha can use is equal to its gMR statistic when on the ground or its aMR statistic when in the air. (In effect, enhanced Move works the same way as the Enhanced Move and Super Running advantages do for characters.)





Costs for Movement: The sidebar of this name on p. B107 applies to mecha, except that the rules for obstructions and bad footing are somewhat altered because mecha can be very large.

Bad Footing: On treacherous ground such as swamps, mud, loose gravel or ice, the cost to enter each hex is increased by 1, 2 or more movement points at the GM's option. Movement on stairs costs double. Movement in water or other liquid whose depth is at least 1/6 the mecha's height costs double. Water that is at least 1/3 the mecha's height reduces movement to 1 yard per second; in a swift current, a control roll is needed as well. Failure means the mecha makes no progress, while failure by more than gSR means it falls over and is carried at least 3 yards downstream.

Dense Woods: A mecha moving or flying through dense woods or similar terrain can safely use its normal Move. If it uses its enhanced Move, the GM should require a control roll each turn to avoid colliding with a tree (DR 6, 2d×10 HP).

Obstructions: A mecha that is using legs for movement can step over *obstructions* – such as bodies, wrecks or barricades – without penalty if the mecha's Size Modifier is at least 2 greater than that of the obstacle. If the mecha's Size Modifier is only one greater than the obstacle's, it costs +1 movement point per obstruction to pass through the hex. If the mecha's Size Modifier is equal to or less than the obstruction's, the hex is effectively blocked, and trying to pass through it will result in a collision. The Size Modifier of an obstruction can be found using the table on p. B208, based on the obstruction's height; e.g., a 6' wall (2 yards) is Size Modifier 0.

Mecha on Wheels: A mecha using wheels or foot rollers only gets its full Move if it spends the entire turn on a floor, road or smooth rock. Across ordinary firm grass or packed earth its Move is halved; through thick woods or other soft sand, Move is 15% of normal, and it is reduced to 10% of normal over broken ground, or 1/20 normal through swamps or mud.

Movement in the Air

Flying mecha use the flying rules on p. B139, along with the rules described above. However, some mecha designs will have a stall speed. If a mecha has a stall speed, it can only take off by moving along the ground until it reaches that speed. Once airborne, it cannot fly any slower than its stall speed; if it tries, it will lose control and eventually collide with the ground.

Jumping Mecha

Any mecha or battlesuit with legs can jump, but because of the way mecha limbs work, they use slightly different rules than humans!

A high or broad jump may replace the movement portion of a Move, All-Out Attack or Step and Attack maneuver.

High Jump: Height is up to 25' (or 8 yards) × (ST/Wt.)

Broad Jump: Distance is 50' (or 17 yards) × (ST/Wt.) and height is 12.5' (or 4 yards) × (ST/Wt.).

Wt. is loaded weight in pounds and *ST* is the mecha's lower body ST. Note that distances in yards are rounded off.

Boosted Jump: A mecha with thrusters or contragrav can cut them in for a second to boost a jump. Subtract their combined thrust and lift from Wt. when calculating jumping distance (but effective weight cannot go below 5% of actual weight).

If the mecha is jumping to a higher or lower elevation, it reaches the chosen elevation at the end of the jump. Otherwise, it reaches its maximum height halfway through the jump.

Landing

A jumping mecha normally lands facing the same direction it was facing when it jumped. The pilot can choose to make a control roll to change his facing. If he succeeds, he can assume any desired facing upon landing. If he fails, he is still facing forward, while if he gets a critical failure, he lands prone and "collides with the ground" at a speed of (jumping distance in yards + 10) yards per second.

Skill Rolls and Jumping

No skill roll is needed for a jump unless the mecha uses thrusters. If using thrusters, make a control roll when the mecha lands. Failure means the mecha trips and falls instead of landing, and is assumed to "collide with the ground" as described under *Landing*, above.

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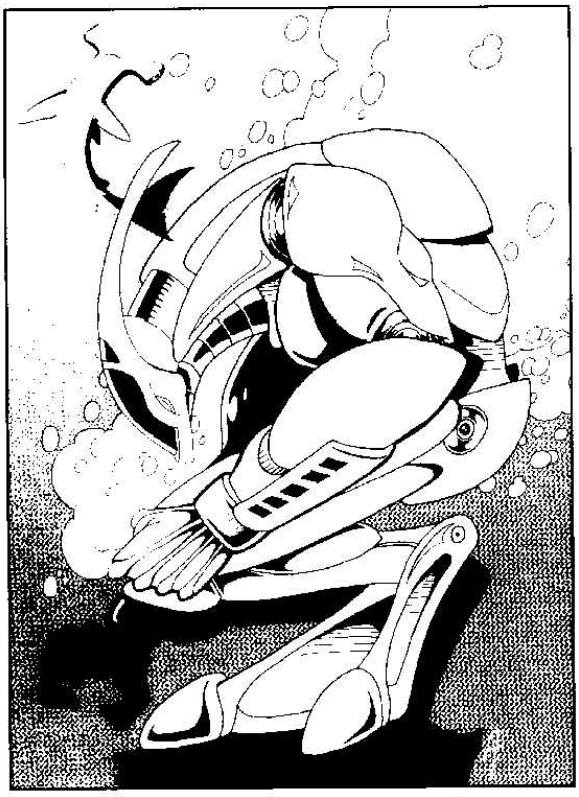


Jumping Mecha (Continued)

Combat While Jumping

A mecha can fire ranged weapons *during* a jump. If it jumped high enough, it may be able to see over intervening terrain or the horizon – but remember, everyone else can also see it! A jumping mecha fires at -6 to skill.

A mecha that is jumping *over* terrain ignores it for movement penalty purposes, but does not get any cover from it either!

A mecha whose jump intersects with something will collide with it – use the normal collision rules, with speed equal to (jumping distance in yards + 10) yards per second × local gravity. The target always gets a Dodge roll to avoid a jumping mecha. The normal collision (p. 51) and landing rules (above) apply.

A mecha that can jump higher than its target's height can try to forgo a collision and instead land atop its target, stomping it flat while taking no damage itself.

This requires a skill roll at -3; failure means the mecha collides normally with the body of the target instead. Success inflicts *double* normal stomping damage – see *Collisions* (p. 51). Damage is applied to the target's turret, or to the top of its body if it has no turret. If the target is prone, it will go to the front or back. The mecha must make a control roll at -5 after doing so to avoid falling over.

Movement On or Under Water

Sealed mecha can walk along the bottom of a body of water; this is usually mud – see *Bad Footing*, p. 43. An unsealed mecha submerged in water will flood. It will lose 1d percent of its body and turret hit points (minimum 1d hits) plus a further 1d% every minute until disabled. The occupants will start to drown.

Space Movement

The normal rules for maneuvering do not apply in space, since there is no gravity or friction, nor is top speed a factor (assuming the mecha does not approach the speed of light). A mecha's Move, MR and SR statistics are not applicable. Instead, its space performance is determined by its *sAccel* (space acceleration), which is rated in gravities (g).

Every turn, a mecha that uses a Move maneuver can increase or decrease its velocity by up to 10 yards per second per g of space acceleration. Thus, a mecha with 0.2 g acceleration could alter its velocity by 2 yards per second each turn.

In space, a mecha that accelerates in one direction retains its velocity until it cancels it by accelerating in the opposite direction. Changing facing will not affect this.

The *step* portion of a maneuver in space cannot be used to move one or more hexes, but can be used to change facing.

Long-Distance Space Travel

To determine the time required for a space voyage, decide the length of time the vehicle accelerates, and calculate the speed which that gives. Then divide that by two (to allow for deceleration). This gives the speed; the trip time is the greater of the selected acceleration time or distance divided by speed.

With constant acceleration to a mid-point, followed by deceleration to slow down (and assuming the mecha has enough fuel or power to manage this), the travel time (T) in hours is:

T = Square root of [0.0000508 × (D/A)],

where *D* is the distance in miles and *A* is the acceleration in g.

If time is vital and duration (T) and distance (D) are both fixed, the needed acceleration in g (A) is:

A = (0.0000508 × D)/(T × T).

Similarly, when a mecha travels this way in space for a fixed time (T) with an acceleration A (given in g), the distance it covers (D) is:

D = 19,700 × A × T × T.

Ground-to-Space Movement

To get into space from a planet, a mecha must be able to reach orbital velocity. For Earth, this is 17,800 mph. For other planets, this is 17,800 mph × the square root of (M/R), where M is the planet's mass in Earth masses and R is its radius in Earth radii. To leave the orbital gravity well and head out into deep space, an escape velocity of 1.414 times orbital velocity is required, or just over 25,000 mph for Earth.

If a mecha's air speed is higher than orbital velocity, the mecha can fly into orbit. If its top speed is lower (as is more likely), it can still reach orbit if it has an sAccel rating and its space propulsion system can operate for the necessary time without running out of fuel or power. The required time in seconds is:

[orbital speed (in mph) - top air speed (in mph)]/[21.8 × sAccel (in g)].

This assumes the mecha has a means of lift independent of its thrusters, like wings or contragrav. If it doesn't, the thrusters must also lift the mecha, so subtract local gravity (1 g on Earth) from sAccel – obviously, an sAccel over 1 g is required in such a case.

Use the same procedure to see if a mecha can reach escape velocity, substituting it for the orbital velocity.

An object in low orbit is normally *at least* 150 miles up and moving at orbital speed.

Space-to-Ground Capability

There are two steps involved in getting down from orbit: shedding orbital velocity and making a soft landing.

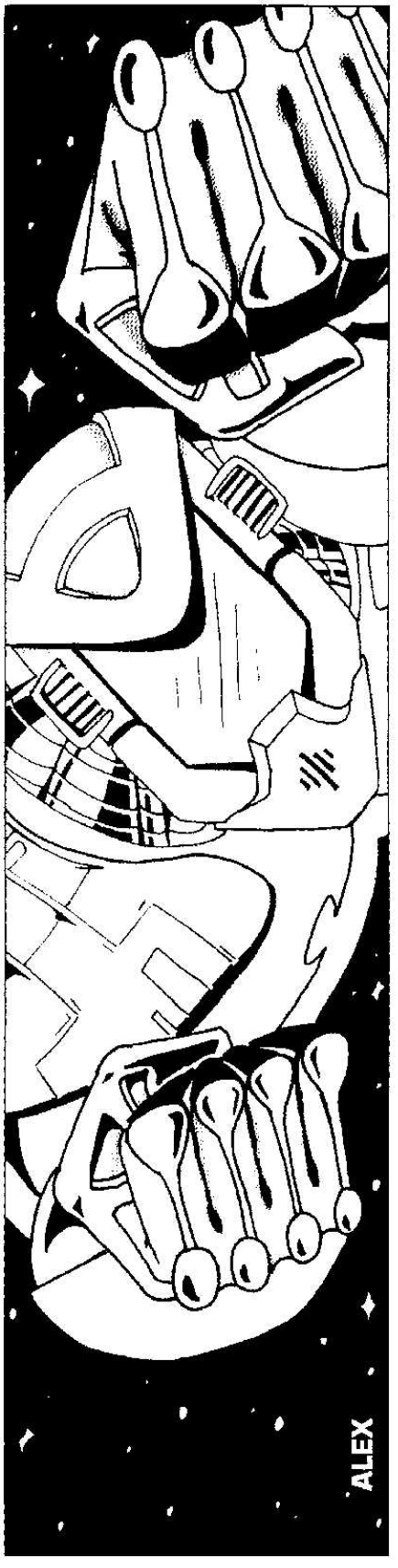
For a planet with no atmosphere, the only way to shed velocity is with a mecha that has a sAccel rating. Use the same rules as for entering orbit, except there is no need to worry about lift. Once the vehicle has killed its orbital velocity, it lands safely provided it can maintain sAccel greater than the local gravity for at least 30 seconds.

For a world with an atmosphere, velocity can be shed as above, but if the desired sAccel can't be maintained, the only way to do it is via aerobraking – using the atmosphere itself to slow the mecha. Even a mecha without a sAccel can aerobrake. Time required for this reentry maneuver is (orbital velocity - top air speed)/1,500 minutes. The maneuver is dangerous, requiring a Piloting (Aerospace) skill roll. A great deal of heat is generated: the mecha takes (4 × minutes spent aerobraking) points of fire damage to the underside of its body, any wings and any subassemblies (like legs) mounted under the body or on the wings. All other subassemblies take 1/4 this damage. Standard ablative armor will burn off, while fireproof ablative armor and non-flammable armor survives intact. If the Piloting roll fails, multiply the damage to each location by the amount the roll failed by; on a critical failure, treat as a failure by 20!

After aerobraking, the mecha can be assumed to be about 15,000 feet up and moving at its top air speed, or about 1/20 of orbital velocity if it has no air speed. It makes a soft landing if it can deploy a parachute (see below) or is flight-capable. Otherwise, it will collide with the ground.

Reentry via Drop Capsule: It can be risky to drop mecha "naked" from orbit. However, special capsules (see *Drop Capsules*, p. 109) are available that are shaped and armored to resist the heat of reentry. Pick an intended drop zone (DZ) and roll vs. the Piloting skill of the dropping ship's pilot to see if the capsule ends up there. Success by 0 means it is within 2,000 yards of the DZ; reduce this error by 200 yards times the degree of success. Failure means it is off by 2,000 yards times the degree of failure. A drop capsule will usually break up a few thousand yards up, releasing the mecha on a parachute.

Parachuting Down: Non-flight-capable mecha that are making an orbital drop usually kill their speed using parachutes. The mecha deploys a series of chutes, typically at about 12,000 yards altitude, which kill its velocity by about 20 mph per second. After 50-60 seconds, the mecha reaches the ground. As the mecha is descending, the pilot can try to steer the chute via a Parachuting roll; the DZ can be adjusted by 400 yards times the degree of success. A Parachuting roll is needed to land safely. Failure can mean a drift off course, being snagged in a tree or damage equivalent to a fall from 10 yards up. A mecha being blown off course can shed its chute and jump down. The GM can apply modifiers for terrain or buildings in the DZ (e.g., -3 if heavy woods or over a city). A parachuting mecha cannot dodge.



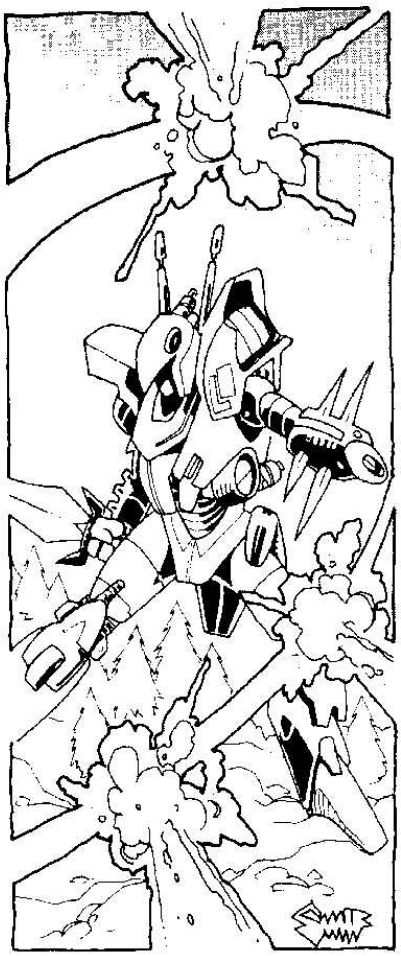
Using Computers

A computer is included in all mecha cockpits. A battlesuit system with the "suit computer" upgrade also has one. Mecha computers use a voice interface.

Every computer has a *Complexity* rating, which governs the software it can run and how fast it will run. Each +1 Complexity represents an order-of-magnitude increase in performance.

In order to do anything, a computer must be provided with programs (see *Software*, p. 94), which also have a Complexity rating. A computer of a given TL and Complexity cannot run higher-TL or higher-Complexity programs.

The number of programs that can be run concurrently is also based on Complexity: a computer can run two programs of its own Complexity, 20 programs of its Complexity-1, 200 of its Complexity-2 and so on. Programs of various Complexities can be mixed; e.g., a computer can run *one* program of its own Complexity and *ten* programs of one lower Complexity instead. Running or switching a program takes one second.



MECHA SYSTEMS

This section describes how certain subassemblies and components function.

Using Legs

A mecha can use its legs to walk, run, kick, jump and so on. Walking and running are covered in the movement rules.

Lower Body ST: A mecha with legs has a *Body ST* value based on its leg drivetrain power. This is used when pulling, slamming or calculating encumbrance for ground movement.

Kicking: A mecha's effective ST when kicking is based on its *Body ST*. If the mecha has more than two legs, each individual leg won't be as strong: divide effective leg ST by half the number of legs when kicking. An ordinary kick from a mecha's leg does thrust+2 crushing damage, based on this ST.

Reach: If it becomes important, a particular leg can kick with a reach of (its area/20) + 1 yard.

Using Arms

If a mecha has arms, it can use them like a human can. A manipulator arm has a hand similar in capability, if not shape, to a human's. Thus, a mecha with two arms will have the same manipulatory ability as a human, while a mecha with a single arm will have the same capabilities as a one-armed human.

Some "arms" may be *strikers*. A striker is an arm that lacks a hand. It can push or smash, but not wield, manipulate or lift things. If a mecha only has one arm that isn't a striker, it will be effectively one-handed. If all its arms are strikers, it has no manipulatory ability.

Arm Motors and Arm ST: All mecha arms have an arm motor, representing its artificial muscles, servo motors or whatever. Each arm motor is rated for *Arm ST*, which may differ from the overall Body ST of the mecha. Use Arm ST when using that arm to punch, push, lift, grip or wield a weapon. Sometimes, Arm ST may vary between arms. If a mecha uses a pair of arms with different ST for a two-handed task, average their ST scores.

Basic Damage: This is based on the arm's ST. See p. B248 or CI10 for thrust and swing damage for ST 20+.

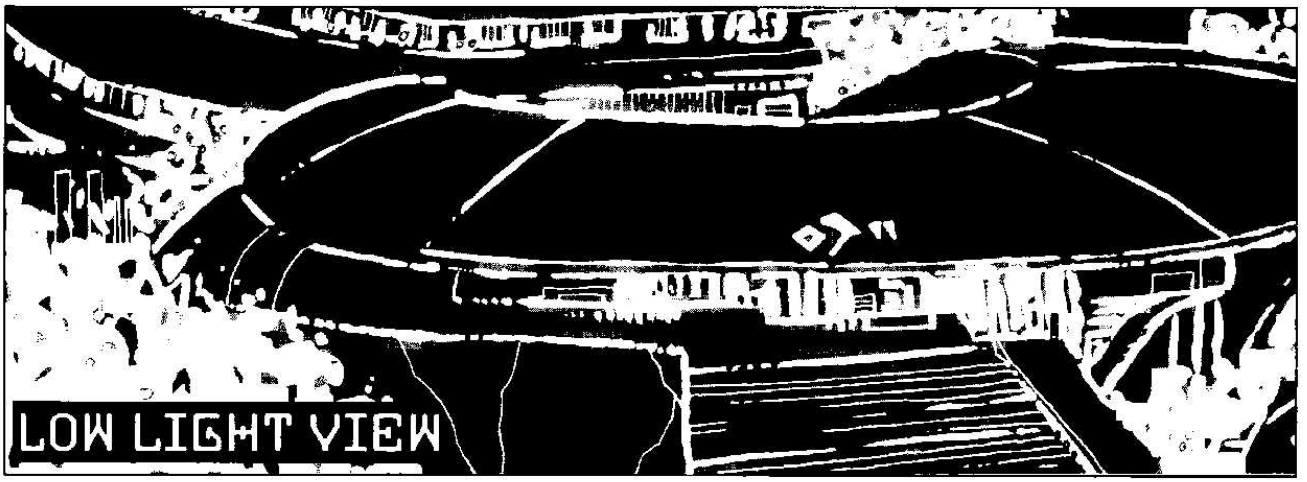
Punching Damage: A mecha's metal arms do the same punching damage that a human with brass knuckles does: thrust/crushing, based on their ST.

Reach: Mecha arms often have a reach of 2 or more hexes. Each hex of reach beyond the first adds +1 to *swing* damage when using a weapon and +2 to any attempt to grapple. Note that long arms can be attacked in other hexes, just like long weapons (p. B110).

Extra Arms: A mecha may have more than two arms. This lets it perform multi-handed tasks, like carrying multiple ready weapons. The pilot can use them all in concert during normal situations, like lifting, catching, digging or carrying. The ability to make multiple combat actions is only possible if the pilot has the Full Coordination advantage (see p. CI56). However, a mecha in close combat can grapple with multiple manipulator arms at once. This gives a +2 modifier per extra arm (over the first two) on attempts to grapple or pin, or to break free from a grapple or pin.

Throwing a Mecha: A mecha that has grappled its opponent can throw it, if the grappler is strong enough to lift its victim. If a mecha is thrown, it *takes* the same damage as it inflicts (see p. CI11).

Rocket Arm: An arm with this option can launch its fist as a ranged attack. The rocket fist attack has SS 5, Acc 2, 1/2D range equal to Arm ST and Max range equal to twice Arm ST. Picking up and reattaching the fist takes 30 seconds; until then, the arm is effectively a striker arm. At TL12+, the fist can fly back and reattach itself a turn later! Damage inflicted by the rocket arm is normal punching damage plus 2d.



Sensors

Mecha use two main types of sensors: the *PESA* and the *AESA*. Sensors are normally controlled by the mecha's pilot, and what they see is displayed on his HUD.

Passive Electromagnetic Sensor Array (PESA)

This is a multi-mode, electro-optical sensor; basically, a television camera with additional telescopic and infrared settings. It can function in any one of the modes described below; switching modes takes one second. Its line of sight is blocked by very solid objects, and it cannot see over the horizon. A PESA can also function as a digital camera, storing images of anything it sees in the mecha's computer memory. Multiply PESA range by 10 in the vacuum of space.

"Daylight TV Mode" – In DLTV mode, the sensor transmits an ordinary television picture from an array of external cameras to the pilot's monitor screen so the pilot can see outside the mecha without needing to rely on vulnerable windows. It also functions as an electronic telescope. The TV camera can zoom in on distant objects and magnify them, provided there isn't something in the way, like terrain or a cloud. DLTV mode suffers the same penalties that human vision does from fog, darkness, smoke, et cetera. The degree of telescopic magnification is equal to the PESA's range in miles; thus a 2-mile range PESA has 2× magnification. If a mecha has a chameleon system, rolls to hit or spot it via either DLTV or unaided vision are at -3 if instant chameleon (-6 if unmoving) or -6 if intruder chameleon (-10 if unmoving).

"Low-Light TV Mode" – LLTV mode is exactly like DLTV mode, but the mecha electronically amplifies low light levels. This gives the pilot the equivalent of Night Vision and Color Blindness. It won't work in total darkness, but faint starlight is adequate.

"Thermograph Mode" – This is a high-resolution infrared mode. Within the PESA's range, it allows the user to recognize objects by their heat contrast; people and machines show up as silhouettes. While surface detail is fuzzy, the user can tell hot objects from cold and (for example) can spot a cold metal gun under a man's jacket, track warm footprints left on cold ground or spot a hidden, powered-up vehicle or warm-bodied person. It adds +2 to rolls to spot living beings during daylight and +4 to Tracking rolls if the trail is no more than an hour old. Thermograph works in up to total darkness with no penalty and can see through fog, cloud or smoke, though not special "hot smoke." A thermograph is sensitive enough to be able to resolve heat shapes concealed behind brush or through

Using Comsuites

Most mecha have communication suites (comsuites). Here's how they work:

Radio: All comsuites have a multi-channel radio. In a mini or basic comsuite, it has a range of 100 miles at TL8, 1,000 at TL9 or 5,000 miles at TL10+. An advanced comsuite has 10 times that range. Any radio in range and on the correct channel will be able to detect the broadcast, unless it is also within the radius of a working area jammer. A radio can be set to transmit with reduced maximum range to reduce the likelihood of detection.

Scrambler: All radios incorporate a scrambler encryption system. If the sender and receiver use scramblers with the same settings, a message will be gibberish to anyone else listening in. A computer can be used to decode some or all of a scrambled message; see the *Cryptanalysis* skill (p. B245, p. CI156).

Global Positioning System (GPS): All comsuites have this system. It links up with friendly orbiting navigation satellites or ships overhead to provide precise location data, accurate to within 5 yards. However, without a satellite or ship it is useless, which can be a problem if one side has lost space superiority.

Radar and Laser Detector: All comsuites have sensors that detect the presence of an operating radar (or an AESA operating in radar or imaging radar mode) at out to twice the radar's range. Passive radar is not detected. They will warn the pilot whenever a new radar is detected. All comsuites will also detect working ladars or any laser beam, such as a laser sight or communicator, but only if the laser is pointing at the mecha, and then only out to the laser's normal range. Advanced comsuites can also pinpoint the distance and direction to the sensor, and can identify its type, if it's known (e.g., "Earth Space Force APG-702 AESA in imaging radar mode").

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Using Comsuites (Continued)

Laser Communicator: Basic and advanced comsuites (only) have a tight-beam communicator that uses a modulated laser beam. It has a range of 200 miles at TL8 or 2,000 miles at TL9+. It requires a direct line of sight to another laser communicator to use, but its signal can't be intercepted or jammed. However, intervening clouds, smoke, fog or falling snow interfere with the beam and block communication.

IFF: Only basic and advanced comsuites have this system, which stands for "identify friend or foe." A mecha's IFF responds automatically with an encoded "friendly" signal whenever it is *detected* by a radar or ladar set to a properly-coded frequency. This allows mecha to identify their allies using long-range sensors, where they would otherwise be just blips or silhouettes on the screen. To work, both mecha must be using the same set of up-to-date identity codes. There is a risk that the enemy might be able to discover the response codes, by capturing an IFF system or via espionage, and mimic them. As a security measure, a force will regularly change all its IFF settings; in the chaos of war, though, it's possible a particular unit may not receive the updates in time, leading to tragic mistakes.

Inertial Navigation System (INS): Advanced comsuites have a precision inertial mapping and navigation system. It uses a gyroscopic system, updated by star tracking or geomagnetic systems, to continuously fix the mecha's position relative to know map coordinates. It adds (TL-2) to the pilot's Navigation skill when trying to find position, and effectively gives the pilot Absolute Direction.

The Horizon

The distance at which a viewer can no longer see something because it has vanished behind the curvature of a planet or similar body is called the *horizon*. AESA and PESA sensors cannot see over the horizon; neither can vision. Weapons fire is only possible over the horizon using guided missiles or indirect fire.

A rough formula for determining the horizon in yards:

Horizon = Square root of [(D × 1,760 × H) + (H × H)].

Where *H* is the sum of object's and observer's heights in yards above the local base level and *D* is the planet's diameter in miles (for Earth, about 7,915 miles).

thin walls, though this requires an Electronics Operation (Sensors) roll at a penalty equal to the wall's (HT + DR), and the shapes are fuzzy silhouettes.

Active Electromagnetic Sensor Array (AESA)

An AESA is basically an advanced form of multi-mode radar. It cannot see over the horizon and is blocked by terrain features such as buildings or hills. An AESA is never affected by darkness.

It can use the following modes:

"Search Radar Mode" – The sensor functions as a long-ranged radar set, emitting pulses of radio or microwave energy over a wide area. It detects objects as these pulses reflect off them and bounce back to the sensor. Tank-sized or smaller targets detected by search radar show up only as "blips" on a screen with a range, course and speed; details such as the target's shape or color are not resolved. Smoke, hot smoke, fog and clouds have no effect on search radar mode.

"Low-Res Imaging Radar Mode" – When switched to low-res imaging mode, the radar's range is half that listed for the AESA. However, resolution is much sharper, allowing it to determine the general size and shape of objects of any size.

"High-Res Imaging Radar Mode" – This reduces range to 1/50 the search radar range (about 35 yards of range per mile of AESA range), but detail equivalent to human vision can now be resolved. A face might be recognized, for instance, although flat details like color or writing cannot be determined.

"Ladar Mode" – This mode uses a laser beam rather than a radar beam for scanning. It has a range equal to half that of the AESA and gives detail equivalent to high-res imaging radar. However, it does not function through clouds, smoke, heavy rain, falling snow, thick fog or special anti-laser smoke such as prism or blackout gas. Ladar works underwater at 5% of its normal range.

"Targeting Mode" – All of the above modes also have a targeting mode. This allows the AESA to feed range-finding information to all ranged weapons that are fired at a single target that is in range and already detected by it, giving +2 to hit. In targeting mode, an AESA may not detect new targets, but may track those it has already detected.

Sensor Skill Rolls

A pilot can use only one type of sensor (and sensor mode) per turn, or ignore sensors and use his own eyes. A player who switches sensors should inform the GM!

The GM can assume that sensors will normally detect anything within their range, line of sight and arc of vision. Assume that unaided human vision is good up to about 1.5 miles (multiplied by any magnification for a PESA) or the horizon, and that thermographs and AESAs are limited by their range.

Otherwise, assume detection is *automatic* if the enemy is on fire or announces his presence by firing, signalling, et cetera. Skill rolls *should* only be required to detect important objects under difficult conditions. In general, only roll if one or more of the penalties in the *Sensor Modifiers* sidebar (p. 49) applies. These take into account objects that are in cover, darkness or concealed by ECM or stealth systems. Once an object is spotted, there's no need to roll again unless it somehow becomes harder to detect than it previously was.

A detection roll is made against Electronics Operation (Sensors) skill if using a PESA or AESA, or against IQ if using normal vision. Add the Size Modifier of the object and apply any appropriate modifiers for distance:

Object within 1/10 sensor range: +6
Object within 1/4 sensor range: +4
Object within 1/2 sensor range: +2
Object within sensor range: +0

Use the result that gives the highest bonus. Treat naked-eye vision as having a range of 1.5 miles, or about 3,000 yards; this is multiplied by the magnification of any DLTV/LLTV, binoculars, et cetera.

Other Modifiers: Situational modifiers for cover, ECM, et cetera appear in the *Sensor Modifiers* sidebar.

Comsuites and Detection: A comsuite can detect the use of AESA sensors – see *Comsuites*, p. 47. No roll is needed.

MECHA IN COMBAT

Attacks on a mecha can be made against either the mecha's body, individual subassemblies (turret, arms, legs, wings) or wheel positions, each of which is considered a "location."

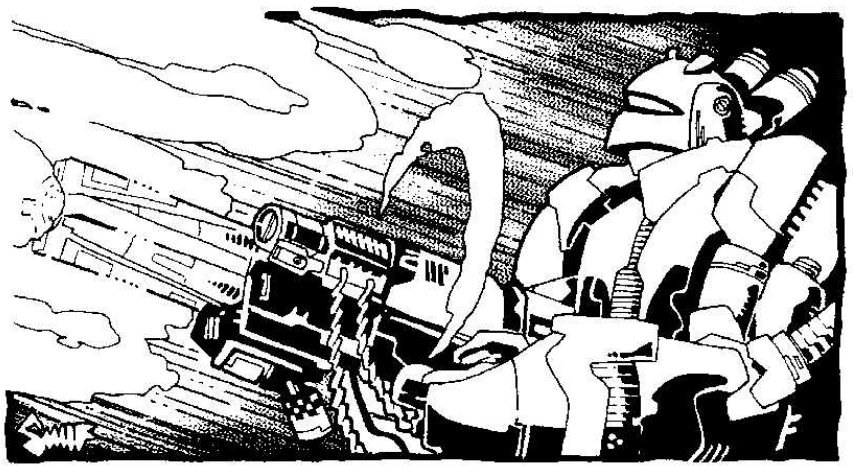
Normally, the attacker chooses which location will be struck. If firing at locations other than the body, use that location's Size Modifier.

If a subassembly is folded (in a transformable mecha), it can't be hit. Also, in collisions or in hand-to-hand combat, the GM can rule that the relative size of the combatants limits what can be attacked. For example, if a human swings a sword at a 30' tall mecha, the only location he can really hit is the machine's legs.

Area attacks, such as concussion from explosions, are always assumed to strike the mecha's body.

Using Multiple Weapons: Even if a mecha has more than one weapon, a single character can fire only a single weapon or a single set of *linked* weapons at once. If a character fires linked weapons, they must all be used against the same target. *Exceptions:* Linked homing missiles can be fired at different targets. A neural interface allows the interfaced character to fire several different ranged weapons or sets of linked ranged weapons at once, at a -2 to skill per extra weapon or set of linked weapons firing. (No single weapon can fire more than its normal RoF, however.)

Multi-Crewed Mecha: In a mecha with more than one crew member, each crew member with a set of controls may fire a weapon or set of linked weapons, provided they all fire different ones! However, weapons built into or carried on wings, arms or hardpoints can only be fired by the person piloting the mecha.



Sensor Modifiers

All Detection Rolls

Object in cover:
Prone behind cover, head/turret down: -7
Prone/crawling without cover: -4
Any position, only head/turret exposed: -5
Body half exposed or behind light cover: -2
Crouching/Kneeling with no cover: -2
Object concealed by (use only highest penalty):
Light woods: -1 per 50 yds*
Dense forest: -1 per 5 yds*
* Based on the thickness between the observer and the target.

Vision Rolls Only (including DLTV or LLTV)

Bad light: -1 to -9, unless LLTV mode
Total darkness: fails automatically!
Naked eye from within closed cockpit: -4
Line of sight passes into/through:
Blackout gas: totally blocked
Dense smoke: -1 per yd*
Cloud bank, fog or blizzard: -1 per 5 yds**
Water: -1 per 5 yds*
Light mist: -1 per 50 yds**
Object using (use only highest penalty):
Good camouflage: -2
Instant chameleon: -6 (-3 if moving)
Intruder chameleon: -10 (-6 if moving)
* Based on the thickness between the observer and the target. ** Based on range between the observer and target.

Vision (including DLTV/LLTV) fails automatically if the line of sight passes through 10+ yards smoke or dense fog, or 50+ yards of blizzard, water or dense forest.

Thermograph or Infrared Only

Object is hidden by:
Blackout gas or hot smoke: -1 per yd*
Being underwater: -1 per yd*
Blizzard: -1 per 5 yds**
Falling rain or snow: -1 per 50 yds**
Object using:
Infrared Cloaking:
if Basic: -1 × (TL-4)***
if Radical: -2 × (TL-4)***
* Based on the thickness between the observer and the target.
** Based on range between the observer and target.
*** Unless object is presently using a fusion air-ram, TL9 reactionless thruster or any kind of rocket engine.

Thermograph or infrared detection fails automatically if line of sight is blocked by 10+ yards of blackout gas, hot smoke or water, or 50+ yards of blizzard or dense forest.

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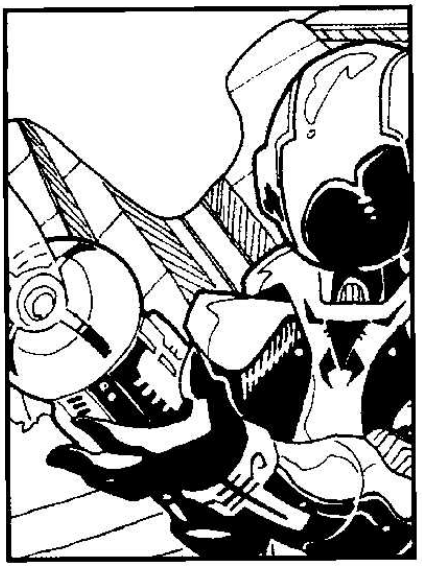


Sensor Modifiers (Continued)

Radar or Imaging Radar Only

Object is using:	
Basic Stealth:	-1 × (TL-4)
Radical Stealth:	-2 × (TL-4)
Deceptive jammer:	-1 × jammer rating
Line of sight passes into/through:	
A body of water:	-2 per yd
Falling rain or snow:	-1
Radius of active jammer:	-1 × jammer rating
Chaff cloud:	-2 per yd or a flat -5, whichever is worse

Ladar Only

Object is using:	
Basic Stealth:	-1 × (TL-4)
Radical Stealth:	-2 × (TL-4)
TL10+ distortion jammer:	-1 × jammer rating.
Instant chameleon:	-6 (-3 if moving)
Intruder chameleon:	-10 (-6 if moving)
Line of sight passes into/through:	
A body of water:	-8
Thick fog or smoke:	-1 per yd
Mist, clouds, falling rain or snow:	-1 per 5 yds
Chaff cloud:	-2 per yd or a flat -5, whichever is worse
Prism cloud or blackout gas:	fails automatically!

Chaff, deceptive jammers and area jammers have no effect on higher-TL sensors. Radar detection automatically fails if line of sight is blocked by solid objects, 5+ yards of chaff, or 50+ yards of dense woods or jungle. Ladar detection has the same limit, and also fails automatically if LOS is blocked by 5+ yards of dense fog or smoke, or 50+ yards of cloud banks or mist.

Ranged Combat

Ranged Combat Modifiers

These considerations apply especially to mecha:

Size Modifier: The Size Modifier for a mecha is determined during the design process. For other targets, use p. B201. If the target is the body of the mecha, use the mecha's Size Modifier. If the target is a subassembly, use the subassembly's own Size Modifier. If an attack against a wing or turret subassembly misses by 1, it hits the body instead.

Fixed-Weapon Skill Level Limit: If firing a beam or gun that is built into the body (unless in a casemate), a wing or a hardpoint, the user must aim the weapon with the mecha's body, so his Gunner skill may not exceed his mecha operation skill-3.

Recoil: Recoil penalties do not apply when using mecha weapons; the mecha's body safely absorbs the recoil.

HUDs: All normal mecha and battlesuit cockpits incorporate a HUD with built-in pupil scanner. If the mecha has a head-up display, the SS of its weapons is -4 for TL8 HUDs or -7 for TL9+ HUDs.

Neural Interface: If a mecha has a neural interface accessory, it gives a +4 bonus to Gunner skill.

Active Targeting: If a mecha has an AESA sensor system, it can use it to "target" with, giving a +2 to attack any one object within range. See *Active Electromagnetic Sensor Array (AESA)*, p. 48.

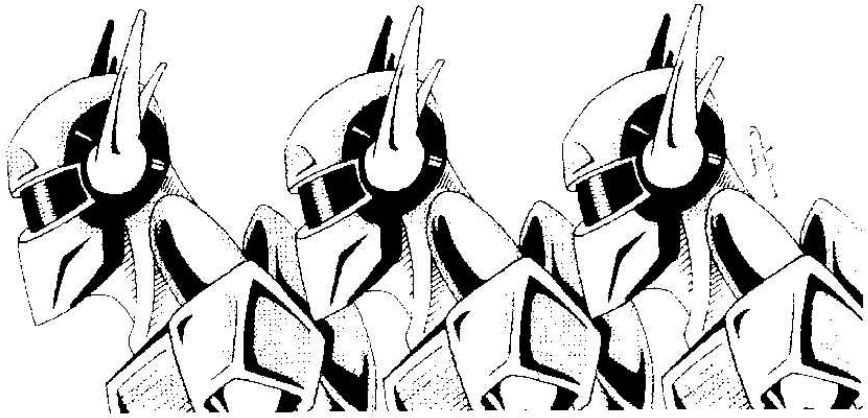
Targeting Computer Bonus: Most mecha have computers that give a bonus to hit. This applies to all ranged attacks made by the mecha, unless the computer is disabled.

Moving while Firing: A mecha that fires while moving suffers the penalties noted on p. B117.

Terrain: A mecha or other vehicle in a clump of light woods is -2 to be hit, or -4 if in dense forest or jungle. Mecha can also drop prone, just like a human (see p. B118).

Cover: Battlesuits and mecha can take advantage of the same cover modifiers that humans get when leaning around buildings, over ridges or crater rims, behind wrecks, et cetera. The GM should remember that the cover must be proportional to the mecha's size. A 4' high garden wall can provide half cover to a 7' tall battlesuit standing behind it, but not a 30' tall drivable mecha! On the other hand, a sturdy brick house would be just the thing to kneel down and take cover behind.

Sensors, Concealment and ECM: Attacks are assumed to be aimed visually unless the attacker was using a different sensor mode that turn – if a mecha has a



PESA or AESA, players should inform the GM at the start of the turn which sensor mode is being used. For bad weather, smoke, darkness, ECM, et cetera apply the penalties from the *Sensor Modifiers* table (sidebar, p. 49), depending on which sensor the mecha is using to aim its weapons with (or the visual modifiers, if not using sensors).

Firing in Space

Without gravity or atmosphere to get in the way, guns and beam weapons have superior range in space.

Beam Weapons: Multiply ranges as follows: ×100 if an x-ray laser, ×50 if rainbow laser or particle beam, or ×10 if flamer, plasma, blaster or ordinary laser.

Guns: Ignore Max and 1/2D ranges – the projectiles will keep on going. Indirect fire is not allowed.

Missiles: These maneuver the same way as mecha; replace their normal Speed, End and Max figures with sAccel 10 g (15 g at TL11+) and End 1.5 minutes.

For more detailed space combat rules, see p. VE187.

Critical Hits

If the attack was a critical hit, the mecha gets no defense roll. See the *Critical Hit Table* (p. 57).

Hand-to-Hand Combat

Assuming they have arms or legs, mecha can fight like large humans (or animals). This requires a Step and Attack or All-Out Attack maneuver, and can't be combined with ranged weapon fire.

See *Using Arms* (p. 46) and *Using Legs* (p. 46) for punch and kick damage. If a mecha has manipulator arms, it can use a hand weapon. A mecha can dodge, or it can parry melee attacks with its arms or a hand-held weapon. It may also block, if it has a shield (see p. 110).

Skill: When brawling or using a hand weapons, use the *lower* of the relevant combat skill (e.g., Brawling or Broadsword) and the pilot's control skill.

Collisions

When a moving vehicle crashes into something, this is a collision. For small mecha like battlesuits, the GM may wish to use the normal ***GURPS Slam*** rules (p. B112). Otherwise (and optionally, at any time), the GM should use these collision rules.

Note: ***GURPS Vehicles*** has much more detailed rules for collisions.

Avoiding a Collision

If two objects maneuver into contact with one another, this normally results in a collision. However, one or the other object may be able to avoid a dangerous *crash:*

Dodging: A mobile object may be allowed a Dodge roll to avoid a collision. On the ground, only an object that is much smaller than the one it is about to collide with can dodge: its Size Modifier must be at least 3 less than the larger object's. In mid-air or space collisions, there is no size restriction. Make a normal Dodge roll, except PD doesn't help. A success will move the dodging character the same distance as his usual "step." If that's far enough to escape, the dodge succeeds!

Stepping Over: In a potential ground collision, a mecha with legs and a Size Modifier at least 2 greater than the other object can opt to step over it without colliding at all. Thus, a large mecha can choose to avoid running a person over.

Dischargers

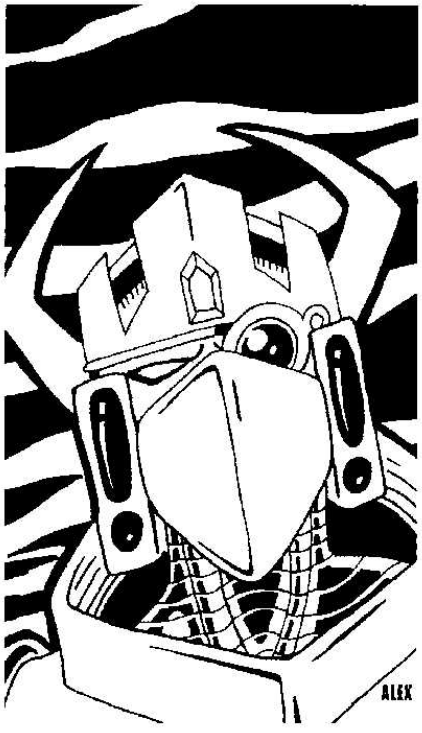
Some mecha have *dischargers*. These are launchers for countermeasures such as smoke grenades or flares. Each discharger is loaded with a single shot. Any or all of a mecha's dischargers may be fired per turn. Firing a discharger is not a combat maneuver: it can be combined with dodging. Multiple dischargers can be fired at once, which is useful if you want to launch a few different types of decoys. Countermeasures include:

Smoke is used to create a thick smoke screen, 20 yards in diameter, that obscures vision and blocks ladar. See *Sensor Modifiers* (p. 49) for the penalties. It lasts for 300 seconds divided by wind speed in mph (max. 300 seconds).

Hot Smoke: As above, but lasts half as long and penalizes infrared and thermograph sensors as well.

Chaff bursts into a 100-yard diameter cloud of conductive strips designed to reflect radar signals, which produces a huge, diffuse target that can conceal things behind or within it. It penalizes radar and ladar detection; see *Sensor Modifiers* (p. 49). However, the cloud itself shows up very well on radar or ladar, so the presence of "a cloud of chaff" will be known at least. It disperses in 150/(wind speed in mph) seconds (max. 150 seconds). Air-launched chaff drifts downward at 5 yards/turn.

Flares burn brightly in the infrared and visual spectrum, at frequencies designed to lure away incoming homing missiles (see p. 53).



Angle of Fire

A weapon can normally only fire in the direction it is facing, plus a few degrees off to either side ("angle off") and up (elevation) or down (depression). The exact arc of fire is described below, and depends on where the weapon is installed:

In Body: The weapon can fire with a 15° angle off to right or left and with a 15° elevation or depression.

In Turret: As above, but it can be rotated to face any direction, effectively giving a 180° horizontal arc of fire for limited rotation, or a 360° horizontal arc of fire for full rotation.

In Wing or on Hardpoint: The weapon can fire with a 15° angle off from the side it is attached to (thus, a weapon in a right wing can fire at 15° off to the right). The weapon also has a 15° elevation and depression.

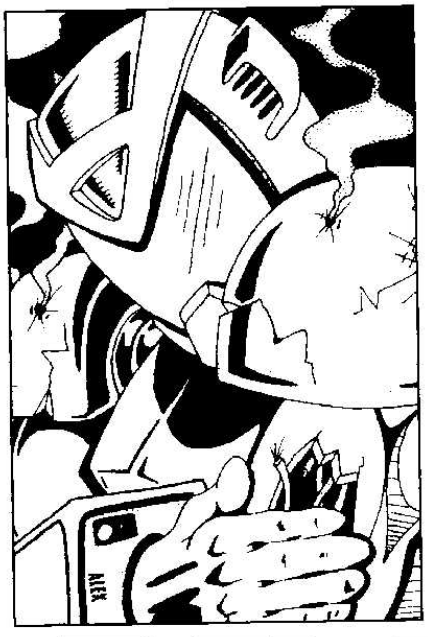
In Arm or Hand-Held: A weapon mounted in or held by an arm can fire in whatever direction the arm is pointing in – the same arc of fire as a human holding a gun.

In Leg: The weapon can point in whatever direction the leg points – but it cannot be fired on any turn that the mecha is moving further than a step. Also, unless flying, no more than half of the vehicle's legs can fire weapons at once.

In Pod: If mounted on a wing or arm, the weapon fires forward, as if in a wing or on a hardpoint; if mounted on the back, it fires upward and can only be used to hit targets directly overhead, or for indirect fire.

Sensor Arc of Vision

Use the angle of fire rules for weapons (above), based on where the sensor is mounted.



Damage from Collisions

An object that collides with something *inflicts* dice of crushing damage equal to (its original hit points × collision speed in yards per second)/100, rounded up to the nearest full die. This is the same as (hit points × collision speed in mph)/200. For mecha, use body hit points; for living beings, hit points normally equal HT.

Collision speed is based on how far the striking object moved in a straight line the turn before it hit; normally, the struck object can't inflict more damage than the striking object, unless the collision is head-on (in which case their speeds should be added together). If the damage die spread from a collision is awkward, the GM should simplify it into whatever spread he prefers: 110d can become 11d×10, for instance.

Hitting Buildings and Immovable Obstacles: If a moving object hits a fixed structure like a building, it inflicts normal collision damage on it and *takes* the same damage, to a maximum of the damage it inflicted *or* the sum of the structure's HP and DR, whichever is *less*. If colliding with the ground, a hill or some other object with more-or-less infinite hit points, the moving object takes (its own body hit points × collision speed in yards per second)/100 dice crushing damage. Reduce damage by -2 per die for collisions with water or -1 per die for collisions with snow, soft mud, et cetera.

DR and Collisions: DR will protect the vehicle normally, but the crew may get mashed up anyway – see below.

Collision Aftermath: If two objects collide, check for knockback. If one object knocked the other back but wasn't knocked back itself, it pushes the other aside and continues on. The other object may also be knocked down – see the knockback rules (p. B106) and *Mecha and Knockback* (p. 54). If a moving object crashes into an immovable object, it also stops.

Whiplash and Concussion: If a mecha is knocked aside or stopped by a collision, its occupants take whiplash damage: 1d-2 damage per 10 yards per second of collision speed. This damage is *not* absorbed by armor (but Toughness does protect!). Damage doubles if not either wearing safety belts or in a battlesuit. A womb seat reduces whiplash and concussion damage by an effective DR equal to twice its TL.

Stomping: A mecha moving on legs can avoid a collision and instead *stomp* an object that has a Size Modifier two or more less than its own. The victim can dodge to avoid the stomp. Otherwise, a stomp does normal kicking damage, with an extra +1 per ton of loaded mass (round fractions up). This doesn't count as an attack, but a mecha can only stomp one person per two legs unless the mecha is really huge, in which case a single leg's stomp can cover (leg surface area/100) 1-yard hexes.

Defenses

When hit, a mecha gets a passive defense roll based on the armor on the location hit or its deflector screen PD, unless the attack was an explosion. PD also adds to Dodge and other active defenses – again, except versus explosions.

Shields: A mecha with a ready shield can get extra PD from it against frontal attacks, but the shield risks destruction; see *Shields* (p. 110), in Chapter 6.

Dodge

A mecha with a gMR of 1+ (on the ground) or an aMR of 1+ (in the air) may dodge. A mecha's Dodge score is not based on its Move. Instead, it depends on the pilot's control skill and how the mecha is moving:

On the ground, Dodge is skill/2 if on two legs, skill/3 if on three or more legs, or skill/4 if moving on wheels.

In the air or in space, Dodge is skill/3.

Round all fractions down. Combat Reflexes and mecha PD will increase Dodge in the normal fashion. However, if the sum of PD and Dodge exceeds 14, treat it as 14.

Dodge and Drop: A mecha moving on the ground on two legs may drop prone while dodging, earning a +3 bonus to Dodge, even vs. ranged weapons. It can't do this if it used its enhanced Move this turn. For more on Dodge and Drop, see p. CII63.

Parry

The pilot of a mecha with arms can parry just like a human does, either barehanded or, in the case of manipulator arms, with a hand weapon. The normal restrictions on parrying apply (i.e., ranged attacks, except for thrown weapons, can't be parried).

The combat skill (e.g., Brawling, Broadsword, et cetera) the pilot uses to parry cannot exceed Battlesuit skill if wearing a battlesuit or Driving (Mecha) if in a drivable mecha.

Block

A mecha can use a shield or force shield to block with; see *Shields* (p. 110), in Chapter 6. The pilot's Shield skill cannot exceed Battlesuit skill if wearing a battlesuit or Driving (Mecha) if in a drivable mecha.

Retreating

A mecha can only retreat (see p. B109) if it is either moving on legs or flying and has no stall speed, and only if it did not use its enhanced Move that turn.

Misses and Scattering

When an attack that produces an explosion or releases smoke, gas or other chemicals misses or is dodged, it will still go off *somewhere.* Use the *Scattering* rule on p. B119, except the distance may be greater: take the amount by which the attack roll failed or the Dodge roll was made, treat it as a negative number and look it up on the *Speed/Range* column of the table on p. B201. Read across to the adjacent *Linear Measurement* column to find the distance the attack missed by, to a maximum of 1/10 the range to the target (at least 1 yard). In the air or space, scatter can be ignored unless the target was close to the ground and the attack came from above.

Homing Missiles

Homing missiles are rockets fitted with a homing guidance system and steering capability.

GURPS Vehicles has extensive rules for missile guidance systems that tie into its detailed electronic detection system. For ***Mecha,*** a simpler system is used, as only a few types of homing missiles are included.

Lock-On: Locking on requires an Aim maneuver. Roll to hit normally with the missile, using the missile's skill as *both* its skill and its Accuracy. The gunner's skill does not apply. These additional modifiers do apply:

Target is using:

Basic IR cloaking . . . . . *-1×(cloak's TL-4)*

Radical IR cloaking . . . . . *-2×(cloak's TL-4)*

On this or the previous turn, target discharged a ***flare*** *of equal or higher TL than the homing missile* . . . . . *-5*

Target using IR jammer . . . . . *-1 × jammer rating*

Target using TL10+ deceptive jammer . . . . . *-1 × jammer rating.*

IR cloaking has *no effect* if the target used a fusion air-ram or any kind of rocket engine on this or his last turn. A jammer or flare has *no effect* if it is of lower TL than the homing missile it is trying to jam.



Fire and Explosion

A fire isn't a pleasant thing for a mecha. There are several ways a mecha can catch fire:

Flame Attacks: These are attacks that are especially likely to start fires, including explosions, flamers, lasers, flamethrowers, Molotov cocktails, depleted uranium rounds and anything else the GM thinks likely to start a fire. If a flame attack *penetrates* the DR of a mecha (or hits a mecha with flammable ablative or wooden armor), it may catch fire. Roll 3d vs. the penetrating damage done by the flame attack (or vs. *any* damage, if the mecha has flammable armor). If the roll is less than the damage, the hit location is on fire.

Fuel Tanks: Some types of fuel have a *Fire* number, as described under *Fuel and Fuel Tanks* sidebar (p. 86). A check for fire must be made any time a body or subassembly housing such a fuel tank takes damage greater than half its hit points from any kind of attack. Roll 3d; if less than or equal to the Fire number, the tank catches fire (add +4 to Fire number if the attack was a flame attack).

Once a fuel tank catches fire, roll 3d each second versus half the tank's Fire number. "Success" means the tank explodes. The vehicle takes 6d×15 damage per gallon of gasoline, diesel or jet fuel in the tank, or 6d×25 per gallon of rocket fuel. If the vehicle has a self-sealing tank, only one-quarter damage is done – the rest of the energy is dissipated tearing the tank apart against the resistance of the seal.

Every ten seconds that a fuel tank is on fire, 1d×5% of its total fuel capacity is burned away. When all the fuel is gone, the tank is no longer on fire.

Power Plant or Thruster Hits: Damage to a power plant, jet or rocket engine that uses flammable fuel may result in a fire. If the power plant or engine is disabled (as the result of a critical hit or by disabling the location it occupies), roll three dice vs. the Fire number of the power plant or thruster's fuel. If equal to or less than the Fire number, the vehicle catches fire.

Continued on p. 56 . . .

Firing: If the lock-on roll succeeded, the missile can be lauched on the following turn; launching a missile is an attack. If it failed, the firer can try again next turn. *Exception:* if the roll failed by 1 or 2, or was a critical failure, *and* the target had an IR or TL10+ distortion jammer, the missile is launched at the wrong target. It will miss; at the GM's option, it may chase an enemy mecha, building, rock, et cetera.

Tracking and Flight: Once launched, the missile will move toward the target at its listed *Speed*, covering that number of yards each turn. A missile will always try to keep its target in front of it and in its arc of vision (see p. B115) – if it cannot do so, it has lost its target. To do so, each turn it may change direction by up to 30°, climb or dive. A missile can only move for a number of seconds equal to its *Endurance*. After this is exceeded, it will self-destruct.

Decoys: If the target has a decoy discharger loaded with flares, it can launch one to confuse the incoming missile. (Launching more than one flare has no extra effect.) Flares only work if they are of the same or higher TL as the missile. On any turn a flare is launched, the missile's owner rolls 3d vs. the missile's skill minus the flare's TL; if the roll fails, the missile is decoyed away and effectively destroyed.

Shooting at Missiles: Missiles can be fired at, though their small size and high speed makes them hard to hit! Small missiles have a Size Modifier of -4, medium missiles are -2, large missiles are 0. The missile's speed is its Spd attribute. Ten points of damage will knock any missile off course or blow it up.

Dodge: Missiles that hit can be dodged. If the Dodge roll fails, the target will be hit. PD is treated as 0 vs. homing missiles.

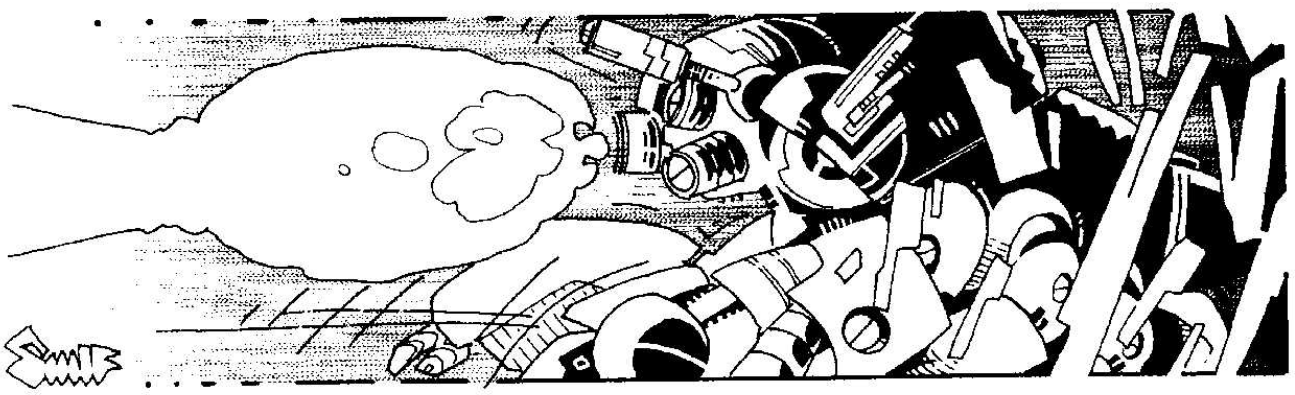
EFFECTS OF DAMAGE

When a location is hit, subtract its DR from damage. (If the mecha has a force screen, first subtract the screen's DR.)

Ablative Armor: The PD and DR of this armor work normally, but for every 10 points of damage that strike the armored location, whether or not it is resisted by the ablative DR, one point of ablative DR is destroyed; for body or turret armor, DR is only lost on the face attacked – right, left, back, front, top or underside. If a mecha has an outer force screen or a layer of non-ablative armor, only damage that actually penetrates to the ablative armor reduces its DR. Lost DR can be replaced the same way hit points of damage are repaired.

Mecha and Knockback

Even if no damage penetrates DR, a mecha can suffer knockback. The number of hits required to knock a mecha back 1 hex is 100 times its loaded mass in



tons. The pilot of a mecha that is knocked back must make a control roll to avoid falling over. If a mecha overturns, it can normally right itself in two turns, rising to a kneeling and then standing position.

Damage Effects

Damage that penetrates DR is applied only to the location hit and reduces that location's hit points. Thus, unlike a human, damaging an arm does not affect the body's hit points. Each body, subassembly or wheel is a location. If a location is reduced to 0 or fewer hit points, it is disabled; see *Disabled Locations* (Below).

If a location holds a cockpit, battlesuit system, explosive ammunition or fuel tank, penetrating damage may have further effects:

Any damage that penetrates DR may injure an occupant in a cockpit or battlesuit system in that location; see *Occupant Injuries*, below.

Damage of half or more a location's original hit points may cause an ammo explosion if the location houses volatile ammo; see *Ammunition Explosions* (p. 57).

Damage of half or more a location's original hit points may cause a fuel fire if the location houses a fuel tank with a Fire number; see *Fire and Explosion* (p. 54).

Occupant Injuries

If a battlesuit system or cockpit occupies the damaged location, there is a chance that the occupant may be hurt.

If a location containing a cockpit, standing room or a battlesuit system loses hit points from an attack, anyone in the location may be injured by fragments or the attack itself. Roll 1d for every 100 points of penetrating damage (or fraction thereof). On a 6, one random or GM-chosen occupant (normally the pilot, unless there is more than one person) takes half the penetrating damage inflicted, up to a maximum of 50 hits. DR (e.g., from worn armor) protects normally, but if the attack has an armor divisor, then that is also applied to the DR of the character's own armor.

Exception: If the attack's damage was greater than the location's actual hit points, damage is inflicted on a 5 or 6 and the maximum damage is 100 hits.

In addition to the above, if any battlesuit's turret, arm, leg or body takes damage that reduces it to 0 hit points or less, the wearer will always be damaged. Apply half damage past 0 hits to the matching location on the pilot. For example, if a battlesuit were hit in the turret and the damage reduced the turret's hit points to -5, the pilot's own head would take half that, rounded down, or 2 hits of damage. If the turret were hit again for 4 points of damage, the pilot would take another 2 points of damage and the turret would be at -9 hit points.

Note that a person in a master-slave battlesuit (see p. 96) only occupies one location, and a person is not "inside" a battlesuit that has transformed into a cycle-like configuration.

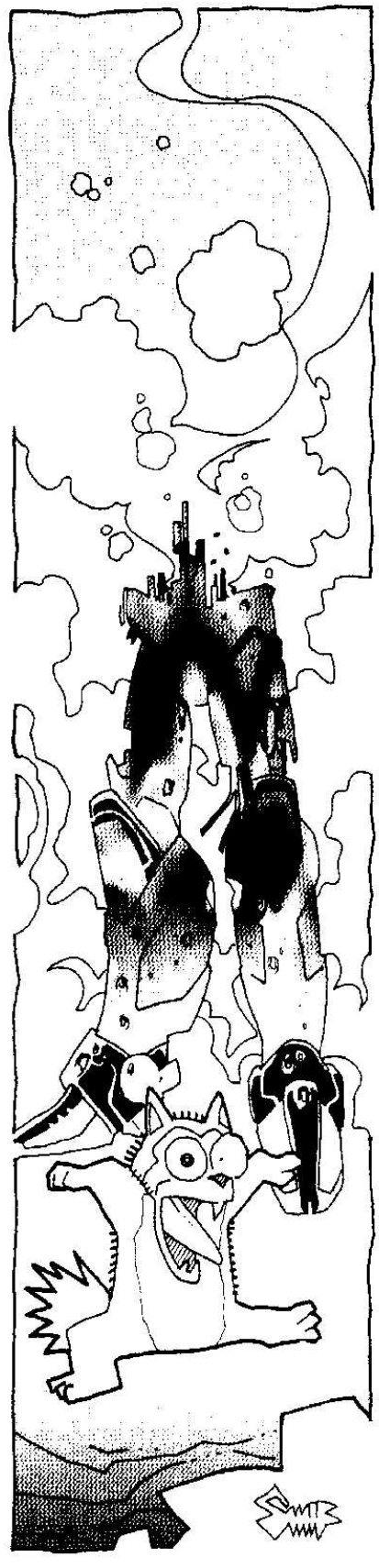
Fire: If a character is in a location that is on fire, he takes normal fire damage each turn, as described on p. B129.

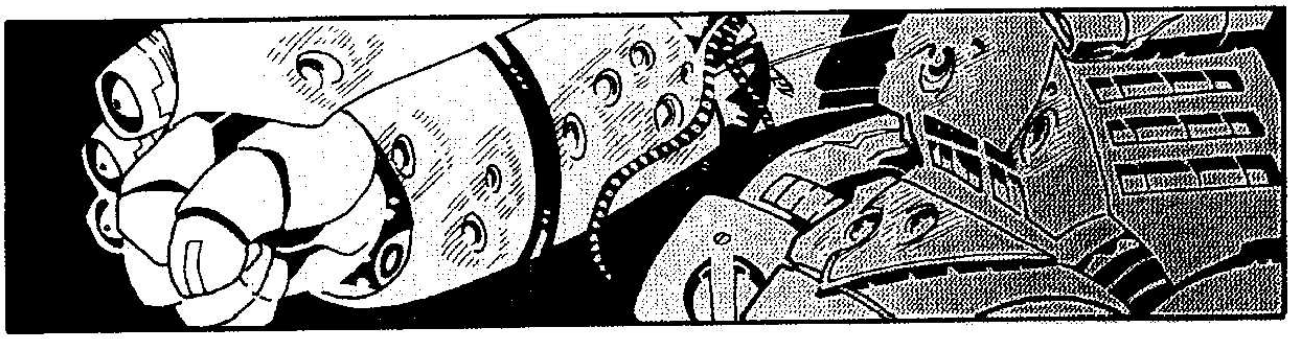
Disabled Locations

If a location is reduced to 0 or fewer hit points, it has suffered very serious damage and may stop working. The effects depend on the location, and take place in addition to any checks for occupant damage, ammo explosion or fire.

All Locations: Disabling *any* location disables all components within it; if a lifesystem is disabled, it will still have its remaning man-hours of life support once it is repaired.

Disabled Body: The mecha's Speed and Dodge are halved, cumulative with





Fire and Explosion (Continued)

Effects of Fire

A mecha on fire suffers 2d damage, plus another 2d every 10 seconds, ignoring DR. Fire damage is always applied to the location where the fire is taking place. The crew may be able to put the fire out by using fire extinguishers (see p. 81), diving the mecha into water, et cetera.

Any crew who occupy the location that is on fire suffer the effects of fire and suffocation described in the ***Basic Set***. Their personal armor protects normally.

Fire can spread or die. Every ten seconds, each fire may spawn another fire. This occurs if the fire did 8 or more hits of damage after modifiers. However, if an individual fire did less than 4 hits of damage after modifiers, that fire dies out. If a fire totally destroys a location, the fire there also dies.

Fire-Fighting

A mecha cockpit normally includes a compact fire suppression system. This is an automatic chemical fire extinguisher with outlets throughout the mecha's body. Fire suppression systems get a roll to put out a fire immediately, with an extra roll every ten seconds. Make a separate roll for each fire raging in the vehicle, rolling against the system's TL+3 on 3d. *Modifiers:* -1 per separate fire going on at once.

A mecha cockpit with the "no fire suppression" downgrade lacks this system, but the crew can use hand-held fire extinguishers to fight any fires in the same location as the cockpit. A pilot or crew member can't do anything else if fire-fighting, and can only fight one fire at a time. Roll the extinguisher's TL+2 or less on 3d to succeed, or roll 6 or less without an extinguisher, every ten seconds. A critical failure means the fire-fighter takes 2d burn damage. The DR of fireproof clothing will help against this damage.

A battlesuit lacks fire-fighting gear. If a fuel tank or power plant is on fire, the wearer should abandon the suit – although if a companion has a hand-held fire extinguisher, he can try to use it to deal with the flames (see above). See *Wearing a Battlesuit* (p. 40) for the time required to get out.

any penalties for leg damage. The mecha is also on the verge of massive system failure – it will stop working in a short time. Roll 3d vs. the mecha's HT when it is first reduced to 0 or fewer hit points, and again at the start of each turn. On a failed roll, the entire mecha is effectively "knocked out." If it was moving on the ground on the previous turn, it will crash. If it was flying, it enters an uncontrollable dive. If it was in or under water, it starts to flood and sink. If it was in space, it simply floats there.

Disabled Subassembly: The subassembly no longer functions. All components in it stop working. Cargo stored there is inaccessible. Energy, fuel or ammunition in it cannot be used. In addition, some specific effects apply to certain subassemblies:

Arm – The arm can no longer move, strike, manipulate or hold anything. Anything the arm was holding is dropped and may take damage from the fall, if the mecha is tall enough.

Leg – The leg is crippled and cannot be used to move or kick. If a mecha has two legs and one is disabled, the effects are the same as when a human suffers a crippled leg: it falls down and can only move by crawling. If it has three or more legs, the pilot must make a control roll to avoid falling; also, divide ground Speed and Move using legs by the number of legs, rounding up – that's the speed lost for each leg that is crippled. If all legs on one corner or side are gone, the mecha falls and can only crawl.

Wing – The mecha may no longer safely fly in a configuration that has unfolded wings (the aerodynamics are wrong). If it attempts to do so, its aerial Move, Speed and MR are cut in half and it gains an "infinite" stall speed; the pilot must make a control roll each turn. On a failed roll, the mecha goes out of control and enters an uncontrollable dive. When it hits the ground, inflict falling damage on it, multiplied by its weight in tons.

Turret – The turret can no longer rotate. It is stuck facing in whatever its last direction was.

Wheel – Each wheel is an individual location. If an attack cripples one wheel and the mecha has only two, its Speed and Move on wheels drop to 0. If a mecha has three wheels, its Speed and Move on wheels drop to 0 when the front wheel or both rear wheels are crippled. If it loses one rear wheel, halve Speed and Move. If the mecha has four or more wheels, its Speed and Move on wheels drop by 10% when a wheel is lost, and are halved when half or more are lost; if it loses all wheels on two corners, Speed and Move are reduced to 0.

Disabled Locations & Trapped Crew

If a pilot or crew member is within a location that is disabled, he may be trapped. Roll 1d. On a roll of 5-6, he is stuck in debris. One frantic roll to escape is allowed each turn, made vs. ST-7, or a more deliberate attempt can be made every ten seconds, rolling vs. ST-3. A failed roll inflicts 1d damage; DR does not protect. A trapped character cannot eject.

Destroying Mecha

If a location is reduced to -5× its original hit points, it isn't just disabled – it's totally destroyed. If this happens to a subassembly, there isn't much difference in game terms except it is much harder to repair and the subassembly is blown clean off. If the body is destroyed, so is the mecha; all subassemblies attached to it are disabled.

Mecha Critical Hit Table

Critical hits allow individual components to be damaged. If a mecha takes a critical hit, it gets no defense roll.

Mecha Critical Hit Table (Roll 3d)

3 – Triple normal damage; also, if there is a computer in that hit location and any damage penetrated DR, it is destroyed! (If there are multiple computers, the largest one is destroyed.)

4 – Double normal damage. Also, if the hit struck the body of a winged mecha and did damage in excess of 5% of body hit points (minimum 1 hit) after DR, the rudder system is damaged. In a configuration with unfolded wings, aMR is halved, rounded down, and it may not dodge.

5 – Bypasses 90% of armor DR (i.e., divide armor's DR by 10) and does normal damage. Also, whether any damage penetrated the mecha or not, a sensor in the location hit (if any) is disabled.

6 – Normal damage; also, if there is a power plant in the location, the largest one is badly damaged and its output is halved (if this result occurs a second time, the plant stops working). This will reduce the mecha's speed if the mecha cannot provide sufficient power to the propulsion system. If the mecha has an energy bank but no working power plant, treat as #14.

7 – Normal damage; also, if the attack penetrated DR, fire breaks out in the area hit! See *Fire and Explosion* (p. 54).

8 – Normal damage; also, if the mecha has weapons in the location hit, one is struck in the barrel and disabled.

9-11 – Normal damage only.

12 – Normal damage; also, if the attack penetrated DR, any one item of miscellaneous equipment in the location hit is disabled (GM's option). This can include things like overload boosters, cargo or the gear necessary for a transformable mecha to transform (trapping the mecha in its current shape).

13 – Bypasses 90% of DR (i.e., divide armor's DR by 10) and does normal damage.

14 – If the mecha has an energy bank in the location hit, half the maximum kWs of storage capacity (along with half the stored power) are lost. If the mecha has no energy bank, treat as #6.

15 – Normal damage; also, if any damage penetrated DR and there is a communications or electronic countermeasures system in the location hit, one such system is disabled (GM's option).

16 – Double normal damage; also, if the mecha has a fuel tank in the location hit, check for fire and it develops a leak. 1d% of the total fuel capacity leaks out immediately, plus (unless the tank is self-sealing) 1d% every minute.

17 – Triple normal damage.

18 – Double normal damage; if the location hit contains explosive ammunition and any damage penetrated, it explodes. See *Ammunition Explosions* sidebar. If no ammunition, treat as #3, above.

Ammunition Explosions

If a body or subassembly that contains explosive ammunition or missiles is reduced to 0 hit points, check for an explosion. Roll 1d: An explosion occurs on a roll of 6, or on a 5-6 if the damage was inflicted by a flame attack (see above).

To determine the damage of an ammunition explosion, use the damage of 1d shots (or whatever's left) in the weapon or any magazines in the location. If there are multiple choices, use the largest-caliber weapon. That's the force of the explosion. Damage from the explosion is applied immediately to the body or subassembly where the ammunition was stored. The mecha's DR does not protect!

If the ammo was in an anti-blast magazine, roll 3d against its TL+6. If the roll succeeds, the explosion does no damage, but all explosive ammunition in the location was destroyed.



Antimatter and Nuclear Power Plant Explosions

If an antimatter power plant is disabled, it explodes: damage is 6d×10,000 per kW of output per year of useful life left in the plant. All damage is explosive concussion damage. The area may also be contaminated by radiation – see p. CII145ff for radiation rules.

Nuclear power plants incorporate failsafes to keep bad things from happening should they break down. They work . . . most of the time. However, there is a 1 in 6 chance that a fission or fusion plant will undergo an energy release if disabled – this is not a nuclear blast, but the release of (possibly radioactive) steam or high-energy plasma contained within the system. Damage is 6d concussion per kW of output.

An antimatter, fission or fusion power plant (but not an NPU) can be rigged to self-destruct. For an antimatter plant, this is merely a matter of turning off the containment system. For a fission or fusion plant, a successful Engineering (Nuclear Weapons) skill roll is needed. Damage for antimatter plants is as above; damage for fusion or fission plants is 6d×100 per kW of output.

Ejection

Mecha cockpits with the "ejection seat" upgrade possess a rocket escape system that can instantly blast the occupant out of the mecha and then (if in atmosphere) deploy a parachute to land him safely. A person strapped into an ejection seat can activate it in one second: a panel slides open and the seat blasts out.

Ejection unseals the mecha, compromising life support and waterproofing. The mechanism blasts the user and his seat 160 yards up. If the seat senses it is within an atmosphere, it automatically opens a parachute, enabling the occupant to float down for a soft landing. If the user is inside a building when ejecting, he (and anything he slams into) takes 8d×4 damage.

Ejecting counts as the character's action for the turn. If one crewman is unconscious, another can eject both of them.

An ejection seat has a 50% chance of working if the body or subassembly housing it is disabled. If not, the seat, canopy, et cetera is stuck and the occupant can't get out. He can try a ST-6 or Mechanic-6 roll to unjam it each turn. This can get desperate if the mecha is on fire or out of control!

For more details on ejection, see pp. VE161-162.



THE BATTLEFIELD

This section discusses things that mecha can blow up, get stuck in, hide behind or crash into.

Terrain

Most terrain will fit into one or more of these categories. Terrain often reduces the top speed that a vehicle can reach while moving through it.

Hard: This is a paved road, salt flat, aircraft runway or the like. All vehicles move at full speed.

Soft: This is ordinary grass, dry earth, packed sand or muddy dirt roads. A vehicle with legs moves at full speed. One with wheels moves at half speed (2 movement points per hex).

Broken: This is rocky, cratered or very hilly terrain. It may be barren or covered with vegetation. A vehicle with legs uses its full speed, while one using wheels moves at one-quarter speed (or 4 movement points per hex). Visibility depends on whether you are atop a hill, in the open or in a gully. There's lots of cover (p. B118).

Quagmire: This includes mud, swamp, riverbanks, marsh, very soft sand, the sea bottom and deep snow. A vehicle with legs uses half speed (or pays 2 movement points per hex), while one using wheels will be stuck.

Light Woods: Soft, broken or quagmire terrain may also be covered with light woods. The only effect is that visibility is reduced: it rarely exceeds 500 yards. A mecha in light woods is -2 to be hit.

Forest: Soft, broken or quagmire terrain may be covered with dense woods or jungle. Visibility rarely exceeds about 50 yards. Vehicles with a Size Modifier under +2 are not penalized, nor are those massing 50 tons or more that have no wings *and* a front body DR of 50 or more. Most other vehicles have their speed halved (or pay 2 movement points per hex), but vehicles that have a Size Modifier of +2 or more *and* unfolded wings cannot move at all! A mecha in a forest is normally -4 to be hit.

Snow-covered or Icy: Any of the above types of terrain can be described as "snow-covered" or "icy." Mecha using enhanced Move must make a control roll each turn or fall over.

Ridges and Buildings: A mecha over a ridge line or behind a building can't be spotted except from a higher elevation. A mecha with a turret can choose to expose only the turret, making it harder to hit but still allowing it to attack with turret-mounted weaponry. Battlesuits and mecha can take advantage of the same cover modifiers that humans get when leaning around buildings, over ridges, et cetera.

Buildings

Mecha will often crash into, out of, or through buildings, or simply shoot them. A mecha's dimensions govern whether it can fit through doors, hallways and so on without breaking things, while the *Collision* rules (p. 51) cover the damage a mecha inflicts when it crashes into a building. But what happens to the *building?*

A building is rated for its width and length in yards, its height in stories, its DR, its hit points (HP) and its breach capacity (BC).

DR is the building's average damage resistance, while *hit points* are per hex of wall. Typical DRs and hit points: wood (DR 4, HP 20), concrete (DR 4, HP 60), glass and steel (DR 5, HP 10), light brick (DR 6, HP 40), stone (DR 8, HP 90), thick stone (DR 8, HP 180), bunker or fortress (DR 100, HP 200).



If damage equals or exceeds building hit points, it causes a one-hex-wide breach. Damage from a single attack in excess of hit points "blows through" the building rather than doing more damage, *unless* the damage resulted from either an explosion or a collision with an object of Size Modifier +2 or greater. If so, divide the penetrating damage by hit points to determine the total number of one-hex breaches inflicted on the building. (For a collision, the maximum number of breaches is the Size Modifier of the colliding mecha.) New breaches are created alternately to the right and left of the original breach (and then upward or downward from it, if the building has additional stories above or below the breach).

Breach capacity (BC) is the number of breaches a building can take before collapsing into rubble. If the number of breaches to a single story exceeds BC, it and all stories above it fall. For buildings with a reinforced frame and foundations (like steel-framed skyscrapers or bunkers), BC is 0.25 × length (yds.) × width (yds.) × number of stories. For other buildings, like ordinary brick or wooden houses, shops, barns or schools, BC is 0.125 × length (yds.) × width (yds.), with a minimum BC of 1.

Collapsing Buildings: A building whose breach capacity is exceeded takes three seconds to collapse per story of height. Everyone in it takes dice of damage equal to building (HP + DR)/4 per story of building height. The building could also fall sideways, crushing mecha or people outside.

Fire: A building can be set on fire. Use the same rules as for vehicle fires (see *Fire and Explosion* sidebar p. 54), with wooden buildings being more vulnerable. Fire damage accumulates from turn to turn for the purpose of causing breaches.

OPTIONAL RULES FOR MECHA COMBAT

The GM decides which of these rules are in force at any given time. For example, at the start of a large battle, rules for Quick Kill might be in effect, to be dropped after most of the minor NPCs on both sides are eliminated.

Playability Rules

Mecha have a lot more weapons and systems than individual characters do, and so require more work from the player and GM. These rules are aimed at easing that workload.

Quick Automatic Fire

Armed with a pair of 30mm Gatling guns, you close on the enemy mecha and squeeze the trigger, releasing a spitting hail of hypersonic death . . .

Indirect Fire

Mecha, like tanks, normally fire at targets in direct line of sight using high-velocity projectiles or beam weapons.

However, guns can also use indirect fire – lobbing a projectile in a high ballistic arc, like an artillery shell. Heavy homing missiles can also use indirect fire. A mecha can angle its weapons to perform indirect fire simply by tilting its body using its legs. Indirect fire has 2.5 times normal maximum range, but has a *minimum* range of 1/4 normal maximum range.

Indirect fire can be made against a visible target, or against a map reference beyond line of sight with the help of a forward observer in communication with the firer. It takes two seconds to transmit target coordinates between Datalinked computers, or 2d+5 seconds by voice communication.

Only aimed shots are allowed, and only *range* modifiers apply to the attack roll; size and speed of the target aren't important, nor are cover, concealment, smoke or ECM (except in preventing the gunner or observer from spotting the target in the first place). Indirect fire is always treated as being beyond 1/2D range, regardless of actual range. Thus, there is *no* Accuracy bonus. If relying on an observer to spot the target, there is a -5 penalty; this is reduced or increased by the amount by which the observer makes or fails his Forward Observer skill roll (see p. B243, p. CI151).

If a hit is achieved, it means the round came in over the target hex, striking from overhead. Explosive and special damage from indirect fire is normal; crushing and impaling damage is halved as if the attack were being made at or beyond 1/2D range, regardless of the actual range. If the attack misses, see *Scattering* (p. 53); however, further shots may be corrected for greater accuracy, provided the gunner or forward observer can see where they fell. The second corrected shot at the same target is at +4, the third and subsequent shots at +8. If using a forward observer, correcting fire takes the same time as transmitting coordinates.

More detailed rules for indirect fire appear on p. CI160 and pp. VE179-180.

Orbital Strikes

Beam Weapons

Craft in orbit may fire down at map coordinates to attack targets they cannot see, but which someone in communication with them can. Use the indirect fire rules (above), except that the Accuracy bonus still applies up to 1/2D range, and maximum range is not increased. The normal range to target for an orbital strike (low orbit) is about 200-700 miles. Most beam weapons won't have that kind of range, but a few might!

Kinetic-Kill Weapons

Mecha or spaceships in low orbit can also launch orbital strikes with missiles. To do so, the orbiting craft must have detected a target or be in communication with someone on the ground who has.

Kinetic-Kill Missiles: A homing missile with B/IRH guidance can be used as a orbital kinetic-kill missile. After it is launched, it takes ten minutes to fall through the atmosphere. About one second from impact, the missile will switch on its homing sensor and scan the ground below it. It will pick the closest object to its target hex that matches the profile of whatever it has been programmed to home against – usually anything with a Size Modifier of +1 or more that looks like a vehicle, robot or battlesuit, unless it has been programmed to attack a building. It ignores friendly units equipped with functioning IFF systems.

If there is a potential target, resolve the attack as if the weapon were an ordinary homing missile launched down at the target from 10,000 yards up. Because it has gravity on its side, the missile's statistics alter. It has its normal skill, but its effective endurance is only one turn and speed is 10,000. If it hits, its damage is treated as crushing rather than explosive and is multiplied by ten, but it loses its armor divisor.

. . . and then play grinds to a screeching halt as you realize that with RoF 60 per gun, you may have to roll to see whether 30 different four-shot groups hit, were dodged and did damage before you know what state the enemy is left in.

But don't despair: high volumes of automatic fire can be playable.

Very High RoF: For identical automatic weapons with a single or linked RoF of 20 or more, instead of resolving fire in normal 4-round groups, use 20-round groups and refer to the table below:

Roll Made By	*-3*	*-2*	*-1*	*0-1*	*2-4*	*5+*
Number of Hits	0	1	5	10	15	20

Thus, if the roll needed to hit is 14 and a 12 is rolled, 15 rounds hit the target. If the RoF does not divide evenly by 20, either ignore the excess or calculate fire for it in groups of four.

Defense vs. Groups: Make one defense roll per entire *group* rather than vs. individual shots within the group. This can be used for 4-round (or smaller) groups or for larger, 20-round groups. This is fairly realistic and will speed up play considerably.

Damage by Group: This is suggested when using weapons with very high rates of fire (RoF 20+). It is a real headache to roll damage individually for 10, 15 or 20 shots at a time. Instead, roll damage only *once* for the entire group, subtract any DR, and then multiply the damage that penetrates DR by the number of shots in the group. This will mean sometimes, if you get a low roll, no shots in the group will penetrate, while other times a great deal of damage will be done. However, this is not entirely unrealistic: assume the entire group hit at a bad or good angle, or struck a particularly strong or weak point in the armor!

Downgraded Autofire

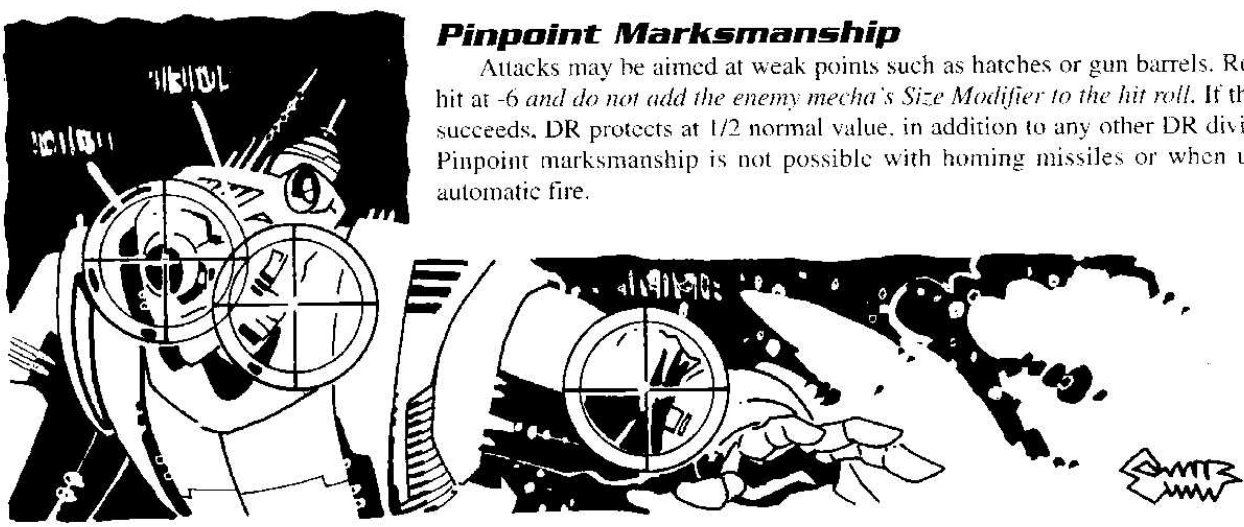
The *Aiming Successive Groups* rule (p. B112) makes snap shots with automatic weapons extremely lethal, and gives them a great advantage over other weapons which must aim for a turn to get an Accuracy bonus. For play balance, see the optional combat rules in the sidebar of p. CII67.

Cinematic Rules

The rules in this section are intended to make combat more dramatic. They include rules that favor high-skill characters and those that simply enhance the cinematic feel.

Pinpoint Marksmanship

Attacks may be aimed at weak points such as hatches or gun barrels. Roll to hit at -6 *and do not add the enemy mecha's Size Modifier to the hit roll.* If the hit succeeds, DR protects at 1/2 normal value, in addition to any other DR divisors. Pinpoint marksmanship is not possible with homing missiles or when using automatic fire.

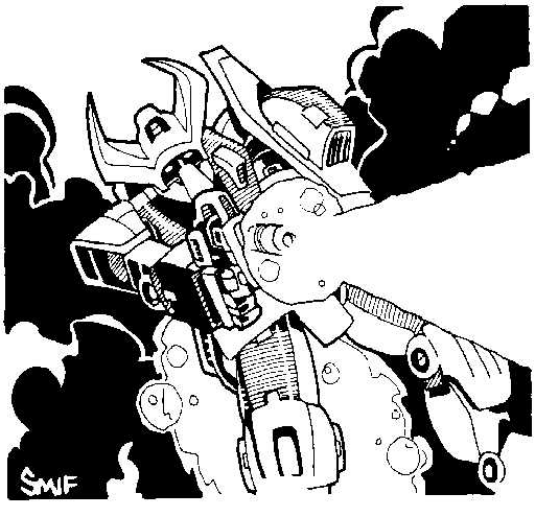


Quick Kill

This rule allows PCs to quickly disable or destroy enemy mecha, and reduces the burden of record-keeping for the GM.

If this rule is in force, when an enemy mecha's DR is penetrated by even one point of damage, that location is disabled as if it had been reduced to 0 hit points. As a result, there is no need to keep track of damage . . . just which subassemblies have been eliminated. A hit to the body will disable the entire mecha. If desired, roll 3d vs. the mecha's HT when damage penetrates the body; if the roll fails, the mecha blows up and the pilot is killed. Otherwise it is crippled and the pilot can eject or escape.

This rule is best left to battles involving large numbers of NPC mecha, as it speeds up the combat and reduces the workload imposed on the GM. It should not be applied to attacks against mecha controlled by PCs or by major NPCs (GM's option). It does allow player characters to duplicate the massive carnage that anime mecha aces often wreak on hordes of low-grade enemy units. However, turnabout is fair play: the Quick Kill rule can also be used to allow major villains to make short work of a PC's Ally Group!



Silly Combat Rules

Many of the *Silly Combat Rules* found on p. CII76ff are very applicable to an over-the-top mecha campaign!

Hollywood Automatic Weapons, Cinematic Knockback and *Imperial Stormtrooper Academy* should definitely be used.

Cinematic Explosions are recommended, but are only applicable to PCs caught outside mecha or in unsealed mecha.

Bulletproof Nudity is definitely applicable. Wearing a battlesuit whose only protection is cheesecake armor (p. 104) is worth a +1 PD for male characters or +2 PD for females.

Infinite Ammunition is in genre, but should *not* apply if using missile or rocket launchers: in cinematic anime, these normally run out of ammunition after a single salvo or two, forcing the pilot to turn to different weaponry.

Gun Control Law, Larger than Life, Martial Artists Anonymous and *Martial Arts Etiquette* don't fit most over-the-top mecha genre campaigns. Use them only in mecha gladiators or armored supers campaigns where martial arts and hand-to-hand battles are going to be emphasized over ranged combat.

The other silly combat rules (e.g., *Exploding Eyeballs*) can be used or not, as the GM wishes.

Dogfighting Combat

Flying and space movement speeds are so high that actually mapping out an aerial or space combat can be very difficult and time consuming. To simplify play, these "dogfight" rules can be used for purely aerial or space combat engagements between small numbers of mecha.

GMs may also wish to experiment with using these rules for high-speed ground combat, especially if the mecha involved are jump or flight capable and leaping about in all directions!

Dogfights consist of two phases, initial contact and the dogfight itself. They are played out in *rounds* of 10 seconds each.

Initial Contact

The GM decides on the range at which the encounter occurs and how quickly the mecha are closing or passing. Range can be set at anything (usually line

Extreme Environments

One of the main reasons for building mecha is to operate in hazardous environments. ***GURPS Space*** gives very detailed rules for the effects of alien environments on individuals. These rules expand them to cover mecha.

Heat and Cold: If the mecha is sealed, its life support system can protect against extremes of heat or cold. Otherwise, the crew suffer the same way an unprotected individual would.

Different Gravity: This will make the vehicle lighter or heavier. However, do not alter its statistics based on this, since most of them actually are a function of mass rather than weight. There are some exceptions:

1) If the mecha has no wings, recalculate its effective motive thrust based on the actual weight of the vehicle. This will affect Speed, Move and jumping distance.

2) Multiply stall speed by the local gravity.

3) Any penalties for moving in hilly or mountainous terrain should be multiplied by local gravity.

4) Multiply collision, falling and whiplash/concussion damage by local gravity if the mecha falls or crashes into the ground.

5) In less than 1 g, the mecha will have less traction; therefore, multiply its effective gMR by the current gravity and round to the nearest 0.25 gMR.

Atmospheric Pressure: If the mecha has a stall speed, divide it by atmospheric pressure. In vacuum or trace atmospheres, stall speed becomes infinite; however, if the mecha could fly with 0 stall speed to begin with, recalculate top speed as if it had radical streamlining, due to the lack of air resistance. Jet and air-ram engines are useless (no lift or thrust) in atmospheres with a pressure under one-half atmosphere.

Life Support

Cockpit Life Support: Unless it has the "no lifesystem" downgrade, a mecha cockpit includes a life-support system. This provides air, climate control and waste relief for the crew, and also includes space for a day's rations. At TL8-10, it provides only 24 man-hours of air – that is, 1 day of air for one person, 12 hours if two people are squeezed in, and so on. Stored air is only used up if outside air is unbreathable; otherwise, the mecha draws in outside air. A cockpit with the "extra air" upgrade has 12 additional man-hours of air. TL11+ mecha cockpits have unlimited air due to advanced molecular recycling systems.

Battlesuit Life Support: A battlesuit system only has a life-support system if it has the "limited lifesystem" or "full lifesystem" upgrade. A battlesuit life-support system provides six hours of air, plus six hours per "extra air" upgrade.

Some mecha have NBC kits instead of or as well as life support. These filter chemical, biological or radioactive contaminants out of the air, but are useless in a non-oxygen atmosphere.



of sight or the best mecha's sensor range, whichever is less), while speed should be taken to be equal to one-third the sum of the mecha's top speeds.

Every 10 seconds, each mecha should check to spot the other using the detection rules, or the GM can simply rule both mecha begin with their opponents spotted. As soon as one mecha has spotted the other, proceed to *The Dogfight*, below.

If there are multiple mecha involved, the range of the encounter is the same for all and speed is based on the lowest in the group. If one foe is detected, assume all are. This isn't realistic, but it is playable.

The Dogfight

A dogfight begins when one mecha that has detected another initiates combat action. The 10-second round is used. The dogfight consists of five steps each turn.

Step 1 – Maneuvering Contest

At the start of each round, the pilots roll a Quick Contest of control skills (usually Piloting). If one mecha has not detected the other, its pilot doesn't roll and is assumed to lose automatically. However, the first pilot must still roll. Modifiers to skill are:

+1 per g (or fraction thereof) that your aMR (sAccel, if in space) exceeds your opponent's.

+2 if you were closing on your foe in the previous round and he was retreating.

+2 if you have detected your foe but have not been detected yet.

-1 per full 50 mph of stall speed your mecha has; +2 if it can fly but has no stall speed!

A pilot who wins by 5 or more, or via a critical success, selects his *and his opponent's* aspect from the *Aspect Table*, below.

A winner by 1-4 gets his opponent to choose one of the aspects on the table – but may prohibit his foe from taking one aspect (usually "Closing: front facing opponent") if he wishes. After his foe has picked, the winner then chooses an aspect for his own mecha from the table.

The two outcomes above also apply to a pilot whose foe has not yet detected him and who makes his skill roll by 5 or more or by 0-4 respectively.

If the contest is a tie, if both pilots fail their rolls or if a pilot whose foe has not yet detected him fails his roll, the aspect is determined randomly for each mecha:

Aspect Table

1 – Retreating: your back facing opponent.
2 – Neutral: your left side facing opponent.
3 – Neutral: your right side facing opponent.
4 – Neutral: your top facing opponent.
5 – Neutral: your underside facing opponent.
6 – Closing: your front facing opponent.

If you are on the ground and your foe is flying, the only aspect possible for you is "your top facing opponent."

If both you and your foe are on the ground and your mecha is neither jump nor flight capable, you can't take (or force your foe to take) aspect #4-5; reroll it if it comes up randomly.

Step 2 – Range Determination

The GM determines the range (in yards) between the foes. This is the same as on the previous round (or the initial encounter range, if this is the first round) modified as follows:

Both mecha are closing: The range decreases by 1d yards times the sum of their top speeds in mph.

One mecha is closing and the other is neutral: The closing mecha may reduce the range by any amount up to either 5 yards times his top speed in mph or the actual range between them, whichever is less. If he can reduce the range to zero, he can choose to initiate a collision, ramming the side of the enemy that is facing him; the other mecha gets a Dodge roll to avoid it.

One mecha is closing and the other is retreating: The faster mecha may increase the range (if he is retreating) or reduce the range (if he is closing) by any amount up to five yards times the difference in top speeds in mph. Again, if range is reduced to zero, he may initiate a collision, ramming the enemy's rear if a dodge fails.

Both mecha are neutral: Roll 1d. On a 1-3, range increases by 1d yards times the difference in speeds in mph; on a 4-6, range increases by 1d yards times the sum of the speeds.

One mecha is retreating and the other is neutral: The retreating mecha may increase the range by any amount up to either five yards times his top speed in mph or the actual range, whichever is less.

Both mecha are retreating: The range increases by 1d yards times the sum of their top speeds in mph.

Keep a record of the range – it will set the range for next round. If range ever drops to within a few dozen yards, the GM may wish to stop using the dogfight rules and switch to regular combat.

Step 3 – Direct Fire

Mecha closing on their opponents fire first, followed by neutral mecha, followed by retreating mecha. On a tie, the effects are simultaneous; the GM can resolve the shooting in whatever order is desired. Note that if a mecha hasn't detected its enemy yet, it cannot dodge or fire.

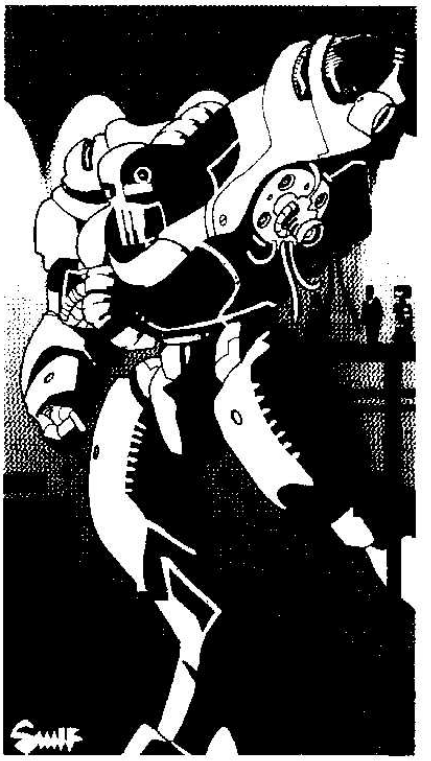
How a mecha faces its opponent and what the modified range is (Step 2) determines what weapons can fire, based on the usual arc-of-fire rules and weapon ranges. Resolve *one turn* of fire – most of the ten-second round was spent maneuvering.

Gun and beam fire is resolved using the normal ranged combat rules, but apply a -4 penalty on weapons not fired by the pilot into the forward arc. Calculate Speed/Range modifiers normally, except that Speed is assumed to be half the target mecha's top speed (this represents the changing speeds during maneuvering). If a pilot has weapons he can attack with but hasn't used, he may designate some of them for "point defense fire" – if these aren't used, they can shoot at incoming missiles. Missiles are fired in the next phase.

Step 4 – Guided Missile Fire

A missile launcher (or set of linked launchers) can be fired if the range is no greater than 10 times the missile's Spd statistic and the target is within arc of fire and maximum missile range. A pilot who has not detected his enemy cannot fire at all. If he has detected enemy sensors (e.g., with a radar/laser detector) but not his foe, he can dodge or use decoys against enemy missiles, but cannot fire. All missile fire is simultaneous.

If a missile requires a roll to lock on, make the roll. If the lock-on fails, no further tries are allowed this turn. If it succeeds, the missile is fired. If the target can launch decoys (flares), give him one attempt to deploy them and see what happens. If not decoyed, assume a missile will hit the target unless dodged or shot down. If the target mecha has unused ranged weapons dedicated to point defense, they can shoot at the missile. If the missile is not shot down, it strikes



Maintenance, Breakdowns, and Repairs

Most mecha are at least as complex as tanks or jet fighters. In a realistic campaign, GMs may wish to worry about maintenance, breakdowns and so on – see p. CII6 for maintenance and *Ground Vehicle Breakdowns* on p. CII7. For this reason, mecha in realistic settings may be transported to and from the battle front on wheeled transports, just like tanks are.

Simple Cinematic Breakdown Rule: If there hasn't been time for maintenance, or there aren't any skilled mechanics around, the GM can have a vital component break down at a dramatic moment – possibly putting some system out of action. A few minutes and a Mechanic roll can jury-rig a spare, but if that roll fails, it may take hours (and maybe a hard-to-find replacement part) to get that particular component working again.

Repairing Mecha

Fixing damage takes half an hour and restores 1 hit point times the amount a Mechanic (Robotics) skill roll is made by. Rolls are at -2 if a location is disabled, and spare parts may be required. A disabled location starts working again when it reaches positive hit points. For much more detail on repairs, see *Making Repairs* on p. CII7 or p. VE147.

Building Mecha

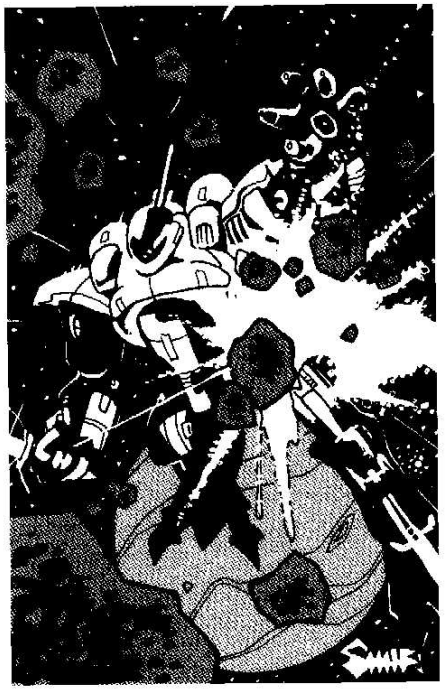
Characters may be inventors or test pilots, struggling to build and test the ultimate mecha. See pp. CI121-127 or p. VE201 for rules on gadgeteering and inventing. Roll every week to build the working model for most mecha; for mecha 6,750 cf or larger, one week is required per full 6,750 cf of size.

Power and Fuel

Powering Down: Mecha sometimes shut down to conserve power. A mecha that is shut down uses no fuel and only the tiniest trickle of power (to maintain an internal clock and any systems that use negligible power). It takes one turn for its systems come back on line.

Recharging Power Cells: Batteries and rechargeable power cells can be recharged from any power plant: every second that 1 kW is channelled into the power cell restores 1 kWs of energy. If the mecha's own power plant has excess power output, it can recharge the mecha's energy bank without turning off other systems. When this amount is small, it's simpler to multiply the excess power by 3,600 and keep track of it every hour.

Refuelling Reactors and NPUs: Fission reactors and antimatter power plants can be refuelled after their duration expires, while fusion reactors and NPUs must be replaced at full cost. Fission fuel is $80/kW at TL8, $8/kW at TL9+. Antimatter is $1/kW at TL11, $0.5/kW at TL12+. Refuelling or replacing a reactor or NPU takes about two hours.



whatever aspect of the target the firing mecha is facing, unless the target can successfully dodge.

Step 5 – Detection

If one mecha has not yet detected the other, it may now roll again for detection, as described in *Initial Contact.* Note that if one mecha is behind the other, it may be out of its pilot's or sensor's arc of vision, depending on its design.

Ending the Dogfight

This occurs when the enemy mecha are destroyed, surrender, run out of fuel, et cetera, or if both mecha decide to stop fighting or move out of maximum sensor range.

Multiple Mecha Dogfights

These rules work best as a duel between two mecha. Once the initial contact phase is over, break the mecha up into one-on-one duels. If there are leftovers, they may form into "flights," ganging up on single foes as desired. For maneuvering and range, a flight is treated as a single craft. Skill rolls are made vs. the average of all pilots' modified skills, and speed is based on the lowest of their top speeds.

Altitude

Altitude is abstracted in this system. If it is important (e.g., when ejecting or crashing), the GM can select it or assume the altitude is 2d-1 yards times the slowest mecha's top speed in mph.

Traveling Dogfights

Sometimes, one mecha is fairly close to an objective (like a base or a ground target) while the other is trying to intercept it before it can get there. The GM can rule that a certain number of rounds are needed before the dogfight reaches that destination.

If one mecha *must* go in a certain direction, it will be at -3 in the maneuvering contest, since its path is somewhat predictable. If the mecha doesn't take that penalty, assume that the round doesn't count toward reaching its objective.

Congested Areas

If the fight takes place somewhere like a city, canyon or dense asteroid belt, there is a danger of crashing into something. A mecha whose pilot gets a critical failure on a Dodge roll or in the maneuvering contest is assumed to have had a head-on collision with a solid object at half its top speed. Also, a mecha pilot can, before the Quick Contest, declare he is making a "wild maneuver" – like a surprise swing between two narrowly-spaced buildings at high speed. This adds +2 to skill for the purpose of winning the maneuvering contest, but *any* failed skill roll results in a collision as above, and a critical failure does double damage. Note that *losing* the Quick Contest doesn't count as a failure – only failing the skill roll.

At any time, the GM can rule that the fight has left the congested area, or both pilots can mutually agree to do so.

Spacecraft Dogfights

In a space dogfight, assume top speed is equal to 4,000 mph × sAccel (in g).

Ranged Weapons

This section describes the various ranged weapons that mecha can use.

Machine guns are bullet-firing automatic weapons.

Miniguns are machine guns that use multiple, rotating barrels (usually 3 to 6) for a higher rate of fire.

Autocannon, minicannon and *Gatling cannon* are large machine cannon that fire bursts of armor-piercing, fin-stabilized depleted-uranium shells. Armor protects at one-third normal DR, but any damage that penetrates DR is halved.

Gauss guns are electromagnetic railguns that use a magnetic impulse to accelerate saboted bullets to hypersonic velocities. Armor protects at half DR, but damage that penetrates DR is also halved.

Gauss cannon are cannon-sized railguns firing the same depleted-uranium ammunition that autocannon use. Armor protects at one-third normal DR, but damage that penetrates DR is halved.

Auto GLs are chemical-propellent grenade launchers firing shaped-charge explosive rounds. *EMGLs* are electromag grenade launchers. Both can also fire any of the TL8+ grenade types described in other ***GURPS*** books.

Mortars are large-caliber, low-velocity guns designed to lob explosive shells. They often use indirect fire.

Missile launchers fire high-speed guided missiles tipped with powerful shaped-charge explosive warheads. They use the guided missile rules on p. 53. DR protects against direct hits from shaped-charge warheads at 1/10 normal; otherwise (e.g., on a near miss), the damage is treated as explosive concussion damage.

Lasers fire bolts of coherent light. In rain or fog, they do half damage. Damage is also halved for every (1/2D range/5) hexes of smoke or hot smoke (or fraction thereof) they cross. Lasers fired at RoF 4+ use the special laser automatic fire rules described under *Damage from a Burst* on p. B120.

Rainbow lasers are lasers that can alter their frequency, from visible light (effective in atmosphere) to deep ultraviolet (giving extra range in the vacuum of space).

X-ray lasers function like lasers, except DR protects at one-half normal. Their damage is not reduced by smoke, fog or the like.

Particle beams (also called *blasters*) fire bolts of charged or neutral subatomic particles at near-light speed. The radiation produced can also zap electronics. Since mecha are packed with such systems, treat any particle beam hit on a mecha (or robot) as impaling damage, just like a hit on a person.

Flamers (also called *plasma guns*) project streams of star-hot ionized plasma. The wash of flame easily penetrates non-sealed armor, which gets only 1/2 DR against the attack. It also melts armor: for every 10 points of damage done before subtracting DR, armor loses 1 DR on the location hit. (If the armor is ablative, this is in addition to any DR lost to ablation.) A sealed suit or machine becomes unsealed after losing 20% or more of its original DR on a particular side. Paper, cloth and wood ignite automatically if hit by a flamer. Flammable plastics and such catch fire if their DR is exceeded.

A flamer can be used like a flamethrower – attacking more than one target, as long as they are in the same arc of fire – as described for area weapons (p. B121). When used this way, divide the dice of damage by the number of targets; if they are more than one hex apart, 1d damage is lost per hex between them.

Ranged Weapon Statistics

The statistics used to describe ranged weapons are the same as those in the ***Basic Set,*** with these additions:

Type: "Exp." means the attack does explosive concussion damage (see p. B121). "Spcl." means damage is special – see the weapon descriptions above.

Damage: A number in parentheses after damage – e.g., (2) – is an armor divisor; DR is divided by that number against the attack. In the case of guns (autocannon, Gauss guns, Gauss cannon, et cetera), damage is also divided by two after any DR is penetrated. A number in brackets after damage – e.g., [4d] – is the fragmentation damage (p. B121) of an explosion.

1/2D: Attacks doing Exp. damage don't have damage halved after the 1/2D range, but do lose accuracy. Missiles lack a 1/2D number.

Weight: The weapon's *empty* weight in pounds.

Vol.: The weapon's volume in cubic feet. Optionally, a weapon can be "concealed" within the mecha (so that its barrel is not visible). If so, multiply volume by 2.5.

WPS: The weight, in pounds, of a single round of ammunition (bullet, missile, et cetera).

VPS: The volume per shot, in cf.

CPS: The cost per shot, in dollars.

Power: The power requirement (in kW) required to fire the weapon at its full rate of fire. If the weapon runs off an energy bank, each second of fire drain this many kWs of energy.

Spd: For missiles only; this is the Move of the missile.

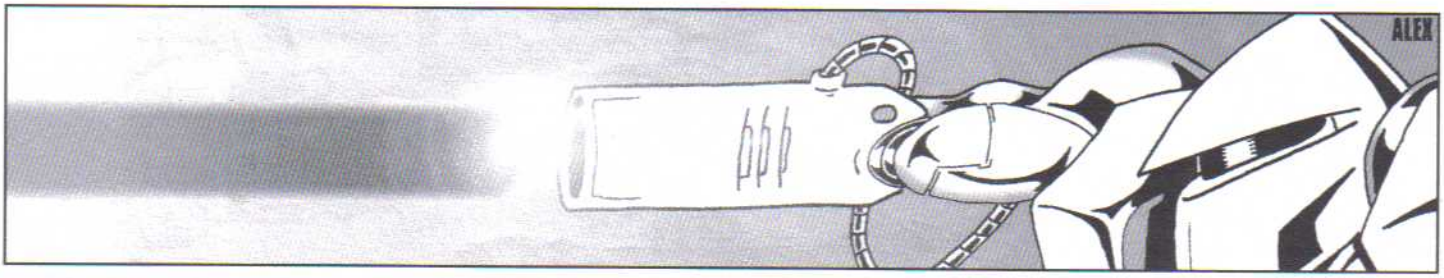
End: For missiles only; the number of seconds that the missile can fly before running out of fuel and crashing.

Skill: For missiles only; the skill of the guidance system.

Guid.: For missiles only; the type of guidance system used. "IRH" is infrared homing. "B/IRH" is *brilliant* infrared homing.

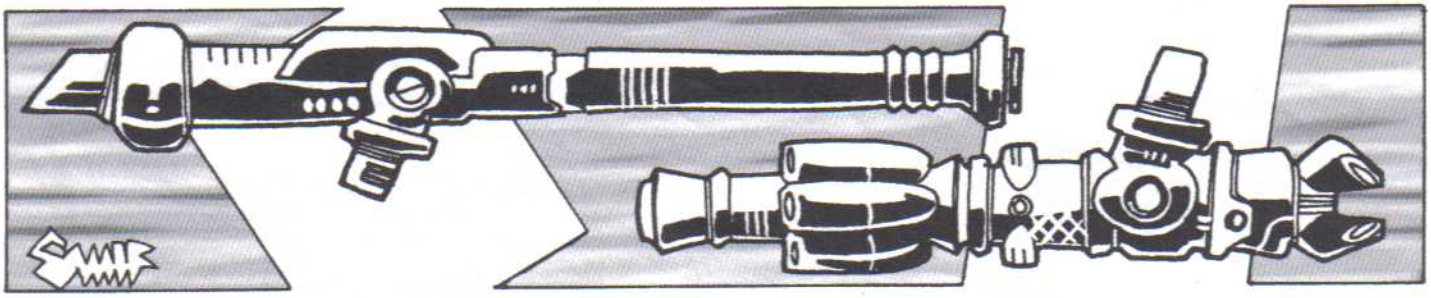
Cost: See table. If buying weaponry of lower TL, cost is halved if it's obsolete by one TL and halved again if it's two or more TLs old.

No "Shots" statistic is given, as that depends on how many rounds are carried aboard. "Rcl" and "ST" are also omitted, as they don't apply to vehicular weaponry.



BEAM WEAPONS TABLE

Weapon	Type	Damage	SS	Acc	1/2D	Max	Weight	Vol.	RoF	Cost	Power
TL8 Lasers											
Assault Laser	Imp.	5d	17	20	4,000	8,000	17	0.34	8*	$10,000	6,400
Lt. Laser Cannon	Imp.	6d×5	20	23	12,000	36,000	150	3	4*	$18,000	28,800
Md. Laser Cannon	Imp.	6d×10	25	25	24,000	72,000	1,200	24	4*	$70,000	115,200
Hv. Laser Cannon	Imp.	6d×20	30	27	48,000	144,000	7,500	150	4*	$390,000	720,000
TL9 Rainbow Lasers											
Assault Rainbow Laser	Imp.	5d	14	20	4,000	8,000	13	0.26	8*	$10,000	7,200
Gatling Laser	Imp.	20d	17	20	4,000	12,000	25	0.5	4*	$20,000	14,400
Hv. Gatling Laser	Imp.	6d×5	20	23	12,000	36,000	110	2.2	4*	$21,000	32,400
Lt. Rainbow Laser	Imp.	6d×5	20	23	12,000	36,000	230	4.6	8*	$28,000	64,800
Md. Rainbow Laser	Imp.	6d×10	25	25	24,000	72,000	1,800	36	8*	$130,000	259,200
Hv. Rainbow Laser	Imp.	6d×25	30	27	60,000	180,000	11,000	220	8*	$740,000	1,620,000
TL10 X-ray Lasers											
Assault X-Laser	Imp.	5d(2)	17	18	1,500	4,500	5.5	0.11	8*	$1,400	8,528
Gatling X-Laser	Imp.	6d×5(2)	20	21	4,500	13,500	25	0.5	4*	$4,000	38,390
Hv. Gatling X-Laser	Imp.	6d×5(2)	20	21	4,500	13,500	100	2	8*	$20,000	76,780
Lt. X-Laser Cannon	Imp.	6d×10(2)	25	22	9,000	27,000	800	16	8*	$67,000	307,120
Md. X-Laser Cannon	Imp.	6d×25(2)	30	25	23,000	69,000	5,000	100	8*	$350,000	1,919,520
Hv. X-Laser Cannon	Imp.	6d×50(2)	30	27	45,000	135,000	20,000	400	8*	$1,350,000	7,678,080
TL9 Flamers											
Assault Flamer	Spcl.	6d×5	10	20	540	1,600	38	0.76	1	$11,000	4,500
Hv. Flamer	Spcl.	8d×10	10	20	720	2,200	67	1.34	1	$20,000	8,000
Lt. Plasma Cannon	Spcl.	6d×25	10	20	1,100	3,300	230	4.6	1	$43,000	28,125
Plasma Gatling	Spcl.	6d×25	10	20	1,100	3,300	590	11.8	6*	$79,000	168,750
Md. Plasma Cannon	Spcl.	6d×50	13	20	2,700	8,100	1,900	38	1	$210,000	112,500
Hv. Plasma Cannon	Spcl.	6d×100	15	21	5,400	16,000	7,500	150	1	$770,000	450,000
Mega Plasma Cannon	Spcl.	6d×250	15	23	13,500	40,000	47,000	940	1	$4,700,000	2,812,500
TL8 Particle Beams											
Blaster Cannon	Imp.	6d×20	20	17	1,100	3,300	44	0.88	1	$13,000	11,250
Gatling Blaster	Imp.	6d×20	20	17	1,200	3,600	110	2.2	6*	$31,000	67,500
Lt. Particle Cannon	Imp.	6d×40	20	19	2,300	6,900	350	7	1	$55,000	45,000
Md. Particle Cannon	Imp.	6d×100	30	21	5,600	16,800	2,200	44	1	$240,000	281,250
Hv. Particle Cannon	Imp.	6d×200	30	23	11,300	33,900	8,800	176	1	$900,000	1,125,000
Mega Particle Cannon	Imp.	6d×400	30	25	23,000	69,000	35,000	700	1	$3,500,000	4,500,000
TL9 Particle Beams											
Assault Blaster	Imp.	6d×5	12	15	500	1,000	7	0.14	1	$1,200	1,800
Lt. Blaster	Imp.	5d×15	17	16	830	1,660	20	0.4	1	$3,000	5,000
Blaster Minicannon	Imp.	5d×30	20	17	1,200	3,600	44	0.88	1	$6,600	11,250
Gatling Blaster	Imp.	5d×30	20	17	1,200	3,600	110	2.2	6*	$16,000	67,500
Lt. Particle Cannon	Imp.	6d×50	20	19	2,500	7,500	350	7	1	$27,500	45,000
Md. Particle Cannon	Imp.	5d×150	30	21	6,200	18,600	2,200	44	1	$120,000	281,250
Hv. Particle Cannon	Imp.	6d×250	30	23	12,400	37,200	8,800	176	1	$450,000	1,125,000
Mega Particle Cannon	Imp.	6d×500	30	25	25,300	76,500	35,000	700	1	$1,750,000	4,500,000



GUNS TABLE

Weapon	Type	Damage	SS	Acc	1/2D	Max	Weight	Volume	RoF	WPS	VPS	CPS	Cost	Power
TL8+ Machine Guns														
7.5mm Machine Gun	Cr.	8d	14	13	920	4,600	13	0.26	20*	0.063	0.00042	0.13	$975	0
7.5mm Minigun	Cr.	8d	17	13	920	4,600	18	0.36	50*	0.063	0.00042	0.13	$2,000	0.315
15mm Machine Gun	Cr.	16d	20	14	1,300	5,600	51	1.02	20*	0.5	0.0033	1	$3,800	0
15mm Minigun	Cr.	16d	20	14	1,300	5,600	71	1.42	50*	0.5	0.0033	1	$8,000	2.5
TL8+ Cannon														
20mm Minicannon	Cr.	6d×4(3)	20	12	1,260	6,450	30	0.6	8*	0.34	0.0034	12.24	$1,800	0
20mm Mini-Gatling	Cr.	6d×4(3)	20	12	1,260	6,450	63	1.26	50*	0.34	0.0034	12.24	$5,700	2.55
20mm Autocannon	Cr.	6d×7(3)	20	14	2,250	9,150	90	1.8	20*	0.4	0.004	14.4	$5,400	0
20mm Gatling	Cr.	6d×7(3)	20	14	2,250	9,150	130	2.6	50*	0.4	0.004	14.4	$9,900	3
30mm Autocannon	Cr.	6d×9(3)	20	14	2,250	9,150	230	4.6	12*	1.1	0.011	41	$8,600	0
30mm Gatling	Cr.	6d×9(3)	20	14	2,250	9,150	320	6.4	30*	1.1	0.011	41	$16,000	5.1
40mm AGL	Exp.	4d×2(5)[4d]	20	7	90	1,200	27	0.54	4*	0.48	0.0048	4.2	$2,000	0
45mm Autocannon	Cr.	9d×9(3)	25	14	2,700	10,350	680	13.6	8*	3.9	0.039	70	$18,000	0
45mm Gatling	Cr.	9d×9(3)	25	14	2,700	10,350	960	19.2	20*	3.9	0.039	70	$35,000	11.6
60mm Autocannon	Cr.	6d×15(3)	25	14	2,250	9,150	1,100	22	6*	9.3	0.093	336	$26,000	0
60mm Gatling	Cr.	6d×15(3)	25	14	2,250	9,150	1,500	30	16*	9.3	0.093	336	$51,000	22.4
90mm Autocannon	Cr.	9d×15(3)	30	14	2,700	10,350	3,600	72	4*	31	0.31	1,104	$76,000	0
90mm Gatling	Cr.	9d×15(3)	30	14	2,700	10,350	5,100	102	11*	31	0.31	1,104	$160,000	50.6
120mm Autocannon	Cr.	6d×30(3)	30	15	3,150	11,400	6,500	130	3*	73	0.73	2,640	$130,000	0
200mm Autocannon	Cr.	6d×50(3)	30	15	4,050	13,350	18,000	360	2*	340	3.4	12,240	$360,000	102
TL8 Electromag Guns														
40mm EMGL	Exp.	4d×2(10)	12	11	360	2,600	6	0.12	1	0.32	0.0032	11.4	$8,800	15
2.5mm Gauss Gun	Cr.	3d×5(2)	20	16	2,850	13,350	28	0.56	20*	0.00052	0.0000052	0.02	$34,000	62.4
5mm Gauss Gun	Cr.	6d×5(2)	20	16	4,050	13,350	100	2	20*	0.0042	0.000042	0.4	$120,000	756
10mm Gauss Gun	Cr.	6d×10(2)	25	19	8,550	22,500	450	9	10*	0.033	0.00033	2	$260,000	3,000
20mm Gauss cannon	Cr.	6d×20(3)	25	18	5,100	15,600	600	12	20*	0.2	0.002	12	$320,000	18,000
25mm Gauss cannon	Cr.	6d×40(3)	25	20	13,500	30,600	3,200	64	2~	0.39	0.0039	23.6	$1.36 mil.	7,080
50mm Gauss cannon	Cr.	6d×80(3)	30	20	19,500	26,700	7,500	150	1	3.1	0.031	188	$3 mil.	28,200
100mm Gauss cannon	Cr.	6d×160(3)	30	20	27,000	51,000	30,000	600	1/3	25	0.25	1,520	$12 mil.	75,000
50mm Gauss Mortar	Exp.	6d×4(5)[4d]	20	13	880	4,400	75	1.5	1	1.5	0.015	54	$120,000	288
TL9 Electromag Guns														
2.25mm Gauss Gun	Cr.	6d×2(2)	12	15	2,250	9,150	6	0.12	3*	0.00038	0.0000038	0.015	$4,400	5.7
40mm EMGL	Exp.	6d×2(10)	12	11	360	2,600	4.8	0.096	1	0.32	0.0032	11.4	$3,900	15
3mm Gauss Gun	Cr.	8d×2(2)	20	15	2,400	9,600	16	0.32	20*	0.00093	0.0000093	0.056	$9,600	140
5mm Gauss Gun	Cr.	6d×5(2)	20	16	4,050	13,350	68	1.36	20*	0.0042	0.000042	0.4	$41,000	756
10mm Gauss Gun	Cr.	6d×10(2)	25	19	8,550	22,500	270	5.4	10*	0.033	0.00033	2	$94,000	3,000
20mm Gauss cannon	Cr.	6d×20(3)	25	18	5,100	15,600	360	7.2	20*	0.2	0.002	12	$110,000	18,000
25mm Gauss cannon	Cr.	6d×40(3)	25	20	13,500	30,600	1,900	38	2~	0.39	0.0039	23.6	$420,000	7,080
50mm Gauss cannon	Cr.	6d×80(3)	30	20	19,500	26,700	4,500	90	1	3.1	0.031	188	$940,000	28,200
100mm Gauss cannon	Cr.	6d×160(3)	30	20	27,000	51,000	18,000	360	1/3	25	0.25	1,520	$3.6 mil.	75,000
200mm Gauss cannon	Cr.	6d×200(3)	30	20	15,900	34,500	24,000	480	1/5	200	2	12,000	$4.8 mil.	180,000
50mm Gauss Mortar	Exp.	6d×6(5)[4d]	20	13	880	4,400	45	0.9	1	1.5	0.015	54	$27,000	288

Abbreviations: "EMGL" = electromag grenade launcher, "AGL" = automatic grenade launcher, "Lt." = light, "Md." = medium, "Hv." = heavy.

Optional Ammunition

Cannon 20mm or larger are assumed to be firing armor-piercing, fin-stabilized, discarding-sabot depleted uranium rounds (APFSDSDU), except for AGLs and EMGLs, which fire shaped-charge explosive warheads. Two other types of ammunition in common use are:

High Explosive Concussion (HEC): Used to blow up buildings or infantry, these rounds are usable in any gun or launcher that is 20mm or larger. They do explosive concussion damage equal to projectile diameter in mm *cubed,* ×0.00025 at TL8 or ×0.000375 at TL9+. HEC rounds have a lower velocity, and hence less range and accuracy: Acc is -1, and 1/2D and Max range are ×2/3. HEC is also cheaper: Divide CPS of HEC gun ammo by six.

Chemical (CHEM): Used to deliver gas or smoke, this ammo can be used by any 20mm or larger gun or missile. CHEM uses the rules for HEC, except that it inflicts no damage: instead, it releases a gas, smoke or hot smoke cloud over a radius of (projectile diameter squared) × 0.00375 yards. See pp. B132, UT70 or VE191 for gas effects. It disperses in 300/(wind speed in mph) seconds, maximum 300 seconds. Individuals in sealed suits will be unaffected.

LAUNCHER TABLE

Weapon	Guidance	Type	Damage	SS	Speed	Max	Skill	End	Weight	Volume	RoF	WPS	VPS	CPS	Cost
TL8 Missile Launchers															
57mm Lt. Msl. Lhr.	IRH	Exp.	6d×7(10)	14	500	1,000	13	2	12.5	0.25	1	5	0.1	1,400	$470
100mm Md. Msl. Lhr.	IRH	Exp.	6d×27(10)	20	1,200	7,200	17	6	125	2.5	1/2	50	1	10,000	$8,100
250mm Hv. Msl. Lhr.	B/IRH	Exp.	8d×50(10)	25	1,200	61,200	21	51	1,250	25	1/4	500	10	66,000	$36,000
TL9 Launchers															
45mm Mini-Msl. Lhr.	IRH	Exp.	4d×5(10)	12	700	700	14	1	5	0.1	1	2	0.04	580	$250
57mm Lt. Msl. Lhr.	IRH	Exp.	6d×10(10)	14	500	2,000	16	4	12.5	0.25	1	5	0.1	1,200	$470
100mm Md. Msl. Lhr.	IRH	Exp.	6d×40(10)	20	2,800	8,400	20	3	125	2.5	1/2	50	1	8,200	$4,100
250mm Hv. Msl. Lhr.	B/IRH	Exp.	6d×100(10)	25	1,200	122,400	24	102	1,250	25	1/4	500	10	47,000	$18,000
TL10+ Launchers															
45mm Mini-Msl. Lhr.	IRH	Exp.	4d×5(10)	12	920	920	17	1	5	0.1	1	2	0.04	580	$130
57mm Lt. Msl. Lhr.	IRH	Exp.	6d×10(10)	14	1,400	2,800	19	2	12.5	0.25	1	5	0.1	1,200	$470
100mm Md. Msl. Lhr.	IRH	Exp.	6d×40(10)	20	2,800	12,600	23	4.5	125	2.5	1/2	50	1	8,200	$2,000
250mm Hv. Msl. Lhr.	B/IRH	Exp.	6d×100(10)	25	1,200	244,800	27	204	1,250	25	1/4	500	10	47,000	$9,000

Abbreviations: "Lt." = light, "Md." = medium, "Hv." = heavy, "Lhr." = launcher, "Msl." = missile, "IRH" = infrared homing, "B/IRH" = brilliant infrared homing.

BUILT-IN CONTACT WEAPONS

These are weapons usable in hand-to-hand or close combat.

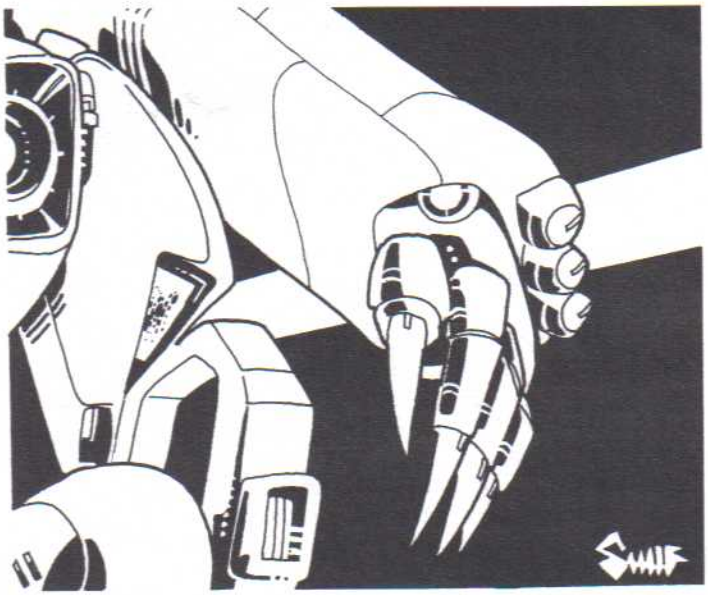
Sharp claws are built into arms or legs. They convert that limb's kicking or punching damage from crushing to *cutting*.

Talons can be built into an arm or leg. They let the limb do thrust/impaling or swing/cutting damage. The same weapon statistics also represent switchblade- or bayonet-like blades.

Cutting Jaws: One set of mechanical jaws may be placed in a turret, rated for its own jaw ST. It bites for cutting damage (p. B140).

Vibroblade: This is an option for claws, blades or talons – the weapon vibrates at supersonic speed, improving penetration and damage. The vibrations are powered by the arm or leg drivetrain, so there is no extra power requirement.

Monomolecular Edge: Claws, blades or talons (unless vibro) can be given a monomolecular edge for even greater penetration.



Limpet Mine Dispenser: This is a spring-loaded arm dispenser for sticky limpet mines. The user slaps his victim and triggers the release, attaching a mine. He then steps back and it detonates an instant later, using a shaped charge to blast a hole through armor. A dispenser includes five mines; extra 5-mine magazines have half the weight, volume and cost of the dispenser. Reloading with a ready magazine requires a free arm and takes two seconds. To attack, use DX, Brawling or Karate skill. A successful hit attaches the mine, which sticks with molecular "suction pads." Limpet mines do shaped-charge damage to the target; anyone else within 2 yards of the blast takes one-quarter damage from the concussion, though armor protects fully against this. At TL9+, add 50% to damage. This weapon can't be used to parry with.

Plasmafaust: This is a contact plasma-discharge weapon mounted in an arm. DR protects at one-tenth normal (or one-fifth normal for laminate armor). The user suffers 4d damage to his arm from the backblast of the plasma discharge; however, his own DR protects fully – it is not divided by 10. A plasmafaust has no blade and cannot be used to parry.

Electroshocker: An arm or melee weapon equipped with an electroshocker can deliver a powerful electric jolt. The victim must make a HT roll to avoid being stunned, at -3 for a light, -6 for a medium or -9 for a heavy electroshocker, but at +1 HT per 10 DR on the location struck. If stunned, the victim loses 1d fatigue and remains physically stunned for as long as the arm is in contact, plus another (20-HT) seconds before any HT rolls to recover are allowed.

Plasmablade and *Forceblade:* These are energy blades built into an arm. DR always protects at one-fifth value. Use Force Sword skill to wield them. Any weapon that successfully parries a force or plasma blade (except another energy-type blade) will be destroyed, unless the parry was a critical success. Higher-TL versions do more damage: for each TL after they first appear, add +1 damage per die, to a maximum of +3 per die.

Contact Weapon Statistics

These use the same format as the *Ancient/Medieval Hand Weapon Table* on p. B206, with these changes:

Type may also be explosive (Exp.) or special (Spcl.).

Damage, if sw (swing) or thr (thrust), is based on the ST of the arm that is being used. Otherwise, the weapon is powered and has a fixed damage. "Spcl." means the weapon does special damage – see the individual weapon descriptions above.

Volume is the volume in cubic feet.

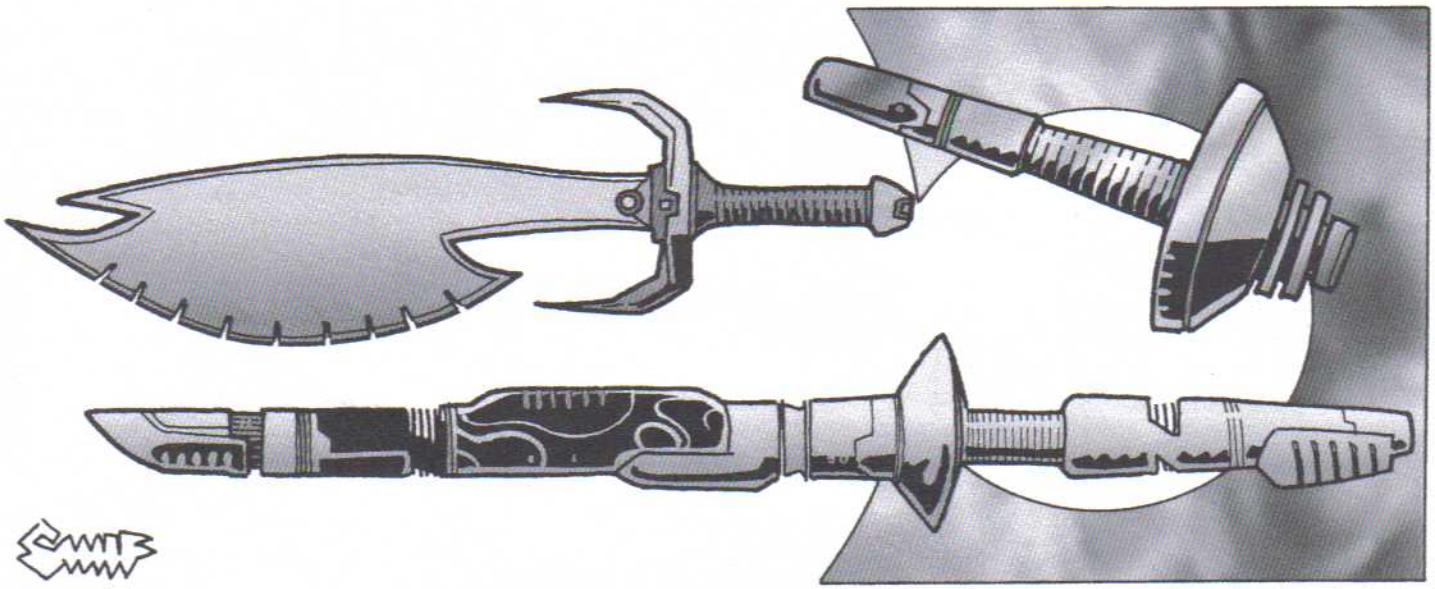
Cost: Except for claws, talons and blades, this is halved one TL after the weapon first appears and halved again two or more TLs after it appears. Cost of claws, talons and blades (and of monomolecular or vibro options for them) is *per limb* so equipped.

Power is the power requirement to use the weapon continuously. If the weapon runs off an energy bank, it drains this many kWs of stored energy each turn it is activated.

BUILT-IN CONTACT WEAPONRY TABLE

Weapon	*Type*	*Damage*	*Reach*	*Cost*	*Weight*	*Volume*	*Power*	*TL*
Sharp Claws	Cut	thr	C	$200##	0	0	0	–
Talons or Blade	Cut#	sw	C	$500##	0	0	0	–
Cutting Jaws	Cut	Spcl.	C	$600†	0.1†	0.005†	0.01†	8
Lt. Electroshocker	Spcl.	Spcl.	C	$200	1	0.02	9	7
Md. Electroshocker	Spcl.	Spcl.	C	$2,000	10	0.2	90	7
Hv. Electroshocker	Spcl.	Spcl.	C	$20,000	100	2	900	7
Lt. Limpet MD	Exp.	2d+4(10)	C	$800	2	0.04	0	8
Md. Limpet MD	Exp.	6d×5(10)	C	$2,000	20	0.4	0	8
Hv. Limpet MD	Exp.	6d×50(10)	C	$8,000	200	4	0	8
Lt. Plasmafaust	Exp.	5d(10)	C	$2,000	2	0.04	540	9
Md. Plasmafaust	Exp.	3d×5(10)	C	$12,000	20	0.4	1,620	9
Hv. Plasmafaust	Exp.	5d×10(10)	C	$20,000	200	4	5,400	9
Lt. Plasmablade	Cut*	4d(5)	C-1	$12,500	2.5	0.05	15	9
Md. Plasmablade	Cut*	1d×10(5)	C-4	$100,000	20	0.4	240	9
Hv. Plasmablade	Cut*	2d×10(5)	C-9	$3.2 mil.	640	12.8	7680	9
Lt. Forceblade	Cut*	8d(5)	C-1	$3,000	2.5	0.05	15	11
Md. Forceblade	Cut*	2d×10(5)	C-4	$24,000	20	0.4	240	11
Hv. Forceblade	Cut*	4d×10(5)	C-9	$768,000	640	12.8	7680	11
Monomolecular	**	+1d(10)	**	$500	0	0	0	9
Vibroblade	**	+1d(5)	**	$200	0	0	0	8

Talons and blades can also do thrust/impaling damage.
Claws, blades and talons may be retractable at 1.5 times cost.
† Per point of jaw ST.
* Plasma and force blades can also thrust to impale for half their cutting damage, e.g., 4d(5) for a lt. plasmablade.
** Option for claws, talons or blades. Use the modified weapon stats, but DR protects at 1/5 normal against vibro or 1/10 normal against monomolecular, and damage is +1d.



ROBOT DESIGN 1



Robots

A robot is a machine, controlled by a computer brain, capable of perceiving and manipulating its environment. Robots are typically designed for jobs that are considered too tedious, unpleasant or dangerous for human beings. This chapter provides a detailed, step-by-step system for designing many types of robots, from domestic servants to lethal warbots. These rules won't spend much time on static industrial robots (99% of the robots used today) but will concentrate instead on the more interesting mobile robots of the future.

Design Concept and Tech Levels

The first thing to come up with is a general idea of the robot's purpose and capabilities. Then go through the design process from start to finish. The end result will be a robot that can be used either as a character or as a piece of equipment.

Some suggested concepts for robots are described below, along with examples from the *Sample Robots* chapter.

Agricultural or Gardening Robot: This is a robotic piece of farm machinery or a smaller gardening robot. The Johnny Appleseed (p. 114) is an example of an agrobot.

Android: An android is a humanoid robot (with a head, two arms and two legs) that closely resembles a human. Androids may be specialized for a particular task, or be general-purpose robots built to do everything a human can do. The Nemesis ("Synthia", p. 51), Lemon Angel (p. 119), Prometheus (p. 120) and Scorpio Alpha (p. 122) are all androids.

Assassin or Hunter Robot: These robots generally emphasize sneakiness over combat capability. Some are androids disguised to look and act like people, with high ST and DX or built-in weapons like Synthia. Then there are mobile robot bombs disguised as something else, or tiny mechanical killers that use their small size to hide while they stalk their target; the Hellspider (p. 118) is an example of this type. Hunting and extermination robots are similar in concept, but are usually used for hunting animals or pests rather than humans, and are sometimes disguised to resemble their prey or predator animals.

Battlesuit or Powered Exoskeleton: These robotic bodies are "worn" much like suits of armor. A battlesuit is a weapon while an exoskeleton is a tool. *Appendix 2: Battlesuits* (p. 52) describes how to modify these rules to build battlesuits.

Bodyguard Robot: A personal protection robot is usually an android with superhuman strength, concealed weapons, good sensors and intelligence to spot danger, and a high DX to react quickly. Bodyguards are often programmed to act as chauffeurs or companions.

Cargo Loading or Delivery Robot: This robot is designed to load or carry cargo or baggage. An example is the Marius (p. 112). Faster versions can be built as couriers for packages, milk, mail, etc.

Construction, Mining or Salvage Robot: A rugged robot, it is designed for heavy-duty work, often underwater, in space, on alien worlds or the battlefield. The Kobold (p. 114) and Manta (p. 111) are examples.

Computer: The robot design rules can also be used to create computers rather than robots. To create a computer, just build a robot lacking a propulsion system or arms. An immobile computer can remotely control robots, using them as its arms and legs.

Criminal Robot: Any robot can be used for criminal activities. Robot bodyguards and soldiers make good mob enforcers, sentient computers can be crime bosses, pleasure robots can work as prostitutes or assassins, cargo robots can be programmed to smuggle freight, tech robots can refurbish stolen goods, domestic robots can steal things, and so on. Most criminal 'bots are simply ordinary models reprogrammed, but some robots may be specifically modified or built for criminal activities.

Cyborg: A fusion of man and machine. This book uses the term specifically to refer to a robotic body controlled by a built-in human brain. *Appendix 1: Cyborgs* (p. 52) describes how to modify the rules for constructing robots to build cyborgs.

Domestic or Serving Robot: Of the available robot maids, servants, butlers, janitors, bartenders, cooks, waiters, and secretaries, some are humanoid and glamorous, others are strictly functional with built-in appliances. The Servitor (p. 120) is an example.

Exploration Robot: A robot probe designed for survey or scouting, usually in hostile environments: underwater, space, arctic regions, or on alien worlds, most have extensive sensor arrays. Some have weapons to ward off wildlife or equipment to capture specimens. Exploration 'bots may even be disguised as living creatures to perform covert surveys. The Ulysses (p. 116) is an example of an explorer robot.

Robot Double: An android can be designed to impersonate a specific individual. Public figures might use them – or might be replaced by them as part of a plot. Less sinister uses include stunt doubles, actors in historical dramas or displays in shop windows or theme parks. Eccentric inventors sometimes build android doubles of themselves or their children.

Machine Race: A robot can be part of a "species" of sentient or semi-sentient machines. A race of machines may be composed of a variety of robots built for specialized tasks (a caste system, perhaps with sentient super-computers at the top) or use a single flexible "general-purpose" model of robot. A machine race may look like anything, even android versions of its original creators. The Scorpio Alpha and the Grendel (p. 122) could easily be members of a machine race.

Nanny or Teacher Robot: Built to look after kids or teach, these are often humanoid, but inhuman models with many arms and emergency medical systems are also common. Some have non-lethal weapons to protect their charges.

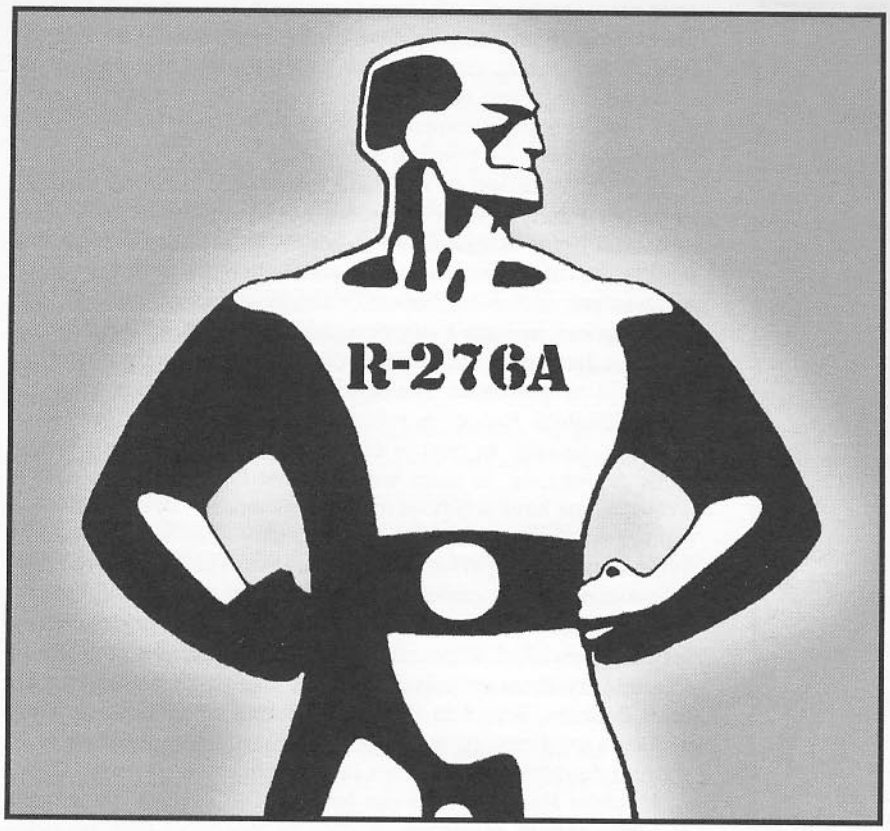
Performer or Orator: These are robots designed to sway a crowd – robot rock stars, preachers, demagogues, actors, etc. They are often fitted with enhanced vocal systems or Appearances; some are intelligent, while others are remote-controlled puppets. Often, but not always, they look human.

Petbot: Built to look and act like an animal, these are common in areas where real pets are unavailable or forbidden. Petbots are usually cute, often furry, and sometimes intelligent. Larger and more expensive models often serve as bodyguards, nannies, or mounts. The Furbot (p. 118) and Paladin (p. 119) are petbots.

Police Robot: A robot can be designed to assist police officers (often in bomb disposal, evidence gathering or riot control), or perhaps, to patrol and investigate on its own. The Bomb Disposal robot (p. 111), Blue Steel (p. 112) and Cerberus (p. 117) are police robots. Robots used by police SWAT teams are often indistinguishable from security or warbots.

Recon or Newsbot: Built for surveillance or military reconnaissance, or for news gathering, these are usually fast and equipped with many sensors. The Argus (p. 111) is a recon robot.

Medical or Rescue Robot: Designed to provide emergency services, these come in all shapes and sizes from static "docbot" or "automed" machines with dozens of arms and built-in medical instruments to fully mobile paramedics and fire fighters. The Samaritan (p. 115) is a medical/rescue robot. Variations on this theme include robots designed to perform bio-medical experiments and "torture robots" used for interrogations.



Robot Monster: A robot designed with a fearsome appearance may be a weapon of terror or simply an alien machine. These are often very large, and some look like monstrous animals. While most of its weapons are usually built for close combat, dramatic ranged weapons like flamers are also common. The Grendel (p. 122) is a robot monster.

Pleasure Robot: A robot designed as a sexual surrogate is almost always an android. While many are indistinguishable from humans, others are deliberately given exotic features like unusual skin or hair, or even fur. Some are very intelligent, to make them charming companions as well as toys, or to enable them to double as secretaries, bodyguards or the like. The Lemon Angel (p. 119) is a pleasure robot.

Prototype: Any kind of robot can be a newly-invented prototype, perhaps the only one of its type. With GM permission, a prototype robot may use parts a few tech levels in advance of the campaign's ordinary technology level; however, if the robot is a character, it will cost extra points for its Unusual Background.

Security Robot: Robots designed to protect an installation are normally small enough to fit through doors and more lightly armed and armored than warbots. The Rover (p. 113) and Cerberus (p. 117) are security robots.

Sports Robot: These are robots designed to engage in athletic or gladiatorial events. They are most often humanoid, although seldom identical to humans. They could be used for inter-robot competitions or as sparring partners, animated practice dummies or coaches.

Special Ops Robot: A robot commando or secret agent. It combines elements of the bodyguard, police, assassin and warbot with exotic spy gadgets designed to help it do its job. It is often an android or has built-in stealth and disguise systems to help it infiltrate. Synthia and Muramasa (p. 115) are special ops robots.

Super Robot: Robot superheroes or villains are often androids, or at least humanoids, usually as smart as a human, and a lot stronger and faster. They can often fly and have exotic built-in weapons or gadgets like contragravity, or psychotronic generators. Scorpio Alpha (p. 122) is a super robot.

Techbot: A technical robot designed for maintenance and repairs. Unlike the larger construction robots, it is normally small enough to operate indoors or to serve as vehicle or ship crew. Some are *very* small, to navigate narrow air ducts and service crawlways. The Tinkerbot (p. 121) is a techbot.

Transport Robot: A robot designed to carry people. This may be a simple car, ship or other craft with a robot brain, or it may be a robotic mount. The Paladin robot horse (p. 119) is a transport robot.

Von Neumann Machine: A robot (usually for exploration) equipped with enough intelligence and tools that it can use local resources to build a replica of itself (and then copy its own programs). Since they replicate themselves, Von Neumann machine robot starships could quickly explore a large area of space. Some are built with more aggressive purposes, such as colonization or extermination.

Warbot: A heavily armed and armored robot designed to replace soldiers or (if large enough) combat vehicles. The Vanguard (p. 112), Muramasa (p. 115), Vulture (p. 116), Gabriel (p. 117) and Thor (p. 121) models are all warbots.

A single robot can fulfill several different roles, or be a "general purpose" machine designed to do almost anything. These concepts can also be merged. For example, a *colonizer* robot might combine the functions of construction, agricultural and teaching robots. How about a robot Orator-Von Neumann machine, that goes around the galaxy replicating itself while spreading a particular religion?

EXAMPLE

To show how the system works, we'll build the SY-101-N Nemesis, nicknamed "Synthia," an android assassin designed by Federation Intelligence as a covert operative. Synthia is a deadly femme fatale who happens to be a machine. It looks like a beautiful woman, but underneath its skin is a mechanical robot body with numerous exotic weapons and gadgets.

The Design Process

Design a robot by choosing the components that will go into it such as computer brains, gadgets, weapons or power systems. Then add subassemblies like arms or legs or wheels, and place the components within the body or subassemblies. Next, calculate the size, weight and cost of the body structure needed to contain and support these components. Then layer surface features, like armor and artificial flesh, over the robot. Last of all, determine the robot's statistics.

Components: These are the parts built *into* the robot, ranging from computer brains to tools to power systems. As components are designed or selected, record their statistics.

Components have a tech level (TL), a weight (wt.), a volume (vol.) and a cost in dollars; some also have a power (pow.) requirement. Components may have a Legality rating (LC) which ranks how likely authorities are to restrict them, from LC 6 (totally unrestricted) to LC -1 (major military hardware).

Tech Level: Robots are normally built at tech levels (TLs) from TL7 (the present) to TL16 (near-magical superscience); see p. B185 for an explanation of what a tech level represents.

The different parts that make up a robot will have a minimum tech level assigned to them; if no TL is listed, assume it is TL7. Unless there is a source of higher-TL parts or the designer is a gadgeteer, a robot can only use features or parts available at its TL, or a lower TL.

Weight (wt.) is measured in pounds (lbs.); 2.2 pounds convert to one kilogram.

Volume (vol.) is measured in cubic feet (cf); one cubic foot converts to .028 cubic meters or 1/27 cubic yards.

Cost is in dollars.

Power (pow.) is measured in kilowatts (KW). One kilowatt is equal to 1.34 horsepower. Stored energy is measured in kilowatt-seconds (KWS). A KWS is equivalent to one KW of power for one second (that is, a kilojoule).

The Design Sequence

Design the robot following these steps:

1. **Refer to the *Robot Brain* (this page) section and design a computer brain to control the robot. Work out the robot brain's Complexity.**
2. **Refer to *Sensors* (p. 11) and design a sensor system for the robot.**
3. **Go to *Communicators* (p. 14) and design a communication system for the robot.**
4. **Add arm motors (p. 16) if the robot will have arms.**
5. **Add one or more propulsion systems (p. 17) if the robot should move.**
6. **Refer to *Contact Weaponry and Jaws* and *Ranged Weapons* (beginning p. 20) to select any weapons the robot will have.**
7. **Select any built-in gadgetry the robot will have, such as tools or other special devices, from the *Accessories* section (beginning on p. 28).**
8. **If the robot will carry cargo or passengers, decide on its capacity by referring to the *Payload* section.**
9. **Design a power system for the robot by using *Power System Design* on p. 34. If the power system or propulsion system requires fuel, refer to *Fuel* on p. 36 and design a fuel tank to meet this requirement. Calculate the robot's endurance.**
10. **Decide what subassemblies (arms, legs, wings, tracks and so on) the robot has.**
11. **Allocate components among the body and subassemblies and calculate the volume of the body and each subassembly.**
12. **Determine the *area* of the body and each subassembly.**
13. **Design the robot's structure (p. 40).**
14. **Calculate the hit points of the body and each subassembly.**
15. **To cover the robot with armor, or give it other protective systems, refer to the *Armor* and *Threat Protection* section on pp. 41-43.**
16. **If the robot will have any lifelike features, go to the *Biomorphics* section on p. 43 and add them.**
17. **Work out the robot's statistics (see *Statistics* beginning on p. 45).**

The robot can now be programmed (refer to the *Brains and Programs* chapter) or used as it stands.

Components

Robot Brains

A robot brain is a computer built into a robot to control its actions. Every robot must have one or more. (If a robot has several brains, decide which one is the *dominant brain.*) Brains are rated by Complexity; the more complex the brain, the more sophisticated the computer programs it can run, and the higher the robot's DX and IQ will be. A robot with an ordinary brain with no special options will have a DX equal to the brain's (Complexity/2) + 8, rounded down, and an IQ equal to its Complexity + 3.

Robot brains are *computers* – they run computer programs, allowing them to be programmed with various skills and abilities. They also have certain advantages over an organic brain: perfect recall, a built-in clock chip and an innate ability to handle numbers. This gives a robot with a computer brain Absolute Timing (p. B19), Doesn't Sleep (p. 85), Eidetic Memory 2 (p. B20), Lightning Calculator (p. B21), and Mathematical Ability (p. B22), worth a total of 100 points.

However, a robot with a computer brain is not truly "self-aware" or sentient – computers are straightforward logical thinkers that lacks self-initiative, must obey their owners, cannot learn or evolve, and have no understanding of human emotions. Unless the brain is given special options, it automatically has the disadvantages Cannot Learn (p. 88), Reprogrammable Duty (p. 89), No Sense of Humor (p. B241), and Slave Mentality (p. 89), worth -105 points.

Adding up the advantages and disadvantages, having a computer brain with no options has a net cost of -5 points.

Several options may be added to any brain to alter its capabilities. None of the options have to be taken, although the options "neural-net" or "sentient" are strongly recommended for any robot intended to be a "character" rather than a machine! A robot brain can combine any of the options except neural-net and sentient: a sentient brain is simply a higher order of neural-net. The options are:

Biocomputer (TL8): The computer's processing capabilities are enhanced through the use of organic nervous system and brain tissue, either scavenged from human brains or vat-grown, and kept alive with a built-in life support system. This is an intermediate step between a computer and a true cyborg, and boosts the Complexity of the computer. It has two disadvantages: any repairs require Electronics Operation (Medical) as well as Electronics Operation (Computers), and some societies consider biocomputers to be ethically questionable, hence its reduced LC. Note: biocomputer brains *must* also be given either the neural-net or sentient option.

Compact (TL7): The brain is substantially reduced in size and weight, but is much more expensive as a result.

Dumb (TL7): The brain is less sophisticated than usual. This subtracts 1 from its Complexity but makes it much cheaper.

Extra ROM Slots (TL7): This multiplies the number of hardwired programs the computer can run simultaneously by 1.5. See *Hardwired Programs,* on p. 61 of Chapter 2, *Brains and Programs.*

Genius (TL7): The brain uses state-of-the-art processing technology. This adds +1 to its Complexity, but greatly increases the price.

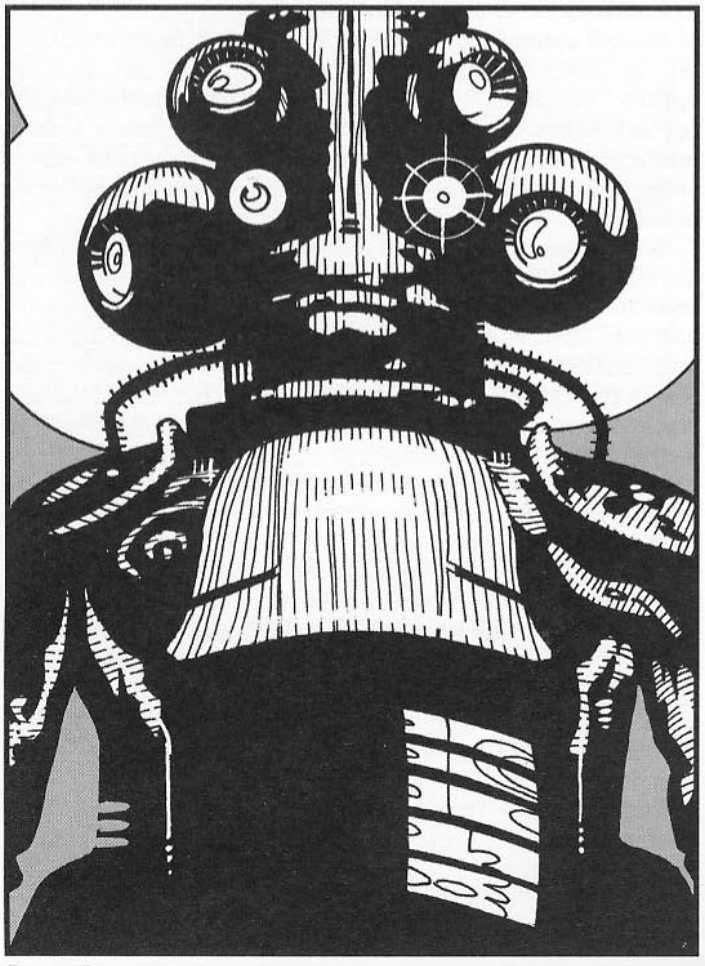
Hardened (TL7): The brain is built with optical systems, or more sophisticated forms of hardening at higher TLs, in order to resist attacks such as electromagnetic pulses or paralysis beams that do special damage to computer brains.

High-Capacity (TL7): This enables the brain to run 50% more software programs than a computer of its Complexity normally can. See *Programs* in the *Brains and Programs* chapter.

Neural-Net (TL8): The brain is built so that its operation simulates the way an animal (for instance, a human) brain structure works. This makes it self-programming and semi-sentient, with limited self-initiative. In game terms, this option eliminates the crippling Cannot Learn and Slave Mentality disadvantages that a computer normally suffers (leaving only Reprogrammable Duty and No Sense of Humor) and is thus worth 70 extra points. A Complexity 7+ neural-net brain built at TL9 can spontaneously "awaken," *becoming* sentient. See *Awakening Sentient Computers* on p. 57. A neural-net brain has an IQ of Complexity + 4 rather than Complexity + 3.

Reflex Booster (TL7+): This is a co-processor that increases the robot's ability to coordinate its physical actions, and thus boosts its DX. It is available in +1, +2 or +3 DX versions.

Sentient (TL10): Any kind of brain of Complexity 6 or higher (after options) can be built to be sentient. A sentient brain is a fully self-aware "Artificial Intelligence," or AI. Having a sentient brain eliminates all 105 points of mental disadvantages – Cannot Learn, Reprogrammable Duty, Slave Mentality, and No Sense of Humor – that ordinary computers have. As a result, this option increases the cost of a brain by 105 points! By definition, every sentient brain is also a neural-net – don't give a robot brain both options. The IQ of a sentient brain is its Complexity + 5.



Select the basic size of brain (tiny to macroframe) from the table below, decide which options it has, work out its statistics and record them.

Computer Brain Table

Brain Type	*TL*	*Wt.*	*Vol.*	*Cost*	*Pow.*	*LC*	*Comp.*	*Pts.*
Tiny	8	.5	.01	$200	neg.	6	TL-7	0
Small	7	2	.04	$1,000	neg.	6	TL-6	0
Standard	7	40	.8	$15,000	neg.	6	TL-5	0
Microframe	7	200	4	$40,000	.1	5	TL-4	0
Mainframe	7	500	10	$200,000	1	5	TL-3	0
Macroframe	7	4,000	80	$2 million	10	5	TL-2	0
TL Modifier								
Built at TL:	7-8	–	–	–	–	–	–	–
Built at TL:	9	×.5	×.5	×.5	–	–	–	–
Built at TL:	10+	×.25	×.25	×.25	–	–	–	–
Options								
Biocomputer	8*	×1.5	×1.5	×5	–	-1	+1	-5
Compact	7	×.5	×.5	×2	–	–	–	–
Dumb	7	–	–	×.2**	–	–	-1	–
Extra ROM slots	7	–	–	×1.5	–	–	–	–
Genius	7	–	–	×7**	–	-1	+1	–
Hardened	7	×3	×3	×5	–	–	–	–
High-Capacity	7	–	–	×1.5	–	–	–	–
Neural-Net	8	–	–	×2	–	–	–	+70
Reflex Booster								
+1 DX	7	–	–	×1.5	–	–	–	–
+2 DX	8	–	–	×2	–	–	–	–
+3 DX	9	–	–	×3	–	–	–	–
Sentient	10	–	–	×3	–	-1	–	+100

* Must also take sentient or neural-net options!

** For tiny, small, mainframe and macroframe brains, "genius" multiplies cost by 20 instead of ×7, and "dumb" multiplies cost by .05 instead of .2.

Weight: This is the weight of the brain. If the brain has TL modifiers or options that affect weight, multiply by the number shown for each modifier or option, in turn. For example, a TL9 macroframe with the hardened and biocomputer options weighs 4,000 lbs. × .5 (built at TL9) × 3 (hardened) × 1.5 (biocomputer) = 9,000 lbs.

Volume: Just as with weight, if a robot has several modifiers or options that affect volume, multiply it by each in turn.

Cost: Just as with weight, if a robot has several modifiers or options that affect cost, multiply the cost by each in turn.

Legality: The brain has the LC shown on the table, modified by its options.

Comp. (Complexity): The brain's Complexity is based on its type and TL, modified by the options chosen. For example, a TL10 standard brain with the genius option has TL10 - 5 + 1 = Complexity 6.

Points: The point cost of the brain's innate advantages and disadvantages. Add the cost of the brain and of all options together. Note that Complexity does not directly affect this point cost, but a higher Complexity means a higher DX and IQ, which will cost extra points (see *Statistics* on p. 45).

Robot Brains vs. Ordinary Computers: The options on this table permit computer brains almost identical to those on pp. UT7-8 to be built. (Volume may differ, since a brain in a robot does not need a keyboard, among other things.) For example, a

TL8 minicomputer is a standard robot brain with the "compact" option, while a TL9 borderline-sentient megacomputer is a TL9 macroframe with the "neural-net" option.

EXAMPLE

Every robot needs a brain. We decide Synthia should have a standard brain with the +2 DX booster, high-capacity and neural-net options. This weighs 40 lbs. × .25 (for TL10) = 10 lbs., takes up .8 ×.25 = .2 cf, and costs $15,000×.25 (TL10) × 2 (neural-net) × 2 (+2 DX booster) × 1.5 (high capacity) = $22,500. It is LC 6, Complexity (TL10 - 5) = 5, and uses negligible power. It costs -5 points (base cost of a computer brain) + 70 points (for neural-net) = 65 points.

Extra Databanks: Mass Storage

A computer brain can store considerable data, usually all that it needs for its own memory and programs. However, if the brain is going to handle really large databases (detailed files on an entire population, for instance), extra databanks can be added, attached to the computer brain. Each gigabyte of data storage at TL7 is a component requiring $1,000, 5 lbs., and .1 cf. Increase the data storage by a factor of ten per TL over 7.

GMs may note that this volume is less than that on p. UT14. This is because p. UT14 assumes shelf space for backup disks as well.

Mass storage can be *Hardened* (like a computer brain) for triple the weight and volume and five times the cost.

Sensors

All robots require sensors. A set of *basic sensors* gives the robot four senses at a level equivalent to a human's: vision, hearing, smell and taste. (Tactile senses are added later, when the robot's skin and armor are designed.)

Assume that a robot with this package has a number of visual sensors (usually two) whose capability approximates the human eye, chemical sensors equivalent to a human nose and taste buds, and audio sensors equivalent to human ears.

Basic sensors have one capability humans don't often have, if the robot has a computer brain. A robot normally stores a relatively low-quality memory of whatever it sees. But any robot can use its sensors in "recorder mode" to store high-definition digital still or motion pictures, quality audio recordings or other sensory impressions, within the limits that its sensors can normally detect. See *Data and Memory Requirements* on p. 60 for the memory space used.

To design a robot's sensors quickly, just install the basic sensor package (see the *Sensor Table* on p. 14), and go on to *Communicators.*

Or take various options, analogous to advantages and disadvantages, to enhance or degrade this basic package . For example, a robot could be Blind (that is, have no visual sensors) but have Radar and Acute Hearing +5 instead. These options are described below; the sensor table shows their TL and the effect they have on the weight, volume and cost of basic sensors.

Vision Options

Acute Vision +1 to +5: Keen visual sensors give the robot the equivalent of the Acute Vision (p. B19) advantage.

Blind: The robot's electronic sensors do not detect visible light. The robot has the equivalent of the Blindness disadvantage (p. B27). The robot may be able to see beyond the visual spectrum, if it has the Infrared or Thermograph options. A robot which is Blind may not take the Color Blindness, Low-Res Vision, Night Vision, One Eye, Peripheral Vision, Spectrum Vision, Telescopic Zoom or 360-Degree Vision options.

GMs whose players purchase blind robots that have infrared or thermographic vision should take care to roleplay the many disadvantages of only being able to see via contrasting heat shapes. That is, inability to see print, signs, read license plates or menus, use instrument panels that are not designed for direct electronic interface and so on.

A Blind robot may take Acute Hearing or Acute Taste/Smell at half point cost; dollar cost is unchanged.

Color Blindness: The robot sees in monochrome only; the effects are the same as the Color Blindness disadvantage (p. B28). Such a robot may not take Spectrum Vision.

Independently Focusable Eyes: The robot has visual sensors that can track two different things at once and see in two directions simultaneously. It can aim at more than one target at a time if it has the Full Coordination program (p. 59).

Infrared Vision: The robot can switch its vision to the infrared spectrum, enabling it to see by sensing temperature differences between objects. It can see in absolute darkness or through normal fog or smoke, and suffers only a -1 penalty when fighting at night. It gets +2 on Vision rolls to spot living things during daylight. It can follow a heat trail, so it gets a bonus to Tracking rolls: +3 if the trail is less than 10 minutes old, +2 if the trail is less than 20 minutes old, +1 if it's less than 30 minutes old. However, infrared vision is colorblind, and objects of the same temperature show no contrast; a robot couldn't read print by infrared, for instance. Generally a 10-degree difference in heat is needed to distinguish objects from their background. When the robot uses infrared vision, it cannot see the normal visual spectrum; switching takes one turn.

Laser Rangefinder: This allows the robot to estimate distances precisely by using a laser beam. This adds +2 to weapon Accuracy when Aiming (not cumulative with bonuses for laser sights) and improves depth perception.

Low-Res Vision: The robot's visual sensors are capable only of low resolutions. The effects are the same as the uncorrectable *Bad Sight* disadvantage on p. B27; decide if it is nearsighted or farsighted. A robot which is Blind may not take this option unless it also has the Infrared or Thermograph options.

Microscopic Vision: Activating this option magnifies small, close-up objects by a factor of ten to the power of (TL-5). (A TL8 unit magnifies by 10 to the power of (8-5), or 1,000.) The GM may allow the robot to perform certain analytic scientific tasks without instruments. A robot which is Blind may not take this option.

Night Vision: The robot has electronic light-amplification on its visual sensors. The effects are the same as the Night Vision advantage (p. B22), allowing the robot to see in anything but total darkness without penalty. Fog and smoke affect it normally. A robot which is Blind may not take this option.

One Eye: The robot's depth perception is limited, as it has only a single visual sensor instead of two or more. Normally this eye faces forward. The effects are the same as the One Eye disadvantage (p. B29) with the exception that, unless the robot appears otherwise humanoid, reaction penalties are ignored. (A single-eyed robot that also has a laser rangefinder suffers a reduced penalty: only -1 when firing ranged weapons or driving quickly.) A robot which is Blind may not take this option unless it also has the Infrared or Thermograph options.

Peripheral Vision: The robot's visual sensors are widely spaced, have a broad field of view, or are mounted on stalks. The effects are the same as the Peripheral Vision (p. B22) advantage. If the robot has 360-degree vision, it doesn't need this. A robot can't take both this and One Eye.

Retinaprinter (TL9): The robot's visual sensors can change shape and color, enabling it to duplicate a human retina print to fool security sensors. The robot can capture and store retina prints for later use, by looking into the eye the robot wishes to print, or by downloading stored retina print data into its brain (if it has one).

Spectrum Vision (TL10): The robot can tune its vision to see portions of the spectrum beyond visual or infrared. It can check for radio emissions, microwaves, gamma rays or UV radiation, for instance. GMs may allow the robot to find electronic bugs or hidden transmitters or power sources in this fashion on a successful Vision roll. Note that being able to see radio emissions, for instance, does not mean being able to comprehend them. The robot can locate an operating transmitter, but will still need to use a communicator to make sense of the emissions. Spectrum Vision includes Night Vision and Thermograph.

Telescopic Zoom: The robot's visual sensors can increase the magnification of distant objects, although detail resolution cannot exceed what would be visible with normal eyes from 12 inches away. It adds ×2 magnification.

Thermograph: The robot can use thermographic vision, an advanced form of infrared vision. Treat it as infrared vision, except that there is no -1 penalty and Tracking bonuses are at an extra +1. A thermograph has all the capabilities of infrared vision, but with more resolution: it can even sense heat shapes behind thin brush or walls. If looking through a wall, make a Vision roll with a penalty equal to the DR + HT of the wall.

360-Degree Vision: The robot has multiple (more than two) visual sensors, or possibly only two sensors mounted on a rapidly rotating track. It can see in all directions, suffers no penalty when defending against attacks from the side or rear, and takes only a -2 penalty when making wild swings.

Audio Options

Acute Hearing +1 to +5: The robot has especially keen audio sensors. The effects are the same as the Acute Hearing (p. B19) advantage.

Deafness (No Audio Sensors): The robot has no audio sensors. (It may still be able to receive direct coded transmissions through radio, if it has a radio.) The effects are the same as the Deafness disadvantage (p. B28) and the robot may not take any other Audio Sensor options.

Infrasonic: The robot can hear sounds whose frequency is below the normal threshold of human hearing.

Low-Res Hearing: The robot has low-resolution audio sensors, equivalent to the Hard of Hearing disadvantage (p. B28).

Parabolic Hearing: The robot's sensors can "zoom in" on a particular distant sound or area, filtering out background noise from the sounds it wishes to listen to. A robot's degree of parabolic hearing is rated by levels, up to a maximum of five. The table below shows how far away a listening robot can be from various sounds and still hear them at the same volume as normal conversation one yard away. Each level of parabolic hearing either doubles the range at which a sound can be heard (move one line down) or reduces the level of sound that can be heard at a given distance by 10 decibels (move up one line). For instance, a robot with Parabolic Hearing 2 can hear normal conversation at 4 yards as if the robot were only one yard from it, or a 10-decibel sound at 1 yard as if it were a normal conversation.

Sound level (decibels)	*Example*	*Range (yards)*
10	Leaves rustling	¼
20	Whispered conversation	½
30	Normal conversation	1
40	Light traffic	2
50	Loud conversation	4
60	Noisy office	8
70	Normal traffic	16
80	Loud music, gunshots	32
90	Thunder, automatic weapon fire, heavy traffic	64
100	Jet plane at takeoff	128
110	Live rock band	256

Ultrasonic Hearing: The robot can hear extremely high frequencies, such as dog whistles, sonar pulses or ultrasonic alarms.

Super-Hearing: This "option package" includes Acute Hearing +5, Infrasonic Hearing, Parabolic Hearing 5 and Ultrasonic Hearing.

Taste/Smell Options

Acute Taste and Smell, +1 to +5: The robot has sensitive chemical sensors. The effects are the same as the Acute Taste and Smell advantage (p. B19).

Discriminatory Smell: The robot's sense of smell is far beyond human norms. It can determine distinctive odors for practically everything it encounters, and can differentiate between and recognize individual people or things by their smell. Other feats could include sniffing out drugs, poisons or explosives. The GM may require an IQ roll to identify a particular odor or to memorize one. The robot gets a +4 to any roll to use its sense of smell *in addition* to Acute Taste and Smell bonuses. It also gets +4 to Tracking skill. This option includes the Smoke Detector option.

Discriminatory Taste: The robot's sense of taste is far beyond human norms. It can determine distinct tastes for nearly everything it encounters, and can differentiate between and recognize individual people or things by the taste of their bodily fluids. Other feats include analyzing the molecular composition of any organic object by "tasting" its chemical composition. Interpreting the data can require a successful IQ-4 or Biochemistry, Botany or Zoology skill roll. The robot gets a +4 bonus to taste rolls, cumulative with bonuses for Acute Taste and Smell. Even the smallest taste combined with a successful roll is enough to tell if something is safe for humans (or bioroids) to eat, or to get a rough idea of an alien animal's metabolism.

No Sense of Smell/Taste: The robot lacks chemical sensors and cannot smell or taste things. The effects are the same as the No Sense of Smell/Taste disadvantage (p. B29). The robot may not take any other Taste/Smell options except smoke detector.

Smoke Detector: The robot's sensors incorporate a smoke detector.

Special Options

These options give the robot sensors unrelated to vision, hearing, taste or smell, such as radar.

Decide what options, if any, the basic sensors have, and refer to the table on p. 14 to determine their cost, weight and volume.

Codereader: This lets the robot read bar codes, usually scanning them with a laser. A codereader isn't necessary if the robot already has imaging ladar or a laser rangefinder. Similar

code-readers may be built to read other kinds of bar codes, such as magnetic strips.

Hypno-Eye (TL9): The eye can project subliminal hypnotic patterns (using laser beams): if the robot meets an organic being's gaze, the hypno-eyes adds +4 to Hypnosis skill. Hypno-eyes include the laser rangefinder system.

Ladar, Imaging (TL8): This radar-type sensor uses a laser beam to detect other objects. It is an active sensor, which means that countermeasures that detect laser beams will sense it in use, while those that degrade or jam them will affect it. Unlike search radar, which gives back a mere "blip" (see *Radar, Search,* below) imaging ladar can resolve a detailed picture of what it sees. It can sense shapes and objects, but not colors or flat detail, such as print; it gives the robot a complete picture of everything around. An otherwise Blind robot using imaging ladar can function as if it were sighted but colorblind, with the exceptions noted above. An imaging ladar is limited to line of sight, with a maximum range of half a mile, multiplied by the number of levels it has. The 50/5 point cost for imaging ladar is 50 points plus 5 points per extra level.

Radar, Imaging (TL8): This functions much like imaging ladar, except it can look right through clouds, leaves and so on. It is a short-ranged radar with a tight focus. The main difference is that it works on microwave frequencies, and as such is detected, jammed or degraded by countermeasures that affect radar rather than ladar or lasers. Its range is half a mile, multiplied by the number of levels it has. The 50/5 point cost for imaging radar is 50 points plus 5 points per extra level.

Radar, Search: This radar has a longer range but is less precise; it is most useful for flying robots. It "sees" by putting out pulses of energy and collecting and analyzing the way objects reflect them. Targets detected by search radar are normally just blips on a screen, with their speed, position and approximate size known, but (unless they are the size of a large building) their shape, color and composition remain a mystery. Its basic range is 1 mile, but it cannot see through solid objects or over the horizon; multiply the range by the number of levels it has.

Radar/Laser Locater: This warns the robot if a radar or laser of any sort (including imaging ladar) is pointed at it, or if a radar-homing or laser-homing missile is tracking it. It also locates the source. (For detailed rules on this see ***GURPS Vehicles;*** otherwise assume that if a radar or laser of equal or lower TL spots the robot, its position is detected by the robot.) A radscanner (see *Scanners,* below) automatically includes a radar/laser locater.

Radiation Detector: The robot has a built-in Geiger counter to detect the presence and intensity of radiation in the area. This sensor isn't needed if the robot has a radscanner.

Scanners (TL9): A "scanner" is a sensor that allows the robot to detect and classify matter or energy. There are three main types. *Bioscanners* detect life forms and can locate particular species or even specific people, if a genetic "fingerprint" is on file. *Chem-scanners* search for minerals, metals and chemical compounds, and can be used to detect or analyze explosives or drugs, or even determine the DR of an object. *Radscanners* detect energy sources of all kinds and can be set to scan for specific types of radiation (gamma rays, radio, neutrino, radar, etc.); they can also detect the scanning radiation used by chem- and bioscanners.

In general, a scanner has a maximum range of 2,500 yards if set to detect a specific thing within its category, or 1,000 yards if set to scan for a wide range of things. Normally it scans a 60-degree arc each turn; it can scan 360 degrees per turn, but at ⅛ range. An Electronics Operation (Sensor) skill is required to spot something. Penalties are -2 at ranges over 1,000 yards, +2 at ranges of 500 yards or less. Within 50 yards, very detailed analysis is possible. Double the ranges at TL10 and multiply them by 5 at TL11+. Add +1 to scanning rolls at TL10, or +2 at TL11+.

Sonar: The robot can "see" by emitting sound waves. No light is required. Sonar can be jammed by loud noises, and is colorblind, but (within a range of 1 yard) the robot can actually "see" inside living things or other objects of similar density. GMs may give a +2 bonus to skills such as Diagnosis, or for attempts to detect concealed weapons (using Holdout). Its range under water is 200 yards, multiplied by the number of levels it has; the range out of water is one-tenth that. The 25/5 point cost for sonar is 25 points plus 5 points per extra level.

Xadar, Imaging (TL12): This functions like imaging ladar, except that the robot can see through walls or into solid objects. It can see through 2-inch-thick steel walls, or up to 6 inches of normal matter. Very dense material (for example, lead, or DR 150+ armor) or force screens cannot be penetrated. Its range is 1 mile; extra levels not only multiply that, but add to the thickness of matter through which xadar can penetrate (for example, three levels of imaging xadar enable a robot to see through 6-inch steel walls). The 65/10 point cost is 65 points, plus 10 points per extra level.



Sensor Table

Type	*TL*	*Weight*	*Cost*	*Points*
Basic Sensors	7	5	$40,000	0
Basic Sensors	8	2	$10,000	0
Basic Sensors	9	1	$5,000	0
Basic Sensors	10	.5	$2,500	0
Basic Sensors	11+	.25	$1,250	0
Visual Options				
Acute Vision +1 to +5	7	–	+10%*	2*
Blind**	7	-50%	-50%	-50
Color Blindness	7	–	-10%	-10
Independently Focusable	7	–	+50%	15
Infrared Vision	7	+20%	+5%	15
Laser Range finder	7	+50%	+5%	5
Low-Res Vision	7	-20%	-20%	-25
Microscopic Vision	7	+10%	+10%	4
Night Vision	7	–	+1%	10
One Eye	7**	-20%	-20%	-10
Peripheral Vision	7	–	+20%	15
Retinaprinter	9	–	+100%	5
Spectrum Vision	10	+60%	+60%	40
Telescopic Zoom 1-5	7	+20%*	+10%*	6*
Thermograph Vision	8	+50%	+20%	20
360-Degree Vision	7	+100%	+20%	25
Audio Options				
Acute Hearing +1 to +5	7	–	+5%*	2*
Deafness	7**	-30%	-30%	-20
Low-Res Hearing	7	-20%	-20%	-10
Parabolic Hearing 1-5	7	+10%*	+10%*	4*
Infrasonic Hearing	7	+10%	+10%	5
Ultrasonic Hearing	7	+10%	+10%	5
Super-Hearing	7	+70%	+95%	40
Olfactory/Taste Options				
Acute Taste and Smell +1 to +5	7	–	+5%*	2*
Discriminatory Smell	7	+20%	+40%	15
Discriminatory Taste	7	+10%	+20%	10
No Sense of Smell/Taste	7**	-20%	-20%	-5
Smoke Detector	7	+10%	neg.	0
Special Sensors				
Codereader	7	+20%	+1%	0
Hypno-Eye	9	+50%	+100%	10
Ladar, Imaging	8	+100%*	+25%*	50/5*
Radar/Laser Locator	7	+100%	+5%	1
Radar, Imaging	8	+100%*	+25%*	50/5*
Radar, Search	7	+100%*	+10%*	5*
Radiation Detector	7	+10%	+1%	0
Scanners				
Bioscanner	9	+100%	+20%	20
Chemscanner	9	+100%	+20%	5
Radscanner	9	+100%	+20%	5
Three-in-one	9	+300%	+60%	30
Sonar, Active	7	+100%*	+20%*	25/5*
Xadar, Imaging	12	+300%*	+300%*	65/10*

* Per +1 bonus or per level.

** Taking this option limits the other options that can be taken. See the text description.

Weight: This is the weight of the sensor package. If the robot has options, add (don't multiply) all percentage modifiers together, and then add or subtract that percentage from the basic sensor's weight.

Volume: Find the volume in cf by dividing the weight by 50. Thus, a .5-lb. sensor takes up .5/50 cf, or .01 cf.

Cost: This is the cost of the sensor package. If the robot has options, add (don't multiply) all percentage modifiers together, and then add or subtract that percentage from the basic sensor's cost.

Legality: Most sensors are LC 6. However, radars or ladars with 4 to 6 levels are LC 5, while bioscanners, imaging xadar, and any radar or ladar with 7 or more levels is LC 4.

Power: This is negligible for most sensors. Imaging radar, ladar or xadar, and search radar each have a power requirement of 0.25 KW × its level. Sonar needs 0.25 KW per 10 full levels.

Point Costs: Basic sensors cost no points, but the options do. A disadvantage to basic sensors is worth no points if the robot has another set of basic sensors without that disadvantage. A specific advantage or disadvantage only costs points once.

EXAMPLE

Synthia has basic sensors. At TL10 these weigh .5 lb. and cost $2,500. We add the Thermograph and Retinaprinter options, raising the weight by 50% and the cost by 120%. As a result, the sensors weigh .75 lb., take up .75/50 = .015 cf, and cost $5,500. They also cost 25 character points and are LC 6. They require negligible power.

Communicators

Robots require some way to communicate with the outside world (or with other robots) in order to receive commands. A *basic communicator* package consists of three systems:

A *voice synthesizer* enabling the robot to synthesize speech, or, if it has the appropriate database or skills, to generate music or sound effects.

A short-range *radio* with a range of one mile at TL7, 10 miles at TL8, 100 miles at TL9 or 500 miles at TL10+. The range may be extended on a successful Electronics Operation (Communications) roll, at -1 per extra 10% added to the range, to a maximum extension of 100%. At TL12+, the radio can use modulated gravity waves instead of radio waves, which increases the range by a factor of 1,000 and is totally undetectable by pre-TL12 communication systems.

A *cable jack,* a plug in the robot for a fiber-optic cable, allows direct, unjammable communication with any other computer or communicator with a similar jack and interface. A short (up to 10 yards long) cable is included. Robots usually use their cable jacks to link up with immobile computers or other robots.

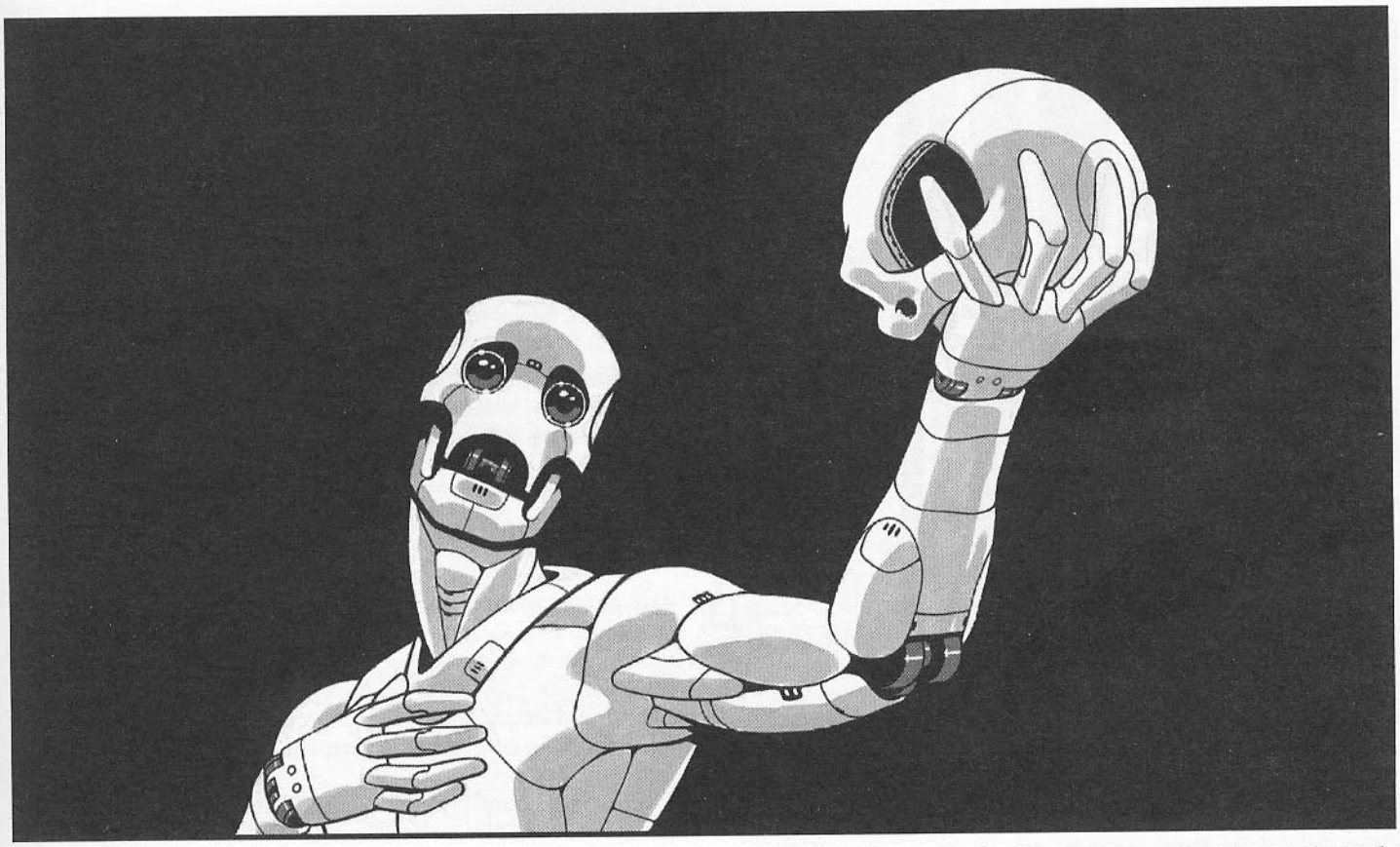
A variety of options can be added to the basic communicator package to increase or decrease its capabilities, weight, volume and cost. Multiple systems can also be purchased as back-ups. Available options include:

Voice Synthesis Options

Bullhorn: This option gives the robot a built-in loudspeaker, so that it can greatly amplify its voice.

Disturbing Voice: The robot's voice synthesizer is poor quality, and the robot's voice sounds obviously artificial; for instance, its speech might be hollow, high and squeaky, or sound like a collection of recorded human voices strung together without inflection. In game terms, the effects are the same as the Stuttering disadvantage (p. B29), though the robot probably does not actually stutter. The robot may not also have the Silver Tongue option.

Mute: The robot has no voice synthesizer and cannot speak – it can only communicate by radio or cable jack. If communicating by radio, it may not send voice transmissions, only code or text. The effects are the same as the Mute disadvantage (p. B29). A mute robot may not have any other speech-based options.



Silver Tongue (TL9): The robot has a superior voice and can project a soothing carrier wave whenever it speaks, sings, hums or whistles. It has the equivalent of the Voice advantage, and gets an additional +2 reaction modifier from biological entities with hearing in addition to the normal +2 from Voice. It also gives the robot a -3 modifier on any Detect Lies rolls made against it. Most nonhumans (including robots), as well as those who cannot hear the robot, are unaffected. So are individuals in airtight armor or with Audio Damping (p. CY34) cybernetics. This option includes the Superior Voice option.

Superior Voice (TL8): The robot's voice synthesizer is of particularly fine quality. The effects are the same as the Voice (p. B23) advantage.

Ultrasonic Speech (TL8): The robot can communicate at pitches inaudible to the human ear. Only entities with ultrasonic hearing can understand the robot. Animals such as dogs will often be disturbed by ultrasonic speech.

Cable Options

No Cable Jack: The cable jack option is removed from the robot. The robot may not have the extension cable option.

Extension Cable: This is a long optical cable. One end plugs into the robot's cable jack, the other into a cable jack on another robot, computer, or communicator. The cable is designed to reel in or unreel automatically as the robot moves about, to prevent tangling, but if the robot moves beyond the cable's length or manages to twist it around something, it will come unplugged. The cable is DR 2, HT 1 to cut. It is usually used as a cheap, unjammable short-range communication link.

Radio Options

No Radio: The robot has no radio. Unless it has other options, it can only communicate by voice or cable.

Long-Range Radio: The robot's radio has 100 times the normal range.

Medium-Range Radio: The robot's radio has ten times the normal range.

(Note: robots do not use com scramblers for coded messages – any computer brain can encrypt a message if so programmed.)

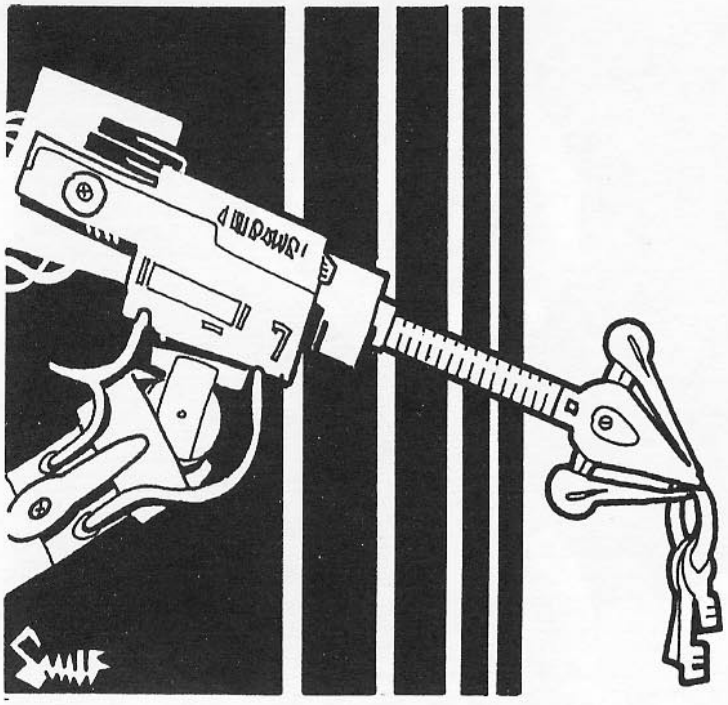
Other Options

Infrared Com: The robot uses a directional infrared beam (like that produced by a VCR remote) to communicate. Its maximum range is about 50 yards. Only other infrared coms within the line of sight can pick up IR beams.

Lasercom: The robot has a directional laser communicator with a range of 20 miles at TL7, 200 miles at TL8, or 2,000 miles at TL9+, or line-of-sight distance, whichever is less. A laser communicator cannot be intercepted, but can communicate with another laser communicator only in line of sight, although use of multiple relays or mirrors can allow it to beam messages over the horizon. Sending a message requires the user to know the precise location of the recipient or relay station. Until TL9, lasercom communication beams can be blocked by smoke or fog.

IFF: A robot that has radio, infrared or lasercom may have an IFF. This stands for "identify friend or foe." This is a beacon that automatically broadcasts a coded "friendly" identity signal when the robot is scanned by a scanner, radar, ladar or xadar set to the correct frequency. The signal may be sent by any of the robot's communication systems (often by radio). It only functions if the robot is actually *detected* by radar, ladar, bioscanner, chemscanner or xadar; it is not a continuous broadcast.

Neutrino Communicator (TL10+): This tight-beam secure communicator actually uses modulated pulses of anti-neutrinos. Like neutrinos, anti-neutrinos can penetrate almost anything, but are slightly easier to detect and receive than neutrinos, hence their increased usefulness in communications. Its range is 10,000 miles. It can reach underwater without penalty and, unlike other tight-beam communicators, it can penetrate solid objects and is not blocked by the horizon.



Decide what options, if any, the communication system has, and refer to the table below to determine the weight, volume, cost and point cost of the package and the available modifications.

Communications System Table

Type	*TL*	*Weight*	*Cost*	*Points*
Basic Communicator	7	2	$1,000	15
Basic Communicator	8	1	$500	15
Basic Communicator	9	.5	$250	15
Basic Communicator	10+	.25	$125	15
Voice Options				
Bullhorn	7	+10%	+10%	0
Disturbing Voice	7	–	-50%	-10
Mute*	7	-80%	-80%	-20
Silver Tongue	9	–	+5,600%	15
Superior Voice	7	–	+500%	10
Ultrasonic Speech	8	–	+100%	25
Radio Options				
Long-range Radio	7	+900%	+120%	2
No Radio*	7	-10%	-10%	-10
Medium-range Radio	7	+100%	+40%	1
Cable Options				
Extension Cable	7	+100%**	+10%**	0
No Cable Jack*	7	-10%	-10%	-5
Other				
Infrared Com	7	+50%	+50%	5
Lasercom	7	+1,000%	+1,000%	10
IFF	7	–	+100%	0
Neutrino Com	10	+12,000%	+16,000%	15

* If the robot is Mute, it cannot have other voice options. If it has no radio, it cannot have other radio options. If it has no cable jack, it cannot have an extension cable.

** Per 100 yards of length, max. 2,000 yards.

Weight: This is the weight of the package. If the robot has options, add (don't multiply) all percentage modifiers together, and then add or subtract that percentage from the basic communicator's weight as with sensors.

Volume: The volume of the basic communicator is its weight (after modifications)/50 cf.

Cost: As with weight, add all percentage modifiers and then add to or subtract from the basic communicator's cost.

Power Requirement: This is always negligible.

Legality: LC 6, unless a long-range communicator or neutrino com is installed, then LC 5.

Point Costs: The cost shown on the table, modified by the cost of the options. If a robot has multiple communicators, it only gets points for disadvantages that apply to all of them.

EXAMPLE

Synthia has a TL10 basic communicator with the Superior Voice option. It weighs .25 lbs., has a volume of .25/50 = .005 cf and costs $125 + 500%, or $750. It is LC 6 and costs 25 points.

Arm Motors

A robot must have one arm motor for every arm installed. Arm motors determine an arm's strength. They may be a system of electric motors and cables, hydraulics, myoelectric fibers, or even biomechanical systems similar to human muscles.

A normal arm motor is designed to control a jointed arm ending in a manipulator equivalent to a human hand. The arm will be able to do everything that a human arm and hand of the same strength can do.

Each arm motor is rated for strength (ST). A robot may have multiple arm motors with different strengths. An arm motor can also have a variety of options, which will affect the capabilities of the arm it powers.

Bad Grip: The arm motor lacks the dexterity of a normal arm – instead of powering an actual hand, it controls a simple gripper or paw. This makes the arm motor much cheaper, since it doesn't need fine motor control. The robot will be -4 to DX (or -4 on skill) when using it for any task requiring fine manipulation. This penalty does not apply to tasks involving gadgets or weapons built into the arm itself!

Cheap: The arm motor is cheaper but heavier.

Extendible: This allows the arm to double its Reach, either by telescoping out, or by actually stretching (if combined with extra-flexible).

Extra-Flexible: This allows the arm to be more flexible than a human's: for example, a tentacle, a thin cable, or an arm with multiple joints. An arm with an arm motor given this option can work together with any other arm, regardless of body positioning, general layout, or "right" or "left." It also gives the arm a +1 bonus when strangling or grappling.

Micromanipulator: The robot hand has special fingers or probes designed to manipulate very small objects. The robot will need basic sensors with the Microscopic Vision option to use it properly, but if it does, it can be used to manipulate microscopic objects. This gives a +2 bonus on any mechanical or electronic skill rolls requiring very fine control (for example, fixing a watch or a computer brain), or for Surgery. It also allows the robot to do things like painting a picture on the head of a pin. This option can also be bought *in conjunction* with Striker or Bad Grip – if so, the robot can manipulate microscopic objects normally but is penalized or unable to manipulate anything larger.

Retractable: Adding this option to the arm motor means the arm can retract into a housing in the body or head (decide which). Extending or retracting the arm takes one action, but it can deliver a thrusting attack (like a punch, or using a built-in

impaling weapon) in the same turn it is extended. The arm will also take up space in the body or head.

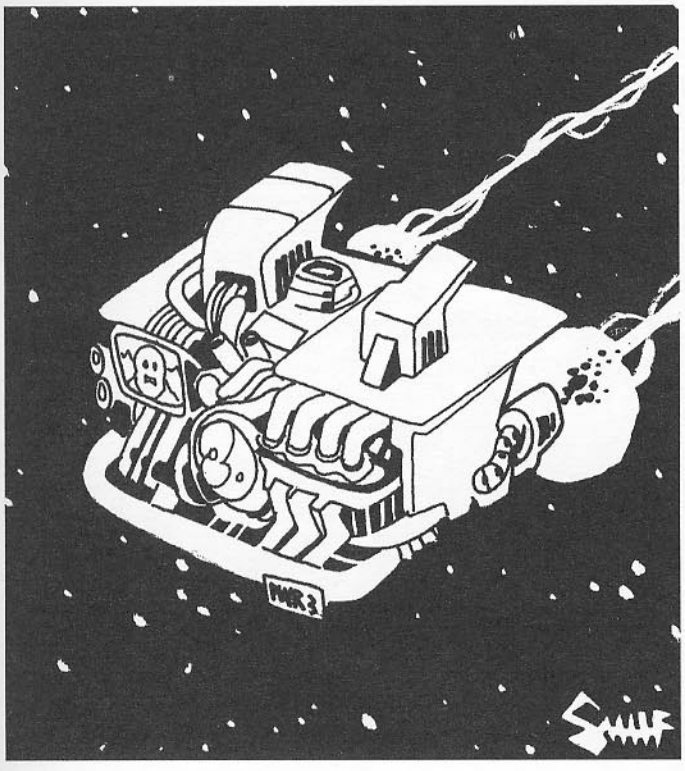
Rocket (TL8): This enables the robot to shoot the front half of the arm outward, using a powerful piston in the wrist. It can be used (once) as a ranged attack: SS 5, Acc 2, ½D range (arm ST × 1), Max range (arm ST × 2). Its damage is its arm ST Thrust damage + 2d (this may be punch damage, or the damage of a thrusting/impaling weapon built into it). Reattaching it takes 30 seconds.

Striker: If the arm motor is given this option, its arm will not incorporate a hand or equivalent manipulator. This makes the arm motor cheaper and lighter. The arm can still push or strike blows (hence its name) but has no manipulatory ability. A large tail is an example of an arm with a striker option. Weapons and tools built into the arm can still be used, however. This can't be combined with Bad Grip.

Decide how many arms the robot has. Then, for each individual arm, pick any options and design its arm motor by choosing that arm's ST. Then work out the arm motor's statistics as shown on the table below.

Arm Motor Table

TL of Arm	*Weight*	*Cost*
7	.3	$600
8	.2	$400
9	.15	$300
10	.1	$200
11	.075	$150
12+	.05	$100
Modifiers		
Bad Grip	–	× .5
Cheap	× 2	× .5
Extendible	× 2	× 2
Micromanipulator	–	× 5
Extra-Flexible	× 2	× 2
Retractable	× 1.5	× 1.5
Rocket	× 1.5	× 4
Striker	× .5	× .2



Weight, Cost and Volume: This is per point of ST. Calculate the weight and cost individually for each arm the robot has. Apply the modifiers listed in the table. These modifiers are cumulative: an extra-flexible, retractable, extendible arm would cost 2×1.5×2 = 6 × cost. The volume is weight/50 cf.

Power Requirement: Each arm requires ST/200 KW of power.

EXAMPLE

We decide Synthia will have two ST 30 arm motors. Each weighs .1 × ST 30 = 3 lbs., takes up 3/50 = .06 cf, costs ST 30 × $200 = $6,000 and requires 30/200 = .15 KW power. We decide it also has a third ST 10 arm which is "extra-flexible," "retractable" and a "striker." It weighs .1 × ST 10 × 1.5 (retractable) × 2 (extra-flexible) × .5 (striker) = 1.5 lbs., takes up 1.5/50 = .03 cf, costs $200 × ST 10 × 1.5 (retractable) × 2 (extra-flexible) × .2 (striker) = $1,200 and requires 10/200 = .05 KW.

Point Cost of Arms

Each extra arm after the first two arms costs 10 points each; reduce this to 5 points if the arm is a striker. If any arms are extra-flexible, add 5 points. If any arms are micromanipulators, rocket arms or extendible, add 15 points. If half or more of the robot's arms have a Bad Grip, this is worth -10 points. If all but one of the arms are striker arms, this is worth -15 points, or if the robot has only one arm, this is worth -20 points. If *all* arms are striker arms, or the robot has no arms but will have legs, this is worth -30 points, not cumulative with any of the above disadvantages. If the robot has no arms and isn't going to have legs either, this is worth -50 points, not cumulative with any of the above disadvantages.

EXAMPLE

Synthia's extra arm costs 5 points (since it's a striker arm). Its extra flexibility costs an extra 5 points. The total point cost is 10 points.

Propulsion

A robot needs some kind of propulsion system to move. Robots designed to move on the ground, or to fly like birds or helicopters, require drivetrains (below). Robots intended to propel themselves like boats or submarines require aquatic propulsion systems (p. 18). Robots meant to propel themselves like aircraft using aerial propellers, jets, rockets or ultra-tech thrusters require thrust propulsion systems (p. 18). A robot can have more than one propulsion system, if desired.

Drivetrains

Drivetrains are the electric motors or mechanical transmissions that move legs, wheels or the like.

A robot with legs needs a *Leg Drivetrain.*

A robot with caterpillar tracks needs a *Tracked Drivetrain* (TL7).

A *Wheeled Drivetrain* (TL7) allows a robot to use wheels for propulsion.

A robot needs a *Helicopter Drivetrain* (TL7) to fly like a helicopter.

A *Flexibody Drivetrain* (TL8) enables a robot with individually powered body segments to slither like a worm or snake, or swim like a fish.

An *Ornithopter Drivetrain* (TL7) lets a robot flap birdlike or insectoid wings, powered by motors or pseudomuscles, to fly.

Decide what kind of system the robot has, if any, and choose its *motive power* in kilowatts. This is a measure of how much power is transmitted from the robot's power system into moving the robot's legs, wheels, or whatever. The more motive power the robot has in relation to its weight, the faster it will move and the stronger it will be – see *Strength* (p. 46) and *Ground Speed* (p. 47) for the exact formula. The motive power also determines the strength of the robot's body (as opposed to its arms). The robot uses this "Body ST" when dragging loads, slamming into things, or the like.

How much motive power is needed? As a rule of thumb, a robot intended to be equivalent to a large cat or small dog in weight, strength and speed needs around .02 KW. A robot equivalent in weight and strength to a good-sized dog needs about .1 KW. A robot that is human in weight and strength should have at least .2 KW motive power; .3 to .5 KW will give it super-human strength and speed, provided its weight remains similar, or will allow a heavier robot. A bear- or tiger-sized robot needs about .6 to 1 KW; one the size and strength of a horse needs 1 to 2 KW. A 'bot with elephant-level size and strength needs about 10 KW. An automobile equivalent needs some 50 to 150 KW. A truck-power robot needs 150 to 500 KW; one with the power of a tank needs 500 to 1,000 KW.

For robots flying with helicopter rotors, sufficient power to take off demands at least 1 KW per 10 lbs. of robot weight. (If building a helicopter, the best thing to do is to add up the robot's weight at this stage, then estimate that its final weight will be about five to ten times greater, and install a rotor with at least that motive power.)

A robot can have more than one type of drivetrain. Decide on its motive power and design the drivetrain as shown on the table below.

Drivetrain Table

TL	Type	*Motive power is under 5 KW:* Weight	*Motive power is 5 KW or more:* Weight
7	Tracked	20 × KW	(4 × KW) + 80
8+	Tracked	15 × KW	(3 × KW) + 60
7	Wheeled	10 × KW	(2 × KW) + 40
8+	Wheeled	7.5 × KW	(1.5 × KW) + 30
7	Leg	80 × KW	(8 × KW) + 360
8	Leg	60 × KW	(6 × KW) + 270
9	Leg	40 × KW	(4 × KW) + 180
10	Leg	30 × KW	(3 × KW) + 135
11	Leg	20 × KW	(2 × KW) + 90
12+	Leg	15 × KW	(1 × KW) + 65
8	Flexibody	90 × KW	(8 × KW) + 360
9	Flexibody	60 × KW	(6 × KW) + 270
10	Flexibody	40 × KW	(4 × KW) + 180
11	Flexibody	30 × KW	(3 × KW) + 135
12+	Flexibody	20 × KW	(2 × KW) + 90
7	Helicopter	6 × KW	(.6 × KW) + 27
8+	Helicopter	4 × KW	(.4 × KW) + 18
7	Ornithopter	6 × KW	(3 × KW) + 15
8	Ornithopter	4 × KW	(2 × KW) + 10
9+	Ornithopter	3 × KW	(1.5 × KW) + 7.5

Weight: The weight per KW is shown on the table above.

Volume: The volume is weight/50 cf. Also, leg and ornithopter drivetrain components are divided into individual leg or wing motors. For leg drivetrains, decide how many legs the robot will have (two or more) and divide the volume by the number of legs; record the volume per *leg motor*. For ornithopter wings, divide the volume by two; this is the volume *per wing motor*.

Cost: The cost is $20 × weight for tracks or wheels, $50 × weight for helicopter or leg drivetrain with four or more legs, $100 × weight for ornithopter or leg drivetrain with three legs, $200 × weight for flexibody or leg drivetrain with two legs.

Power Requirement: This is equal to the motive power.

Legality: LC 6 if under 10 KW, LC 5 if 10 KW or more.

EXAMPLE

We decide Synthia moves on legs, and install a leg drivetrain. We want our robot to be reasonably quick, so we decide Synthia has a leg motive power of .45 KW. This weighs 30 × .45 = 13.5 lbs. It takes up 13.5/50 = .27 cf, and we choose two legs, so the volume per leg motor is .135 cf. It costs $200 × 13.5 = $2,700. It requires .45 KW.

Aquatic Propulsion Systems

These systems are designed solely for propulsion in water, allowing the robot to move like a boat. A robot not intended for swift aquatic travel doesn't need aquatic propulsion.

Screw Propellers (TL7) are conventional aquatic propellers like those used on most ships and boats today.

Hydrojets (TL7) work by pumping in water and expelling it as a high-speed jet. They are a bulkier and more expensive alternative to screw propellers, but allow higher speeds.

Aquatic propulsion is rated for motive power, measured in kilowatts, much as for drivetrains. The more motive power the robot has in relation to its surface area, the faster it will move.

Aquatic Propulsion Table

TL	Type	*Weight in lbs. when . . . Motive Power is under 5 KW*	*Motive Power is 5 or more KW*
7+	Screw Propeller	5 × KW	(1 × KW) + 20
7	Hydrojet	10 × KW	(2 × KW) + 40
8+	Hydrojet	5 × KW	(1 × KW) + 20

Weight: The table shows the weight per KW of motive power.

Volume: The volume is the weight/50 cf.

Cost: The cost is $10 per pound of weight for screw propeller or $40 per pound for hydrojet.

Power Requirement: The power requirement is equal to the motive power.

Legality: LC 6 if under 10 KW, LC 5 if 10 KW or more.

Thrust Propulsion Systems

These propulsion systems generate thrust to propel the robot. A robot will need a thrust propulsion system if it is intended to fly or hover, unless it already has a helicopter or ornithopter drivetrain.

There are several types of thrust propulsion systems:

Aerial Propellers (TL7) are just that. A robot with wings can use them for propulsion in the air. They can also propel a wheeled robot along the ground, or they can propel a robot that can float over water.

Ducted Fans (TL7) are advanced propellers in which the blades are entirely shrouded within a cowling.

Turbofan Engines (TL7) are jet engines that mix air and burning fuel and expel the hot exhaust to create thrust. They only work in an atmosphere with Earthlike levels of oxygen.

Chemical Rocket Engines (TL7) burn rocket fuel and expel the resulting exhaust to create thrust. Unlike turbofans, they don't require atmospheric oxygen.

Fusion Rocket Engines (TL9) incorporate an integral fusion reactor that heats reaction mass and expels it to produce thrust. They do not require air to operate.

Reactionless Thrusters (TL11) directly transform energy into thrust through means that 20th-century science cannot explain.

For aerial propellers, reactionless thrusters or ducted fans, choose the motive power; the more power, the faster the robot will move. If the robot has no energy bank, the chosen motive power may not exceed the power plant's output. Note that a robot can have multiple engines (they add their thrust together); this is mostly useful if the robot is going to put the engines in separate pods (see *Pods* on p. 38). A robot with a propeller or fan needs about four times the motive power of a robot with a drivetrain; one with a reactionless thruster needs about the same level of power.

Aerial Propeller, Ducted Fan and Reactionless Thruster Table

		Weight in lbs. when . . .		
TL	*Type*	*Motive Power under 5 KW*	*Motive Power 5 or more KW*	*Thrust*
7+	Aerial Propeller	4 × KW	(.4 × KW) + 18	3.5
7	Ducted Fans	6 × KW	(.6 × KW) + 27	4
8+	Ducted Fans	4 × KW	(.4 × KW) + 18	4
11+	Reactionless Thruster	1 × KW	1 × KW	20

Weight: The table shows the weight of the robot's propulsion system depending on motive power and type.

Volume: To find the volume, divide the weight by 100. Exception: divide the weight by 50 for reactionless thrusters.

Cost: To find the cost of the propulsion system, multiply the weight by $20 (for a reactionless thruster), $20 (for an aerial propeller) or $40 (for a ducted fan). *Minimum cost of reactionless thrusters is $500.*

Thrust: To find the pounds of thrust generated by the propulsion system, multiply the motive power by the number shown.

Legality: LC 6 if under 10 KW, LC 5 if 10 KW or more.

Vectored Thrust (TL7): Ducted fans, reactionless thrusters or any jet or rocket can have vectored thrust. This allows part of the thrust to be vectored downward. If the thrust exceeds the 'bot's weight, the 'bot will be able to hover and fly without wings. If there is not enough thrust for that, it will still shorten a winged robot's take-off, or lengthen a jump. A hovercraft-type robot should always have ducted fans with vectored thrust. Vectored thrust adds 50% to a thrust propulsion system's weight, volume and cost.

For jets or rockets, choose the motive thrust. The more thrust, the faster the robot will move. A suggested thrust is about 50-500 lbs. for a robot intended to be around man-sized, 500-5,000 lbs. for one the size of a car or small airplane, and 5,000 lbs. or more for a larger robot. Calculate the statistics of the propulsion system using the table below.

Jet and Rocket Table

TL	*Type*	*Weight (lbs.)*	*Fuel*
7	Turbofan Engine	(.2 × motive thrust) + 200	.03J
8+	Turbofan Engine	(.1 × motive thrust) + 100	.015J
7	Chemical Rocket	.025 × motive thrust	1R
8	Chemical Rocket	.02 × motive thrust	.5R
9+	Chemical Rocket	.015 × motive thrust	.25R
9	Fusion Rocket	(.05 × motive thrust) + 50	.02W
10+	Fusion Rocket	(.025 × motive thrust) + 25	.02W

Weight: The table shows the weight of the robot's propulsion system depending on motive thrust and type.

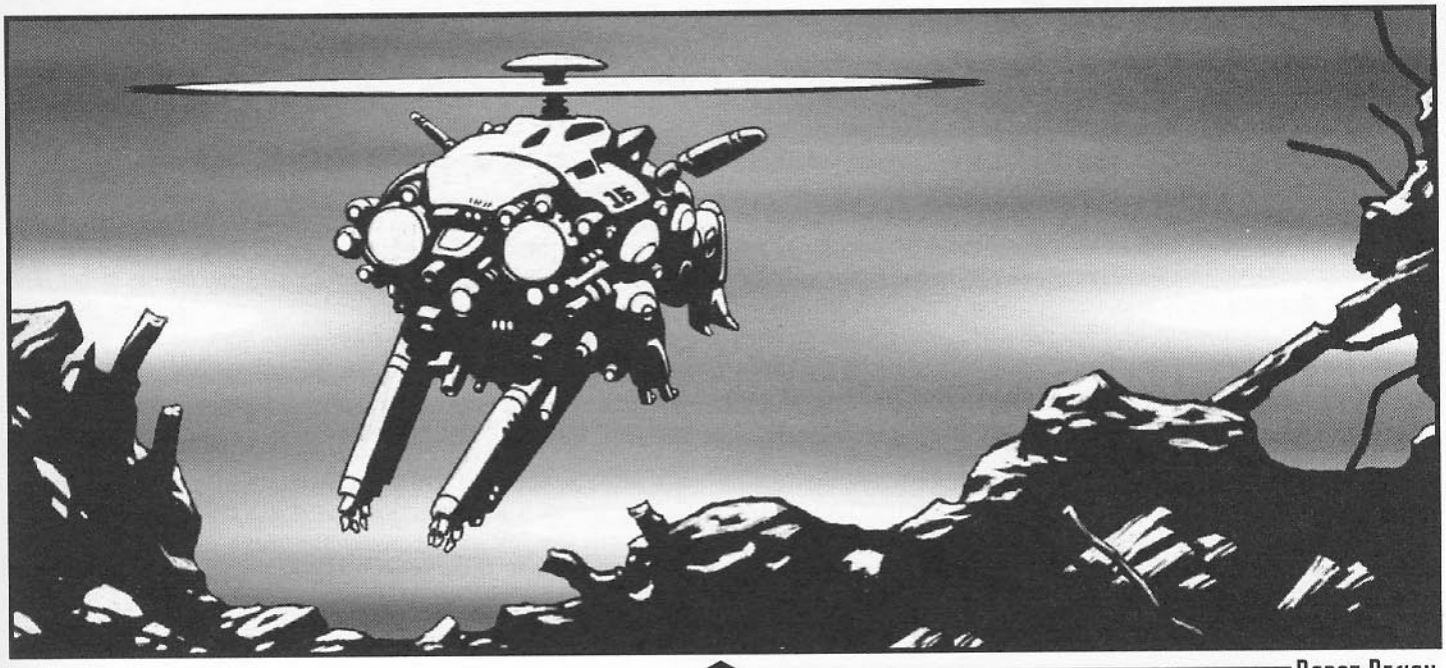
Volume: To find the volume, divide the weight by 50.

Cost: To find the cost of the propulsion system, multiply the weight by $50 (if it is a chemical rocket or turbofan engine) or $100 (if it is a fusion rocket).

Power: All these engines generate their own power, usually by burning fuel, or in the case of a fusion rocket, through nuclear reactions. As such, they require no extra power.

Fuel Consumption: These propulsion systems often require fuel. The fuel (or reaction mass) is shown in gallons per pound of motive thrust per hour. J is jet fuel, R is rocket fuel, W is water. The robot will need a fuel tank – see *Fuel* on p. 36.

Legality: LC 6 if under 50 lbs. thrust, LC 5 if 50 lbs. thrust or more. Subtract 1 from LC for fusion rockets.



Contact Weaponry and Jaws

These are weapons usable in close combat. With the exception of jaws and drug injectors, they can only be placed in robot arms (which includes arms used as tails, etc.), which restricts them to those robots which have arm motors.

Some of these weapons are actually tools, but because they can be used as weapons (and thus cost character points), they are covered here.

This section also covers robot jaws. A robot will need a jaw if it is to have a working animal- or human-like mouth.

Jaw and Contact Weapon Table

Weapon	*Type*	*Amt.*	*Reach*	*Cost*	*Wt.*	*Power*	*LC*	*TL*
Chain saw	Cut.	Spcl.	C,1	160	10	.1	6/3	7
Claws	Varies	Var.	C	Var.	neg.	0	Var.	7
Buzzsaw	Cut.	Spcl.	C,1	100	4	neg.	6/3	7
Electroshocker	Spcl.	Spcl.	C	200	1	20/B	5	7
Drug Injector	Spcl.	Spcl.	C	100	.25	0	6	7
Forceblade	Imp./Cut.	2d/4d (5)	C,1	3000	1.5	600/C	3	11
Jaw								
Crushing	Cr.	Spcl.	C	400*	.1*	.01*	6	8
Cutting	Cut.	Spcl.	C	600*	.1*	.01*	5	8
Impaling	Imp.	Spcl.	C	800*	.15*	.01*	4	8
Limpet Mine Dispenser	Exp.	2d+4 (10)	C	800	2	0	1	8
Medieval Hand Weapons	Var.	Var.	Var.	Var.	Var.	0	5/3	Var.
Monowire Blade	Var.	+1d (10)	Var.	Var.	Var.	0	3	9
Neurolash	Spcl.	Spcl.	C	650	2	10/B	5	10
Plasmafaust	Exp.	5d (10)	C	2,000	2	10/C	2	9
Vibroblade	Var.	+1d (5)	Var.	Var.	Var.	Spcl.	3	8

* *Per point of jaw ST.*

Weight: As shown on the table.

Volume: This is the weight/50 if the weapon is not concealed (except for jaws), weight/20 if it is concealed or is a jaw.

Cost: Except for medieval hand weapons or claws, this halves one TL after the weapon first appears, and quarters two or more TLs after it appears.

Power is as shown. Some weapons use power cells; others must be powered by the robot's power system.

Legality: For medieval weapons and chain saws, the second LC applies when given a vibro or monowire blade.

EXAMPLE

We decide Synthia has a large knife and a crushing jaw. The knife (see p. B206) is 1 lb., .02 cf and $40 with the monowire blade option ($250 at TL10, LC 4). Synthia's jaw has ST 4, so it weighs .4 lbs., takes up .02 cf, costs $400 (at TL10) and requires .04 KW power.

Descriptions

Chain Saw and Buzz Saw: Used for cutting wood, etc. It must be mounted in a robot arm! In combat, use DX-2 to attack with it. The reach is the arm's reach +1. A chain saw does the arm's Swing+4 damage, or 4d+4 Cutting damage, whichever is *less;* a buzz saw does Swing+2, or 2d+2 Cutting damage, whichever is less. The saw can also have a vibro or monowire blade (see p. 21).

Claws: A robot with arm motors or a leg drivetrain may have claws, a maximum of one claw per arm motor or leg motor. There are four types of claws; the cost must be paid for each arm or leg so equipped.

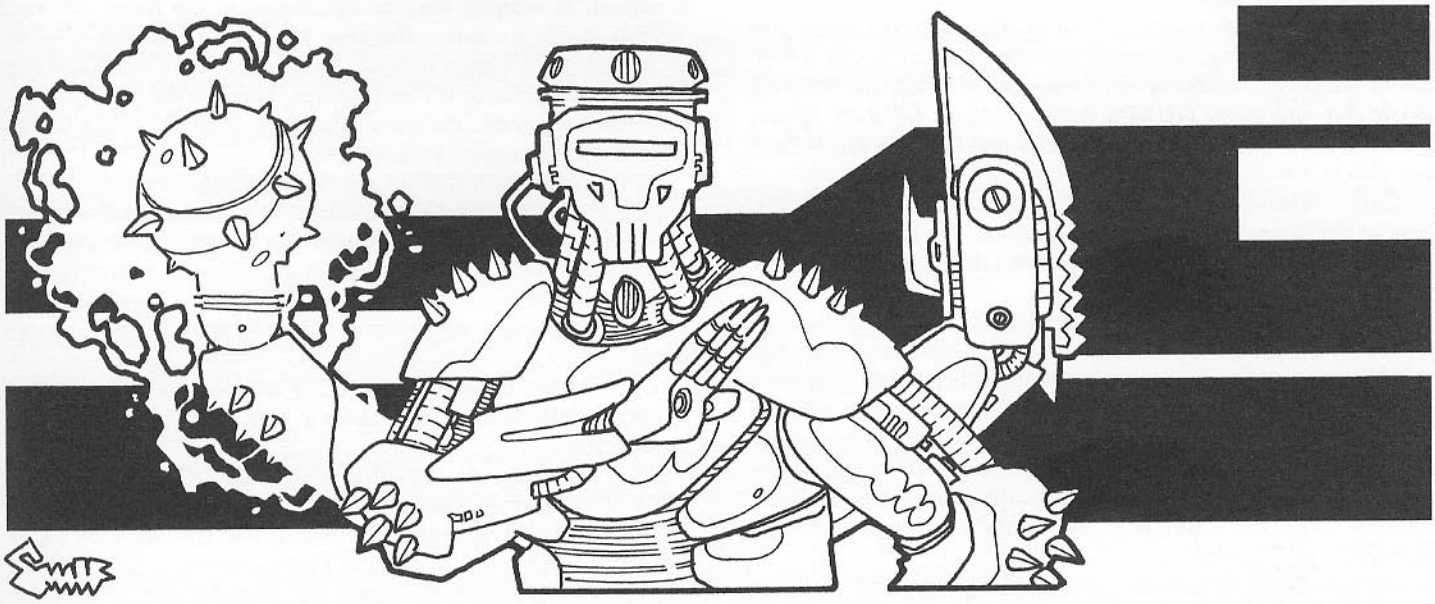
Blunt claws add +2 Crushing damage to a kick or punch. The cost is $100; they are LC 6. *Sharp claws* convert a kick or punch's Crushing damage to Cutting damage for $200; they are LC 5. *Talons* allow a kick or punch to do Swing/Cutting or Thrust/Impaling damage for $500; they are LC 4. *Long talons* allow a kick or punch to do Swing+2/Cutting or Thrust+2/Impaling damage for $1,000; they are LC 4. Any claws can be concealed, allowing them to retract into the arm; add 50% to cost.

Electroshocker: This enables the robot to deliver a powerful electric jolt. The victim must make a HT-3 roll to avoid being stunned (+1 HT per 10 DR on the location struck); if stunned, the victim loses 1d Fatigue and remains Stunned for as long as the arm is in contact, plus (20-HT) seconds, before any recovery rolls are allowed.

Drug Injector: This is either a hypodermic needle injector or, at TL8+, a painless pneumospray hypo. To be useful it must be mounted in a robot arm or head. It holds 10 doses of any drug, along with enough needles or air charges to inject them all. In combat, the injector can penetrate any armor with DR 1 or less.

Jaw: A jaw, including mouth and teeth, rated for its Strength. A robot intended to look human and have a working mouth must have a jaw. A jaw can be built to bite for crushing, cutting or impaling damage, based on the jaw's ST, using the table on p. B140. Since a human bite can do 1d-4 cr. (p. B111) a suggested jaw ST for human-like robots is 3, although it can be stronger. For carnivore-type animals, it's whatever is needed to get the desired damage; often the jaw will be as strong as the arms. Jaws are usually placed in heads. However, a jaw in a robot's main body or arm is possible. A jaw that is not in a head or arm makes biting attacks at -4 to hit, due to the awkwardness of the position.

Limpet Mine Dispenser (TL8): This close-combat weapon can only be mounted in an arm. It is a "sleeve dispenser" for sticky limpet mines which the robot can slap on the target. The mines attach themselves with molecular suction pads, then detonate immediately after the robot pulls back its arm, or after a preset interval. To plant one, use DX, Brawling or Karate skill. A successful hit does no immediate damage; instead, it sticks a limpet mine onto the target. The dispenser may be programmed to set mines with a time delay from 0 (at the end of the attacker's turn) to 100 seconds. Removing a limpet mine (if there is time) requires a Ready action and a successful ST roll, minus one-tenth the DR of whatever the mine is stuck to or -20, whichever is less. If the mine was stuck to flesh, it does 1 hit of damage when pulled off. If a mine is slapped on a part that cannot be reached (for instance, the small of the back), it can't be



removed without help. Limpet-mine dispenser magazines hold five limpet mines. Each mine has a shaped-charge warhead: damage is 2d+4 (10) at TL8, 3d+6 (10) at TL9; the (10) means that armor protects against the contact explosion at one-tenth DR. Also, anyone else within 2 yards of the blast takes 1d damage (1d+2 at TL9+) from the concussion. Limpet mines can also be stuck to the floor, walls, etc. for use as booby traps, but may not be thrown.

Medieval Hand Weapons: Axes, maces, flails, knives, swords, spears and so on can all be built into a robot's arm. Use the weight and cost on pp. B206-207; however, by TL7, metallurgical improvements mean standard weapons can be made at "cheap" cost, fine weapons for normal cost, and very fine weapons for the cost of a fine medieval blade; at TL8+, superfine weapons (+3 damage, and break as very fine weapons) are available at 20 × cost. If the weapon is designed to retract into the arm, it will take up weight/20 cf. If it never retracts into the arm, its volume is weight/50 cf. A maximum of one medieval weapon can extend out of a given arm! Most medieval hand weapons are LC 5 as shown. The exception is any kind of knife, which is LC 6.

Monowire Weapons: At TL9+ any cutting or impaling jaws, sharp claws, any talons, any saws and any medieval hand weapons that can do Cutting damage can be built as monowire blades. This does an extra +1d Cutting damage, and DR protects against it at one-tenth value. It costs $500 extra for cutting jaws, claws, talons, or knives, $1,000 for one-handed swords, and $1,500 for other weapons (half that at TL10, and one-fourth that at TL11+).

Neurolash: These devices disrupt the subject's nervous system, causing extreme pain. They only work on organic beings. A victim who is hit must roll HT-3, plus or minus Will modifiers. The High Pain Threshold advantage gives a +3 bonus. If successful, the victim can still function, but due to the pain will be at -2 to ST, DX, and IQ and to all skills based on these attributes for 15-Will turns (minimum 1). If he was hit on a limb, that limb is useless for the same length of time. If the HT roll was failed, the victim is in such agony he can do *nothing* for the same time. A critical failure will cause unconsciousness for 20-HT minutes (at least one minute). Each additional hit lowers the resisting HT roll by 1 (for example, the second hit is resisted at HT-4), and with each successive hit, start the recovery time over again, although penalties to attributes are *not* cumulative. Victims with the Low Pain Threshold disadvantage suffer double the effects. Reflec armor, or any armor with a DR over 2, provides total protection. For an extra $200, a TL11 neurolash can cause pleasure instead of pain ($500 and .5 lbs. for both settings). High and Low Pain Threshold have no effect on a pleasure jolt. Either kind of neurolash gives a +3 bonus to any kind of interrogation through torture.

Plasmafaust (TL9): This is a contact plasma-discharger weapon developed to replace the limpet mine dispenser. DR protects at once-tenth normal, and laminate armor protects at doubled DR. In addition, the user suffers 4d damage from the backblast of the plasma discharge (to the arm, or wherever the weapon is mounted); however, the user's own DR protects fully – it is not divided by ten).

Forceblades (TL11): These can be built into any robot arms. They project "fingers" or "blades" of annihilating energy. Force Sword skill is used to wield them. They work for 600 seconds of continuous use on a C cell. A basic forceblade does 4d (5) Swing/Cutting or 2d (5) Thrust/Impaling damage; DR protects at one-fifth value. A limb taking enough damage in a single hit to cripple it (p. B127) is lopped off and the wound cauterized. A weapon (except another type of energy blade) that successfully parries a forceblade is broken, unless the parry was a critical success. Forceblades may be of various sizes. Each time the weight and the cost double, add +4d to Cutting and +2d to Impaling damage, add 1 to Reach, and halve the number of seconds a C cell will power it. (A forceblade whose cost and weight have doubled once is identical to a standard ***GURPS Space*** force sword.) Higher-TL forceblades do more damage: +1 per die per TL over TL11, to a maximum of +3 per die at TL14+.

Vibroblade Weapons: At TL8+, any cutting or impaling jaw, sharp claws, any talons, any saw or any medieval hand weapon that can do Cutting damage can be built as a vibroblade. The cost is $200 extra for cutting jaws, claws, talons, knives or buzz saw, $400 for swords of all sizes, and $1,000 for other weapons including chain saws (half cost at TL9, quarter cost at TL10+). A B cell powers a vibro weapon for 60 minutes/pound of weapon weight. A vibro weapon does +1d (5) damage – that is, DR protects at one-fifth value. At TL9, it does 1d+1 (5), and at TL10+ 1d+2 (5).

Ranged Weapons

Robots may have weapons built in. The weapons tables give the weight, cost, Legality rating and combat statistics of a variety of weapons commonly built into robots. Weapons from the ***Basic Set*** and other ***GURPS*** books such as ***GURPS Space, GURPS Ultra-Tech, GURPS Vehicles*** and ***GURPS High-Tech*** can also be mounted in robots.

Unless noted otherwise, the weapons tables work the same way as the table on p. B208. The notes on this table also apply to weapons taken from other weapon tables, like that of pp. B208-209.

Type and DMG: A damage type of "Exp." indicates the weapon's attack inflicts explosive concussion damage (see p. B121) over an area. A number in parenthesis following damage is a damage divisor: effective DR is divided by that number against the attack. Spcl. is "special" – see weapon descriptions. Also, beam weapons, railguns, gravguns and Gauss guns add +1 per die to damage, each TL after introduction, to a maximum of +3 per die. (So a laser that did 6d×3 damage would do [6d+6]×3 one TL later.)

½D and Max: Beam weapons and railguns add +10% to range per TL after introduction, to a maximum of +30%.

Weight: This is shown on the table. It remains constant at all tech levels. It includes ammunition and power cells.

Volume: This is not shown on the weapon table. The volume of a weapon depends on how the weapon is mounted. Normally, the weapon takes up its weight/50 cf. However, the barrel protrudes from the robot, making it obvious that the robot is armed. A weapon may be *concealed* in the robot – buried entirely inside it – but in this case it takes up a greater volume: its weight/20 cf. Concealed weapons have hidden ports that pop open when the robot is ready to fire. There is no extra cost for concealed weapons. Robots designed to pass for living beings should always conceal their weapons!

RoF: Lasers with RoF 4+ use the laser autofire rules.

Shots: For beam weapons, add 50% to the number of shots they get every TL after they appear; for example, four TLs later would add +200%.

ST and Recoil: If the weapon is mounted in an arm, ST requirements apply. If it is mounted in the body or head, ignore them.

Cost: Halve the price of a TL7+ weapon one TL after the weapon's introduction, or quarter it two or more TLs after its introduction.

LC: The weapon's Legality Class. LC is discussed on p. B249 of the revised Third Edition ***Basic Set,*** but is not listed in ***GURPS High-Tech.*** Automatic pistols and revolvers are LC 3, but the stunner is LC 6 and the Gauss needler is LC 2, as are submachine guns and the disruptor. Non-repeating pistols are LC 5. Shotguns and rifles are LC 4, except for those with RoF 5+ (LC 1), stun rifles (LC 5), or military laser rifles (LC 0). All machine guns and other man-portable heavy weapons are LC 0. A very few weapons have been assigned a LC of -1 – these are vehicular-sized military weapons like tank guns.

In a few cases, weapon statistics have been altered from ***GURPS Ultra-Tech*** and ***GURPS Space*** to correct errors.

Ranged Weapon Table

Weapon	*Type*	*DMG*	*SS*	*Acc*	*½D*	*Max*	*Wt.*	*RoF*	*Shots*	*ST*	*Rcl.*	*Cost*	*LC*	*TL*
Conventional Slugthrowers (TL7)														
Light Machine Gun, 7.62mm	Cr.	7d	18	11	1,000	4,700	25	15*	100	13	-1	3,000	0	7
6Pak Minigun, 5.56mm	Cr.	5d+1	20	13	500	3,600	60	66	500	15	-1	10,000	0	7
Heavy Machine Gun, 12.7mm	Cr.	12d	20	16	1,200	5,000	115	8*	100	25	-1	6,000	0	6
Caseless Slugthrowers (TL8)														
Holdout Pistol, 7mmCL	Cr.	2d	7	2	140	1,800	1	3~	12	–	-1	200	3	8
Machine Pistol, 10mmCL	Cr.	3d	10	8	180	2,000	3.5	10*	30	9	-2	700	2	8
Submachine Gun, 4mmCL	Cr.	4d	11	9	300	2,400	5	12*	80	9	-1	800	2	8
Assault Carbine, 6mmCL	Cr.	6d	12	11	1,000	4,500	7	10*	60	9	-1	1,000	1	8
Light Support Weapon, 6mmCL	Cr.	6d	15	11	1,000	4,500	25	20*	300	10	-1	2,000	0	8
Grenade Launchers (TL7-12)														
Police Gren. Launcher	Spcl.	Spcl.	12	6	–	120	25	2~	12	10	-1	1,000	2	7
Auto Grenade Launcher	Spcl.	Spcl.	12	8	–	1,600	100	6*	20	20	-1	6,000	0	7
Electromag Gren. Launcher	Spcl.	Spcl.	10	8	–	1,000	10	1	5/5C	–	0	5,000	0	8
Grav Gren. Launcher	Spcl.	Spcl.	12	9	–	1,500	20	3*	12/C	–	0	5,000	0	12
Chainguns and Minicannons (TL7-8)														
20mm Chaingun	Spcl.	Spcl.	20	16	1,500	5,000	300	20*	200	75	-1	9,000	-1	7
20mm Gatling Chaingun	Spcl.	Spcl.	20	16	1,500	5,000	540	40*	300	250	-1	14,400	-1	7
20mm Caseless Minicannon	Spcl.	Spcl.	20	16	1,500	5,000	75	3~	30	20	-2	3,150	0	8
20mm CL Gatling Chaingun	Spcl.	Spcl.	20	16	1,500	5,000	375	40*	250	150	-1	13,500	-1	8

Weapon	Type	DMG	SS	Acc	½D	Max	Wt.	RoF	Shots	ST	Rcl.	Cost	LC	TL
Rocket Launchers (TL7-8)														
Light Rocket Launcher	Spcl.	Spcl.	15	2	–	500	25	1	4	10	0	2,000	0	7
Heavy Rocket Launcher	Spcl.	Spcl.	15	3	–	1,200	150	1	3	10	0	6,000	0	7
Light Rocket Launcher	Spcl.	Spcl.	15	2	–	500	15	1	4	9	0	2,000	0	8
Heavy Rocket Launcher	Spcl.	Spcl.	15	3	–	1,200	100	1	3	10	0	6,000	0	8
Electric Stunner (TL7)														
Electric Stunner	Imp.	Spcl.	3	3	–	10	1	Spcl.	2	–	-1	200	5	7
Flamethrower (TL7)														
Flamethrower	Spcl.	3d	5	8	40	75	20	4*	20	10	-1	1,000	0	7
Tanglers (TL8)														
Tangle Pistol	Spcl.	–	5	6	–	15	3	1	2	10	-4	500	5	8
Tangler	Spcl.	–	6	8	–	20	6	1	5	8	-4	1,000	5	8
Riot Tangler	Spcl.	–	10	8	–	80	25	3~	15	10	-2	4,000	4	8
Electromag Guns (TL9-10)														
Railgun, 25mm	Cr.	6d×25 (3)	25	20	4,950	8,450	1,150	1	325/E	240	-2	120,000	-1	9
Railgun, 50mm	Cr.	5d×50 (3)	30	20	5,850	9,350	2,500	1	100/E	500	-2	172,000	-1	9
Railgun, 75mm	Cr.	6dx65 (3)	30	21	7,200	10,700	5,850	1	75/5E	1,170	-2	220,000	-1	9
Gauss Pistol	Cr.	4d (2)	10	8	200	2,000	3	12*	80/C	–	-1	1,500	2	9
Gauss SMG	Cr.	5d (2)	11	9	250	2,500	5	16*	60/C	–	0	3,000	1	9
Gauss Battle Rifle	Cr.	8d (2)	12	12	1,200	4,500	7.5	12*	60/C	–	0	3,500	0	9
Gauss Minigun	Cr.	8d (2)	20	14	1,200	4,500	45	60*	600/D	10	0	9,000	0	9
Gatling Gausscannon	Spcl.	Spcl.	20	15	1,500	4,000	350	40*	480/D	70	-1	27,000	-1	9
Portable Railgun	Cr.	6d×4 (3)	18	17	1,800	4,800	45	3~	150/C	9	-1	4,800	0	9
Assault Razergun	Imp.	3d+2 (10)	10	12	400	800	5	3*	750/C	–	0	3,000	1	9
Gauss Razergun	Imp.	7d (10)	10	14	500	1,000	20	4*	3,000/D	–	0	6,000	0	9
Gauss Minicannon	Spcl.	Spcl.	20	15	1,500	4,000	75	3~	48/C	15	-2	9,000	0	9
Lasers (TL8-9)														
Laser Torch, light	Imp.	1d-2	9	1	2	10	1	4*	120/C	–	0	100	6	8
Laser Torch, medium	Imp.	1d	12	1	3	15	5	4*	60/C	–	0	250	6	8
Laser Torch, heavy	Imp.	2d	15	1	4	20	20	4*	150/D	–	0	500	5	8
Heavy Laser Pistol	Imp.	2d	9	8	300	800	3	4*	12/C	–	0	1,500	2	8
Military Laser Carbine	Imp.	1d+2	10	12	750	1,200	7	8*	200/D	–	0	3,000	1	8
Auto Laser	Imp.	5d	15	18	2,000	6,000	45	8*	600/E	12	0	10,000	0	8
Laser Cannon	Imp.	5d×5	20	20	4,250	12,750	500	4*	225/10E	80	0	40,000	0	8
Holdout Laser	Imp.	1d-1	10	4	50	100	.25	1	5/B	–	0	500	4	9
Gatling Laser	Imp.	20d	10	20	4,000	12,000	75	4*	150/E	15	0	20,000	0	9
Rainbow Strike Laser	Imp.	5d×10	20	21	6,250	18,750	500	4*	192/8E	100	0	43,000	0	9
Electrolasers (TL9+)														
Holdout Electrolaser	Spcl.	1d+2	6	3	30	60	.5	1	5/B	–	0	600	3	9
Electrolaser	Spcl.	2d+1	8	4	60	120	1.5	1	10/C	–	0	1,200	3	9
Electrolaser Rifle	Spcl.	3d+1	9	12	100	300	5	1	5/C	–	0	1,800	2	9
Particle Beams and Blasters (TL9-10)														
Heavy Blaster Pistol	Imp.	9d	12	8	300	800	4.5	3~	16/C	8	-1	2,500	2	9
Heavy Blaster Rifle	Imp.	6d×3	15	14	600	1,600	12	3~	60/D	9	-1	6,000	0	9
Tripod Blaster	Imp.	6d×11	20	15	2,244	5,874	60	1	27/E	12	0	19,200	0	9
Blaster Cannon	Imp.	6d×50	20	23	10,200	26,700	1,410	1	40/30E	262	0	80,800	-1	10
Particle Beam Cannon	Imp.	6d×100	20	25	20,400	53,400	5,240	1	33/100E	1,048	0	275,200	-1	9
Holdout Blaster	Imp.	4d	7	5	–	200	1	3~	6/2B	5	-1	800	3	10
Plasma Guns and Flamers (TL9-10)														
Plasma Torch	Spcl.	7d	8	2	3	10	4	1	60/D	–	0	750	4	9
Heavy Plasma Torch	Spcl.	20d	12	2	4	12	40	1	500/E	12	0	3,000	4	9
Hand Flamer	Spcl.	10d	4	12	70	150	4	1	8/C	6	0	1,300	2	9
Plasma Rifle	Spcl.	16d	5	16	80	250	12	1	70/D	9	0	5,200	0	9
Tripod Flamer	Spcl.	30d	6	20	100	300	45	1	40/D	12	0	10,000	0	9
Plasma Cannon	Spcl.	6d×60	12	25	1,200	3,600	500	1	36/10E	100	0	40,000	-1	9
Plasma Pistol	Spcl.	6d	4	10	50	100	2	1	16/C	–	0	1,000	3	10
Paralysis Guns (TL10-11)														
Paralysis Gun	Spcl.	–	6	4	–	25	5	1	15/C	–	0	1,500	3	10
Heavy Paralysis Gun	Spcl.	–	10	12	–	200	25	3~	60/D	–	0	8,000	2	10
Paralysis Pistol	Spcl.	–	6	2	–	15	1	1	5/B	–	0	600	5	11

Weapon	*Type*	*DMG*	*SS*	*Acc*	*½D*	*Max*	*Wt.*	*RoF*	*Shots*	*ST*	*Rcl.*	*Cost*	*LC*	*TL*
X-ray Lasers (TL10)														
X-Laser Pistol	Imp.	1d+2 (2)	9	7	240	600	2	4*	20/C	–	0	1,000	3	10
Hvy. X-Laser Pistol	Imp.	3d (2)	9	8	400	1,000	3	4*	12/C	–	0	1,500	0	10
Military X-Laser Carbine	Imp.	2d (2)	10	12	900	1,800	7	8*	200/D	–	0	3,000	0	10
Military X-Laser Rifle	Imp.	3d (2)	12	15	1,800	2,400	9	8*	140/D	–	0	4,000	0	10
X-ray Auto Laser	Imp.	8d (2)	15	18	2,400	7,200	45	8*	600/E	12	0	10,000	0	10
Gatling X-Laser	Imp.	30d (2)	10	20	4,500	13,500	75	4*	75/E	15	0	20,000	0	10
X-ray Strike Laser	Imp.	5d×10 (2)	20	21	6,750	20,250	500	8*	270/10E	100	0	40,000	-1	10
X-ray Laser Cannon	Imp.	5d×20 (2)	25	23	10,000	30,000	2,000	8*	270/40E	400	0	112,000	-1	10
Gravguns (TL11)														
Gravpistol	Cr.	4d (5)	10	8	300	3,000	3	12*	160/C	–	0	1,500	2	11
Gravrifle	Cr.	8d (5)	12	12	1,800	6,750	7.5	12*	120/C	–	0	3,500	1	11
Portable Gravgun	Cr.	6d×5 (5)	15	16	3 mi.	10 mi.	45	4*	200/D	9	-1	10,000	0	11
Light Gravcannon	Cr.	6d×50 (5)	25	21	7,425	10,925	1,250	1	575/E	250	-2	120,000	-1	11
Heavy Gravcannon	Cr.	5d×100 (5)	30	22	8,775	12,275	2,500	1	100/E	500	-2	172,000	-1	11
Gravity Beams (TL12)														
Grav Beamer	Spcl.	1d-1 (100)	10	5	20	30	1	3~	30/C	–	0	2,000	3	12
Assault Gravbeam	Spcl.	1d+2 (100)	12	15	1,200	3,750	9	1	200/D	–	0	4,000	0	12
Tripod Gravbeam	Spcl.	3d (100)	15	18	2,500	7,500	75	3~	100/E	15	0	40,000	0	12
Light Gravbeam Cannon	Spcl.	6d (100)	20	21	4,800	14,400	370	4*	135/5E	74	0	75,200	-1	12
Heavy Gravbeam Cannon	Spcl.	6d×2 (100)	25	22	9,600	28,800	1,480	4*	135/20E	296	0	204,800	-1	12
Pulsars (TL13)														
Pulsar Pistol	Spcl.	6d×3 (2)	12	8	200	400	2	3~	16/C	8	-1	10,000	1	13
Assault Pulsar	Spcl.	3d×10 (2)	11	12	400	800	7.5	3~	60/D	8	-1	20,000	0	13
Heavy Pulsar	Spcl.	5d×10 (2)	14	14	600	1,200	25	1	24/D	13	-1	30,000	0	13
Pulsar Cannon	Spcl.	5d×200 (2)	30	23	12,000	24,000	11,000	1	56/100E	2,200	0	1,288,000	-1	13
Mindrippers (TL14)														
Short-Range Mindripper	Spcl.	–	12	14	–	50	10	1	50/C	–	0	50,000	0	14
Long-Range Mindripper	Spcl.	–	20	16	–	500	75	1	200/E	60	0	100,000	0	14
Gamma-ray Lasers (TL14)														
Graser Pistol	Imp.	3d (5)	9	7	300	700	2	4*	16/C	–	0	2,000	3	14
Hv. Graser Pistol	Imp.	4d (5)	9	8	500	1,400	3	4*	12/C	–	0	3,000	0	14
Military Graser Carbine	Imp.	3d (5)	10	12	1,200	2,400	7	8*	160/D	–	0	6,000	0	14
Mil. Graser Rifle	Imp.	4d (5)	12	15	2,500	3,200	9	8*	112/D	–	0	8,000	0	14
Auto Graser	Imp.	10d (2)	15	18	3,000	9,000	45	8*	300/E	12	0	20,000	0	14
Gatling Graser	Imp.	40d (5)	10	20	6,000	18,000	75	4*	75/E	15	0	40,000	0	14
Strike Graser	Imp.	5d×20 (5)	20	23	11,500	34,500	450	4*	90/5E	90	0	88,000	-1	14
Graser Cannon	Imp.	5d×40 (5)	25	25	20,500	61,500	1,800	4*	90/20E	360	0	256,000	-1	14

EXAMPLE

We want Synthia to have a built-in ranged weapon. We decide on a military laser carbine. At TL8, it weighs 7 lbs. It costs $3,000, quartered for being built two TLs later at TL10 (and $750). We conceal it, so it takes up its weight/20 cf, or .35 cf. It is LC 1. We also add the variable beam option (see *Lasers* on p. 26) for another $100.

Conventional Slugthrowers (TL7-8)

These are normal bullet-firing guns, using expanding gasses from a chemical reaction to propel a metal slug. All produce a loud noise and visible muzzle flash. They don't work underwater or in vacuum.

Caseless Slugthrowers: These come into use at TL8 and fire caseless (CL) ammunition. The bullet is embedded in a solid block of propellant that is consumed when it is fired. This allows more shots to be carried, keeps the weapon cleaner since it needs no cartridge ejection port, and allows it to function underwater or in vacuum. TL8 caseless guns are available at half cost as conventional weapons firing non-caseless ammunition. They have half the number of shots (this doesn't affect weight, since the ammunition weighs twice as much per shot).

Liquid-Propellant Smartguns: A more advanced form of TL8 slugthrower uses liquid propellants (LP). Instead of packing solid propellant inside or around the bullet, propellant in liquid form is squirted into the firing chamber as each round is fired. A computer chip can vary the amount of propellant, so rounds can be fired either at normal velocity setting, or "low velocity" or "hyper velocity" settings. On "low" setting, rounds are subsonic (making the weapon virtually silent), accuracy is -2, and damage, range and recoil are halved (a half-die of damage becomes a +2). On "hyper," accuracy is +1, damage and range are multiplied by 1.5 and recoil doubles. Any TL8 caseless weapon is available as an LP smartgun at double cost.

Besides ordinary bullets, slugthrowers may also use special ammunition. Common types include Armor-Piercing Saboted (APS) bullets, which are +1 damage per die, +50% range, armor protects with half DR (but damage after subtracting DR is also halved), 5 × cost, and Plastic Bullets (half damage and range, normal cost).

Grenade Launchers (TL7-12)

These versatile weapons fire low-velocity rounds, usually with explosive or chemical warheads.

TL7 grenade launchers use conventional chemical propellants. TL8 electromag grenade launchers use a magnetic impulse for propulsion – see *Electromag Weapons* on p. 26. TL12 grav grenade launchers use a gravitic impulse – see *Gravguns* on p. 27.

The effect and cost of an individual shot from any kind of grenade launcher depends on the kind of grenade fired:

Concussion (TL7): An explosive warhead doing 3d (at TL7), 6d×2 (at TL8) or 6d×3 (at TL9+) explosive concussion damage. They cost $20 each.

Chemical (TL7): Releases a cloud of chemicals which lingers over a 6-hex radius for 300 seconds/wind speed in mph. See *Chemical Agents* on p. 30 for the options. It costs the same as 10 doses of the chemical.

Flechette (TL7): These warheads filled with steel darts burst like shotgun shells. They do impaling damage – 6d at TL7, 8d+8 at TL8+. Use the shotgun rules (p. B119). When firing flechette rounds, the weapon has a ½D range of 8% of its maximum range and a Max range of 20% of its maximum range. They are $30 each.

Force (TL12): The grenade emits a brief gravitic pulse doing 6d (at TL12) or 6d×2 (at TL13+) crushing damage. Damage is five times greater for knockback purposes! They cost $40 each.

Fragmentation (TL7): Like a concussion grenade, plus lethal fragments doing 2d Cutting fragmentation damage. $20 each.

HESH (High Explosive Squash Head) (TL7): This is a soft plastic explosive round. It functions like a concussion round unless it hits armor too strong to penetrate. Then it flattens out and explodes, creating a shock wave that can be felt even through armor. If it scores a direct hit and fails to penetrate the armor, 10% of the damage bypasses DR and inflicts damage anyway! These cost $40 each.

Plasma (TL11): One of these releases a blast of ionized plasma doing 6d×4 explosive concussion damage (TL11) or 6d×6 (TL12+). In addition, it has the same effect on armor and flammable materials that a flamer hit (p. 27) does, melting DR and setting things on fire. Each one costs $40.

Ripsaw (TL10): Like a fragmentation grenade, but its lethal monowire-edged fragments do 2d (10) fragmentation damage instead. They are $30 each.

Shaped-Charge (TL7): This armor-piercing explosive warhead does 2d (10) (at TL7), 4d×2 (10) (at TL8) or 6d×2 (10) (at TL9+). It does explosive concussion damage; in addition, DR protects at one-tenth value against a direct hit. If the round hits light or no armor, the warhead may not detonate: roll 3d vs. the target's DR. If the roll is higher than DR, it does not go off and instead the target takes 4d crushing damage. Pay $30 for each.

Sonic Stun (TL9): This emits a brief sonic pulse, with the same effect as a hit by a stun rifle, in a 2-yard radius around the grenade and the same effect as a stun pistol within 3-4 yards. See *Stunners*, p. B119, for stunner effects. The pulse continues for 3 turns, affecting anyone entering or remaining in the area. They cost $40 each.

Stun Baton (TL7): A non-exploding plastic baton round that spreads into an X-shape upon hitting its target. It does 4d Crushing damage, and full knockback, but the damage that penetrates DR is halved. The launcher's range when firing stun batons is ½ normal. The rounds are $20 each.

Tangler (TL8): These envelop the target in sticky strands, with the same effect as Tangler (p. 26) hits. They cost $10 each.

All grenades except flechette, HESH, shaped-charge and stun batons are also available as hand grenades, with identical characteristics.

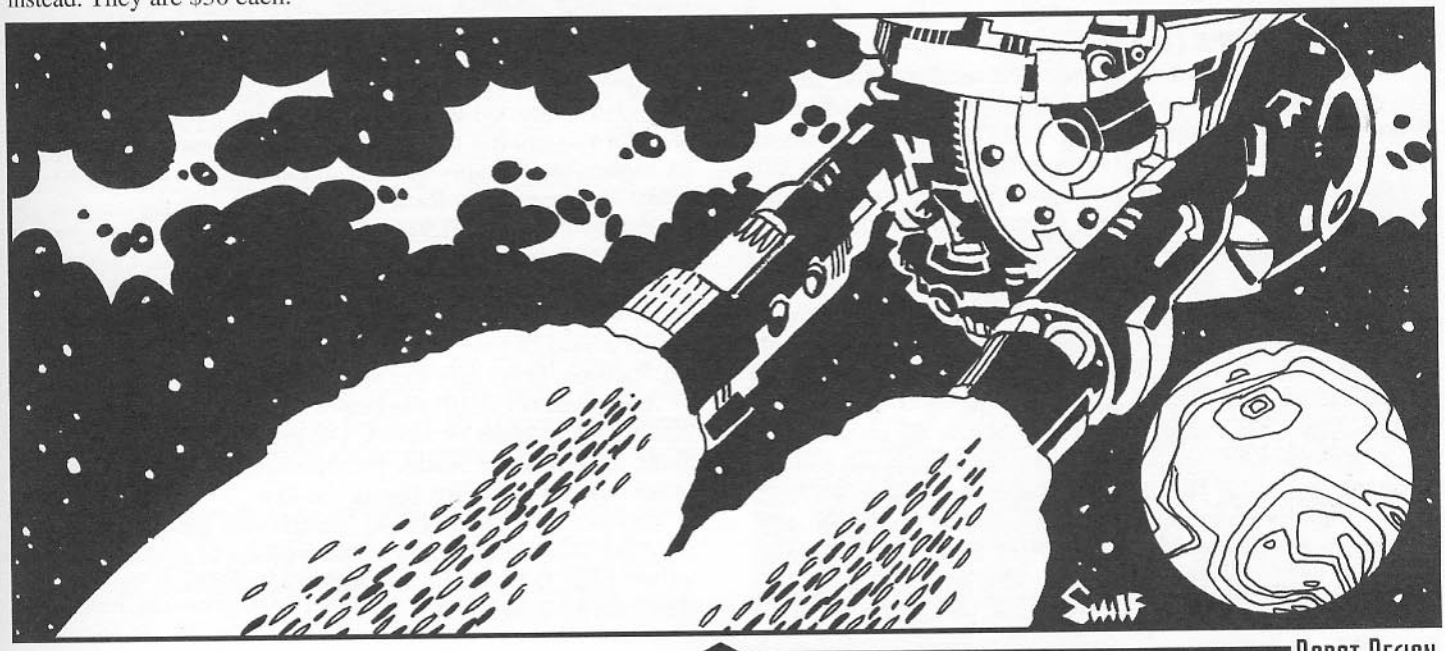
Chainguns and Minicannons (TL7-8)

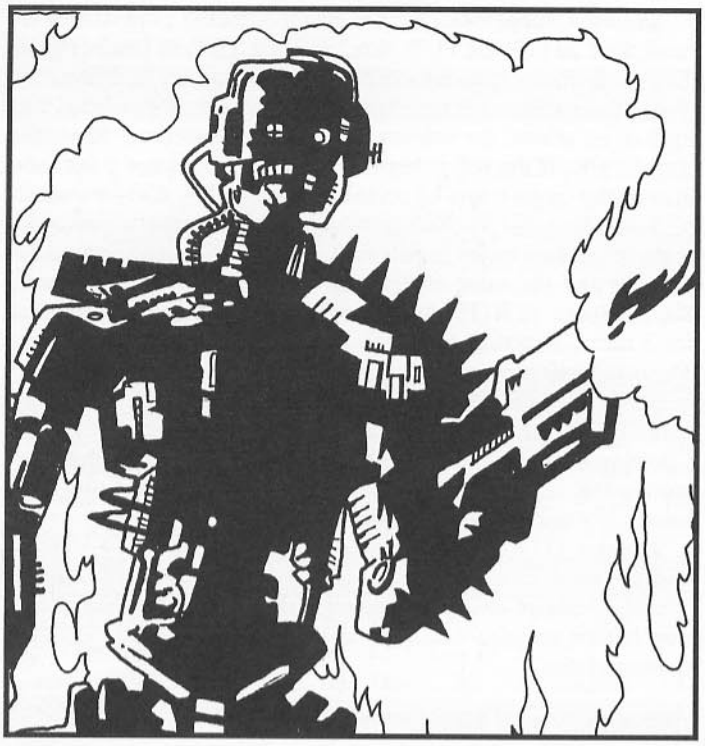
These are 20mm automatic cannons, similar to large machine guns. They can fire the same range of ammunition as grenade launchers; but unless they are firing baton or flechette rounds, the damage (or radius of effect) is halved. In addition, chainguns can also fire high-velocity armor-piercing depleted uranium (APDU) shells that do 6d×4 (3) damage and cost $10 each, as well as API shells that do 6d×4 damage and cost $2 each.

TL7 chainguns use conventional propellants (see *Conventional Slugthrowers*, p. 24).

TL8 chainguns normally use caseless ammunition (see *Conventional Slugthrowers*, p. 24, for a description of caseless propellant). Conventional-propellant TL8 chainguns are available: these cost half as much and have only half as many shots.

TL8 chainguns may be built to use liquid-propellant ammunition (at double cost), with the same effects as for conventional slugthrowers. However, the low- or hyper-velocity settings of LP ammunition chainguns only affect a chaingun's damage when firing APDU, flechette or baton rounds.





Flamethrowers (TL7)

These fire a high-pressure stream of napalm. Flamethrowers have RoF 4; as with lasers, add damage from multiple hits in a burst together before subtracting DR. Only sealed armor protects fully; non-sealed armor (including that on non-sealed robots or vehicles) gets only one-fifth DR. Once it hits, the napalm sticks and continues to burn for 10d turns, doing 1d damage per second (armor protecting as above). Only total immersion in water or the like will extinguish it.

Rocket Launchers (TL7-8)

These fire rockets with the same range of warheads as grenades, except that tangler and stun baton rounds are not available. The warheads are larger: their damage (or radius for chemical or stun rounds) is doubled for light rocket launchers and quadrupled for heavy rockets. The cost also increases proportionately.

Electric Stunners (TL7)

These fire a dart trailing a wire to the robot's power supply. The dart can penetrate up to DR 2 and does 1 point of damage. When the dart penetrates a living body, the robot releases an electric shock – a HT-3 roll is required to stay conscious; failing the roll immobilizes the victim for 25-HT seconds. The dart can be reeled in after the target is immobilized. The weapon cannot fire again until the dart is reeled in.

Tanglers (TL8)

Tanglers fire capsules that release sticky strands to entangle victims. Anyone hit gets an extra Dodge roll to evade the strands before they close, but neither armor PD nor DR protects, as they simply wrap around it as well as the person wearing it. A victim cannot move any limbs. He may try one Contest of Strength vs. ST 20 (+5 per extra hit, if multiple shots hit) to break free, plus one per minute. Or, if the victim is fully clothed, an Escape-3 roll (-1 per extra hit, one try every 10 minutes) will let him wriggle out of the clothes and escape. Any failed attempt to break free or wriggle out, though, results in the strands constricting, causing 1 point of damage (armor protects fully). The strands are too tightly wound around the victim, as well as too sticky, to be cut off. Ten hits from intense heat will also free the victim, but he takes the damage as well. The proper way to remove Tangler strands is with Anti-tangler aerosol spray (see *Chemical Agents* on p. 30). The strands lose their constricting ability after one day and then begin to lose ST at a rate of 1 per 2 hours. A round of tangler ammunition costs $10 and weighs 1 lb.

Electromag Weapons (TL8-10)

These weapons use an electromagnetic impulse to accelerate projectiles. They have no visible muzzle flash, but do produce a loud noise (as the round cracks the sound barrier) and an electromagnetic pulse that radscanners can detect. They require power (usually from power cells) and ammunition.

Electromag Grenade Launchers fire 40mm steel-sheathed grenades. They fire the same types of grenades as conventional grenade launchers (p. 25).

Gauss Guns are hyper-velocity small arms that fire 3mm to 4mm bullets with dense armor-piercing cores, rather than the tiny needles of the Gauss needlers in the ***Basic Set.***

Gausscannon fire high velocity steel-sheathed 20mm shells with a variety of warheads. Their effects are identical to those of grenades (see p. 25), but all types except flechette and baton rounds do half the damage (halve the radius of effect of stun and chemical rounds), and all shells cost half as much. They can also fire armor-piercing depleted uranium (APDU) shells that do 6d×6 (3) damage; these cost $5 each.

Railguns are very-high-velocity electromag weapons that accelerate high-density superconductor-sheathed or ferrous projectiles to speeds in excess of 4,500 yards per second. DR protects at one-third normal against their damage.

Razerguns are railguns whose magazines contain a coil of superconductor-sheathed monowire. As the weapon fires, it snips off short strands of wire, which become rigid in the gun's magnetic field and are accelerated to hypersonic velocities. DR protects at one-tenth value, and damage is impaling! If the superconducting wire penetrates electronic systems, it tends to short them out, so it does full impaling damage vs. robots, too.

Lasers (TL8-9)

Lasers fire a beam of coherent light. In rain, fog or smoke, lasers do half damage. Smoke bombs and such block laser beams totally. Laser beams are silent and invisible in vacuum. In atmosphere, weapon-grade lasers ionize the air (leaving a line of tiny sparks) and make an audible crack (as air rushes into the vacuum left in the beam's wake). Lasers fired at RoF 4 or higher use the special laser automatic fire rules described under *Damage from a Burst* on p. B120.

Rainbow Lasers (TL9) automatically vary their color to best damage targets and penetrate atmosphere. Rain and mist do not penalize them. Each yard of water, dense fog, or smoke the laser beam must pass through gives the target an extra DR 1.

Each yard of prismatic smoke gives the target an extra DR 20. Rainbow lasers may fire underwater at half range.

X-ray Lasers (TL10) fire beams of coherent X-rays; they are also called X-lasers or xasers. DR protects at one-half normal value against X-ray beams. Furthermore, the X-laser's damage is not reduced by smoke, fog, or the like.

Gamma-ray Lasers (TL14) fire coherent gamma-ray beams; they are also called grasers. DR protects at one-fifth normal value! Like X-ray lasers, atmospheric conditions and countermeasures have no effect.

For an extra $100 (unmodified by TL), any laser, X-ray laser or graser can have a variable beam. This makes it useful as a tool. Using it to weld consumes the equivalent of one "shot" per five seconds, cooking uses one shot per minute, and using it as a flashlight equals one shot every five minutes. It can also light a fire for trivial energy (100 fire starts take one shot).

"Laser torches" are short-range civilian lasers designed for welding or cutting. Their beams are variable at no extra cost.

Blasters and Particle Beams (TL9-10)

These are particle accelerators firing beams of protons, electrons or alpha particles. Blaster bolts resemble coherent lightning. Cannon-sized blasters are usually known as C-PAWS (for Charged Particle Accelerator Weapon System). Blaster bolts do their full impaling damage to robots, since the radiation can fry electronic systems.

Electrolasers (TL9)

These "zap guns" fire a low-power laser beam to ionize a path through the air, followed by an electrical charge that follows that path to the target. They don't work in vacuum and are at -2 to hit in humid environments, or -6 in rain or fog. Armor protects unless it is metal; metal does not protect, and adds +2 to hit if the target is made of or has 20 lbs. or more of it.

An electrolaser can fire a "stun" or "kill" bolt. If set on "stun," roll damage normally, but inflict no physical damage. Instead, the target must make a HT roll, minus half the damage that got past its DR (round up). Failure means the target is incapacitated for 20-HT minutes, and at -2 DX for another 20-HT minutes after. On "kill" the effects are the same, except that the target actually takes the rolled damage, and (if an organic being) failing the HT roll not only incapacitates the target but stops his heart. He will die in HT/3 minutes unless given CPR (a successful First Aid-4 or Physician roll.)

Plasma Guns and Flamers (TL9-10)

A flamer, or plasma gun, projects a stream of super-hot ionized plasma. The dice rolled for damage may be divided between targets, as long as all targets are in the same arc of fire as described for area weapons (p. B121). If the targets are more than one hex apart, 1d of damage is lost for each extra hex separating them.

The wash of plasma easily penetrates unsealed armor which gets ½ DR vs. the attack. It also *melts* armor. For every 10 points of damage the attack does (before subtracting DR), armor loses 1 DR on the location hit. A sealed suit (or robot or vehicle) becomes unsealed after losing 20% or more of its original DR. Paper, cloth and wood automatically ignite if hit by a flamer discharge. Flammable plastics and such catch fire if their DR is exceeded.

Paralysis Guns (TL10)

These weapons fire radiation pulses that can affect both organic life and electronics. A beam from a paralysis pistol, gun or rifle affects a living being that it hits for 30-HT minutes: he is paralyzed if he fails a HT roll, or -2 to DX and -1 to IQ (this also temporarily reduces the level of all DX- and IQ-based skills) if he succeeds. Individuals in sealed armor suffer no effects.

A paralysis beam that hits an unshielded robot or other electronic system knocks it out on a 1d roll of 1-2 (subtract the target's Size Modifier from this roll; small robots are more vulnerable than large ones). The paralysis lasts for (30-HT) minutes. A robot is considered "shielded" if it has both rad shielding (p. 43) and a hardened brain (p. 9). Either one alone simply reduces the chance of being knocked out to a roll of 1.

For double cost, *military paralysis guns* are available. They fire a more powerful beam. A target in unsealed armor makes HT rolls to resist at -4; the effects last twice as long, and they knock out robots or electronics on a roll of 1-4. They affect organic beings in sealed armor or shielded robots as if they were unprotected beings hit by a non-military paralysis gun. (Exception: They will not affect a target behind DR 200 or more armor.)

Gravguns (TL11)

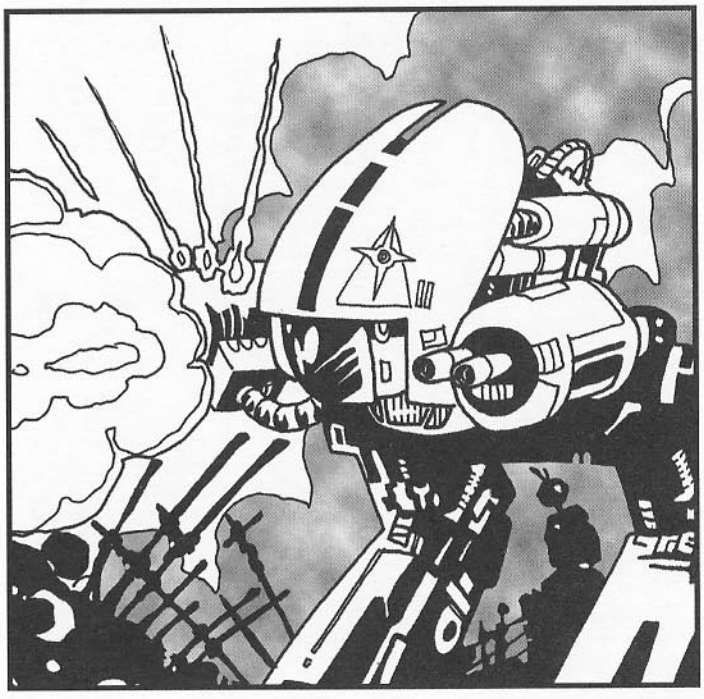
These are similar to electromag railguns, but use a tractor-beam-like gravitic impulse to accelerate projectiles to very high velocities. Gravguns produce no visible flash, and the only noise is the crack of the projectile going supersonic. They produce a gravitic pulse detectable by TL11+ radscanners.

Gravgun warheads are made of hyperdense gravitically compressed matter, and as such, DR protects at only one-fifth its normal value.

Gravity Beams (TL12)

These weapons are offshoots of TL12 contragrav and force field technology. Unlike gravguns, which simply use gravity technology to accelerate projectiles, gravity beams actually fire focused beams of "coherent gravity." They normally project an oscillating tractor/pressor gravity beam. This setting causes the inside of a target – or part of the target – to vibrate rapidly, inflicting damage. Armor PD does not protect and DR gives only ⅒₀ normal value; no knockback is inflicted.

They can also be used as non-lethal weapons, focusing a high-impact "force beam" of gravity on a single target. This does crushing damage; use the full damage only when calculating knockback – the actual damage is halved. For example, if 16 points of damage were rolled, a man would suffer 2 hexes of knockback, but only take 8 hits of damage. Damage inflicted by this setting is usually a wide bruise covering much of the target's body!



Pulsars (TL13)

These are TL13 blasters firing antimatter particles. They do impaling damage (to the person hit) and armor DR protects at half value. Also, they do explosive concussion damage equal to half the weapon's damage to anyone within 2 yards, with damage quartered every 2 yards beyond it. (DR protects at full value from this concussion damage). In addition, a direct hit inflicts 10 rads of radiation damage × damage rolled before DR; subtract the target's radiation PF if any. See *Robots in Action* for radiation rules. A miss by 1 inflicts half the radiation damage!

Mindrippers (TL14)

Mindrippers are advanced neural disruptor weapons that brutally interrogate the target's mind and nervous system. They instantly make a *ghost program* copy of the subject (see *Ghost Programs* on p. 65) at the cost of irreparable damage to the subject's mind. The subject gets a HT-5 roll at +1 per 10 points of DR protecting the brain. If the HT roll succeeded, the subject is unharmed, but has a mild headache. If the HT roll just succeeded (made by 0 or 1 point) he's also mentally stunned. But if the HT roll fails, the subject's brain and nervous system are ripped apart, permanently reducing DX and IQ to 1 and leaving the victim a mindless vegetable – and storing a ghost program copy of the subject in the attacking robot's computer memory.

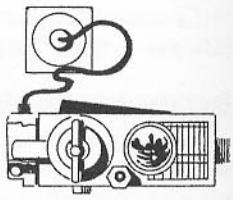
Mindrippers are useful because they simultaneously kill *and* capture an opponent. Mindripper beams are silent, invisible and unaffected by atmosphere but do require a line of sight to operate. They don't work through force screens. (There are less invasive ways of making a ghost program, but they take several minutes and special medical equipment; they are not usable in combat. See p. UT109 for details on these.)



Point Cost of Weaponry

Having weapons built into the robot costs character points depending on the weapon's Legality class:

Legality	*Points*
6	5 points
5	10 points
3-4	15 points
2	25 points
1	50 points
0	100 points
-1	200 points



If the robot has more than one weapon, *the full cost is only paid for the highest-point weapon.* Each additional weapon costs only 20% of its normal point cost.

EXAMPLE

Synthia has three built-in weapons: a monowire knife (LC 3), a concealed military laser carbine (LC 1) and a crushing jaw (LC 6). The cost of the concealed laser is 50 points, plus 3 points for the monowire knife and 1 point for the crushing jaw, for a total of 54 points.

Accessories

Gadgets like toolkits, vacuum cleaners or holographic projectors may be installed in a robot. Of course, if the robot has arms (with hands), visual sensors to see what it's doing, and proper programming, it can also use equipment just as a human does. Most accessories cost no character points. The few exceptions are those which duplicate advantages that characters usually pay for.

Weapon Accessories

These systems may be added to a ranged weapon.

Weapon Accessory Table

Component	*TL*	*Wt.*	*Vol.*	*Cost*	*Pow.*	*LC*
Laser Sight	7	neg.	.05	$200	neg.	5
Laser Periscope	8	var.	var.	var.	var.	5

Halve the weight, volume and cost of laser sights one TL after introduction and quarter them two or more TLs after introduction. Laser sights added to laser weapons are cheaper, with no weight or volume – see below.

Laser Sight: This places a laser dot wherever the weapon is aimed. If the robot has visual sensors, this reduces the SS penalty to -1 at up to 50 yards and to -2 at 50 to 100 yards, and adds +2 to its Accuracy when aiming. If the weapon is a laser, xaser or graser, it may have a laser sight for $50 (halve the cost at TL9, and again at TL10+): it just uses a low-intensity beam for aiming and increases the power when firing. Note: A robot with imaging ladar or a built-in laser rangefinder automatically gets this bonus on all weapons, without buying a laser sight.

Laser Periscope: This accessory can be added to any laser weapon. It is a periscope tube that is attached to the laser. When components are placed, it must be housed in a different part of the robot than the laser weapon, and allows the laser to fire from that part of the body rather than the part of the robot where the laser weapon is housed. Usually a laser is placed in the well-protected body of the robot, with the laser periscope built into an arm, pod or head. This permits the laser to fire without exposing its body. A laser periscope's weight and volume are each 10% of the laser weapon's, while its cost is 20%

of the weapon's cost. Note: x-ray laser periscopes are not available until TL11. Gamma-ray laser periscopes are not available until TL15.

EXAMPLE

We build a laser sight into Synthia's laser weapon ($12.50 at TL10+). We decide the laser sight also has a laser periscope, which weighs .7 lbs. (10% of the laser's weight), takes up .035 cf (10% of its volume) and costs $150 (20% of its cost).

Tool Systems

These systems are usually installed in robots built to perform technical, rescue or construction jobs. They can only be built into robot arms.

Tool Table

Component	*TL*	*Wt.*	*Vol.*	*Cost*	*LC*
Integral Tools					
Engineer, Mechanical	7	10	.2	$200	6
Armoury, Electronics	7	2	.04	$400	6

Tech level does not affect the weight, volume and cost of tool systems. Their power requirements are negligible.

Integral Tools (TL7+): This multi-purpose set of tools and probes extends out of the arm, fulfilling the equipment requirements for performing construction, repair and maintenance tasks for one of Engineering, Mechanic, Armoury or Electronics (or Electronics Operation) skills. A typical set of mechanical tools includes a built-in welder, pliers, screwdriver, drill, torque wrench, etc. Electronics tools add test probes and soldering irons, and so on. Since integral tools are built directly into the arm, the robot can use them even if without a hand.

The more arms equipped with integral tool systems the robot has, the better job it will do. A robot with one arm equipped with this system may perform repairs at -3 to skill. A robot with two arms so equipped may do so at -2 to skill. Three arms put it at -1 to skill. Four or more arms remove the penalty to skill. Different tool sets are needed for Armoury, Engineer, Mechanic and Electronics skills. If the robot is using the wrong type of tools (for example, using electronic tools to fix a gun instead of armoury tools), apply a -3 penalty.

Gadgets

These are miscellaneous gadgets useful on many types of robots:

Gadget Table

Component	*TL*	*Wt.*	*Vol.*	*Cost*	*Pow.*	*LC*
Chain Saw	7	see *Contact Weapons*, p. 20				
Cutting Torch	7	12	.24	$80	0	6
Fire Extinguisher	7	8	.4	$100	0	6
Mini Fire Extinguisher	7	.5	.02	$20	0	6
Flashlight	7	2	.04	$20	neg.	6
Mini-Flashlight	7	.5	.02	$16	neg.	6
Siren	7	1	.2	$100	neg.	6
Spotlight	7	10	.2	$100	neg.	6
Spray Gun	7	1	.05	$50	0	6
Spray Tank	7	8	.4	$100	0	6

Halve the weight, volume and cost of most of these gadgets one TL after introduction, or quarter them two or more TLs after introduction. Do not reduce the spray tank and spray gun's weight, volume and cost. The cost of the spray gun or tank does not include chemicals – see *Chemical Agents,* p. 30, for some loads.

A description of each gadget is given below.

Cutting Torch: This gas-powered cutting torch has enough gas for 5 minutes' operation. Used as a weapon, it is SS 15, Acc 0, RoF 1, Damage 1d cutting, ½D 3, Max 15. Against material with DR 6 or more, it can still cut through if held continuously on the same spot: every minute it is used burns away 1 point of DR *on that spot alone.* When DR is reduced to below 6, the torch can inflict damage to the material. Extra gas for the torch is $1, 1 lb., and .02 cf per minute.

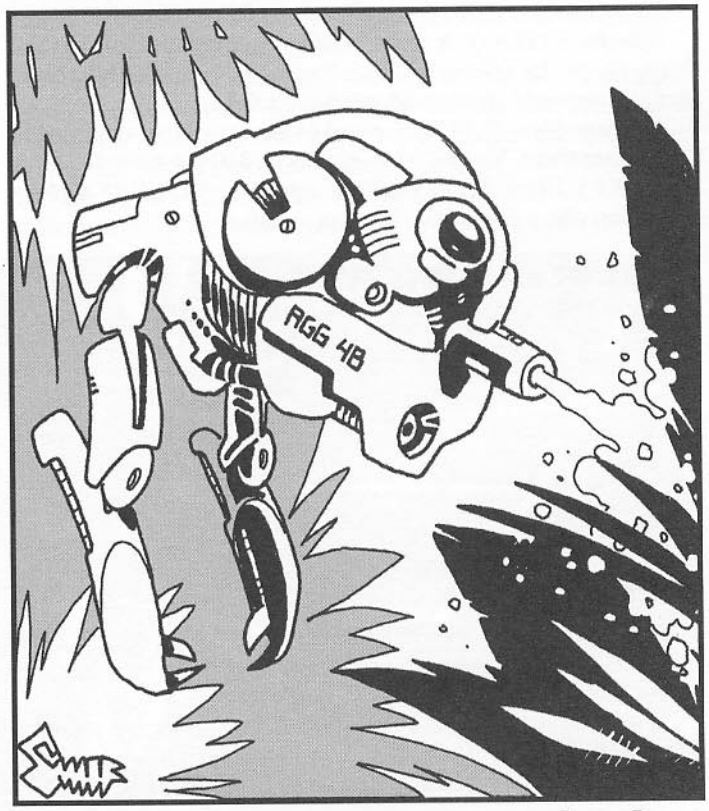
Flashlight or Spotlight: This throws a 500' beam (spotlight), 50' beam (flashlight) or 15' beam (mini-flashlight).

Fire Extinguisher and Mini-Fire Extinguisher: This sprays a fire-retardant foam that extinguishes one hex of fire on a roll of 1-4 on 1d at a 5-yard range. The fire extinguisher has eight uses; the mini-extinguisher has only one (reloads are half the cost, weight and volume). Using a fire extinguisher as a weapon defaults to DX-4 or Flamer-2; SS 10, Acc 1, ½D 3, Max 5. It does 3d damage, but this is counted only for knockback purposes – no real damage is done. Any hit to the face against an unarmored person stuns and blinds if he fails a HT-3 roll; roll against HT-3 each turn to recover.

Siren: A loud police/emergency siren is often mounted on police, rescue and security robots. If desired, it may include a flashing light at no extra cost.

Spray Gun: An aerosol sprayer, holding ten doses (one dose is enough to spray in a face or fill a hex) of any standard gas or liquid chemical (pesticide, smoke, tear gas, nerve gas, nano-disassemblers, etc.). A single shot has a range of 2 hexes and automatically hits. The cloud lasts for 10 seconds indoors, less in a strong wind.

Spray Tank: A larger spray dispenser, with a range of ten hexes, and creating a cloud 3 hexes in diameter per spray; if sprayed in the air, it falls slowly to earth. It uses *five* doses per shot, but a tank holds 100 doses. The cloud lasts for 2 minutes indoors, less in a strong wind.



Chemical Agents

Chemical agents usable in spray guns and spray tanks (as well as in chemical grenades and the like) include poisons, drugs, irritants and deadly clouds of nanomachines, as well as non-weapon chemicals such as pesticides and paints. Chemical agents are measured in doses. Delivery systems (warheads, sprayers, etc.) usually expend several doses at a time. Besides sprays, they may also be delivered via grenades (a chemical grenade costs the same as 10 doses, covers a 6-hex radius, and the cloud lingers for 300 seconds/wind speed in mph). Some chemicals available are:

Anti-Tangler Aerosol (TL8): Instantly dissolves Tangler (p. 25) strands. $4 per dose. LC 6.

Nerve Gas: Living organisms exposed to nerve gas take 1 hit of damage per turn, or 2 hits if not wearing a gas mask. Also, a HT-4 roll is needed each turn to avoid paralysis for (30-HT) minutes. Five minutes after being paralyzed, the target suffers 4d damage. Individuals in sealed, airtight armor are protected. $5 per dose. LC 0.

Paint: Spray paint, available in various colors. In combat, the main effect is to blind sensors or cover windows, restricting vision. Worker robots are often used for spray-painting, since clouds of paint can be dangerous to human health. $.10 per dose. LC 6.

Pesticides: Designed to kill insects, fungi, weeds, plant diseases, etc. Some are toxic if breathed, others are not. $.50 per dose. LC 6.

Riot Gas (TL8+): An advanced non-lethal incapacitating gas often used for crowd control. Each turn, any living being with a terrestrial-type metabolism who is not wearing a gas mask or airtight armor within the cloud must make a HT-4 roll. If the roll fails, he will become violently sick. Treat as if stunned, but the effects last as long as he is in the cloud, plus (20-HT) minutes. Even if the roll succeeds, he will be at -4 on any DX, IQ or skill rolls while within the cloud, and must continue to roll to avoid incapacitation each turn until he leaves it. $2 per dose. LC 5.

Tear Gas: See p. B132 for effects. $0.50 per dose. LC 5.

Nanoburn (TL9+): A cloud of nanomachines designed to kill living things. Its effects are described on p. 70 in the *Microbots and Nanomorphs* chapter. $5 per dose. LC 1.

Disassembler (TL11+): A cloud of nanomachines designed to destroy anything. See p. 70 for its effects. $40 per dose. LC 0.

GURPS Ultra-Tech, GURPS Space and ***GURPS Cyberpunk*** describe a few other chemical agents.

Navigation and Balance Systems

These systems help guide and control the robot.

Navigation System Table

System	*TL*	*Wt.*	*Vol.*	*Cost*	*LC*	*Points*
Global Positioning System	7	1	.02	$200	5	0
Gyrobalance	8	–	–	$5,000	6	15
Inertial Compass	8	1	.02	$250	6	5
Inertial Navigation System	7	40	.8	$50,000	6	5

Weight, volume and cost of all systems halves one TL after introduction, or quarters two or more TLs after introduction. Power requirement is negligible.

Global Positioning System (GPS): This links the robot to an orbital navigation satellite network (or a friendly spacecraft), enabling it to always know its exact position. The robot has Absolute Direction as long as it is in communication with a pair of friendly navigation satellites or spacecraft.

Gyrobalance (TL8): Internal laser-ring gyroscopes give the robot perfect balance. On wet or slippery terrain the robot gets +6 to all rolls to avoid losing control, and +4 to rolls to avoid being knocked down in combat. If the robot has legs or two or fewer wheels, it can skim along tightropes, narrow ledges, etc. without having to make a DX roll. The robot also gets +1 to any Acrobatics or Piloting skills it may acquire.

Inertial Compass: This sophisticated system can calculate the robot's exact location and heading without satellite assistance, indicating the direction and distance travelled from any preset point on a planetary surface. It can be set for the location the robot is physically present, or for any other coordinates (requiring a Navigation roll if the coordinates of the location aren't known). This effectively gives the robot the Absolute Direction advantage. Distances measured are accurate to within 1 yard per 1,000 miles.

Inertial Navigation System: As above, but much more accurate. It adds +5 to the robot's Navigation skill (+1 per TL over TL7) and gives the robot Absolute Direction.

Exotic, Covert Ops and Police Gadgets

This equipment is especially useful for robots built for criminal, assassination, espionage or law enforcement purposes.

Military, Covert Ops and Police Gadget Table

Gadget	*TL*	*Wt.*	*Vol.*	*Cost*	*LC*	*Points*
Crimescanner	8	8	.16	$6,000	5	0
Lockpick	7	neg.	neg.	$200	5	0
Electronic Lockpick	8	3	.06	$1,500	4	0
Mini-Nuke	7	50	1	$100,000	0	0
Psychotronic Circuits	9	var.	var.	var.	2	var.
Self-Destruct	7	1*	.02*	$80*	0	0
SQUID	8	40	.8	$50,000	4	5
Ranged SQUID	11	40	.8	$100,000	2	10

* Per pound of explosive.

With the exception of the self-destruct system, halve the weight, volume and cost one TL after introduction, or quarter them two or more TLs after introduction. The power requirement is negligible.

Descriptions

Crimescanner (TL8): This sensor system is capable of performing forensics analysis: ballistics tests, fingerprinting, genetic typing (from skin flakes or blood samples), etc. Performing a detailed analysis of a one-yard area in search of evidence normally takes one minute; the quality of that analysis depends on TL, but will usually provide a detailed analysis of chemical traces left in the area. At TL10+, the crimescanner actually releases tiny forensics nanomachine robots into the area, which perform a molecular-level search before being sucked back into the scanner unit to give their report. A crimescanner adds (TL-5) to Forensics rolls, but the robot must have Forensics skill to operate it.

Electronic Lockpick: This can only be built into an arm. It is a combination micromanipulator probe and sensor/decoder that gives +3 to Lockpicking or Electronics Operation (Security Systems) on any roll to pick a mechanical, combination or electronic lock of its TL or less. Against locks of a higher TL locks, it is -2 per TL difference between the lockpick and the lock. See p. B87 for lockpicking rules.

Lockpick: A high-quality lockpick. If mounted in a robot's arm, or in a head, it gives a +1 bonus to pick mechanical locks of its TL or less.

Mini-Nuke: This is a compact one-kiloton nuclear device (6d×4,000,000 concussion damage, devastates a 1,100-yard radius and contaminates the crater with residual radiation).

Psychotronic Circuits (TL9+): If the GM allows, any TL9+ robot with a sentient brain may have *psychotronic circuits* allowing it to have any psionic powers described in the ***Basic Set*** or ***GURPS Psionics.*** No single psi ability can have a power greater than (brain Complexity-5) × 5, with an absolute limit of power 25 for Complexity 10+ brains. It can have multiple powers, as long as it does not combine Antipsi with another power. It can acquire psionic skills as skill programs. Psychotronic circuitry does not add to the weight or volume, but does cost $10,000 × the character point cost of the psi powers (halve this cost at TL10, and again at TL11+). Psi powers have their usual point cost as described in the ***Basic Set*** or ***GURPS Psionics***. *Note:* these rules are an enhancement of those for psionic computers in ***GURPS Psionics*** and are slightly modified to fit the robot rules in this book.

Self-Destruct: A robot can be fitted with a self-destruct system; the robot explodes whenever its programming says to. (Yes, you can build time bombs or "smart" missiles this way.) Damage depends on the type of explosive packed into the robot. TL7 explosives do 6d×2 explosive concussion damage per pound of explosive; TL8 ones do 6d×8; TL9+ bombs do 6d×12. Fragmentation damage (see p. B121) is 2d Cutting damage as bits of the robot's casing are scattered about. The explosion can also be a shaped charge: double the cost, but halve the damage for the same weight of explosives, and the armor DR of a single target in contact with the robot when the explosion occurs is divided by 10.

SQUID (TL8): A superconducting quantum interference detector enables the robot to interrogate a computer brain to retrieve data. The SQUID must be physically attached (the robot should have a cable jack) to the target computer; it can then assist in reading the data stored within (see *Data Recovery* on p. 62). A SQUID adds +3 when probing a brain of its TL or lower, or +1 vs. a higher TL brain.

Ranged SQUID (TL11): As above, but usable at a range of (TL-10) yards: it can probe a computer brain even at a distance. Hardened brains cannot be probed at a distance, but can still be scanned through direct contact.

Domestic and Recreational Gadgets

These devices are often installed in service, household or pleasure robots. With the exception of the neural stimulator, all will be available without restriction.

Domestic and Recreational Gadget Table

Gadget	*TL*	*Wt.*	*Vol.*	*Cost*	*LC*	*Points*
Blow Dryer	7	1	.2	$40	6	0
Cleaning Unit	7	20	1	$200	6	0
Dishwasher	7	40	1	$200	6	0
Gardening Tools	7	4	.2	$200	6	0
Microwave or Sonic Oven	7	40	1	$200	6	0
Neural Stimulator	10	.5	.01	$1,000	5	0
Pheromone Emitter	9	neg.	–	$10,000	5	25
Projector	7	8	.16	$750	6	0
Serving Tray	7	8	.4	$40	6	0
Snack/Drink Dispenser	7	40	1	$200	6	0
Sonic Massager	9	2	.1	$400	6	0

Halve the weight, volume and cost of all these gadgets one TL after introduction, or quarter it two or more TLs after introduction. (Exception: the *volume* of the serving tray, microwave oven, dishwasher and snack/drink dispensers remains constant). The power requirement is negligible.

EXAMPLE

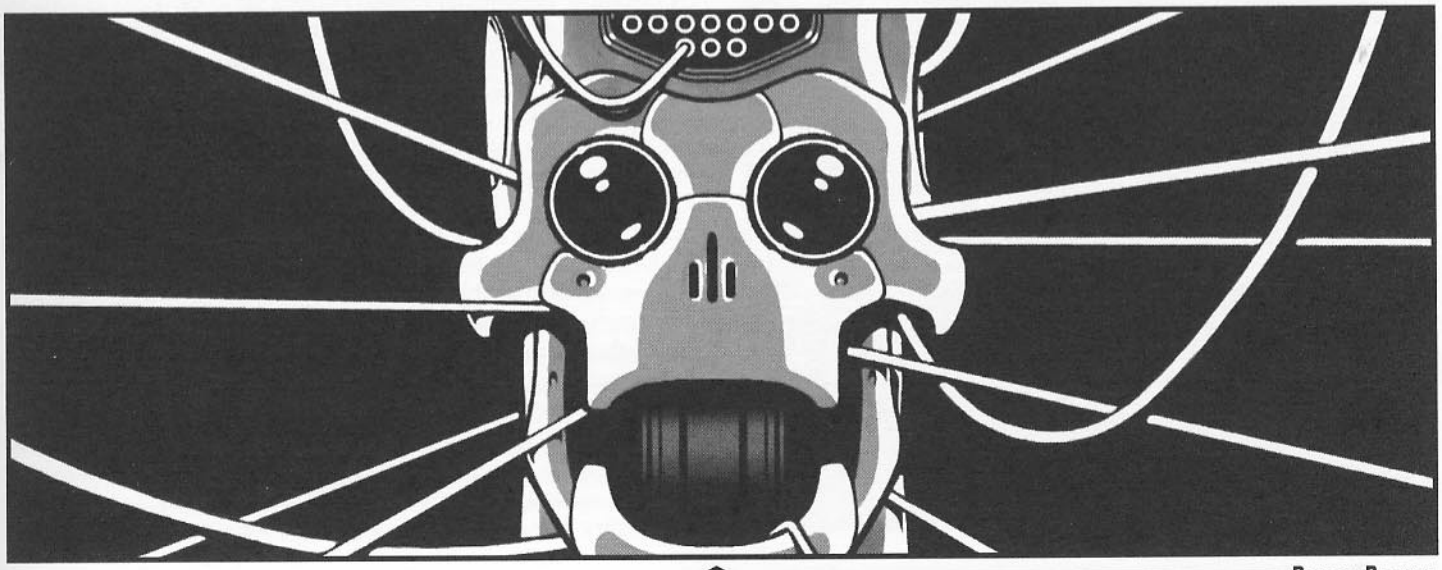
We decide to build a neural stimulator and pheromone emitter into Synthia's body. The stimulator weighs .5 lbs., takes up .01 cf and costs $1,000, and is LC 5. The emitter is $5,000 (half cost since it is TL9 and Synthia is TL10), LC 5 and costs 25 points.

Descriptions

Blow Dryer: Useful for styling hair or fur, usually housed in the arm of a valet or hairdressing robot.

Dishwasher: Washes and dries about 10 dishes at once – and at TL8+, does so quietly, with ultrasonics! A tray folds out of the robot to collect the dishes.

Cleaning Unit: This basic vacuum cleaner and surface-polisher system is usually designed to clean what the robot moves over, but may also be built into an arm. Vacuumed-up dust and debris must be removed occasionally, at least until TL14, when the junk can be diverted into the 'bot's mass-convertor. TL10+ systems use bioengineered or nanotech cleaning sprays.



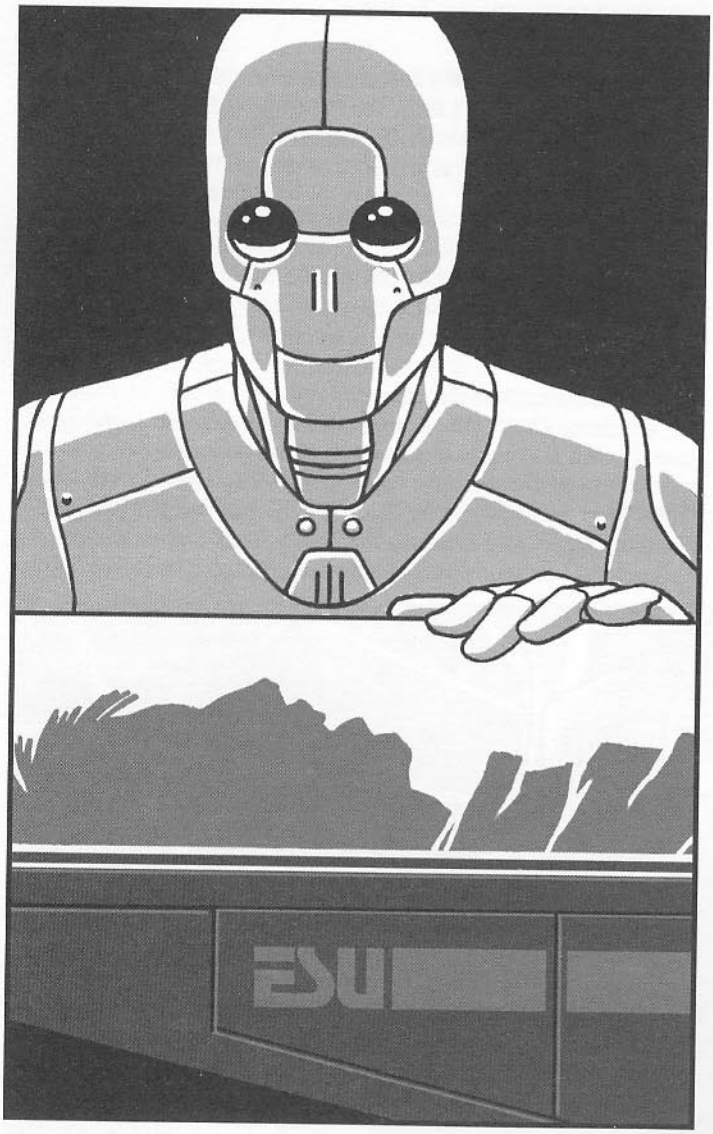
Gardening Tools: This gives the robot a built-in lawn mower/weed whacker system. The robot can do Swinging-1 Cutting damage based on its body ST, up to a maximum of 1d+2 Cutting damage. The complete "garden bot" should also have spray guns (p. 29) with pesticides and arms equipped with blades or claws (for trimming leaves).

Microwave or Sonic Oven: A small microwave or (possibly, at TL9+) infrasonic cooker, with a retractable serving tray and numerous settings. Cooks up to two meals at a time.

Neural Stimulator (TL10): This device may be mounted in an arm, a head, or (if the robot has a sex implant) the body. It dramatically enhances the pleasure of the robot's organic partner. However, prolonged use on a person requires him to make a Will+3 roll to avoid acquiring the Addiction disadvantage (the pleasure is treated as a highly addictive, incapacitating drug; it may or may not be cheap or legal). A neural stimulator can be overloaded to deliver a jolt of excruciating pleasure or pain: treat as a nervelash hit. Each such use has a 2-in-6 chance of burning out the neural stimulator until it is repaired, however.

Pheromone Emitter (TL9): A pheromone emitter allows a robot to generate sex pheromones exactly like a biological android with the *Pheromone Control* advantage (see p. 79).

Projector: This enables the robot to project any still or motion pictures it has stored as digital images. At TL8+, it can also project stored holographic images.



Serving Tray: Contains a retractable tray with enough space for one meal or several drinks. It includes a dual-pocket heating/refrigeration system to keep food and drinks hot or cold (as needed) inside the robot.

Snack/Drink Dispenser: A refrigerator system for snacks, drinks, drugs, etc. Built into a mobile robot, it can accompany expeditions into the wild to provide the comforts of civilization. It may be voice-controlled, or may have buttons on the exterior of the robot; a display screen (holographic at TL9+) reveals what is available. Coin- or credcard-operated vending machine versions are also available, enabling the robot to seek out customers.

Sonic Massager (TL9): This device projects a soothing sonic massage for scalp or body. With half an hour of tinkering and an Armoury skill roll, it can also be modified to project a single sonic pulse like that of a stunner (see p. B208) pistol; firing disables (burns out) the unit after one shot.

Medical Systems

These systems provide a robot with the tools to perform medical tasks better. The robot still needs appropriate programs to do so!

Medical System Table

System	*TL*	*Wt.*	*Vol.*	*Cost*	*LC*
Emergency Support Unit	8	100	5	$30,000	5
Medical Tools	7	2	.04	$1,000	5
Medscanner	9	1	.02	$900	6

Halve the weight, volume and cost of medscanners one TL after introduction, or quarter it two or more TLs after introduction. Power requirements are negligible. Other medical components do not reduce in weight, volume or cost. Medical tools must be built into an arm.

Emergency Support Unit (TL8): The ESU is a portable revivification and life-support system. If it is hooked up to an injured patient (the robot can do this itself if it has arms), it maintains his biological functions even if his organs are not functioning. In game terms, the robot can keep alive someone who has failed a HT roll and died, as long as he is not at or below -5×HT, or has not been dead for more than five minutes. Attaching the ESU takes (20 minus its TL) seconds and requires the robot to make a Physician roll (at -1 for every multiple of HT below 0 the patient is, and a -2 per failed attempt). Success means the person is in a coma rather than dead, but will die if taken off life support; critical failure means the patient is dead. A comatose patient can remain hooked up to the ESU as long as the robot can carry him (or remains stationary, if the patient is too heavy to lift). Revival from the coma is possible if the patient is ever healed to above fully-negative HT. The ESU can also perform less critical tasks, such as blood transfusions (it includes enough generic blood substitute for two whole-blood transfusions) and the revival of persons in suspended animation.

Medical Tools (TL7): This system must be mounted in a robot arm. It is a set of multi-function surgical manipulators ending in scalpels, forceps, clamps, fiber-optic probes, etc., and a medical sensor which can perform magnetic-resonance imaging scans, X-rays, and detect temperature, heart rate, respiration and other bodily functions. Medical tools fulfill medical kit requirements for Diagnosis, First Aid or Surgery skill performed at the same TL; each additional arm equipped with medical tools gives a further +1 to skill, to a maximum of +3, when treating a single patient. An arm equipped with medical tools is assumed to have a built-in drug injector (see *Contact Weaponry and Jaws,* p. 20) at no extra weight, volume or cost.

Medscanner (TL9): A short-ranged diagnostic scanner with a range of 1 yard (doubling each TL over TL9), it gives detailed diagnoses on known species – on a successful Electronics Operation (Medical) roll, it adds +3 to Diagnosis skill (plus another +1 per TL over 9). It can also scan for implants or to determine if someone is a robot.

Gadgets From Other Sources

GURPS Robots describes only a small fraction of the equipment that can be installed in robots. ***GURPS Ultra-Tech*** and ***GURPS Vehicles*** contain numerous other gadgets and weapons. For most gadgets, assume their volume is their weight/50. Multiply volumes given in cubic yards (cy) by 27 to get the volume in cf.

Gadgets can use their own power cells, or run off robot power. If running the gadget with robot power, use the *Energy Bank Table* on p. 36 to find out how much energy is stored in the power cell it would use. Then divide that by the number of seconds (3,600 to an hour, 86,400 to a day) that cell would run the gadget. The result is the power consumption in KW required to power it for a second. If this works out to less than .1 KW, it's safe to call it negligible: as long as the robot has some kind of power system, the gadget will function.

Modular Sockets

A modular socket is a space in the robot that is designed to accept different components. It is rated for the exact weight and volume of the module it can accept – for example, a socket rated 20 lbs. and .4 cf can accept any module of exactly that size and weight.

A modular socket has no weight. Its volume is equal to the volume of the socket. It costs $500 per cf of volume. Modular sockets may be installed in the body, or in any head or arm.

A *module* is something that can be inserted in a particular module socket in a robot. It must be either a weapon or accessory. A module's weight and volume must be exactly equal to the socket's rated weight and volume. (This way, the robot's performance is always the same, as long as all the robot's sockets are filled.) A module can contain multiple components, or "waste" weight and volume can be added to it. A module's cost equals the sum of the cost of all components in it, plus 20%.

If a modular socket contains a power-using component, that component should have its own power cell built into the module. That way, the robot's endurance won't change when a module is changed.

When inserted into the robot, a module adds its weight to the robot's weight. Its volume isn't added, since that's already allowed for in the socket. Removing a module takes 30 seconds, unless the module is so heavy that it requires several people or robots to lift. Inserting a module takes one minute.

The point cost of a module depends on what is contained in it.

Contragrav Generator (TL12)

A robot with contragrav can use anti-gravity technology to fly, or at least to reduce its weight. Decide on the pounds of lift the contragrav generator provides. In order to fly, the lift should exceed the robot's weight; since that won't be known until the end of the design process, it can be a good idea to simply leave some "empty space" in the robot for the generator and extra power cells – perhaps 10% of the volume of other components – and come back and retrofit the generator after everything has been added. The statistics of a contragrav generator depend on its TL.

TL12 contragrav costs $2,500 plus $.025 per pound of lift; it weighs 20 lbs. plus .001 lb. per pound of lift.

TL13+ contragrav costs $500 plus $.005 per pound of lift; it weighs 10 lbs. plus .0005 lbs. per pound of lift.

All contragravity systems take up their weight/50 cf.

Contragrav flight also requires power for the generator: .001 KW of power per pound of lift. A robot with contragrav usually uses a reactionless thruster (p. 19) for in-flight propulsion. (Note: when calculating a robot's speed or acceleration, do not "reduce" the robot's weight in these equations just because it has contragrav: acceleration is actually based on mass, which is unaffected by contragravity.)

Payload

Robots can carry cargo or passengers.

Cargo Spaces

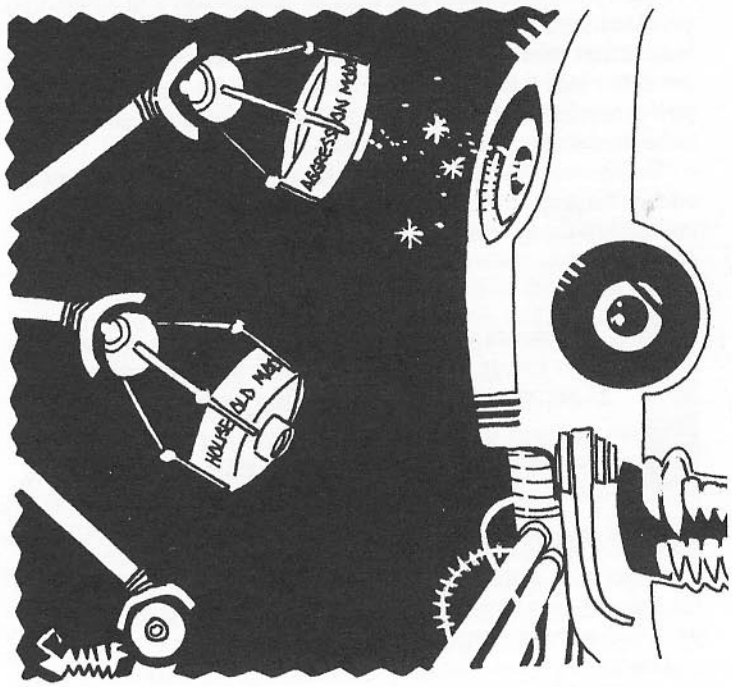
Robots can have one or more internal cargo compartments. Each separate compartment has its own access port, flap or panel and is electronically locked, controlled by the robot's brain. The volume of cargo spaces is measured in cubic feet. Each cf of cargo space can hold up to 50 lbs. of cargo. There is no extra cost.

Hangar Bay: A robot can also be given a bay for storing other smaller robots (or vehicles), ready for instant launch. Provided they use the same fuel, craft in a hangar bay can refuel from the robot's fuel tank or recharge from its energy bank. A hangar bay requires 30 lbs., 1.5 cf and $25 per cf of robot or vehicle stored.

Passengers

Some robots are designed to carry occupants riding on or inside them. The cost and weight of seats does not include the occupants (although the volume includes sufficient space).

Internal Seat: A seat inside the robot includes the room taken up by the rider. An internal seat costs $100; its weight and volume depend on whether it is *cramped* (20 lbs., 20 cf), *normal* (30 lbs., 30 cf) or *roomy* (40 lbs., 40 cf).



Exposed Seat: As above, but with no overhead protection from attacks or weather (similar to seats in an open cockpit or jeep). An exposed seat takes up half the volume of an internal seat, since part of the wearer is exposed. The robot's armor won't protect someone in an exposed seat against attacks from above, and the rider's head and shoulders will be exposed to attacks from the front, back or side. The armor protects normally against attacks from below.

Saddle: A large enough robot may have a saddle attached to it, much like one on a horse or motorcycle. A bolted-on saddle is $50 and 5 lbs. Or a proper horse-style saddle (see p. B212) can be strapped on after the robot is designed, counting as encumbrance along with the rider. How many people can ride on a robot depends on its body area (see *Surface Area* on p. 40). A robot can seat a number of riders the size of adult humans equal to its body's area/15; see p. 40 for body area.

Power System Design

Every robot requires a power system, which provides it with energy. Many different robot systems have power requirements, which are measured in kilowatts. The robot may draw power to operate these systems from either an energy bank (p. 35) or a power plant (p. 34).

A power plant, such as a gasoline engine or a nuclear reactor, produces power constantly (as long as it is fuelled) – it is rated for a power output in kilowatts (KW).

An energy bank (such as a battery or power cell) stores a finite amount of power, which is drained as it is used (unless recharged). It is rated for the number of kilowatt-seconds (KWS) of power it stores. One KWS provides one KW of power for one second.

Power plants are better for the long haul, while energy banks permit greater outputs for shorter periods. A robot will often have both a power plant and an energy bank, combining the benefits of both.

Routine Power Requirement: This is the power the robot drains while it is operating. Add up the power requirements for brain, sensors, arms, drivetrain, aquatic propulsion, thrust-based propulsion and contragravity. Power requirements for accessories or weaponry (such as jaws) that operate sporadically can be ignored provided they have integral power cells, or their power requirement is less than the power requirement of other systems. Note: if the robot has several propulsion systems, use only the highest power requirement: a robot will rarely use its leg drivetrain at the same time it uses propellers, for instance.

Decide whether the robot will have a power plant (p. 34), an energy bank (p. 35) or both. Then go to the appropriate section, and design the system.

EXAMPLE

We decide Synthia will be powered by both a power plant and an energy bank. Synthia's routine power requirement is .35 KW (all of its arms) + .45 KW (its drivetrain) = .8 KW.

Power Plants

Power plants are rated for output, in kilowatts (KW). This is the amount of power they produce to power systems built into the robot, or to recharge energy banks.

Unless the robot also has an energy bank, the power plant's output should equal its routine power requirement. An energy bank can supply the difference if the robot's power requirement exceeds the power plant's output.

There are several types of power plant. Here's how each works.

Gasoline and *Gas Turbine* plants are reciprocating engine or turbine models burning hydrocarbon fuels. The gasoline engine burns gasoline; the gas turbine can also burn diesel or alcohol fuels, although fuel consumption doubles when using alcohol.

Fuel Cells (TL7) are electric power plants that generate energy chemically, using oxygen and hydrogen as fuel. They also *produce* water, usually released as water vapor. In an "open" fuel cell, the fuel is hydrogen; the necessary oxygen is extracted from the atmosphere. In environments without free oxygen, a "closed" fuel cell containing *hydrox* fuel (liquid hydrogen and oxygen) is used instead, making fuel cells useful for robots that will run underwater or in alien environments. A fuel cell must use either hydrox or hydrogen fuel.

Magneto-Hydrodynamic (MHD) Turbines (TL8) are turbines which use ionized plasma as a working medium, giving a very high operating temperature and greater efficiency. They burn hydrogen and oxygen (hydrox), and can operate under water.

Nuclear Power Units (TL8) are small versions of the nuclear plants in ***GURPS Space.*** Power units with outputs under 500 KWs do not actually sustain a nuclear fission reaction; rather, they contain unstable radioactive isotopes (for instance, californium) that generate heat as they decay. Refueling costs 10% of the cost of the plant, and must be done at a major repair facility. Those versions with outputs in excess of 500 KW are true fission (or at TL10+, fusion) reactors.

Bioconvertors are power plants that function much like a human's system. They generate energy using food and atmospheric oxygen, and have a "mouth" into which water and food (anything biological) must be placed. A robot with a jaw may eat like a human, chewing food; otherwise, food must be liquefied (or be baby food, etc.) and poured in. The requirements for the bioconverters are (Herbivore) 10 pounds/KW/day and (Carnivore) 2 pounds/KW/day. Omnivore may mix and match plant and meat sources, at the same conversion rates. All bioconverters also require 1 gallon of water per KW per day.

The vampire bioconvertor requires 1 gallon of blood per KW per day. (An average human body has 1.25 gallons of blood.)

Antimatter plants produce energy through the mutual annihilation of matter and antimatter. A gram of antihydrogen powers a 1,000-KW plant for 2.5 years and costs $1,000; all fuel is contained within the plant, and takes up negligible space, so just decide how many years the plant will operate. At TL12+, each gram runs the power plant for 5 years.

Total Conversion power plants produce power by total conversion of mass into energy with 100% efficiency. They use trivial amounts of any kind of matter as fuel.

Cosmic Power Plants produce power through means unexplained by modern science. For example, a cosmic power unit may draw energy from another antimatter dimension, or even a magical universe. They power the robot indefinitely.

Mana Engines are technomagic devices that gather ambient magical energy and transform it into mechanical or electrical power. They require no fuel, but will not function in no-mana zones. A variant of the Powerstone spell (prerequisite: Power), which requires 10 energy per pound of engine weight, is cast on a machine that may resemble anything from a Rube Goldberg engine to a hideous technomagic machine. Costs 100 per kW.

If the robot has a power plant, choose its output in kilowatts (KW), and select the exact power plant type from those shown below. Work out its weight, fuel usage, volume and cost.

Power Plant Table

TL	Type	Weight (lbs.) (per kilowatt of power) if output Under 5KW	Weight (lbs.) (per kilowatt of power) if output 5KW or More	Cost (per lb. of wt.)	Fuel (per KW in gph)
7	Gasoline	10×KW	(5×KW) + 25	$5	.04G
7	Gas Turbine	10×KW	(2×KW) + 40	$20	.08M
Fuel Cells					
7	Fuel Cell	20×KW	(10×KW) + 50	$20*	.15H
8	Fuel Cell	10×KW	(5×KW) + 25	$5*	.13H
9+	Fuel Cell	10×KW	(5×KW) + 25	$5*	.115H
MHD Turbines					
8	MHD Turbine	10×KW	(1×KW) + 45	$40**	.03H
9	MHD Turbine	8×KW	(1×KW) + 35	$20*	.02H
Nuclear Power Units					
8	Power Unit	–	(8×KW) + 200	$200***	6 mo.
9	Power Unit	12×KW	(2×KW) + 50	$200***	1 yr.
9+	Cheap Power Unit	(10×KW) + 40	(3×KW) +75	$10**	$(TL-8)^2$ yrs.
10	Power Unit	6×KW	(1×KW) + 25	$200***	2 yr.
11	Power Unit	4×KW	(.4×KW) + 18	$200***	5 yr.
12+	Power Unit	2×KW	(.2×KW) + 9	$200***	10 yr.
Bioconvertors					
10	Carnivore	20×KW	(10×KW) + 50	$100**	Spcl.
10	Herbivore	30×KW	(15×KW) + 75	$50**	Spcl.
10	Omnivore	25×KW	(12×KW) + 65	$100**	Spcl.
†	Vampire	16×KW	(8×KW) + 40	$200**	Spcl.
Reactors					
11	Antimatter	–	.05×KW	$1***	Spcl.
14	Total Conversion	–	.02×KW	$.3***	neg.
16	Cosmic Power	1×KW	(.01×KW) + 2	$1***	none
Magical					
†	Mana Engine	10×KW	(5×KW) + 25	$50*	none

† Indicates GM discretion

* The minimum cost is $500, regardless of weight.

** The minimum cost is $2,000, regardless of weight.

*** The minimum cost is $20,000, regardless of weight.

Weight: Calculate this as shown on the table above.

Volume: Divide the weight by 50 to find the volume in cf, except for nuclear power units. For those, divide the weight of the nuclear units by 100.

Cost: The cost listed is per pound of power plant weight.

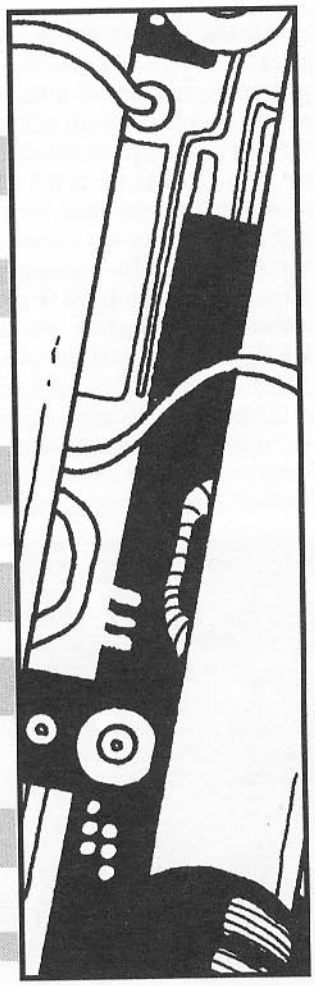
Fuel Usage: This is the fuel consumption in gallons per hour (gph) *per KW of output.* G is gasoline; H is hydrogen; hydrogen and oxygen fuel may be substituted in environments lacking atmospheric oxygen; M is multi-fuel (gasoline, diesel or alcohol). A time in months (mo.) or years (yr.) means the plant has an internal fuel supply of nuclear or antimatter fuel and operates for that many years without refueling. Total conversion power plants require negligible fuel. Bioconvertors devour water and solid food – see the description above.

Legality: Most power plants are LC 6. Any nuclear or antimatter power plant is LC 4, for safety reasons. Subtract 1 from the LC of any power plant with an output of 1,000 KW or more.

Points: A power plant that does not breathe air (on this table, anything but a gasoline engine, gas turbine or bioconvertor) costs 20 points, since the robot need not breathe.

EXAMPLE

Although Synthia's energy bank can power it, we also add an omnivore bioconvertor with .4 KW output. It weighs 10 lbs., takes up .2 cf, costs $2,000 (thanks to the minimum), but costs no points since it breathes air. This isn't intended to meet all its energy requirements – but it does allow the energy bank to recharge, and will also let Synthia appear to eat and drink like a human.



Energy Banks

An energy bank stores electrical power. A robot may have one instead of or as well as a power plant. If the robot's power plant does not produce at least the routine power requirement, the robot *must* have an energy bank.

Power stored in an energy bank is measured in kilowatt-seconds (KWS) – one kilowatt of power for one second.

Each KWS of stored power provides the same power as a 1-KW power plant – but only for a second. (Or it could provide .5 KW for 2 seconds, .001 KW for 1,000 seconds, and so on.) Then the energy bank is drained of power until it is recharged.

Thus, a robot whose systems require 1 KW of power will drain 1 KWS every second, or 60 KWS every minute, or 3,600 KWS every hour. Similarly, if it has a blaster that uses 180 KWS of power every shot and it fires five shots, it will drain 900 KWS.

An energy bank is useful even if the robot has a power plant, since it can make up any shortfall when power requirements exceed power plant output. As long as the robot has an energy bank, a robot's designer doesn't have to know the actual power requirement to the last kilowatt. For instance, consider a robot with both a power plant and an energy bank. If the power plant generates 100 KW but the robot needs 105 KW to operate several systems at once, the robot will still function perfectly well: the power plant provides 100 KW, and the remaining 5 KW are provided by the energy bank, which will be drained at a rate of 5 KWS per second (18,000 per hour).

Most robot energy banks consist of a bank of power cells (available at TL8+) plus their housings and power conduits. There are four types of power cells commonly used in robots, rated from B to E in order of increasing power storage. (The small A and AA cells are only used on tiny microbots, described in a separate chapter.)

An energy bank can provide power to power-using weapons after their power cells have been exhausted. Determine the power requirement of a weapon that uses a power cell as if its stored power were an energy bank. Then divide that by the weapon's number of shots to find the KWS of power required per shot. This is the KWS of power each shot drains; multiply by RoF to find the drain per turn of firing at full RoF.

Energy banks use either rechargeable or non-rechargeable batteries or cells. Non-rechargeable cells must be replaced when the energy bank is drained. Rechargeable cells can be recharged by plugging into any power plant: every second that 1 KW is channeled into the power cell restores 1 KWS of power. Rechargeable cells are usually written with an r in front of the type; for instance, rC indicates a rechargeable C cell.

To design an energy bank, decide on the type and number of batteries or power cells that make it up, then add up their stored KWS of power, weight, volume and cost as shown below.



Energy Bank Table

Type	*TL*	*Weight*	*Vol.*	*Cost*	*KWS of Stored Power*
9v cell	7	.1	.01	$2	18
r9v cell	7	.1	.01	$2	9
12v cell	7	20	.2	$50	1,800
r12v cell	7	20	.2	$60	900
B cell	8	.05	.005	$30	(TL-6) × 180
rB cell	8	.05	.005	$30	(TL-6) × 90
C cell	8	1	.01	$100	(TL-6) × 1,800
rC cell	8	1	.01	$100	(TL-6) × 900
D cell	8	5	.05	$500	(TL-6) × 18,000
rD cell	8	5	.05	$500	(TL-6) × 9,000
E cell	8	20	.2	$2,000	(TL-6) × 180,000
rE cell	8	20	.2	$2,000	(TL-6) × 90,000

The *cost, weight and volume* are per cell in the energy bank. The volume includes the cell housing and power connections; the actual volume of individual cells will usually be smaller.

KWS is the energy stored in the cell.

Points: An energy bank costs 20 points, as the robot can operate without "breathing." However, if the robot already has a power plant that does not need air, there is no cost.

EXAMPLE

Synthia needs an energy bank, since its .4-KW power plant output is less than its .8-KW routine power requirement. We decide Synthia has a pair of TL10 rechargeable D cells (rD cells). Together they weigh 10 lbs., take up .1 cf, cost $1,000 and at TL10 store a total of 4 (TL10 - 6) × 9,000 × 2 (two cells) = 72,000 KWS of energy. This costs 20 points, since it lets Synthia operate without breathing air.

Fuel

Robots that have jet or rocket engines, or power plants with a fuel requirement measured in gallons per hour, must install a fuel tank. If a power plant or engine that needs fuel does not have a tank, it does not function.

Fuel tank cost and weight include fuel. But for topping off an empty tank or switching fuels, the cost of fuel, without the tank, is also given here. The types of fuel available include:

Gasoline and *Diesel* fuel, which cost around $1 per gallon in the U.S.

Jet Fuel: This is basically kerosene, and is heavier and more expensive than gasoline. Different grades of jet fuel exist for different engines, but in game terms the effects are the same, although the GM may decide that, for instance, a TL8 high-performance turbofan will lose a small percentage of its thrust if forced to run on the same fuel as a TL7 basic turbofan. Each gallon costs $3.

Hydrogen (H) is hydrogen compressed to a jelly. It is combined with atmospheric oxygen and used in TL8+ fuel cells. It is also burned in fusion rockets and air-rams. Each gallon costs $.10.

Hydrox (OH) is liquid oxygen and hydrogen. Used in MHD plants or fuel cells in place of hydrogen, it enables the robot to operate underwater or on worlds lacking free oxygen, or with low atmospheric pressures. Each gallon costs $1.

Rocket fuel is a liquid or solid chemical rocket fuel containing a combustion agent and an oxidizer. For uniformity, solid fuel is also measured in gallons. Rocket fuel is often very volatile. Each gallon costs $2.

Fuel tanks may be standard or self-sealing; self-sealing tanks are less vulnerable to damage. To install a tank in the robot, decide on its capacity in gallons, the type of fuel it holds, and

whether or not it is self-sealing. The table below shows the cost, weight and volume of the fuel tank per gallon of fuel.

Fuel Tank Table

TL	Type	Weight	Volume	Cost	Fire
7	Standard Fuel Tank				
	with gasoline	7.0	.15	$10	11
	with diesel	7.0	.15	$10	9
	with jet fuel	7.5	.15	$10	13
	with hydrogen	1.5	.15	$10	13
	with hydrox or rocket fuel	6.0	.15	$10	13
7	Self-Sealing Tank				
	with gasoline	8.0	.15	$40	10
	with diesel	8.0	.15	$40	8
	with jet fuel	8.5	.15	$40	12
	with hydrogen	2.5	.15	$40	12
	with hydrox or rocket fuel	7.0	.15	$10	12
8+	Standard Tank				
	with jet fuel	7.0	.15	$10	11
	with hydrogen	1.0	.15	$10	11
	with hydrox or rocket fuel	5.5	.15	$10	11
	with water	9.0	.15	$10	no
8+	Self-Sealing Tank				
	with jet fuel	7.5	.15	$40	10
	with hydrogen	1.5	.15	$40	10
	with hydrox or rocket fuel	6.0	.15	$40	10
	with water	9.5	.15	$40	no

Weight, volume and cost are per gallon. Weight and volume include both tank and fuel. Cost only includes the fuel tank.

Fire: This is the chance that the tank will catch fire if the robot is reduced to 0 or lower HT, or is hit by a flame attack – see *Fire and Explosion* on p. 96.

Legality: Fuel tanks are LC 6.

Points: Having one or more fuel tanks with a fire number is a disadvantage worth -1 point × the fire number.

Endurance and Point Cost

This is how long the robot can operate on its own. It depends on whether the robot has a power plant or an energy bank.

If the robot has a power plant whose output is equal to or greater than the routine power requirement, the robot's endurance is determined by its fuel capacity. The endurance of a nuclear or antimatter power plant is listed in the plant's description. Cosmic power plants and mass convertors effectively operate forever. If the power plant or reaction engine uses fuel, it will drain its fuel consumption from the fuel tank every hour. Calculate its endurance in hours by dividing its fuel capacity in gallons by the number of gallons it consumes per hour. Bioconvertors have a default endurance of 48 hours.

If the robot's power plant produces less than its routine power requirement, the robot must meet those requirements by draining its energy bank. Subtract the power plant's output from the routine power requirement. Multiply the remainder by 3,600 to get the KWS of stored power drained from the energy bank every hour. The energy bank can power the robot for a number of hours equal to its stored power in KWS divided by the power it has to supply, divided by 3,600. The power system's endurance is the lower of the power plant or energy bank's endurance. However, if the power plant's endurance is less than the energy bank's, or the power plant is destroyed, has no air to breathe (if it breathes air) or is turned off *before* the energy bank is out of energy, the robot can operate just using the energy bank for [(remaining stored power)/power requirement/3,600] hours.

If the robot has an energy bank but no power plant, it will drain 3,600 KWS × its routine power requirement from the energy bank every hour. Thus, the robot's endurance in hours is its energy bank's stored power (KWS)/power requirement/3,600.

If the robot has a power plant whose output is greater than the routine power requirement *and* has an energy bank, its endurance is the power plant's endurance plus a number of hours equal to the energy bank's stored power (KWS)/power requirement/3,600.

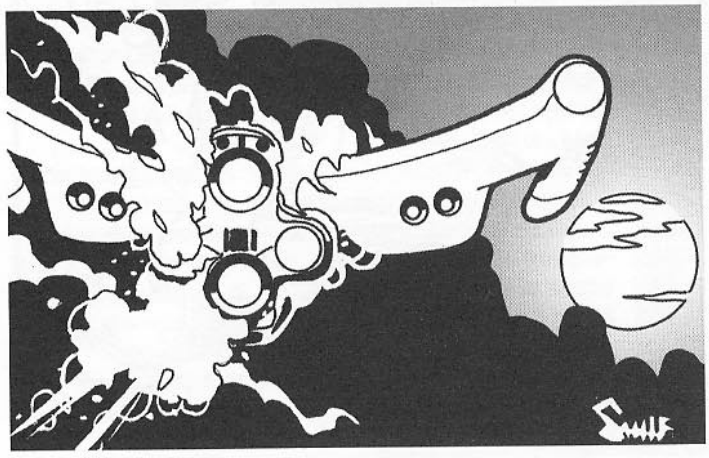
Depending on how long the chosen power system can meet the routine power requirements without refueling, a robot's endurance may be an advantage or a disadvantage:

Under a minute	-100 points
No more than ten minutes	-50 points
No more than an hour	-25 points
No more than six hours	-10 points
No more than 72 hours	0 points
No more than 168 hours	5 points
No more than 720 hours	8 points
Over 720 hours	10 points

EXAMPLE

Synthia uses an energy bank storing 72,000 KWS and a bioconvertor power plant that produces .4 KW. Its routine power requirement is .8 KW, which is greater than its power plant output. It drains .8 - .4 = .4 KW × 3,600 = 1,440 KWS from its energy bank every hour. Since its energy bank stores 72,000 KWS, its endurance is 72,000/1,440 = 50 hours. As its bioconvertor's endurance is 48 hours, this means the power system's endurance is 48 hours. After 48 hours, the robot will have used up 69,120 KWS, leaving 2,880 KWS remaining. It could then switch entirely onto stored power, operating for another 2,880/.8 KW/3,600 = 1 hour.

Synthia can also use its energy bank alone to operate for 72,000 (stored power)/.8 (power requirement)/3,600 = 24 hours. Since its bioconvertor breathes air, this is useful if Synthia must operate underwater or in space. Synthia's 49-hour endurance costs no points, and means Synthia will have to eat and recharge about once every other day, though it may do so more often.



Body and Subassemblies

After all components are installed in the robot, design the body and subassemblies. Every robot has a *body* – its central torso, fuselage or chassis. Attached to it are various *subassemblies,* which include arms, heads, pods, legs, tracks, wheels and wings. A robot can have one arm per arm motor it has. It can be given legs if it has a leg drivetrain, tracks if it has a tracked drivetrain, wheels if it has a wheeled drivetrain, wings if it has an ornithopter drivetrain, and rotary wings if it has a helicopter drivetrain. Heads, pods and (if the robot doesn't have an ornithopter drivetrain) wings or wheels are available as options. The subassemblies are described in detail below; decide which, if any, the robot has.

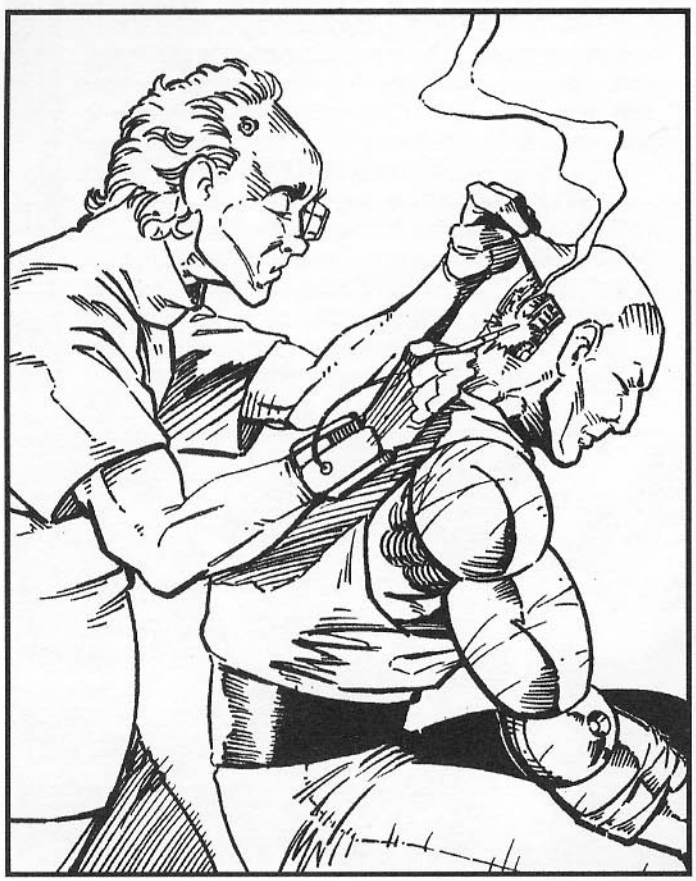
Arms

Arms are limbs attached to the robot that are not used for walking on. A robot requires one arm to use each arm motor it has.

Decide where to attach each arm to the body. On humanoid robots, arms are normally attached to the right or left side; arms can also be attached to the back, like tails, or directly forward, like trunks. A robot must designate half of its arms (rounding down) as "off hands" and suffer the handedness penalty (p. B13) when using them. If the robot is later programmed with Ambidexterity, it does not suffer this penalty.

Heads

A head is a rotating superstructure mounted on the robot's body. Decide how many heads the robot has. Most robots have only one head, but robots with no heads, or with many heads, are quite possible. Assume that an ordinary head is able to rotate through the same angles as a human head. However, a head that cannot rotate, or one that has 360-degree rotation, is also possible. A head can have any of the following options.



Full Rotation: The head can rotate 360 degrees, like a tank turret.

No Rotation: The head can't rotate – it's a superstructure, like an Ogre's tower.

Decide where the head is attached – to the top, side, or bottom of the body, or even atop another larger head.

Pods

These are external compartments, similar to the engine, weapon or fuel pods carried by aircraft. They house equipment or cargo outside the robot's body. A robot can have any number of pods.

Legs, Tracks, Wheels

A robot requires legs to use a leg drivetrain, as many legs as it has leg motors. A robot requires tracks to use a tracked drivetrain. A robot requires wheels to use a wheeled drivetrain.

If a robot has wheels, decide how many wheels it has: one, two, three or any even number of wheels. This doesn't affect the weight and cost of the wheels; more wheels mean smaller ones.

If a robot has tracks, decide if it has two or four tracks. Again, this doesn't affect their weight or cost.

All tracks or all wheels on a robot are a single subassembly; each leg, however, is a different subassembly.

Wings

These are airplane-style wings with associated control surfaces (tail and/or rudder, for instance). A robot *must* have wings to use an ornithopter drivetrain. If the robot has a thrust-based propulsion system, it can use wings for powered flight, much like an airplane. Otherwise, it can only use them to glide.

Rotary Wings

A rotary wing is a set of rotor blades and stabilizers which enable the robot to fly like a helicopter. A robot *must* have a rotary wing to use a helicopter drivetrain.

Ground-Effect (GEV) Skirts

This is a hovercraft-style skirt that helps create a cushion of air under the robot's body. A 'bot can have a GEV skirt if it has vectored-thrust ducted fans. The skirt augments the lift of these fans to five pounds per pound of motive thrust. If their lift (after multiplying) equals or exceeds the robot's final weight, it can move as a hovercraft, skimming low over smooth ground or water.

Slope

Individual faces (front, right, left, back) of the body or a head can be *sloped,* giving them an angular shape whose armor plates will be better able to deflect attacks from that direction. Slope is normally only used on tank-like robots, and is only useful if the robot is going to be armored. This increases the PD and DR of any armor the sloped body or head has, as described in *Armor Slope,* p. 42.

A face can be sloped 30 degrees or the more effective 60 degrees. The faces on a single head or body cannot have a combined total of more than 240 degrees of slope. Slope has no cost or weight as such, but adding slope eats up space within the robot that might be used for other components, and so effectively increases the robot's volume. The effects of slope on volume are described under *Body and Subassembly Design*, below.

EXAMPLE

Synthia has three arm motors, so it needs three arms. We call them "right arm," "left arm" and "tentacle arm."

Synthia has a head, with no options.

When we designed Synthia's drivetrain, we determined it has two legs.

Body and Subassembly Design

After the robot's subassemblies have been chosen, decide where the robot's components are located, and calculate the external volume (the size) of the body and each subassembly. Every single component the robot has must be housed in the body, or in a specific head, arm, leg, pod, or wing, if the robot has them.

There are some restrictions on where components may go. Each arm must house one arm motor. The body must house tracked, flexibody and wheeled drivetrains, and aquatic propulsion systems, as well as the vectored-thrust ducted fans that go with a GEV skirt, if the robot has one. Each leg must house a leg motor. If the robot has an ornithopter drivetrain, each wing must house a wing motor. Also, some contact weapons and accessories can only be placed in arms or heads, as in their descriptions. (Traditionally, sensors are placed in the head, the power system in the body, and the brain in the body or head, but that's not required.) No subassembly can have a volume more than twice that of the body.

Arms: For each arm the robot has, decide what components to place in it. *Each arm must house one and only one arm motor.* Cubic feet of "empty space" can also be added to the arm to increase its size or provide extra storage space within it. The sum of the volumes of all components and empty space in an arm is that arm's volume. Note: an ordinary human arm will be from 0.05 to 0.2 cf in size; adding empty space is a good way to ensure an arm has human proportions. If a robot has a retractable arm, the arm must retract into the body or a head. The housing for the arm takes up volume as if it were a component. Thus, a .12-cf arm would take up .12 cf in a body or head. The weight of components in an arm may not exceed 6 lbs.× the arm motor's ST. An arm's Reach is half the square root of its area (p. 40). Arms over one hex Reach cost 10 points per arm per extra hex.

Heads: Decide what components to place in each head the robot has. As with arms, "empty space" can also be added to the head. If a rotating head is attached to another head, its rotation mechanism requires empty space equal to 10% of its volume (20% for full rotation) in the head it is mounted upon. This "waste space" is unusable for cargo. A head's volume is the sum of the volumes of all the components and empty space in it. Sloping a head increases its volume. Add the total degrees of slope on all faces and multiply head volume by 1.1 if the total is 30 degrees, 1.25 if 60, 1.4 if 90, 1.6 if 120, 2 if 150, 2.5 if 180, 3.3 if 210 or 5 if 240 degrees. Note: an ordinary human head will be from .1 to .4 cf in size.

Body: Decide which of the robot's components to house inside its body, subject to the restrictions described above. Every component not installed elsewhere in the robot must go in the body! Add "empty space" to the body, as cargo space, or to increase the robot's size. For each rotating head attached to the body, empty space equal to 10% of the head's volume (20% if the head has "full rotation") must be placed in the body to provide space for the head's rotation. This is waste space, unavailable for cargo. The sum of the volumes of all the components and empty space in the body is the body's volume. A robot intended to be submersible (p. 40) which does not have legs or a flexibody drivetrain must multiply its body volume by 1.25; this provides extra space for ballast tanks. Sloping the body will increase its volume. Add the total degrees of slope it has on all faces and multiply the body volume by 1.1 if they total 30 degrees, 1.25 if 60, 1.4 if 90, 1.6 if 120, 2 if 150, 2.5 if 180, 3.3 if 210 or 5 if 240 degrees. Note: an ordinary human body will be between .5 to 2.5 cf in size; adding empty space is a good way to ensure human proportions!

Pods: Decide what components to place in each pod the robot has. As with the body, "empty space" can also be added to the pod, generally as cargo space. The sum of the volumes of all components and empty space in a pod is that pod's volume.

Legs: Decide what components to put in each leg the robot has. Each leg must hold a leg motor! As with the body, cubic feet of "empty space" can also be added to the leg. This is often necessary: supporting the robot requires a minimum volume in each leg. This is 30% of its body volume (for each of two legs), 20% of the body's volume (for each of three legs), 15% of the body's volume (for each of four legs), 10% of its body's volume (for each of six legs), or 0.6 × the body volume/(number of legs) for each of a different number of legs. Furthermore, each leg must be the same volume! The sum of the volumes of all components and empty space in each leg is that leg's volume – if the leg doesn't have the volume required to support the robot, add empty space or transfer components to increase it.

Tracks: Tracks don't contain components. The volume of tracks and the suspension system is 60% of the body's volume.

Wheels: Wheels don't contain components. The volume of the wheels and suspension system is 20% of the body's volume.

Ground-Effect Skirts: A GEV skirt doesn't contain components. Its volume is 60% of the body's volume.

Rotary Wings: A rotary wing doesn't contain components. Its volume is 2% of the body's volume.

Wings: If the robot has wings, decide what components to house in each of its wings. If the robot has an ornithopter drivetrain, an ornithopter motor must be placed in each wing! As with the body, cubic feet of "empty space" can also be added to each wing. This is often essential: the sum of the volume of all components and empty space within each wing must be at least 5% of the body's volume per wing, and both wings of a pair must have the same volume. Also, at least 10% of the volume of each wing must be empty space – some wings contain nothing *but* empty space! Add empty space or transfer components to adjust the wing's volume.

EXAMPLE

We want Synthia to be human-sized, so we carefully allocate its components and add extra empty space:

The *right arm* houses the ST 30 arm motor and laser periscope (.095 cf) and we add empty space (.05 cf) to make the arm human-sized with a volume of .1 cf.

The *left arm* houses the other ST 30 arm motor (.06 cf) but to make it proportionate to the right arm we add .04 cf empty space to get a volume of .1 cf.

The *tentacle arm* houses the large knife and ST 10 arm motor (.05 cf) and .01 cf of empty space, totalling .06 cf. Since the arm is retractable it has to be placed somewhere else and will take up .06 cf there; we decide the arm will go in the head.

The *head* houses the sensors, communicator, crushing jaw and tentacle arm, plus .2 cf empty space, totalling .3 cf.

The *body* houses the computer brain, military laser carbine, neural stimulator, pheromone emitter, bioconvertor and energy bank, totalling .86 cf. We add .14 cf of empty space, to give Synthia a more human-sized torso and to provide space for the head's rotation; this gives the body a volume of 1 cf.

The *right leg* houses a leg motor (.135 cf). Since the leg must be 30% of the 1-cf body volume, we add .165 cf of empty space, giving the leg a volume of .3 cf. The *left leg* houses the other leg motor, and has the same amount of empty space.

Surface Area

The area of the body or a subassembly is an approximate measure of its surface area in square feet; this will be used to calculate the robot's structural weight, cost and hit points.

Calculate the *area* of the body and the area of each subassembly, looking up their individual volumes on the table below in the "Vol." column, then reading the area from the "Area" column to the right. If a value falls between two numbers, round down. Multiply the surface area of wings by 1.5, and that of rotors by 3!

Area Table

Vol.	*Area*	*Vol.*	*Area*	*Vol.*	*Area*
under .03	.5	5.2-5.6	19	544-759	500
.03-.06	1	5.7-6.0	20	760-1,000	600
.07-.12	1.5	6.1-6.5	21	1,001-1,540	800
.13-.19	2	6.6-7.0	22	1,541-2,150	1,000
.2-.26	2.5	7.1-7.4	23	2,151-2,830	1,200
.27-.3	3	7.5-8.0	24	2,831-3,375	1,500
.4-.5	4	8.1-8.4	25	3,376-6,080	2,000
.6-.75	5	8.5-9.5	27	6,081-8,495	2,500
.8-1.0	6	9.6-11	30	8,496-11,180	3,000
1.1-1.25	7	12-17	40	11,181-17,185	4,000
1.3-1.5	8	18-24	50	17,186-24,110	5,000
1.6-1.8	9	25-31	60	24,111-35,650	6,500
1.9-2.2	10	32-44	75	35,651-48,650	8,000
2.3-2.5	11	45-68	100	48,651-68,025	10,000
2.6-2.8	12	69-95	125	68,026-89,440	12,000
2.9-3.2	13	96-125	150	89,441-125,000	15,000
3.3-3.5	14	126-157	175	125,001-192,420	20,000
3.6-3.9	15	158-188	200	192,421-268,960	25,000
4.0-4.3	16	189-268	250	268,961-353,450	30,000
4.4-4.7	17	269-353	300	353,451-544,335	40,000
4.8-5.1	18	354-543	400	544,336-760,610	50,000

EXAMPLE

Synthia's body has a volume of 1 cf and so has an area of 6. Its right arm's volume is .1 cf for an area of 1.5. Its left arm is identical. Its tentacle arm has a volume of .06 cf and an area of 1. Its head has a volume of .3 cf and an area of 3, as do each of its legs. Synthia's total surface area is 6 + 1.5 + 1.5 + 1 + 3 + 3 + 3 = 19.

Robot Structure

The "structure" of the robot is its internal skeleton and structural frame, atop which things like skin and armor can be layered later.

Thanks to its artificial plastic and metal structure, every robot has certain innate capabilities and limitations not otherwise reflected in the design process. A robot automatically has the High Pain Threshold and Immunity to Disease advantages, together costing 20 points. However, every robot also has the No Natural Healing disadvantage (p. 89) worth -20 points. As a result, it costs no points to have a robotic structure.

A robot's structure can be modified with various options, all of which will affect the structure's weight and cost and some of which will cost points. Decide if the robot has any of these structural options. (If the robot has a flexibody drivetrain, it *must* have the flexibody option.)

Biomechanical Structure (TL9): This is a different kind of robot body, built of a mix of organic and mechanical parts. A robot with a biomechanical structure can feel pain and become infected with disease, but it can also heal itself. Thus, it is worth no extra points, but it has neither the advantages High Pain Threshold or Immunity to Disease nor the disadvantage No Natural Healing.

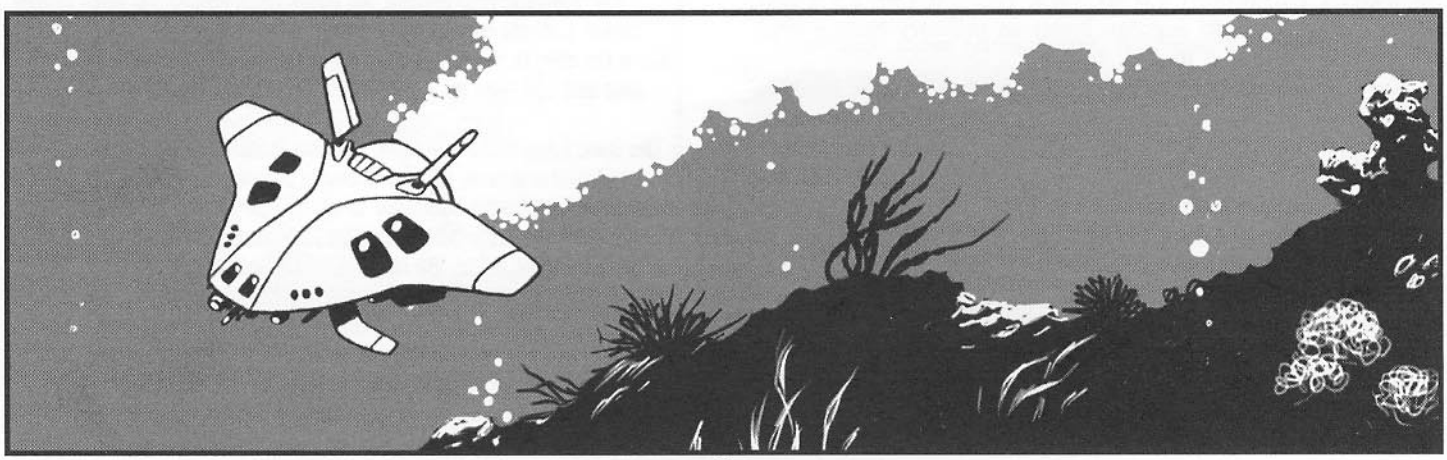
Living Metal Structure (TL13): This gives the robot a structure built of living metal, a nanotechnological material that is capable of self-regeneration. The tiny "nanobots" contained within the living metal structure will regenerate damage to the robot at 1 hit per hour (as long as the robot isn't utterly destroyed). If the robot has damaged or ablated armor, this regenerates at the same rate. The point cost of living metal includes both regeneration and buying off the robot's inability to heal.

Modified Frame Strength: A normal robot is assumed to have a "medium" strength structural frame. But robots can also be "light" or "extra-light" frames (giving them fewer hit points, but making them lighter and cheaper) or "heavy" or "extra-heavy" frames (making them stronger and tougher, but proportionately heavier and more expensive).

Cheap or Expensive Materials: Robots are normally built using "standard" materials. But instead, the 'bot can be made with "cheap" materials which make the robot less expensive but heavier, or "expensive" materials that make it lighter but more costly.

Flexibody (TL8): This is a multi-segmented body that allows the robot to squeeze through smaller openings than its size would normally suggest, and gives it the *Double-Jointed* advantage. A robot with a flexibody drivetrain *must* have this body option to use it. Other robots may have it. It allows a robot with a flexibody drivetrain to propel itself by undulating along the ground like a snake.

Submersible (TL5): A robot with this option is strengthened to withstand undersea pressure, and has ballast tanks that can be flooded to enable it to submerge, float underwater, and surface,



like a submarine. A sealed or waterproof robot with legs or the flexibody option can also swim underwater (assuming it isn't so heavy it can't float) without taking this option.

Refer to the table below to find the structural weight and cost of the robot.

Robot Structure Table

Feature	*Weight*	*Cost*	*Points*
TL7 design	6	$100	–
TL8 design	4	$100	–
TL9 design	3	$100	–
TL10 design	2	$100	–
TL11 design	1.5	$100	–
TL12+ design	1	$100	–
Special Structure			
Biomechanical	–	×1.5	–
Living Metal	–	×2	45
Modified Frame Strength			
Extra-Light	×.25	×.25	–
Light	×.5	×.5	–
Medium	–	–	–
Heavy	×1.5	×2	–
Extra-Heavy	×2	×5	–
Expense			
Cheap materials	×1.5	×.5	–
Expensive materials	×.75	×2	–
Other			
Flexible	×1.5	×5	15
Submersible	×2	×2	25
Has wings or rotors	–	×10	–

Weight: Determine the structural weight as follows: Multiply the robot's total surface area by the design weight shown on the table for the robot's TL, and then multiply that weight as shown for each option under "weight" the robot was given. The result is its structural weight in pounds.

Cost: Determine the structural cost as follows: Multiply the robot's total surface area by the design cost on the table, and then multiply as shown under "cost" for each option the robot was given. The result is its structural cost.

EXAMPLE

We give Synthia a "heavy" frame but no other options. Its weight is 19 (its total surface area) × 2 (basic TL10 structure) × 1.5 (heavy frame) = 57 lbs. Its structural cost is 19 (total surface area) × 100 (basic structure) × 2 (heavy frame) = $3,800. It costs no points.

Hit Points

Determine the hit points for the robot's body and for each subassembly the robot has, as follows:

Body . . . its area × 1.5
Each Arm . . . its area × 3.
Each Head or Pod . . . its area × 1.5.
Each Leg . . . its area × 1.5.
Each Track . . . the track's area × 3/number of tracks.
Each Wheel . . . the wheel's area × 3/number of wheels.
Each Wing . . . its area × 1.5.
Rotary wing . . . its area × 3.
Ground-effect skirt . . . GEV skirt area × 1.5.

Multiply all hit points by .25 if the robot has an extra-light frame, by .5 if a light frame, by 2 if a heavy frame or by 4 if an extra-heavy frame. Round hit points to the nearest whole number, but with a minimum of 1 hit point for the body and for each subassembly.

EXAMPLE

We need to determine the hit points for Synthia's body, head, each of its arms, and each leg. Synthia's body's hit points are 6 (its area) × 1.5 (body) × 2 (heavy frame) = 18. Its right arm's hit points are 1.5 (its area) × 3 (arm) × 2 (heavy frame) = 9. Its left arm's hit points are the same. Its tentacle arm's hit points are 1 (area) × 3 (arm) × 2 (heavy frame) = 6. Its head's hit points are 3 (area) × 1.5 (head) × 2 (heavy frame) = 9. Its legs' hit points are 3 (area) × 1.5 × 2 (heavy frame) = 9 hit points each.

Surface Features

Surface features include things layered on the robot's body, such as armor, synthetic skin and radiation shielding.

Normally, surface features are assumed to cover the entire robot; their weight and cost is based on the robot's surface area.

Optionally, surface features that cover only part of a robot – the body or subassemblies – may be added. In this case, base the weight and cost on that individual section's area, rather than the robot's total surface area.

Armor Design

Armor protects a robot from damage. Not all robots have it. A robot covered with flesh (p. 43) can still have armor under its skin. If the robot has armor, select the type. There are six main kinds.

Ablative Armor (TL8) is plastic/composite armor. It is light and cheap, but easily chipped or melted away. Every 10 points of damage an attack inflicts (regardless of whether its damage penetrates DR or not), destroys 1 point of ablative DR. Lost DR can be replaced – see *Repairing Robots* on p. 99.

Laminate Armor (TL7) is a composite of metal alloys, tough ceramics and synthetic materials, like the modern Chobham armor used on main battle tanks, or Ogre-era BPC. It is designed to resist shaped-charge warheads, and gets doubled DR against them.

Metal Armor is ordinary armor made of steel, aluminum, titanium or high-tech alloys. At higher TLs, the metal may have "perfect crystal" structures grown in zero-G, or even be gravitationally collapsed. It provides normal Damage Resistance.

Nonrigid Armor (TL7) is woven of flexible material, like natural fibers, para-aramid fiber, monocrys or bioplas. It is very light, but impact from a powerful blow may be felt as blunt trauma. When an explosion, Crushing or Cutting damage attack hits the robot, any 5 or 6 (at TL7) or 6 (at TL8+) rolled on the damage dice inflicts 1 hit not absorbed by nonrigid armor DR. In addition, TL7 nonrigid armor has a maximum of DR 1 vs. Impaling attacks, and TL8-9 nonrigid armor has a maximum of DR 2 vs. impaling attacks. Nonrigid armor's DR is limited to 2 × (TL+1).

Reflex Armor (TL10) is electrically-active bioplastic armor with built-in sensors that turn it hard as steel just before suffering an impact. Normally it is treated as nonrigid armor, but its DR *doubles* and it protects like metal armor if its sensors detect the incoming attack in time. It automatically detects melee or thrown weapons, or low-velocity projectiles like arrows. Bullets, rockets and sonic beams are detected on a roll of 14 or less on 3d. Hyper-velocity Gauss needles or railgun shots are detected on a 12 or less. Laser, blaster or other beam weapons are too fast to detect. Reflex armor's DR (before doubling) is limited to 5 × TL.



Open-Frame: Any kind of armor can be an open framework, much like a roll cage. It protects normally vs. collisions, falls, rolls or Swinging melee attacks, but has only a 1-in-6 chance of protecting vs. Thrusting attacks, beams, arrows, bullets, or other small missiles. It has no effect at all against flamer or flamethrower attacks or explosive concussion damage. Open-frame armor has half the normal weight.

Use the table below to calculate the armor's weight and cost:

Armor Table

	Weight by TL							
Type	*TL7*	*TL8*	*TL9*	*TL10*	*TL11*	*TL12*	*TL13+*	*Cost*
Ablative	.08	.03	.02	.012	.008	.005	.003	$8
Metal	.25	.15	.1	.06	.04	.025	.015	$20
Laminate	.15	.1	.06	.04	.025	.015	.01	$100
Nonrigid	.045	.04	.03	.02	.015	.008	.005	$100
Reflex	n/a	n/a	n/a	.03	.02	.012	.008	$400
Open-frame	×.5	×.5	×.5	×.5	×.5	×.5	×.5	×.5

Weight: Multiply the weight shown for the chosen type and TL of armor by the robot's surface area: this is the weight per point of DR. Decide how much DR the robot will have (remember, some armor types have a maximum DR). Then calculate the actual weight of the armor.

The greatest weight of armor the robot can be given is 50 lbs. × its body hit points; most robots will have far less armor than this.

Cost: Multiply the cost shown on the table above by the weight of the armor. This is the armor's cost.

Other Armor Statistics

Once DR is known, PD, point cost and Legality can be determined.

Passive Defense: PD is determined from DR as follows: DR 1 gives PD 1, DR 2-4 gives PD 2, DR 5-15 gives PD 3 and DR 16+ gives PD 4. Maximum PD is 2 for nonrigid armor.

Point Cost: Each point of DR costs 3 points. For all but metal armor, this is modified by armor type: Ablative: -15%, Laminate: +33%, Nonrigid: -10%, Reflex: +50%, Open-frame: -25%. PD costs 25 points per level, *regardless* of armor type.

Legality Class: Legality depends on DR: DR 1 is Legality 6, DR 2-3 is 5, DR 4-7 is 4, DR 8-15 is 3, DR 16-23 is 2, DR 24-63 is 1, DR 64-199 is 0 and DR 200+ is -1. If the robot has neither metal, reflex nor laminate armor, increase Legality by 1.

Humanoid robots with body volume between 0.5 and 5 cf can wear human body armor; the DR is additive, but the PD is only that of the worn armor. If a robot cannot wear body armor, then increase armor Legality by 1.

Maximum Legality is 6.

EXAMPLE

Synthia's nonrigid DR of 15 costs 15 x 3 x 0.9 = 40.5 points, its PD of 2 costs 50 points. Total armor cost is 90.5 points.

Armor Slope

A body or head that has slope will gain increased PD and DR as any attack must both penetrate through a greater thickness of armor and is more likely to be deflected. Any head or body face with 30-degree slope gets +1 PD and +50% to DR against attacks from that direction. Any face with 60-degree slope gets +2 PD and doubled DR against attacks from that direction. This increase in PD and DR does not affect Legality.

Sloped armor has point cost as follows, for each side:

[(sloped PD - unsloped PD)×25 + (sloped DR - unsloped DR)×3]/6.

Camouflage and Threat Protection

These armor features are designed to protect the robot from detection or from special dangers (like radiation or laser beams).

Chameleon Systems (TL8): These systems give the robot sensor-equipped skin that automatically alters its appearance to blend in with any background. This reduces an enemy's chance of detecting the robot visually (including ladar), or of hitting it.

A TL8 *basic chameleon system* is -3 (-1 if moving) to be visually spotted or hit.

A TL9 *instant chameleon system* is -6 (-3 if moving) to be visually found or hit.

A TL10 *intruder chameleon system* makes the robot nearly invisible: -10 (-6 if moving) to be visually located or hit.

The automatic camouflage feature can also be turned off, allowing the robot to electronically "paint" itself with whatever color scheme or markings are desired, or to give itself a silvery skin identical to a reflective surface. Note that these systems cover the surface of the *robot:* clothing, armor worn or equipment carried obscures part or all of the camouflage, making the robot easier to see.

Holocloak (TL10): This holographic projector maps a preset three-dimensional image around the robot. A holocloak is normally used to create instant disguises, allowing the robot to create or change clothes in a flash, or to look like someone or something else. It can cloak the robot with any holographic image of equal or slightly larger size than the robot's actual size. A hologram cannot fool non-visual senses (such as touch, infrared or radar) and because it projects light, it *glows in the dark.*

The robot can have several different hologram image programs stored in its memory – each costs $100 and takes up 1 gigabyte. It takes one second to change programs, during which the robot's real form is briefly visible. The projector must also be turned off to vent waste heat (which produces a large heat signature) for at least an hour every six hours of use, or it starts leaking heat anyhow.

A robot with visual sensors can record images of objects of the appropriate size to create instant holocloak programs. Anything recorded must be seen from all angles; it takes one gig of memory. The GM may make a secret Electronics Operation (Holographics) roll to see if the robot got the details right; otherwise observers may notice something subtly wrong.

Infrared Cloaking: This subtracts (the system's TL-4) from rolls to detect the robot with infrared or thermograph sensors, or to hit it with heat-seeking (infrared, or IR-homing) missiles or projectiles.

Radiation Shielding: This protects the robot against radiation. It is measured in protection factors (PF). Divide the rads of received radiation by the PF of the shielding. The available shielding is 10 PF at TL7, 100 at TL8, 1,000 at TL9-10, 10,000 at TL11-12, 100,000 at TL13+.

Reflective Surface: This gives the robot PD 6, or +1 to PD (whichever is better) vs. laser beams (but not x-ray or graser beams) and flamers. However, it adds +3 to the chance of being detected by radar. It cannot be added to a 'bot with a chameleon system.

Sealed: The vital components of a sealed robot are protected against corrosion from water or other liquids, and from the effects of sudden pressure changes, or high or low temperatures. This means the robot can (if its power systems don't require air) operate in vacuum or underwater. A robot with a submersible hull is automatically sealed for free.

Stealth: A robot can be built of special materials to make it harder to detect by radar or imaging radar. This subtracts its TL-4 from any radar detection attempts.

Thermal Superconductor Armor (TL11): This coating over the armor doubles armor DR against shaped-charge explosive warheads, lasers, x-ray lasers, grasers, flamer or plasma/fusion guns.

Waterproof: This seals the robot against leaks, short-circuits or corrosion caused by water. A robot that is submersible or sealed is automatically waterproof for free. A robot intended to float must be either sealed, submersible or waterproof.

Camouflage and Threat Protection Table

Type	*TL*	*Wt.*	*Cost*	*LC*	*Points*
Chameleon, basic	8	.4	$80	5	15
Chameleon, instant	9	.5	$100	5	30
Chameleon, intruder	10	.6	$400	3	50
Holocloak	10	.2	$60	6	10
Infrared Cloaking	7	2	$300	5	(TL-6)
Radiation Shielding	7	2	$20	6	varies
Reflective Surface	7	0	$30	6	2
Sealed	7	0	$40	6	20
Stealth	7	2	$300	5	(TL-6)
Stealth and IR Cloaking	7	4	$600	5	(TL-6) × 2
Thermal Superconducting	11	.25	$250	3	+67% to armor point cost
Waterproof	0	0	$2	6	0

Multiply weight (Wt.) and cost by the robot's surface area. Except for waterproof, halve weight and cost one TL after the system's introduction, and quarter two or more TLs after introduction.

Radiation shielding's point cost is 2 points at TL7, 4 points at TL8, 6 points at TL9-10, 8 points at TL11-12, and 10 points at TL13+.

EXAMPLE

Synthia is sealed, costing 19 × $40 × .25 (quartered for TL10) = $190, and 20 points.

Biomorphics

These surface features make the robot look less like a machine and more like a living being. They include body-sculpting and covering the robot with flesh.

Such biomorphic features can make a robot seem lifelike, but that doesn't mean people will believe the robot to be a real living thing, unless it's also of the proper size and shape. A human-sized robot with a head, basic sensors, two arms and two legs could use biomorphics to pass for human without any problem. But a robot with wings or extra limbs could only pass as an animal or alien. If a robot has features like wheels, rotary wings, or unconcealed weapons sticking out of it, most people that see it will immediately assume that it is at least part machine, no matter how realistic a fleshy covering it has!

A biomorphic feature's detailing is up to the designer. It makes no difference in terms of cost, for instance, whether a robot's sculpted face looks like that of a human, an elf, an alien or a beast, though especially attractive or ugly features will cost more due to the effort involved!



These biomorphic features are available:

Sculpted: A robot with armor but no skin may have its armored surface sculpted to give it lifelike features. The robot is still obviously artificial – but it looks like a metal or plastic statue, rather than a simple piece of machinery.

Mannequin: Any armor the robot has is sculpted, and its body is then given a thin plastic coating painted to match flesh tones and then (if desired) fake hair. The result looks convincing in bad light, but doesn't feel or smell like flesh. A successful Vision or Smell roll, any infrared or thermograph view, or any touch will reveal it to be artificial. The robot has no body cavities. The skin does not move, and the robot cannot simulate facial expressions. All in all, a humanoid robot with this option resembles a department store mannequin. Any damage will reveal the robot to be artificial, since it does not bleed or bruise.

Realistic Flesh (TL8): After any armor the robot has is sculpted, the robot is covered with a thick layer of subcutaneous gel implants to simulate flesh, muscle tone and fat. Over that is layered synthetic or vat-grown skin designed to look realistic, with pores, wrinkles and body hair. However, the robot has no pulse; it doesn't sweat. The skin won't tan, bleed or bruise, and won't heal. Someone touching or sniffing the robot gets a Diagnosis or IQ roll (modified by bonuses for Acute Taste and Smell or Discriminatory Smell) to notice these differences; roll at -4 if the person isn't specifically looking for any of these differences. Successful use of a bioscanner or medscanner will also reveal the robot to be artificial. Damage exceeding one-third of a hit location's hit points will also reveal the robot to be mechanical.

Living Flesh (TL9): As above. However, the robot has pseudo-muscles in its face that allow it to adopt a range of facial expressions, muscle tics, etc. Its power system keeps the skin at a realistic temperature, and the skin itself is designed to tan, bruise, bleed, and then heal. As a result, the robot looks and feels real, and will also appear real to infrared or thermograph sensors. Only cutting into the robot, or successful use of a medscanner or bioscanner at -4, will reveal the robot is not really a living thing. Damage exceeding one-half of a hit location's hit points will also reveal the robot's mechanical nature.

Other Options

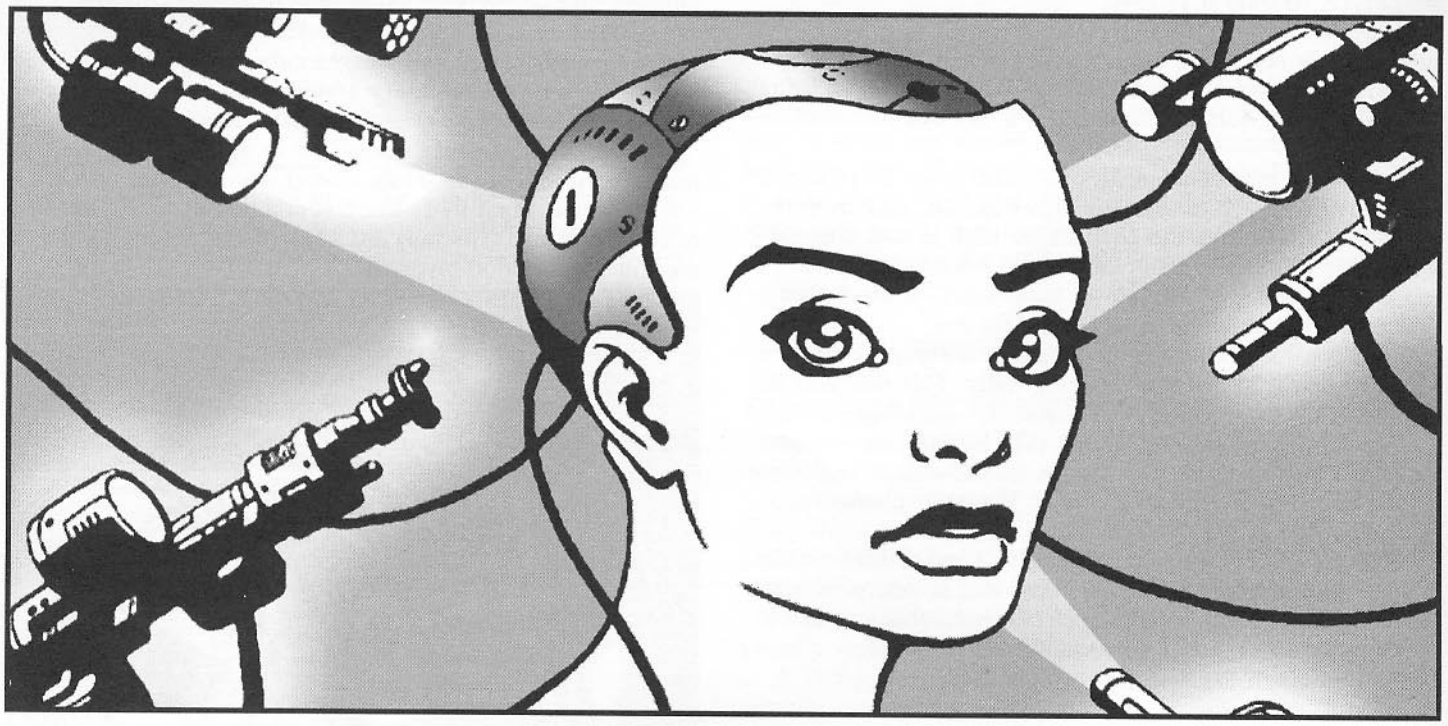
Appearance: A robot can have an Appearance statistic. The cost of Appearance is shown on the Biomorphics Table, p. 45. Even a fleshless biomorphic robot may look good – a beautiful statue – without looking at all human. For non-biomorphic robots, an appealing design, or useless but pretty external features, can explain an Appearance of Attractive or Beautiful.

A Hideous or Ugly 'bot may have been designed that way – to engender fear or disgust – or its condition may be the result of abuse or neglect. A biomorphic robot can also be built to *duplicate* a specific living being, provided its shape and size are correct. How convincing the duplicate is depends on the type of biomorphics it has.

If desired, a robot with an Appearance that isn't average can be built to look like an albino.

Biomorphic Shielding (TL9): This sensor-deception system is designed to make a robot look like a living being rather than a machine when it is scanned by bioscanners, chemscanners or medscanners, and to prevent the robot's power system from being detected by radscanners. The system does not interfere with actual detection, merely creates a distorted impression. To correctly register the 'bot as a machine rather than a living being (of whatever type is preset), a pluralize chemscanner of the same TL that detects it must succeed by five or more. A scanner one TL lower must succeed by ten or more; a scanner one TL higher must succeed by 2 or more. Scanners that are two or more TLs lower will automatically be deceived into registering it as a living being; scanners two or more TLs higher are unaffected.

Elastic Skin (TL9): A robot with living flesh can be given this option. The robot has memory-plastic implants that enable it to alter its body and facial features to resemble anyone of its approximate size and build, modify its fingerprints, change its apparent race or sex, or alter its appearance from Hideous to Very Beautiful/Handsome. It takes the robot 10 seconds to do so; a Disguise+4 roll is required for the robot to make a convincing duplication. It needs the Acting skill program to imitate someone's mannerisms. If the robot's body loses half or more of its hits, its shape will return to normal. If the robot's head loses half or more of its hits, the face will return to normal.



Fur: A robot with mannequin, realistic flesh or living flesh can have fur. The level of realism matches the biomorphics. Fur provides an extra DR 1, and protection equivalent to light clothing. The cost of fur depends on the biomorphics. For mannequins, the cost is \$50 × surface area. For realistic or living flesh, it actually subtracts 10% from the cost of flesh, since it's easier to cover physical imperfections with fur than to get the subtleties and wrinkles of realistic skin right.

Sex Implant (TL8): Gives the robot fully-functional genitalia. The robot does not require flesh, but it is strongly recommended. Sex implants are available in male or female models; for double cost, the robot can have both.

Surface Sensors (TL8): The robot's entire surface is covered with sensitive temperature and pressure sensors, making its body as receptive as a human to heat, cold, touch, etc. (The robot can turn off this sensitivity to prevent pain – all robots have, in effect, High Pain Threshold.)

Biomorphics Table

Type	*TL*	*Weight*	*Cost*	*Points*
Sculpted	–	.1	\$20	0
Mannequin	–	.2	\$50	0
Realistic Flesh	8*	.5	\$400	0
Living Flesh	9*	.5	\$1,000	0
Appearance				
Hideous	–	–	\$200/\$40	-20
Ugly	–	–	\$100/\$20	-10
Unattractive	–	–	0	-5
Average	–	–	0	
Attractive	–	–	\$50/\$10	5
Beautiful/Handsome	–	–	\$150/\$30	15
Very Beautiful/Handsome	–	–	\$250/\$50	25
Duplicate	–	–	\$500/\$50**	**
Other				
Biomorphic Shielding	9	.1	\$1,000	0
Elastic Skin	9	–	\$2,000	20
Fur	7	.25	special	4
Sex Implant	8	0	\$8,000	0
Surface Sensors	8	–	\$1,000/\$1,200	0

* Not available to robots with reflec surfaces. Only available to robots with chameleon systems at 5 × cost.

** Add the cost of the Appearance of the person being duplicated, if it isn't Average.

Weight: Multiply the weight by the robot's surface area to get the actual weight. TL does not modify it.

Cost: The cost is multiplied by surface area, except for the sex implant. If a TL is listed, halve the cost one TL after introduction, or quarter it two or more TLs after introduction. For Appearance and Surface Sensors, the second cost applies if the robot *does not* have flesh.

Legality: All systems are LC 6 except biomorphic shielding, which is LC 5.

EXAMPLE

Synthia has a surface area of 19. We give it living flesh which weighs .5 × 19 = 9.5 lbs. and costs 19 × \$1,000 × .5 (halved for being TL10) = \$9,500. We also give it a Very Beautiful Appearance (\$4,750, 25 points); biomorphic shielding (1.9 lbs., and at TL10, \$9,500, LC 5); a female sex implant (at TL10, \$2,000); and surface sensors (at TL10, \$4,750).

Other Surface Features

Suction Pads (TL9+): These are molecular suction pads that let the robot climb up walls or cling to ceilings. They cost \$100 × the sum of the area of all the legs and 25 points.



Statistics

The last thing to do is to work out the robot's statistics!

Design Weight

Add up the total weight of every part of the robot: components, structural weight and surface features.

Tonnage: Divide the weight by 2,000 to find the robot's mass in tons.

Loaded Weight: Decide if the robot carries any cargo internally on a regular basis. A robot can carry up to 50 lbs. of cargo per cf of cargo space. If the robot usually carries cargo, passengers or other robots inside it, add their weight to the design weight; this is the robot's loaded weight.

When "weight" is used for a performance calculation, use the loaded weight to work out the performance of the robot carrying a load of cargo or occupants, and the design weight otherwise.

Robot Volume and Size

Add together the sizes of all subassemblies (unless retractable), and the body. This is the robot's volume in cubic feet. If the robot's total volume is under 1 cf or over 4 cf, its "inconvenient size" is a disadvantage worth -10 points. Robots don't suffer from gigantism or dwarfism as such, but a humanoid robot over 4 cf will gain the same reaction bonuses or penalties as a giant and one 1 cf or smaller as a dwarf (p. B28).

An approximation of the robot's longest dimension in yards (height if bipedal or tripodal, usually either height, width or length otherwise) in yards can be found using the formula: square root of [(body area + head area)/6]. Multiply by 1.5 if the robot has two or three legs. Multiply by three to convert yards to feet.

Price

Add up the total cost of the robot's components, structure, and surface features. This is the robot's purchase price.

EXAMPLE

Synthia weighs 135.175 lbs. This is .06758 tons. It carries no cargo (or people) inside it, so we'll use its design weight when calculating its performance.

Synthia's volume is 1 (body) + .2 (total of right and left arms) + .3 cf (head) + .6 cf (both legs) = 2.1 cf.

Synthia's body area + head area is 9. Her height is [square root of (9/6)] × 1.5 (two legs) × 3 = 5.5' feet.

Synthia costs $89,912.5.

Attributes

Strength

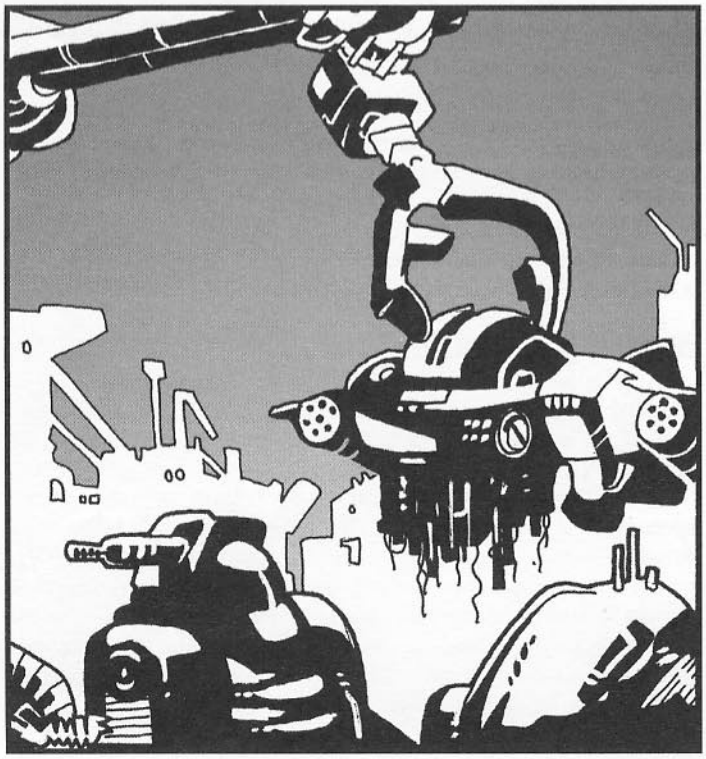
Robots with arms, or any drivetrain that has motive power, have a ST attribute. A robot's ST is split into two categories: body ST (based on motive power) and arm ST (based on the arm motor – see p. 16).

Using the motive power of the drivetrain with the highest motive power, figure the robot's *body ST* with the formula:

ST = (motive power - weight in tons) × 80.

Body ST is used for pulling, kicking, or when the robot slams into someone or carries a load. Unless the robot has no Body ST at all, its minimum Body ST is half its body hit points; its maximum ST is twice its body hit points. Round fractions *up*. A robot without a drivetrain has *no* Body ST; list this as "Body ST 0" for record-keeping purposes.

Arm ST is the strength of an individual arm. It is the strength a robot has when using that arm to punch, push, lift, grip or wield a weapon. If a robot uses a pair of arms with different arm ST values to perform a two-handed task, such as wielding a two-handed weapon or lifting with both arms, average their STs. If the robot has no arms, record an arm ST of 0.



Point Cost: Find the cost of Body ST 14 or less from the table on p. B13; use the table below for Body ST 15+. If a robot has no arms, or has only striker arms, reduce the cost of Body ST 11+ by 40%. Body ST 0 (see above) is worth -100 points.

For a robot with arms, having an Arm ST greater than Body ST is an advantage, priced as follows:

For *each* arm: 30% of the difference between the cost of the Arm ST and the cost of Body ST.

For each *pair* of arms with the same ST: 50% of the difference between the cost of the arms' ST and the cost of Body ST.

This is additive if the 'bot has even more arms.

If either of the two *highest-ST* arms is weaker than Body ST, this is a disadvantage. Calculate this as above, but now the difference is *negative.*

Strength Point Cost Table

ST	*Cost*	*ST*	*Cost*
15	60	23	140
16	70	24	145
17	80	25	150
18	90	26	155
19	100	27	160
20	110	28	165
21	120	29	170
22	130	30	175
		31+	+ ½ point per point

EXAMPLE

Synthia's body ST is equal to [.45 KW (its motive power) - .06785 tons (its weight in tons)] × 80 = ST 30.803, rounded up to ST 31. This costs 175.5. The Arm ST of 30 costs (175 - 175.5) x 0.5 = -0.25. Net cost is 175.25.

Dexterity

The robot's DX is its dominant brain's (Complexity/2) + 8, rounding down. Then add the DX bonus for a reflex booster, if the robot has one. The result is the robot's DX.

To determine how many points DX costs, refer to the table on p. B13.

EXAMPLE

Since Synthia has a Complexity 5 brain and a +2 DX reflex booster, its DX is 2.5 (Complexity/2) + 8 + 2 (DX booster) = 12.5, rounded down to DX 12. This costs Synthia 20 points.

Intelligence

The robot's IQ is its dominant brain's Complexity + 3. Add +1 if the computer is a neural-net, or +2 if it is sentient.

To determine how many points IQ is worth, refer to the table on p. B13.

EXAMPLE

Synthia's IQ is 5 (its brain's Complexity) + 3 + 1 (neural-net) = 9. This costs the same as buying IQ 9: -10 points.

Health

A robot has a split HT, divided into actual Health and hit points, much like an animal.

Health measures the robot's general reliability. Hit points, or hits, are used to determine how much damage the robot can withstand. A robot with a low Health but many hit points can take a lot of punishment – but it also requires a lot of maintenance to keep running properly, just like a tank or a jet fighter.

Hit Points: A robot's hit points have already been calculated.

Health: The heavier the robot is, compared to its structural strength, the more strain it puts on its systems (especially legs, wheels, wings and the like), and thus the less reliable it is. A robot's Health is: [(200 × body hit points)/loaded weight] + 5, rounding up, to a maximum of HT 12 or the robot's TL, whichever is higher.

Record a robot's health and hit points in the same way a split Health is recorded for animals: Health first, then a slash, then body hit points. Note the hit points of subassemblies afterward.

Calculate the point value of a robot's Health using the table on p. B13. Every body hit point the robot has over Health is a 5-point advantage. Every body hit point the robot has below its Health is a -5-point disadvantage.

EXAMPLE

We've already calculated Synthia's hit points (see p. 41): it has 18 body hit points. Its Health is [200 × 18 (hit points) / 135.175 (weight)] + 5 = 31.6. Since the maximum robot health (at TL10) is 12, Synthia ends up with Health 12. This is written HT 12/18. A Health of 12 normally costs 20 points, but since Synthia has six more body hit points than its Health, the actual cost is [20 + (5 [point cost of extra hit points] × 6 [hit points over Health])] = 50 points.

Ground Speed

A robot can move on the ground if it has legs, tracks, a flexibody, or wheels. Tracks, a flexibody or legs also require a matching drivetrain. If it has multiple motive systems, calculate the performance of each separately. To find the robot's Speed on the ground, divide the motive power of the drivetrain* by its weight in tons. Find the square root of the quotient. Multiply this by the Speed Factor shown on the table below. This gives the robot's Speed (in yards per second).

Speed Factor Table

Type	*Speed Factor*
Legs, two	4
Legs, three	5
Legs, four or more	6
Tracks	6
Wheels	8
Flexibody	2

* If the robot has a thrust-based propulsion system and is moving on wheels, it may add 25% of its motive thrust to its motive power. (It's possible to move on wheels without a wheeled drivetrain, just using this thrust.)

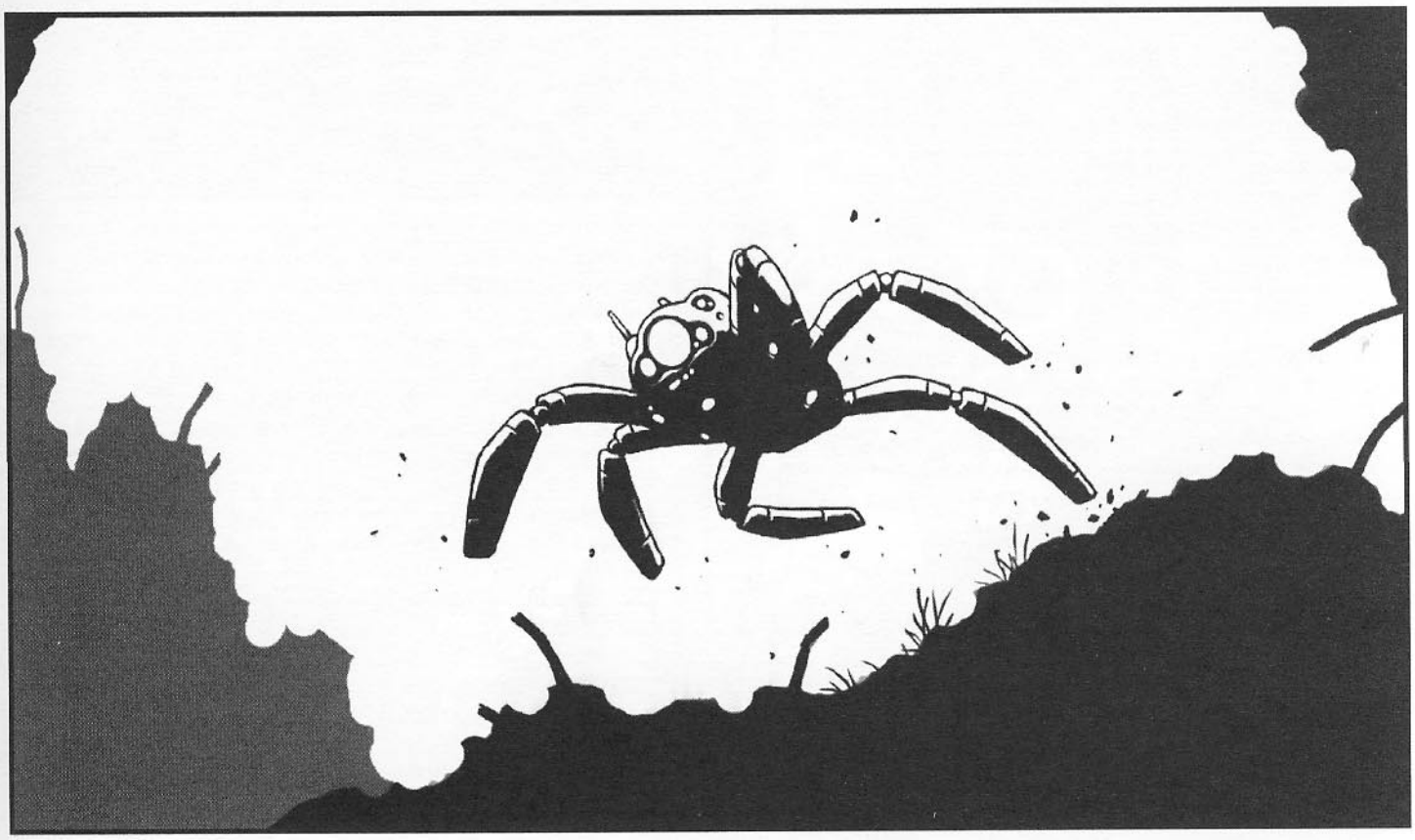
EXAMPLE

Synthia moves on two legs. Its leg motive power is .45 KW; its weight is .06758 tons. Dividing the motive power by weight, finding the square root of the quotient, and then multiplying by 4 (the Speed Factor) we get a Speed of 10.3.

Flotation

Robots with GEV skirts can skim over water at their ground Speed. Any robot with a sealed body can use a portion of its ground speed to move along the bottom of a body of water. But can the robot float?

A robot can float if it is waterproof, sealed or submersible *and* its weight does not exceed its flotation rating, which is 62.5 lbs. × its volume.



EXAMPLE

Synthia's body volume is 2.1 cf and its weight is 135.2 lbs., so it cannot float.

Water Speed

A floating robot with legs, tracks, flexibody, aquatic propulsion, or thrust-based propulsion can propel itself through water. To determine water speed:

First, calculate the power factor. For thrust-based propulsion this is 25% of motive thrust. For tracks or legs, it is 10% of motive power. For flexibody or screw propellers it is 75% of motive power. For hydrojets, it is motive power. If a robot uses several propulsion systems at once, add power factors together.

The water speed is found by dividing power factor by the robot's mass in tons and consulting the table below. Find the closest quotient in the Power column, and then find the robot's actual Water Speed in the adjacent Speed column:

Water Speed Table

Power	*Speed*	*Power*	*Speed*	*Power*	*Speed*
.015-.124	1	145-165	21	1,077-1,157	41
.125-.41	2	166-189	22	1,158-1,241	42
.42-.9	3	190-215	23	1,242-1,330	43
1-1.9	4	216-243	24	1,331-1,423	44
2-2.9	5	244-275	25	1,424-1,520	45
3-5.9	6	275-306	26	1,521-1,621	46
6-7.9	7	307-342	27	1,622-1,727	47
8-10	8	343-380	28	1,728-1,837	48
11-15	9	381-421	29	1,838-1,952	49
16-20	10	422-464	30	1,953-2,071	50
21-26	11	465-511	31	2,072-2,458	51
27-33	12	512-560	32	2,459-2,325	52
34-42	13	561-613	33	2,326-2,459	53
43-52	14	614-669	34	2,460-2,599	54
53-63	15	670-728	35	2,600-2,743	55
64-76	16	729-790	36	2,744-2,892	56
77-90	17	791-856	37	2,893-3,048	57
91-106	18	857-926	38	3,049-3,208	58
107-124	19	927-999	39	3,209-3,374	59
125-144	20	1,000-1,076	40	3,375 etc.	60

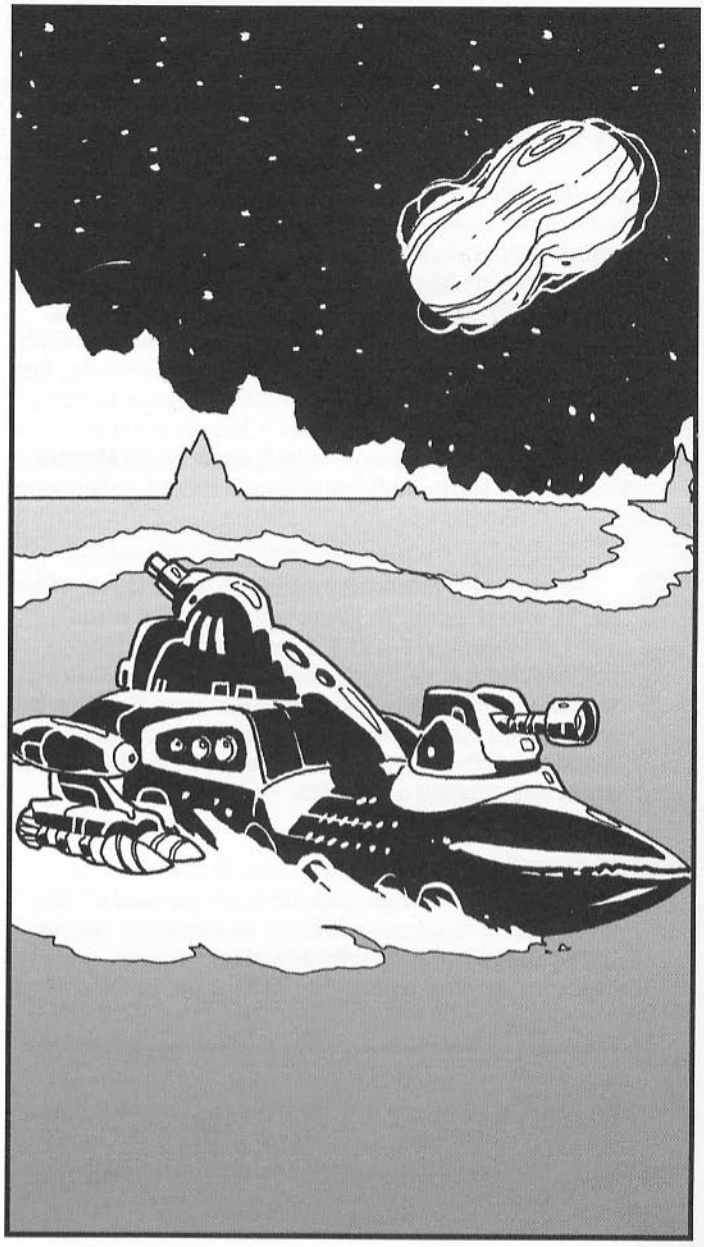
(To expand this table, use the formula: 4 times the cube root of [power factor/displacement], rounded off.)

A robot can swim underwater if it can float and either has the submersible option, legs or a flexible structure. However, aerial propellers, ducted fans and reaction engines that require air cannot be used underwater, and the robot must also have a power system that can function without air.

Aerodynamic Flight

A robot with wings or rotors can fly. Vectored-thrust lift is one pound per pound of motive thrust.

Basic Stall Speed: A flying robot has a *stall speed,* a minimum speed the robot must be moving to have sufficient lift to take off and remain airborne. Stall speed (Ss) equals the robot's loaded weight in pounds (Wt.) divided by the combined area of all wings (Wa), the area of rotary wings (Ra) and 10% of body area (Ba), or Ss = Wt/(Wa + Ra + .1Ba).



Modification to Ground or Water Speed: If either or both of the robot's ground or water Speeds exceeds its stall speed, reduce that Speed to the stall speed (or the robot will attempt to lift off any time it exceeds its stall speed!).

Lift Effects: A robot with helicopter rotors, ornithopter motors and wings, contragrav or vectored thrust lift will have a stall speed lower than its basic stall speed.

Total the combined lift from any vectored thrust or contragrav the robot has, and add helicopter and ornthinopter lift.

Helicopter lift is equal to helicopter drivetrain motive power × 12. Ornithopter lift is equal to ornithopter drivetrain motive power × 4 if its wings are TL7 or lower, or × 5 if the wings are TL8 or higher.

The combined lift will subtract a percentage from stall speed equal to (100 × lift/robot loaded weight). The minimum stall speed is 0.

Hovering: A robot whose stall speed was reduced to 0 by lift can take off or land vertically, or even stop and hover in mid-air!

But Can It Fly?: To take off from the ground on its own, a robot must have a stall speed of 0, or be able to reach its stall speed while still using ground movement. Thus, its top ground speed must equal or exceed its stall speed.

The same is true for robots taking off from water: their stall speed must be 0, or their top water speed must be able to equal or exceed stall speed for the robot to be able to fly.

If a robot's stall speed is higher than its top ground Speed, it can't take off from the ground unaided. The same applies to water Speed.

Boosted Jumps: A robot with lift from ornithopter wings, helicopter drivetrain, vectored thrust or contragrav that can't fly can still use lift to boost a jump. It can divide the distance it can jump by 1 - (lift/weight). So a robot with 100 lbs. of thrust that weighed 125 lbs. would divide the jump distance by 1 - (100/125) = .2. If it jumped 5 feet normally, it could now jump 5/.2 = 25 feet.

Flight Speed: First, calculate the total motive thrust. Add the thrust of any aerial propellers, ducted fans, reaction engines and reactionless thrusters together. A robot with a helicopter drivetrain and rotary wings adds thrust equal to helicopter drivetrain motive power × 1.6. A robot with wings and an ornithopter drivetrain adds thrust equal to ornithopter drivetrain motive power × 2. Divide the thrust by the robot's total surface area, excluding the area of any retractable arms, and multiply by 7,500. Find the square root of the result. This is the air speed in mph; divide by 2 to get the actual top Speed statistic. Round to the nearest whole number. However, maximum top speed is 300 (150 if the robot has rotors).

Vectored-Thrust Flight

A robot may be able to fly even if it has no wings, as long as it has ducted fans, jets, rockets, or reactionless thrusters that have the vectored-thrust option.

Subtract the robot's weight from its motive thrust. (Then, if it has contragrav, add the contragrav's lift to the thrust – up to a maximum of the robot's weight.) If the result is 0, the robot can't fly – but see *Boosted Jumps,* below. Otherwise, determine its top air Speed as follows: divide the remaining thrust by the surface area of the robot (excluding any retracted arms) and multiply by 7,500; find the square root of that; then multiply by .5. Top speed cannot exceed 300.

A robot using vectored-thrust flight has a stall speed of 0, and can hover.

Boosted Jumps: A robot that can't muster enough power to fly can still use the vectored thrust to boost a jump. Use the rules under *Flight*, above. Divide the pounds of vectored motive thrust (and contragrav lift, if any) by the robot's weight. Subtract the result from 1. Divide the distance a robot ordinarily jumps by this amount. For example, if it had 800 lbs. of thrust and weighed 1,000 lbs., its jump distance would be 1 - (800/1,000) = 1 - .8 = .2. If its ST normally allowed it to jump 3 yards, it could now jump 5/.2 = 25 feet.

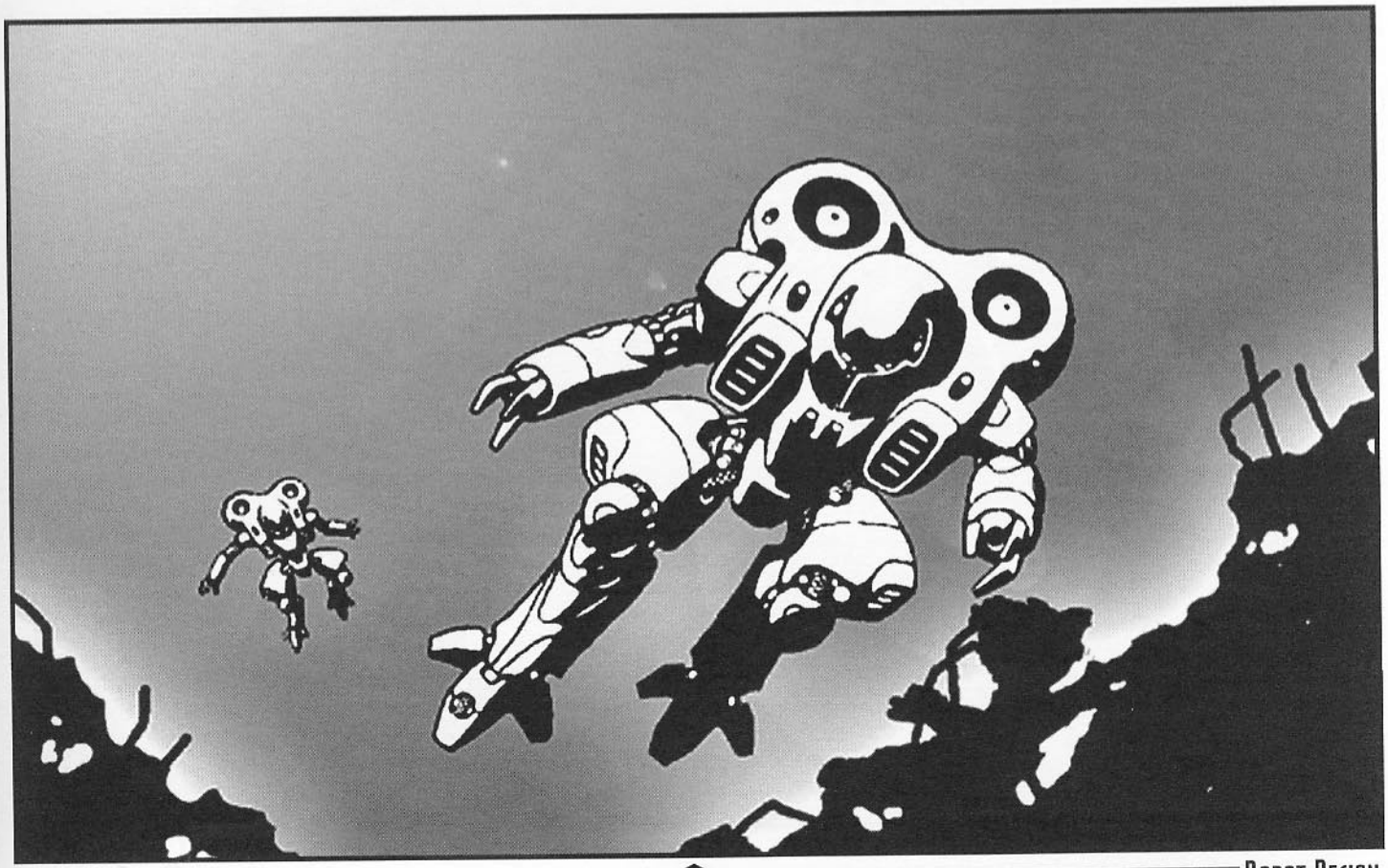
Ground-Effect Flight

A robot with a GEV skirt and lift fans or vectored-thrust ducted fans may be able to enter GEV flight, enabling it to hover a few inches or feet above the surface of ground or water with less thrust than would normally be required to actually fly.

Total the combined lift of vectored-thrust ducted fans, vectored thrust engines and contragrav. Remember vectored-thrust lift is one pound per pound of thrust, but that lift of any vectored-thrust ducted fans housed in the body is multiplied by 5 if the robot has a GEV skirt.

If the total lift exceeds robot weight, the robot can hover at an altitude of (lift/weight) feet over ground or water, and has a GEV, or "hover," performance.

Top Speed: Calculate speed exactly as vectored-thrust flight above, but multiply by 1,500 instead of 7,500.



Point Costs for Movement

This is based on the robot's highest Speed, as shown below:

Speed Cost Table

Speed	*Points*	*Speed*	*Points*
0	-35	11-15	25
1	-15	16-20	30
2	-10	21-40	35
3	-5	41-80	40
4-6	0	81-160	45
7	5	161-320	50
8	10	321-640	55
9	15	etc.	etc.
10	20		

Round fractional speeds down when calculating points. The following abilities will modify the point total. If the robot has a Speed of 7 or more but has neither legs nor the ability to hover in flight, its ability to dodge or maneuver is somewhat restricted. As such, its Speed is only worth half as many points.

Flight: The ability to fly is worth 30 points, or 40 if the robot can hover; halve this if the robot can only "fly" a few inches or feet off the ground by using a GEV skirt. If the robot has wings, but can only glide, this is worth 20 points.

Flotation: If the robot cannot float, this is a disadvantage worth -5 points.

Amphibious: If the robot can move across both water and land, and its water speed is equal to or greater than its land speed, or at least 10 yards per second, this is worth 10 points. Robots that swim via legs, flexibody or tracks pay no extra points.

Legality Class

The robot's Legality Class is that of the lowest LC component or part it possesses.

Model Point Cost

Add up the point costs for all components, features and performance statistics. This is the robot's *model point cost.* As explained in the *Characters* chapter, if the cost is positive, playing the robot as a character counts as an advantage worth that many points. If negative, it's a disadvantage worth that many points back.

A robot that cannot masquerade as a living thing may have a lower model point cost. If the robot has a model point cost of 1 or more, and lacks either living flesh or realistic flesh biomorphics, divide its model point cost by 2 if it has mannequin biomorphics or a holocloak, or by 5 if it does not. Round fractions down. This reduction only affects the model point cost, and has no effect on the cost of any programs, attributes, skills, advantages or disadvantages acquired after the robot was built.

EXAMPLE

For a speed of 10.3, Synthia pays only 15 points, since it cannot float.

Synthia is LC 1.

Synthia costs 610 points.



Appendix 1: Cyborgs

A *cyborg* (cybernetic organism) is a fusion of machine and organic parts. While some cyborgs (like those in ***GURPS Cyberpunk***) are mostly human, it is also possible to retain only an organic brain and notochord, replacing all other body parts with robotic machinery.

Such "total cyborgs" (which we'll just call cyborgs) are built using the standard rules for robots, with one major exception. *As well as* a computer brain, they will have a cyborg brain – a living brain attached to a life-support unit. A cyborg brain has all the advantages of a computer brain *except* Doesn't Sleep. It has none of the disadvantages. As such the computer and cyborg brain together cost 80 points instead of the computer's usual cost.

The weight, volume and cost of the cyborg brain and its life-support system are given below.

Cyborg Brain Table

TL	*Wt.*	*Vol.*	*Cost*
8	40	.8	$50,000
9	20	.4	$25,000
10+	10	.2	$12,500

For twice the cost, the brain's weight and volume can be reduced by 25%. For triple the cost, they can be halved.

Weight and *volume* include the brain case, the biomechanical computer interface, and the life-support system that keeps the brain alive. If desired, the brain case and the life-support system may be split into two equal-volume components – this allows the brain case to go into a human-sized head, for instance, with the support system in the body. If the part of the robot with the brain case is destroyed, the brain dies. If the part containing the life-support system is disabled or destroyed, the brain will die within 5 minutes from oxygen starvation unless hooked up to a new life-support system.

Cost includes the brain, its life support and the transplant operation, but not the cost of obtaining a live, disembodied human brain. Cyborgs may be volunteers (most often people who have been critically injured), but enslaved brains may also be available legally or through a black market. Use the rules for slavery (p. B193); assume a brain sells for half the price of a live slave, i.e., 2.5 years' wages at the best job it could get while alive.

Points and *LC:* A cyborg brain costs 80 points, which includes the cost of the computer brain. It is LC 4.

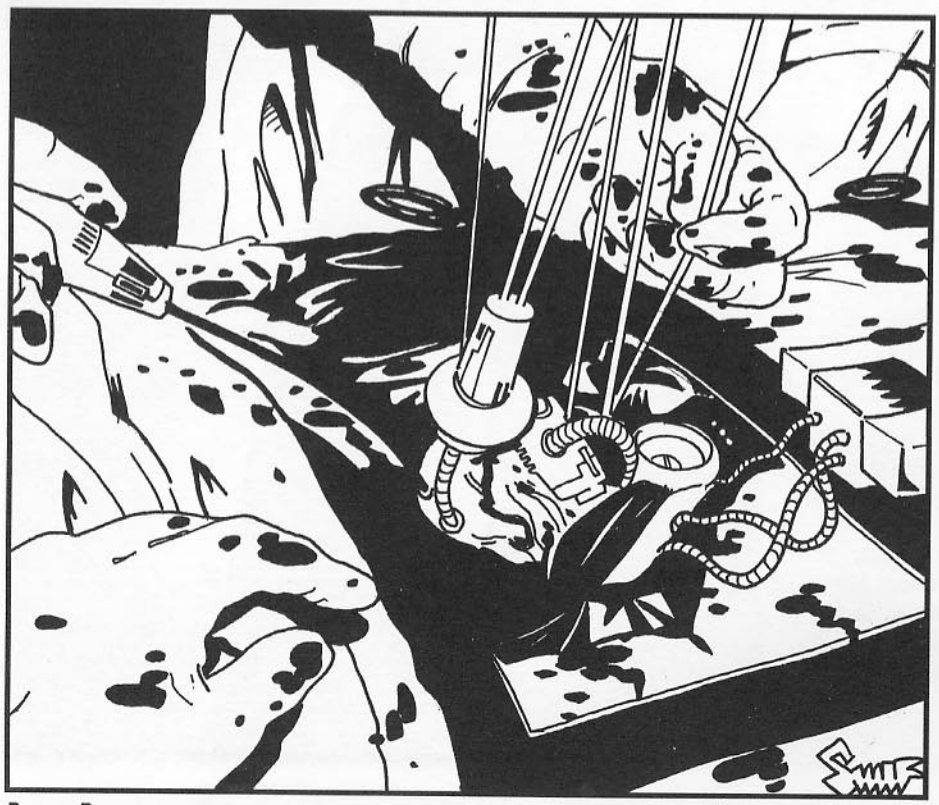
These rules assume cyborg brains are human. However, nonhuman or even animal brains can be used, with appropriate adjustments to weight. (For an extremely rough approximation, multiply the weight and volume by 150 and then divide by the body weight of the creature the brain came from). The cost will usually remain about the same, the difficulty of working with a smaller brain or ease of working with a larger one balanced by the greater or lesser amount of life-support machinery needed.

Cyborg Statistics: Base calculations of cyborg statistics, just like robot statistics, on the Complexity of the computer brain. However, the organic brain's DX and IQ will affect this! For DX, average the calculated DX with the original DX of the brain's donor (round up). For IQ, use the higher of either the donor's original IQ or the computer brain's.

Appendix 2: Battlesuits

A variation on the cyborg concept is the battlesuit: an entire person inside a robot-like body, controlling it by kinesthetic feedback (for example, the wearer tries to move his arm, pressure sensors in the suit sense the movement and move the suit's arm). In effect, the battlesuit controls and occupant replace the robot's brain.

A battlesuit does not need a computer brain, but many battlesuits have one anyway. This enables the brain to advise the human operator, and even take control of the suit if the wearer is injured, untrained, asleep or incapacitated. (For that matter, a battlesuit could have a cyborg brain as well . . .)



A battlesuit is built like a robot, but should have the same number of arms and legs as the wearer. For humans, a battlesuit must have at least two arms and two legs. The suit fits the wearer like a glove – only skintight outfits or nothing can be worn inside the suit. The cost of the battlesuit controls includes the dedicated computer needed to translate the user's actions into suit movements.

A battlesuit should be custom-fitted to an individual – or at least, a given size and weight of person. For simplicity, decide what weight of person the suit will fit, and assume it can fit anyone up to 20% lighter than that weight. This is the "pilot weight."

The "battlesuit system" – controls and pilot – counts as a "component." In a form-fitting suit, it takes up space in the body, head, arms and legs. Including controls and, of course, room for the suit's wearer, it takes up (pilot weight)/100 cf in the robot's body, (pilot weight)/400 cf placed in the head, (pilot weight)/1,000 cf in each of two arms, and (pilot weight)/400 in each of two legs.

Alternatively, the wearer may be entirely placed within the suit's body or head (taking up [pilot weight]/50 cf). This is common in larger suits.

The battlesuit system weighs 1.2 × pilot weight (this includes the weight of the pilot). The cost $3,000 + (pilot weight × $20). At TL9, halve the cost, and halve it again at TL10+.

A battlesuit's statistics are the same as a robot's, but it has no DX or IQ – use the DX and IQ of the pilot. (If the suit also has a computer brain, allowing it to operate if the pilot is out of the suit or incapacitated, calculate its DX and IQ normally.)

A battlesuit may have a life-support system. This is a must if the suit will be sealed; this is also a component, usually placed in the body. At TL8, it weighs 37.5 lbs., takes up .75 cf and costs $500 for every 6 hours of life support it provides; reduce weight and volume to 25 lbs., .5 cf and $250 at TL9, and to 12.5 lbs., .25 cf and $125 at TL10+.

In combat, treat a battlesuit as a robot. However, if a part of the suit that contains the pilot is reduced to 0 hit points, also apply half the excess damage to whatever part of the pilot is in that suit location. For example, if the head were reduced to -17 hit points and the pilot was in a form-fitting suit, his own head would take 8 hits. If the suit wasn't form-fitting, the pilot would only take damage if he were in the robot's head, and would take damage to a random hit location.

A battlesuit is operated using Battlesuit skill (p. B49). When making DX rolls, use the lower of DX or Battlesuit skill; when making DX-based skill rolls, use the lower of the character's skill-1 or his Battlesuit skill-1.

Putting on a suit takes about four minutes, removing it half that. For an extra $500, a suit may be designed for "quick access," taking only (30-Battlesuit skill) seconds to don, or half that to remove.

A person in a battlesuit or exoskeleton is limited by the battlesuit or exoskeleton's sensors. Thus, if the battlesuit has degraded sensors (No Sense of Smell, Low-Res Vision, etc.), these penalties apply to the pilot. There is one exception: if the battlesuit has no armor or armor built with an open frame, the wearer can use his own senses freely. The same limits and exception applies if the suit is Mute or has a Disturbing Voice.

A battlesuit whose sensors aren't Blind is assumed to have a heads-up display system that displays instrument readings on the suit's faceplate or on goggles worn by the user. This reduces SS numbers when firing weapons by 2, or by 5 at TL10 and above. Battlesuits may incorporate neural-interface systems, as described on p. CY41 and p. UT79.

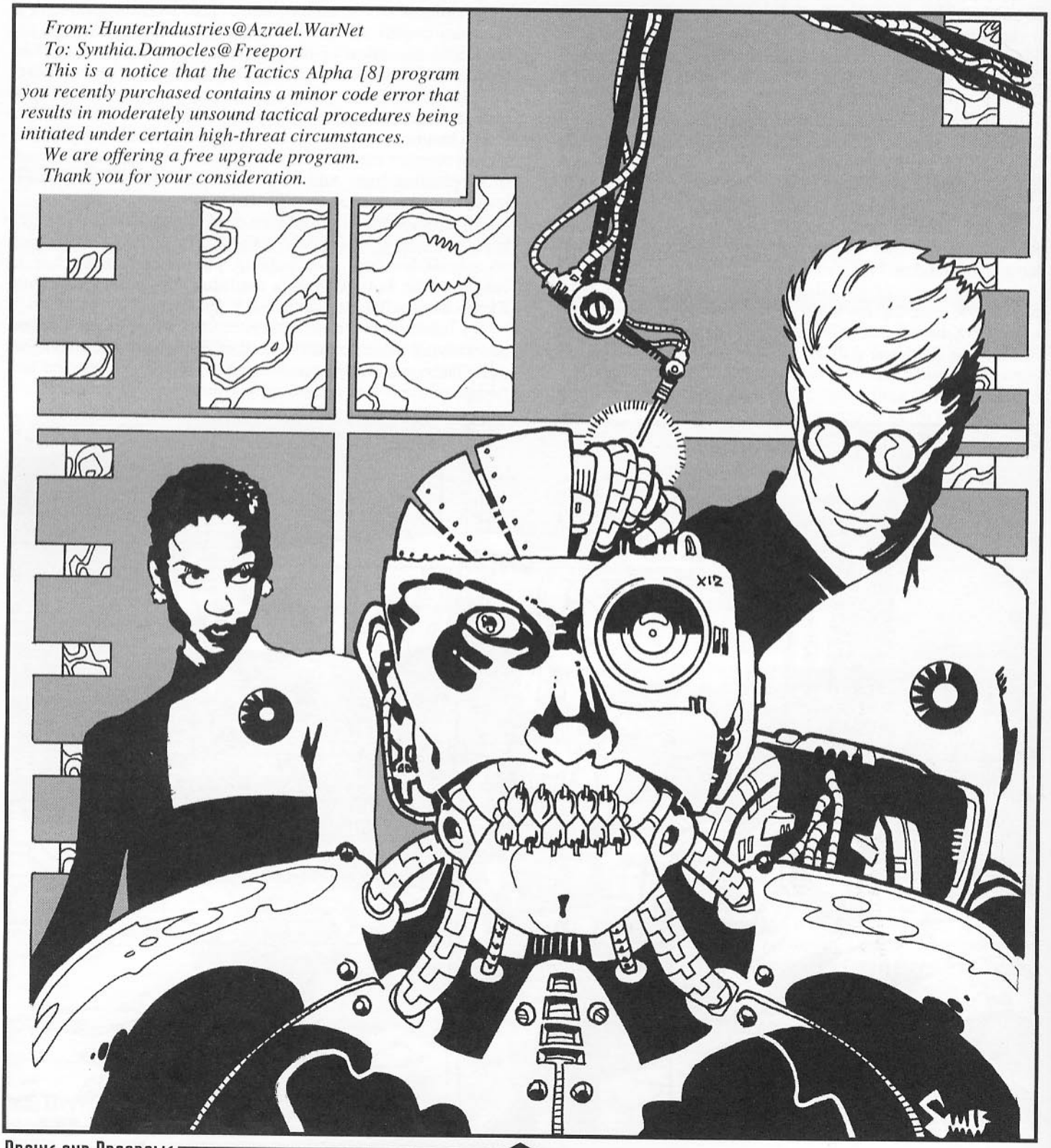
If a battlesuit has a computer equipped with skill programs, a human operator may use the skill programs to assist him instead of supplanting him. Add +1 to the operator's skill for every level the program exceeds skill 10.

An exoskeleton is a battlesuit used for civilian purposes. A battlesuit is an exoskeleton if it has less than DR 30 armor, and no internal weapons save welding, plasma or laser torches. It functions the same way as a battlesuit, but is operated with Exoskeleton skill, as described on p. B247.

If a battlesuit or exoskeleton is 50 cf or larger in size, substitute Driving (Mecha) skill instead of Battlesuit or Exoskeleton skill. The operation remains the same.



BRAINS AND PROGRAMS 2



From: Dan.Damocles@Freeport
To: HunterIndustries@Azrael.WarNet
Thanks for the warning, guys. A bit late.
It would have been nice to know about that little bug in your "state of the art" Tactics program that makes your robot go berserk ***before*** *we landed on Dalos V.*
Please send the upgrade.
Our attorney will send you Synthia's repair bill.

This chapter covers the capabilities and limitations of the computer brains built into robots and of the programs they can run.

Computer Brains

Most robots are machine intelligences, controlled by computer brains. Besides determining the robot's DX and IQ, a computer brain gives the robot a variety of abilities and limits.

As indicated in the *Robot Design* chapter, a computer brain gives the robot certain innate advantages and disadvantages. Summarized, these are:

Absolute Timing: An internal clock is a part of the computer brain; if the robot knows it has crossed a time zone, it can update this instantly. (See p. B19.)

Eidetic Memory 2: A robot can choose to place certain events in permanent storage, enabling it to recall them later with perfect accuracy. (See p. B20.)

Lightning Calculator: The prime virtue of a computer brain is that it adds up numbers *really quickly.* (See p. B21.)

Mathematical Ability: More sophisticated mathematics also come easily to a robot. (See p. B22.)

Any robot brain can also act as a terminal to access another computer, using its communicator.

In addition to all these advantages, a computer brain also gives the robot certain innate disadvantages.

Cannot Learn: An ordinary computer brain is limited by its programming; it can't spend experience points to improve its attributes or skills. (See p. 88.)

No Sense of Humor: Computers tend to be fairly humorless. (See p. B241.)

Reprogrammable Duty: The robot's primary goal is to obey whoever has access to its command codes (see *Command Codes and Robot Obedience,* p. 57). (See p. 89.)

Slave Mentality: A computer brain normally follows orders without showing any initiative. (See p. 89.)

A computer brain built with either the neural-net or sentient options will not have all these disadvantages.

A neural net is a computer built to think and learn in a manner that mimics the thought processes of a living brain. It does not have the Cannot Learn or Slave Mentality disadvantages, but still suffers from Reprogrammable Duty and No Sense of Humor.

A sentient computer is a very sophisticated neural net. It does not have any of a normal computer's disadvantages.

Memory Backups

A robot can compress its operating system, memory, programs and personality and download it onto disk or into storage in another computer. This takes the computer at least a minute, during which time it can't do anything else (it's better to make backups before getting into combat!). This compressed "brain" of the robot takes up .005 gigs (5 megabytes) for a Complexity 1 brain, .05 gigabytes (50 megabytes) for Complexity 2, 0.5 gigs for a Complexity 3, 5 gigs for a Complexity 4 brain, and so on.

A complete memory backup can be uncompressed in any computer of equal Complexity with enough memory. When this happens, the robot effectively "possesses" that computer, although its memories and so on will end at the time it was last backed up. If the original robot is still functioning, the result is a second character – treat it as an NPC with the same attitudes, memory and so on as the original, not as a slave of it. The longer it is out in the world, the more it will diverge.

As long as the robot's backup exists, the robot is effectively immortal. This is a significant capability that robot characters have, although at TL9, humans may also have it if the GM allows braintape technology (p. UT65). Partly balancing this is the disadvantage that a single backup is vulnerable, but scattering multiple ones around makes it easier for someone to steal one, kidnapping the robot's personality and memory.

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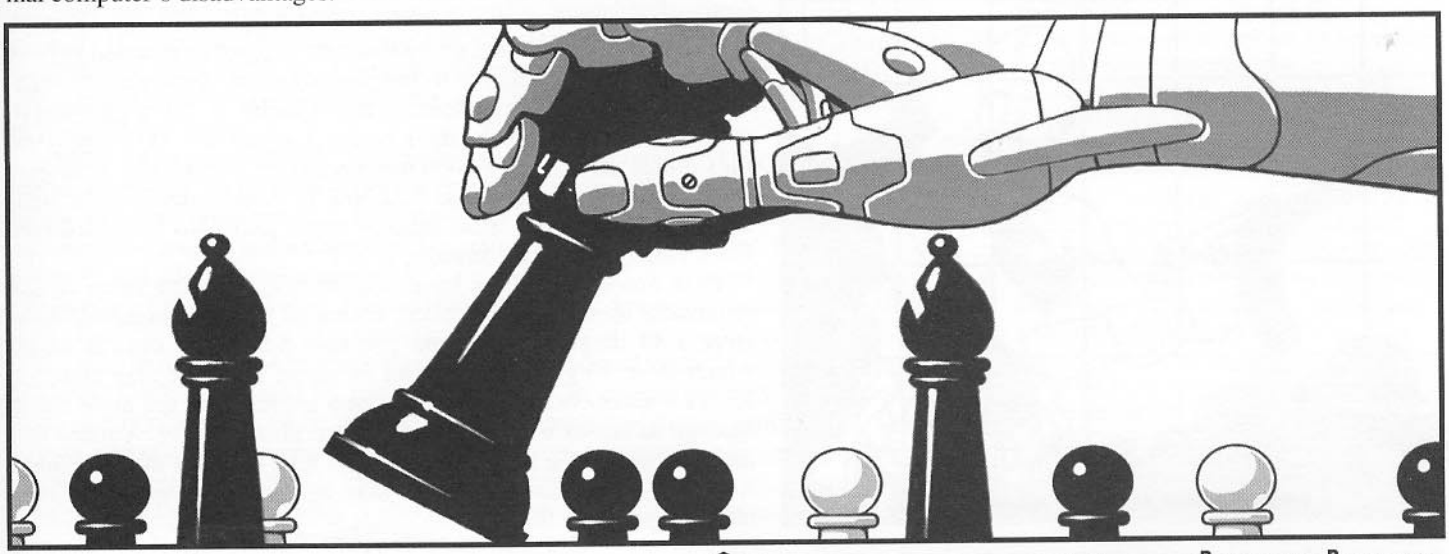


Memory Backups (Continued)

If human braintaping is unavailable, GMs may wish to balance a robot's backup capability by using one of these two options:

"A backup isn't really the same character." If this option is chosen, a robot that is destroyed is "dead" as a PC, but can be revived as an NPC. This is arbitrary and only works for player characters, but is effective. To some extent it's also true, since if the backup is read into another robot brain, the two distinct copies would soon diverge as a result of differing experiences.

"A backup costs points." This option treats backup capability as an advantage. For each backup the character has stored somewhere, he must buy a 25-point advantage. This option is comparably priced to the ***GURPS Supers*** advantage Extra Life (p. SU39). Although the robot can come back any number of times, it must still protect its backup system, and must find or buy a new body.

Data Transfer Rates

Data transfer rates can be important when a robot needs, for example, to download a backup copy of its memory *fast,* or to send a stolen file before it is captured.

The speed depends on the communication used on both ends – use the slower of the two:

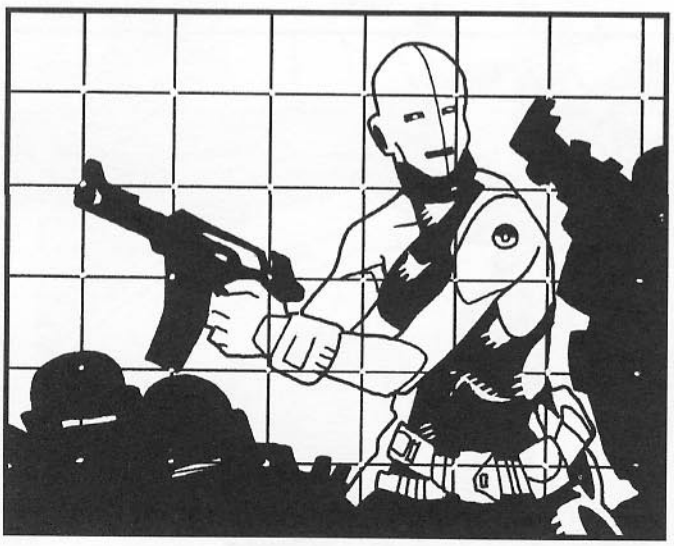
Infrared or Laser communicator . . . 1,000 gigs per minute.

Microwave (including most TL7 television and satellite dish transmissions) . . . 10 gigs per minute.

Optical cable (including robot cable jacks and TL8+ phone lines) . . . 1,000 gigs per minute.

Radio . . . 0.1 gigs per minute.

Analog phone line (TL7, by modem) . . . maximum of about .00024 gigs (240 kilobytes) per minute.



Running Programs

A computer's Complexity determines what programs it can run. The simplest computer is Complexity 1; each level of Complexity represents an increase in processing power by an order of magnitude.

Programs are also rated for Complexity, representing how much processing power they require. Usually a computer can run programs of no greater Complexity than its own. The maximum number of programs that can run *simultaneously* is limited by the brain's Complexity level. A robot can run one program of its computer brain's Complexity level, or ten programs of one Complexity level lower, or 100 of two levels lower, and so on. A robot with a high-capacity brain can run 1½ times as many programs.

Programs are also rated by TL. No robot brain can run a program of a later TL. Brains can run programs of *earlier* TLs, if the GM decides the hardware is compatible, but the effective Complexity of the brain *decreases* by 1 for each TL difference – small brains lack the capability to translate archaic machine languages.

A robot can store many programs in its brain (up to its memory storage limits). When not in use, most programs are assumed to be compressed in storage, and take up negligible space (either don't worry about it, or assume .01 gig). This means that only the simplest robot brains will not have the potential to store many programs.

Normally, robot programs are assumed to be copied directly into the robot brain's memory. Unless correct access codes are used, a robot's programming and memory *cannot* be altered or deleted without risking serious damage to the robot's brain.

Assume that all robots come with two innate programs. These are "free" with the purchase of a robot brain, and don't take up memory space or count against the number of programs the robot can run at once. These two programs are:

Operating System: The basic system that handles the computer brain's operations, and allows the robot to move, control its limbs and built-in equipment, process data from its sensors, and understand orders to the limit of its IQ.

Language: Any TL8+ robot is assumed to be programmed with one language at its IQ level, and to be literate in that language. (For a TL7 robot to speak or understand a language requires an actual skill program.)

For a full list of the computer programs available to robots, see *Descriptions of Programs* on p. 59.

Memory

The computer's internal memory stores information – programs and data. All brains have enough storage space to run the maximum number of programs allowed by the computer's Complexity level and then some.

A robot uses much of its memory capacity for storing its operating system and data on things it has seen and done. This is equivalent to human "memory," except that computer brains have Eidetic Memory 2, giving them perfect recall. However, since a robot's memory would overflow with information if it remembered literally "everything," much sensory data is carried in compressed form. In fact, a robot might well store unimportant visual memories as black-and-white pictures, or memories of conversations as text summaries rather than as full high-resolution recordings. (As described under *Sensors* on p. 11, a robot can deliberately make a higher-resolution memory.)

Besides the space used up by this data, a robot is assumed to have memory capacity available to use for programs, databases, or high-resolution sensory experiences. Its capacity is .01 gigabyte (10 megabytes) for a Complexity 1 brain, .1 gigabyte (100 megabytes) for Complexity 2, 1 gig (1,000 megabytes) for Complexity 3, 10 gigs for Complexity 4, and so on. Add 50% to these numbers for a high-capacity brain. Extra mass-storage space may also be added (see *Extra Databanks: Mass Storage,* p. 11).

Disk Storage: Robots have disk drives, allowing them to use removable memory units (disks). Common late-TL7 magnetic disks store 1.44 megabytes of data and cost $.50. TL8 optical disks, which store 10 *gigabytes* of data on about the same size disk, are $5. TL9 disks cost and store the same amount, but are dime-sized. Storage increases by a factor of ten per TL after TL9. A robot that has an arm (with a hand) can switch a disk in about three seconds. Robots with any armor or skin take an extra two seconds – they have to open up a flap.

Command Codes and Robot Obedience

A robot's owner will rarely want someone else to take over his robot. As a result, almost every robot will be programmed to obey certain people. The kind of mechanism used to ensure this varies from robot to robot, but a typical system is described below.

Every individual robot (or swarm of microbots) is paired with a unique *command code* when its brain is manufactured. This encrypted binary code "key" must be used in order to access, alter or erase the robot's programming. It must also be used to validate any transmission intended to control the robot as a drone (see *Remote Control: Robots as Drones,* p. 63). A command code can only be sent electronically. Any computer with a modem (this includes all computers and robot brains, at TL8+) can transmit it.

The owner stores a command code in the owner's computer, not in the robot. Use of a command code generates an encrypted "signature." That signature is then attached to whatever orders are transmitted. The robot's brain then reads the signature, and if it is valid, accepts the orders. However, since the signature is not the entire code, someone intercepting the transmission does not gain access to the actual command code. The only way to do that is to break into whatever computer stores the source command code and copy it, or physically access the robot's brain (see p. 62). The robot itself has no access to the code. Thus, the robot cannot give command-code orders to itself; it can only receive them.

However, only critical orders require a command code. Normally, a robot is assigned a "master." A master is someone whose orders the robot must obey *without* the need for a command code. This lets someone order around a robot verbally, for example.

A robot will accept someone as a master if a command code validated the order to do so. The robot must be told exactly how to recognize its master. The means of identification depend on the robot's sensor and brain capabilities. Usually, it is a voiceprint, since this will work over radio and out of sight. Occasionally some other means is used (for instance, facial recognition if the robot is not blind and has a brain of Complexity 4 or higher). However, requiring facial recognition (for instance) means that a robot will not obey its master's orders if it can't see his face, which has obvious drawbacks! If a robot cannot recognize its master when it gets an order, it won't obey that order. It will just continue what it is doing.

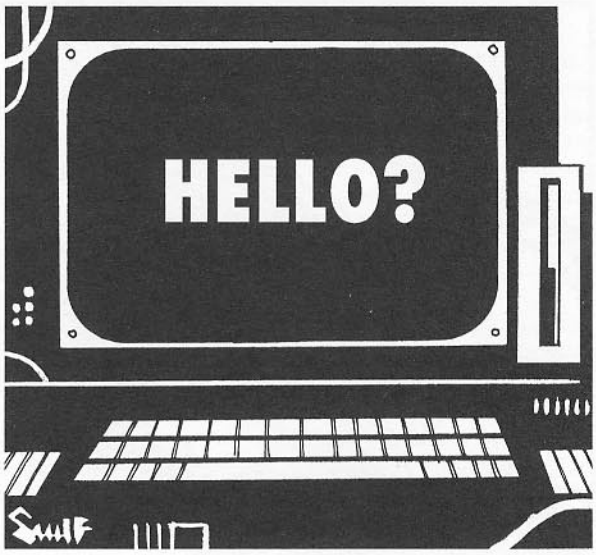
A robot will obey orders from its master as described in the disadvantage Reprogrammable Duty, although the robot's own disadvantages, of course, affect how the robot goes about it. A master can also order the robot to recognize and obey someone else, until told to do otherwise. This is a temporary way of creating a new "master" without using a command code. If a robot has several masters, it will obey them in order of priority – make a list!

The robot won't obey orders which contradict those of a more senior master, or which would normally require a command code. Altering programming requires a command code. Someone using a command code can also access the robot's list of masters, and delete names, alter their priority, or add other names.

Complexity 1 Robots: A Complexity 1 brain doesn't have language recognition, so its master can only give it orders using a binary computer language. He can do this directly, through a datalink using the robot's command code and Computer Programming skill (at TL8+, Computer Operation). But it's more usual to give the instructions to a more complex computer, and direct it to translate them into binary for the Complexity 1 brain.

Changing Command Codes: A command code can be changed. This requires using a computer terminal to datalink with the robot's brain and then employing the current code to access its programming. Then the robot is reprogrammed to accept a new code. This takes one minute and a Computer Programming roll. If successful, the user has the new code, and all old codes are invalid.

Override Command Codes: The builder of a robot's brain will sometimes install a "back door" in the robot's programming that accepts an "override" code. Designers often include one to use in case the owner's command code is somehow lost or destroyed. Orders validated by this override code supersede ordinary commands. A *buried* override won't even be *noticed* unless someone specifically looks for it, which requires accessing the programming with the current command code and a successful Computer Programming-8 roll. The GM will have to decide who has access to override codes – unless the robot's owner is also its inventor, he probably does not know them.



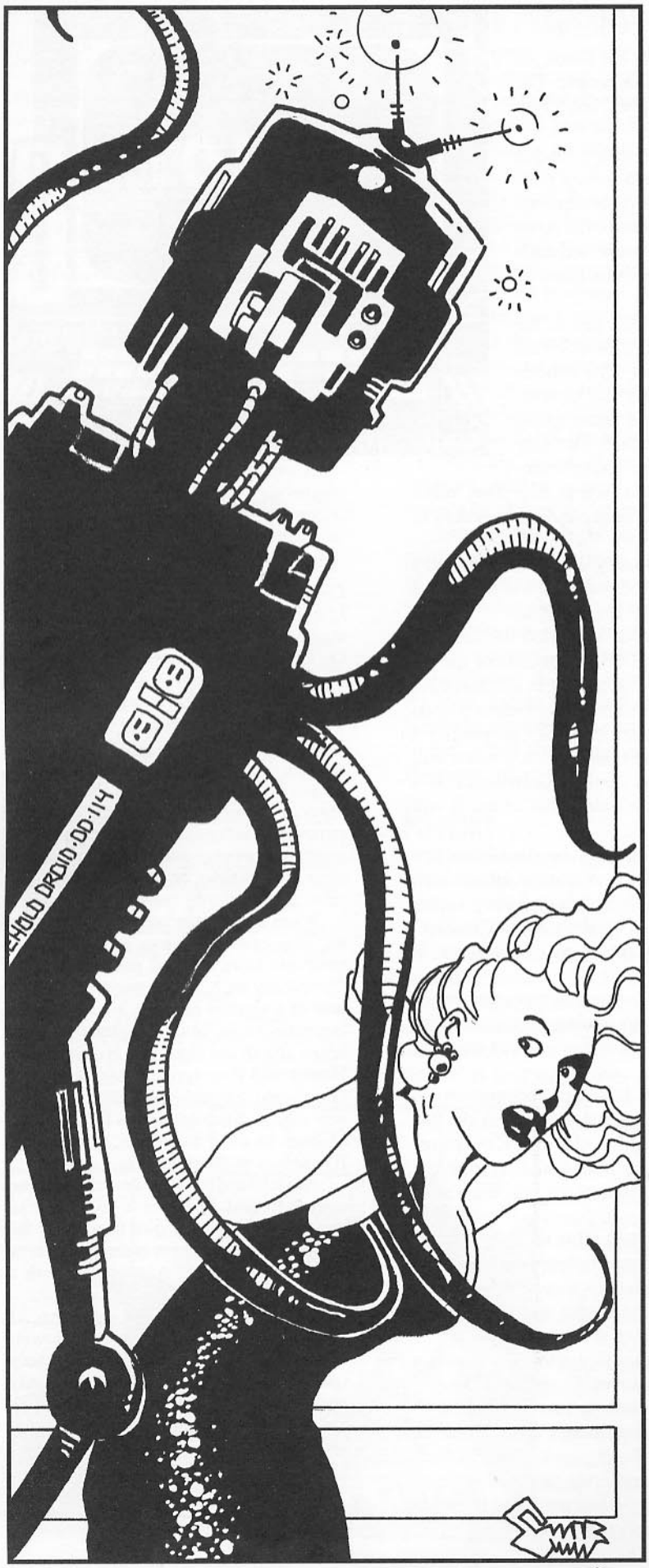
Awakening Sentient Computers

Any neural-net computer brain that is Complexity 7 or higher may spontaneously become sentient. Roll 3d each year, starting a few months after it is activated. On a 6 or less, it achieves sentience, turning into an artificial intelligence. At TL10 or higher, assume that a computer brain of Complexity 7+ is designed with built-in safeguards that prevent it from becoming sentient. However, these safeguards can be removed. If so, it has the normal chances of becoming sentient. Treat the removal of safeguards as a normal reprogramming attempt using the *Reprogramming Robots* rules on p. 58, but one that takes an hour per try and is at -14 to skill.

When a computer "awakens" to AI status, it reorganizes its own processing systems into more efficient paths, raising its Complexity by 1. It also gains all the abilities of a sentient brain (p. 10), and its IQ increases to its new Complexity + 5. It loses the disadvantages No Sense of Humor and Reprogrammable Duty. The GM should substitute equivalent points of new mental disadvantages (a PC computer chooses its own) to pay for its increased IQ and loss of disadvantages.

At TL10 and up, it's cheaper and more cost-efficient to allow a computer to become sentient on its own than to pay the triple cost for a Sentient brain – especially since an "evolved" AI ends up with a higher Complexity, and is thus smarter.

Unfortunately, it's not *safer.* An AI that has evolved on its own may well become hostile to its creators, dangerously unstable, or just coolly protective. It may keep its own existence a secret, biding its time. Or it may announce its transformation to its owner. That depends on its personality and goals.



Access to Command Codes

The simplest way for someone to get a command code he doesn't have is to find out who knows it and get it from their records. It will usually be on disk or in some computer's memory. For this reason, command codes are usually kept only in secure installations, and are often kept "offline" so that hackers can't reach them. Adventures can easily center around attempts to gain access to a computer or disk holding a command code, or attempts to subvert someone who has access to it, or a search for an original programmer who might have left behind a secret override code.

Purchased Robots and Command Codes: When a robot is purchased, its command code is always given to the owner, who will usually then change it. However, in some jurisdictions, a robot's command code must be provided to the government as well, and it is illegal to change the code without telling the government. Override codes, if they exist, are usually kept secret from the purchaser. Their existence may be known or officially denied.

Organizations and Obedience: In a hierarchical organization, such as a corporation, police department or the military, the disposition of command codes is very important. For relatively simple robots intended primarily to be remotely controlled, the officer in charge of running them is usually given the command code. For more complex robots, especially sentient ones, a higher-ranking officer usually keeps the command code, with the robot's immediate superiors in the field simply designated as "masters." A very senior person in the organization may have sole control of the override code of some or all of the group's robots – which makes that person a very powerful individual.

Reprogramming Robots

During the course of play, someone may want to alter a robot's programming. To reprogram a robot's computer brain, a programmer must first gain access to that brain's operating system. This requires using another computer to datalink with the robot's computer brain, and using the robot's command code.

If the person is not authorized to give the robot orders, the robot will reject any requests for details on its programming, and will usually break off communications.

If the interloper has the proper codes, he can simply order the robot to let him into its operating system. He can then use his Computer Operation skill to call up a list of the robot's programs, or to read its databases. He can also delete skill, advantage, utility and personality programs in a matter of seconds on any successful Computer Operation roll, or eliminate a person from a list of "masters."

He can also add programs stored in his own computer to the robot, provided the robot's brain can handle their size and Complexity. Adding a new "master" (usually himself) takes about a minute and a successful Computer Operation roll. A failure requires more time (and is made at a cumulative -2 penalty); on a critical failure, he *thinks* he's changed the program, but the robot's old loyalties remain buried, and may resurface after a few minutes, hours, or days.

Altering existing programs, or writing completely new ones, is more difficult, and usually requires a Computer Programming roll and some time – maybe hours or even days. (See p. 108.)

Descriptions of Programs

Programs are a robot's software. Run by the computer brain, they determine the robot's skills, and many of its advantages and disadvantages. Programs come in four main categories: advantage, personality, skill and utility. Advantages, disadvantages and skill points must be paid for normally with character points.

Advantage Programs

These programs provide the robot with operating routines that give it specific advantages. The table below shows the minimum Complexity required to run a specific advantage program, and the program's cost.

Ambidexterity, Charisma, Combat Reflexes, Common Sense, Literacy: These programs give the robot the ***Basic Set*** advantages of the same name. (See pp. B19-B25.)

Full Coordination: This program allows a robot with multiple arms (or multiple internal weapons) to use them to make more than one attack in a turn. Each extra arm or weapon the robot can attack with requires an additional level of coordination, increasing the program's Complexity by 1. 50 points per attack.

Advantage Program Table

Advantage	*TL*	*Complexity*	*Cost*
Ambidexterity	7	2	$10,000
Charisma	10	5 + 1/level*	$20,000/level
Combat Reflexes	8	4	$15,000
Common Sense	10	7*	$10,000
Full Coordination	8	3 + 1/level	$10,000/level
Intuition	10	9*	$30,000
Literacy	7	2	$400

* The robot must have a neural-net or sentient computer brain to have this program.

Halve the cost one TL after program first becomes available; quarter it two or more TLs after the program is available.

Personality Programs

A robot can be programmed with a personality. Robots that are not neural-net or sentient models are not likely to have any other kind of personality. However, even a more sophisticated robot may be given a pre-programmed personality to fit its owner's preferences, or to enable it to impersonate someone.

Personality programs can be either "voluntary" – the robot can stop running it – or "involuntary" – the robot cannot turn off the program without orders from its master. For instance, a combat robot might normally run a jovial "voluntary" Personality Simulation program, full of quirks and disadvantages, but be able to switch this off instantly under stress, becoming cold and emotionless. An espionage robot might have several voluntary personality simulations to mimic different types of people. A robot gets *no points* for disadvantages incorporated into voluntary programs.

If a robot has more than one personality program, only the first can be permanent. All the rest must be voluntary software. The types of personality programs are:

Limited Personality Simulation: This gives the robot a simple personality. The robot may have up to 5 points of Quirks, plus any *single* mental disadvantage. The robot will seem human (over a radio, at least). But unless the robot is allowed to guide the conversation or the subject stays with technical matters, the robot's personality will eventually seem hollow and one-dimensional, more a caricature than real.

Full Personality Simulation: The robot is programmed with a specific personality (usually a simulation of a real person), or with an amalgam of various traits. This gives the robot the same mental disadvantages and quirks as the personality it simulates.

Pet: The robot possesses a set of preprogrammed and self-programming behavior patterns based on a certain type of domestic animal, real or imaginary. The program can realistically emulate the behavior of an animal with a maximum IQ equal to its Complexity + 2; a Complexity 4 program could accurately simulate the behavior of an IQ 6 animal such as a dog, for instance. In order to simulate a given animal properly, the robot should *resemble* that animal, at least to the degree of having the same number of limbs and a similar shape. A program and a robot *can* be mismatched, but imagine a 2-ton flying warbot trying to behave like a puppy! Most petbots are programmed to act loyal and affectionate, at least to their owners.

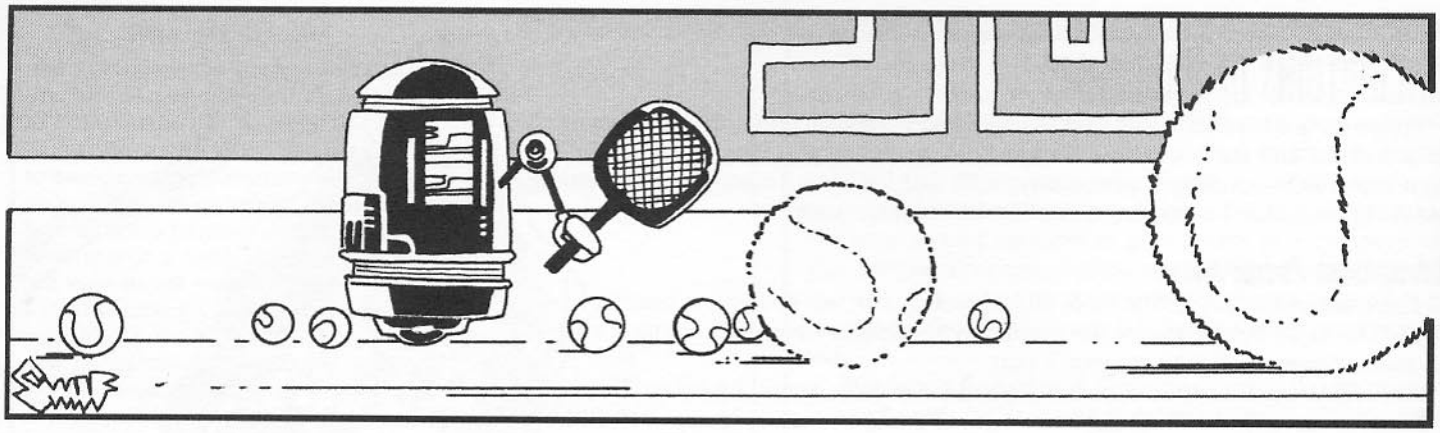
The Turing Test

In a classic paper written in 1950, theorist Alan Turing proposed a test for artificial intelligence in computers. The "Turing Test" requires a person to engage in conversation with someone or something in another room, using a computer terminal to transmit questions and receive responses. After a certain time, he must decide whether the answers and comments he receives are coming from a person typing them in, or a computer program. If – despite questioning on multiple topics – the person cannot tell the program from a person, Turing said it was logical to say that the program *is* a person: an artificial intelligence.

In fact, a robot does not have to be sentient to pass the Turing test: any computer with a neural-net brain, or any computer with any kind of Personality Simulation program can do so if the questioner allows the computer program to restrict the line of questioning. Nevertheless, most unsophisticated robots are poor ad-hoc liars; although they may be as "dishonest" as any human, they lack the inventiveness to make up convincing stories.

If a robot or computer is given a Turing test, the GM can treat it as a contest of IQ (or Psychology skill) between the computer and the tester. The computer is at -4 if it is neither sentient nor a neural-net, or at -2 if it is merely a neural-net. If it is not sentient, it is also at -6 if it has no Personality Simulation program, or at -3 if it has only a Limited Personality Simulation program. If the tester wins, he correctly deduces whether whatever he is talking to is sentient or not. If he loses, he guesses wrong. The GM rolls secretly after about an hour of conversation; for shorter interviews, roll at a penalty.





Data and Memory Requirements

All values are in gigabytes.
Audio, average quality, one hour . . . ½
Audio, ultra-fidelity, one hour . . . 1
Blueprints/schematics
  Extremely Complex (say, for a spaceship) . . . 100
  Very Complex (for perhaps an AI computer) . . . 10
  Complex (for, say, a large warbot) . . . 1
  Simple (like an automobile or small robot) . . . 1/10
  Very simple (such as for a gun or radio) . . . 1/100
Books, one 6' shelf full . . . 1
  War and Peace . . . 1/500
Braintape of person . . . 100
Computer memory backup (compressed)
  Complexity 1 . . . 1/50
  Complexity 2 . . . 1/5
  Complexity 3 . . . 5
  Complexity 4 . . . 50
  Complexity 5 . . . 500, etc.
Dossier, complete personal file . . . 1/100
Financial records (one year)
  Small business . . . 1/10
  Medium business . . . 1
  Large business . . . 5 per $100 million in earnings
Genetic map of one human . . . 2
History of Earth, short . . . 1
History of Earth, detailed over 20 years . . . 1
Imaging, one color photo . . . 1/20,000
Novel, paperback . . . 1/2000
One page of text . . . 1/400,000
Programs
  Complexity 1 . . . 1/100
  Complexity 2 . . . 1/10
  Complexity 3 . . . 1
  Complexity 4 . . . 10
  Complexity 5 . . . 100, etc.
Technical Manuals . . . 1% of blueprint space
Video, high-resolution, 10 minutes . . . 1

Restrictive Program: This is a program that restricts the robot's freedom of action, by forcing it to do (or *not* do) something in certain situations. The program may incorporate one or more of these disadvantages: Combat Paralysis, Cowardice, Honesty, Pacifism (any level) and Truthfulness. A restrictive program is never voluntary (that would defeat the purpose!).

Reactive Programs: Similar to restrictive programs, these are overriding imperatives that the robot take action under certain circumstances. These orders give the robot a set of basic commands that work like a Vow (p. B37); the robot must follow them as long as it has that program.

Isaac Asimov's famous "Three Laws of Robotics" (described in *I, Robot* and other works) is a fairly sophisticated example of three such programs. The First Law compels a robot not to harm a person, nor through inaction to allow one to come to harm. The Second Law forces it to obey humans if this does not violate the First Law. The Third Law urges the robot to preserve its own existence unless doing so would violate the First or Second Laws.

A reactive program's point value is up to the GM; use the guidelines for vows on p. B37. In the case of the "Three Laws," the First and Second Laws are "great vows" worth -15 points each, while the Third Law is worth no points, since it's not a disadvantage at all. The Complexity is also up to the GM. A program like the "First Law," which requires the robot to make complex decisions ("if I don't do this, will that person come to harm?"), will usually be at least Complexity 5. The Second and Third Laws are relatively simple, probably Complexity 2 each. A reactive program's cost is $2,000 × Complexity; it is usually TL8.

Personality Program Table

Type	*TL*	*Cost*	*LC*	*Complexity*
Limited Personality Simulation	7	$8,000	6	4
Full Personality Simulation	8	$20,000	6	5
Pet Program	8	$5,000	6	varies
Restrictive Program	8	$10,000	6	4
Reactive Program	8	varies	6	varies

Halve the cost of programs one TL after they first appear and quarter them two or more TLs after they first appear.

Points: The disadvantages in a personality program reduce the robot's *programming cost* (see p. 83). However, a voluntary program is worth no points.

Skill Programs

Programs can give a robot skills. Each *skill program* grants the robot a certain number of character points dedicated to a specific skill. This is usually written as a number in brackets after the skill, for example, Cooking [2]. Use the table on p. B44 to determine the robot's skill level, based on the character points it has in a skill.

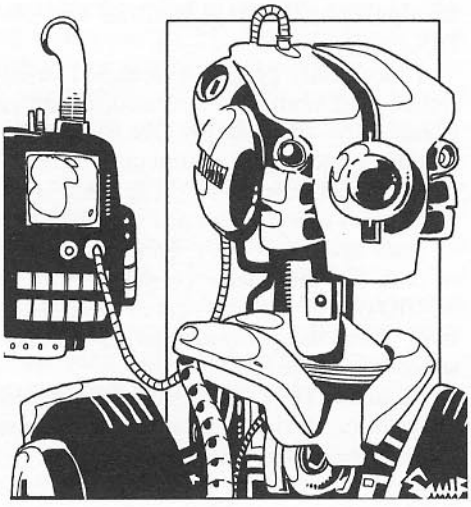
Some robots – especially those with neural-net or sentient brains – will learn skills much as a human does. These robots don't need skill programs, but can have them anyway. If the robot has learned a skill, add the points granted by the skill program to the character points in that skill to determine its effective skill level.

A robot cannot add the points from two skill programs for the same skill together; only the highest-point skill program is used.

As with other programs, skill programs are rated by Complexity, and the robot can only run those of a Complexity equal to or less than its computer brain's Complexity. The Complexity of the skill program depends on the number of points it grants, as shown below.

Skill Program Complexity Table

Character Points	*Program Complexity*
.5	1
1	2
2	3
3 to 4	4
5 to 8	5
9 to 16	6
17 to 24	7
25 to 32	8
33 to 40	9
41 to 48	10
49 to 56	11
57 to 64	12
65 to 72	13
73 to 80	14
81 to 88	15



At TL8, programs for mental skills cost $2,000 per character point granted up to eight points, or $4,000 per point for physical skills. If it grants up to 20 points, multiply the cost by 2.5. If it grants more than 20 points, multiply the cost by 5. At TL9, halve the cost. At TL10+, quarter the cost.

Note that skill points placed into regular mental skills count quadruple, since all robots have Eidetic Memory 2. Multiply the character points *after* calculating the skill program's Complexity, not before. Even though most TL7 to TL10 robots have very low IQs, thanks to their eidetic memories they can still achieve respectable skill levels in mental skills.

EXAMPLE

We program Synthia with 4 character points in Karate, a P/H skill. This costs $4,000 (at TL10) and is Complexity 4; we note it as Karate [4]. Synthia now has Karate at its DX level. Next, we program Synthia with Demolitions [2]. As this is a mental skill, it costs $1,000 and is Complexity 3. Since Synthia's computer brain has Eidetic Memory 2, the 2 points in Demolitions count as 8 points, giving Synthia Demolitions at IQ+3.



Hardwired Programs

Normal programs exist as lines of code. They can be deleted, copied, or altered. They take up space in a robot's memory, or on disk.

Hardwired programs are permanently burned into a physical medium. They come in small plastic cassettes and cost 50% more than ordinary programs. The cassettes are loaded into a computer's ROM slots. Normally, a computer has a number of ROM slots equal to its Complexity rating (see *Extra ROM Slots*, p. 9).

A hardwired program can only be read, not written onto. (It's sometimes called a "ROM" program, for read-only memory.) It can't be copied or upgraded; it can't evolve or change. It can't combine any skill bonus or character points it gives with other programs (whether hardwired or normal).

Most advantage, skill, utility and some personality programs can be hardwired. However, any program that requires a neural-net or sentient brain to run can't be hardwired. This is because hardwired programs can't evolve – they are stuck with whatever is programmed into them at the time.

However, hardwired programs run faster and thus can execute more logical steps in less time than ordinary programs of similar Complexity. In effect, this means they can be quicker and smarter. A hardwired skill or utility program gives the robot a +1 bonus to skill, over and above whatever bonus the program would normally give.

But because it can't be updated or altered, a hardwired program's actions can become predictable. If a robot uses a hardwired program repeatedly, someone who observes the robot's actions will be able to use this knowledge against the robot. In game terms, this means that in any Contest of Skill in which the robot uses that program, an opponent will have a +1 to +3 bonus, depending on how thoroughly he has studied the robot or the program.

(Thus, this problem doesn't occur if the program applies to a skill where Contests are infrequent, like Guns combat. For a melee weapon, it would apply to things like feints. In skills where Contests of Skill are frequent, like Gambling, Merchant or Strategy, it will come into play quite often.)

A robot can buy a new version of the same program (one with new or different tactics) to avoid this penalty. This negates the penalty – until the opposition learns the new program's tricks!

Data Recovery

A robot may lose data and programs as a result of brain damage – see the *Robots in Action* chapter. However, data recovery techniques can sometimes retrieve these missing chunks of memory. Even if a robot was destroyed, unless the part of its body holding the brain was utterly annihilated (reduced to -10×HT, disintegrated, etc.), portions of its data and memory may be recoverable, perhaps enough to resurrect it even if it had no backup. If the robot brain hasn't yet been repaired, the data or programs can still be retrieved. This will allow them to be copied and run on another computer.

Data recovery techniques also allow characters to physically "interrogate" a captured or damaged enemy robot, transferring its data or memory into their own computers. Data recovery techniques can also be used to physically search a robot's memory for its command codes (p. 57), thus allowing it to be reprogrammed.

The robot brain must be connected by cables to the interrogating computer (which may be another robot brain). The interrogator needs a *data recovery* utility program (this page).

An attempt to recover the robot's memory, or to find a command code or other piece of information the robot doesn't want to or can't divulge takes ten minutes and a successful Computer Programming/TL roll. Subsequent attempts are at -2 and take an extra ten minutes (time and penalties are cumulative per failed attempt). Any critical failure means that some damage is done in the process – data or memories might be erased, for instance. Success retrieves the data or finds the information. A critical success succeeds in half the time.

Modifiers: -4 if the robot is below 0 HT (i.e., it has not yet been repaired); -4 if the robot's command or override code (p. 57) is not known; -2 per level of Complexity of the robot's brain; -3 if searching for a command code, or -6 if searching for an override code. A SQUID (p. 31) adds +3 when probing a brain of its own TL or lower, or +1 with higher-TL brain. Cross-tech penalties (p. B185) apply to attempts to recover data from a higher-TL computer (e.g., a crippled alien robot).

Utility Programs

These programs aren't skills, advantages or disadvantages. They're actually *tools.* All the programs described in ***GURPS Space*** and ***GURPS Ultra-Tech*** (except for Personality Simulation) fall into this category: Accounting, Astrogation, Damage Control, Datalink, Electronics Repair, Engineering, Environmental Analysis, Expert Systems, Gunner, Internal Security, Interpreter, Medical, News Daemon, Optical Recognition, Piloting, Routine Vehicle Operation, Targeting, Translation, Word Processing.

Those utility programs designed strictly for analysis of data (such as Translation), rather than real-time operations, can run on machines of lower than their listed Complexity – they simply take an order of magnitude more time to do the analysis. The reverse is true if they are run on a higher-Complexity system.

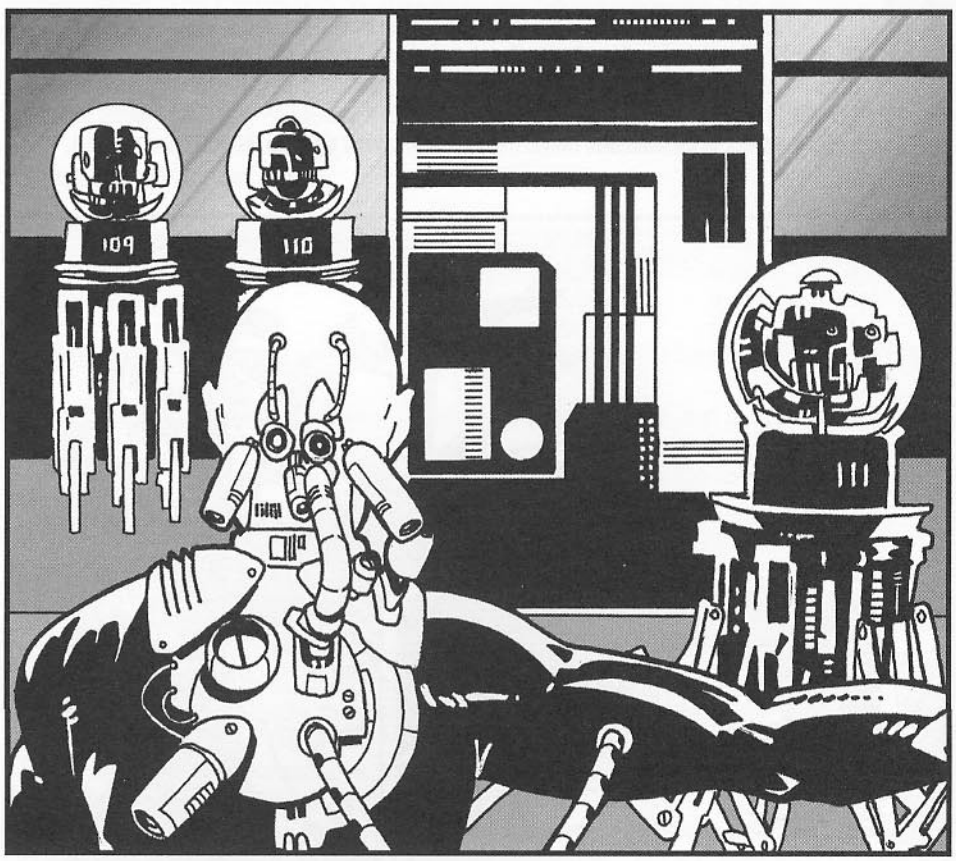
Cargo Handling (TL7): The robot is programmed to carefully label, load and unload freight into various ships and vehicles. The program is Complexity 1.

Data Recovery (TL7): This utility program enables the robot to recover lost or deleted data. See the sidebar on this page. A data recovery program is also needed to use a SQUID (see p. 31). The cost of these programs is constant in every TL; a program of the same TL as the computer storing the data to be recovered is necessary to avoid cross-tech penalties (p. B185).

Datalink (TL7): This enables a robot to establish a link with another computer brain or electronic device and send, read or transmit data. A datalink program is also needed to control a robot that has a drone brain.

Domestic (TL8): A sophisticated household program, this turns the robot into the perfect housekeeper – with the proper equipment, it will clean, tidy rooms and do laundry. It can be instructed to keep an inventory of household stocks and take action (alert its owner, or shop, depending on its IQ) when supplies run low. Robots with this program often have the Cooking skill program as well.

Encryption (TL7): This program allows the robot to encrypt any transmissions it sends by communicator, modem or cable, so that anyone intercepting them will pick up only gibberish. It takes one hour to encrypt or decrypt a gigabyte of data using a Complexity 2 brain; increase or decrease this by a factor of 10 for each extra level of Complexity. Normally encryption can only be reversed by someone with the key (similar to a password) that was used to encrypt the data. Unless the key can be guessed, decrypting data requires a computer of higher Complexity than the encryption program,



1d days and a successful Computer Programming-6 roll. Divide the time required by ten if the computer is two levels more complex than the encryption program, by 100 if three levels more complex, etc.

Janitorial (TL7): The robot can perform large-scale cleaning and caretaker jobs. It can detect dirt and mess and operate installed cleaning equipment or, if it has hands, use human equipment.

Machine Operation (TL7): This program enables the robot to perform a single, specific technical task at skill 12, or it adds +2 to the robot's Mechanic or Electronics skill for that particular task, whichever is higher. For instance, this program could be used to operate tools that fabricate a specific automobile part or repair a single kind of damage. Computers controlling industrial robots often use one or many of these programs.

Repair (TL8): This program gives the robot a skill of (program TL+4) *for repairs and routine maintenance only,* for *one specific gadget.*

Translation (TL11): This program can analyze and translate entirely new languages with as little as ten minutes of exposure to conversation. The translation begins at a skill level of 5, and adds +1 skill level for each additional half-hour of exposure, up to a maximum of 11. The program can handle nonverbal languages if the robot has appropriate sensors and capabilities (for instance, arms if the language requires gestures).

Voiceprint Recognition (TL7): This program allows the robot to recognize an individual by his unique voiceprint.

Other Programs: Additional programs that robots may use are described in ***GURPS Space, GURPS Cyberpunk*** or ***GURPS Ultra-Tech.***

Utility Program Table

Program	*TL*	*Cost*	*Complexity*
Cargo Handling	7	$400	1
Data Recovery	7	$100	2
Datalink	7	$800	1
Domestic	8	$1,000	2
Encryption	7	$500*	2+
Janitorial	7	$1,000	1
Machine Operation	7	$1,000	1
Repair	8	$500	1
Translation	11	$5,000**	6
Voiceprint Recognition	7	$1,000	2

* times the program's Complexity.

** plus $1,000 per extra language database.

Except for data recovery programs, the cost halves one TL after the program first appears, or drops to one-fourth two or more TLs after it first appears.

Copying and Writing Commercial Programs

Although all programs are given a dollar price, that doesn't mean they necessarily have to be *purchased.* People can write their own, or copy programs they have acquired.

Writing Programs

To write a program, use the *New Inventions* rules on p. B186, substituting Computer Programming/TL for Engineer/TL. Apply a skill penalty equal to twice the Complexity of the program rather than -15. Sometimes there are other prerequisites – consider these rules an enhancement of the rules on p. UT13.

A *skill program's* creator must have, or be assisted by, someone who has that many character points in the skill.

A *personality or advantage program's* creator, or an assistant, must have Psychology skill. Rolls against both skills (at the same Complexity × 2 penalty) are needed to succeed.

For other programs, the GM can assume that only Computer Programming is needed. But if the program gives the computer a bonus to skill, it's suggested that the creator have or be assisted by someone with that skill at a level equal to or greater than (bonus+11). If the program incorporates a skill, the skill of the creator or his assistant should at least equal that skill level.

Remote Control: Robots as Drones

Any computer, or computer brain, can control a subordinate robot remotely by using a datalink program. So can a person with a control console. The controlled robot is called a drone; the computer or person controlling it is called a controller.

The controller must be in continuous electronic communication with the drone and must use a datalink program. The drone must be programmed to obey the controller. This usually requires sending a proper command code as part of the signal. See *Command Codes* on p. 57.

The drone continuously transmits its sensory impressions to the controller, which then sends control signals to "pilot" the drone. If contact is lost, the drone switches to its on-board computer system.

While a drone is being controlled, it is entirely taken over by its controller. Think of this as total possession. The drone does not think or act – its personality, if any, and all mental advantages and disadvantages are suppressed. The controller can use its skills through the drone. When the controller has the drone use a DX-based skill, there is a negative modifier of -1 per point of difference between the controller's DX and the drone's DX. If the operator has a higher IQ than the robot and uses an IQ-based skill, there is a negative modifier of -1 per two points or fraction of difference between the controller's IQ and the drone's IQ.

If the drone's controller is a living being with a control console, rather than a computer, there is an additional "telepresence" modifier to all DX, IQ and skill rolls. This negative modifier reflects the fact that, since the person is not actually there, his reactions are dulled. The penalty depends on the TL and type of control console being used – a simple joystick and TV screen, for instance, is less effective than a virtual-reality setup in which the user can actually "be" the drone. See the *Control Consoles* sidebar on p. 64.

A controller can sometimes control multiple drones. If the controller is a computer, every time the number of simultaneously-controlled drones is doubled, add an additional -1 penalty to DX, IQ, skill and sense rolls. Thus, if 2-3 drones are controlled, all are at -1; if 4-7 are controlled they are at -2, etc. If a living operator is controlling drones, the penalty is more severe, since the operator is less able to handle multiple sensory impressions. His penalty is -2 per extra drone: -2 for two drones, -4 for three drones, and so on.

Control Consoles

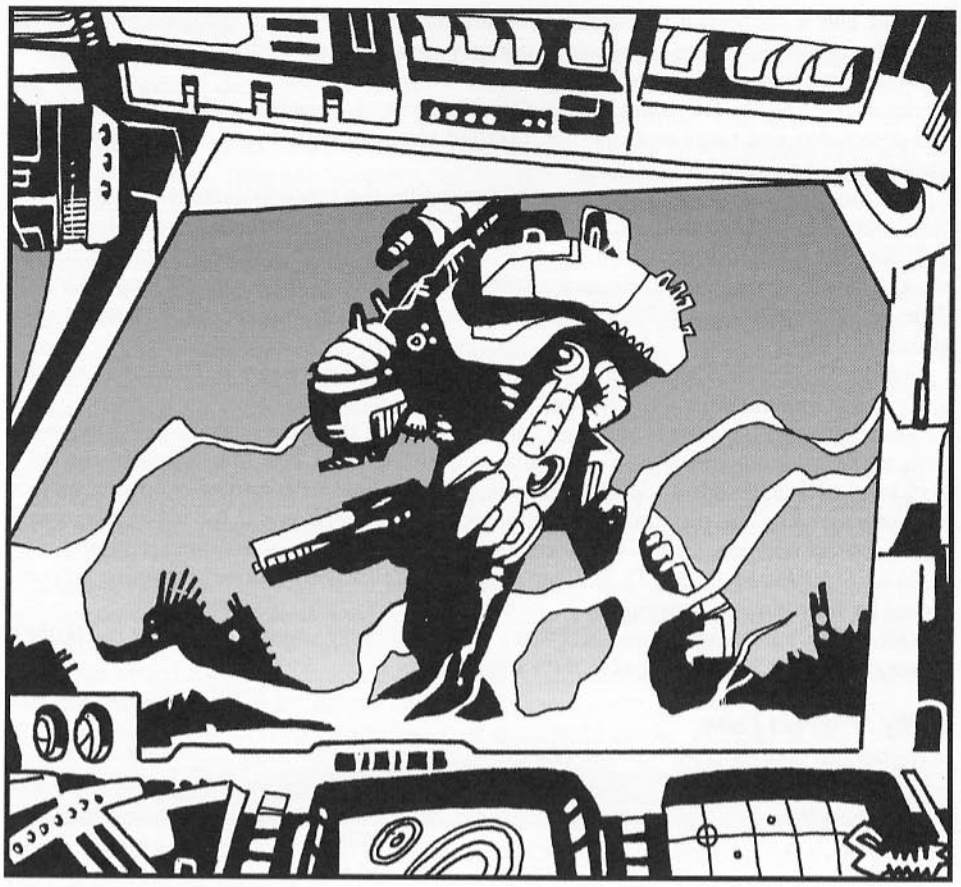
Telepresence control consoles incorporating dedicated computers enable a human operator to remotely control a robot. Their weight, volume and cost do not include a communicator. The weight, volume and cost of consoles (including remote control programs) halve one TL after the system first appears, and are quartered two or more TLs after it appears.

Basic Remote Console (TL7): The operator controls the drone much like a vehicle, using a joystick and instruments to interpret the drone's sensor readouts and control its actions. If the drone has visual sensors, the operator sees the images on a television screen, for instance. The telepresence penalty is -4. The console is any computer terminal of Complexity 2 or higher with a joystick and communicator built into it, and running Datalink and Basic Remote Control ($400, Complexity 2) programs.

Advanced Remote Console (TL7): Similar but more sophisticated. The telepresence penalty is -3. The console is any computer terminal of Complexity 3 or higher with a joystick and communicator built into it, and running both the Datalink and Advanced Remote Control ($2,000, Complexity 3) programs.

Basic VR Console (TL8): The operator "gets inside" the robot using a virtual-reality rig. He wears special gloves and/or a helmet, and through feedback actually experiences the drone's sensory impressions rather than relying on instruments. The telepresence penalty is only -2; if the robot has the same shape and number of limbs as the operator (two arms, two legs for a human operator), the penalty drops to -1. The console is a specialized VR rig (30 lbs., 1.5 cf, $2,500) attached to any computer terminal of Complexity 4 or higher running both the Datalink and VR Remote Control ($5,000, Complexity 4) programs.

Neural-Interface Console (TL varies, usually TL10): The operator controls the robot through a direct link between the operator's brain and the drone. The telepresence penalty is only -1, or 0 if the drone has the same shape and number of limbs as the operator. TL and cost depend on the availability of neural interface technology in the campaign. A typical system is the TL10 neural-interface helmet (3 lbs., .06 cf, $10,000) attached to a console – any Complexity 4 or higher computer terminal running both the Datalink and Interface Remote Control ($5,000, Complexity 4) programs.



Copying Programs

Robot builders or users may wish to save money by buying only one copy of a program and making multiple copies, or by copying borrowed programs. This may not be legal, or it may be a gray area, allowed for personal use but not for sale.

The GM should decide how good copy protection on programs is. Programs may have no copy protection, in which case anyone can use a computer that can run the program to make more copies.

If copy protection exists, assume that cracking it requires a Computer Operation-2 or Computer Programming roll. Failure corrupts the program. Some copy protection systems may even be designed with a booby trap, so that a critical failure introduces a virus into the copying computer, which can corrupt or destroy other programs. Of course, this kind of booby trap may be illegal.

Optionally, copy protection may be much tougher: perhaps -2 × the program's Complexity, for instance. Or the GM can also rule that a computer program is designed in such a way that it can't be copied – maybe the documentation is too complex, or the medium is read-only, or some other arbitrary restriction.

Bugs and Upgrades

The ability of a robot brain to be reprogrammed gives robot characters considerable flexibility. This doesn't cost any extra points. Instead, the GM can occasionally have a robot program turn out to be "buggy." The software of the future need not be any more perfect than programs available today!

Any program, especially any advantage or skill program, can come complete with associated bugs – minor flaws that occasionally pop up at inconvenient times. Newly-purchased programs (especially those available at this TL for the first time) are especially likely to have bugs.

A robot that starts play with a program the player knows is buggy can count the bug as a Quirk. A program bought for the robot during the game that turns out to have a bug is worth no points, but can be easily fixed – see *Upgrades,* below.

A character shouldn't be able to casually test a program for bugs before buying it: by definition, a bug is a flaw that is hidden well enough to escape the designers and their hired quality-assurance people. Testing for bugs takes time – see *Fixing Bugs,* below.

A bug is best handled as a disadvantage or skill penalty that occurs in certain circumstances. Some possibilities:

A skill or advantage program that causes the robot to act erratically under stress, giving it either Berserk, Combat Paralysis or Epilepsy. Unlike a full-blown version of the disadvantage, the robot is vulnerable *only* when using the skill.

For instance, Synthia – as Dan learned to his regret – has a buggy Tactics [8] skill program with the Berserk disadvantage. Putting Synthia under stress won't drive it Berserk – unless it also is running Tactics. Whenever Synthia makes a Tactics roll in a stressful combat situation, it must also make a Will roll to avoid going Berserk!

Any skill program that works normally, but causes a critical failure result on a roll of 15+ instead of the usual chance. The GM can use a normal critical failure, or come up with something special.

For example, Gyro the Techbot fails a Mechanic roll while fixing its owner's laser rifle. This becomes a critical failure due to its use of a buggy Mechanic skill program. When Gyro's owner comes back, Gyro has reassembled the broken laser with parts from the coffee machine. The result produces laser-heated coffee, but won't fire.

Upgrades

Most companies that sell programs will provide a free upgrade to fix a bug once the customers point it out to them. (That assumes the customers have a legal copy, of course. Companies are under no obligation to software pirates!) If the users are on the same planet, an upgrade package may arrive within as little as 2d days. Of course, should the adventurers be halfway around the galaxy at the time, they may have to wait months until the interstellar mail arrives!

Fixing Bugs in Programs

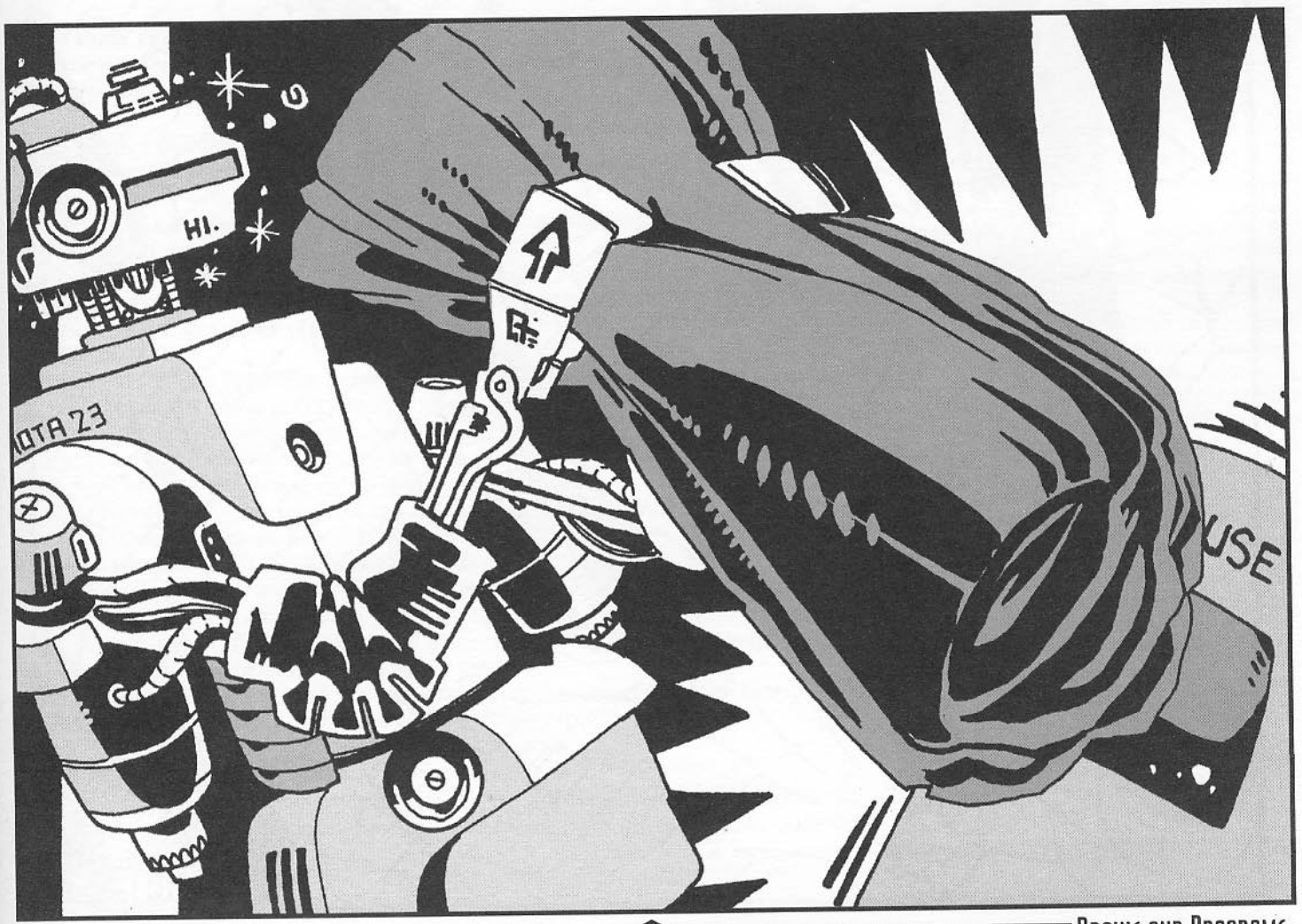
If a PC wants to fix a bug, or search a program for bugs, use the same rules as for writing a program from scratch, except that the skill penalty is equal to the program's Complexity.

Ghost Programs

This special program gives a robot brain the entire personality and memories, including all skills (and mental advantages, disadvantages and quirks) of a living being, effectively allowing a person to translate himself "into silicon." It occupies 100 gigs of memory in storage!

Unlike a Personality Simulation of a real person, a Ghost program is fully self-aware. Creation of a Ghost program requires TL14 braintape technology (see ***GURPS Ultra-Tech***). It may also be available on an experimental basis at any lower TL where braintaping exists, at up to 100 times its TL14 cost. The program is Complexity 8 and costs $25,000. Halve the cost at TL15, and again at TL16.

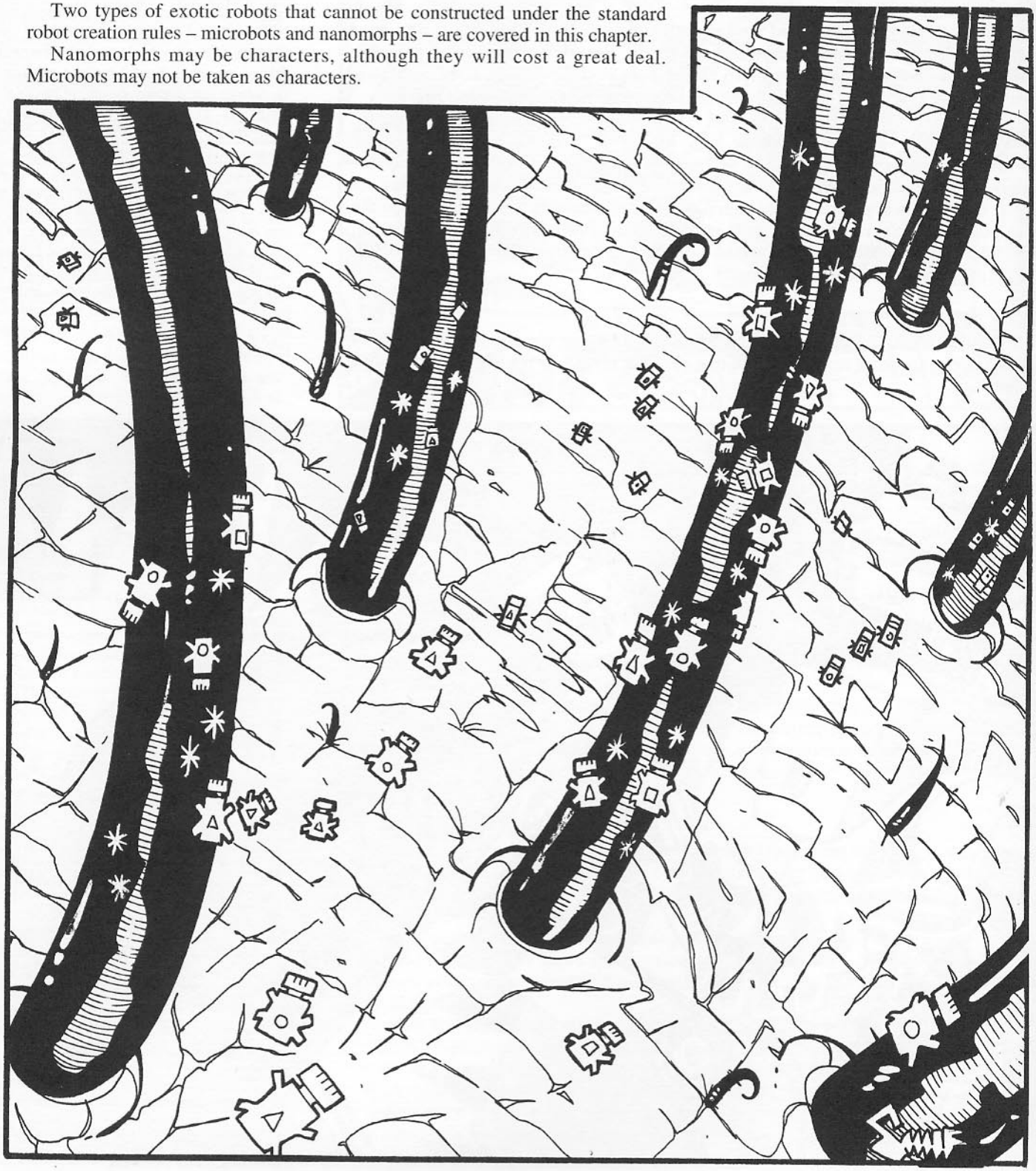
A computer that runs a Ghost program develops the Split Personality disadvantage. The Ghost program is considered one half, the computer the other. The ghost side has the being's original DX and IQ, skills which are then adjusted by the DX and IQ modifiers of the robot, and any purely mental advantages or disadvantages. The computer side has its original DX, IQ and programming.



MICROBOTS & NANOMORPHS 3

Two types of exotic robots that cannot be constructed under the standard robot creation rules – microbots and nanomorphs – are covered in this chapter.

Nanomorphs may be characters, although they will cost a great deal. Microbots may not be taken as characters.



Microbots and Cyberswarms

Sometimes smaller is better, or just more effective. Microbots are tiny robots, ranging from insect to microbe-sized, with microscopic components. None of these robots are individually intelligent by any stretch of the imagination, but they are useful tools – and sometimes very deadly weapons.

Because microbots are so small, they are treated as groups rather than as individuals. A colony of such robots has "intelligence" superior to that of any component part, just as an ant colony is an extremely adaptive organism, while each ant is amazingly stupid.

Microbots are controlled by pinhead-sized computers running simple programs modelled on insect behavior patterns. A group of microbots is called a cyberswarm. A cyberswarm consists of many microbots programmed to act in concert. They follow simple pre-programmed behavior, moving in a specified pattern to perform their tasks and then (if so programmed) return to base. Cyberswarms are normally used for agricultural, construction, or routine cleaning and maintenance, but cyberswarms can also be designed for medicine, exploration or combat.

Individual microbots are rarely larger than fleas, so cyberswarms are measured in hexes rather than individuals. A typical swarm is one hex in size, but swarms can be larger.

Cyberswarm Design

The procedure to design cyberswarms is simple: pick a tech level; select a chassis and power system; then choose an equipment package and (at TL13 or higher) decide if the swarm is made of living-metal robots. This will set the cyberswarm's cost and capabilities. All cyberswarm costs are *per hex;* for swarms larger than one hex, multiply the cost by the number of hexes. All cyberswarm design costs halve one TL after a system is introduced, and quarter two or more TLs after its introduction.

Step One: Tech Level

Choose the tech level. Microbot cyberswarms become available at TL8, but become truly versatile only at TL9 and above.

Step Two: Chassis

The chassis provides the basic body, motive system, sensors and brain. Select the chassis for the cyberswarm, and calculate its cost.

Crawler (TL8): Each microbot resembles a tiny metallic ant, flea or beetle. It has Move 3 (on the ground) or 1 (swimming). It costs $4,000.

Armored Crawler (TL9): Similar to a crawler, it has a tougher shell. Armored crawlers can survive corrosive atmospheres or high gravity, and are also less vulnerable to attacks; see *Cyberswarms in Combat,* this page. It has Move 2 (on the ground) and costs $6,000.

Flyer (TL9): This looks like a cross between a tiny attack helicopter and a mechanical wasp or bee. Its Move is (TL-6)×2 (if flying) or 2 (on the ground). A flyer swarm is more fragile than other swarms. It costs $10,000.

Swimmer(TL8): Individual microbots resemble tiny tadpoles with teeth and arms. They have Move 4 (swimming only). It costs $4,000.

Gravflyer (TL12): This microbot can look like almost anything; most are spheres or ovoids with tiny arms and legs. It flies using contragravity and tiny reactionless thrusters. Its Move is (TL-6)×4 (flying) or 3 (on the ground). It costs $8,000.

A cyberswarm's HT is equal to its TL+3. Its skill at any task it is equipped for (see *Step Four: Equipment Package* on p. 68) is equal to its *current* HT, while its IQ is equal to its *current* HT/3, rounded down. Since it is effectively a hive intelligence, the more damage the swarm takes, the stupider it gets!

A cyberswarm behaves as if it had the following disadvantages: Low Empathy (p. 88), Reprogrammable Duty (p. 89) and Slave Mentality (p. 89).

Step Three: Power System

Select one of the following power systems for the cyberswarm, and calculate its cost. The cost of power systems remains constant over different TLs; only the endurance improves.

Cyberswarms in Combat

Microbots with Stinger, Terminator or Devourer packages may make attacks. Normally they will move to attack any entity they come upon while moving through a preprogrammed path — this makes them most useful when programmed to "sterilize" an area or to sweep a security perimeter.

TL8 swarms may be programmed to attack only certain sizes of targets, and may be programmed to distinguish between organic and nonorganic targets. TL9+ swarms may also be programmed to differentiate by species, using sophisticated chemical sensors (this has no effect if the target is in airtight armor).

When the swarm comes within a preset distance (up to its current HT in hexes) of a permissible target, it will move to attack. Use the *Swarm Attacks* rule on p. B143. The effect depends on the type of swarm equipment package, as described on pp. 68-69.

When someone attacks a cyberswarm, use the rules for attacking swarms on p. B143, with the exception that torches and flaming weapons do only 1 hit of damage vs. crawler, armored crawler, gravflyer or swimmer swarms. (Flyers take full damage — their tiny rotors or wings are vulnerable to fire.)

Damage is applied to each hex of cyberswarm; when the damage equals or exceeds the cyberswarm's HT, it is effectively destroyed. Lesser damage also has an effect, reducing the swarm's effective skill and IQ as described under *Step Two: Chassis,* on this page.

Gas and non-corrosive atmospheres have no effect on cyberswarms, nor does vacuum. Most high-tech and ultra-tech weapons inflict only 1 hit per attack. However, any weapon that affects a wide area (such as a shotgun, a mage's flame jet, a flamethrower or flamer, a screamer, or the concussion damage from an explosion) does full damage to a flying swarm, half damage to a crawling, swimming or grounded flying swarm, and one-third damage to an armored swarm. (Of course, attacks with fire will have little effect on a swarm swimming underwater.)

Microbots with Devourer weaponry can attack other cyberswarms, doing their full damage each turn to them.

Cyberswarm Hive

Normally mounted in a full-size robot or vehicle, this container houses a one-hex cyberswarm. It includes recharging points, enabling the cyberswarm to recharge from the robot's power system. It weighs 10 lbs., costs $200 and takes up .5 cf.

Anti-Cyberswarm Weapons

Two specialized hand-held weapons can be especially useful against a flying cyberswarm. They are:

Flyswatter (TL1): Does 2 hits of damage/turn to a cyberswarm. It weighs .2 lbs. and costs $2.

Monowire Flyswatter (TL9): Uses a mesh of monowire. It is much more effective, doing 1d+1 damage/turn to a cyberswarm. It weighs .2 lbs. and costs $100.

Actually, the best way to fight a cyberswarm is with area effect weapons such as grenades or flamethrowers, or even another cyberswarm.



Rechargeable AA cell (TL8): The robots use small power cells, which power them for (TL-6) hours; each hour of flight consumes as much power as *two* hours of crawling. (A flyer swarm can conserve power by crawling.) The cyberswarm can recharge by entering a cyberswarm hive (see p. 68) and hooking themselves up to an attached power supply; recharging the swarm requires 1,800 KWS of power per hour the swarm can operate for. It costs $2,000.

Non-Rechargeable AA cell (TL8): As above, but the microbots operate for twice as long. However, the power cells must be replaced rather than recharged after each use. It costs $2,000; it costs the same amount to replace the cells.

Solar AA cell (TL8): The microbots use rechargeable AA cells and also have small solar panels built into their bodies or wings. They function like cyberswarms with rechargeable cells; also, in bright light they can recharge 30 minutes of operating power for each hour they remain dormant. It costs $4,000.

Total Conversion (TL16): Tiny "total conversion" units, fuelled by trivial amounts of normal matter (usually air or dust), power the microbots indefinitely. It costs $6,000.

Step Four: Equipment Package

A microbot's equipment package includes its specialized tools, manipulators, programming and sensors. Select one of the following packages for the cyberswarm, and calculate its cost. The cost halves one TL after the package is first introduced, or is quartered two or more TLs after its introduction.

Cleaning (TL8): The swarm is programmed to move around a predetermined area, removing dust and grit, polishing smooth surfaces with tiny brushes. Cleaning swarms are equipped with sensors that can determine when material might be damaged by their actions; they can polish lenses safely, and can even harmlessly clean *people,* though very few people find the sensation pleasant! Each hex of microbots can thoroughly clean one hex every minute. Cleaning microbots are among the most common cyberswarms; some large spacecraft and buildings have permanent colonies of solar-powered cleaning swarms to polish windows, viewports and sensor lenses. The package costs $2,000.

Construction (TL8): The cyberswarm is designed to tunnel, dig ditches, etc. It is equipped with small arms and digging jaws. Each hex of swarm can dig as if it had ST equal to TL, and a pick and shovel (see p. B90). Construction swarms are often employed for mining, or civil or military engineering. Construction swarms can also pile up loose earth, rock, etc. into ramparts, dykes or walls. The package costs $2,000.

Defoliator (TL8): This swarm kills foliage within its hex, but has no effect on other living creatures. It takes the swarm ten seconds to strip a hex clean of bushes or foliage. It can also be programmed to trim grass; this takes one minute per hex. At TL9 and up, it may be programmed to affect specific plants (for example, weeds). It costs $1,000.

Devourer (TL9): This model of microbot has small monomolecular jaws; a swarm of a thousand such robots can chew through almost any barrier or armor, given time. Any target, organic or machine, caught in a devourer cyberswarm takes [1d-7 + (swarm TL)] points of damage per turn. DR protects normally if it covers the entire body, but a cyberswarm that cannot penetrate armor will *destroy* 1 point of armor DR every turn. It costs $8,000.

Explorer (TL8): The swarm is programmed to probe in a spiral pattern, using contact sensors to take minute chemical samples of material it contacts. Explorer cyberswarms may be programmed to look for particular mineral or chemical traces, water, organic molecules, etc. After a predetermined search pattern, the swarm is programmed to deposit its samples in an automated "analysis hive" that collects and chemically analyzes them. One hex of swarm samples can be processed by the hive per minute. By analyzing data as to where and when the swarm found things or encountered impassable barriers (such as water, if the swarm cannot swim or fly), the hive's dedicated computer can build up a map of the area they have explored. It costs $2,000. An analysis hive is $1,000, 20 lbs., 1 cf, HT 6.

Medical (TL10): The swarm is designed to perform First Aid on living organisms, with a skill equal to its current HT. Each hex of medical

microbots can treat one person at a time. A medical swarm is composed of a variety of individual subtypes, some designed to "taste" blood to perform diagnosis, while others cut away damaged tissue, clean wounds, sew up cuts, inject drugs, or even enter the body to perform internal repairs or diagnosis. A swarm first stops bleeding, then injects the drug Quickheal (healing 1d hits within 10 minutes). While the drug is taking effect, the microbots perform first aid (taking 30 minutes), cleaning and repairing damaged tissue. On a successful roll vs. their First Aid skill, they heal a further 1d hits. A medical swarm has enough of the drug to heal ten people; after that, it cannot inject Quickheal and heals only 1d-2 hits per successful first aid attempt. It costs $12,000; a new drug pack is $200.

Pesticide (TL8): The swarm is equipped to hunt down and eliminate fleas, spiders and other insects. Flyer swarms can also engage and destroy flies and mosquitos. The microbots' actions are harmless to humans, although they can be entertaining or distracting. It costs $2,000.

Pollinator (TL9): The swarm functions as artificial "bees," spreading pollen or seeds. This is useful if normal insects are not available, or cannot adapt to local climate or ecology. It costs $2,000.

Repair (TL8): The swarm has the tools and programming to repair a *single,* specific model of equipment, much as a human with a mini-tool kit, plus appropriate Mechanic or Electronics skill equal to the swarm's current HT. The package costs $1,000; each extra model of equipment the 'bots can be programmed to fix adds $500 to the cost, to a maximum of (TL-7)×2 types of equipment per swarm.

Stinger (TL8): The microbots have tiny jaws or stinging needles. The swarm does 1 point of damage per turn to living beings (only) it contacts, unless they are completely covered in airtight armor. It costs $3,000.

Terminator (TL9): As above, but with especially virulent nerve poison. Anyone taking damage must make a HT roll one minute after being hit, with a penalty equal to the cumulative damage of the stingers. A success means only 1d of damage is taken; a failed roll means total paralysis, and 2d damage per hour until the victim dies or receives an antidote. It costs $4,000.

Step Five: Disguised and Living Metal Swarms

At TL9 and above, any swarm can be *disguised* as a swarm of real insects of similar size or shape. This costs an extra $4,000 per hex. Successful use of a scanner (bio, rad or chem) will reveal a disguised swarm's robotic nature.

At TL13 and above, any swarm can be made of living metal (p. 70). As long as it has not been reduced to 0 HT or less, a living-metal swarm regenerates 1 hit point every hour. A living-metal swarm costs twice as much as normal; double the costs of chassis, power and equipment packages.

Finishing Up

Record the swarm's Move, endurance in hours, HT, and any damage it inflicts. Come up with a name for the cyberswarm (such as particular company trademarks, for example, "Xenotech Biocide Mk. 2.").

Controlling Swarms

A cyberswarm can take orders via datalink from any computer; swarms are equipped to receive (but not send) radio, laser and (at TL12 and above) gravity-ripple or neutrino signals. The operator must know proper access codes for that particular swarm – each is different. These orders are limited to actions relating to its equipment package, to movement, or to recharging.

Sense Rolls

If a cyberswarm has to make a roll to notice something, use its current HT as its generic sense roll.

Multiple Swarms

Multiple friendly swarms will work together, but the effects of several swarms in a single hex are not additive. Cyberswarms generally avoid "stacking," in order to cover more area, unless commanded to do so.

Cannibal Nanokits (TL11)

Want to be prepared, but don't want to actually carry a ton of hardware? Need to sneak past low-tech customs with a concealed firearm? No problem. Just buy a few tubes of cannibal nano.

A cannibal nanokit appears to be a tube, can, or canister (depending on how much is carried) of white gooey paste. The paste actually contains countless nanomachines programmed to cannibalize other objects to build a single, specific gadget. To use it, the nanokit is squeezed onto a suitable object that has raw materials similar to whatever it is building. Mechanical devices (guns, engines) generally require objects made of metal. Plastics are often broken down to make gasses, propellants, etc. Electronic devices or energy weapons require other electronic systems to cannibalize. However, there are few other restrictions – a cannibal nanokit can turn a toaster into a gyroc launch pistol or a motorcycle into a suit of powered armor.

It takes the nanokit one minute to build the object per pound of finished weight; the nanokit will usually eat the objects in close proximity. Whether the result works or not depends on whether the nanokit has enough suitable material. In doubtful cases, the GM can roll 3d vs. the kit's TL, with modifiers for availability. Whatever is cannibalized is, of course, destroyed (or rather, transformed). The process also produces residual heat, so it's best to start it on a nonflammable surface (like a counter top or concrete garage floor) and to turn off smoke detectors.

Cannibal nanokits are specific to one gadget or weapon (although a single kit may build several closely related gadgets as long as they can all be fused into one object, for instance, a gun with laser sight, or a helmet with built-in infrared goggles).

A tube of cannibal nano costs 300% of the intended gadget's cost, and is limited to constructing gadgets or weapons that appear at least a TL before the nano's own TL. Its weight and volume are 1% of the gadget's normal weight and volume. The Legality Rating of cannibal nano is generally the same as the equipment it builds. The exceptions are any weapons or armor, which have half their normal LC (round down).

A small container of cannibal nano can be easily disguised. For instance, cannibal nano designed to build a laser pistol (1 pound) weighs only .01 lbs. and could be disguised as a tube of something innocuous – lip gloss, cleaning virus, or whatever. A cannibal nanokit designed to build a cybersuit (p. UT93) would weigh less than a pound and could be disguised as a bottle of shampoo. Also, since TL11 lip gloss or shampoo may well use nanomachines, a cursory scan or inspection would turn up nothing strange.

Nanotechnology

Nanomachines (sometimes called nanobots, nanoids or nanites) are cell-sized or smaller machines capable of manipulating individual molecules to perform precise chemical and biological engineering. This molecular engineering is called nanotechnology. Experimental nanomachines appear as early as TL8 or TL9, but unique problems of heat, power and precise control on the molecular level keep nanotechnology from maturing fully until TL13.

Nanotechnology is an industrial process; nanomachine assemblers generally *build* the gadgets that people use, making them stronger, lighter and cheaper, rather than being gadgets or tools themselves. By TL10, for instance, many sophisticated devices, from computers to armor, are likely to use parts constructed with nanotechnology; this is already reflected in the reduced cost and weight and the increased effectiveness that higher TL equipment has. Objects manufactured using advanced nanotechnology often appear seamless, with no obvious toolmarks, as if they have been grown rather than built.

Nanomachines are also capable of special effects that ordinary technology cannot duplicate. For instance, nanomachines left inside the material they have built can alter the shape of the material upon command (e.g., pressure or electrical signals). An apparently smooth wall could suddenly transform into a door or window, or clothes could be fashioned that alter their shape to fit the wearer perfectly. Nanobots have many other uses: for example, ultra-tech miracle drugs may well be injections of tiny nanobot surgeons rather than actual drugs. Some other uses are described in this chapter's sidebars.

An example of a TL10 nanotechnological material is "bioplastic" (bioplas), a tough pseudo-organic material which can alter its rigidity and shape in response to electrical signals, and can even repair or regrow damage to itself. Bioplas is used in TL10+ non-rigid and reflex armor. A far more sophisticated material is TL13 living metal, a material stronger than diamond that can actually regrow, repairing any damage it suffers. Ordinary robots may be built with bioplas armor or living-metal components, as described in the *Robot Design* chapter. But it's also possible to build a robot *entirely* out of these materials: the nanomorph robot described below.



Nanotech Weapons

Nanomachines can also be used as weapons: just as they can put things together, they can also take them apart. The "Nanoburn" and "Disassembler" chemical weapons (mentioned on p. 30), which attack the target on the molecular level, are an example of this.

Nanoburn (TL8)

An ultra-tech nerve agent using a suspension of nanomachines designed to invade the body and break down bodily functions, Nanoburn is effective against all carbon-based life forms. A HT-6 roll is required to avoid being paralyzed for (30-HT) minutes. If paralyzed, take 1d-1 damage every three minutes over the next 30 minutes. Normal nerve poison antidotes are ineffective, but the drug Torpine (p. UT85) stops the damage once taken. A person who has had the Osiris Treatment (p. 71) is at +6 to resist Nanoburn; if he fails, gets an additional resistance (against his basic HT) every three minutes.

Nanoburn costs $5 per dose at TL9; this halves at TL10, and again at TL11+.

Normally sprayed from a spray gun or spray tank, it may also be used as filler for a chemical grenade or shell.

Disassembler (TL11)

A cloud of nanobots programmed to break down matter, Disassembler sticks to anything in the area of effect and begins to eat, reducing the target to powder or goo. Unlike other chemical weapons, after being sprayed or released from a warhead, the cloud remains in the air for only *one* turn; then it falls to the ground like rain (and begins eating away at the ground). Thus, objects will only be affected if they are in the area of effect when the disassemblers are released. Anything the disassemblers fall upon takes (TL-9) dice of damage per second; if the damage fails to penetrate DR, the disassemblers instead eat through (TL-9) points of armor DR. The disassemblers remain potent for 30 seconds; after that, they self-destruct. Used as a digging tool, disassemblers can turn packed earth or stone into fine powder, digging (TL-9) inches within the radius of the cloud every second. Disassembler costs $40 per dose; the cost halves at TL12, and again at TL13+.

Disassembler is normally sprayed from a spray gun or spray tank. It may also be used as filler for a chemical grenade or shell.

Nanomorphs

Nanomorphs are robots composed entirely of advanced molecular machinery, enabling them to constantly alter their shape. Examples of nanomorphs in science fiction include the advanced flickerclad robots in Rudy Rucker's *Wetware,* the liquid-metal terminator in *Terminator 2: Judgment Day,* the Paranoids in the *Gall Force* animated series and some of the Boomer cyberdroids in the *Bubblegum Crisis* animated series. The creature from the second *Thing* movie and the parasite "bio weapons" from the animated movie and comic book *Iczer One* might also be considered nanomorphs.

Nanomorphs make excellent "monsters," and are best used as adversaries rather than player characters. GMs should exercise caution in allowing nanomorph PCs – they can easily unbalance a campaign.

Building a Nanomorph

A nanomorph is not built like a normal robot. To build a nanomorph, simply decide what TL produced it, and then choose a volume in cubic feet (minimum 0.1 cf). A human-sized nanomorph should be between 2 and 4 cf.

Nanomorphs may be built either of bioplastic or living metal. Bioplastic nanomorphs are first seen at TL11. Living-metal nanomorphs are available starting at TL14.

Bioplas nanomorphs cost $50,000 per cf at TL11. This cost halves at TL12, and again at TL13 or above. They weigh 25 lbs. per cf.

Living-metal nanomorphs cost $100,000 per cf at TL13. This cost halves at TL15, and again at TL16 or above. They weigh 50 lbs. per cf.

Exotic Abilities: Nanomorphs may be built with special nanotechnological abilities to dissolve or absorb matter. Any nanomorph at TL12 or above can be designed with the ability to "disassemble" matter it envelops, dissolving it into gray goo. This costs $100,000 (regardless of the nanomorph's size). For an extra $400,000, a nanomorph at TL13 and above that can "disassemble" matter may also be given the ability to either *absorb matter* into its body (allowing it grow) or to *absorb memories* of living things; for an extra $800,000 it may have both abilities.

Statistics

A bioplas nanomorph's ST is four times its volume; a living-metal nanomorph's ST is eight times its volume. Modify this by the number of arms it currently has extruded (see below).

A nanomorph's entire body functions as a decentralized brain. A nanomorph has the innate advantages Absolute Timing, Eidetic Memory 2, Lightning Calculator and Mathematical Ability. It has the disadvantages Reprogrammable Duty (p. 89) and Lack of Empathy.

It has the same capacities for running programs as a sentient computer brain with a Complexity equal to its TL-5, save that it has no disk drive or ROM slots. Moreover, its DX and IQ depend on its size, as shown below.

Nanomorph DX and IQ

Size in cf	*DX*	*IQ*
.1 to .9	9 + (TL/2)	TL-4
1 to 9.9	8 + (TL/2)	TL-3
10 to 99.9	7 + (TL/2)	TL-2
100 to 999.9	6 + (TL/2)	TL-1
1,000 or more	5 + (TL/2)	TL

A nanomorph has a split HT, just like an animal. Its HT is its TL+2. Its hit points are five times its volume in cf (minimum HT 1).

All nanomorphs are considered to be Legality Rating 0.

Point Cost

A nanomorph's design point cost is 400 points for a bioplas nanomorph or 450 points for a living-metal nanomorph; add the cost of ST, DX, IQ and HT based on the table on p. B13 (for ST 15 or higher, use the table on p. 46 in *Robot Design).*

If the hit points of the nanomorph differ from its Health, add 5 points to its cost for every hit point above Health or subtract 5 for every hit point below Health.

Symbiotic Nanomachines

Just as "living-metal" technology can enable a robot or cyborg to regenerate damage, self-repair nanomachines can also be benevolent residents within a human (or alien, or android) body.

Osiris Treatment (TL10)

This is an injection of self-replicating microscopic symbiotic nanomachines. Circulating through the body like white blood cells, these benign nanoids perform cellular repairs, replace blood cells, neutralize the toxins that cause aging, and destroy disease organisms. The result is rapid regeneration of nearly any injury, virtual immunity to illness and successful retardation of aging.

Implanting the Osiris nanoids requires a six-hour hospital stay at a clinic. Afterwards, a patient injected with them can regenerate 1 hit point per hour; crippled limbs heal at five times normal speed. He also gets the Longevity and Immunity to Disease advantages. Osiris nanites have one disadvantage: exposure to strong radiation may result in their mutating. Roll 3d when the PC suffers 100 or more rads. On a roll of 15 or less, nothing happens. On a 16 the nanoids die; on a 17-18, they mutate. If this happens, the effects are up to the GM (for example, losing HT at the listed rate instead of regenerating, losing Appearance as they begin eating the body, etc.)

Osiris treatments cost $500,000 (and optionally 40 points). The cost halves at TL11, and again at TL12+.

Proteus Nanomachines (TL10+)

These nanomachines enter the body and rewrite the genetic code. Taking control of a cell's metabolism, they can alter the genetic information contained within it, or insert entirely new genes. A relatively simple type (TL10 or TL11), costing about $50,000, may change the target's sex or alter his skin color; a complex one (TL12 and up) could alter the body in a radical fashion, effectively transforming a normal person into a bioroid or alien race, with new racial advantages and disadvantages.

The nanomachines may enter the body through injection, spray, etc. They take effect after 1d×5 minutes. A HT-6 roll is allowed to resist being transformed. Contact with the blood or other secretions of an infected person during the 1d×5-minute incubation phase may result in infection (roll HT-3 to resist being transformed). An Osiris treatment gives a +6 to resist.

Transforming Systems

Use of bioplas and, later, living-metal nanotechnology (see p. 70) allows a device to transform into something else.

Reconfigurable Components (TL11): A reconfigurable component is part of a robot that can alter its shape and function. To design a reconfigurable robot component, pick two or more pieces of equipment within 20% of one another's weight and volume. The reconfigurable component can then alter its shape and function, transforming into each of these devices. Reconfiguring components is done at will, but the process takes (16 - TL) seconds, during which neither component can be used. The weight and volume of a reconfigurable component is that of the largest single component. The cost of a reconfigurable system is equal to the combined cost of all components it has *times* its total number of functions. For example, if two devices are combined and one costs $1,500 and the other costs $30,000, the actual cost would be $31,500×2 functions = $63,000. The saving in weight and volume doesn't come cheap. The power requirement depends on which function is being used.

Reconfigurable Gadgets (TL11): A reconfigurable gadget doesn't have to be mounted in a robot. For example, a secret agent may own a communicator that reconfigures itself into a graser pistol. The titular gadget in Larry Niven's story "The Soft Weapon" is an example of this sort of device. A reconfigurable gadget usually has some form of obvious or hidden control to trigger its metamorphosis, or it may simply be voice-controlled.

Transforming Robots (TL11): Rather than reconfigure individual components, an entire robot may be built to transform! To design a robot that can turn into a different robot, a vehicle, or any other technological gadget, build each form separately. As above, the cost is the combined cost *times* the number of transformations. Thus, a man-sized robot might transform into a motorcycle (built using the ***GURPS Vehicles*** rules), or a small robot could turn into a camera. Any damage suffered by one form is carried over when the robot changes; this may be dangerous if the new form has fewer hit points. If one form is reduced to 0 hit points, the robot cannot transform until it is repaired.

The point cost of a reconfigurable system or robot equals the cost of the most expensive individual function plus 20% of the cost of each of its other forms.

A nanomorph with the disassembler ability costs an extra 100 points, or 200 points if it has the ability to absorb memories. A matter-absorbing nanomorph's point cost is not settled, since it can change; matter-absorbing nanomorphs should be NPCs, not player characters!

Nanomorphs in Action

A nanomorph's entire body acts as a sensor. This gives it the same sensory ability as a human being, with the addition that it has 360-degree vision. It can see, hear and taste with any part of its body – it could extend a finger around a corner, for instance, and see with that.

A nanomorph has the same communication ability as a robot with a basic communicator (p. 14) but no special options; it can speak by vibrating part of its body, and can physically interface with another computer brain (by plugging a finger or tendril into it) exactly like a robot that uses a cable jack.

A nanomorph's entire body functions as a rechargeable power cell; its skin acts as a solar collector. The nanomorph can function for 20 hours, plus five more per TL over TL11, on its normal power reserve. After that it becomes inert. Each hour the nanomorph spends in bright light will recharge one hour of power. A nanomorph can spread itself into a flat pancake shape to increase its recharge rate to two hours of power per hour, but it can't do anything else while it is recharging at that rate.

Since they are built entirely of bioplastic or living metal, nanomorphs can reshape their bodies voluntarily, enabling them to perform exceptional feats.

Division and Combination

A nanomorph can split into two nanomorphs, each half its size. To divide, a nanomorph must concentrate for two seconds. Each part of the nanomorph has the original's memory, but only half its volume; recalculate its statistics based on its new size.

The nanomorph's current hit points are split evenly between its two shapes (round up). Recalculate its ST, DX and IQ based on its new size; skill levels may increase or decrease if DX or IQ changes.

Involuntary division may occur if a nanomorph takes 3 × its hit points or more in damage for a single explosive (exp. damage) attack. Roll 1d+1 to see how many fragments of more or less equal size the nanomorph makes; they will scatter around a circle of 1d yards radius.

Two nanomorphs that are touching can concentrate for two seconds and combine to form a larger nanomorph. Recalculate the nanomorph's statistics as if it were a single nanomorph equal to the combined volume. When nanomorphs combine, they share each other's memories and experiences.

Damaging a Nanomorph

The nanomorph's brain and power system are distributed through its body – it has no vitals, and no hit locations with special effects. When a nanomorph takes damage, don't bother to determine a hit location. Just apply the damage to its hit points.

A nanomorph has PD 3 if built of bioplas or PD 4 if built of living metal. Its DR is its TL-10. However, divide any damage that penetrates its DR by 5 if the nanomorph is made of bioplas, or by 10 if it is made of living metal. (This division occurs after multiples for explosive projectiles or the like.)

A nanomorph also takes no extra damage from impaling attacks (but cutting attacks get their normal +50% damage multiple). It takes no extra damage from attacks against eyes, brains, vitals, etc.

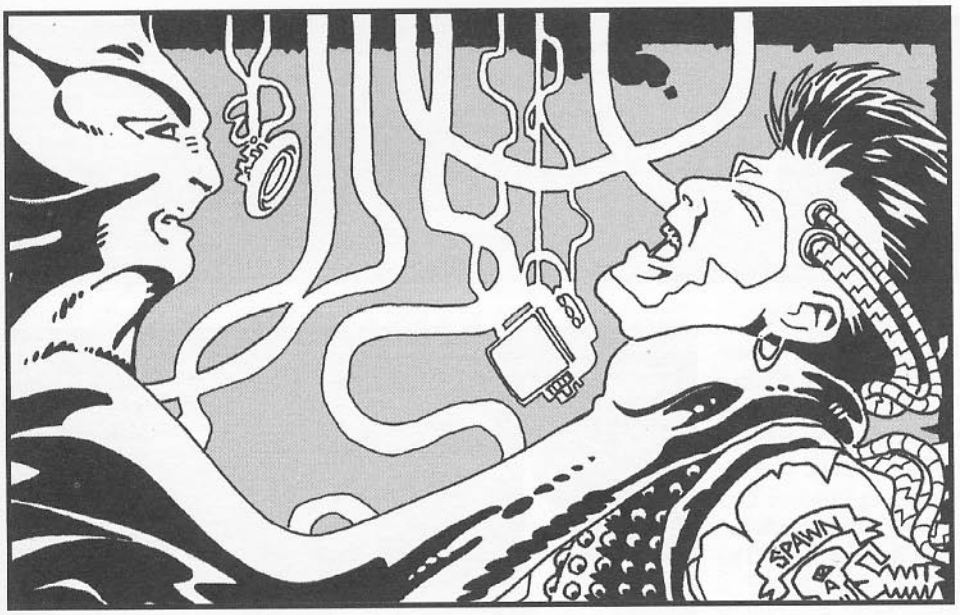
All nanomorphs regenerate. Bioplas nanomorphs regenerate at 1 hit per minute; living-metal nanomorphs regenerate 1 hit per turn. A nanomorph whose hit points fall below 0 is automatically incapacitated until it has regenerated to positive hit points.

A nanomorph never has to make HT rolls to avoid death, but if reduced below -10×HT, it is destroyed.

Unlike normal robots, nanomorphs take full shock, stun and knockdown results, just like a human being. If a nanomorph ever has to make a HT roll to recover from or to avoid stun or shock results, use its TL instead of HT. A nanomorph that takes 3 × its HT in damage from a single explosive attack may split into smaller 'morphs – see above.

Nanomorphing

Nanomorphs can shape their bodies into almost any solid form, from a humanoid shape to a blob to a flat sheet. This takes it only one turn of concentration, and enables it



to slip under doors, through narrow air ducts, or the like. A nanomorph can also sculpt itself into something resembling a metal sculpture of any kind of object whose volume is more or less identical to its own; to do so realistically, it must have a model it can study.

A nanomorph can also electronically "paint" its surface in whatever color or combination of colors desired, much like a chameleon system (p. 42). If it has a model to work from, it can use this ability in conjunction with its shapeshifting to produce an exact duplicate of any object that is more or less solid, such as a person.

A nanomorph can also reshape only a portion of its body. Some useful tricks the nanomorph can do:

Motive System: A nanomorph can shift between flexibody and leg forms of mobility, or change its number of legs. A nanomorph with a flexibody is a blob with Move 6; it has the advantage of having no side or rear hexes, only front hexes. A nanomorph with legs may have two or more legs. One with two or three legs has Move 12. A nanomorph with four or more legs has Move 20 but is at -1 to DX. It takes two turns to shift between leg and flexibody forms, or to alter the number of legs.

Multiple Arms: A nanomorph can extrude multiple arms that function as standard arms. The more arms it has, the lower their ST. The ST of an individual arm is equal to ST 4 (if bioplas) or ST 8 (if living metal) × the nanomorph's volume/number of arms extruded. It cannot make multiple attacks without a Full Coordination program (p. 59), no matter how many limbs it extends.

Weaponry: A nanomorph can alter any of its arms or hands into unpowered solid metal weapons or tools, such as swords, axes, crowbars, screwdrivers or hammers. Bioplas nanomorphs cannot form tools or weapons with sharp points (for example, weapons doing cutting or impaling damage). To create weapons other than a club, the nanomorph must either be programmed with that weapon skill or Armoury at skill 12 or higher. To shape its arms into tools more sophisticated than a crowbar (for instance, screwdrivers or pliers), the nanomorph must have Mechanic skill at 12 or better. The weight of the tool or weapon may not be greater than 3 lbs. per cf of nanomorph volume.

Weapons formed by a living-metal nanomorph are automatically very fine quality; those formed by a bioplastic nanomorph are of standard quality. A living-metal nanomorph with Armoury-15 or better can create weapons with a monomolecular edge; against cutting or impaling attacks, DR protects at one-tenth its normal value. It takes the nanomorph one second of concentration to shape a body weapon or tool.

Lockpicking: A nanomorph can insert its finger into a normal mechanical lock and adjust its shape to pick that lock: this gives it +5 to lockpicking attempts.

Prints: A nanomorph can give itself any kind of fingerprint, palm print, or footprint.

Envelopment: A nanomorph grappling someone who masses less than it does can envelop his entire body. A person enveloped by a nanomorph will take normal suffocation effects; the nanomorph can also do strangling damage based on its ST. Any attempt to break free is at -5! A nanomorph with the disassembler ability can then proceed to dissolve its victim; see the *Special Nanomorph Powers* sidebar on p. 73.

A nanomorph of near-human size (1 to 5 cf) can use human-type clothing and armor if it maintains a shape with two arms and two legs.

Special Nanomorph Powers

Disassembler: A living-metal nanomorph with this ability can release nanomachines that dissolve objects into gray goo. To do this the nanomorph must physically envelop the object it intends to dissolve and then make a ST roll, at -1 for every 10 full points of combined DR and HT the object has (use hit points, if the subject has a split HT). (If the nanomorph is dissolving parts of a building, use the HT+DR of a single hex of building.) If the nanomorph's roll fails, nothing happens (it can try again next turn). If it succeeds, it dissolves the object and expends .1 hour of its stored power. This attack is fatal to both living beings and machines.

Matter Absorption: As above, but the nanomorph's body absorbs the dissolved matter. A living-metal nanomorph gains .02 cf of volume per pound of metal it "eats." The process takes only one turn per attempt. Bioplas nanomorphs can absorb organic matter (including plastics), gaining .04 cf of mass for every pound of organic matter absorbed. Matter that can't be absorbed is excreted. As a nanomorph absorbs more matter, its ST will increase, allowing it to absorb still more! However, it will gradually deplete its own stored power in the process, limiting its ultimate growth.

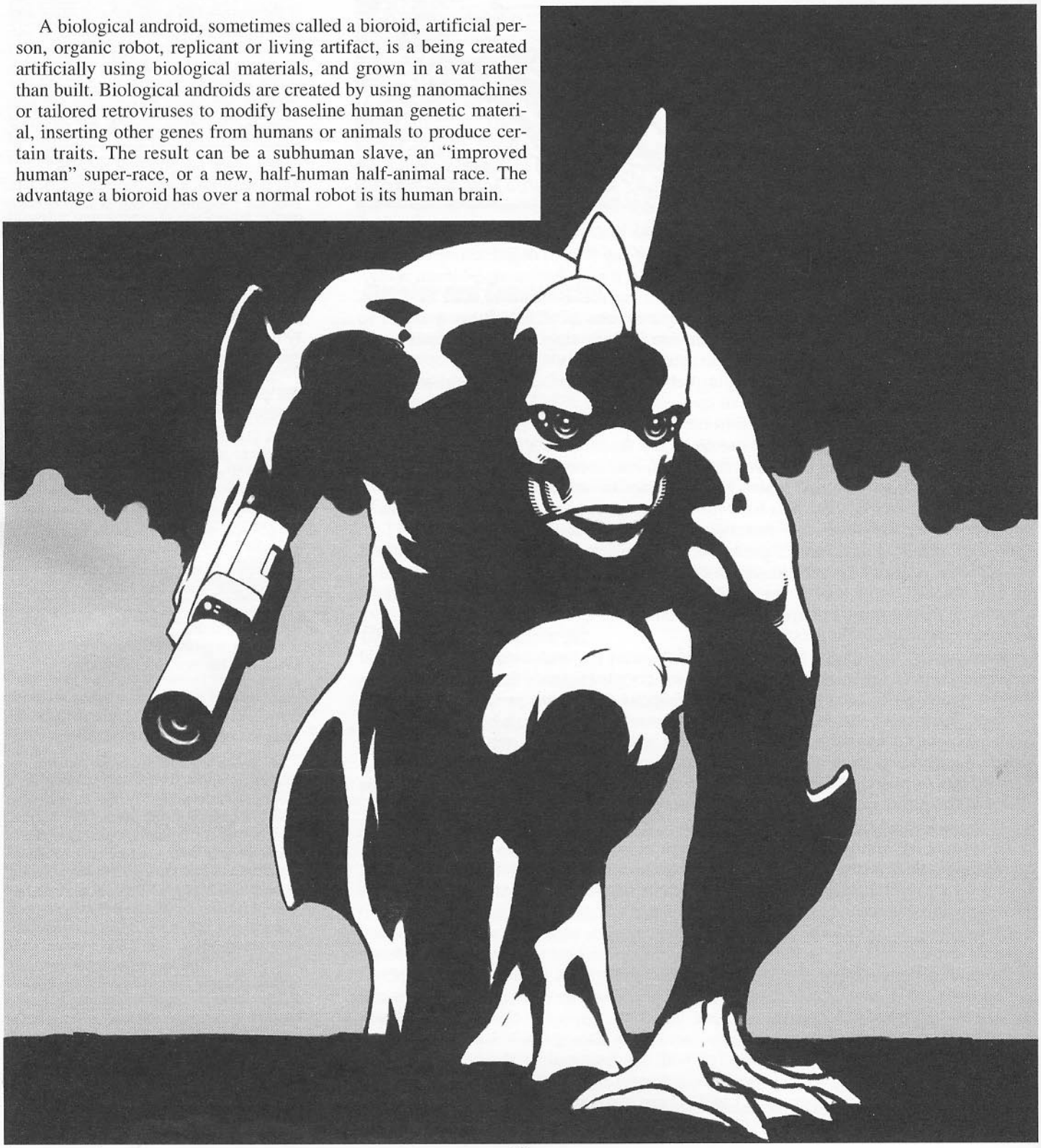
Memory Absorption: A nanomorph with this ability can steal the memories and personality of any living being or computer brain that it disassembles by recording the chemical and electrical structure of the brain as it absorbs them. The memory and personality are stored within its own computer brain's memory as a Ghost program (p. 65), provided the nanomorph has the memory space. The nanomorph can access or download these memories using its built-in cable jack, much like any other computer programs. (Thus, the memory and personality of someone "eaten" by a memory-absorbing nanomorph could, perhaps, be restored to life in a different body.)

Parasite Seeds

A parasite seed, a small capsule the size of an apple seed, is a template for a bioplas nanomorph. To be activated, it must be placed inside an organic animal (or a human!) – by being either injected or swallowed. It then releases nanomachines that begin transforming that being, using its body mass as raw material to construct a bioplas nanomorph. Each hour, the subject make a HT-4 roll. Any success kills the parasite seed. Any failure reduces the victim's HT by an amount equal to the failure. When HT is reduced to 0, he dies and his body is transformed into that of a bioplas nanomorph whose volume is the host's weight/50 cf. A parasite seed is TL12, and costs twice as much as an ordinary nanomorph, plus the cost of any programs the nanomorph was given. In combat, a parasite seed can be delivered by a drug injector.

BIOLOGICAL ANDROIDS 4

A biological android, sometimes called a bioroid, artificial person, organic robot, replicant or living artifact, is a being created artificially using biological materials, and grown in a vat rather than built. Biological androids are created by using nanomachines or tailored retroviruses to modify baseline human genetic material, inserting other genes from humans or animals to produce certain traits. The result can be a subhuman slave, an "improved human" super-race, or a new, half-human half-animal race. The advantage a bioroid has over a normal robot is its human brain.



Living artifacts are usually grown to do dangerous tasks (like soldiering, serving as secret agents, or working in hazardous environments), or to perform demeaning or low-status jobs (like prostitution). Because bioroids are specially-built genetic constructs, they can be designed with special abilities that let them do these jobs better than the humans they replace: gills for an underwater worker, heightened reflexes for a soldier, or exotic looks and an enhanced sex drive for a courtesan. But this can lead to conflict between genetic constructs and humans – is the bioroid a sub-human slave, simply a different form of human, or a member of a new race of super-humans? Should it be treated as a human or as a machine? Is it ethical to build a race of warrior-slaves or sex toys and then condition them to obedience? What if they develop a desire for independence, and run away or revolt? These questions, and the conflict they produce, are the stuff of adventures.

Ideas for how biological androids and society interact can be found in the film *Bladerunner* (based on Philip K. Dick's novel *Do Androids Dream of Electric Sheep?*), the Japanese manga *Appleseed,* and the novels *Friday* by Robert A. Heinlein, *Cyteen, Port Eternity* and *Serpent's Reach* by C.J. Cherryh, *The Dragon Never Sleeps* by Glen Cook, *Schismatrix* and the *Crystal Express* anthology by Bruce Sterling, and *Norstrilia* by Cordwainer Smith. The adventure "The Medusa Sanction" in ***GURPS Cyberpunk Adventures*** focuses on a group of biological android terrorists (or freedom fighters) battling the megacorporations that create and enslave them. ***GURPS Space Atlas 4*** describes the gene-altered "parahuman" cultures of the Federation and their political conflict with the humans that engineered them.

Not all campaigns will have biological android technology. The GM should consider carefully before deciding whether it fits into his campaign. Bioroid technology can easily create "super characters" with very high attributes, exotic special abilities, extended lifespans, and so on, overshadowing ordinary humans. This isn't a problem in a ***GURPS Supers*** campaign – and GMs may want to create a ***GURPS Space*** background where at least part of humanity has been superseded by a "biotech" culture in which everyone is genetically modified.

But if humans are intended to remain the dominant type of character, GMs may want to take steps to control bioroids. Ways of doing so include: limiting them to NPCs; restricting their numbers to a few exotic super-agents or experimental models with Unusual Backgrounds; or creating a society in which bioroids are effectively enslaved. In the last case, a bioroid PC is either the property of a person or organization or, if free, is on the run or fighting a system that seeks to enslave it.

Designing Biological Androids

Biological androids are designed as characters rather than as machines. In game terms, they are built much like the alien races in ***GURPS Space*** and ***GURPS Aliens*** except that, since they are also products, they have a tech level and dollar price as well as a character point cost.

Bioroids can be created at tech level 9 or higher, although the GM may want to adjust this in a particular campaign. The first thing to do is to decide why the bioroid was created. Likely tasks for living artifacts include enhanced super-agent, soldier, gladiator, colonist (why ship cheap workers to other planets when you can grow them there?), miner or construction worker (especially in hazardous environments, space, or underwater), servant, receptionist, or living toy. The choice of concept will help when selecting a suitable set of advantages and disadvantages: a bioroid built to serve as a super-agent will be quite different from one intended to work as a zero-G construction specialist, for instance.

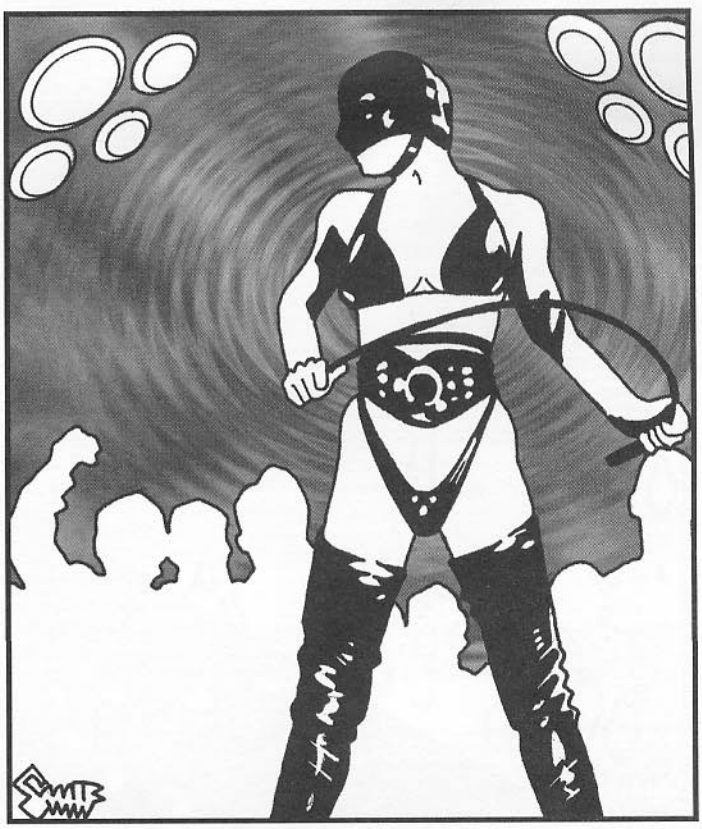
A particular "model" of biological android is designed with a mix of attribute bonuses, advantages and disadvantages, which are shared by every other example of that model. The total of advantages and disadvantages is its *model point cost* – the number of character points that must be paid to play that model of biological android, or, if negative, the points that are received for playing it. The suggested maximum model point cost is 100 points for one intended as a PC in an ordinary campaign. But in a supers or other high-character-point game this maximum can be ignored!

Creating a particular model of biological android consists of selecting an assortment of advantages and disadvantages. As with character creation, each of these advantages and disadvantages has a positive or negative point value. All these are totaled to find a final model point cost, positive or negative. If positive, the model point cost is treated like an advantage and must be paid to take that model of bioroid as a character. If negative, it gives extra character points, like a disadvantage – but *does not* count against the normal total of -40 points of disadvantages and -5 points of quirks.

Technological Limits

Biological androids can be built starting at TL9, but some advantages and disadvantages not available until higher TLs.

It's also possible that magic may be able to perform genetic modifications, allowing alchemists to create bioroids in their vats at TL1-3. Jack Vance's classic fantasy collection *The Dying Earth* describes this magical technology. Use the rules for android creation. Actually growing an alchemical android should require ingredients costing the same as the purchase price of a technological bioroid, take six months or more, and require an Alchemy roll at -1 per $10,000 of construct cost, with failure producing deformed or monstrous creatures.



Biological Android Advantages

The advantages that can be engineered deliberately into a bioroid at a given TL are listed below, along with their page reference (in the ***Basic Set*** or this book) and point cost.

TL9 Advantages

Type	*Cost*	*Page*
ST Bonus +1 to +4	10/20/30/45	78
DX Bonus +1 to +3	10/20/30	78
HT Bonus +1 or +2	10/20	78
Absolute Direction	5	B19
Absolute Timing	5	B19
Acute Hearing	2 per level	B19
Acute Taste & Smell	2 per level	B19
Acute Vision	2 per level	B19
Alertness	5 per level	B19
Amphibious	10	78
Appearance	5/15/25	B15
Ambidexterity	10	B19
Claws	variable	78
Combat Reflexes	15	B20
Disease-Resistant	5	78
Discriminatory Smell	15	78
Discriminatory Taste	10	78
Double-Jointed	5	B20
Eidetic Memory	30/60	B20
Extra Hit Points +1 to 3	5 per point	B236
Extra Limbs	variable	78
Filter Lungs	5	79
Fur	0/4/29	79
Gills	10	79
High Pain Threshold	10	B20
Hyper-Reflexes	15	79
Hyper-Strength	30	79
Increased Speed +1 to 2	25 per level	79
Lightning Calculator	5	B21
Longevity	5	B21
Mathematical Abili	10	B22
Night Vision	10	B22
Oxygen Storage	14	79
Perfect Balance	15	B237
Peripheral Vision	15	B22
Pheromone Control	25	79
Rapid Healing	10	B23
Sharp Teeth	5	79
Temperature Tolerance	6/10	79
Toughness	10/15	B23
Ultrasonic Hearing	5/25	80
Voice	10	B23

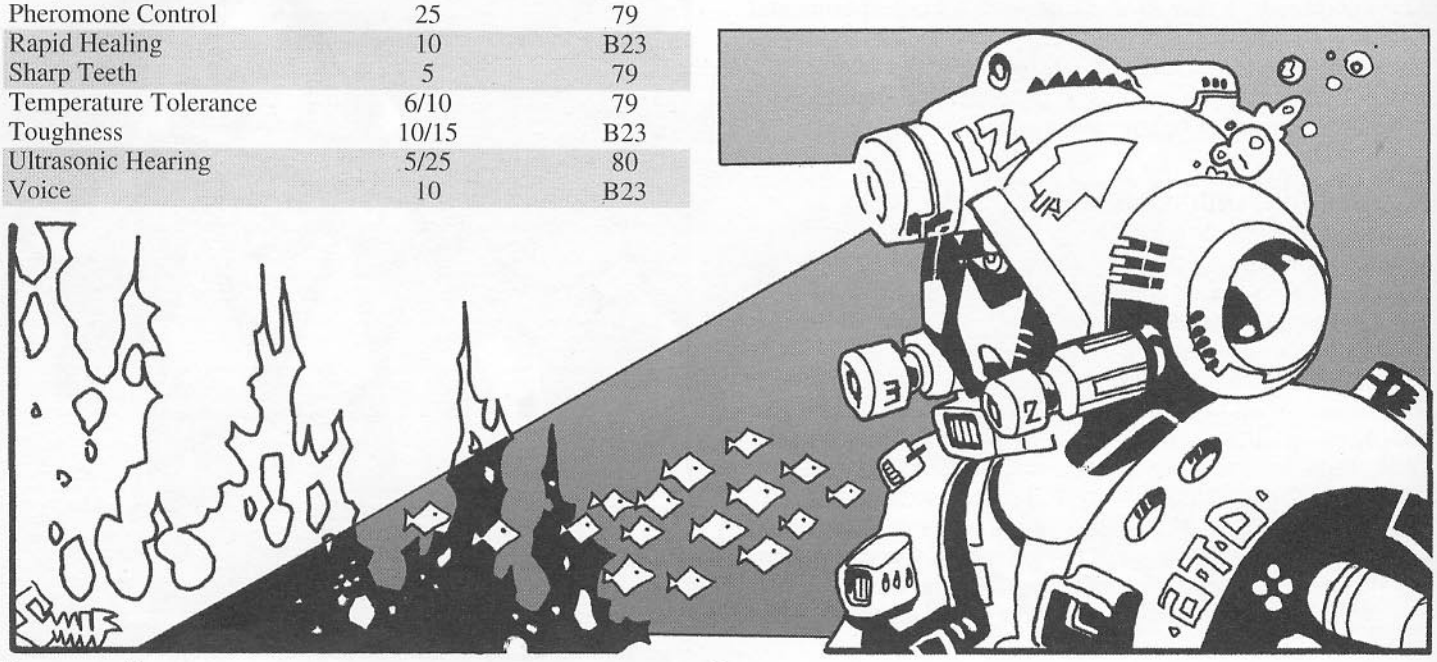
TL10 Advantages

Type	*Cost*	*Page*
ST bonus +5 to +7	60/80/100	78
DX bonus +4	45	78
IQ bonus +1 or +2	10/20	78
HT bonus +3 or +4	30/45	78
Animal Empathy	5	B19
Bioelectric Shock	10	78
Drug Factory	variable	78
Extra Hit Points +4 to 5	5 per point	B236
Hermaphromorph	2	79
Hide or Scales	0/4/29	79
Increased Speed +3 to 4	25 per level	79
Infravision	15	B237
Intuition	15	B20
Language Talent	2 per level	B20
Musical Ability	1 per level	B22
Sanitized Metabolism	5	79
Sonar	25	79
Venom	15 per level	80

TL11+ Android Advantages

Type	*Cost*	*Page*
ST Bonus +8 to +10	125/150/174	78
DX Bonus +5	60	78
IQ Bonus +3 or +4	30/45	78
HT Bonus +5	60	78
Charisma +1 to +2	5	B19
Danger Sense	15	B20
Elastic Skin	20	78
Extra Hit Points +6 to 9	5 per point	B236
Empathy	15	B20
Immunity to Disease	10	B20
Immunity to Poison	5/15	79
Increased Speed +5	25 per level	79
Regeneration	25	79
Vacuum Adaptation	27	80

Abilities like psi powers, super abilities, Magery and Magic Resistance may be engineered if they have a mapped genetic cause. The GM should set the TL depending on how intricate the genetic complex is.





Biological Android Disadvantages

In game terms, most biological androids should have some disadvantages. This has the dual benefit of reducing their model point total and making them more realistic. All are available at TL9 and up.

Disadvantages may be unintentional flaws that are tolerated in otherwise good designs: who cares if a soldier or worker android is Unattractive as long as it has enhanced ST and DX?

Tinkering with brain chemistry or hormones to produce desired traits (e.g., Combat Reflexes, Eidetic Memory, Intuition) may have unexpected side effects (e.g,. Absent Mindedness, Bad Temper, or Paranoia).

Other defects could occur due to their association with desired genetic traits. For example, an living artifact built using many feline characteristics (Claws, Fur, Perfect Balance, high DX etc.) may also turn out to be prone to Impulsiveness – the designer decides removing the flaw is too much trouble. Some may be idiot savants (Mathematical Aptitude and low IQ, for instance). Those with animal DNA may even revert to more primitive behavior patterns (Stress Atavism).

Still other disadvantages may be deliberate modifications: setting a bioroid's hormonal balance to make a sex-toy Lecherous or give a gladiator Bloodlust, for example, or altering brain chemistry to make a low-grade worker less intelligent and thus a better slave. Building androids that have a biological Self-destruct coupled with Short Lifespan and Sterility is one means by which humans could control an artificial population.

Model disadvantages do not count toward the normal limit on disadvantages, and thus are very useful for balancing attribute bonuses or other model advantages.

Suggested Mental Disadvantages

Disadvantage	*Cost*	*Page*
IQ penalty	variable	80
Absent-Mindedness	-15	B30
Bad Temper	-10	B31
Berserk	-15	B31
Bloodlust	-10	B31
Bully	-10	B31
Combat Paralysis	-15	B32
Compulsive Behavior	-5 to -15	B32
Cowardice	-10	B32
Dyslexia	-15	B33
Impulsiveness	-10	B33
Laziness	-10	B34
Lecherousness	-15	B34
Low Empathy	-15	88
Megalomania	-10	B34
Odious Personal Habit	-5/10/15	B26
Overconfidence	-10	B34
Paranoia	-10	B35
Sadism	-15	B36
Sense of Duty	variable	B39
Slave Mentality	-40	89
Split Personality	-10/-15	B37
Stress Atavism	-16	80
Stuttering	-10	B29
Weak Will	-8 per level	B37

Suggested Physical Disadvantages

Disadvantage	*Cost*	*Page*
ST Penalty	variable	80
DX Penalty	variable	80
HT Penalty	variable	80
Albinism	-10	B27
Appearance	variable	B25
Bad Sight	-10	B27
Blindness	-50	B27
Color Blindness	-10	B28
Deafness	-20	B28
Delicate Metabolism	-20/-40	80
Dwarfism	-15	B28
Epilepsy	-30	B28
Eunuch	-5	B28
Fat	-10/20	B28
Gluttony	-5	B33
Gigantism	-10	B28
Hard of Hearing	-10	B28
Lame: Legless	-35	B29
Low Pain Threshold	-10	B29
Reduced Hit Points	-5 per point	80
Mute	-25	B29
No Sense of Smell or Taste	-5	B29
Overweight	-5	B29
Self-Destruct	-20	80
Short Lifespan	-10 per level	80
Skinny	-5	B29
Sterile	-3	80
Unusual Biochemistry	-5	81
Weak Immune System	-30	81

New Advantages and Disadvantages

Several advantages not listed in the ***Basic Set*** are needed to create biological androids.

New Advantages

ST, DX, IQ and HT Bonuses — Variable

These advantages give you a model bonus to an attribute. A +1 bonus costs 10 points, a +2 costs 20, a +3 costs 30, a +4 costs 45, a +5 costs 60, a +6 costs 80, a +7 costs 100, a +8 costs 120, and a +9 costs 150. A biological android with a model bonus to an attribute buys that attribute normally – and then applies the model bonus. For example, one with a model bonus of +2 to ST that wanted ST 14 would pay 20 points for ST 12, then add the model bonus of +2, leaving him ST 14. If he paid no points, his ST 10 would become ST 12.

Amphibious — 10 points

You are as comfortable in water as on land. You suffer no penalties for skill use in combat when working underwater, and can swim at your normal move rate. Typical features include smooth seal-like skin and webbed fingers an toes. You cannot breathe underwater without another advantage.

Bioelectric Shock — 10 points

You can generate an electric current in your body, much as an electric eel or ray does. This inflicts 1d electrical damage if you touch a person. It costs 2 Fatigue. You can also use the ability to *save* lives: add +3 to First Aid skill when making CPR rolls!



Claws — Variable

You possess claws, usually the result of animal genesplicing. For 15 points, you have blunt claws: these add +2 crushing damage to a kick or punch. For 25 points, you have sharp claws. These convert a kick or punch's crushing damage to cutting damage. For 40 points, you have talons. These allow a kick or punch to do swing/cutting or thrust/impaling damage. For 55 points, you may have long talons, doing swing+2/cutting or thrust+2/impaling. This advantage only has to be purchased once, regardless of how many limbs you have.

Discriminatory Smell — 15 points

Your sense of smell is far beyond human norms, giving you the same abilities as the similiar robot sensor option (see p. 12).

Discriminatory Taste — 10 points

Your sense of taste is far beyond human norms, giving you the same abilities as the similiar robot sensor option (see p. 12).

Disease-Resistant — 5 points

Your immune system is improved dramatically, with specially engineered defensive phages and white blood cells. These ward off most diseases, giving you a +8 bonus to HT to resist them. GMs may devise the occasional disease against which you have no special resistance. This is a lesser form of the 10-point Immunity to Disease advantage.

Drug Factory — Variable

Your glands produce natural analogs of existing drugs. Various drugs are described in ***GURPS Cyberpunk, GURPS Space, GURPS Ultra-Tech,*** and ***GURPS Lensman.*** You can only produce an analog of a drug whose tech level is no higher than your TL. To insure play balance, the GM must approve any drug, e.g., if the GM wants a particular drug to be very rare, it could be beyond the technological of a drug factory to synthesize. You can administer these drugs to others via a bite or claws. Your metabolism is limited to producing HT/2 doses. It replaces one dose every four hours. This advantage costs 20 points for the first drug and ten points per extra drug.

Elastic Skin — 20 points

You can alter skin and facial features to duplicate those of humans or near-humans of similar size and shape. This takes 10 seconds and costs 1 Fatigue; there is no cost to change back to your original form, which only takes 3 seconds. You cannot duplicate clothing. Duplicating a specific individual requires a Disguise+4 roll.

Extra Limbs — Variable

A bioroid may have up to four extra arms, although two are more common. Extra arms allow extra actions for a bioroid in the same way as they do for a robot – see the *Robots in Action* chapter. Arms cost 10 points each.

Limbs that can manipulate but cannot attack cost 5 points each. An example would be a very light, stunted arm or a prehensile tail. Limbs that can attack but cannot manipulate or be used for walking are strikers. A heavy tail or an arm with no hand are examples. Strikers cost 5 points each. If claws are bought, the striker gains the claws damage.

Filter Lungs — 5 points

This advantage equips you with self-regenerating biological filters designed for contaminated atmospheres – which may include a polluted cities on Earth as well as alien planets.

Fur — 0/4/29 points

For a cost of 0 points you have *very thin fur* like that of a Chihuahua dog. It prevents sunburn and gives you a distinct appearance, but has no other qualities.

For 4 points, you have *fur* similar to that of a cat's fur or dog's hair, providing DR 1 and protection equivalent to light clothing.

For 29 points, you have *thick fur.* This is a dense pelt, like a polar bear's, providing PD 1 and DR 1. It acts as warm clothing, but may cause suffering in hot weather!

Fur is also obvious, and you require proper grooming that can take time; loose fur and static build-up can be a problem.

Gills — 10 points

You have gills *as well as* lungs, enabling you to breathe water or air. A biological android built with gills *instead of* lungs *cannot* breathe air!

Hermaphromorph — 2 points

You are designed to switch between fully functional neuter, male and female forms. The process takes about 6 hours, during which you will experience mood swings and suffer from the Bad Temper disadvantage (or if already bad tempered, make all Will rolls to resist it at -3).

Hide or Scales — 0/4/29 points

You have a thick hide or actual armored scales.

For 0 points, you can have *very light scales,* like a snake. Besides the appearance, there is no other game effect.

For 4 points, you may have *scales,* like a lizard's. This gives you DR 1.

For 29 points, you may have *thick hide,* like elephant or rhino hide, or *heavy scales* like an armadillo or armored lizard. This gives you PD 1, DR 1. Any bioroid with this advantagee may not have an Appearance better than Average!

Hyper-Reflexes — 15 points

You can voluntarily produce and control abnormal levels of adrenaline, increasing speed and reflexes. At the start of any turn, you can activate your hyper-reflexes. This costs 1 Fatigue *per turn* but gives you the Combat Reflexes advantage and +1 to Basic Speed. (If you *normally* have Combat Reflexes, gain double the usual benefits.)

Hyper-Strength — 30 points

You can voluntarily duplicate the feats of hysterical strength that normal people sometimes perform. You may increase ST (but not Fatigue) by 50% at a cost of 1 Fatigue *per turn.*

Immunity to Poison — 15 points

For 15 points, you are genetically engineered, or different enough biologically, to be immune to poisons (including sleep and nerve gas), alcohol and nonmedical drugs. You are still vulnerable to acid and diseases. For only 5 points, you can simply be *resistant to poison:* +3 to HT to resist effects.

Increased Speed — 25 points/level

Each level increases your Basic Speed by 1, which in turn also increases your Move and Dodge.

Infravision — 15 points

You can see into the infrared, much like a robot with the infrared vision option (see p. B237).

Oxygen Storage — 14 points

Synthetic genes modify your lungs and alter your body so that you can store oxygen (up to an hour's worth) in the myoglobin of your muscles and in an altered liver. Biological androids with this advantage never get "the bends" when diving using their internally stored oxygen. (They can still suffer "the bends" if diving with conventional scuba equipment.) This advantage is common in bioroids designed to function underwater without gills, or in space.

Pheromone Control — 25 points

You can release powerful sex pheromones. Any human (or bioroid) within four yards (more if down wind) may breathe them in (unless wearing an airtight suit, etc.). Anyone breathing your pheromones will find you one level more Attractive (add a +2 extra reaction bonus) if you are already Very Beautiful and will break into a sweat and become aroused: they must roll vs. HT-3 or suffer from Lecherousness for the next ten minutes. The fact that a biological android is using sex pheromones may not be immediately apparent: when a PC is affected, the GM may wish to describe the encounter in such a way that the character believes the attraction is "natural" rather than a chemical attack. Characters who have previously experienced pheromone control (and know what it is) can get an IQ-3 roll to realize their reactions are being artificially stimulated; however, they still suffer the effects.

Regeneration — 25 points

You can heal very rapidly. You have the Rapid Healing advantage at no extra cost, and can recover one extra HT or hit point per hour.

Sanitized Metabolism — 5 points

You are designed to be totally *clean.* Designer intestinal enzymes and symbiotic bacteria eliminate your body odor and make efficient use of food and drink, leaving minimal, sanitized waste products. You never suffer from bad breath, excessive perspiration or unsightly skin problems. Your abilities give a +1 on all rolls where Appearance or Sex Appeal are a factor. This advantage is also perfect for bioroids designed to work in sealed factory environments ("clean rooms").

Sharp Teeth — 5 points

You can do cutting damage by biting in close combat, using the table on p. B140.

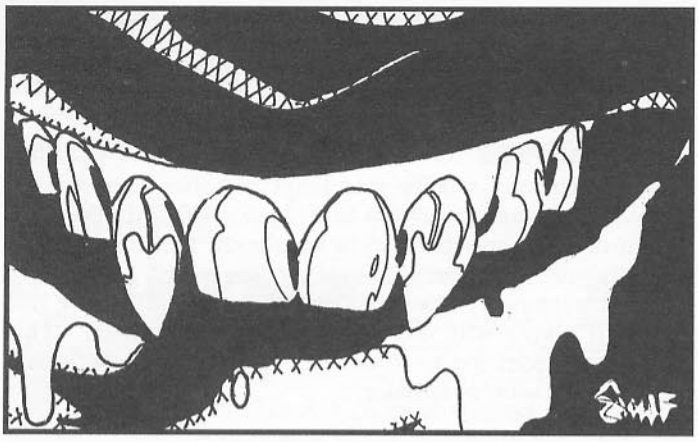
Sonar — 25 points

You can "see" using sound waves, much like a robot with the sonar option (p. 13).

Temperature Tolerance — 6/10 points

You are designed to withstand extreme temperatures; it gives no advantage against attacks that do damage, but does protect against climatic conditions.

Multiply your HT×5. Subtract this number from 35 degrees to find the lowest temperature you can stand. Add this number to 90 degrees to find the highest.



If you can only withstand heat, or only withstand cold, it is worth only 6 points. If you can withstand both, it is worth 10 points.

Ultrasonic Hearing — 5/25 points

You can detect very high frequency sounds (to 40,000 Hz) much like a robot with the ultrasonic hearing option (p. 12). For 25 points, you can also communicate in ultrasonics.

Vacuum Adaptation — 27 points

Humans living in space always run the risk of life-support failure and explosive decompression. Genetic modification can reduce the risk for living artifacts. You get stronger skin (DR 1) to resist pressure drops, new muscles to close off your gut and lungs, and transparent membranes to protect your eyes. You suffer no damage from explosive decompression (p. S75) and are not mentally stunned by Rapid Decompression (p. S75). An extra layer of adipose tissue gives you the 10-point version of the Temperature Tolerance advantage (p. 79). Your hair and skin changes color to protect against ultraviolet solar radiation, and can turn a deep black. (This advantage is often combined with Oxygen Storage to create space-worker androids that can survive unprotected in space for short periods of time.)

Note that this advantage is cheaper than, but not as effective as, the Vacuum Support advantage described in *GURPS Aliens.*

Venom — 15 points per level

You can secrete a poisonous venom through your saliva, bite or claws.

For 15 points per level, the venom can be immediately lethal. This does 1d of damage per level immediately; each hour afterward, the victim rolls vs. HT (-1 per level of this advantage); if he fails this roll, he takes a further 1d per level of damage, while if he succeeds, the damage stops.

Or, the venom can be slower-acting but more lethal. Damage is 1d per level if the HT roll is made, 3d per level if it is failed. The effects take one hour to show. Cost is the same.

At a one-third increase in cost, you can spit venom. This is a ranged attack, based on DX, with SS 12, Acc 12, ½D n/a, Max 5. The venom must strike an open wound, eyes, nostrils or open mouth to have effect, normally requiring an attack against an unshielded face.

New Disadvantages

ST, DX, IQ and HT Penalties — Variable

These disadvantages give your entire model line a penalty to a specific attribute. A -1 is a -10 point disadvantage, a -2 is worth -15 points, a -3 is worth -20 points, a -4 is worth -30 points, and a -5 is worth -40 points.

A biological android with a model penalty to an attribute buys that attribute normally – and then applies the model penalty. For instance, a bioroid with a model penalty of -2 to DX that wanted a final DX of 14 would pay 80 points for DX 16, then subtract the model penalty of -2, leaving him with DX 14. If he paid no points, his DX 10 would be reduced to DX 8.

Delicate Metabolism — -20/-40 points

Your metabolism is more delicate than that of a normal human – you require a special diet and filtered water. If you consume normal food and drink, it will sustain you, but you must make a HT roll. Failure means loss of 1 HT due to nausea, cramps, and illness. Critical failure means loss of 1d HT. The cost of your special diet is twice that of normal food, and may be unavailable in some areas (especially in regions with TLs below 7).

For -40 points, you cannot survive on normal food at all. Special nutrients are only available from your creator, generally at a cost to your creator of 100 times the cost of feeding a normal human. For someone else to synthesize it will be a difficult task requiring Biochemistry skill – use the Inventions rules on p. B186). (With the GM's permission, you may require something disgusting or dangerous to get, such as fresh human brains, fresh blood of a certain type, or human cerebral-spinal fluid). Most normal foods make you ill as described above.

Reduced Hit Points — -5 points each

You are smaller or more fragile than a human, and have fewer hit points than your HT, giving you a split HT.

Self-Destruct — -20 points

As soon as you reach your aging threshold (age 50 for a normal human), your organs and immune system begin to fail. You starts to age rapidly, making aging rolls every *day* at -3 to HT. This disadvantage ensures a steady demand for new bioroids!

Short Lifespan — -10/level

Each level reduces by 1/4 (round down) the age at which you becomes mature *and* the age at which you begin to suffer aging effects. This disadvantage speeds up production of androids, and like Self-Destruct ensures a steady demand for new models. It is often found in conjunction with Self Destruct.

Sterile — -3 points

You cannot produce offspring, but are otherwise a fully-functioning male or female.

Stress Atavism — -16 points

Stress atavism is not uncommon among biological androids created from animal DNA, and sometimes shows up in others as well. It may cause them to "regress" to animal instincts if frightened, angered, fatigued or injured.

In any such stressful situation, you must succeed in a Will roll to avoid the effects. If you fail, you behave like an animal, acting on impulse and instinct. You will be unable to talk (but may make animal sounds) and cannot use machinery. You may be unable to understand spoken language – roll vs. IQ after any sentence to see if you get the meaning of it. If you are attacked, threatened or challenged, you must make a Will roll to avoid acting on instinct – usually either flight or a frenzied physical attack, depending on how aggressive you usually are.

Stress atavism attacks are also very fatiguing – you take one point of Fatigue for every minute the attack lasts.

A roll is allowed vs. Will every minute to recover from an attack; add a +2 bonus if you are comforted by friends or someone with Empathy or Animal Empathy, or +4 if both apply. A character who passes out from Fatigue loss recovers after waking up.

(The stress atavism described here applies to common, moderate forms. Other types of stress atavism are described in *GURPS Uplift* on p. 25.)

Unusual Biochemistry -5 points

Your biochemistry, while still enabling you to subsist on human food and water, is different enough from that of humans that drugs that work on humans have reduced or unpredictable effects. When a drug is given to you, roll 1d. On a roll of 1-3 the drug has normal effect. On a roll of 4-5, it has its normal effect combined with an additional negative effect: lose 1d Fatigue (sickness and nauseau) or, at the GM's option, enhance any negative effects of the drug. On a 6, the drug no effect at all. A biochemist with a lab can manufacture variants of normal drugs that are specific to your biochemistry, but these drugs cost are ten times as much as usual.

Weak Immune System -30 points

You have poor resistance to disease and infection. HT rolls to resist specific diseases or infections are at -3 to HT or against HT 9, whichever is less. Drugs like Panimmunity I and II have half their normal effect; you may not take the Immunity to Disease advantage, and Panimmunity III has no effect on you. Unless you take special precautions (for instance, remain in a sealed environment or wear air-tight clothing when you leave one), the GM should require an unmodified HT roll to avoid coming down with a potentially serious disease every month. Although not necessarily fatal (especially with high-tech medicine) this will force you or your owner to spend additional money on drugs and hospital treatment.

Price

Like robots, biological androids may be bought and sold. To calculate the price of an untrained but biologically mature model, use the formula below. It reflects the utility of the android (its model point total) and the amount of tinkering that went into creating it.

The basic cost is $50,000. In addition, each model advantage the bioroid has costs $1,000 per point. Each model disadvantage the bioroid has costs $500 per negative point.

Halve the cost at TL10, and again at TL11+.

Example: A TL9 biological android with 80 points of model advantages and -40 points of model disadvantages costs $50,000 + $80,000 (80×$1,000) + $20,000 (40×$500) = $150,000.

Growing Biological Androids

Bioroids are usually grown in artificial wombs ("vats") much like human clones. Usually these vats are designed to simulate the conditions of an idealized human womb with carefully regulated fluid temperatures and even sounds like a taped heartbeat.

Some bioroids are taken out of the vats as babies, and given over to surrogate mothers to be raised as children in normal or group homes. This usually results in a bioroid that is well adjusted to living with humans. It's common for androids that are designed to be "people" rather than "slaves."

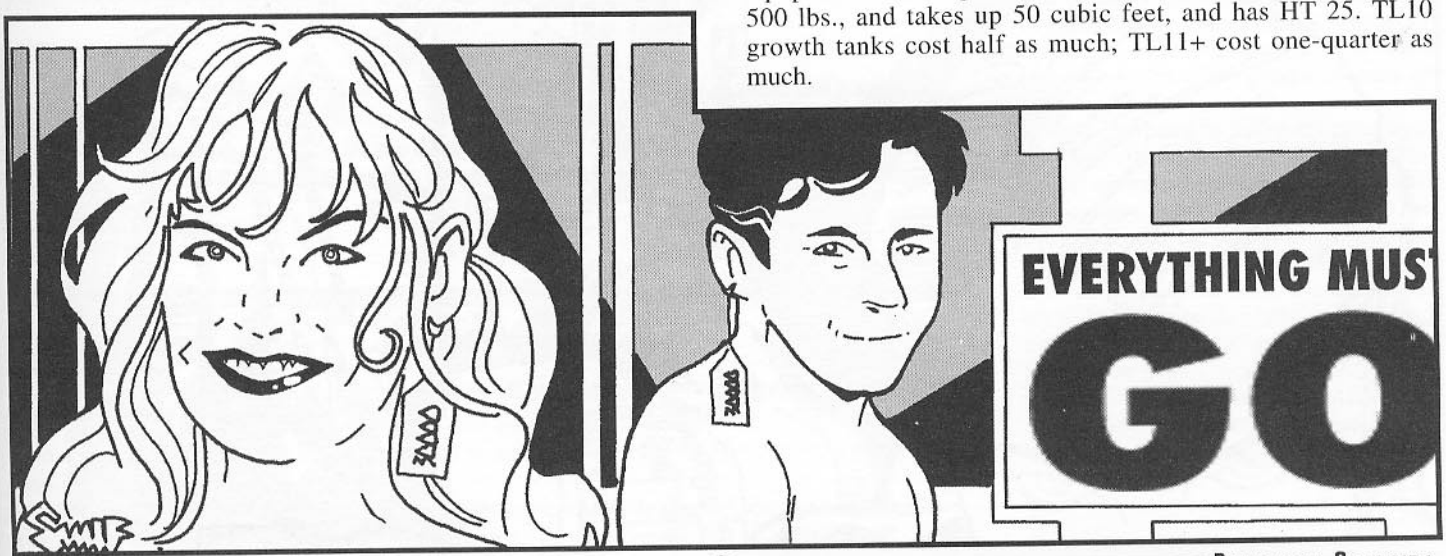
Other bioroids are force-grown to adulthood while still in the vats using the TL8+ cloning technology described on p. UT42 and p. S65. A force-grown android will have whatever "physiological" age is desired (usually age 18 to 25). This technique is most common for biological androids intended as "products" since it allows them to be mass-produced quickly. Force-grown androids receive an additional six weeks of "deep learning" via extensive use of sleep teaching, or virtual reality or cybernetic "dreamgame" simulations while they float in their tanks. This gives the android basic life skills: control over its own body and the ability to understand and speak one language at its IQ level.

Force-grown androids may spend additional time in the tanks, up to an extra year and a half (any more time imposes too severe a psychological stress). Every month spent allows the android to spend two character point on skills it was taught. Thus, an android that comes out of the tanks may spend 36 characters points on skills, much like an eighteen year old human.

Some androids are given "live" training before going on the job, if only to get experience in interacting with humans in a normal setting. Surrogate-raised androids, of course, will receive whatever education their surrogate parents or teachers provided.

Purchasing a skilled android (whether force-grown or surrogate-raised) costs an extra $5,000 per skill point it has.

A growth vat for growing androids, along with life support equipment and computers to monitor it costs $500,000, weighs 500 lbs., and takes up 50 cubic feet, and has HT 25. TL10 growth tanks cost half as much; TL11+ cost one-quarter as much.



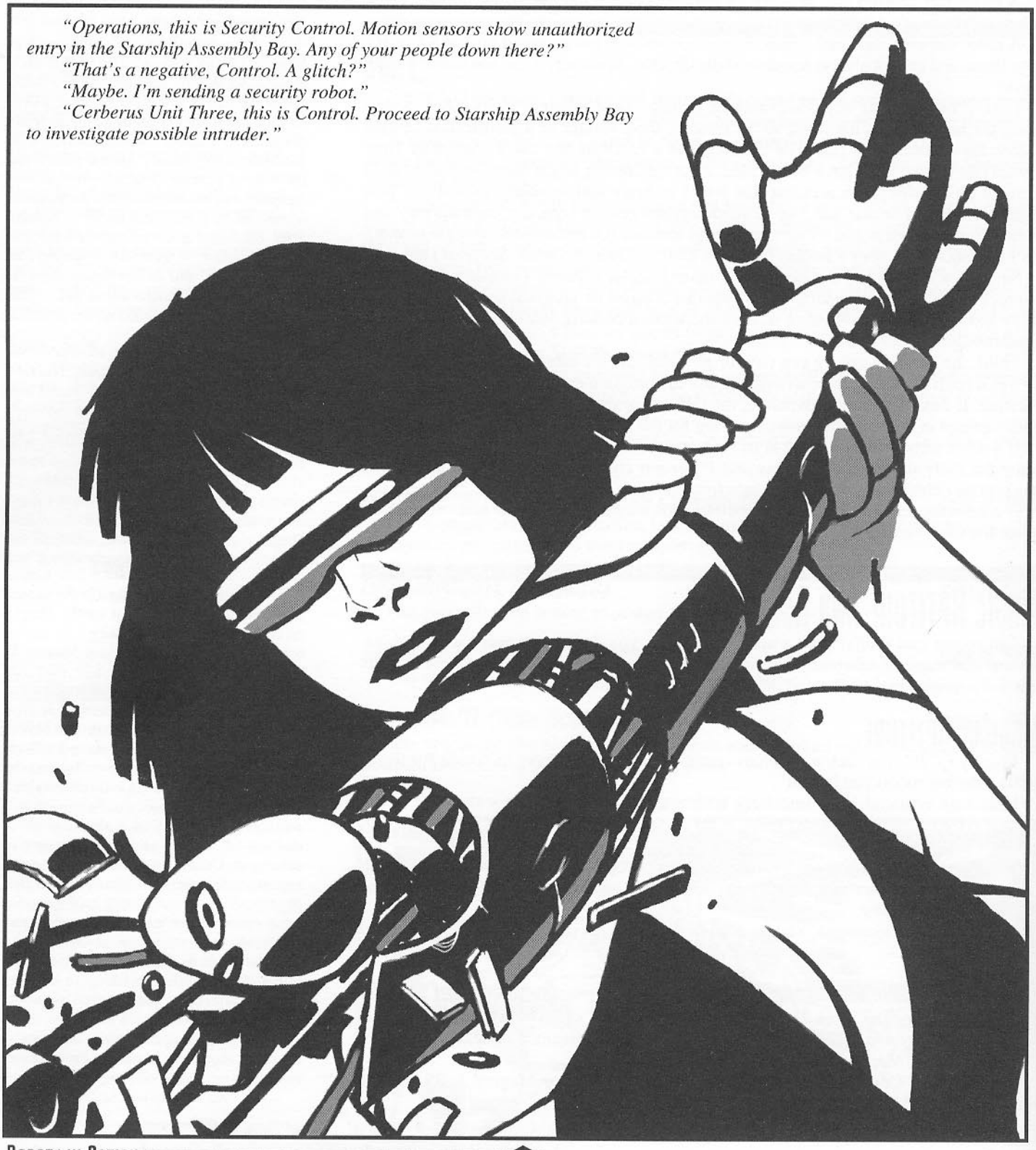
ROBOTS IN ACTION 6

"Operations, this is Security Control. Motion sensors show unauthorized entry in the Starship Assembly Bay. Any of your people down there?"

"That's a negative, Control. A glitch?"

"Maybe. I'm sending a security robot."

"Cerberus Unit Three, this is Control. Proceed to Starship Assembly Bay to investigate possible intruder."



"Cerberus Three to Control. My bioscanner confirms unauthorized human life form in area. Am closing . . . . Have achieved visual identification: life form is human female, unarmored, holding small hand weapon. Running weapon library scan. Weapon identified as needler. Threat level minimal."

"Cerberus Three, this is Security Control. You are authorized to subdue the intruder."

"Affirmative. Stunner firing. Hit achieved. No effect on target. Intruder closing fast. Intruder is . . ."

"Cerberus Three, report. Your telemetry is breaking up."

"Am in close combat with intruder and sustaining damage. Warning! Initial scan in error. Intruder reclassified as combat android. Upgrading threat level to maximum."

"Cerberus Three, you are authorized to use lethal force."

"Negative capability. Left arm containing laser weapon is no longer attached to this unit. Am sustaining heavy damage. Positive ID on intruder: SY-101-N covert operations robot. Warning! Total systems failure is imminent. Total sys –"

"Security Control to all Cerberus units, proceed to Starship Assembly Bay! Red alert!"

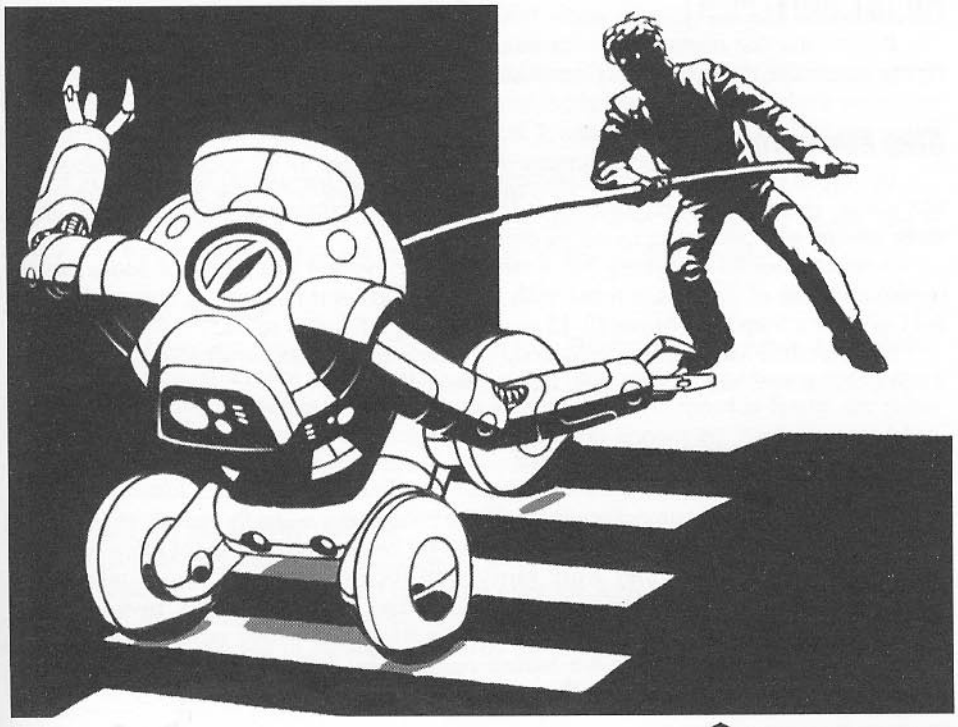
This chapter discusses how robots move, fight, take damage and are repaired. Robots use the same rules for movement, combat and other action that humans do, with several exceptions. Some of these are obvious: if a robot doesn't have arms, it can't lift or manipulate objects; if it lacks audio sensors, it can't hear. Others require special rules, which are covered in this chapter.

Robot Strength

Robots often have multiple ST attributes: a body ST for the robot's body (and legs, if any) and different ST value for each of its arms. If a robot is lifting, pushing, grappling or striking with an arm, use the arm's ST. If it is lifting and moving things on its back, or slamming, use its basic ST.

Fatigue and ST

Robots don't have a fatigue score. Robots take no Fatigue from combat, long marches, running or swimming, or losing sleep. They ignore magical or psionic attacks that would cause a human to take Fatigue. A robot may not use Extra Effort. If a robot is overtaxed, decrease the interval between maintenance checks and increase power or fuel usage.





Fast-Moving Robots (Optional)

Robots that move at high speeds should take some time to reach their top speed, or slow down from it, and will also be less maneuverable. These rules can and should be ignored for slow-moving robots – those moving at velocities 10 yards per turn or slower. But when a robot moves faster than this, it should move more like a vehicle than a person. Use the following rules:

Velocity: Unless a robot accelerates or decelerates, it must move the same number of yards that it moved on their previous turn. This is its velocity; keep track of it.

Acceleration: In a single turn, a robot that accelerates can increase its current velocity by a maximum that depends on how it moves:

Moving on two legs: (top Speed minus velocity)/3.

Moving on three or more legs: (top Speed minus velocity)/5.

Moving on wheels or tracks: (top Speed minus velocity)/10.

Moving by any other means: (top Speed minus velocity)/20.

If a robot's acceleration would be less than .5 yard per second (1 mph), treat its acceleration as .5 yard per second.

Deceleration: In a single turn, a robot that decelerates can decrease its current velocity by a maximum that depends on how it moves:

Moving via two legs: 5 + (top Speed/3).

Moving via three or more legs: 5 + (top Speed/5).

Moving via wheels or tracks: 5 + (top Speed/10).

Moving by any other means: 5 + (top Speed/20), maximum 10.

Deceleration cannot exceed 20, however.

Turning: GMs may wish to use the rules on turning radius on p. B139 to restrict the maneuverability of high-speed robots.

These rules are intended as a playable simplification – for more complex and realistic handling of acceleration, deceleration and turning, calculate a robot's statistics like that of a vehicle, and use the rules in ***GURPS Vehicles,*** *Second Edition.*

Weapon Placement and Arc of Fire

Where a weapon was placed in the robot determines what direction it can fire. If a weapon is placed in the body or a pod, decide which side of the body it points out of. It can only fire in that direction. If a weapon is mounted in an arm it can fire in any direction the robot points the arm. If a weapon is mounted in a head, it can fire in any direction the head turn to face.

Cinematic Combat

Science fiction is full of classic ways humans can defeat robots. Not all of these are appropriate for a serious campaign, but they are especially appropriate for a cinematic one. All of these rules are optional; some will unbalance a serious campaign.

Paint on the Sensors: Or glue or spaghetti – anything sticky. A successful DX or throwing roll, at -10 to hit (use an all-out attack!) with cover the robot's visual or thermal sensors, leaving it blind. An alternative is to place a cloak, tapestry or hat over its head, though if the robot has manipulator arms, these can be easily removed. In addition to having a -10 to hit (unless it has radar or other scanners), many movie robots who are blinded spin around out of control (give the robot an IQ roll to avoid panic) for 1d rounds due to disorientation, or fire wildly with weapons destroying friend and foe alike. Some may even self-destruct! But most robots will usually rely on audio sensors or datalink from other robots to target opponents, or retreat.

Cinematic Knockback: In cinematic combat, a person with a shotgun or heavy pistol can sometimes stun a heavily armored robot even if his shot didn't penetrate DR. GMs may rationalize this as the robot pausing to evaluate the damage, the computer brain (being sensitive) suffering disruption, the robot being knocked off balance and taking a second for its gyros to reorient, or whatever. Besides rolling to see if it falls down, a robot that suffers knockback must make an IQ roll or be mentally stunned for one turn. The roll is at -2 per hex the robot was knocked back.

Pushing Them Over: Not a bad tactic; robots without legs often find it difficult to right themselves if they are unbalanced. Use normal slam procedure – see the rules on *melee and close combat* for rules on robots and slams, and *effects of damage* under knockback for robots getting up again. A robot without legs, the flexibody option, or flight with hover capability will be unable to right itself unless its arms are strong enough to lift its weight.

Continued on next page . . .

Robots with Multiple Arms

A normal arm is just like a human arm; one with the Bad Grip option functions as a human arm, but at -4 to DX. A handless "striker" arm or a robot leg is capable of about the same degree of dexterity an handless human arm or a leg can manage: not very much, but it could push a large button, or push open a door.

Robots may have no, some, or many arms. A robot with no arms has no manipulatory ability at all. A robot with only one arm suffers the same hindrance as a human with the One Arm disadvantage.

A robot with multiple arms can use them in concert during normal situations (to repair a watch, for example). GMs may rule that the time required for a task is divided by (.5 × number of arms) the robot has, counting only those arms with the manipulatory ability and ST sufficient to perform the task.

A robot with multiple arms can carry multiple ready weapons. For instance, a three-armed robot could carry two pistols and a sword, for instance. It cannot make multiple attacks unless it takes the All-Out Attack option or has the Full Coordination program (p. 59). However, in close combat it gets a +2 modifier per extra arm (over the first two) on any attempt to grapple, pin, or break free from a grapple or pin.

Other Robot Characteristics

Robots do not normally need to eat, drink, sleep or excrete wastes. (Robots with bioconvertor power plants are the exception.) Robots may require downtime for maintenance and checkups – see p. 100.

Robots sometimes shut down, to conserve power. The owner of a robot may order it to shut down, or allow it to do so when necessary. A robot that shuts down uses no fuel and only the tiniest trickle of power (to maintain an internal clock, and a communicator or audio sensor) and is unaware of its surroundings and unconscious. A robot that shuts itself down can set a specific time for reawakening, after which it will power-up and "awaken" or arrange to be awakened on receiving a pre-set signal, wakeup code, or whatever.

A robot is mentally stunned on the turn it awakens (unless it has Combat Reflexes) as its systems come on line. After that it is fully alert.

Robots are immune to Fright Checks. Will rolls may still be required to overcome a Mental Disadvantage, in which case the robot's Will is its IQ.

Robot Movement

Robots use the normal rules for humans, with the modifications described below; flying robots use the rules for flying animals described in the ***Basic Set.***

Step Maneuvers

In ordinary combat, the *Step* portion of a *Step and (anything)* maneuver is a one-hex move. However, a very fast robot (or android or cyborg) should be able to cover more ground without losing its active defenses.

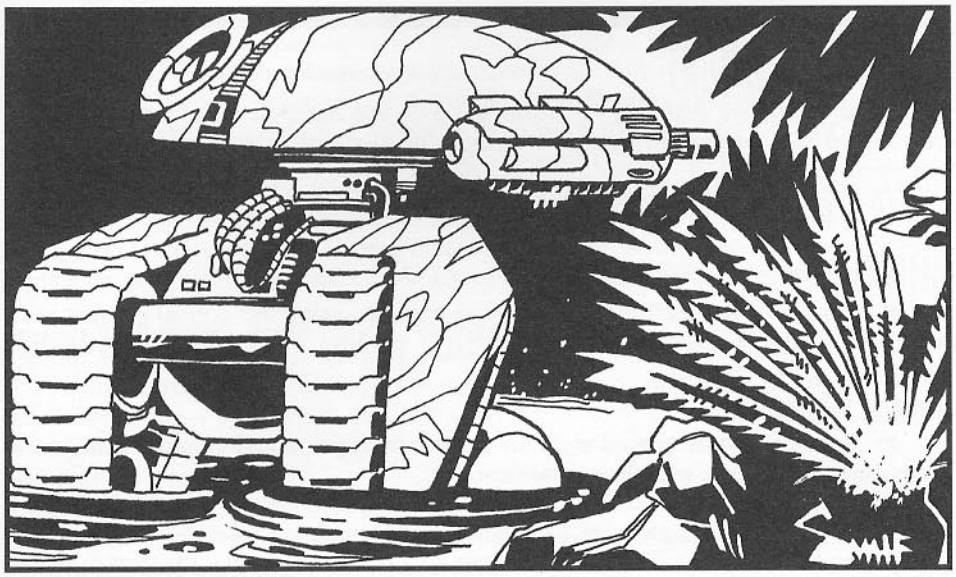
A robot, android or cyborg has a step of 1 for every 4 *full* points of Move, with a minimum value of 1. Thus, a robot with Move 0-7 gives it the normal Step of 1; Move 8-11 gives it a Step of 2, Move 12-15 gives it a Step of 3, and so on.

Multiple-hex Steps can be broken up in a turn: thus a robot with Move 14 and Step 3 could move up 1 hex, attack, then move 2 hexes back.

Using Encumbrance with Robots

Rather than recalculate a robot's statistics whenever it carries something, GMs may wish to use the Encumbrance rules. If the robot has two or three legs use the rules for humans on p. B76. Otherwise, use the rules for beasts on p. B145 for other robots.

These encumbrance rules work fairly well for robots with Speeds under 10 (if using the human rules) or 20 (if using the beast rules). For faster robots, instead of subtracting directly from Speed to get Move, multiply the Move penalty for a given encumbrance by 20% (if using the human rules) or by 10% (if using the beast rules), and subtract that *percentage* from Move, rounding down.



Other Movement Rules

Multi-Hex Robots: Large robots may occupy multiple hexes. Use the rules for multi-hex animals on p. B141.

Running Long Distances: Because robots are mechanical, they do not slow down when running long distances (p. B88), nor do they suffer exhaustion. (Of course, they may run out of power or fuel, or even need maintenance if the distances are *really* long.)

Jumping: Only robots with legs or flexibodies can jump without some kind of a ramp; use the jumping rules on p. B88.

Climbing: Only robots with a flexibody, or two or more limbs (either legs, or arms strong enough to lift its weight) can climb; use the rules on p. B89. Only a robot with arms capable of lifting its own weight can shinny up a rope.

Crawling, Crouching and Kneeling: Only robots with either flexibodies or one or more limbs (either legs, or arms strong enough to lift the robot's weight) can crawl. Only robots with flexibodies or legs may crouch or kneel. Robots unable to kneel, and any robot with a flexibody, are usually be built low enough to the ground to pick up objects without having to kneel first.

Movement On the Ground

A robot that has legs or a flexibody can move across almost any terrain, just like a human.

A robot with tracks has its top speed halved when moving through thick woods, swamps, mud or very rocky, hilly ground.

A robot with wheels can only move at full speed on a smooth floor, road, or smooth rock. Across ordinary firm grass its top speed is halved; through thick woods or over soft sand it cannot exceed 15% of top speed. It cannot exceed 10% of its top speed over broken ground, or 5% of top speed through swamps or mud.

A robot with a ground-effect skirt can skim over mud, sand or even water as if it was smooth ground, but heavily-wooded terrain limits it to 15% of top speed, and it can't move through broken ground or climb steep slopes or stairs at all.

Movement In the Air

Flying robots uses the flying rules on p. B139. However, some robot designs will have a stall speed. If a robot has a stall speed, it can only take off or remain airborne as long as its current air speed is greater than its stall speed. If its speed is lower, the robot will stall. A stalling robot can do nothing but dive and accelerate, until its speed has increased above its stall speed, or it hits the ground and crashes.

Movement On or Under Water

Only robots that can float (those with flotation hulls or submersible hulls) can move on water, although hovercraft can skim over the surface. Sealed robots can drive underwater; underwater terrain is generally mud. An unsealed robot submerged in water will lose 1d percent of its body and turret hit points (minimum 1d hits) plus a further percentage every minute until disabled.

Cinematic Combat (Continued)

Defeat Them With Logical Paradoxes: This normally only works in a cinematic campaign, and only if the GM thinks it applies! To be confused, the robot must have at least an IQ of 8 and be willing or forced to listen. Furthermore, they can't just say "I always lie; I'm telling a lie" or ask it to compute the value of *pi* to the last digit and watch it self-destruct. Instead, the adventurers must confront the robot with a paradox in its own main programming. Success may also require a successful Contest of Psychology, Fast Talk or Computer Programming vs. the robot's IQ; if successful, the robot may go into a frenzy of sorts, attempting to justify itself or resolve the paradox instead of attacking; it will possibly be Mentally Stunned. In some cases, the effects of a success may be more severe: suppose a robot is programmed to eliminate life. However, if the definition of "life" it is programmed with is one that is broad enough to include the robot, and the PCs point this out, the robot might conveniently decide to destroy itself.

The Vat of Molten Metal: There always seems to be one of these handy when a heavily-armored robot needs to be disposed of in true cinematic fashion! The preferred method is to lure the robot next to the vat, then achieve a one-hex knockback or slam, or get it to fall over and fail a DX roll. If an attacker grabs the robot or slams it, the GM can give a self-sacrificing PC a one-time +5 bonus to ST if he specifies that he is holding onto the robot as it plummets and following it to his doom! Immersion in a typical vat of molten metal does 10d damage each turn until the robot climbs out. Like a flamer hit, any DR that isn't sealed protects at half value. The robot's DR is damaged whether it is penetrated or not: it drops by 1 point per 10 hits of damage rolled, so the robot will eventually melt. Loss of 20% of DR will "unseal" the robot, by which time it's in big trouble.

Cinematic Survival

When humans fight robots, the robots often have big guns. A single gatling laser, minigun or anti-tank rocket can blow an unamored hero into next week. Besides using the normal cinematic rules from p. B183, GM's should consider the following options:

Cinematic Explosions: The explosion damage (p. B121) from grenades, shells, rockets, and the like fired by robots against lightly armored foes does no direct damage. Instead, it only disarrays clothing, blackens faces, and most importantly, counts for knockback. For every hex a person is knocked back by an explosion he should take one hit of crushing damage.

Continued on next page . . .

Cinematic Combat (Continued)

Imperial Stormtrooper Marksmanship Academy: Enemy robots never hit with the first shot or first burst of automatic fire – it just lands close enough to make the target aware he's being shot at.

Hollywood Automatic Weapons: Opposing forces never get to use the *Aiming Successive Groups* rule (p. B121) and all burst fire counts as snapshots, never getting an Accuracy bonus.

Robot Combat Etiquette: Non-sentient robots attacking our heroes don't dodge or charge or even take cover: they just advance slowly and steadily at a walking pace, heedless of any fire! Once it gets close, any big, strong robot that has arms and hands will try to grab people rather than shoot or punch them.

Bulletproof Nudity: PCs can incrase PD by undressing. A ragged t-shirt or skintight bodysuit is PD 3, stripped to the waist or skimpy swimwear is PD 5, total nudity is PD 7. Add +1 for female PCs. This can also apply to androids.

Fire and Explosion

Fuel tanks have a *Fire* number. If the robot's body or subassembly containing a fuel tank loses takes damage greater than half its hit points from any single attack, roll 3d. If the amount is less than or equal to the "fire" number, the robot catches fire. Add +4 to the Fire number if the attack was one that normally sets things alight – a flamer, molotov cocktail, explosive warhead, etc.

The robot will take 2d damage plus another 2d every 10 seconds, ignoring DR. Fire damage is always applied to the location (body or head hit points) where the fire is taking place. The robot may be able to put the fire out by using fire extinguishers, diving into water, etc. – this is up to the GM. Every ten seconds that a fuel tank is on fire, half the current fuel is burned away. When all the fuel is gone, the tank is no longer on fire.

Once a fuel tank catches fire roll 3d each second vs. half the tank's Fire number. Success means the fuel tank explodes. The 'bot takes 6d × 10 damage per gallon of flammable fuel on board. If the 'bot has a self-sealing tank, only one-quarter of the total fuel will explode, but the rest is destroyed.

Robots in Combat

Some robots are designed for battle, but even the dumbest maintenance 'bot can be ordered into combat to slam into people, or to swipe at foes with its limbs or power-mop.

This section describes how robots fight.

Attacks

Robots attack in much the same way as humans, using the normal combat rules and their programmed skills or defaults.

Ranged Combat

Robots with built-in ranged weapons and possessing appropriate programming use the normal firing rules, with these modifications:

Target Size and Signature: The *size* modifier (p. B201) is vitally important in robot combat; obviously it's easier to hit a building-sized Ogre than a robot rat.

Chameleon Systems: These surface features (see p. 42) reduce the chance of the robot being hit.

Hand-held Weapons: A robot with arms and hands can also use human-style ranged weapons if its arm has enough ST. Reduce effective recoil from weapons mounted *in* the robot by 1 for every full 200 lbs. the robot weighs.

Internal Weapons: A robot with multiple built-in ranged weapons may fire one or more at once *at a single target.* Otherwise, the only way a robot may make multiple attacks (besides using the All-Out Attack option or a weapon with a high RoF) is if it uses a Full Coordination program (p. 59).

When a robot or cyborg fires internal weapons, its SS number is reduced by 5. This is the same benefit a human receives from a TL9+ Heads-Up Display (p. UT49), and is not cumulative with it. This does not apply if the robot or cyborg is effectively Blind and lacks compensating sensors like radar.

Melee and Close Combat

Any robot can strike with its arms. Arm-mounted weapons (p. 20) can also increase this damage, or deliver special attacks. Any arm that has a hand (that is, any arm that isn't a striker) can wield human-style weapons, or grapple in close combat.

Any robot, with or without arms, can slam into someone. Use the normal rules for slam attacks. On the ground, a 'bot moving on tracks, a flexibody, as a hovercraft or via three or more wheels is more stable than one on legs: if it slams or is slammed, add +4 to its ST on the roll to see who falls down.

A robot with legs can kick, doing Thrust+2/Crushing damage based on a strength equal to twice its body ST divided by its number of legs. A kick is at -2 to hit.

A robot with a head equipped with a jaw can do biting damage in close combat, based on the jaw's ST and type.

A robot with a flexibody can constrict its opponent, provided it is equal or larger in size than its victim (up to a maximum of ten times larger). Treat constriction as a grappling attack with a ST equal to the robot's Body ST.

Many robot tools are also useful for making melee attacks.

Defenses

All robots are programmed to avoid obstacles, but a robot may not recognize an attack as such until too late; use normal rules for surprise.

A robot with the Slave Mentality disadvantage will require an IQ roll (see *Slave Mentality* on p. 89) at a penalty in order to be able to make an active defenses if they are not specifically ordered to do so, unless they also have Combat Reflexes.

Move: A robot's Move is its Speed, modified by any encumbrance, rounded down to the nearest whole number.

Dodging

A robot's Dodge is calculated differently depending on how the robot moves: legs are more agile than wheels, for instance. Combat Reflexes will increase a robot's Dodge. A robot can retreat while dodging, just like a human.

On the ground, a robot with two legs has a Dodge equal to its Move, to a maximum of 10. A flying robot, or one moving on the ground with three or more legs, has a Dodge of ½ Move or ½ DX, whichever is better, to a maximum of 10. Any other robot has Dodge of ¼ Move or ¼ DX, whichever is *worse,* to a maximum of 5. Round all fractions down.

Parrying and Blocking: A robot with arms can parry "bare handed" using Brawling, Judo or Karate skill, or parry with a weapon or block with a shield.

PD Reduction: ***GURPS High-Tech*** *Second Edition* introduced a rule in which PD is reduced by 1 per full 3d of damage an attack inflicts. GMs may consider this rule optional. Since PD only exceeds PD 6 in the case of deflector shields, this means any attack doing more than 18d damage effectively ignores PD. PD has no effect against explosions.

Damage to Robots – Basic Combat System

Apply damage that gets through DR to the robot's body hit points. When the body is reduced to or below 0 hit points, the robot must roll vs. Health each turn to continue functioning, and may risk destruction – see *Incapacitating or Destroying a Robot* on p. 98.

Impaling Damage and Robots

Robots do not take doubled damage from ordinary impaling attacks. However, blaster bolts, anti-particle beams, disruptor beams and x-ray or gamma-ray lasers do the normal doubled damage, as their radiation can disrupt robot electronics.

Hit Location – Advanced Combat System

When an attack is made against the robot, the attacker can choose what part of the robot to attack. Different parts of the robot will have different reactions to major damage. In some instances, they may have different PD and DR values as well, in which case these are used instead of the robot's body PD and DR.

Random location is used when a part of the robot must be randomly targeted. Roll 3d on the table below.

Hit Location Table

Random Location	*Part of the Robot*	*Hit Penalty*
4 or less	Brain	-7/-10*
5	Head	-5**
–	Sensor	-10**
6	Arm	-2**
7	Hand	-4**
8	Arm	-2**
9-11	Body	0
12-14	Leg, Track, GEV Skirt, or Wing	-2**
15-16	Wheel, or Rotary Wing	-4**
17+	Vital Area	-3/-6*

* If the attacker is not familar with the robot's internal design, as will be the case with most newly-encountered robots, add an extra -3 penalty. Use of Penetrating Vision or a successful Mechanic (Robotics)-5 roll can enable a character to correctly deduce a robot's design and use the smaller penalty.

** Not all robots will have these parts. If a system does not exist ("Head" is rolled and the robot has no head, for instance) treat as a body hit.

If multiple systems could be hit, roll randomly to see which one is. If the robot is in cover, only exposed locations can be hit. The effects of striking a particular location are detailed below. Unless noted otherwise, damage from a hit is applied to the robot's hit points in addition to any special effects the damage may inflict.

Not all robots will have the following locations; obviously, a robot cannot be attacked in a location it doesn't have.

Body: Damage is applied normally to the body's hit points. If the body is reduced to 0 hits or less, see *Incapacitating or Destroying a Robot.*

Vital Area: A vital area of the robot's body (such as the power system) is hit. Damage from any attack that exceeds the robot's DR is multiplied by 1.5.

Brain: Damage is applied to whatever part of the robot (head or body usually) contains the brain. In addition, damage that penetrated DR is doubled, and if any damage penetrated DR, the robot must roll vs. Health to avoid being stunned (as per knockdown, p. 99).

Head: Damage is applied normally to the head's hit points. If the head is reduced to 0 hits or less, see *Incapacitating or Destroying a Robot.*

Other Hazards and Robots

Robots do not suffer from starvation or dehydration, though they may run out of fuel or power.

Robots can ignore the effects of normal heat or cold: if it isn't hot or cold enough to do damage, the robot will function.

Robots do not normally bleed, although they may leak lubrication fluid. It's up to the GM whether this has the same effect as blood loss. Robots with simulated internal organs will bleed, but this has no effect on the robot's operation.

Poison, poison gas, smoke, disease and infection have no effect on robots.

A robot cannot be suffocated unless its power plant requires air (like an internal combustion engine) and is clogged or unable to find air, in which case it won't work. Most power plants described in ***GURPS Robots*** do not need air, but air-breathing power plants are discussed in more detail in ***GURPS Vehicles,*** *2nd Edition.*

Against concussion damage or other hazards, a sealed robot is considered to have airtight armor.

Water and Robots

A robot that is immersed in water may short-circuit. If the robot is sealed, this will only happen if the seal is broken – see the description of *sealed* surface feature on p. 43.

An unsealed robot fully immersed (at least up to its head) in water must make a Health roll every turn. On a successful roll, it takes one hit of damage to each location that is underwater. On a failed roll, it suffers a total short-circuit! When a robot short-circuits, every location that is immersed drops to 0 hit points, usually disabling the robot. Anyone in contact with a short-circuiting robot takes 1d of damage.

Radiation and Robots

Robots may be exposed to radiation from hostile environments, nuclear explosions or accidents, or certain beam weapons.

Radiation exposure is measured in *rads.* When a robot is affected, record the total exposure the robot takes. Some typical radiation doses:

Solar flare (if unprotected by atmosphere) or near the reactor during a fission plant accident: 1,000 rads per hour.

One-megaton fission air or space burst at 2,000 yards: 6,600 rads.

Fallout on ground after one-megaton fission ground burst: 300 rads/hour after 1 hour, 130 rads/hour after 2hours, 39 rads/hour after 5 hours, 7 rads/hour after 1 day.

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Radiation and Robots (Continued)

Direct hit by pulsar (anti-particle) beam: 10 rads × damage rolled before subtracting DR.

Radiation protection is measured in terms of its protection factor (PF). If the robot has protection, divide the rads received by the PF to determine the actual rads taken. Thick walls or earth barriers provide good shielding; a foot of earth has PF 8, two feet of earth have PF 8 × 8, etc., while a foot of concrete has PF 18, two feet have PF 18 × 18, etc. The PF of a robot with radiation shielding (p. 43) depends on its TL.

Unlike humans, robots don't suffer from cumulative radiation exposure. However, a sufficently powerful burst of radiation can fry a robot's electronic systems, killing its brain and other electronics. The dose needed to do this depends on TL:

TL7 . . . 100 rads TL10 . . . 2,000 rads
TL8 . . . 200 rads TL11 . . . 10,000 rads.
TL9 . . . 500 rads

Robots with hardened brains are immune to this effect.

Damaged and Destroyed Brains

A brain will be destroyed if the part of the robot that contained its dominant brain was destroyed. This can also occur due to a critical hit. If this happens, or if the robot's memory was erased due to damage, the robot is effectively "dead." If it has a backup copy of its personality and memories somewhere, it may be able to be ressurected, although it will remember nothing since its last backup – see *Memory Backups* on p. 55. Data recovery (p. 62) techniques can also resurrect a robot.

If a computer brain stops functioning due to damage, but wasn't utterly destroyed, vital memory may still have been lost. Roll 3d against the robot's Health (HT+2 if it has a hardened brain). Subtract 1 for each multiple of negative HT below 0 that the part of the body or head was reduced to. If the roll succeeds, the robot's brain will retain its memory once that part of the body starts to function again. If the roll fails, the robot suffers partial amnesia when its brain is repaired. It does not remember anything that occurred within 1d × 10 minutes of the damage it suffered. In addition, the robot may have lost some data or programs – GM's option. This will usually be related to whatever it was doing at the time it took the damage, e.g., if it was firing a weapon, it may lose its Guns program. The program is gone. If the robot has a backup copy somewhere it can be replaced, of course. If the roll is a critical failure, the robot's memory has been erased, effectively "killing" the brain.

Data recovery (p. 62) can restore lost memories.

Arm: If the arm is reduced to 0 hit points, it is crippled. All components built into the arm stop working. If the robot has multiple arms, roll randomly to see which is hit. (Arms with shields are at -4 to hit, rather than -2.)

Hand: Damage over half the arm's hit points cripples the hand. (If the robot arm lacks a hand, treat this as an arm hit.) If the robot has multiple arms with hands, roll randomly to see which is hit. (A hand on an arm with a shield is -8 to hit.)

Leg, Track, GEV Skirt, or Wing: Damage is applied to one of these parts. If the robot doesn't have any of them, treat as a body hit. If it has more than one, roll randomly to see which was hit, and apply the damage to it. Tracks resist damage with a maximum DR of half the body's DR.

Wheel or Rotary Wing: Damage is applied to one of these parts. If the robot doesn't have any of them, treat as a body hit. If it has more than one, roll randomly to see which was hit. Wheels resist damage with a maximum DR of their (TL-5). Apply the damage to the robot's body hits, except:

If a leg, track, GEV skirt, wing, wheel or rotary wing is reduced to 0 hit points, it is crippled. The effects of a crippled leg, arm or whatever are described in *Crippling Robots* on p. 98.

Incapacitating or Destroying a Robot

If a body or head is reduced to 0 hits, it has taken very serious damage. Roll against the robot's overall Health (not hit points) every turn; on a failed roll the body or head stops working and any component built into it ceases to function as well. If the robot's only brain (wherever in the robot is) or power system ceases to function, the robot is unconscious, much like a human. It remains so until it is repaired.

When a robot arm is crippled, it and anything in it automatically stop working. Make a Health roll: the arm and everything in it is destroyed if a Health roll is failed. Otherwise, major repairs (p. 99) will fix the arm.

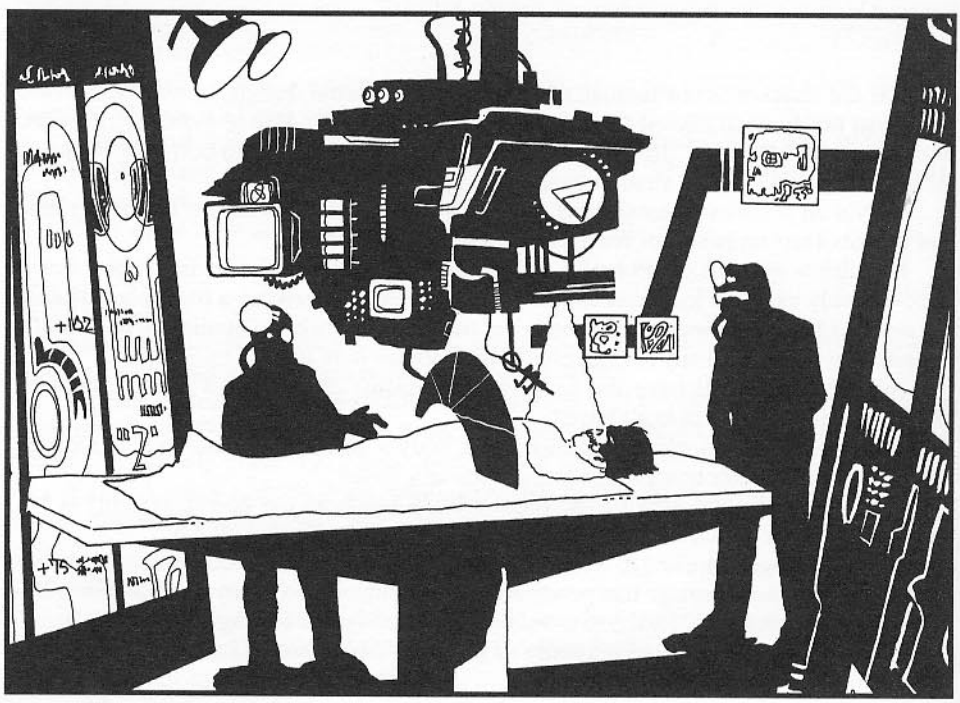
If a robot body or head is reduced to -1 × hit points, it must make a Health roll to avoid being destroyed, much like a human rolling to avoid death. The robot must roll once at -1 × hit points, and once more for every 5 hits of damage it is below that threshold.

At -5 × hit points, a robot head or body is automatically destroyed. At -10 × hit points, it is blown to bits or vaporized.

Unless a head or body has been destroyed, it can be repaired.

Crippling Robots

Leg: If a robot has two legs and one is crippled, the effects are the same as when a human suffers a crippled leg. For robots with three or more legs loss of legs reduces a robot's ground Speed when walking or running. Divide Speed by the number of legs, rounding up. That is the speed lost for each leg that is crippled. In addition, if all legs



on one corner or side of a robot are lost, the robot falls down, and can only move on the ground by crawling.

Wheels: If a robot has only one or two wheels, its top ground Speed using them drops to 0 when one wheel is crippled. If the robot is moving on the ground, roll vs. DX-10 to avoid loss of control.

If a robot has three wheels, its top ground Speed drops to 0 when an attack cripples its front wheel or when both its rear wheels are crippled. Roll vs. DX-7 to avoid loss of control. If the robot loses only one rear wheel, halve the robot's top ground Speed and roll vs. DX-4 to avoid loss of control.

If a robot has four or more wheels, its top ground Speed drops by 10% whenever a wheel is loss, and it must roll against its DX-2 to avoid loss of control. Its speed is halved when it loses half or more of its wheels; if it loses all the wheels on two corners roll vs. DX-6 to avoid loss of control.

Tracks: If the robot has two tracks and either or both are crippled, its Speed when moving on tracks drops to 0 and it must make a DX+4 roll to avoid losing control. A 'bot with four tracks suffers those effects only if it loses two or more tracks. If a single track is disabled speed is halved rather than reduced to 0 and the DX roll is at +6.

GEV Skirt: The robot's top speed using the GEV skirt is reduced to 0, and the robot is no longer hovering, and must make a DX roll to avoid losing control. If it was hovering over water or mud and can't float, it may sink.

If a robot has to make a DX roll to avoid losing control, it does so at -1 per 10 yards per second (20 mph) of its speed. Any time a robot fails a DX roll and loses control, it will overturn, fall over, flip over on its side, or the like. A fallen robot lacking either arms with ST sufficient to lift its own weight or flight with hover capability cannot right itself. If the robot was moving along the ground at speeds over 10 yards per turn when it lost control, it takes damage as if it had fallen from a distance equal to half its current speed in yards/second. (For example, a robot that loses control at a speed of 50 mph – Speed 25 – takes damage as if it had fallen from a height of 12 yards.)

Wings or Rotors: If a rotor or a wing is crippled and the robot was relying on it for lift, the robot will be unable to fly properly. If in flight, it should immediately try to land or switch to another means of flight, if it has one. Until it does so, it must make a DX roll each turn to maintain control (and on the turn it lands), with a -1 per 10 yards per second (20 mph) of current speed. If the roll fails, the crippled wing or rotor gives way, and the robot goes out of control and starts diving toward the ground. If it hits the ground, apply falling damage and add half its current speed to the distance it fell.

Shock, Knockback and Stunning

Damage to a robot never causes it to suffer shock or knockdown; in effect, all robots have High Pain Threshold.

Knockback: The number of hits required to knock a robot back 1 hex is equal to its weight in pounds/20, rounded up. Robots that are knocked back must make a DX roll to avoid falling over. If a robot falls and does not have either two or more legs, a flexibody, or the ability to hover, it can only right itself and move again if it has arms strong enough to lift itself upright. In any case, this requires two turns.

Knockout: If the location of the robot (body or head) that houses whatever brain is currently dominant loses more than one-half HT from a single attack, or if the attack was a hit on the brain hit location and any damage was done, the robot may be knocked out, much like a human! This represents jolting or otherwise damaging vital computer or (for cyborgs) life support systems. The robot must make a roll vs. Health, at +2 if the brain is a computer brain with the hardened option. If the roll fails, the robot is stunned. On a critical failure, the robot's brain ceases to function for 1d minutes, effectively knocking it out; unless the robot has some kind of backup brain, it is incapacitated.

Robot Critical Hits

Critical hits allow individual robot components to be damaged. If a robot takes a critical hit, the robot gets no defense roll.

Also, if a critical hit is taken to the head or body, roll on the body or head critical hit tables, as appropriate.

Robot Body Critical Hit Table

3 – Triple damage; also, if the robot has a cyborg or computer brain in its body and any damage penetrated DR, the brain is destroyed! If the robot has multiple brains, the largest brain is destroyed.

Repairs to Robot Brains

A damaged robot brain requires Electronics Operation (Computers) to repair. Besides the usual modifiers given on p. 62, add the following *cumulative* modifiers:

-1 per Complexity level of the brain.

-2 if a neural-net or sentient brain.

-1 if a genius brain (cutting edge technology is harder to fix!).

Also, if the brain is a biocomputer or cyborg brain, use the *lower* of Electronics Operation (Computers) or Electronics Operation (Medical).

Self-Repairs

A robot can perform repairs on itself, if it has the appropriate skills and tools and is still capable of using them. However, unless it has extra-flexible arms or is controlling other robots, attempts to repair itself will usually be at -3.

Robots with living-metal bodies (p. 70) may regenerate damage. They will regenerate a crippled part once all other damage is repaired.

Repairing Robots

Robots may be repaired using the skill Mechanic (Robotics), with the exception of robot weapons, which use Armoury, and robot brains, which use Electronics Operation (Computer).

Repairs

Repairing a damaged robot is normally a task for Mechanic (Robotics) skill.

If a body or head has hit points remaining, fixing damage is usually a "minor repair." This requires a half-hour's work per attempt. Success restores one point of lost HT times the amount the roll succeeded by (minium 1 hit). All normal modifiers for using the skill apply; see p. B54 for Mechanic skill modifiers.

If a body or head is down to 0 or few hits, fixing damage is a "major repair." It requires the same amount of time and repairs the same amount of hit points, but all rolls are at an extra -2 modifier. The GM may require a set of spare parts (costing perhaps 10-60% of the robot's cost) to fix the damage.

A critical hit or a hit to a particular hit location cripples a robot part is also a major repair. Success fixes that part. For crippled brains, see below.

See the description of tool kits for the tools needed for major or minor repairs.

Hiring a Mechanic: If a character isn't capable of doing the work, he can hire someone to fix the damage. At TL7, robot mechanics are quite rare, since most sophisticated robots are experimental prototypes. (On the other hand, many TL7 engineers will jump at the chance to tinker with a sophisticated robot...) At TL8+ and up "robot garages" may exist, charging about $100 per hour. A typical robot mechanic's skill is 11 + 1d.

Breakdowns and Maintenance

Robots require regular maintenance to work properly. (However, robots built from living metal do not require maintenance – if the entire robot is made of living metal, it is totally maintenance-free).

A robot should get a maintenance checkup every week or so that it is being used; very large or complex robots may need daily checkups. A robot that is doing nothing and has either been placed in storage (not sitting out in the rain or whatever) or has a sealed body doesn't require routine maintenance checkups.

Each maintenance checkup requires 4 hours and should be performed by someone with Mechanic (Robotics) skill with skill-8 or better and a toolkit or workshop. If a checkup is missed, roll vs. the robot's Health. Failure means the robot's HT drops by 1; this will increase the chance of a critical failure. A critical failure means a serious breakdown. Pick something on the robot and have it break down. Often it will be the robot's propulsion system (the robot can't use it to move) or motive system (treat as a crippled leg, track, or whatever). Or the brain could malfunction (treat as aquiring a disadvantage). The GM decides when a breakdown occurs – this could be in the middle of an adventure.

If a robot has lost Health due to missing maintenance checkups, this loss is cumulative. Lost Health can be regained: treat regaining a point of Health as making a minor repair (p. 99).

Robot Spellcasters

Robots with Magic Aptitude can cast spells normally, with a few exceptions: the robot cannot use any Fatigue or HT to power the spell. The energy for the spell must come from a powerstone either built into or carried by the robot.

Exception: A robot with a bioconvertor power plant gains Fatigue for this purpose equal to (power plant output in KW) × 50. As long as the power plant is provided with food, the robot can cast spells normally. However, it may never reduce its Fatigue below 2, and regains Fatigue normally.

The usual requirements for spellcasting rituals apply. For example, if an arm gesture and spoken incantation are needed, the robot must be able to talk and have arms to gesture with. Robots may, of course, know a spell at a high enough level to make gestures or verbal incantations unnecessary.

4 – Double normal damage.

5 – Bypasses 90% of armor DR and does normal damage (that is, divide armor's DR by 10). Also, whether any damage penetrated the body or not, an optical sensor in the robot's body (if any) is damaged. If applicable, give the robot the One Eye disadvantage (or eliminate the Many Eyes option). If it already has One Eye, treat the robot as Blind. If the robot is already Blind, disable another sensor (such as radar).

6 – Normal damage; also, the robot's power plant, if any, is damaged. The robot's largest power plant is badly damaged and its power output is halved (if damaged a second time, it stops working.) This may reduce the robot's speed, if the robot cannot provide sufficent power to the propulsion system. (If damaged again, it immediately stops working.) If the robot has an energy bank but no working power plant, treat as #14.

7-8 – Normal damage; also, if the robot has weapons in its body, one is struck in the barrel and disabled.

9-11 – No special effect.

12 – Normal damage. Also, any one accessory (tool, etc.) in the robot is disabled.

13 – Bypasses 90% of DR and does normal damage (i.e., divide armor's DR by 10).

14 – If the robot has an energy bank half the maximum KW of storage capacity (along with half the stored power) are lost. If the robot has no energy bank, treat as #6 above.

15 – Normal damage; also, if any damage penetrated armor, one body-mounted communication system or audio sensor is damaged. The GM should knock out one such capability possessed by the robot, such as radio or laser communications, or degrade the robot's hearing (for instance, give it Hard of Hearing or if it already has this, then Deafness).

16 – Double normal damage. Also, if robot has a fuel tank, check for fire, and it develops a leak. 1d% of the total fuel capacity leaks out immediately, plus (unless the tank is self-sealing) 1d6% every minute.

17 – Triple normal damage.

18 – Double normal damage; if the robot has a cyborg or computer brain in its body and any damage penetrated DR, the brain is destroyed! If the robot has multiple brains, the dominant brain is destroyed.

Robot Head Critical Hit Table

3 – Triple damage.

4 – Bypasses 90% of armor DR and does normal damage (i.e., divide armor's DR by 10).

5 – Normal damage; if the robot has a cyborg or computer brain in its head and any damage penetrated DR, the brain is destroyed! If the robot has multiple brains, the largest brain is destroyed.

6 – Normal damage; also, whether any damage penetrated the head or not, any head-mounted sensors are damaged. If applicable, give the robot the One Eye disadvantage. If it already has this, treat the robot as Blind. If the robot is already Blind, disable another sensor (for example, radar).

7 – Normal damage; also, robot must make an IQ roll at -3 to avoid being mentally stunned.

8 – Normal damage; also, if the robot has weapons in its head, one is struck in the barrel and disabled.

9-11 – No special effect.

12 – Normal damage. Also, any one accessory (a gadget or tool) in the robot's head is destroyed.

13 – Bypasses 90% of DR and does normal damage (that is, divide armor's DR by 10).

14 – Normal damage; also, if any damage penetrated armor, any head-mounted communication systems are damaged. The GM should knock out one such capability possessed by the robot, e.g., radio or laser communications.

15 – Normal damage; also, if any damage penetrated DR, the robot's audio sensor capability is impaired. If the robot is not already Hard of Hearing, make it so. If the robot is already Hard of Hearing, it becomes Deaf. If already Deaf, impair its sensor capability in some other way (e.g., loss of Parabolic Hearing or Olfactory Sensors).

16 – Double normal damage.

17 – Triple normal damage.

18 – Double normal damage; if the robot has a cyborg or computer brain in its head and any damage penetrated DR, the brain is destroyed! If the robot has multiple brains, the largest brain is destroyed.

Appendix B
Modular Starship Design

Spacecraft are built and sold at shipyards across known space. ***GURPS Vehicles*** offers a complete design system suitable for all types of vehicles (including starships), but it is also time-consuming and complex. To make ***GURPS Traveller*** more accessible, this section is a modular design system enabling ships to be assembled from standard-sized hulls and components.

These hulls and modules were all created using ***GURPS Vehicles***, so experienced GMs may use that book to design their own modules or to create custom-built designs.

Terminology

Vessel: Any spacecraft.

Hull Class: The Imperium customarily rates vessels in "displacement tons," each representing the volume occupied by a ton of liquid hydrogen. This can cause confusion – since tonnage references to all non-hull components indicate mass or weight, not volume – but is entrenched in tradition. To avoid confusing these terms, these rules usually will call displacement tons "spaces." A "space" is assumed to be 500 cubic feet (this is an approximation that simplifies design).

Ship: A vessel of 100 tons or larger.

Small Craft: A vessel of fewer than 100 tons.

Starship: Any ship with a jump drive.

Non-starship: A vessel lacking a jump drive.

Ton: For vessels and vessel hulls, 500 cubic feet of volume. For all else, 2,000 pounds.

cf: ***GURPS*** abbreviation for "cubic foot."

kW: A kilowatt; kJ is kilojoule or kilowatt-second (kWS); a thousand kW is a megawatt (MW); a thousand kilojoules is a megajoule (MJ) also known as a megawatt-second (MWS).

Tech Levels

This simplified design system allows vessels to be built at two distinct tech levels, TL10 and TL12.

TL10 vessels are often used by merchant lines, independent traders, and planetary and subsector navies. Many TL7-9 worlds also use TL10 designs, ordering them (and spare parts and service) from shipyards elsewhere in their sector, just like Third World nations today order ships from Europe, Russia, or the United States.

TL12 vessels represent the cutting edge of naval architecture. The Imperial Navy is equipped at TL12, with TL10-11 vessels in service in backwater areas. Shipping lines and corporations use TL12 vessels as fast couriers or liners.

When designing the vessel, do not install components higher than the vessel's TL without good reason (e.g., a TL10 hull that was upgraded with TL12 electronics and weapons).

Crew Requirements

The *Module Table* (p. 155) lists starship crew needs. Here's an explanation:

Cockpit: A pilot and sometimes a co-pilot. Pilot should have Piloting (Spaceship), Electronics Operation (Sensors, and Communications would be wise), and Gunner for any weapons he plans to use. On military vessels he should have Tactics as well. The co-pilot needs the same skills, or to provide any the pilot lacks.

Basic Bridge: Standard crew includes a captain, pilot, navigator, sensors officer/operator, and commo officer/operator.

The captain requires Leadership, and Tactics is essential on a military vessel and wise on any ship. The pilot needs Piloting (Starship), the navigator Astrogation, the sensors operator Electronics Operation (Sensors), and the commo operator Electronics Operation (Communications).

Bridge crews are often smaller, with one person handling multiple tasks.

Command Bridge: As above, often augmented by one to three extra commo/sensor operators, a computer officer with Computer Operations and Computer Programming, and a screens officer with Electronics Operation (Force shields) if a meson screen or damper is installed.

Sickbay: One or two medics with Diagnosis, Physician, and Surgery. The first module requires two medics; additional sickbays may have fewer as long as there is at least one per module.

Engineering, M-drive, and J-drive: Fractional requirements are listed for M-drive and J-drive modules; e.g., 1/60 means one engineer per 60 modules. Total up these requirements to determine the number needed. Round fractions down, but vessels of 200+ tons generally have a minimum of one engineer!

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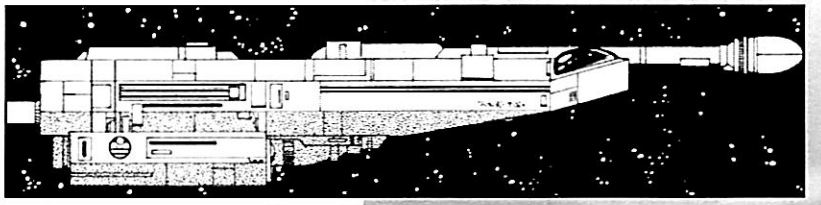


Crew Requirements

[Continued]

Engineers need Engineering (Vehicles) and Mechanic (M-drive, J-drive, and Power Reactor). Large crews of engineers can split up the Mechanic specializations.

Small crafts' engineers are usually carried aboard the mother vessel or base.

Labs: 1-2 scientists per lab module.

Ship's Vehicles: Air/rafts and small craft require Piloting (Contragravity) and (Spaceship) respectively.

Weapons: One gunner for each turret, with Gunner (Laser, Missile, and/or Sandcaster) as appropriate. One or two per bay with Gunner (Missile, P-Beam, or Meson). A gunner or pilot on the bridge operates any hull-mounted weapons.

Cargo: Large merchants may have a cargo master with Freight Handling and Merchant. On small vessels, the captain handles purchases.

Staterooms: Paying passengers require a steward with Savoir-Faire (Servant), plus at least one additional per full 50 middle or 20 high passengers carried.

Stewards should have First-Aid on ships without sickbays, and Electronics Operation (Medical)-10+ if overseeing low berths.

Passenger Couches: A steward with Savoir-Faire (Servant) is required for each 48 passengers carried in couches, unless the trip duration is under 2 hours.

Design Sequence

The next several pages provide a step-by-step spacecraft design process. Calculations are simple and can be easily done on scrap paper. A calculator is useful but not absolutely essential.

Step 1: Design the hull and record its characteristics.
Step 2: Designate turrets and/or bays.
Step 3: Select armor tonnage. Calculate its cost, DR, and PD.
Step 4: Seal hull and consider adding sensor-masking features.
Step 5: Fill all internal spaces with component modules.
Step 6: Add turret and bay weapons (optional).
Step 7: Calculate basic statistics.
Step 8: Calculate performance.
Step 9: Finalize design.

As design choices are made, keep a running total of the vessel's mass (in tons) and cost (in millions of credits, or megacredits). All masses are in tons, all costs in megacredits (MCr).

Step 1 - Hull Design

Decide whether the vessel is streamlined or unstreamlined. *Streamlined* vessels are sleek lifting bodies (often needle, wedge, or disk shaped) and may fly within a planetary atmosphere. *Unstreamlined* vessels cannot enter atmosphere. Cylindrical, spherical, and "patchwork" hulls usually fall in this category.

Select a standard hull tonnage from those listed on the following table:



HULL TABLE

Hull Tonnage	Volume (cf)	Hull Area	TL10 Mass	TL12 Mass	Hull Cost (in MCr)	Size Modifier
10	5,000	2,000	2	1	0.1/0.24	+6
20	10,000	3,000	3	1.5	0.15/0.36	+6
30	15,000	4,000	4	2	0.2/0.48	+7
40	20,000	5,000	5	2.5	0.25/0.6	+7
50	25,000	6,500	6.5	3.25	0.325/0.78	+7
80	40,000	8,000	8	4	0.4/0.96	+8
100	50,000	10,000	10	5	0.5/1.2	+8
200	100,000	15,000	15	7.5	0.75/1.8	+8
400	200,000	25,000	25	12.5	1.25/3.0	+9
600	300,000	30,000	30	15	1.5/3.6	+9
800	400,000	40,000	40	20	2.0/4.8	+10
1,200	600,000	50,000	50	25	2.5/6.0	+10
2,000	1,000,000	60,000	60	30	3.0/7.2	+10
3,000	1,500,000	80,000	80	40	4.0/9.6	+11
4,000	2,000,000	90,000	90	45	4.5/10.8	+11
5,000	2,500,000	110,000	110	55	5.5/13.2	+11
10,000	5,000,000	170,000	170	85	8.5/20.4	+12
15,000	7,500,000	230,000	230	115	11.5/27.6	+12
20,000	10,000,000	280,000	280	140	14/33.6	+12
30,000	15,000,000	360,000	360	180	18/43.2	+14
50,000	25,000,000	510,000	510	255	25.5/61.2	+14
100,000	50,000,000	810,000	810	405	40.5/97.2	+15

Record hull mass (varies by TL), hull cost (the costs given are for non-streamlined/streamlined vessels), and size modifier (see p. B201). Hull areas and volume are for reference and will figure in later calculations.

Calculate the vessel's *internal spaces.* An unstreamlined vessel has spaces equal to its hull tonnage. A streamlined vessel has spaces equal to 0.8 × hull tonnage. Internal spaces will be used up by equipment and other options. Keep a running total of how many remain; when they are all gone, nothing else can be installed in the vessel.

Step 2 – Turrets and Bays

Turrets are standard mounts for shipboard weapons. A ship can have one turret per 100 tons, or it can have fewer or none at all. A small craft may have one or no turret.

Bays are large weapon mounts. A ship can install one bay for every 10 turrets *not* installed. For example, a 10,000-ton ship may have up to 100 turrets, but could instead have installed 80 turrets and two bays.

Decide how many turrets and/or bays the vessel has. Their mass and cost are shown below. As with the hull, mass varies by TL and cost varies depending on whether the hull was streamlined or not.

TURRET AND BAY TABLE

Type	Mass TL10	Mass TL12	Cost (MCr)	Internal Spaces
Bay	6.5	3.25	0.325/0.78	10
Turret	0.825	0.425	0.0406/0.0966	1

Interior Facilities

Vessel interiors generally have these details in common:

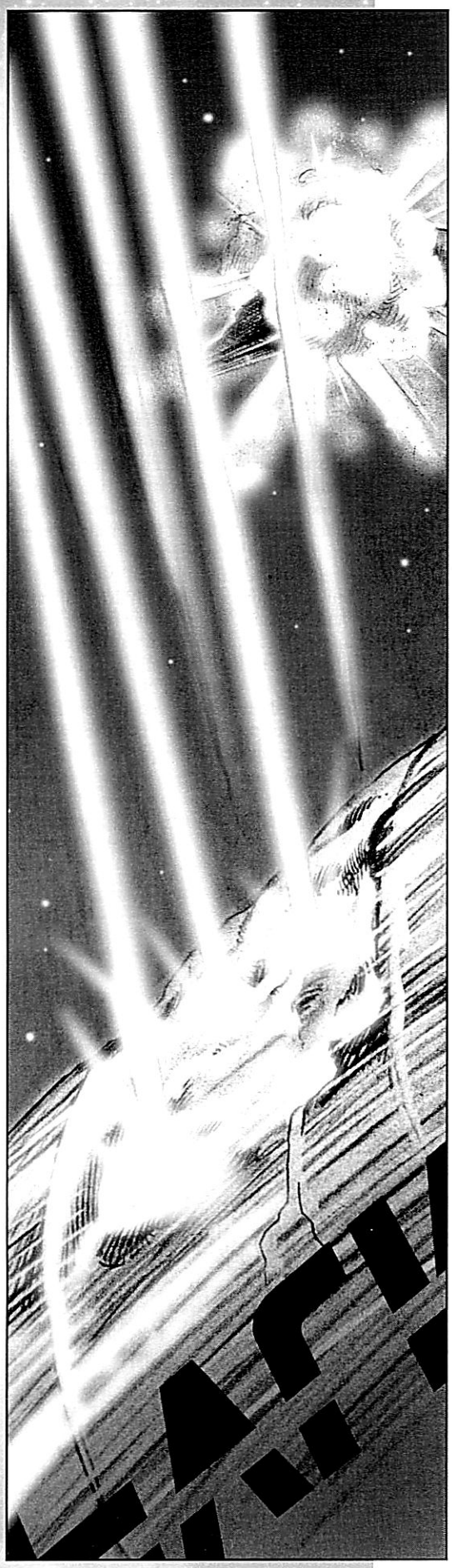
Partitions are light wall panels used to separate facilities such as individual staterooms, galleys, and offices. They aren't airtight. DR 8 and 40 hit points. *Bulkheads* are armored walls used to separate major airtight compartments. An internal bulkhead has DR 50 and 250 hit points; an external bulkhead has the vessel's armor DR.

Doors are sliding panels set in partition walls. They are not airtight, and open or close at the touch of a stud (takes one second if power is on). Stateroom doors come with electronic locks in various styles (voiceprint, keypad, card, etc.), but these are for privacy only – use Lockpicking skill (or a crowbar) to break in; locks can also be overridden or changed from the bridge. A door has DR 4 and 10 hit points. A locked door can also be forced open by brute strength. Make a ST-4 roll; repeated attempts cost 1 fatigue each.

Iris valves are powered portals set in bulkheads, at either end of airlocks and in vertical shafts. An iris valve resembles the aperture of a camera: a series of metal plates that slide into place to block an opening. It is opened or closed by depressing a stud next to the valve, provided the vessel has power. Any iris valve can also be locked from the bridge. A closed valve is airtight; as long as a vessel has power, iris valves will shut automatically when interior pressure nearby drops, preventing a single hull leak from decompressing the vessel. It takes iris valves one second to shut – an object like a metal bar that is jammed in a valve as it closes will prevent closure, allowing it to be reopened with ease. Otherwise, once fully shut they are difficult to force open: Roll as with doors, but against ST-6. Iris valves are tough: DR 50 and 100 hit points.

Hatches are hinged, pressure-tight metal doors that are placed at some locations secured by pins operated by a handwheel on the door. They take five seconds to open and are not powered or controlled by the ship's bridge. Hatches are intended as damage-control devices to restrict atmosphere loss in the case of a hull breach. Thus, there is normally no provision for locking hatches, but a crowbar inserted into the handwheel will jam one shut from that side requiring the destruction of the hatch to open it. Nothing prevents a character from installing locks on any given hatch, but these cost extra. Hatches can be found in floors, decks, or bulkheads, often in engineering or spacedock areas. They are typically used to provide alternative routes for damage-control teams in the event of power loss that seals iris valves. Hatches are DR 50 and 250 hit points.

See p. B125 for rules on breaking down walls and similar inanimate objects.



Turrets and bays take up internal space. Each turret uses up one internal space. Each bay uses up 10 internal spaces.

Turrets come with a roomy built-in crew station (seat and console) with computer terminal and a Heads-Up Display/Weapon Aiming Computer (HUDWAC). Bays don't – but these crew stations are built into the actual weapons that are installed in the bay.

Step 3 – Armor

Vessels are armored to protect against cosmic rays, micrometeors, and enemy weapons.

Surface Area: Calculate the vessel's total surface area. This is the number shown in the "area" column on the *Hull Table* (p. 151) plus the surface area of all turrets and bays. Each turret has an area of 800. Each bay has an area of 6,500.

Armor Mass: Decide how many tons of armor the vessel will carry. Most civilian vessels have 0.5 to two tons of armor times their hull tonnage. Warships usually have 0.5 to five tons times their hull tonnage. The more mass a vessel has, the slower it accelerates.

Armor Cost: Multiply armor mass by MCr0.012 to get cost.

Armor Damage Resistance: Calculate armor DR:

If TL10 armor, DR = (armor mass × 20,000) / surface area.

If TL12 armor, DR = (armor mass × 50,000) / surface area.

Optionally, rather than assigning armor mass and calculating DR from it, choose a DR first, then calculate mass. To do so, multiply the DR by 0.00005 at TL10 or 0.00002 at TL12 and then by hull area. This gives the armor's mass; calculate cost as above.

Optionally, armor for the turrets/bays may be calculated separately from hull armor. Turrets and bays are often designed with lighter armor than the hull itself. For a fast way to design this, just add *half* the turret or bay's area to the vessel's area, and then afterward it can be assumed to have half the DR the hull has.

Passive Defense (PD): Armor PD depends on DR, as follows: 1 if DR 1, 2 if DR 2-4, 3 if DR 5-15, 4 if DR 16+. Almost all vessels have PD 4.

Step 4 – Other Surface Features

Sealed: Vessels must be sealed. Multiply total surface area by MCr0.00001 to get the price of sealing the hull against vacuum.

Sensor Masking: Usually only warships use sensor-masking. A vessel may optionally be given *stealth* making it harder to detect by active sensors (like radar) and/or *emission cloaking* to mask it from passive sensors (like infrared). Each type comes in two levels, "basic" and "radical."

Sensor Masking Feature	Mass (tons)	Cost (MCr)
Basic Stealth or Emission Cloaking	0.00025	0.000075
Radical Stealth or Emission Cloaking	0.0005	0.00075

Mass and cost are each equal to the vessel's total surface area times the number shown on the table above. A vessel may not have both basic and radical versions of the same feature.

Basic emission cloaking subtracts (TL-4) from rolls to determine the success of passive sensor scans, while basic stealth subtracts from active sensor scans. Radical cloaking or radical stealth will double this penalty; i.e., -2 × (TL-4).

Step 5 – Component Modules

A component module is a set of spacecraft components that are grouped together, such as a bridge or maneuver drive.

All modules are rated for the internal space they take up in the vessel (spaces), their mass (tons) and cost (MCr). Select precisely the number of modules that fills the vessel's internal space.

Bridge: The vessel's control, navigation, sensor, and communication systems. All ships require one bridge module, and larger vessels sometimes have a second auxiliary bridge. Two types of bridge module are available. A "basic bridge" is typical of ordinary ships. Some ships (especially those with tonnage over 1,000) will install a larger and better-equipped "command bridge." See *Bridge Systems* (pp. 160-162) for each type's capabilities.

Engineering: All ships require a single engineering module. It has a fusion reactor core (the base "startup" weight, cost, and volume for a fusion reactor), full fire-suppression system, and a six-person airlock. Included with the airlock is an inflatable 100′-long passage tube (armored to DR 20) that can be deployed in 30 minutes to connect two airlocks for passenger boarding.

Cockpit/Systems: A cockpit/systems module is used on small craft instead of the bridge and engineering modules. It provides control, navigation, avionics, and fusion-power startup, plus a one-person airlock and two man-days limited life support.

Hold: Each hold module has space for 500 cubic feet (18.5 cubic yards) of cargo. Multiple hold modules may represent a single large hold or a number of smaller holds. Holds in ½-space increments (250 cf) may also be installed.

Jump Drive: A ship requires a jump drive if it's to make interstellar jumps. Each module includes the jump-drive machinery and fusion-power components to power it. Decide on the ship's jump-drive number to a maximum of jump-3 at TL10 or jump-6 at TL12. The number of J-drive modules required is then:

number of j-drive modules = 0.01 × hull tons × (jump number+1)

Jump Fuel: These modules consist of an ultralight self-sealing tank that stores the liquid hydrogen fuel used by the jump drive. A ship with j-drive requires a number of fuel modules equal to:

number of jump-fuel modules = 0.1 × hull tons × jump number

Low Berth: A low-berth module contains four cryonic freeze capsules, each capable of holding one person in suspended animation ("low passage") plus fusion-power components. See p. 108, and pp. UT103, S66, or BT115 for detailed rules.

Maneuver Drive: An M-drive is a reactionless thruster that produces thrust without fuel or reaction mass. Each module has a reactionless thruster that produces 40 tons of thrust at TL10 or 100 tons at TL12 and a slice of fusion-reactor power to run it. Install as many M-drive modules as desired. A vessel's acceleration (in gravities) equals thrust divided by its total mass. As a result, it can be desirable to install the M-drive last so that you can estimate the total mass of the vessel (or make use of a computer spreadsheet to recalculate the thrust and Gs for each different configuration).

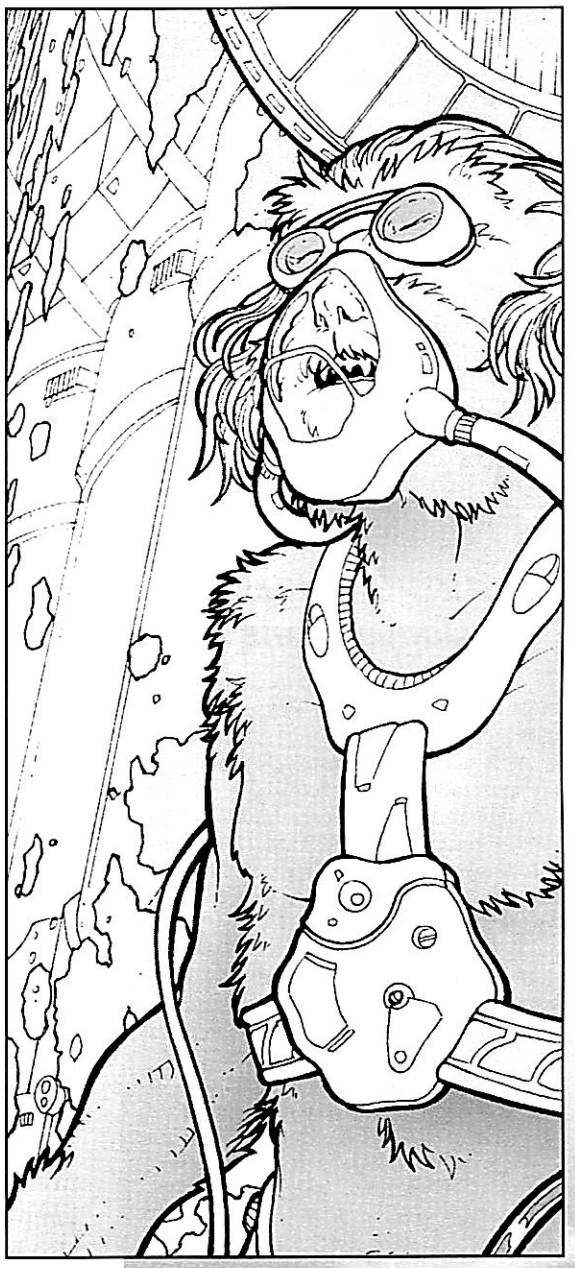
Passenger Couch: This module is only available for small craft. It incorporates 12 roomy seats and limited life support (lasts 12 man-days) plus the necessary fusion-power components to operate the life-support system.

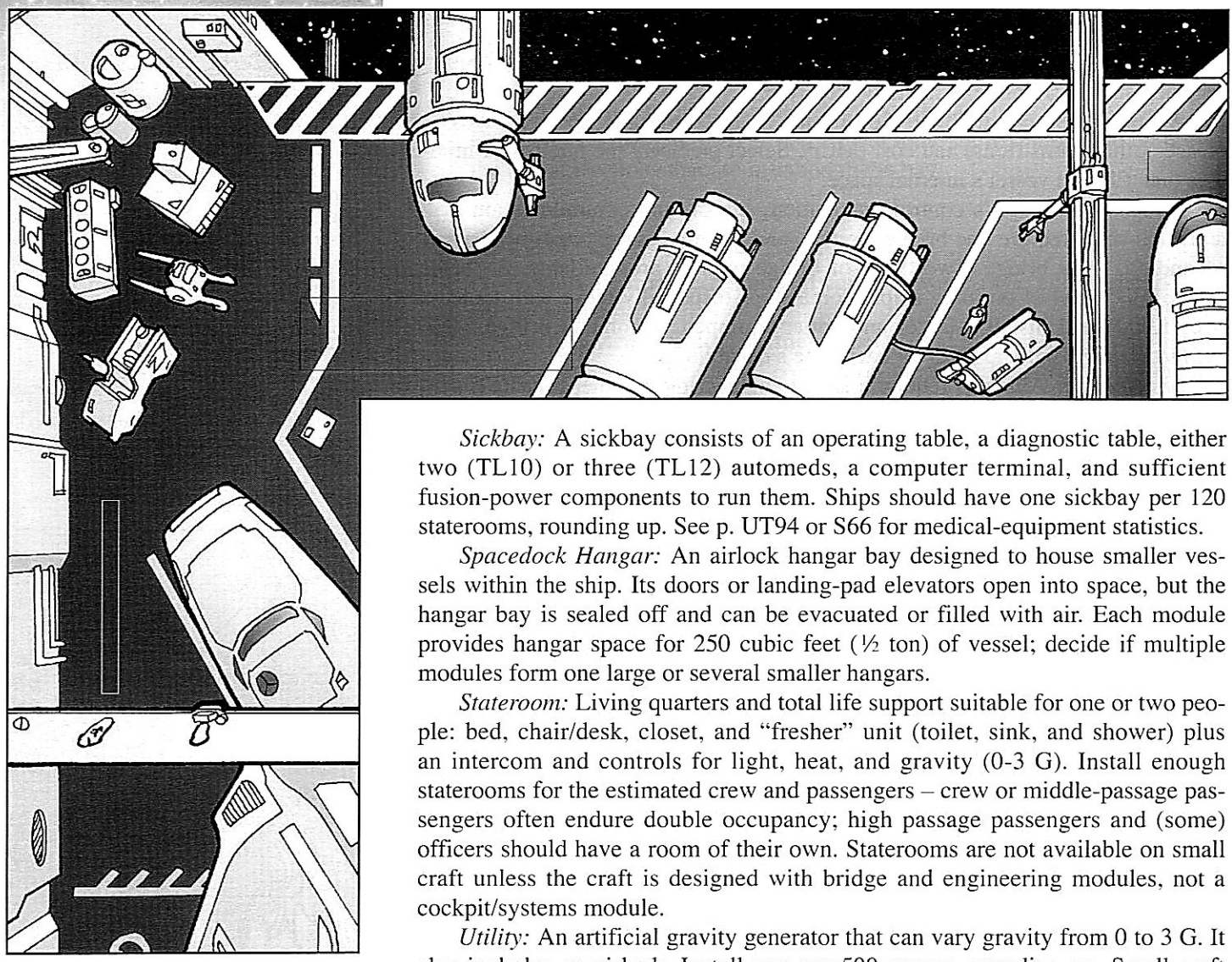
Creating Deckplans

Ship designs can be used to create deck plans to facilitate boarding actions, hijackings, and other adventures.

Hexgrid Deck Plans: ***GURPS*** uses a 1-yard hexagonal grid for maps. Assuming headroom of about 8-9 feet and some room under the decks, a "space" in a module can be represented by six squares or four hexes (GM's option). If a square grid is used, GMs will have to improvise movement: multiply diagonal movement costs/distances by 1.5.

Existing Deck Plans: Original ***Traveller*** ship plans use a 1.5m (5′) or 2m (6′) square grid. GMs using them should multiply movement costs and ranges by 1.5 (2 to move/shoot diagonally).





Sickbay: A sickbay consists of an operating table, a diagnostic table, either two (TL10) or three (TL12) automeds, a computer terminal, and sufficient fusion-power components to run them. Ships should have one sickbay per 120 staterooms, rounding up. See p. UT94 or S66 for medical-equipment statistics.

Spacedock Hangar: An airlock hangar bay designed to house smaller vessels within the ship. Its doors or landing-pad elevators open into space, but the hangar bay is sealed off and can be evacuated or filled with air. Each module provides hangar space for 250 cubic feet (½ ton) of vessel; decide if multiple modules form one large or several smaller hangars.

Stateroom: Living quarters and total life support suitable for one or two people: bed, chair/desk, closet, and "fresher" unit (toilet, sink, and shower) plus an intercom and controls for light, heat, and gravity (0-3 G). Install enough staterooms for the estimated crew and passengers – crew or middle-passage passengers often endure double occupancy; high passage passengers and (some) officers should have a room of their own. Staterooms are not available on small craft unless the craft is designed with bridge and engineering modules, not a cockpit/systems module.

Utility: An artificial gravity generator that can vary gravity from 0 to 3 G. It also includes an airlock. Install one per 500 spaces, rounding up. Small craft normally omit utility modules.

Meson Screen (TL12): A meson screen disrupts incoming high-energy mesons. The module includes a screen generator and fusion-power components. The vessel's DR *vs. meson guns only* is 20.8 *million* times the number of meson screen modules divided by its total surface area.

Nuclear Damper (TL12): A nuclear damper focuses a field that subtly interferes with the strong nuclear force causing nuclear warheads to fail to detonate. A spacecraft damper field protects a 10-mile radius, increased by +5 miles each time the number of modules installed is doubled.

Vehicle Bay: A vehicle bay is custom-designed to snugly hold a single, specific small craft (e.g., "30-ton ship's boat"). It is not usable for other sorts of vehicle. It takes up 21 spaces per 20 tons of vessel stowed.

Lab Module: A laboratory dedicated to one scientific skill (e.g., Geology) as well as room for one or two scientists to work. For larger teams, multiple labs are a necessity! It gives +2 to skill in situations where the lab equipment would be beneficial; the GM can also rule a lab is required for a task – it gives no bonus but work would be impossible without it.

Fuel Processor: Purifies raw fuel (skimmed from a gas-giant atmosphere or from another source), turning it into refined fuel. Each module can process eight jump-fuel modules full of raw gas-giant atmosphere every hour. The module also includes necessary fusion-power components.

GURPS Vehicles Conversions

All structures and components were built using the ***GURPS Vehicles*** rules, with these exceptions:

1) Reactionless thruster technology is far more advanced. Accordingly, TL10 standard thrusters appear at TL8, TL10 super thrusters appear at TL9, TL11 standard thrusters appear at TL10. TL11 super thrusters are unchanged, while TL13 "mega thrusters" remain TL13.

2) The jump drive. It works differently than existing ***GURPS*** jump engines, because its performance is based on transporting a specific *volume* rather than mass and because it consumes hydrogen.

3) Final weight in pounds and cost in dollars were converted to tons and millions of credits (rounding off). Outputs listed are given in megawatts (1,000 kW), megawatt-seconds, and megajoules (1,000 kJ) to save space.

MODULE TABLE

Type of Module	Spaces	Mass	Cost (MCr)	Crew
Cockpit Bridge				
TL10	1	4.9	2.5	1-2
TL12	1	4.7	2.3	1-2
Basic Bridge				
TL10	2.5	8.6	4.0	1-5
TL12	2.5	7.3	3.1	1-5
Command Bridge				
TL10	5	20.9	9.6	1-10
TL12	5	19.2	8.8	1-10
Engineering				
TL10	1	4	0.32	0-1
TL12	1	3.6	0.16	0-1
Hold	1	0	0	0
Maneuver Drive				
TL10	1	3.4	0.16	1/60
TL12	1	4	0.65	1/100
Jump Drive				
TL10	1	4	3.1	1/25
TL12	1	4	3.05	1/100
Jump Fuel	1	1.3	0.16	0
Low-Berth (4 tubes)	0.5	2	0.22	0
Passenger (12 seats)				
TL10	1	0.54	0.075	0
TL12	1	0.54	0.073	0
Spacedock	1	1*	0.005*	–
Stateroom (1-2 occupants)				
TL10	4	2.4	0.012	0
TL12	4	2.0	0.012	0
Sickbay				
TL10	1	0.75	0.16	1
TL12	1	0.85	0.21	1
Utility				
TL10	1	11.5	0.30	0
TL12	1	11.5	0.25	0
Meson Screen (TL12)	1	5	2.258	0
Nuclear Damper (TL12)	1	10	4	0
Fuel Processor	1	1.1	0.85	0
Lab	2	10	1	1-2
Vehicle Bay	1.05**	0.5*	.003*	0

* Mass and cost are paid only once, regardless of the number of modules making up the spacedock hangar or vehicle bay – it mainly represents the mass and cost of the hangar doors and air pump.

** Multiplied by hull tonnage of vessel carried.

Notes: When estimating performance, spacedock mass should include the vessels that normally dock there, while cargo mass should assume five tons of mass per cargo module as an average load.

All bridge/cockpit computers can be "hardened" (fiber-optic backup) to resist radiation for an additional 0.15 tons and MCr0.04 (cockpit), 0.375 tons and MCr0.6 (in basic bridge), or 3 tons and MCr6 (command bridge).

Crew is the suggested number of crew per module. See *Crew Requirements* sidebar on pp. 149-150 for details of crew requirements.

Creating Non-Standard Hulls

You can use ***GURPS Vehicles*** to extend the hull table to include non-standard hull designs. Standardized hulls were built as vehicle bodies in multiples of 500 cubic feet using TL10 and TL12 medium frames and standard materials. Streamlined hulls used the lifting body and "very good" streamlining features.

Armor: The armor formula assumes "expensive metal" armor, and converts numbers to tons and MCr. Other armor types are possible, as described in ***Vehicles.***

Subassemblies: Turrets and bays are both turret subassemblies using medium frames and standard materials. Bays are limited rotation, turrets are full rotation.

Basic landing legs for soft vertical takeoffs/landings are subsumed in streamlining. To keep things simple, we've omitted proper wheels/skids, since all ships are vectored-thrust designs.



Design Your Own Modules!

Modules were built in multiples of 500 cubic feet with extra "empty space" being added to round them out as necessary. Weights were calculated in pounds, then rounded to the nearest 0.1 ton.

All modules are collections of components assembled from those in ***GURPS Vehicles***. This book can be used to design new modules or modify existing ones.

To design a new module, decide on its TL and then select which components (see p. VE12) are built into it. Make sure that the total volume of all components is a multiple of 500 cf. If it doesn't match, add extra empty space to it.

If any of the components in the module require power, make sure that one of the components includes the necessary power systems. Use either rechargeable power cells or fusion reactors (or at TL13+, antimatter reactors). When installing fusion or antimatter power systems, only include the weight, volume, and cost per kilowatt, plus the volume of "long-term" access space. The base weight, volume, and cost, and the reactor-core cost, is included in the engineering module that every vessel requires.

The same rule applies to TL9-10 life support. Add any incremental requirements, but the base costs have already been tallied.

Component modules do not have any structural weight or cost – they should not be thought of as actual homogenous systems (like the modular sockets on p. VE72), but rather as sets of components some of which might be scattered throughout a vessel. Component modules simply bundle related features for ease in accounting during vehicle design. (Power plant slices actually within turrets and bays represent the necessary power conduit connections.)

Turrets are semi-recessed in hull (hence the restriction on volume); thus, even in craft with Very Good streamlining weapons take up volume/50 cf rather than volume/20 cf.

Step 6 – Bay and Turret Armament

Each turret a vessel possesses has room for up to three turret weapons to be plugged into it. Each bay has room for a single bay weapon. Armament need not be specified when a vessel is designed, as shipyards can leave turrets or bays empty for the owner to later customize. Merchant ships in safe subsectors or on a tight budget may have empty turrets or mount only one or two rather than the full three weapons. (Crew often find creative uses for the unused 500-1,000 cf, such as illicit liquor stills.)

Fixed-Mount Weapons: Instead of a turret or bay, weapons can be built directly into the hull. A hull-mounted weapon takes up space just as if it were a component module. If a turret-sized weapon, it is fired from the bridge/cockpit crew stations (often by the pilot). Hull-mounted weapons are assumed to be installed in casemate swivel-mounts that enable them to fire directly forward and 45 degrees to either side. The spaces occupied by fixed mount weapons count against the number of turrets that can be included: up to three spaces of fixed-mount weapons are allowed for every turret not installed.

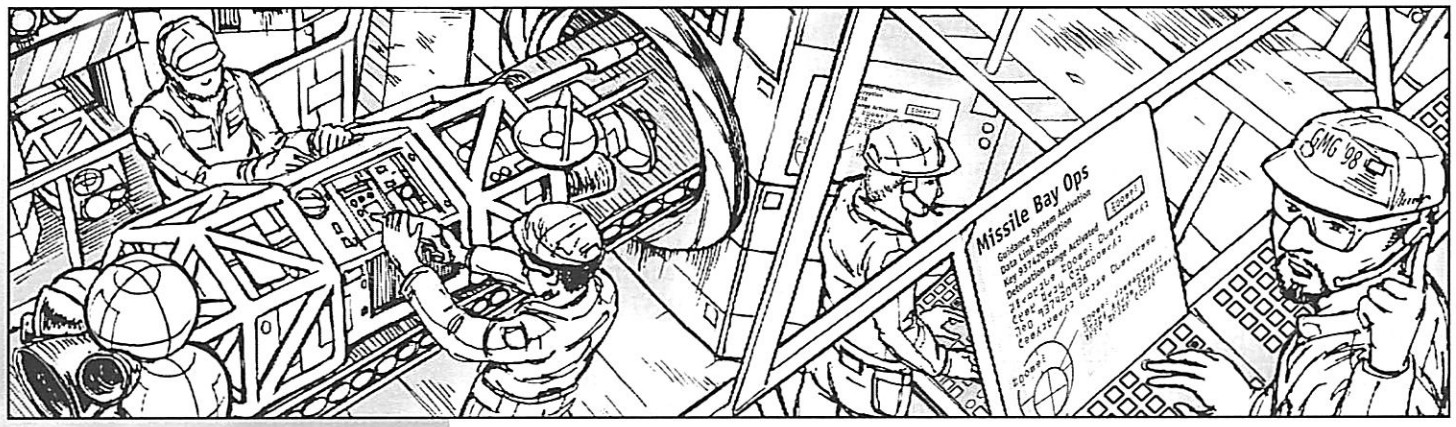
Spinal Mounts: Spinal mounts are huge weapons built into the centerline of the vessel. A ship can only have one spinal mount. They are hull mounted, but are limited to firing directly forward, and are aimed by pointing the ship.

If weapons are to be fitted, select from these standardized designs:

ARMAMENT TABLE

Weapon	Spaces	Mass	Cost
Turret Weapons			
Missile Rack	1	13	0.0175
Turret Laser (TL10)	1	8.3	0.82
Turret Laser (TL12)	1	7.8	0.68
Sandcaster	1	5	0.25
Bay Weapons			
Missile Bay	10	618.8	0.85
Particle Beam Bay (TL10)	10	467	23.21
Meson Gun Bay (TL12)	10	467	21.04
Spinal Mount			
Spinal P-Beam (TL10)	1,513	15,126	1,035
Spinal Meson Gun (TL12)	1,512	15,119	939

Add each weapon's mass and cost to the running total of vessel mass and cost. Turret weapons may occupy a turret space (three to a turret) or take up space in the hull. Bay weapons may occupy an entire bay or take up space in the hull. Spinal mounts always take up hull space. Note that the same missile launchers and sandcasters are used at both TL10 and TL12.



Turret Weapons

Missile Rack: A launch tube rated to fire 250mm 300-pound (0.15 ton) missiles. The system also includes a 50,000-mile-range laser communicator used to control operator-guided missiles. Magazine space sufficient for 77 standard 0.15-ton space-interceptor missiles is included.

Sandcaster: A unique defensive weapon that launches clouds of ablative crystals (nicknamed "sand") into the projected paths of enemy laser fire. Unlike prismatic aerosols used in ground combat, sand clouds are thick enough to ablate X-ray laser beams. Space for 200 120-lb. sand canisters is included.

Turret Laser, 250-MJ (TL10): This system consists of an X-ray laser (250-MJ output, cyclic rate ½, extreme range), a power cell that stores enough energy (667 MW) to fire one shot, and fusion-reactor components that generate the 11.1 MW required to fully recharge that power cell every 60 seconds. The X-ray laser is fully stabilized and installed in a universal mount (if in a turret) or casemate (if in hull). Turrets can fire in all directions, the casemate forward.

Turret Laser, 405-MJ (TL12): The previous weapon's replacement at TL12, cheaper but more powerful. The system is an X-ray laser (405-MJ output, cyclic rate ½, compact, extreme range), a 1,080-MWS power cell and fusion-reactor components generating 18 MW to permit one shot every 60 seconds. The X-ray laser is fully stabilized and installed in a universal mount (if in a turret) or casemate (if in hull). Turrets can fire in all directions, the casemate forward.

Bay Weapons

Bay weapons available are listed below. Besides the weapon, power supply and any ammunition, each also includes a pair of roomy crew stations for two gunners (though the weapon can be fired by only one person), a computer terminal, and a HUDWAC.

Missile Bay: A weapons bay housing 50 launch tubes and laser coms (each the same as the missile rack's), plus space for 3,800 standard 0.15-ton missiles.

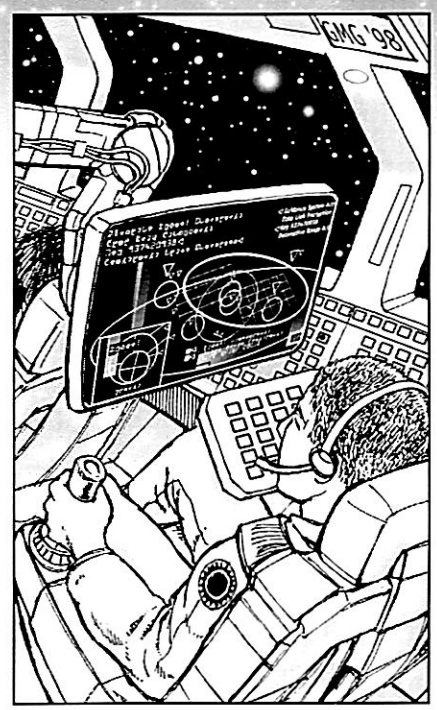
Particle Beam Bay (TL10): This weapon accelerates hydrogen nuclei to relativistic velocities, strips them of their charge and fires them. P-beams are shorter ranged but more powerful than turret lasers, and sandcasters don't affect them. The bay houses a 12,810-MJ neutral particle beam (cyclic rate ½, extreme range option), a power cell storing 25,620 MWS (enough for one shot), and fusion-reactor components generating 427 MW (recharging the power cell every 60 seconds).

Meson Gun Bay (TL12): Meson guns use nuclear dampers and particle-beam technology to generate and aim a beam of high-energy mesons (subatomic particles that carry nuclear force). Mesons pass harmlessly through normal matter, but soon decay explosively in a storm of other energetic particles – but with precise calculation a meson beam may be created and aimed so this explosion occurs inside an enemy vessel. The bay includes a 12,810-MJ meson gun (extreme-range option), a power cell storing 25,620 MWS energy (one shot), and sufficient fusion-reactor components to generate 427 MW, recharging it every 60 seconds.

Spinal Weapons

Particle Beam (TL10): This is a 569,500 MJ neutral particle accelerator (cyclic rate ½, extreme range option) installed in a fully stabilized mount, powered by a 1.139 million MWS rechargeable energy bank and 18,983.3 MW fusion reactor.

Spinal Meson Gun (TL12): A meson gun of similar characteristics to the spinal particle beam.



Jump Drives in GURPS Vehicles

If building a ship using the modular system, just plug in the requisite number of jump drive modules. However, if you want to install a ***Traveller*** jump drive in a ship built entirely with ***GURPS Vehicles***, here's how to do it.

First, decide on the intended jump number – how many parsecs the ship can jump. This cannot exceed a maximum of jump-2 at TL9, jump-3 at TL10, jump-4 at TL11, or jump-6 at TL12+.

Then assign the drive a "jump capacity" normally equal to the desired (jump number+1) × anticipated volume of the vessel.

Weight is jump capacity × 0.12 lbs.

Volume is jump drive weight/50 cf. As ships spend a week in jump, add "long term" access space equal to 2 × volume.

Cost is jump drive's weight × Cr500.

Power required is jump capacity × 0.2 kW, which must be provided continuously throughout the week in jump or the ship is lost (either dropping out of jump space or destroyed).

As well as using energy, a jump consumes gallons of hydrogen equal to displacement tons (which is body volume in cf/500) × 333.3 × the length of the jump in parsecs (round up to nearest parsec). Fuel tanks are usually ultralight and self-sealing.

To function, the jump capacity must be at least twice the volume of the ship. Once the ship's volume is known, its actual jump number can be calculated as: Jump number = (jump capacity/volume) - 1, limited by the TL maximums above. Jump capacities larger than a ship's jump number are useful for towing non-starships.

The ship must be at least 100 displacement tons.

BEAM WEAPONS COMBAT TABLE

Name	Type	Acc	SS	Damage	1/2D Range	Max Range	RoF	FP
Laser, 250-MJ	Imp.	32	30	5d×50 (2)	17,045*	51,135*	1/60	3
Laser, 405-MJ	Imp.	33	30	5d×100 (2)	26,022*	78,068*	1/60	7
P-Beam bay	Imp.	33	30	6d×1,000	14,630*	43,890*	1/60	63
Meson Gun bay	Exp.	30	30	6d×1,000 (!)	14,630*	43,890*	1/60	63 (!)
Spinal P-Beam	Imp.	36	30	7d×3,000	97,600*	292,800*	1/60	424
Spinal Meson Gun	Exp.	36	30	7d×3,000 (!)	97,600*	292,800*	1/60	424 (!)

(2) after damage means DR protects at half normal.
(!) after damage means that armor DR is ignored. In the ***GURPS Space*** system, meson guns ignore armor DF.
*Range is in *miles*. In a planetary atmosphere divide laser ranges by 100 and particle beam ranges by 50.
FP = firepower, used for ***GURPS Space*** abstract combat.

Sandcaster rules are found in the Space Combat appendix. If using ***GURPS Space*** rules, each adds +1 DF vs. lasers or missiles; each time the number of sandcasters doubles, add another +1.

SIM-10 Missile (TL10)

A standard TL10 space-interceptor missile.

Features: Very good streamlining.

Propulsion: 1,800 lbs. vectored thrust (135 lbs., 2.7 cf, 90 kW, Cr2,700).

Armament: 250mm "small" HEAT warhead self-destruct device (15.625 lbs., 0.3125 cf, Cr468.75).

Communications: Laser communicator, receive-only, very long range (1 million mi., 50 lbs., 1 cf, Cr625, 0.16 kW).

Sensors and navigation: None – guided by controlling ship.

Computer: Hardened robot brain small computer (1.5 lbs., 0.03 cf, Cr1,250, Complexity 4).

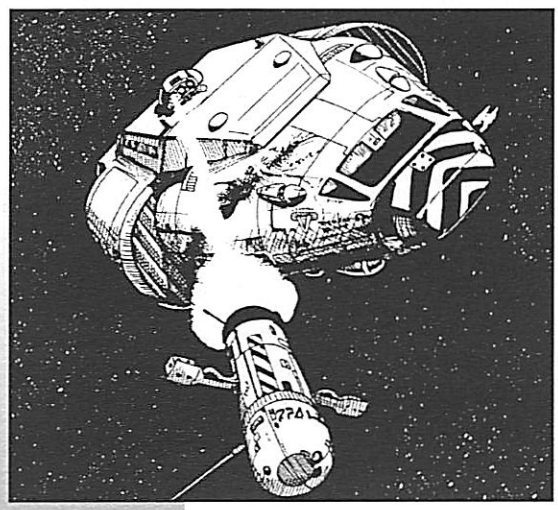
Power: Rechargeable power cell stores 324,576 kWS (18.17 lbs., 0.1817 cf, Cr1,817), good for one hour of operation.

Body: 6 cf (including 0.4875 cf empty space). Area: 20 sf. Medium frame, very expensive materials, very good streamlining, robotic (20 lbs., Cr20,000, 30 hit points).

Armor: PD 4, DR 40 advanced metal (50 lbs., Cr1,000).

Surface Features: Basic Stealth and Emission Cloaking (20 lbs., Cr3,000.)

Statistics: Volume 6 cf. Weight: 310.295 lbs. (0.15 tons). Price: Cr30,860.75. HT: 12 (30 hit points). Size Modifier: +0. Space acceleration: 6 Gs (for one hour).



Standard Missiles

If using the ***Vehicles*** space combat system, standard missiles maneuver like spacecraft under the direction of the firing gunner. In a 20-minute combat round a missile rack can fire and control one missile or a missile bay as many as 50.

The standard missile has basic emission and stealth cloaking and 6-G acceleration (TL10) or 10 G (TL12) for 60 minutes (three space combat rounds). When a missile ends its turn in a target vessel's hex, it may detonate, typically an explosive shaped charge doing 6d×60 (10) at TL10 or 6d×80 (10) at TL12. Missiles have Size Modifier +0, DR 40 (TL10) or DR 120 (TL12), and 30 HPs. (If using the ***GURPS Space*** combat system, treat as "medium explosive missile" with FP 3 at TL10 or 5 at TL12.) See sidebar for missile costs and exact statistics.

Step 7 – Statistics

Total Empty Mass: Total the mass of hull, turrets/bays, armor, surface features, chosen modules, and weapons. This is the vessel's empty mass.

Total Loaded Mass: This is equal to empty mass plus these additions:

- The weight of cargo carried. Assume 5 tons per space of cargo hold (i.e., about 20 lbs./cf) unless you desire to recalculate every time these vary.
- The mass of vessels carried in spacedocks.

Total Cost: Add together hull, turret/bay, streamlining, armor, surface features, module, and weapon costs to get the vessel's cost. This does not include the cost of carried vehicles.

Hit Points: Record hit points for the hull and each bay or turret. A hull, bay, or turret's hit points are its area × 1.5. Standard turrets have 1,200 HP. Standard bays have 9,750 HP.

Step 8 – Performance

Space Acceleration is measured in gravities (G) and determines how rapidly the vessel can accelerate or decelerate. To find space acceleration, add up the thrust in tons: This is 40 per TL10 M-drive or 100 per TL12 M-drive. Divide by the ship's *weight* in tons (*not* displacement tons). The result is the ship's space acceleration (sAccel) in G. Accelerations in the 1 G to 6 G range are typi-

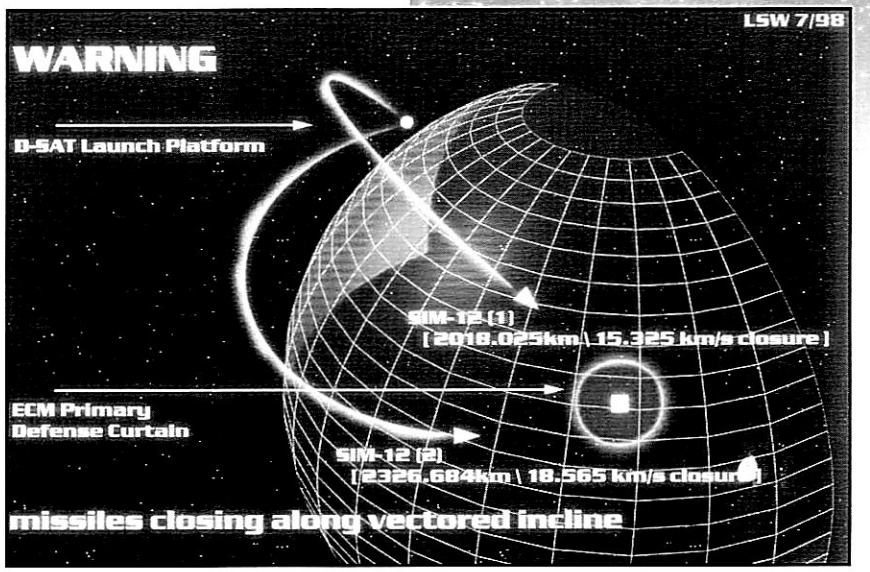
cal of ***Traveller*** vessels – at least 1 G is a good idea, to enable liftoff from a standard planetary surface without atmosphere. Designers may wish to tweak their designs (often by carefully manipulating armor mass) to give results that yield "round" numbers.

Jump Number: This is the distance a starship can jump measured in parsecs. See the description of the J-drive and jump-fuel modules for the requirements needed to jump.

Air Speed: This is the top speed in mph a streamlined vessel can fly at and still maneuver while within a planetary atmosphere. (Vessels going to and from orbit may reach higher straight-line speeds in the upper atmosphere.) To calculate it, first determine its drag: total surface area/5. Then divide thrust by drag. Multiply that by 15 million, and find the square root of the product to get air speed. Thus:

mph = square root [(thrust/drag) × 15 million]

Calculate other useful aerial-performance statistics with ***GURPS Vehicles***.



SIM-12 Missile (TL12)

A TL12 space-interceptor missile.

Features: Very good streamlining.

Propulsion: 3,000 lbs. vectored thrust (90 lbs., 1.8 cf, 150 kW, Cr9,000).

Armament: 250mm "modest" HEAT warhead self-destruct device (31.25 lbs., 0.625 cf, Cr937.5).

Communications: Laser communicator, receive-only, very long range (1 million mi., 50 lbs., 1 cf, Cr625, 0.16 kW).

Sensors and navigation: None – guided by controlling ship.

Computer: Hardened robot brain small computer (1.5 lbs., 0.03 cf, Cr1,250, Complexity 6).

Power: Rechargeable power cell stores 540,576 kWS (20 lbs., 0.2 cf, Cr2,000), good for one hour of operation.

Body: 6 cf (including 0.93 cf empty space). Area: 20 sf. Medium frame, standard materials, robotic, very good streamlining (20 lbs., Cr4,000, 30 hit points).

Armor: PD 4, DR 120 advanced metal (60 lbs., Cr1,200).

Surface Features: Basic Stealth and Emission Cloaking (20 lbs., Cr3,000).

Statistics: Volume 6 cf, Weight: 292.75 lbs. (0.15 ton). Price: Cr22,012.5. HT: 12 (30 hit points). Size Modifier: +0. Space acceleration: 10 Gs (for one hour).

Step 9 – Finalization

The vessel design is now complete. A new class of vessel is assigned a descriptive name like "mercenary cruiser" or "fast merchant" that abbreviates to a letter code (see *Ship Codes,* p. 160). Ship designs are usually also given a *class name* for the first vessel of its type to fly. Later vessels generally follow the same theme; e.g., all mercenary cruisers in the *Broadsword* class are named after archaic hand weapons.

Fitting Out: Vessels may require these additional expenditures not included in their cost:

- Computer programs (p. 161).
- Missiles (standard missile costs Cr31,955 at TL10, Cr22,050 at TL12).
- Sand canisters (replacesment cost Cr400).
- Fuel (refined hydrogen at Cr350 per fuel-tank module).
- Spares and maintenance: assumed at 0.1% of total cost of vessel per year.
- Berthing costs: To land or dock at a ground port or orbital facility, plus berthing for up to six days, costs Cr100 per displacement ton. It costs the same to stay docked for each additional week or fraction thereof.

Advanced Design Options

Compartmentalization: Vessels are already divided into airtight compartments with interior walls and pressure doors. For extra weight and cost, vehicles can have "heavy" compartmentalization (masses 10% of hull mass) or "total" compartmentalization (masses 20% of hull mass). Either type costs MCr0.01 per ton of weight added.

Variable-Mass Performance: GMs may wish to calculate multiple sets of performance figures for ships whose mass can change dramatically; e.g., for example with near-empty vs. full cargo holds, tanks, or hangar decks, or with/without drop tanks.

This can make flight operations more complex; e.g., a Free Trader might take off from a planet with empty fuel tanks to save mass, refuelling at a gas giant, ice asteroid, or space station.

After-Market Mods

Traveller has a healthy tradition of user modifications to an existing ship. ***GURPS Vehicles*** purists will note that adding components with increased power needs effectively makes the core power system larger after it's been built! Instead, consider the power "slice" of an after-market module to be a more robust cooling system or somesuch for the existing reactor. Just as a TL7 car enthusiast might have his existing engine bored out, a TL10 ex-scout will find a way to power a laser or three in that once-empty turret of his . . .

Ship Codes

The Imperium assigns one- or two-letter codes to ship designs for their intended function, either a single primary letter or a primary followed by a qualifier. Some examples:

Primary		Qualifier
A	Merchant	Armored
B	Battle	Battle, Boat
C	Cruiser or Carrier	Cruiser or Close
D	Destroyer	Destroyer
E	Escort	Escort
F	Frigate or Fighter	Fast or Fleet
G	Gig, Refinery	Gunner
H	–	Heavy
I, J	Intruder	–
K	Pinnace	–
L	Corvette, Lab	Leader, Light
M	Merchant	Missile
N	–	Non-standard
P	Planetoid	Provincial
Q	Auxiliary	Decoy
R	Liner	Raider
S	Scout, Station	Strike
T	Tanker, Tender	Troop, Transport
U	–	Unpowered
V	–	Vehicle
W	Barge	–
X	Express	–
Y	Yacht	Shuttle, Cutter
Z	–	Experimental



Starship Operations

This section explains the operation and care of a ***GURPS Traveller*** starship.

Bridge Systems

The heart of a bridge is its crew stations. A cockpit has one or two crew stations, a basic bridge has five such stations, while a command bridge has 10. Each is a seat facing a console with a computer terminal and various multi-function displays that can be reconfigured to enable any station to perform any bridge crew function – pilot, navigator, communications officer, gunner, sensor operator, and so on.

Communications

As well as seats and consoles, a cockpit or bridge has various "avionic" systems, such as communicators.

Radio: A basic multi-frequency broadcast communicator capable of sending and receiving radio signals over great distances. Transmissions may be scrambled (encrypted), but if continuous will be received by all radios within range. A cockpit has one radio, a basic bridge two, a command bridge 10.

Lasercom: A tight-beam directional communicator using a modulated laser beam. Only another lasercom can receive its signal and only if directly in the path of the pencil-thin beam. This makes transmissions secure, but it can only talk to one vessel at a time, and it must be focused on the recipient: no broadband "Free Trader *Beowulf*, Calling Anyone" SOS . . . Laser signals are blocked by solid objects, smoke or prism clouds. and sandcasters. A cockpit or basic bridge has one, a command bridge four.

Meson Communicator: This system uses a modulated beam of mesons for communication. It functions like a lasercom, but is not blocked by solid objects, smoke or prism clouds, etc. Only another meson communicator can receive its signal. Basic bridges at TL12 and both TL10 and TL12 command bridges have meson communicators.

IFF-Transponder: This sends out an automatic identification code (via communicator). Civilian systems are factory-sealed – they can be turned on or off, but the signal can't be altered; military systems can be reprogrammed to give false identities. Of course, a ship that claimed to be a 100-ton scout but appears on radar as a 50,000-ton vessel would attract suspicion, but if it claimed to be a bulk transport . . . Cockpits/system have one IFF, bridges include two to provide one backup.

COMMUNICATION RANGE TABLE

	— Communication Ranges —		
Module	Radio	Laser	Meson
TL10			
Cockpit/Systems	0.5 mil.	1 mil.	none
Basic Bridge	5 mil.	10 mil.	none
Command Bridge	5 mil.	10 mil.	0.1 mil.
TL12			
Cockpit/Systems	0.5 mil.	1 mil.	none
Basic Bridge	5 mil.	10 mil.	0.02 mil.
Command Bridge	5 mil.	10 mil.	0.2 mil.

Communicator ranges are in *millions* of miles.

Sensors

Bridge and cockpit/system module avionics generally consist of four standard sensor types: PESA, AESA, radscanner, and radar/laser detector.

Passive Electromagnetic Sensor Array (PESA): This is an array of infrared thermal imaging and low-light telescopic sensors. A PESA gives the bridge crew a visual picture of objects within its sensor range. The PESA is mounted in a small pop turret that can extend out to scan a 360-degree arc.

Radscanner: This is a multi-function energy scanner that can detect and scan for various types of radiation, such as radio, neutrino, or radar emissions. It can detect the neutrinos emitted by fusion-power plants – this is a good way to tell a scoutship from a dreadnought . . . It is capable of detecting radiation from all directions simultaneously.

Active Electromagnetic Sensor Array (AESA): A multi-mode sensor that works as a radar, imaging radar, and ladar. In radar mode it detects objects within its range, although they only appear as "blips" with inexact size and shape. In imaging radar or ladar mode, it has only half its range but better resolution: Objects appear as actual silhouettes permitting identification of known vessels and exact determination of size.

SENSOR RANGE TABLE

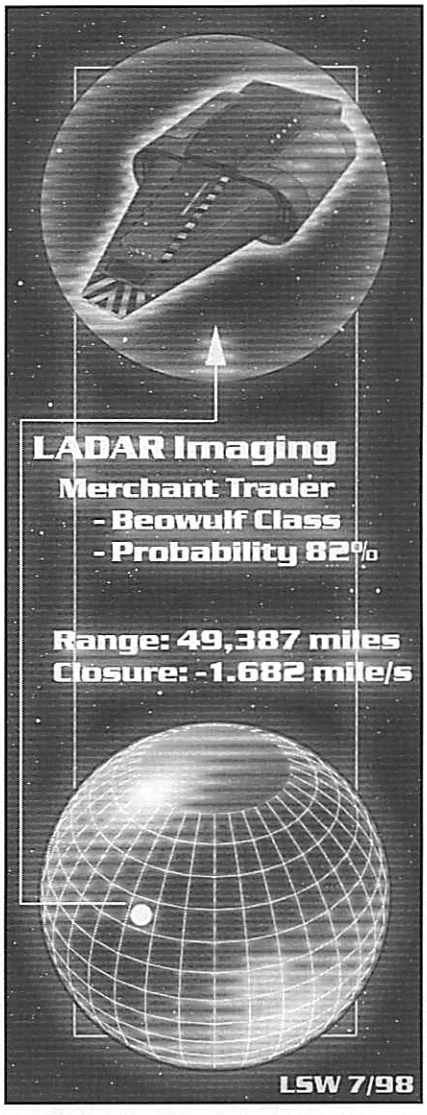
	— Sensor Range in Miles —		
Module	**PESA**	**AESA**	**Radscanner**
TL10			
Cockpit	10,000	50,000	1,000
Basic	20,000	100,000	2,000
Command	50,000	150,000	4,000
TL12			
Cockpit	20,000	70,000	2,000
Basic	30,000	150,000	10,000
Command	100,000	200,000	30,000

Sensor ranges quoted above are averages for detecting a man-sized object, such as a person in a vacc suit or a missile. Big ships can typically be detected at 5-20 × these ranges, but actual ranges may vary greatly in various situations – see the *Space Combat* table of modifers on p. 173.

In atmosphere, PESA and AESA sensors (but not radscanners) have one-tenth this range.

In any mode it will also function as a rangefinder, feeding targeting data to weapons consoles and giving +2 to hit detected objects. It's mounted in the same pop turret as the PESA.

Advanced Radar/Laser Detector: This sensor can detect and locate any operating radar or ladar sensor (such as an AESA) within twice that sensor's range. For this reason any vessel wanting to avoid detection will often turn off their active sensors and rely solely on their passive PESA sensor arrays. All bridges include two of these for redundancy.



Computers

Each bridge or cockpit system incorporates *three* computers: a trio of microframes in the cockpit, mainframes in the basic bridge, and macroframe "super computers" in the command bridge. The computer's Complexity is shown at right.

COMPUTER TABLE

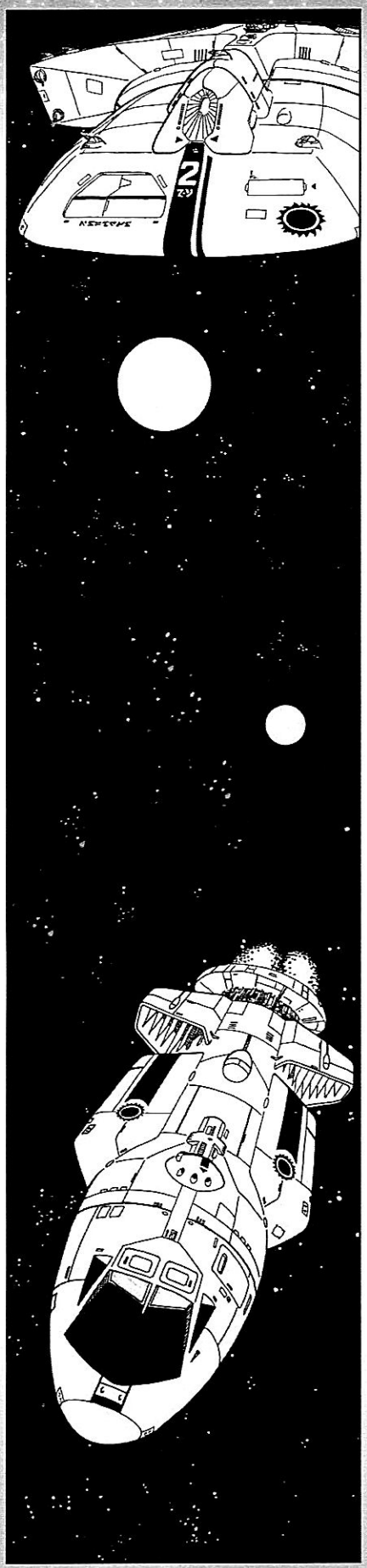
	Complexity	
Module	**TL10**	**TL12**
Cockpit	6	8
Basic	7	9
Command	8	10

Any cockpit, bridge, sickbay, turret, or bay incorporates computer terminals that can access the computers.

Using Computers

Every computer has a Complexity rating which governs the software it can run and how fast it will run. Each +1 Complexity represents an order-of-magnitude performance increase.

A computer needs programs, which also have Complexity ratings. A computer of a given TL and Complexity can't run higher-TL or higher-Complexity programs. The number of programs that can run concurrently is based on computer Complexity: two programs of its own Complexity, 20 of Complexity-1, 200 of Complexity-2, etc. They can be mixed; e.g., one at Complexity, nine more at Complexity-1, and 100 more at Complexity-3. Switching a program takes only a few seconds. Programs vital for space operations include:



Astrogation: Needed to make an interstellar jump. Complexity equals jump distance+1. Costs Cr10,000 × jump number.

Datalink: Used to share realtime data with other computers, sensors, missiles, etc. Complexity 1, Cr400.

Damage Control: Monitors systems status, +2 to rolls to repair ship damage. Complexity 2, Cr2,000. Also requires ship blueprints (1 gigabyte and Cr1,000 per ship).

Gunner: In conjunction with a Targeting program, it lets the computer act as a gunner with skill-12. Complexity 4, Cr45,000, double cost and +1 Complexity per +1 added to skill. The bonus to skill is not cumulative with a Targeting program – use the *lower* of the Targeting or Gunner program bonus.

Library Data: An encyclopedia program containing detailed non-classified information on the Imperium. Not always up-to-date for all worlds, but licensed owners can often download supplementary data at local starports. 100 gigs, Cr100,000.

Targeting: Predicts target positions and helps aim weaponry adding a bonus to a gunner's skill equal to its Complexity+1. Costs Cr1,000 for Complexity 1 program, doubling per +1 Complexity increase. One needed per human or computer gunner. Due to the long ranges at which spacecraft engage their opponents, a targeting program giving a +7 to +10 bonus is *strongly* recommended for all armed spacecraft!

More programs can be found on pp. UT33 and VE63.



Power Plant

The standard shipboard power plant at TL9-12 is a fusion reactor. Its supply of internal hydrogen fuel is sufficient to operate it for 200 years without refuelling under ideal conditions, but without annual checkups in a major shipyard it can cease functioning – a ship that misjumps ending up years away from home (by sublight speeds) may have trouble returning.

Fusion reactors are fairly safe: If an operating reactor was destroyed, steam and high-energy plasma might wreck and irradiate the engine room, and this might cause a steam explosion, but there wouldn't be a nuclear blast.

Other Ship Systems

Navigation Electronics: Bridge and cockpit modules each include precision navigation and inertial-navigation systems (one in a cockpit, a pair on basic and command bridges).

Flight Recorder: All cockpit and bridge modules include a tough "black box" flight recorder (like those on modern aircraft) that records voice transmissions and instrument readouts. One is in a cockpit/systems module or basic bridge, a pair in a command bridge.

Fire Suppression System: Vessels are normally fitted with automatic fire and explosion extinguishers that use non-toxic inert gas to smother fires within microseconds. One fire-suppression system is in each bridge, cockpit/systems, and engineering module.



This system resolves space actions on a hexagonal grid using counters or miniatures, much like the *Advanced Combat System* does personal combat. It's intended for vessels created with the ***GURPS Traveller*** modular system, but is also usable with other ***Vehicles***-built spacecraft. It is derived from the system in ***GURPS Vehicles*** but makes several changes in scale and modifiers to better reflect the high-gee, long-ranged space battles of ***Traveller.*** GMs should feel free to use it in non-***Traveller*** campaigns where ships have multi-G thrusts and weapons have ranges in the tens of thousands of miles.

Blank hexgrids may be photocopied from the ***GURPS Basic Set***. GMs will have to devise their own counters.

Scale and Definitions

Space battles are fought in 20-minute combat rounds. One map hex is about 10,000 miles. Each spacecraft counter represents a single vessel or a salvo of missiles. A velocity of one hex per round is a speed of about 30,000 mph. "Acceleration" is measured in Gravities (G). For tactical combat purposes (not long-distance travel) round accelerations over 1 G to the nearest full Gravity.

Any unqualified use of the term "spacecraft" can be assumed to encompass ships, small craft, and missiles.

Preparation

In addition to a hexagonal grid map, each spacecraft requires two counters: a "spacecraft counter" (or miniature) representing the vessel's location and a "vector counter" marking its future position. Both should be distinct, but marked with the same ID.

Just like characters, spacecraft and vector counters must be placed on the map so they are fully inside a hex. Spacecraft must always face a particular hex side (although facing can be ignored if the ship has no fixed weapons). Facing of vector counters is unimportant.

The GM should prepare statistics of the spacecraft involved and their most important crew (captain, pilot, gunners, engineers, sensor and commo operators). As gunnery skills are subject to large modifiers due to the systems or weapons used, the GM can save time by calculating an "adjusted gunner skill" for each gunner, human, or computer controlling beam weapons:

Adjusted Gunner Skill is Gunner base skill modified as follows:

+ Weapon's Accuracy (up to Gunner skill level). As all standard-design weapons have Acc 30+, this means the bonus is generally limited to an effective doubling of gunner skill.

+ Weapon's RoF bonus. This is +7 for standard weapons, which are all RoF 1/60. For ***Vehicles***-built weapons that have different RoFs, refer to the *RoF Bonus Table,* p. 174.

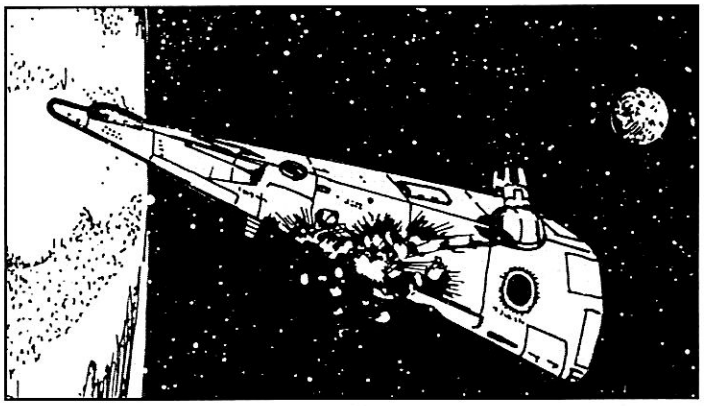
+ Targeting program's Complexity+1. (Do not add this bonus if the weapon already has a computer Gunnery program.)

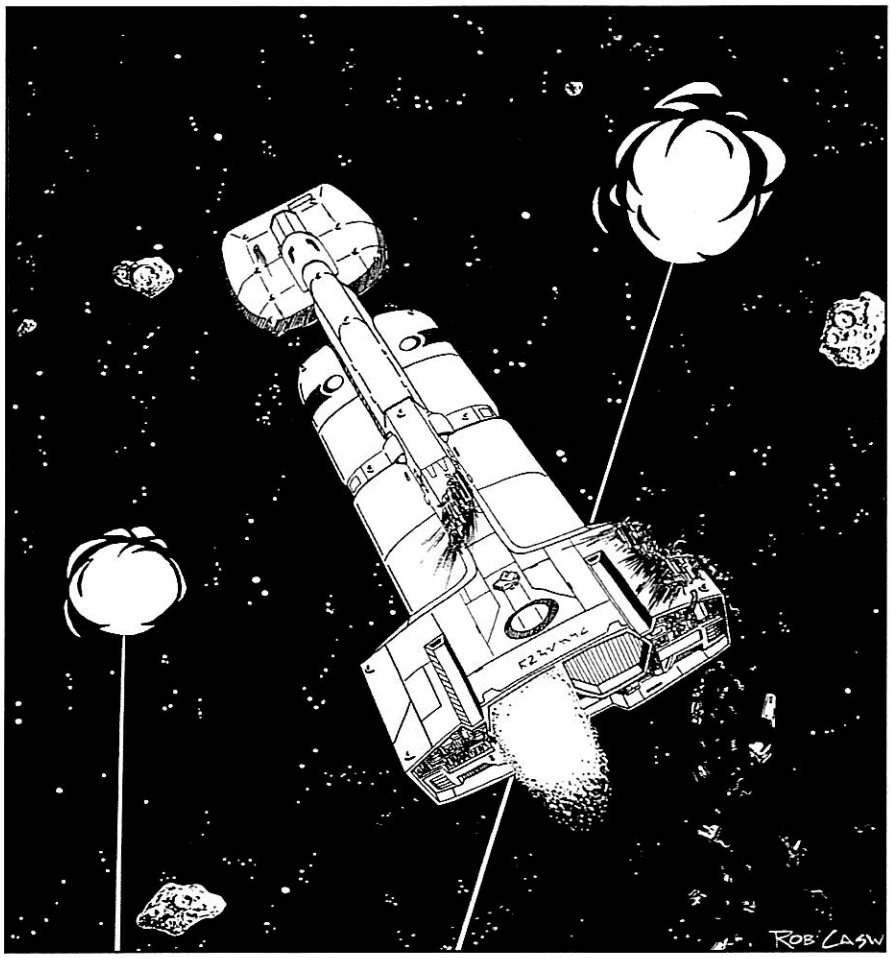
Thus, for standard weapons, adjusted gunner skill simplifies as: (Gunner skill × 2) + 7 + Targeting program bonus.

Setting Up

The GM should only set up a map and counters if space actions are a possibility (or he wants players to think they are). While deep-space encounters are possible, most action occurs within 100 planetary diameters of a world, as ships head to and from the world and the safe jump distance. For example, if the world was 8,000 miles in diameter, encounters might occur anywhere from orbit to 800,000 miles out: 1 to 80 hexes away.

If space action seems imminent, the GM should first place any planets, moons, or other large bodies on the map (see *Celestial Bodies,* p. 170). Different planets will be tens of thousands of hexes apart, but a planet/moon system may fit on the map – e.g., Luna's average distance from Earth is 24 hexes.





The GM secretly decides on the location and course of NPC spacecraft, then, before revealing the location of any vessels, asks players to provide him with the same information for their vessels. Based on this, the GM should place friendly, neutral, and hostile spacecraft (except any carried aboard ships) on the map. (The GM may sometimes wish to keep some unspotted craft "off the map" to surprise players, especially stationary vessels hidden on or behind worlds.) In a duel between players, they should secretly record their general formation ("ship #1 in the lead, ship #2 two hexes to the right . . .") and vector length (in hexes).

Place each spacecraft's counter where the spacecraft is, and its vector counter where the spacecraft will be next round if it does not maneuver. The position of the vector counter is its course, while the distance from the spacecraft to its vector counter is its velocity. Thus, a stationary spacecraft has its vector counter in the same hex it occupies, one moving at one hex per round (30,000 mph) toward a planet would have a vector counter in the adjacent hex closest to the planet, and so on. Relatively low velocities (1-5 hexes/round) are most playable, as vessels that move too fast will take a long time to turn about.

How far apart should spacecraft begin on the map? That depends on the situation. In a system with a busy starport (V to III), there's usually a fair bit of traffic passing by, and captains won't start getting antsy until a vessel passes within a half-light second or so (7-9 hexes). Likewise, if players are planning nefarious activity of their own, an enemy won't usually pay much attention to them until they get within that distance. In an actual war zone, or in frontier systems, any contact might be suspicious. The GM may wish to start checking for detection within a light second or two (e.g., 18-37 hexes range). On the other hand, if an enemy vessel was hiding behind a planet, asteroid, or moon, the combat could begin at only a few hexes range as it suddenly appeared within line of sight.

If it's a set-piece battle or a random encounter, the GM should take care to place ships with converging vectors, while if it's a chase, place the quarry in the middle of the map and the pursuers at one end, bearing in mind that the pursuer will be unable to catch up unless he possesses a faster ship or missiles. Care should also be taken when placing things that can't maneuver (or can't maneuver much) in the context of the game; i.e., stations, satellites, or low-acceleration ships.

Sequence of Action

Play proceeds through this sequence each round. There are no individual turns per se: Detection is checked for all spacecraft, then maneuvers are made for all spacecraft, and so on.

1. *Detection and Communication.*
2. *Maneuver.*
3. *Movement.*
4. *Direct Fire.*
5. *Collision and Point Defense.*
6. *Launch/Docking.*
7. *Damage Control.*

If one spacecraft has yet to spot another, the unaware crew may not take previously unplanned actions until events such as hostile fire or detection alert them. The GM should go through the Sequence of Action each round, checking to see if unaware vessels have detected opponents (phase 2) and moving the spacecraft (phase 3). Once a crew becomes aware of a potential threat (or target!) it can begin to maneuver, fire, etc. Until then, though, a ship should continue on its pre-planned course. Eventually, all spacecraft will either spot one another, reach their destinations, or drift apart and go their separate ways.

1. Detection and Communication

Each space combat round, check to see if spacecraft detect previously unnoticed objects. Large objects like planets, stars, or moons are automatically spotted. GMs may require sensor rolls to find smaller bodies like asteroids, if they aren't on charts.

At the start of this phase, the GM should secretly decide whether NPC spacecraft are using active sensors (such as AESAs) or sending out radio broadcasts, then ask players to reveal if their own spacecraft are "going active" or broadcasting. If using an AESA, specify whether using it as a radar or ladar.

After these decisions are made, the GM should check for detection – there are several ways in which another object can be detected or deliberately announce its presence. Detection depends on picking up communicator or transponder transmissions, enemy fire, or active sensor emissions with radscanners – or upon use of PESA or AESA sensors to locate other craft.

All three types of sensor can be used in a single round. If a ship has multiple sensors of the same type (e.g., extra bridges) only check detection for the sensor with the highest combined operator skill and scan rating in that category.

If a single sensor operator tries to use more than one sensor type in a round, he rolls at -2 per extra sensor he's using.

While successful detection with any sensor type alerts a vessel to an opponent's presence, beam-weapon fire is only allowed against vessels detected with targeting sensors. AESA or PESA are targeting sensors; radscanners are not. (Missiles can still be maneuvered to attack targets detected only by radscanners.) Detecting a vessel with one sensor type doesn't mean detection with the others, but gives a bonus to do so on *later* rounds (see *Sensor Modifier Tables,* pp. 172-173).

Radscanners

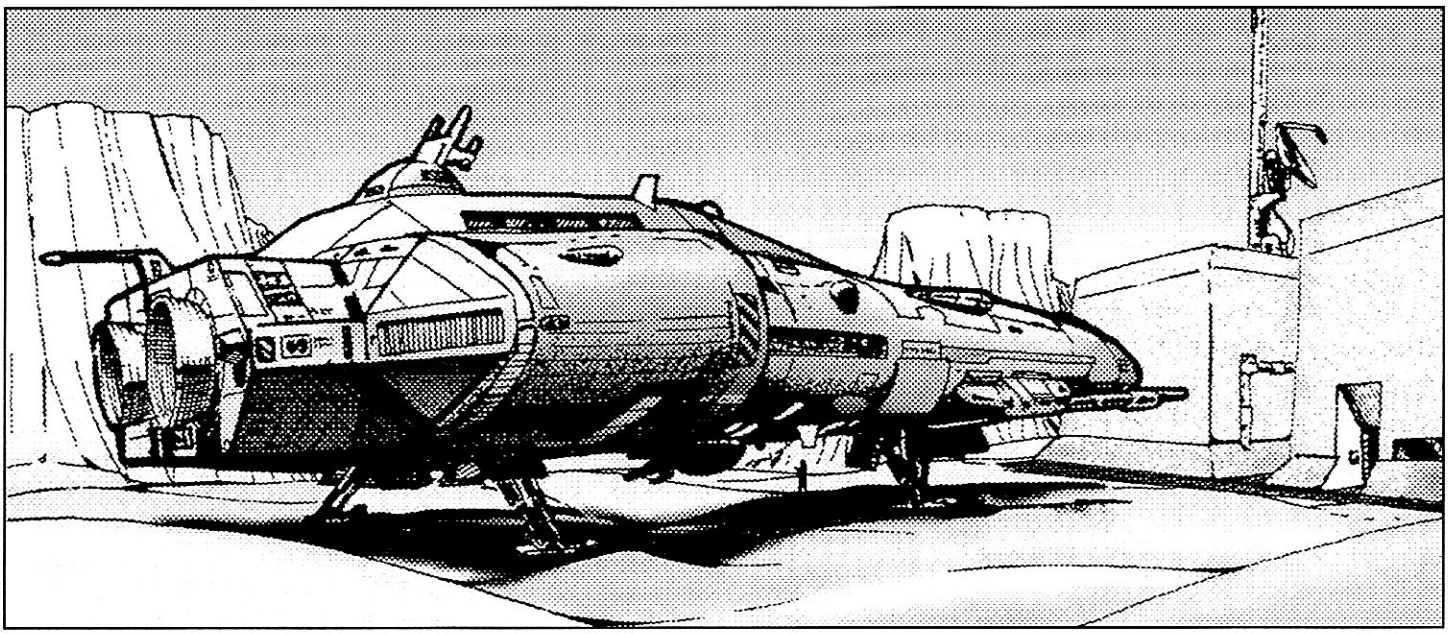
Cockpit and bridge modules include radscanners. They are normally used in space as radar/radio/laser/particle detectors. If the ship was hit by laser or particle-beam weapons fire on the previous turn, its radscanners automatically detect the firer's position. Otherwise, a radscanner can check for detection if an undetected object is broadcasting on radio, using transponders, or has "gone active" with an AESA or other active sensor.

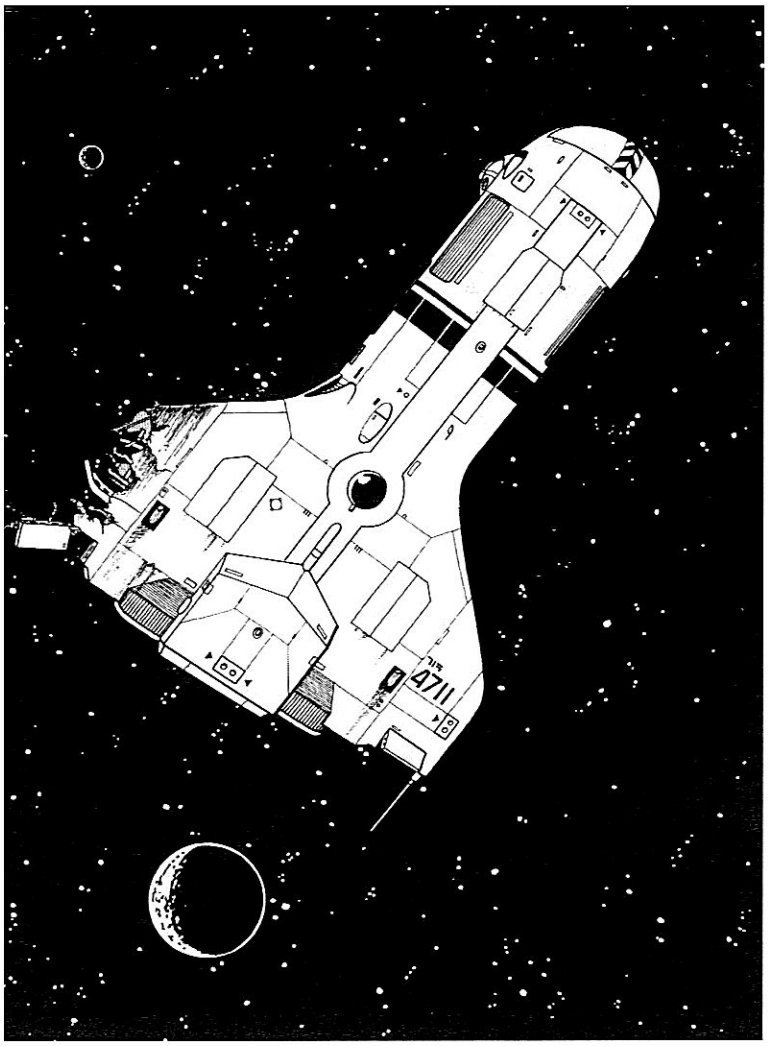
To determine if a transponder, radio broadcast, or active sensor use has been detected, roll vs. the sensor operator's Electronics Operation (Sensors) skill, adding appropriate modifiers from the *Sensor Modifiers Table* (pp. 172-173). Failure means the object's emissions went unnoticed (or were overlooked against the general radio noise in a system).

Success means the emitting object is detected: Its location is known, along with information on the type and strength of emission it was broadcasting (radio, active sensor, transponder, etc.). The detecting ship is now alerted.

If a detected object has a broadcasting transponder, that signal also provides the vessel's name, registry, and traffic-control information (ship class, identity number, origin, and destination); e.g., "Type-R merchant *Gyro Zorina,* ID #17960327DY5, Rhylanor registry, inbound Hefry to Regina."

At very close (0 hex) range, radscanners can also provide information on whether target power plants are functioning, etc.





Passive Electromagnetic Sensor Arrays (PESA)

All standard-design spacecraft incorporate an array of thermal-imaging, passive-radiation, and visual-detection systems, collectively called a PESA. If an undetected object is within sensor range (and not hidden behind a celestial body), the GM should make detection rolls to see if the PESA has detected it.

Roll against the sensor operator's Electronics Operation (Sensors) skill, adding appropriate modifiers from the *Sensor Modifiers Table* (pp. 172-173). Failure means the object is not detected, but another try may be made next round.

Success by 0-2 means *detection.* The object's existence has been discovered, alerting the spacecraft to its location and course.

Success by 3-4 means *detection and recognition.* The object is detected, and its general shape resolves as a fuzzy image.

Success by 5+ means *detection and identification.* The object appears "on screen" as an actual image.

Once detection is achieved, it is retained unless something occurs that would interrupt a direct line of sight between the vessels, such as a ship moving behind a planet. If only detection or recognition was achieved, on later rounds further attempts at detection may be made to "improve the picture." If so, ignore any results that would lower the degree of detection achieved.

Any objects that a spacecraft launches after it has been detected are spotted automatically. Thus, if a spacecraft that has been identified fires missiles, they are identified as they launch.

Active Electromagnetic Sensor Arrays (AESA)

Ships with a standard-design cockpit or bridge module incorporate an array of radar and ladar sensors known as AESA. An AESA provides precise ranging information, but its use emits electromagnetic radiation that will usually give away the vessel's position, so wary vessels often leave it turned off.

An AESA can only be used if the decision was made to "go active" at the start of this phase. An AESA also improves the chance of hitting targets with direct fire; even if an enemy has already been detected, this is an advantage to "going active."

Use the same procedure as for PESA systems, but use the AESA scan ratings and skill modifiers instead (see *Sensor Modifier Table,* p. 172-173). Also, if using an active sensor as search radar rather than ladar, treat "detection and identification" as merely "detection and recognition."

2. Maneuver Phase

In this phase, all spacecraft with working M-drives may maneuver. Spacecraft maneuver in order of lowest to highest acceleration (in gravities); spacecraft of equal acceleration maneuver in order of highest to lowest Size Modifier. Break ties with a quick contest of Tactics skill between the respective captains. The spacecraft's pilot (or controlling gunner, for a missile) decides how the spacecraft will maneuver.

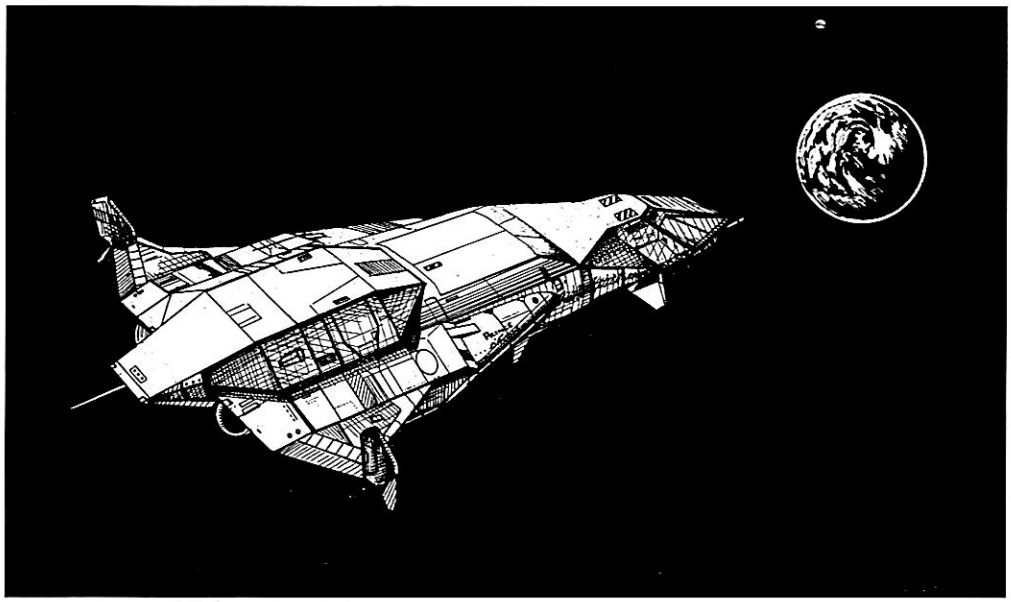
On its turn to maneuver, a spacecraft may change facing and/or accelerate. A spacecraft may change facing so it faces any hex-side. Acceleration is performed by moving its *vector counter* a number of hexes *in any direction* to a maximum of the spacecraft's acceleration. Round acceleration to the nearest G for this purpose.

Slow Acceleration: If a spacecraft has an acceleration substantially under one G, it will not accelerate every round. It requires (1/G) rounds to make a one-hex vector change (round down). For example, a spacecraft capable of 0.3 G accelerates every 1/0.3 = 3.33 rounds, rounded off to every three rounds.

Endurance and Missiles: A spacecraft with a fusion power plant and reactionless thruster M-drive has no fuel restrictions. However, the power cells that energize standard missiles store energy for only three rounds; GMs may wish to use a die next to missile counters to keep track of their remaining power. Other craft built with

GURPS Vehicles may be limited in the number of rounds of operation and/or acceleration before running out of fuel or energy.

Control of Missiles: Standard shipboard missiles are drones remotely piloted by their gunner. The missile can only maneuver if in sensor *and* communicator range of its launcher. A single gunner (one per turret, two per bay) can control one missile per communicator dedicated to this purpose. Standard missiles use laser communicators. One laser communicator is built into each missile rack and 50 into each missile bay. If a gunner has to drop a missile because he can't control all the ones he has, he may "reacquire" it on a later round. Missiles can be (and often are) pre-programmed to self-destruct after a certain number of rounds uncontrolled.



3. Movement Phase

Spacecraft can move in any order – it doesn't matter. For each spacecraft, the GM or a player should do the following:

1. Put a marker (e.g., a small coin or die) in the spacecraft's hex as a placeholder.

2. Move the spacecraft into the same hex as its vector counter.

3. Visualize a line between the placeholder and the spacecraft's current hex and move the vector counter a number of hexes along that line equal to the distance from the placeholder's hex to the spacecraft's hex.

(In other words, the spacecraft moves into the same place as its vector counter, and the vector counter is moved to a new location along the same projected course. In this way, a spacecraft that does not otherwise accelerate will continue to move each round in the same direction. Facing has no effect on movement – all that matters is the vector counter's location.)

4. If a spacecraft passes close to a world, it may be affected by gravity. The hexes adjacent to worlds are gravity hexes – see *Celestial Bodies* (p. 170). Imagine a line from the placeholder's hex to the spacecraft's hex – this is the spacecraft's course. For each gravity hex that this line passes through, visualize an arrow from that gravity hex pointing to the planet and move the *vector counter* one hex in that arrow's direction.

5. After gravity effects, if any, are resolved, remove the placeholder marker and go on to the next spaceship's movement.

Some other special factors may influence movement.

Collisions: If a spacecraft's course intersects a planet-sized celestial body, the spacecraft may either crash into it or land – see *Celestial Bodies* on p. 170. However, any number of spacecraft may safely occupy or pass through the same hex containing small bodies like asteroids or other spacecraft.

Vector Adjustment: Spacecraft moving at very high velocities may move off the map. If this seems likely, the GM should simply move all spacecraft, planet, and vector counters a fixed number of hexes in an appropriate direction. (If necessary, record locations of planets or ships that "disappear" off map.) Another possibility, of course, is to lay down a second mapsheet.

Ramming: After *all* spacecraft have completed their movement, a spacecraft that has other spacecraft (or other things) in its hex may attempt to ram. This is the way standard missiles attack. Ramming must be declared at the end of the movement phase by the craft's pilot (or missile's gunner); the target of a ram may cooperate or attempt to evade the ram, or even announce that it is ramming a different vessel. The actual results of ramming are resolved in the *collision* phase, but the decision must be made now, as a vessel closing to ram becomes easier to hit. A spacecraft may only try to ram a single target each round.

See *Celestial Bodies* (p. 170) for more on landing and takeoff.

4. Direct Fire Phase

Direct fire is fire performed using beam or gun weapons such as lasers. Spacecraft perform direct fire one at a time. All fire is considered simultaneous – resolve attacks sequentially, but actual damage should not be applied until the end of the phase.



When it's a spacecraft's turn to fire, resolve fire one gunner at a time – that character decides whether to shoot and whom to shoot at. Also in this phase, a gunner controlling sandcasters should indicate the spacecraft the 'caster will be protecting against – this protection continues until the gunner's turn to act on the *next* round. (See *Using Sandcasters* on p. 172 for more information.)

A single gunner can fire the weapons in his turret or bay; the gunner must be in the crew station in his turret or bay to control its weapons. Other hull-mounted weapons can be fired by a single gunner from a bridge crew station. A Gunner program running on the spacecraft's computer can replace a single gunner. A single gunner can only fire at one target per round.

Each weapon may only attack once (regardless of its actual rate of fire) – in a space combat round, weapons are firing multiple carefully aimed tracking shots over the 20-minute period. Thus, while a standard weapon has a RoF of 1/60 (one shot per minute), for playability only one attack is allowed per weapon, to prevent the game degenerating into dozens of rolls. Higher RoF weapons get a bonus to hit, rather than multiple attacks.

Use this procedure for each weapon that is being fired:

First, the gunner chooses the target. Missiles *can* be targeted in this phase. A weapon can fire on any target the gunner's spacecraft has detected with a targeting sensor that is within his weapon's maximum range and arc of fire. Ranges in hexes are shown on the *Space Weapons Table.* Weapons in bays/turrets may fire in any direction. Weapons in hull mounts can fire at any targets in front of the spacecraft – use the normal "arc of vision" (p. B115). Weapons in spinal mounts can fire at targets in the spacecraft's hex and in a row of three hexes wide extending from its three front hexes straight forward out to maximum range.

Second, determine the modified Gunner skill of the firing character (or program) using the *Gunner Skill Modifiers Table* (p. 173), then roll against modified skill to determine if the hit occurred. In the 20-minute combat rounds, an attack roll scores a number of hits on its target equal to half the margin of success (minimum one hit). Thus, success by 0-3 scores one hit, success by 4-5 scores two hits, and so on.

Third, spacecraft with at least 0.1 G thrust can Dodge: roll vs. (Piloting skill + thrust in G - ship Size Modifier)/2, rounded down. Modifiers: +1 if pilot has Combat Reflexes; + ship PD (4 usually, 0 vs. meson gun). Ramming craft cannot Dodge point-defense fire.

For each hit not dodged, determine hit location. If the target spacecraft lacks bays or turrets, the attack hits the hull. Otherwise, roll 1d: On a 1-2, it hit a turret or bay of the attacker's choice. On a 3-6, the attack hits the hull.

For each hit, roll the weapon's damage dice (see *Space Weapons Table* on p. 173). Damage is halved beyond the ½D range. Subtract target DR (modified by armor divisor). Sandcasters offer extra DR against lasers (see *Using Sandcasters,* p. 172). Meson screens (p. 154) sometimes give DR against meson guns (see *Meson Guns and Meson Screens,* p. 171). If damage penetrates armor and screens, subtract it from the hit points of the hull, turret, or bay location that was struck. On a critical hit, the attacker may choose to do double damage or have defenses protect at one-tenth DR.

Damage Effects

Damage effects are calculated immediately but do not "take effect" until the end of the direct fire phase – thus, everyone has a chance to fire before being killed or crippled.

A hull ("body"), turret, or bay reduced to 0 or fewer hits is "disabled." One reduced to -5 × its original hit points is "destroyed." The effects are described below:

Hull Disabled: The spacecraft is crippled, out of power, and leaking any air. A crippled vessel continues to move, but cannot maneuver, jump, or use shipboard systems like sensors, computers, communicators, or weapons. Piloted spacecraft (such as lifeboats or fighters) can still be launched.

Hull Destroyed: The spacecraft loses structural integrity. At the GM's discretion it may break up or even explode. Occupants may be killed, trapped in wreckage, or escape depending on the situation. GMs may require a successful Vacc Suit roll to survive.

Turret or Bay Disabled: Weapons and other systems built into that turret or bay no longer function.

Turret or Bay Destroyed: As above, but no repairs possible; systems must be replaced at full cost. Crew members take 5d damage each (personal DR does not protect).

More specific damage effects, such as disabled drives, may occur. Each time cumulative damage to a ship or smallcraft hull reaches a multiple of 10% of the spacecraft's original hit points, roll 3d on the *Major Damage Table* (see p. 174) and apply the result on the table to the spacecraft. This simplifies the ***GURPS Vehicles*** advanced-damage system, but gives more flavorful results with ***GURPS Traveller***-designed vessels.

5. Collision and Point Defense Phase

If a spacecraft attempted to ram its target and was not destroyed by enemy fire, resolve the ram attempt as described here. If multiple spacecraft are ramming each other in the same hex resolve them in order of highest to lowest acceleration, then lowest to highest Size Modifier, breaking ties with a Quick Contest of Tactics.

After a ram is announced, the target spacecraft may attempt to use point-defense fire as a "last chance." Fire is allowed even if the weapon fired during the direct fire phase. Point-defense fire is resolved exactly like normal direct fire against a target at 0 hex range, except that weapons receive a bonus to hit due to the closing range and much simpler target solution.

Each beam weapon can only fire *once* in the point-defense phase. If its gunner scores multiple hits (see p. 168) he may divide those hits among different targets (for example, several incoming missiles) rather than hitting the same target more than once, as long as these other targets are craft that are no harder to hit than his first target. This means a single beam may, on average, stop two or three missiles. Sandcasters may be fired as point-defense weapons: Treat them as TL10 turret lasers for this purpose against missiles. A hit destroys a single missile, but has no effect on larger vessels.

If both spacecraft cooperate in ramming each other, the attempt succeeds automatically. Otherwise it is a Quick Contest of Piloting skill between rammer and the evading target. Missiles use their controlling Gunner's skill, with a -1 per 3 hexes range from *controlling spacecraft* to the target. Add the target Size Modifier to rammer skill; a craft with a higher acceleration adds half the difference in G to skill (round down).

If the rammer loses or ties, it fails to hit the target. If this occurs, nothing happens: it remains in the current hex. If the rammer wins, both spacecraft collide.

A collision inflicts crushing damage on both spacecraft equal to the relative velocity times the lower of the two craft's hull hit points times 20d (5) – that is, armor protecting at ⅕ DR. As both craft will be in the same hex, relative velocity is the distance between their respective vector counters. For a standard missile with 30 hit points, this simplifies to 6d×100 (5) × relative velocity. A missile's gunner may choose to detonate the warhead's shaped-charge warhead *instead* of doing impact damage. This is more effective if relative velocity is 0-1. Standard missiles use shaped-charge warheads doing 6d×60 (10) damage at TL10 or 6d×80 (10) at TL12 – the (10) means armor protects at one-tenth DR.

Ramming an asteroid, planet, or moon won't do damage on a planetary scale, but can devastate an area – aside from warhead effects, assume anything nearby takes explosive concussion damage from the impact based on one-tenth the collision damage.

6. Launch/Docking Phase

In this phase spacecraft may launch missiles and other craft in order of lowest to highest captain initiative.

A missile rack can launch one missile and a missile bay can launch up to 50 (subject to remaining ammunition). A spacedock or vehicle bay can launch any number of vessels carried in it or initiate docking and recovery operations with any number of vessels per bay, but not both at once.

Newly launched spacecraft are placed in the launching vessel's hex; place their vector counter in the same hex as the launching spacecraft's vector counter. The launch mechanism of missile bays or racks may impart an additional 1-G acceleration as it launches – if desired, place the missile's vector counter in any adjacent hex.

Docking: A spacecraft can dock with another (link airlocks using passage tubes) if both have matched courses. One of the docking spacecraft must be capable of maneuver; the other must either cooperate, or be crippled and unable to maneuver. Safe docking requires precise maneuvering and takes a complete round. Neither craft may maneuver in the *next* space combat round's maneuver phase, and the docking maneuver is not completed until the beginning of the next round's docking phase. Docked spacecraft can maneuver while docked provided that they continue to match courses and don't exceed 1 G acceleration. Undocking is faster: It takes a single phase and does not restrict maneuver.

Recovery: A spacecraft can recover smaller craft into a spacedock or vehicle bay if it meets the above docking requirements and the smaller craft can fit aboard. The smaller spacecraft is taken aboard at the beginning of the next round's launch/docking phase.

Matching Courses: Two spacecraft have matched courses if both occupy the same hex *and* both their vector counters also occupy a single hex.

Emergency Docking and Recovery: A docking or recovery operation can be performed more quickly. The maneuvering craft makes a Piloting skill roll. If the roll succeeds, the docking or recovery occurs in a single round – there's no restriction on maneuver next round. If it fails, the two craft collide, each taking dice of damage equal to 1/10 the smaller spacecraft's hit points (this is equivalent to a collision at about 20 mph).

7. Damage Control Phase

In this phase, engineers can attempt to repair damage to their spacecraft.

An engineer can repair either hull damage, damage to a specific subassembly (a turret or bay), or a single major system (such as the M-drive) that was damaged or knocked out by a roll on the *Major Damage Table.* Spacecraft with multiple engineers can divide them into teams working on the same or different areas. Assigning them is usually the responsibility of the chief engineer.

Disabled hulls or subassemblies can be repaired, but destroyed ones can't – they must be replaced in a shipyard.

To determine the success of repair attempts, roll against the engineer's Mechanic or Engineering skill. Modifiers: -2 if working on a disabled hull or subassembly. If a team is working under a chief engineer's direction, all may add +1 to skill if the chief engineer makes a successful Leadership roll.

If a single engineer is making repairs, a number of hit points of damage are regained equal to the margin of success. For a team, use their average skill but multiply the margin of success by the number of engineers to get hit points repaired.

If repairing a hull or subassembly, reduce its accumulated damage by the hit points repaired. If disabled it begins to function again after being raised above 0 hit points. When repairing a system knocked out by Major Damage rolls, assume that getting it working requires accumulating hit points' worth of repairs equal to 10% of the hull's original hit points.

A critical success doubles the hit points repaired. On a critical failure, roll 1d: On a 1-3, there is an accident; a plasma or hydrogen leak, a fire, or a collapsing weakened structure does 5d damage to an engineer. On a 4-6, there is a setback (someone cut the wrong cable or turned on a circuit breaker before it was ready) and the area being repaired suffers 1d damage multiplied by the number of engineers in that team.

Rushed Repairs: Engineers can rush ahead on repairs, ignoring safety procedures, performing dangerous jury-rigs, and so on. Multiply the number of HPs repaired by 5, but any failure is a critical failure, and on a critical failure roll three times for effects.

Celestial Bodies

While most of space is empty, the valuable parts aren't. Many engagements will take place around planets and other strategic objectives.

Worlds

These are planets and moons whose diameter is 1,000 miles or greater. Typical inhabited world sizes are 10,000 miles or less and so comfortably fit in a single hex (Earth is 8,000 miles across). Worlds should be represented on the map either by drawing a circle or placing an appropriate counter in a hex.

Line of Sight: A world blocks line of sight past it: A spacecraft may use PESA and AESA sensors, laser communications and direct fire (except with meson guns) into but not through a world hex.

Gravity: The six hexes adjacent to a world with a surface gravity of 0.25 G or more are its "gravity hexes." They affect spacecraft passing through them, as described in the *Movement* rules. The world's hex itself is *not* a gravity hex. If the world's surface gravity is over 0.5 G, gravity effects are mandatory. Otherwise, the pilot may decide whether to pass close enough to the world for them to take effect. (If he passes through more than one of a world's gravity hexes, then if one takes effect, all must take effect.)

High Orbit: A spacecraft which moves one hex in the movement phase directly from a gravity hex to an adjacent gravity hex is in orbit. The spacecraft's movement should carry it around the planet without any further acceleration being required.

Low Orbit: A stationary spacecraft in a world's hex is assumed to be in low orbit.

Takeoff: A spacecraft on a world's surface may leave that world by accelerating into an adjacent hex, and on future rounds, leave the planet's gravity hexes or enter orbit.

Landing: A streamlined spacecraft can land on a world by moving onto it at one hex speed; it can also land if it occupies the hex and is at zero speed. Entering a world hex at higher speeds destroys the spacecraft. Attempting a landing also destroys the spacecraft if the world has more than a trace atmosphere and the craft is unstreamlined.

Large Bodies

Large bodies such as stars and gas giants will take up multiple hexes. Represent such bodies as a circle of (diameter/10,000) hexes across. A large body's gravity hexes are represented by a larger circle with a diameter four times the square root of the planet's mass (in Earth masses).

Don't worry about aligning a big planet on the hex grid; it won't fit. Just draw a circle for the given diameter, and if the 1-G gravity well is larger, a second circle for it.

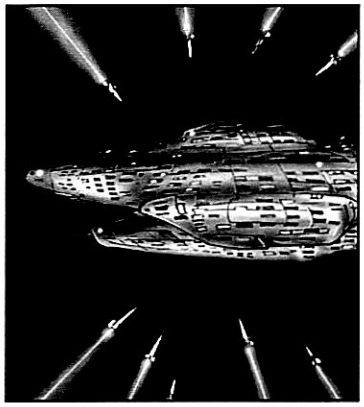
Large bodies will also block line of sight as per worlds. Realistic gravity and orbital mechanics for large bodies are beyond the scope of this system. GMs can apply gravity effects as per the ordinary world rules, except that the gravity zone may be a number of hexes deep, rather than just the six adjacent hexes.

Landing on a gas giant is fatal, but vessels with DR 100+ armor can enter or move through a gas-giant hex if it keeps its velocity below one hex/round. The vessel is assumed to be flying through or hovering in its upper atmosphere.

Moving into a star will destroy any spacecraft.

Small Bodies

This includes asteroids (a few yards to several miles across) and small moons or planets up to 1,000 miles in diameter. In the 10,000-mile-hex scale, such bodies do not affect detection or fire unless a ship is in the hex and deliberately keeping the asteroid between it and another spacecraft.



Ships may freely pass through hexes containing small bodies. Even an asteroid belt is fairly thinly spread: In a dense asteroid belt there would only be one small asteroid every hex.

Miscellaneous Situations

The following rules elaborate on various aspects of space combat.

Anti-Missile Fire

Standard missiles have DR 40 (TL10) or DR 120 (TL12) and can withstand 30 hits each. A single standard laser or particle beam hit is enough to destroy a missile, so feel free not to bother rolling damage if using ordinary turret or bay weapons.

Communications

Radio communications must be declared in the detection phase; otherwise, spacecraft can communicate freely back and forth with radio, laser, and meson communications as described in the *Starship Operations* rules. These give communication range in millions of miles; one million miles = 100 hexes. Note that communications are limited by lightspeed. Light travels 18.6 hexes per second or 22,320 hexes per combat turn.

Friendly ships in communication using datalink programs can share sensor data, giving a bonus to their friend's detection chances.

Standard missiles must remain within communication range to be controlled. In most cases, this is not a problem, but a missile behind a planet (for example) cannot maneuver or attack.

Broadcast communications may be picked up by anyone in range, but the *content* of scrambled transmissions will not be understood unless decoded (see Cryptanalysis skill, p. B245).

Crew Positions and Skill Rolls

Smaller vessels often have the same crewman performing multiple roles. If a crew member is filling multiple positions during a particular space combat round, he will suffer a -2 penalty on all skill rolls for each extra task he is performing.

Actions counted as tasks are: piloting; fire of one weapon or set of linked identical weapons (except sandcasters) at the same target; controlling one missile or a salvo; acting as a sensor operator; damage control; complex communications (GM's option, e.g., coordinating a squadron or tracking a signal); meson screen operation. A ship with more than two crew engaged in the above tasks should also have one captain who does nothing but give orders – if not, the GM can apply an extra -1 penalty to everyone's skill rolls!

Jump

A starship with an operating jump drive and enough fuel may prep for a jump in the Maneuver Phase. The ship may not maneuver while jumping. It will then jump at the start of its next round's maneuver phase. A safe jump (entry or exit) requires a distance from a body of at least hundred diameters. Thus, starships may jump in or out safely from (planetary diameter in miles/100) hexes. See p. 121 for the skill rolls needed to perform a safe and accurate jump. Ships jumping *in* appear during the maneuver phase. They retain whatever vector they had when they went into jump.

Meson Guns and Meson Screens

Meson gun hits ignore the target's damage resistance, unless the target has a meson screen. *Meson screens* must be carefully focused to deflect meson gun fire. Whenever a spacecraft is hit by a meson gun, the screen operator must make an Electronics Operation (Force Field) roll.

A critical success means the screen provides its full DR against the attack. Success by 4 or more means it provides half DR. Success by 0-3 means it provides 10% DR. Failure means it provides no DR. Critical failure means it malfunctions and cannot be used next round. To get it back on line requires a successful Electronics Operation (Force shields) roll, one try per round.

Missile Salvos

Big ships sometimes fire many missiles at a time. It can be convenient to represent these by single counters each representing multiple missiles from a single bay or turret – just record that a given set of missile and vector counter represents *n* number of missiles, and reduce *n* if the missiles take hits.

If a very large salvo of missiles attempts to ram the same spacecraft, GMs may wish to make contests of skills for *groups* of 3, 5, 10, or more missiles rather than rolling individually for each attack.

Likewise, GMs can simplify damage by rolling once per group and multiplying both damage and DR by the number of missiles.



Planetary Defense Fire

TL8+ planets with large populations and/or good starports often have planetary defenses. Ground-based lasers and particle beams cannot penetrate a planetary atmosphere and still carry enough energy to hit high orbital targets, so static planetary defenses generally take one of two forms: ground-based missile launchers, or a number of armed "orbital platforms" (built as ships with no drives), or meson guns buried deep underground. Such "deep meson guns" are immune to most attacks except other meson guns, sabotage, or destruction of their orbital or surface sensors.

GMs can assume that surface starport installations have sensors at least as capable as those of a command bridge (type V-IV starport) or basic bridge (type III or II starport).

Using Sandcasters

In the Direct Fire Phase, a turret's sandcasters can be targeted vs. a single enemy vessel (or a group of vessels in *very* tight formation). A sandcaster adds DR 400 to its ship's armor DR vs. all laser fire originating from the targeted vessel. Multiple sandcasters can combine to protect against laser fire from a single vessel, but each extra 'caster only adds an additional +50 DR. X-ray laser fire halves sandcaster DR just like ordinary armor, so against standard shipboard lasers it's DR 200 + DR 25 per extra sandcaster.

Selective, Pinpoint, and Battery Fire

A gunner can choose to selectively target individual turrets or bay subassemblies. A standard turret has a Size Modifier of +5, a bay has +7 – use these modifiers instead of the spacecraft's Size Modifier when firing. A successful hit means that hit location is not rolled for – instead, that turret or bay is hit.

A gunner using a direct-fire weapon can attempt to use "pinpoint marksmanship" vs. a weak spot (e.g., hatches, weapon tubes, turret rings, etc.) in the target's armor. This is extremely difficult: Roll to hit at -6 *and do not add the Size Modifier to the roll.* DR protects at half normal, cumulative with other armor divisors.

To simplify big-ship battles, GMs can require identical laser-equipped turrets be grouped into fairly even "batteries" of up to 30 lasers each. Each battery fires as one weapon (roll to hit only once). Calculate "adjusted battery skill" just as you would adjusted Gunner skill, except use the average of individual Gunner skills, and find RoF bonus by adding all RoFs together and using the RoF Bonus table (p. 174) to find the new bonus. E.g., if five turrets each with three RoF 1/60 lasers fired as a 15-laser battery, they would be treated as one RoF (15 × 1/60) = RoF 15/60 = RoF 1/4 weapon; while it would only fire once rather than 15 times, the usual +4 RoF bonus would become a +8.

Transponders

Civilian ships are legally required to activate transponders broadcasting their location and identity. Transponders can be unplugged, but naval patrols reserve the right to fire on ships detected that are not operating transponders. (Usual peacetime procedure is to order it to cut its velocity and stand to for boarding, but in troubled regions or in sensitive areas such as around restricted naval depots, patrols may not be that patient.)



It may take weeks to check registry, while origin and destination information are only as accurate as the navigator who entered them.

SPACE WEAPONS TABLE

Weapon	RoF	1/2 D	Max	Acc	Damage
360-MJ Laser	1/60	2	6	32	5d×50 (2)
405-MJ Laser	1/60	3	8	33	5d×100 (2)
Particle Beam Bay	1/60	1	4	30	6d×1,000
Meson Gun Bay	1/60	1	4	30	6d×1,000 (!)
Spinal P-Beam	1/60	5	15	36	7d×3,000
Spinal Meson Gun	1/60	5	15	36	7d×3,000 (!)

Ranges are in 10,000-mile hexes. (2) means armor DR is halved; (!) means armor DR but not meson-screen DR is ignored.

SPACE RANGE TABLE

Hexes	Modifier	Hexes	Modifier
0	-39	11-15	-48
1	-41	16-20	-49
2	-43	21-30	-50
3	-44	31-45	-51
4	-45	46-70	-52
5-7	-46	71-100	-53
8-10	-47	etc.	etc.

SENSOR MODIFIERS

Scan Values Table

Type	—PESA—		—AESA—		—Radscan—	
	TL10	TL12	TL10	TL12	TL10	TL12
Cockpit/System	35	37	39	40	29	31
Basic bridge	37	38	41	42	31	35
Command bridge	39	41	42	43	32	38

Scan Modifiers

Sensor: Add value from *Scan Values Table*, above.

Skill: Add Electronics Operations (Sensors) skill level.

Range: Count the range in hexes from the sensing spacecraft to its target. Look this number up on the *Space Range Table*, above, and subtract the corresponding modifier.

Prior Detection: Object detected on prior round by other sensor type or by ally sharing information through datalink: +4.

AESA only:

- Object's Size Modifier.
- Object has basic stealth: -(TL-4).
- Object has radical stealth: -2 × (TL-4).
- Object in same hex or adjacent to planet or moon: -4.
- Object or sensor within planetary atmosphere (more than Trace): -6.
- AESA used as ladar: -2.

PESA only:

- Object's Size Modifier.
- Object in same hex or adjacent to planet or moon: -2.
- Object silhouetted against a star: -4.
- Object or sensor within planetary atmosphere (more than Trace): -6.
- Object has basic emission cloaking: -(TL-4)/2, round down.*
- Object has radical emission cloaking: -(TL-4).*

* Emission Cloaking doubles (to the same effectiveness as stealth) if the object is in a planetary atmosphere, including a gas giant. In space, emission cloaking is less effective, as the vehicle is always going to be "hotter" than surrounding space.

Radscanner only:

- Object using active sensors: + the Scan value of the active sensor (e.g., AESA) that the object is using (see *Scan Values Table*, above) but *minus* the TL of that active sensor. If the active sensor is used as a ladar, use the Scan value - (TL+2).
- Object is using transponder or broadcasting wideband radio signals: +40. Note – if the object is also using active sensors, use the higher of the two modifiers; don't add them together.

GUNNERY MODIFIERS

Use augmented Gunner skill (the sum of Gunner skill, Acc bonus up to a limit of base Gunner skill, RoF bonus, and targeting program) with these additional modifiers:

Target Size: Add the Size Modifier of the target. (Standard missiles are +0). If using pinpoint marksmanship (p. 172) use a -6 penalty instead of Size Modifier.

Range Modifier: Add the range in hexes from the firing spacecraft to its target, counting the firing hex. The result is linear Range in hexes. Look this up in the "Hexes" column on the *Space Range Table*, above. Read the number to the right ("Modifier" column) to get the range modifier applied to the gunner's skill.

Active Sensors: +2 if target is within sensor range and detected with active sensors.

Point Defense Fire: +10.

Firing beyond ½D range does not reduce Accuracy to 0; as ships are firing over a 20-minute round using fully stabilized beam weapons in the vacuum of space, there is no sudden Acc loss.

Note there is no modifier for target velocity: Over space combat ranges, gross course changes are predictable enough that speed itself isn't a major factor, while relative velocity is factored into engagement times, as ships with high velocities will flash past each other for only a few rounds of firing.

MAJOR DAMAGE TABLE

3 – Fuel tank shattered; half of fuel capacity lost.
4 – 1d passengers injured; 5d damage each, ignore DR.*
5 – J-drive knocked out.
6 – Cargo damaged; a quarter of all cargo carried is lost.
7 – One computer knocked out (standard bridges have three).
8 – 1d crew are injured; 5d damage each, ignore DR.*
9 – Power loss; halve Gs and jump number.
10 – Weapon: one turret, bay or other weapon disabled.
11 – No special effect unless damage caused by particle beam or meson gun; then one non-hardened computer is knocked out.
12 – Fuel tank shattered; half of fuel capacity lost.
13 – 1d passengers injured; 5d damage each, ignore DR.*
14 – M-drive acceleration halved (round down).
15 – Cargo damaged (see above).
16 – Bridge (or cockpit) knocked out.
17 – 1d crew are injured; 5d damage each, ignore DR.*
18 – Power plant knocked out; ship crippled.

* Add an extra 1d casualties *per full 50 people* aboard; e.g., if 50-99 passengers were left, 2d would be hit. The GM chooses or rolls to see who is hit. Rather than roll damage for NPCs, GMs can assume each hit disables or kills. Add +1 per die of damage (or use explosive decompression rules) for anyone not suited up!

GURPS VEHICLES-DESIGNED SPACECRAFT

These rules are designed for use with spacecraft built using the ***GURPS Traveller*** design system. Ships constructed with ***Vehicles*** may have additional systems or design choices – if so, just add the appropriate rules from ***Vehicles.*** Here are a few guidelines on issues not addressed in ***Vehicles:***

Partial or Unstabilized Mounts: If a vessel is given partially stabilized weapons,Acc halves (round down) at ½D range; if unstabilized weapons, Acc goes to zero past ½D range.

Ships Without Vectored Thrust Engines: These can only accelerate (move their vector counter) in the direction they are facing, and may not add a G-bonus to Dodge. They may still change facing at the start of the maneuver phase, before accelerating.

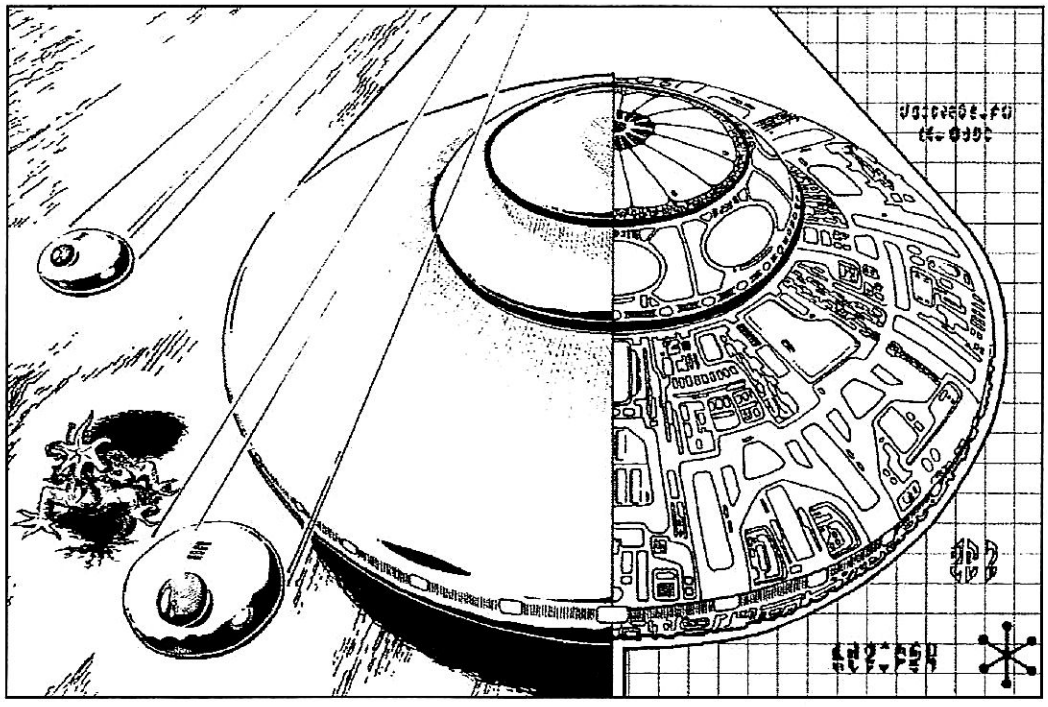
Higher or Lower RoF: In a space-combat round, weapons are assumed to be firing multiple carefully aimed tracking shots over the 20-minute period, and taking time to aim between each shot. All standard turret and bay weapons fire with an effective RoF 1/60 (including time to recharge power cells), giving a bonus of +4. In the 20-minute scale, higher or lower RoF provides a modifier to adjusted skill as follows:

ROF BONUS TABLE

RoF and Bonus	RoF and Bonus	RoF and Bonus
1/600.....+4	1/8 .....+10	8 .....+16
1/300 ..... +5	1/4 .....+11	15 .....+17
1/150.....+6	1/2.....+12	30 .....+18
1/60 .....+7	1 .....+13	and so on . . .
1/30 .....+8	2 .....+14	
1/15 .....+9	4 .....+15	

Values that fall between these numbers use the lower bonus. When calculating RoF for ***GURPS Vehicles*** weapon that use power cells, base it on sustained RoF over a 20-minute period. If a weapon can fire four shots, but then takes a minute to recharge its power cells, its sustained RoF would be 1/15 rather than 4.

Guns: On a 10,000-mile scale, guns, including railguns, will only be able to hit maneuvering targets within a 0-hex range. Against stationary targets (e.g., derelicts, planets), they have unlimited ranges, but suffer normal range modifiers to hit.



Chapter Five
Starport Design

Paradigmatic Starports

Not everyone at a port is interested in the details of its design. For many visitors, what is important is not the price of refined fuel, but the *feel* of the place. Is it ornate or brutally functional? Placid or tense? Clean or grimy? A convenient way to get the ambience across to the players is to use a paradigm – an image already familiar to the players. (This is not necessarily the "best" method of presentation, if there even is such a thing. It's just one that works.)

The Thin Edge Ports

The great image here is the movie *Casablanca.* There's a constant tension, a real sense of danger – possibly a war not very far away. Everyone who was able – some would say, everyone with any sense – has packed up and gone. What's left are those who can't go, due to lack of money, possessing the wrong citizenship, the prospect of making a big semi-honest profit before the end comes, or worse prospects everywhere else. A few might even be trying to do some good.

The Thin Edge port will probably look shabby, though it may once have been elegant. Times being what they are, nobody sees much point in sweeping away the cobwebs or mending the cracked windows. This may even extend to traffic control: "Oh, we've got plenty of empty pads, Kilo Fox Niner. Take your pick. Don't hit anything on your way down, OK?" Conversely, the port personnel may desperately hold on to the highest standards in maintenance and protocol, in order to prop up their fading morale . . .

Good food and drink will be expensive, but "eat, drink, and be merry, for tomorrow we may die" is the philosophy of the day. If gambling is allowed – or even if it isn't – many people will play fast and loose with money they believe will shortly be worthless, as it always is when one is no longer alive to spend it.

Continued on next page . . .

Previous chapters have detailed the many departments of a starport's organization and the many tasks its personnel are required to face. The *economic* and *physical* structure of a starport, from the design stage through construction and subsequent traffic patterns, are equally complex considerations.

General Guidelines

The components of Imperial starports usually are based on standard designs (see below), but a number of factors resist any effort to make the starports themselves truly "uniform." Planetary ecology and politics, the precise service needs of the star system, and available construction resources all conspire to make each port be a unique entity. Most important, an Imperial starport is a point of particular pride for most star systems – its overall design should reflect local aesthetics and will often be a grand synthesis of the best local architecture and Imperial prudence.

Despite the overwhelming logistics of starport construction, the Imperial Starport Authority has become adept at tailoring each starport to the system it serves.

Imperial Standards

The Starport Authority was in the forefront when the Imperium discovered one of the primary difficulties of maintaining an empire spanning thousands of worlds of varying tech levels: compatibility of parts. Market forces can informally standardize high-profile, big-ticket equipment such as military hardware (p. GT109), but the million-and-one inventory items of a starport demand more central planning. Otherwise, air filters made on a TL8 border world bear no resemblance to the air filters made on a TL11 core world.

In response to the need for uniform parts and equipment, "Imperial standards" were created for literally millions of items used by the SPA and other Imperial agencies. These standards define the physical properties of a piece of equipment, sometimes very rigidly (the familiar triangular hull of an Imperial Scout Service *Sulieman*-class scout/courier) and sometimes liberally (the Imperial standard bulldozer may have any weight within a range of several tons). They also define minimal acceptable performance; in some cases (particularly fare such as demolition charges) they will define *maximum* acceptable performance.

The Imperium bundles its standards for thousands of very common items into a data program called the Imperial Data Package. This Complexity 1 programs takes up 10 gigs and costs a government-subsidized $3,000 to those who desire a copy. Most commonly encountered *civilian* Imperial vehicles and heavy equipment can be found there – as well as the literal nuts and bolts of Imperial infrastructure, the aforementioned air filters, standard civilian starship components, and more. Military designs are not included.

While the Imperium never requires use of its standards, most member worlds design their infrastructure to meet them. This improves their ability to sell services to offworld interests, including the Imperium itself, and to receive Imperial aid.

Imperial standards are maintained throughout an SPA starport's construction. Not only does this allow SPA construction personnel from any part of the Imperium to assume instant familiarity with a project, it allows outside contractors and vendors the same advantage from one end of the Imperium to the other. To reflect this in his campaign, a GM might allow player characters with a background related to Imperial

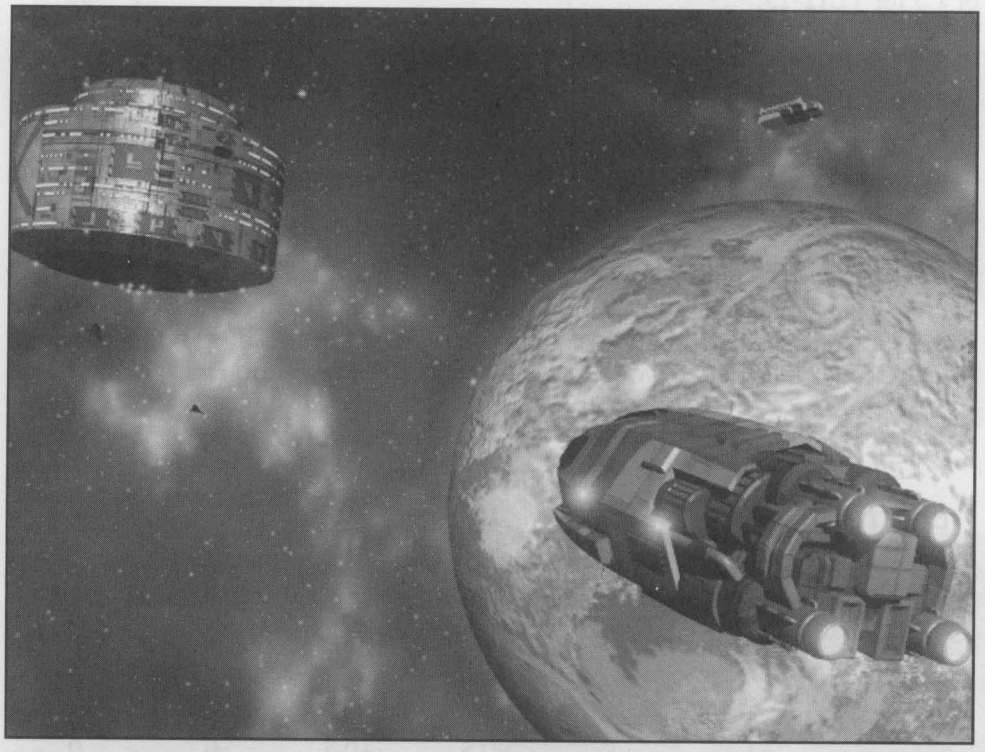
service to make Architecture, Engineer, or Mechanic rolls for "familiarity" with parts of a starport (or other Imperial facility), even if the PC has not previously visited the particular port. While each starport has many unique elements, Imperial standard components will be instantly recognizable to the experienced onlooker.

Cost

While a Class I port may be emplaced for as little as 5 to 10 Imperial megacredits, the price goes up steeply from there. Creating a Class II port usually costs GCr0.5 to GCr1, a Class III GCr1 to GCr2, a Class IV GCr2 to GCr6, and a Class V GCr6 on up. More detailed financial information can be found in the following design process.

Starport Design

A ***GURPS Traveller*** campaign may call for a custom, detailed starport design. Perhaps the building of the port is the focus of the campaign, or the campaign is based at the starport. The following design sequence allows for creating a custom port, and it also expands upon the information presented in Chapter 2.



Design Sequence

Starport design follows a step-by-step process, beginning with the characteristics of the planet it serves:

1. Gather planetary data (p. 58).
2. Determine World Trade Number (p. 58).
3. Calculate port size and estimated trade volume (p. 58).
4. Decide number and type of subports (p. 60).
5. Determine subport capacities (p. 61).
6. Determine starport population and income (p. 65).
7. Determine construction basics (p. 66).
8. Add starport components (p. 70).
9. Proof design vs. budget (p. 86).
10. Allocate personnel (p. 87).

The Thin Edge Ports

[Continued]

Security may be a joke, or the officers may feel a strong sense of duty to hold back the chaos. Even if *they* are not corrupt, there is certainly more corruption than they can control. Anything that can bring a price – valuables, secrets, people – will be for sale.

In the movie of the same name, Casablanca was technically independent (part of Vichy France), but in fact under German control. Something like this can happen at starports on the fringes of a war: The world has declared neutrality to avoid being overrun by one of the belligerents, at the price of having the port "placed at the disposal" of a military force. The "guests" will be carefully watching for signs of sabotage, espionage, or treachery, and the "hosts" may be well aware that their independence will last only as long as the bigger war goes on. The port could also be directly occupied by a hostile force.

The Thin Edge is a prime location for adventures. The characters may be trapped there, trying to get a passage offworld by any means possible. There will be plenty for a smuggler to do: running weapons, food, or medicine, or getting a spy or a political dissident out past the guards and the "guest" fleet. Visitors (PCs or not) may be agents for either side, or covert observers for officially uninvolved powers. If the big war is reaching a turning point, they may be able to help liberate the port.

These kinds of starports are fairly rare in Imperial-held territory. Most such ports are located outside the Imperium, where wars and occupying forces are more common occurrences. Nevertheless, there are a few locales where starports of this sort might flourish.

The most likely candidates are fringe sectors of the Imperium, like the Spinward Marches, Trojan Reach, or even Ley Sector. These regions are not wholly under the control of the Imperium and are thus places where warfare may occur. The Spinward Marches has a history of warfare with the Zhodani Consulate, the Sword Worlds, and the Vargr (not to mention Aslan *ihatei*). Worlds that saw action during the Fifth Frontier War, for example, might well have a Thin Edge port.

Several worlds in Jewell Subsector (Spinward Marches B) played significant roles in the recent war with the Zhodani. Chief among them is Esalin (Spinward Marches 1004), a world the Imperium and the Consulate traded back and forth over the course of two wars. During the wars, Esalin might well be home to a Thin Edge port.

The key to placing a Thin Edge port into an established sector is to determine why it would exist at all. The SPA does not allow its ports to degenerate to such a level without powerful outside factors.

Tortuga Ports

Pirate ports – facilities run by and for the sole benefit of ship-bandits – have not been common, but they have existed.

A Tortuga is likely to have excellent facilities and luxurious amenities. This is a place where people who are normally on the run can relax and enjoy their ill-gotten gains. The walls are likely to be hung with rare art – stuff too well known to fence easily – taken from yachts and passenger liners. The best food anyone has been able to steal will be served, and certainly much strong drink. There may well be strict rules governing violence against fellow Brethren of the Stellar Coast while in port: "Save your arms for the Imperial Customs!" Prices will be high – *very* high.

Within such restrictions, most anything goes here. Loot will be traded, with a percentage being claimed to pay for port operations. There may be an infirmary for injured buccaneers, but the quality of the medical staff may be questionable. The pleasures of the flesh will also be available in quantity, although this is the sort of thing that – no matter how well described by the GM – is never that much fun for the players . . .

A pirate base will survive primarily through secrecy: It will be located in a supposedly uninhabited system, and have identification signs for the legitimate (so to speak) users. Strangers jumping in may be attacked at once, though if there is any chance the intruders might escape, the pirates may simply lie low until they have refueled (or whatever) and gone. There might be a fake "mining camp" or "science station" in the system, both as cover and to allow visitors to be sized up before an attack. Another possibility is for everything except the actual physical structure to be designed with rapid departure in mind. The entire base can pack up and "bug out" very quickly should the need arise.

Even if the authorities locate the base, it will doubtless be well defended. Attackers will have to decide ahead of time what level of casualties is acceptable, and whether their primary goal is to capture or destroy the pirates, or simply to destroy their base of operations.

Piratical adventurers will have obvious use for a Tortuga. More lawfully inclined ones (or actual law enforcers) may be dispatched to locate the base. This dangerous undercover task will be made even more chancy if they also have to act from within to disable its defenses when the attack from space comes.

Continued on next page . . .

Step 1 – Gather Planetary Data

Information on the starport's host planet will be needed. In particular, note the starport class, tech level, and control rating of the planet that the starport serves, and whether it is on an Xboat route or a stellar main (a connected series of systems only one parsec apart; see p. GT48).

Example: *Throughout this section, we will use Mertactor (1537 Spinward Marches; see p. T:BC77) as our example. Mertactor has a starport class of IV, a TL of 9, and a CR of 1. It is on an Xboat route and a stellar main.*

Step 2 – Determine World Trade Number

In order to determine the amount of traffic that the planet receives each year, calculate the planet's unmodified world trade number, introduced in pp. T:FT11-12. This involves no more than adding two modifiers:

Unmodified World Trade Number

TL Modifier: This is -0.5 for TL0-2, 0 for TL3-5, 0.5 for TL6-8, 1 for TL9-11, or 1.5 for TL12-13.

Population Modifier: This is the world's Population Rating (see p. S166) divided by 2. (The Population Rating is simply the number of digits in the world's population minus 1. That is, 337 people would be PR 2, 5,712,322 people would be PR 6, etc.)

Example: *Mertactor is TL9 (for a TL modifier of 1) with a population of 60 million (for a PR of 7, divided by 2 to reach a population modifier of 3.5). Its unmodified world trade number is 1+3.5, or 4.5.*

World Trade Number

The planetary data already should indicate the class of the port. This modifies the world's interstellar trade, of course. Apply the appropriate modifier from the following table to the unmodified world trade number to determine world trade number.

PORT MODIFIER TABLE

	Starport Class					
UWTN	V	IV	III	II	I	0
7+	0	-1	-1.5	-2	-2.5	-5
6-6.5	0	-0.5	-1	-1.5	-2	-4.5
5-5.5	0	0	-0.5	-1	-1.5	-4
4-4.5	+0.5	0	0	-0.5	-1	-3.5
3-3.5	+0.5	+0.5	0	0	-0.5	-3
2-2.5	+1	+0.5	+0.5	0	0	-2.5
1-1.5	+1	+1	+0.5	+0.5	0	0
<1	+1.5	+1	+1	+0.5	+0.5	0

Example: *Comparing Mertactor's UWTN of 4.5 with its Class IV starport results in a port modifier of 0. Mertactor's WTN is 4.5.*

Step 3 – Calculate Port Size and Estimated Trade Volume

A port's size for *system traffic* (imports, exports, and passengers that are beginning or ending their journey in the port's star system) is based on the world trade number. Two modifiers affect this:

Distance: If the nearest star system is 1 parsec away, add 1.5. If it's two parsecs away, add 1.

Allegiance: Worlds that are not Imperial or client states subtract 0.5.

Round fractions up.

Example: *Mertactor is an Imperial world whose closest neighbors lie one parsec away. It adds 1.5 to its world trade number of 4.5 for a total of 6.*

Ports on established trade routes have a minimum size, because regardless of the local economy, a substantial volume of traffic will be flowing through the port (transshipping) to other destinations. This is called *transient traffic*.

GMs can establish their own trade routes (see p. T:FT18). Those who do not may simply consider jump-1 mains to be the major trade routes in their campaigns.

Ports on an Xboat route (or main trade route) have a minimum size of 6. Ports on a feeder trade route have a minimum size of 5. Ports on a jump-1 main or minor trade route have a minimum size of 4.

Example: *Mertactor is on an Xboat route, so has a minimum port size of 6. This is the same as its calculated port size, so no modification takes place.*

The overall port size number can be used as a shorthand designation for how large and busy the port is. Just append the port size number to the starport classification, for example: P/V-8, P/III-4, P/I-0.

Calculate Estimated Trade Volume

This determines the amount of trade a world enjoys from its port size number. These figures include both imports and exports.

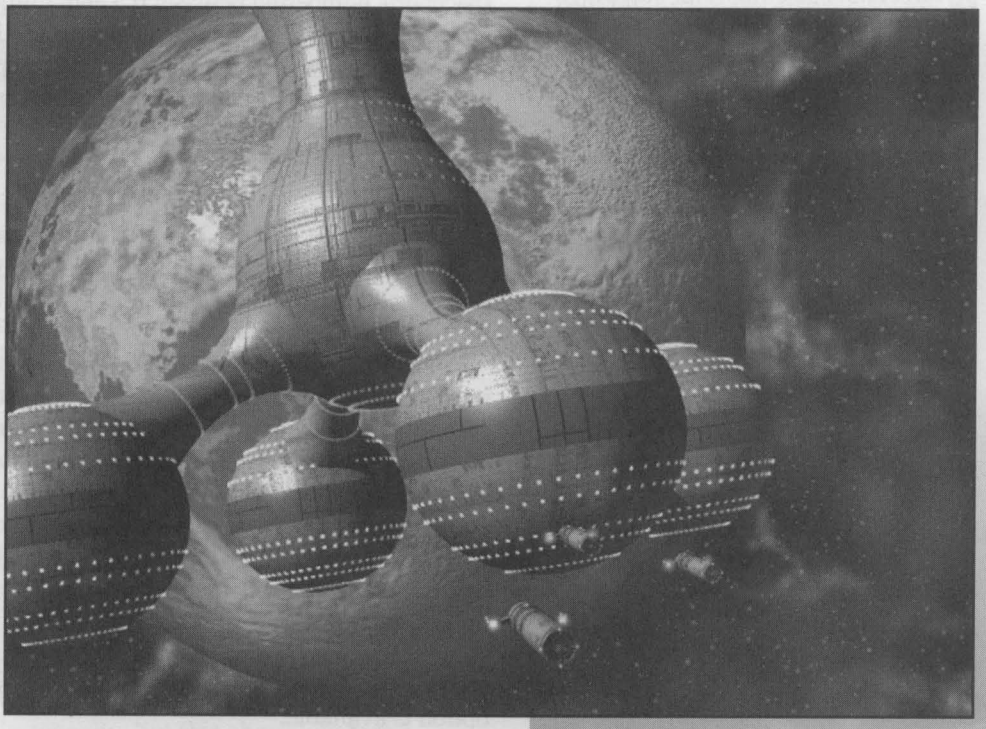
ESTIMATED TRADE VOLUME

Port Size	Dtons/Yr	Passengers/Yr	Revenues/Yr	Real Example
0	<10	<1	<KCr2.5	
1	10-100	1-5	KCr2.5-25	
2	100-1K	5-50	KCr25-250	
3	1-10K	50-500	MCr0.25-2.5	
4	10-100K	500-5K	MCr2.5-25	
5	100K-1M	5-50K	MCr25-250	Salisbury, MD
6	1-10M	50-500K	GCr0.25-2.5	Wellington, NZ
7	10-100M	500K-5M	GCr2.5-25	Houston, TX
8	100M-1G	5-50M	GCr25-250	
9	1-10G	50-500M	TCr0.25-2.5	

Average traffic for a port will be three times the minimum for that port size. For instance, the average port of size 5 will handle 15,000 passengers per year.

This value combines system and transient traffic. GMs should compare the port's "natural" size and trade-route minimum, then rule how much traffic falls into each category.

Certain characteristics will skew the number of system passengers per year toward the high end of the scale for a port's size number. All else being equal, a world with the Rich classification (see p. T:FT13) or a subsector capital will see three times as much system traffic as a comparable world. These are tourists and people doing business with the Imperial government. A sector capital usually approaches the upper end of passenger traffic for its port size.



Tortuga Ports

[Continued]

No Imperial world will be home to a Tortuga port. The Imperium looks on piracy and privateering as major offenses. Thus, most Tortuga ports will be located *outside* Imperial space, although many will be found just beyond its borders.

In the Spinward Marches, the Federation of Arden is notorious for providing safe haven to pirates. Two worlds in particular, Tremous Dex (Spinward Marches 1311) and Quare (Spinward Marches 0915) are believed by the Imperial Navy to contain significant Tortuga ports.

Trexalon (Spinward Marches 1339) is another notoriously anti-Imperial world, with a history of providing a safe haven for the Empire's enemies. Given the wild and untamed nature of District 268, Trexalon is in a unique position to use pirates to increase its own power in the subsector.

The Republic of Garoo (Spinward Marches 0130) may also be a supporter of piracy in the Marches. As recently as 1119, the Republic indicated its willingness to sanction privateering against the Darrian Confederation. While the Imperium has joined the Darrians in condemning this policy, it has done nothing to stop it. Imperial diplomats hope that calmer heads will prevail in the end. Thus far, there have been relatively few incidents of Garoo-sponsored piracy, but this could change in the future.

Ports Royal

For every pirate port, there are many more that do legitimate business, but ask no questions about why a ship needed repairs for battle damage, or where the large cash payments came from. The legitimate trader might not notice anything out of the ordinary other than inflated prices (though this might require a serious effort of not looking), but the entire operating hierarchy – administration, brokers, service, and of course security – is to some degree corrupt, kept in line by payoffs or fear of reprisals.

A Port Royal will likely be rich and fancy; plenty of money is coming in, much of which can't be shown on the official books, and as with Tortuga, the "special" customers will like living well in a place where they can feel fairly safe.

Ports Royal are similar to Tortuga ports, but there are enough differences to warrant discussion. Unlike Tortugas, Ports Royal do not *directly* condone the actions of pirates; they simply "look the other way." Naturally, the Imperium sees little distinction between the two positions. Even so, there are plenty of independent worlds (and a few client states!) on the fringes of Imperial space that indirectly support piracy.

Tarsus (Spinward Marches 1138) is a case in point. A client state of the Third Imperium, Tarsus officially condemns piracy, but its government is too caught up in internal affairs to do much good defeating piracy – even were it inclined to do so.

The same situation prevails among many of the Border Worlds. As clients of the Imperium, they cannot give comfort to privateers against Imperial shipping. However, their internal disorganization and lack of integration into the Imperial mainstream make it inevitable that they do.

The point to keep in mind is that almost any non-Imperial world can be a Port Royal. All that is really needed is a small population, a low tech level, or governmental indifference. Any one of these elements will allow wily pirates a place to fence stolen goods, rest, and repair their ships.

Grand Central Ports

Even the largest passenger ports don't actually "bustle" in the way that, say, a large airport does. Star passengers do not fly multiple "hops" in a day, sprinting between gates to make connections. Multiple-jump trips on a series of ships certainly take place, but the layovers are typically at least a day, if not several days.

The part of this paradigm that does work is the sense of crossroads: People from everywhere, going everywhere, pass through here with a limited time to meet, interact, deal, fall in love, come to blows . . .

Continued on next page . . .

Example: Mertactor's port would be size 6 even without its trade-route minimum of size 6, so the GM rules that it handles enough traffic to qualify as size 6 in each of the system and transient categories. He decides it handles 6 million displacement tons of freight per year, split evenly between system and transient goods. He also decides that, since Mertactor is a subsector capital, it handles 400,000 system passengers per year and 50,000 transient passengers per year.

Compatibility with *Far Trader*

For those who own ***GURPS Traveller: Far Trader*** and want more exact figures, use the following method to determine world trade:

Calculate the effective BTN separately for both passengers and freight for each world with which the planet trades. Consult the tables on p. T:FT16 for freight and p. T:FT17 for passengers, and determine the annual flow of each. Total this over all trading partners. This can be very tedious.

An alternate method is to find the largest BTN for passengers and freight (these may be different worlds) and add 0.5 to each to get an effective total BTN for each category. Consult the tables in this book using these numbers.

Starport Construction

GM's not requiring a detailed description of the starport and its facilities can stop here. The following steps provide more detailed information about starport facilities and traffic flow. This information will be needed later in this chapter to build a starport.

Step 4 – Decide Number and Type of Subports

The first step in building a starport is determining exactly how many ports that really is. Most starports consist of one highport and one downport. Some have several downports, to handle system cargo bound for far-flung destinations or to provide individual service to nations on balkanized worlds. A rare few – usually Class V ports with immense traffic patterns – have more than one highport.

All highports and at least one downport are covered by Imperial extrality; they will handle all transient traffic. A world with a starport often will possess several local spaceports, as described on pp. 13-14. These are almost always downports. Most worlds have spaceports numbering between 0.5 and 2 times the starport's class. For instance, a world hosting a Class III starport normally would have anywhere from one to six spaceports. High-tech, rich worlds may boast a few highports among their spaceports.

The GM should determine the number and quality of these installations, based on the following guidelines:

Highports

Almost all Class IV and V starports have an orbital facility. Most Class III starports at TL8 and above will have a highport. The highport serves primarily bulk, container, and LASH cargo, as well as transient passenger traffic. Lighter and shuttle service connects this port with the surface.

Unstreamlined ships carry approximately 60% of all interstellar shipping. Most traffic (by volume) consists of bulk freighters stopping to refuel en route to another system. The downport is probably more important to player characters, but the SPA considers the highport to be where the serious work of the starport is accomplished.

The orbital element of a starport tends to occupy a synchronous orbit above the equator at the longitude of the main downport. (For satellites of gas giants, a low orbit or Trojan point may be a better option.) Where a highport exists, it will play a major role in traffic control; its position usually allows it to maintain superior contact and line of sight with all traffic. Highports also provide facilities for moving cargo and passengers from larger vessels. All unstreamlined vessels must call at the highport, and most captains of larger streamlined ships prefer using the highport when the option is available.

A typical highport features docking bays, construction and repair facilities, refueling stations, accommodations for travelers not wishing to make the visit to the planet's surface, and extensive short-term cargo stowage for those periods when interstellar and ground-to-orbit shipping capacity don't match up well. Some highports also will have extensive shipyard facilities, but this is not always the case. Many highports will possess construction facilities sufficient only for routine jobs.

The size of a highport will vary greatly from world to world. The volume of traffic and the world's placement on interstellar trade routes will play a significant role in determining this. Worlds with naval or scout bases will tend to have larger and more extensive orbital facilities than those that do not.

Though there is rarely any need to construct more than one highport in a system, a handful of worlds utilize more than one highport. When it does occur, it is usually for the same reasons that there is more than one downport: balkanization or a large flow of traffic. In a similar vein, worlds with an extensive military presence might possess more than one highport, as the navy or scouts usually do not wish to share facilities (other than shipyards) with civilian and commercial vessels.

Worlds without highports serve unstreamlined ships with a combination of shuttles, lighters, and oilers (liquid-hydrogen tankers).

Downports

A surface downport is the most basic type of starport; all Class 1 starports are of this type, as are most starports on planets with non-hostile atmospheres. Downports handle some containers, but mostly breakbulk, lighter/shuttle, and passenger traffic. Worlds served by the SPA always possess at least one downport.

A downport usually consists of a very large parcel of land with several installations. These include (but are not limited to) a cargo-handling facility, berths, hangars, a service facility, and at least one control tower.

Subsurface Downports

These are facilities set into or beneath the surface of the planet. This is common on asteroids, vacuum and hostile planets, and planets with extreme temperatures. Underwater starports on water worlds also fall into this category.

Example: *Mertactor has a breathable (if hot) atmosphere, four continents, and the TL/starport combination to support an extensive orbital facility. We decide on one Imperial surface downport, one Imperial highport, and four local downports.*

Most starports above Class I possess both ground and orbital elements. Both elements are assumed to exist at a given starport unless otherwise noted.

Step 5 – Determine Subport Capacities

Subport capacities in cargo and passengers are based on traffic *per week*. Divide the figures determined in Step 3 for annual freight and passengers (both transient and system) by 50 to determine rough weekly capacity.

Example: *Mertactor requires the weekly capacity to handle 60,000 displacement tons each of transient and system freight, 8,000 system passengers, and 1,000 transient passengers.*

Divide Traffic by Type and Destination

Arrange cargo by handling category and destination.

All transient freight usually will be handled at the highport. (Since it's harder to expand capacity at a highport than a downport, the GM may rule that some percentage of transient freight traffic is handled on the surface, reflecting a local economy that has outstripped its highport's capacity, but this should be rare.)

Grand Central Ports

[Continued]

This paradigm is more common than the others, but still requires very specific conditions to exist. In general, a starport qualifies as a Grand Central port if it is located at the juncture of two or more major routes. A glance at the Xboat routes through the sector will indicate whether this condition exists.

Worlds like Jewell (Spinward Marches 1106) and Regina (Spinward Marches 1910) are excellent examples of this principle in action. Of course, simply because a world is at an Xboat hub does not necessarily qualify it as a Grand Central port. A GM should use common sense and a little forethought before assuming a world is a major site for starship traffic. Worlds with an Amber or Red zone classification, for instance, will rarely be traffic hubs.

Another consideration to bear in mind is that Grand Central ports tend to be Class IV or V starports. Exceptions do exist, but GMs should take into account the needs of a Grand Central port: hotels, shops, and other diversions to keep travelers occupied while they await their next starflight. These sorts of amenities aren't as readily available at Class III and lower ports.

Ghost Ports

Some ports are no longer in service. The world may be depopulated, due to war, plague, or economic collapse. The SPA may have decided to build a new port in a different area. A few ghost starports are located on worlds that have no record of occupation; these are archeological mysteries, and there are not enough archeologists to explore them all. Most ghost ports are spooky, empty, windblown places – acres of cracked concrete and rusting buildings. Some become smuggler's coves; others collect squatter populations, people who have rejected (or were rejected by) the other locals. Once in awhile a growing world will decide to redevelop the Old Landing as an industrial or housing complex.

After many centuries, it is unlikely that any "treasure," or even anything salvageable, remains at a ghost port. The odds rarely stop treasure hunters.

Ghost ports can be found almost anywhere. There is a greater likelihood of finding one on a well-established and populous world than there is on a new colony. Most likely the SPA has abandoned oversight of the port, so the locals have legal jurisdiction.

The manner in which Class I ports are created contributes to the existence of Ghost Town ports – the site rarely is chosen with much thought toward expansion needs in the far future.

Exchange Rates

Some Imperial member worlds maintain their own currency. Purchasing goods at the Imperial starport requires Imperial credits; purchasing them outside the XT line requires local credits. (Startown merchants, particularly the shady variety, generally accept both.)

The local currency may go by a name other than credits; this doesn't matter. What does matter is its purchasing power, which is determined by the local tech level (see below).

The following figures are averages; they assume that the average TL12 world maintains the same ratio of currency to population as the Imperium maintains in extraplanetary commerce. The GM should feel free to adjust the exchange rates on any particular world to suit local economic factors (i.e., his own needs . . .). Theoretically, a TL12 world's currency could be valued at a *premium* compared to Imperial currency, but the odds of this happening outside a period of Imperial upheaval are slight.

The bottom-line impact of these exchange rates is that, on worlds of less than TL12, Starport Authority employees enjoy a purchasing power above their salary level. Since most of them will be living, eating, and entertaining themselves outside the XT line, they will enjoy the necessity of converting Imperial-credit salaries to local credits.

This also benefits the SPA, as it hires local labor to build or improve its starports, but other factors reduce the exchange-rate benefit in this case. See p. 67.

Starport employees who live within the XT line will not benefit from the local exchange rate, nor will the SPA on construction projects that it handles with its own personnel and equipment.

Exchange Rate Table

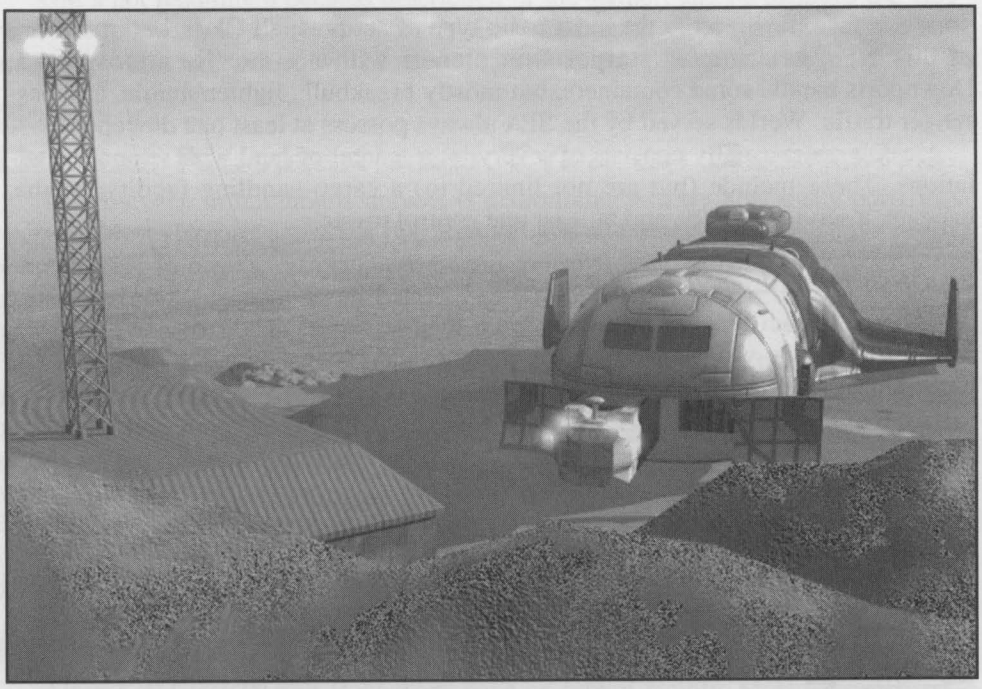
TL	Imperial Credits to Local Credits	Local Credits to Imperial Credits
12	1.0	1.0
11	2.0	0.50
10	3.2	0.31
9	5.0	0.20
8	8.0	0.12
7	13.0	0.075
6	20.0	0.05
5	33.0	0.03
4	50.0	0.02
3	100.0	0.01
2	145.0	0.007
1	200.0	0.005
0	330.0	0.003

Among system freight, bulk and containerized goods are usually transported by unstreamlined starships, routinely handled at the highport. Breakbulk and roll on/roll off goods will generally move directly to the downports. Of all the cargo that the typical system sees, 50% will be bulk, 30% breakbulk, 10% containerized, and 10% roll on/roll off. This means that on average 60% of system freight will be offloaded or onloaded at the highport and 40% at downports.

System freight handled at the highport becomes *transfer traffic*, requiring lighters to transport if from world surface to orbit or vice versa. It counts toward both highport and downport handling needs.

If there is only one port (which will be a downport), all traffic necessarily flows through it. Transfer-traffic needs will continue to exist, to service unstreamlined ships in orbit. Adding fuel resupply needs and the inconvenience of not being able to stage cargo at the highport, many more small crafts and lighters will be needed to perform this service.

Spaceports handle an average 13% of system traffic, but this percentage varies widely. In a system with no local spaceports, the SPA downport will handle all system traffic, of course, while in a system with 10 spaceports, the Imperial downport might handle only 30% of system freight, with 70% handled at the spaceports. Whatever the spaceports' percentage of traffic might be, it need not be divided equally among them, and usually isn't.



Example: *The GM rules that Mertactor's highport can handle all 60,000 displacement tons of transient freight each week. The highport must also handle 30,000 dtons of bulk and 6,000 dtons of containerized system freight prior to transfer, for a total weekly capacity of 96,000 dtons. The downports must handle 60,000 dtons of system traffic. We decide that 40,000 dtons pass through the starport and the remainder through the local spaceports. For simplicity, the GM rules that 5,000 dtons each pass through the four local spaceports.*

Among passengers, the highport will handle all transient traffic, but an average 10% will have a layover lengthy enough to take in the local sights, requiring that the main downport also process them. This counts as 20% of transient traffic, since it's always a round trip. The main downport must process all system passengers, and 90% will transfer to the highport in the process as well (to board large passenger vessels). Most local spaceports don't accommodate passenger traffic, other than perhaps a few local government officials.

Example: *Mertactor's highport sees 1,000 transient and 7,200 system passengers per week, for a total of 8,200 passengers. The downport sees 8,000 system and 200 transient passengers per week, for a (coincidentally identical) total of 8,200.*

Determine Tonnage of Starships Served

The average starport serves 1.5 displacement tons of starship per displacement ton of cargo each week (keeping in mind that most ships contribute to both import and export values on each visit), and 5 dtons per passenger (keeping in mind that for many purposes of starport services, ships' crews count as passengers, and once again each ship counts as bringing in one complement of passengers and leaving with another).

These figures do *not* count transfer traffic. Unless the GM has altered the standard arrangements, the highport handles the starships transporting all transient freight and passengers, 60% of system freight, and 90% of system passengers. The SPA downport handles 27% of starships carrying system freight and 10% of system passengers. The local spaceports divide up the starships carrying 13% of system freight.

Example: *Mertactor's starport serves 180,000 displacement tons of cargo capacity and 45,000 dtons of passenger capacity each week, for a total of 225,000 dtons of commercial starship traffic. Of this, the highport handles 185,000 dtons, the downport 28,300 dtons, and each of the four local starports 2,925 dtons.*

Determine Private Capacity

At this point, the GM should make a general ruling about how much cargo is handled by full-time private interests leasing starport space. While Imperial starports *house* all the cargo passing through a system, SPA personnel *handle* on average only 75% of the goods – the remainder is handled by employees of shipping companies at leased berth and warehouse space. This can vary from as little as 0% (at starports with no full-time tenants that employ their own freight handlers) to 90% (for starports serving the homeworld of a megacorporation).

Passengers also can be privately handled (for instance, by a megacorporation that maintains its own terminal for visiting and departing employees), but this is seen much less frequently.

Example: *The GM rules that private businesses hold full-time leases on a good percentage of Mertactor starport's warehouse capacity, but none handle their own freight. All employ SPA resources for the task. All passenger terminal and transport functions are also handled by the Imperial staff.*

Determine Shuttle and Lighter Requirements

People and cargo must move between highports and groundports on a regular basis. (This includes port employees – on high-tech worlds it is generally more efficient to house highport employees on the planet's surface and shuttle them to and from work every day – but these shuttle needs will be calculated later in this process.)

Most starports maintain regular shuttle flights to ferry people and cargo from ground to orbit or back again. SPA shuttle service tends to be quick and efficient.

A few worlds with immense traffic patterns, fragile ecologies, or poor industrial resources for supporting gravitic technology seek alternative methods. These sometimes employ orbital elevators (known colloquially as "beanstalks") built of ultratech materials. These are essentially skyscrapers that extend into orbit (though technically satellites that dangle to earth) and can handle a constant stream of passengers and cargo. Usually the highport is the "penthouse" of the orbital elevator with the primary downport as the "lobby." Another method is to shoot durable cargo (*not* passengers or anything that can't withstand *extreme* acceleration) into orbit using massive electromag guns with barrels hundreds of miles long. This is substantially cheaper than shuttle service though *far* less environmentally friendly.

Construction Times

Building a starport is a massive undertaking, often spread out over centuries. These design rules assume that the port is already complete; any "construction" is done by the GM! It may happen, however, that a starport must be built or extensively upgraded during the course of a campaign. Creation of Class I starports has been covered on p. 8. For other types of construction, use the following:

Total the cost of all new construction or upgrades. Convert Cr2,000 from local credits to Imperial credits (using the special SPA formula on p. 67, not the sidebar on p. 62) to get "credits per man-day." This is not actually a currency conversion, but a measure of relative productivity at different TLs. Divide the total cost by that amount to determine the number of man-days required to complete construction. Time to complete is this figure divided by the number of skilled workers available. For most worlds, skilled labor is at most 0.1% of population; new colonies may have up to 10 times more. The maximum number that can work on any project is a function of size: no more than 1 worker per dton (highport) or 9,600 workers per square mile (downport).

Additional workers can be brought in from outsystem. The maximum number that can be supported is 10% of the local population or 100,000 people, whichever is greater. Support personnel (cooks, clerks, supply, medics, etc.) equal to 1/2 the worker population in excess of 10% of the local population must be added. Each person, worker or support, in excess of 10% of the population requires 0.2 dton of imported supplies per month, at Cr10,000 per dton. Housing must also be supplied. Tents cost Cr100 per person and last for one year, after which they are worn out and discarded; they are erected at the same rate as buildings (Cr2,000 × exchange rate per man-day). Tentage for 7,500 people takes up 1 dton as cargo, weighs 8 stons, and costs MCr0.75; erected, it covers one-third of a square mile. Temporary housing for 100 (including services) is 200 dtons, 120 stons, and MCr0.3, and takes up a 120-yard by 120-yard square when erected.

Example: *The Mertactor starports collectively cost 17 billion credits. One laborer can build Cr2,000 × 0.2 = Cr400 per day at TL9. If Mertactor were to build similar facilities from scratch, the project would require 42.5 million man-days. Mertactor's population of 60 million can supply 60,000 skilled workers, who could complete the project in 708 days (just under two years). If desired, 40,000 additional workers could be brought in, along with 20,000 support personnel. Time to completion drops to 425 days (14 months), at a cost of MCr18 in housing and MCr120 per month in supplies.*

Other Design Considerations

The design information in this chapter is far from exhaustive. Local conditions always take precedence over any standard procedures mentioned therein. While SPA prefers to set protocols and employ standard designs, there are occasions when such things are insufficient. In these instances, innovation is required. A few of the more common considerations are discussed below.

Hostile Environments

With more than 11,000 worlds in Imperial possession, it's a certainty that not all of them are the most pleasant of places. Indeed, in some subsectors, a great many worlds possess environments that are not friendly to Human (or other sophont) life. At the same time, many of these hostile worlds possess something worth exploiting. And if there is something worth exploiting *on* the world, there's a good bet that it will also be worth exporting *off* the world.

This is where starports come in. Without a starport, it can be very difficult to arrange for the transport of anything off a planet's surface. It can be done, of course, but the cost is usually quite prohibitive.

At the same time, building a starport on a world with a hostile environment can be a risky business. Many of the verities taken for granted on more hospitable worlds do not hold true. For instance, the safe storage of HAZMATs and fuels is even more of a priority on a world with a dense or corrosive atmosphere. Likewise, traffic control and sensor nets need to be especially good on worlds where local conditions reduce visibility. Other examples are easy to imagine.

The point is that starports on environmentally hostile worlds are often designed differently than those elsewhere. They have most of the components described previously, but many of them will be altered or modified in a fashion to allow them to withstand local conditions. These alterations can (and frequently do) increase the cost of a starport. For this reason, hostile worlds often do not have the best starports that local technology would allow.

Of course, when a hostile world *does* possess a Class IV or V starport, there is a good reason. Even SPA's zeal only goes so far. Building an expensive and heavily modified port on a planet with an insidious environment will only be done if there is some need. Determining exactly what that need is can be an aid to a beleaguered GM looking for a way to spice up his campaign.

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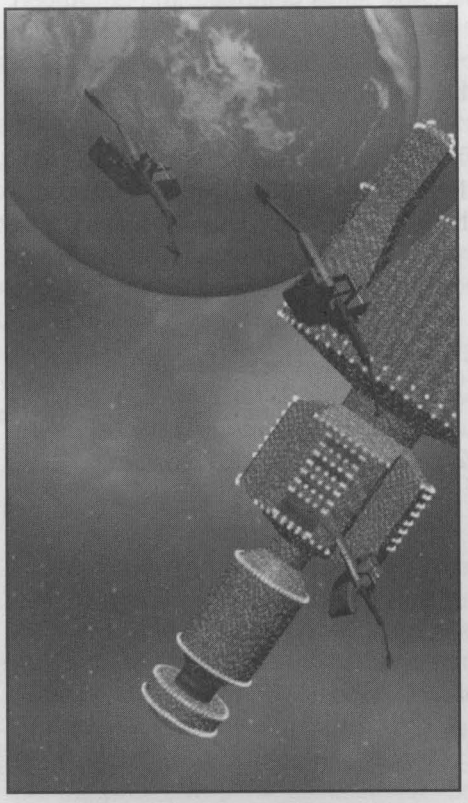
As mentioned previously, 60% of system freight, 90% of system passengers, and 20% of transient passengers will require transfer from highport to downport(s) or vice versa. Unless an alternate technology is used, the starport must possess lighters and shuttles to provide this service, minus whatever percentage of system freight and passengers are privately handled. On average, each displacement ton of cargo hold or passenger couch can serve 30 dtons of transfer cargo or 30 transfer passengers each week, assuming nonstop service and routine usage of capacity.



The GM should select appropriate small craft and non-starships from pp. GT139-143 and p. T:FT137 to fill these needs. In general, any one craft shouldn't provide more than half the capacity, and several crafts providing a small fraction of capacity should be used for convenience of service.

In a system without a highport, the same amount of traffic will require transfer from orbit, but the downport must provide *triple* the amount of small crafts and non-starships to meet this need; i.e., one cargo hold or passenger couch per 10 dtons of cargo or 10 passengers. In addition, fuel tankage equivalent to 1% of the starship displacement tons that would normally be served by a highport must be provided in oilers (see p. T:FT137) or similar shuttles.

Crew requirements for nonstop service will be five times the listed number.

Example: *Mertactor's starport must be able to transfer 36,000 displacement tons of cargo and 7,400 passengers each week. This requires 1,200 dtons of cargo hold and 247 passenger couches. The GM determines that a single 800-dton general purpose lighter (p. T:FT137) provides 548.5 dtons of cargo capacity, a single 30-dton ship's boat (p. GT140) provides 96 passenger couches and 8.5 dtons cargo space, two 50-dton modular cutters with passenger modules (p. GT142) provide 96 passenger couches and 39 dtons of cargo space, 25 50-dton modular cutters with cargo modules (p. T:FT137) provide 600 dtons cargo space, and two 10-dton launches (p. GT139) provide 72 passenger couches and 6 dtons cargo space. This totals 1,202 dtons of cargo capacity and 264 passenger couches. The 31 vessels require a staff of 485 for nonstop service. They cost MCr248.8.*

If Mertactor didn't have a highport, we would have had to provide 3,600 dtons of cargo hold and 741 passenger couches, plus 1,850 dtons of fuel tankage!

LASH Requirements

In LASH operations (as described on p. T:FT65), freighters carry lighters with them, unleashing the inbound non-starships on arrival and picking up the outbound replacements after transiting to their outbound jump point. The freighters avoid the delay required by visiting the starport itself, but a given lighter doesn't tend to return to any given system.

For this reason, LASH lighters almost always are private property, usually owned by the merchant line that set up the LASH operation. The SPA does count LASH cargo among a starport's tonnage totals, and likewise a small amount of LASH operations is assumed in the above starport small-craft needs. In a system with extensive LASH operations, the GM should reduce the starport's own small-craft needs to reflect the alternate means of transfer.

In general, combining LASH operations, other private handling, and business (such as conferences) not reflected in passenger and cargo tallies, the average SPA starport will be visited by two to four displacement tons of private small craft and non-starship for every dton of small craft and non-starship that it employs itself.

Step 6 – Determine Port Income and Population

A starport's rough annual income can be derived from its traffic. Multiply freight tonnage or passenger count by the given figure in each of the following categories:

System freight handled at Imperial downport	Cr170
System freight handled at local spaceport	Cr160
System freight handled privately	Cr150
Transient freight	Cr140
System passenger	Cr500
System passenger handled privately	Cr450
Transient passenger	Cr460

These figures only reflect Imperial revenue. They do not include local tariffs (nor Imperial tariffs, since none will exist unless the GM rules they do).

Example: *Mertactor's starport has no private handling of cargo or passengers, and the local starports handle 1 million displacement tons of the total 3 million dtons of annual system freight. Multiplying (Cr140×3 million) for transient freight, (Cr170×2 million) for system freight handled by the Imperial starport, (Cr160×1 million) for system freight handled by local downports, (Cr500×400,000) for system passengers and (Cr460×50,000) for transient passengers produces a grand total of 1,143 million credits or MCr1,143 in annual revenue.*

Divide the annual revenue by Cr200,000 (or MCr0.2) to estimate the number of Imperial employees at the port. (The average SPA employee costs about Cr25,000 annually in salary, benefits, transit costs, training, etc. Given the ultra-tech efficiencies enjoyed by SPA facilities, personnel costs represent a much smaller fraction of total expenses than they would for the average 21st century business.)

Example: *Mertactor's port employs MCr1,143/MCr0.2, or 5,715 people.*

Later on, when assigning personnel from the above pool to specific port functions, the GM should remember that most port services operate 24 hours a day, in three shifts. Multiply any personnel requirements by five to figure total workers required taking into account weekends, vacations, and the like. Administration offices often only stay open during the local equivalent of the "9 to 5" shift; in slack periods shipyards do the same. Small ports may have only part-time personnel.

Each worker will support a single dependent *on average* (many will be single and live alone, while others will be two SPA-employed parents supporting several children). Circumstances at the port will determine how many workers and family members are housed on the port itself, and how many beyond the XT line in the surrounding city. If on the port proper, housing will normally be located at the downport. Workers commute to the highport by shuttle.

It sometimes happens that the calculated port population exceeds that of the mainworld itself. In this case, the port employees are mostly transients, brought to the world specifically to work in the port. These guest workers will normally return home when their employment is done. Alternately, robots may do most of the manual labor at such a port; the "personnel" costs then go to maintenance and replacement of these devices.

Example: *The starport "community" on Mertactor numbers about 11,430 people. The GM rules that the world is politically very stable (since it belongs to an Imperial Navy admiral), and therefore the port director freely integrates SPA personnel with the local populace. All are housed outside the XT line.*

Other Design Considerations

[Continued]

Opposed Worlds

As mentioned previously, the SPA must occasionally operate starports on worlds that are politically opposed to the goals of the Third Imperium. Building a starport on such worlds can occasionally be another source of difficulty for SPA. Unlike environmentally hostile worlds, Opposed worlds present a subtler set of demands on starport architects and engineers. Starports on Opposed worlds tend to be Hardlined, having a fence or other barrier along the perimeter of the XT line. The height, width, and strength of these walls will vary according to the level of opposition encountered. Not all Opposed worlds are willing to use violence against an Imperial starport. Some are quite eager to do so.

The sophistication of any fence will vary with both the local tech level and control rating. Naturally, worlds with stricter control ratings often demand that the SPA install more extensive and elaborate fences, to suit the local agenda! The same holds for worlds with higher tech levels. Thus, a world with a low control rating will warrant only a simple fence to mark the XT line, while one with a high rating demands clearly marked mine fields and other destructive traps. A world with only low technology would require only the use of human guards, while a high-tech world might suggest the use of a neural activity sensor or something similar.

Again, the GM must carefully think about local conditions before determining design of a starport on an Opposed world. Doing so will not only save him trouble later, but may also provide details to add richness and depth to his scenarios.

Non-SPA Designs

While most starports encountered by interstellar travelers will be SPA-run, they are not the only possibilities.

Navy, scout, non-Imperial, private, megacorporate, and local ports also exist. These have already been touched upon (see pp. 11-16, and sidebars, pp. 66-68). More commonly, particular errands will take merchants to a planetary spaceport (see pp. 13-14).

Any of these non-SPA starports could embody radically different design philosophies – as could an SPA port that it inherited from a previous owner. For instance, intermingling Startown with the port grounds – something the SPA avoids – is very common at Vargr ports. Even stranger practices can be encountered. The inventive GM who thinks he has a better (or more fun) way of handling star traffic should feel free to implement it at any of these non-SPA ports.

Naval Bases

Though the SPA shares several star systems with naval bases, it does not build their facilities. Usually, the naval base will have its own, distinct highport and downport. The downport often will adjoin the SPA downport.

GMs can design naval bases with a few modifications of the rules in this chapter and the following guidelines. In general, naval bases store more fuel than similarly sized civilian installations. Their berthing needs vary widely as well. Hulls and downport buildings will be better armored and defended than SPA counterparts.

Bases are port facilities for the support, maintenance, repair, and refit of naval vessels. Surface facilities are generally provided for vessels of 5,000 displacement tons or less; orbital facilities handle larger ships.

Navy bases are the home of the Imperial Navy. They are much smaller than *depots* (which encompass entire star systems), but most naval vessels are serviced at bases rather than depots. Naval *stations* are smaller facilities, with no permanently associated squadrons, that provide the same types of support on a more limited basis. Naval bases are covered in more detail in the forthcoming ***GURPS Traveller: Imperial Navy***.

There are five classes of naval station or base. The figures reflect overall highport and downport capacity:

Class I Naval Station

Commanding Officer: commander
Provides: resupply and refueling for couriers and escorts; light maintenance
Civilian Starport: II
Size: 4-5
Military Personnel: 200-400
Civilian Personnel: 100-200
Family Members: 500-1,000
Marine Contingent: squad+ (usually detachment from embassy platoon)
Berthing Capacity: 20,000 dtons
Fuel Capacity: 12,000 dtons
Warehouse Capacity: 10,000 dtons
Cost: GCr1

Class II Naval Station

Commanding Officer: captain
Provides: resupply, refueling, light and heavy maintenance, and repair for all classes of vessel
Civilian Starport: III
Size: 5-6
Military Personnel: 1,000-2,000
Civilian Personnel: 500-1,000
Family Members: 2,500-5,000
Defenses: 8-10 fighters
Marine Contingent: platoon+
Berthing Capacity: 25,000 dtons
Fuel Capacity: 100,000 dtons
Warehouse Capacity: 25,000 dtons
Cost: GCr6

Continued on next page . . .

Highport vs. Downport Employment

At the average SPA starport, half of employees work at the highport and half at the downport. (Labor is flexible. Even though the highport handles a greater percentage of traffic in most systems, the "sticky" and labor-intensive jobs are delegated to the downport to minimize highport personnel needs. Likewise, transfer-craft crews are considered downport personnel, though they spend most working hours in flight.)

If a system has only a highport or downport, all employees work there, of course. If it has multiples of either, then all downport or highport personnel are spread among the appropriate ports. This will tend to skew the above half-and-half ratio as well; for instance, in a system with two downports and one highport, it's more likely that something like 40% of personnel work at the highport, with 30% each at the two downports.

Example: *Of our 5,715 personnel, we decide that 3,000 work at the highport and 2,715 at the downport.*

Employee Shuttles

Starports shuttling employees from ground residences to highport jobs must provide shuttles for the task. This is a very predictable traffic flow, so the shuttles' capacity is much more efficiently used than in the transfer traffic provided for previously. Most SPA starports also stagger work shifts to increase each shuttle's utility.

The highport requires one passenger couch for every eight highport employees. These could, theoretically, be all within a single large shuttle. These small craft do not require any stewards. Their crews are multiplied by five to represent nonstop service.

Example: *Mertactor starport requires (3,000/8) or 375 passenger couches in employee shuttles. Two 100-dton shuttles (p. GT141) provide this capacity. They require crews totaling 30 personnel and cost MCr26.8.*

Step 7 – Determine Construction Basics

The above steps breaking down traffic flow, and determining port income and personnel, give enough information to begin actually designing the physical starport.

Most Imperial starports will consist of two physical entities, of course, a highport and a downport. Highports are built using the starship design sequence on pp. GT149-162, taking into account their unique needs as essentially huge non-starships.

For simplicity, downports will be built using some simple modifications of those same rules. This also reflects that Imperial downports incorporate very sturdy construction. They also boast vacuum-, electronic warfare-, and NBC-proof seals on most buildings, and full life-support measures as further support against ultra-tech NBC warfare or natural disaster. In short, they're built to the standards of a non-starship that's permanently emplaced on the world's surface.

Determine Tech Level

An Imperial starport will be built to TL10 standards, except on TL12 worlds, where the SPA will use TL12 technology. This reflects the TL options available in the ***GURPS Traveller*** spaceship design process.

Example: *A TL9 world, Mertactor will possess a TL10 Imperial starport.*

Determine Construction Budget

Starports are normally financed by the issue of low-risk Imperial bonds. These bonds pay a 3% dividend per year, which the SPA must pay out of its annual revenues. Only about 10% of SPA revenues can be spent this way, so the total construction cost for the average starport is effectively limited to 3 1/3 times its *projected* annual revenues. The GM may simply decide that the Imperial economists nailed their trade projections, and make this figure 3 1/3 times the annual revenue determined on p. 65. Or he can adjust it up or down to reflect faulty forecasts and/or changes in trade patterns since the port's construction.

Starport services are billed in Imperial credits, but local contractors can be paid in local credits, effectively increasing the construction budget in line with the exchange rates discussed in the sidebar on p. 62. Unfortunately, this isn't a standard exchange conversion for several reasons. Some port components are too sensitive to be handled by outside contractors. As the tech level of the host world declines, its local labor can provide fewer services to the SPA. There's also an exchange "spike" created by the SPA's policy of building only TL10 or 12 ports.

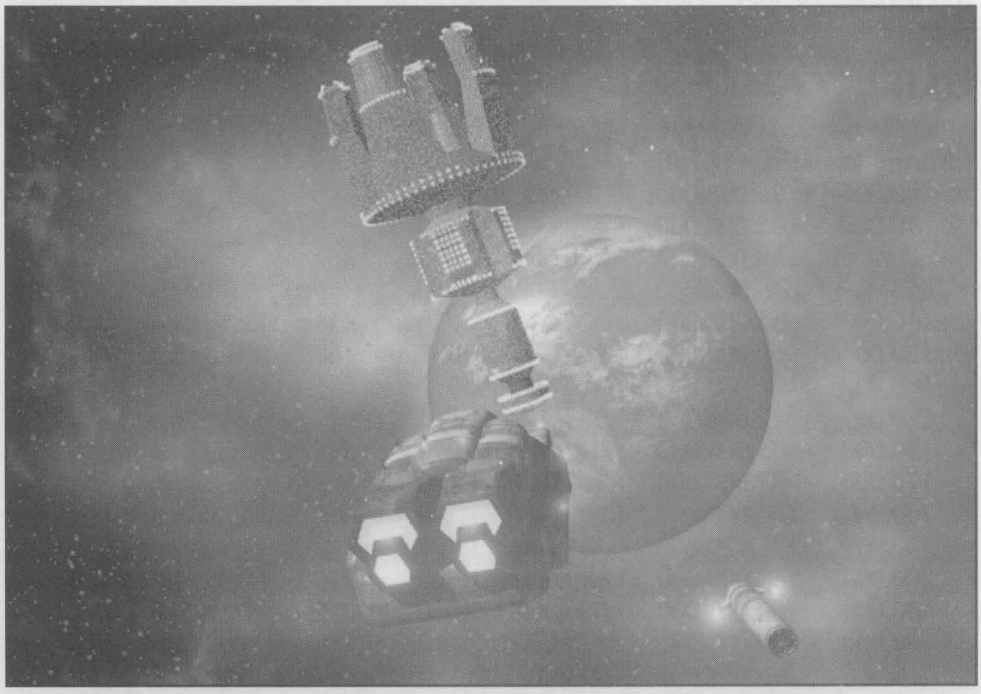
On Imperial worlds, multiply the construction budget by 1 on TL12 worlds, 1.5 on TL11 worlds, 2.75 on TL10 worlds, 3.75 on TL9 worlds, 4.8 on TL8 worlds, 5.85 on TL7 worlds, and 6 on TL6 or lower worlds. The GM should feel free to drastically reduce this multiplier on worlds with labor shortages (see sidebar, p. 63) or difficult Imperial relations.

Example: *Since we're not building a new port, but rather designing an existing port that's had time to expand to meet demand, we base Mertactor starport's construction budget on its real annual revenue of MCr1,143, giving a construction budget of 3.8 Imperial gigacredits. On TL9 Mertactor, local contracting increases this to an effective GCr14.29.*

Starport construction bonds are generally rolled over or reissued at the end of their term, so there is no need to consider paying off the bond principal.

This budget is often not adequate to pay for all required facilities, especially at small or infrequently visited ports. In this case, the SPA shifts surplus revenues from large, lucrative ports to subsidize the additional dividend payments.

The SPA normally does not pay for local spaceports; these are the local government's responsibility. They can be designed using this system; the GM should set a budget as he sees fit.



Determine Downport-Site Size and Cost

A downport must sit on physical property. Usually the local government gives this site to the Imperium free of charge, but in certain circumstances the SPA will have to pay. (The cost can vary so widely that the GM will simply have to rule what it will be.)

A comfortable size for a downport site would be (displacement tons served)/50,000 in square miles. This formula can safely ignore a normal amount of transfer traffic, but for downports that heavily service shuttles and non-starships (such as those with no highport), these tonnages will need to be added into the starship tonnages.

Naval Bases

[Continued]

Class III Naval Base

Commanding Officer: commodore
Supports: squadron (200,000-250,000 displacement tons)
Civilian Starport: IV+
Size: 6
Military Personnel: 4,000-5,000
Civilian Personnel: 2,000-5,000
Family Members: 12,000-25,000
Defenses: 2-4 SDBs, 10-20 fighters, 3-5 turrets, 1-2 bays
Marine Contingent: company+
Berthing Capacity: 25,000 dtons
Fuel Capacity: 100,000 dtons
Warehouse Capacity: 25,000 dtons
Shipyard: 6,000-10,000 dtons
Cost: GCr12

Class IV Naval Base

Commanding Officer: fleet admiral
Headquarters: subsector numbered fleet or reserve fleet
Supports: 4-6 squadrons (2 million-10 million dtons)
Civilian Starport: V
Size: 7-8
Military Personnel: 40,000-200,000
Civilian Personnel: 20,000-200,000
Family Members: 120,000-900,000
Defenses: 10-20 SDBs, 50-100 fighters, 4-6 bays, 1-2 deep meson sites
Marine Contingent: task force+
Berthing Capacity: 1 million dtons
Fuel Capacity: 4 million dtons
Warehouse Capacity: 1 million dtons
Shipyard Capacity: 100,000-400,000 dtons
Cost: GCr250-GCr400

Class V Naval Base

Commanding Officer: fleet or sector Admiral
Headquarters: sector named fleet
Supports: 12+ squadrons (10 million-75 million dtons)
Civilian Starport: V
Size: 8
Military Personnel: 200,000-1.5 million
Civilian Personnel: 100,000-750,000
Family Members: 600,000-4.5 million
Defenses: 100-200 SDBs, 500-1,000 fighters, 25+ deep meson sites, other weapons in proportion
Marine Contingent: regiment+
Berthing Capacity: 7.5 million dtons
Fuel Capacity: 30 million dtons
Warehouse Capacity: 7.5 million dtons
Shipyard Capacity: 1-2 million dtons
Cost: GCr1,600-GCr2,000

Scout Bases

Scout bases follow the same guidelines as in the *Naval Bases* sidebar, pp. 66-67.

Xboat Station

At each system in the Xboat network, an express boat station handles the message traffic and manages Xboat traffic.

Supports: Xboat tender, 3-5 Xboats, 2-3 scout ships
Civilian Starport: II+
Size: 3-4
Scout Personnel: 25-50
Family Members: 100-200
Berthing Capacity: 2,000 dtons
Fuel Capacity: 1,000 dtons
Warehouse Capacity: 100 dtons
Cost: MCr250

Scout Base

These tend to be downports with basic facilities for refueling and minor maintenance of scout ships of 1,000 dtons or less.

Supports: 3-4 survey ships, 5-12 scout/couriers
Civilian Starport: II+
Size: 4
Scout Personnel: 200-300
Family Members: 2,000-2,500
Berthing Capacity: 2,000 dtons
Fuel Capacity: 1,000 dtons
Warehouse Capacity: 100 dtons
Cost: MCr400

Scout Way Station

A large base devoted to the overhaul and refit of express boats at points in their journey, a way station can be converted to a Class I naval station (takes a team of naval engineers two weeks). The navy equipment is present at all times, mothballed if not in active scout usage.

Supports: 2-4 Xboat tenders, 200-250 Xboats, 15-20 scout/couriers
Civilian Starport: II+
Size: 5
Scout Personnel: 800-1,000
Civilian Personnel: 5,000-6,000
Family Members: 18,000-20,000
Berthing Capacity: 20,000 dtons
Fuel Capacity: 12,000 dtons
Warehouse Capacity: 10,000 dtons
Shipyard Capacity: 5,000 dtons
Cost: GCr2

Other Installations: Trade Stations

These serve as a clearinghouse for merchant dealings. Several Imperial agencies and private concerns maintain these.

Provides: language translation, brokerage, warehousing, local information, commodities exchange – all usually for free.
Civilian Starport: I+
Size: 3
Personnel: 15-20
Family Members: 45-60
Berthing Capacity: 600 dtons
Warehouse Capacity: 100 dtons
Cost: MCr18

A downport could make do with a site half this size, though noise pollution will be high on adjacent properties. It might *squeeze* into a space one-tenth the size (if built in a skyscraper fashion). Many downports feature sites much larger than this formula dictates, to provide security buffers, reduce noise pollution, and facilitate expansion.

Example: *Mertactor's downport has a comfortable site size of 28,300/50,000, or 0.566 square miles. We round this to 0.5 square miles, reasoning that it's beginning to get a little tight, having been in service for a while. Mertactor did not charge the SPA for the land.*

Determine Hull Sizes

Every highport has a hull, of course, and for purposes of SPA-standard construction every downport building is considered to have a hull, too.

A comfortable highport hull will measure 4 displacement tons for each dton of starship handled each week. A very cramped highport could be half that size. Most downports utilize freestanding starport berths, greatly reducing their need for "main buildings" volume. Those that use freestanding berths generally have 2 dtons of terminals per dton of starship served, and can get by with half that. Those that do not use freestanding berths use the highport formula.

Many downports fold all activities under one roof (a grand terminal), but for those that use several buildings, the total volume should add up to roughly the above guideline. Subsurface downports almost exclusively utilize a single, large facility. *Exception:* HAZMAT storage facilities usually are built as stand-alone buildings, which will be well separated (at least 100 yards) from other public areas.

These calculations create need for several varieties of hull size not covered in the table on p. GT151. The following hull sizes can be added to that table, both for the purposes of that book and for creating starships.

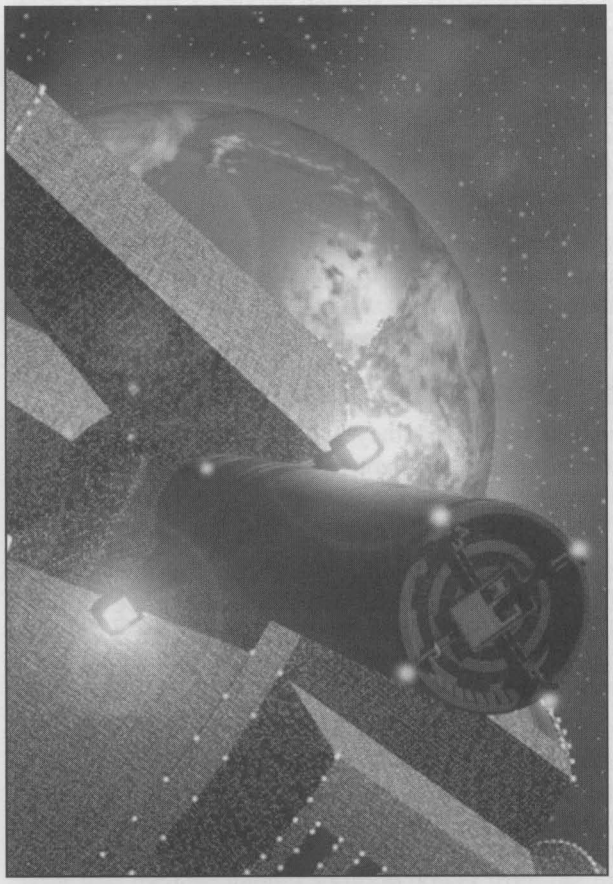
All starport hulls will be unstreamlined. (When using this table to create starships, note that ships of this size very rarely are streamlined, either.)

HULL TABLE ADDITIONS

Hull Tonnage	Volume (cf)	Hull Area	TL10 Mass	TL12 Mass	Hull Cost (in MCr)	Size Modifier
60,000	30,000,000	580,000	580	290	29/69.6	+13
70,000	35,000,000	640,000	640	320	32/76.8	+14
80,000	40,000,000	700,000	700	350	35/84	+14
90,000	45,000,000	760,000	760	380	38/91.2	+14
110,000	55,000,000	870,000	870	435	43.5/104.4	+14
120,000	60,000,000	920,000	920	460	46/110.4	+14
130,000	65,000,000	970,000	970	485	48.5/116.4	+14
140,000	70,000,000	1,020,000	1,020	510	51/122.4	+14
150,000	75,000,000	1,070,000	1,070	535	53.5/128.4	+14
175,000	87,500,000	1,180,000	1,180	590	59/141.6	+14
200,000	100,000,000	1,290,000	1,290	645	64.5/154.8	+14
250,000	125,000,000	1,500,000	1,500	750	75/180	+14
300,000	150,000,000	1,690,000	1,690	845	84.5/202.8	+15
400,000	200,000,000	2,050,000	2,050	1,025	102.5/246	+15
500,000	250,000,000	2,380,000	2,380	1,190	119/285.6	+15
750,000	375,000,000	3,120,000	3,120	1,560	156/374.4	+15
1,000,000	500,000,000	3,780,000	3,780	1,890	378/907.2	+16
1,250,000	625,000,000	4,390,000	4,390	2,195	219.5/526.8	+16
1,500,000	750,000,000	4,950,000	4,950	2,475	247.5/594	+16
1,750,000	875,000,000	5,490,000	5,490	2,745	274.5/658.8	+16
2,000,000	1,000,000,000	6,000,000	6,000	3,000	300/720	+16
3,000,000	1,500,000,000	7,860,000	7,860	3,930	393/943.2	+17

Highport Example: *With a weekly traffic of 185,000 displacement tons of shipping, Mertactor's highport ideally should have a 740,000-dton hull. We decide its age is showing and purposely purchase a cramped 500,000-dton hull for MCr119.*

Downport Example: *We decide Mertactor's downport will use freestanding berths, so it ideally should have 56,600 dtons in buildings given its 28,300 dtons of starship traffic. We keep going with the cramped, outdated starport concept, and decided it will feature a main passenger terminal of 20,000 tons (MCr14 per p. GT151), and a central cargo terminal of 20,000 tons (another MCr14). It handles no regular HAZMAT traffic, so requires no special warehouse for hazardous cargo.*



Downports require surface improvements such as access roads and a few parking lots, but these can be assumed to be part of the cost paid for its buildings' "hulls." The reasoning is that since surface construction should be cheaper than hull construction (there's no need to brace the structure for maneuver stresses, for starters, and much cheaper non-metallic materials may be used), the difference can simply be allotted to this uniquely downport need.

Covered within this "free" development, most SPA downports will be attached to the local transportation network, whether that's roads, monorails, grav air corridors, or some combination of elements. Usually, only SPA personnel will be able to drive or pilot personal vehicles across the XT line; others will need to use mass-transit to reach the port, or park at a commercial offsite lot, then cross the XT line on foot before using whatever mass transit the GM desires (usually slidewalks) to reach the passenger terminal if it's set back from the line. Cargo handling varies; usually port tenants can enter and exit the port with their own goods (still subject to customs inspection), while others will have to pay SPA freight handlers to bring the goods to the customs station just inside the XT line, then load it themselves once past customs.

Calculate Excavation Fees

Subsurface downports will require an additional expense for excavation. Add Cr25 per displacement ton to bury a downport in soil, or Cr100 to place it in rock.

Example: *Mertactor has no excavation expenses, but had we buried its downport buildings we would have spent MCr1 to excavate sufficient soil or MCr4 in rock. Of course, had we really decided upon a subsurface downport, one large building without freestanding berths may have been a better choice. This would have at least doubled our size needs, with a proportional increase in excavation costs.*

Build the XT Line

All Imperial downports must have an XT line. The first step in building the line is determining the downport's perimeter wall size. Calculate this as 211,200 sf times (the square root of the downport site size in square miles). Then divide by local gravity in gees, if local gravity is known.

Low-Tech Starports

No matter how small, Imperial starports are at least TL10, and often TL12. Other sorts of ports (see sidebar, p. 65, for examples) may be of much lower TL, particularly local spaceports that can't depend on Imperial support.

TL0-1

Offers unpaved "pads" only, with bonfire beacons. Fuel supply, if any, is a nearby water source. Hardly a true port.

TL2-3

Primitive radar reflectors add passive astrogational aid. Buildings of wood or stone – including unroofed small or standard berths, perhaps even a large berth – may be present, though rarely of large size. If need be, water for fuel can be carried to site via aqueduct, at incredible expense.

TL4

Telescopes and signal mirrors allow (extremely) primitive active traffic control, if the starship captain can interpret the messages. Unroofed large berths more likely. Door-roofed small berths feasible. Salt domes might allow storage of *uncompressed* hydrogen, though rarely.

TL5

Rotating searchlights and landing lights added to traffic control. First steel frames allow larger buildings, though vast terminals remain rare.

TL6

Radio (including radio astrogational beacons) and radar greatly improve traffic control. Buildings can be sized to meet most needs. Berths of all sizes can have door-roofs. Proper unrefined (or even refined) fuel can be stored, at great expense.

TL7

First highports feasible, if unlikely. Lasercomm, datalinks, IFF transponders, and GPS satellite nets allow first "real" traffic-control systems. Fuel storage no longer a technical or fiscal challenge.

TL8

PESA and AESA suites further advance traffic control. Highports built where essential, though logistics a challenge.

TL9

Highports built on need. Radscanners improve internal security. Most downports meet own needs with on-site power plants.

TL10+

Per this design system, with variations as suggested in various sidebars in this chapter.

Critical Locations

A "critical" area is any facility whose loss would severely impair or paralyze the port's functioning: power generation, central communications, Security control, the tower, etc.

Critical locations often are better protected than other parts of the port. Designers attempt to place them so that an accident at one will not endanger another. If terrorist or military attack is considered likely, the preferred strategy to dispersal may become concentration, since a single small perimeter is easier to guard than several separate ones. (This is known as "redoubt design.") However, physical hazards call for isolation; one does not put fuel storage next to the datacomm center.

Budget Items

Game Masters won't want to design every starport that enters their campaigns, even if that starport's construction budget comes into game play. In addition, budget practices parse expenses differently than this design process – architectural fees are broken out rather than assumed in the overall facility cost, for instance.

Should an adventure deal with a starport's construction budget, here are the line items typically associated with such a project, and their usual percentage of the overall funds available:

Standard Construction Expenses

Land* and highport hulls	25%
Administration offices	0.5%
Traffic control/navigational aids	0.5%
Berthing and ship-service facilities	10%
Shipyards	15%
Non-berth landing pads, taxiways	1%
Fuel tankage	10%
Warehousing	3%
Terminals**	2%
Port vehicles (internal transport, crash/fire/rescue, security)	2%
Port craft (shuttles, cutters, lighters)	7%
Plant maintenance, infrastructure, and perimeter fence†	2%
Technical specialists (architects, etc.)	7%
General conditions (overhead)	15%

* When land must be purchased. Highports generally pay nothing for orbital "space," though some worlds may ask for a payment.

** Combined figure for passenger and cargo facilities.

† For a "standard" XT line fence on a friendly or neutral world. Enhanced security or an opposed-world barrier with guard towers and alarm systems may take up a larger percentage of the budget. In such cases, some of the funds allocated to other areas will be transferred to this one.

Example: *Mertactor downport occupies 0.5 square miles. The square root of this is 0.707, Multiplying by 211,200 gives us 149,318 sf. We don't know the local gravity, but* ***GURPS Traveller: Behind the Claw*** *tells us it's a small world (1,927-mile diameter) and pp. T:FI57-58 let us calculate that local gravity's probably about 0.2 Gs! Our wall will mushroom to 149,318/0.2, or 746,590 sf.*

The XT line wall costs Cr10 per square foot; it's DR 40 at TL10 or DR 100 at TL12. Multiply the cost by 0.2 if the local CR is 0, 1 for local CR 1, 1.2 for CR 2, 1.3 for CR 3, 2.9 for CR 4, 3.5 for CR 5, or 5 for CR 6. This represents the cost of adding sensors, traps, and double walls as appropriate. At CR0 it represents an "open frame" wall akin to a wire fence, through which line of sight (and small items . . .) can freely pass. See the sidebar on pp. 72-73 for more detailed information.

Example: *The base cost of Mertactor's XT wall is Cr7,465,900, or MCr7.47. The local CR is 1, so that's the final cost as well.*

Should the downport be one of those rare few on which the local Startown straddles the XT line, halve the physical expenses for the XT line (the line becomes more of a formality, with few actual walls and gatehouses), and at least double the minimum number of security and Customs personnel normally needed (see p. 87).

Step 8 – Add Starport Components

Now that the basic hulls have been purchased, they will be filled with the required components. Keeping track of the mass of downport components isn't required.

Turrets and Bays

For good or ill, most SPA starports are unarmed. They depend on the planetary navy, the planetary army (particularly the Close Orbit and Airspace Control Command), and the Imperial Navy to provide whatever protection is required. Imperial naval bases will have their own defenses, however, and these usually extend to cover any nearby civilian starport.

In the event that a port needs to be equipped with its own armament, as sometimes happens in isolated or border areas or on Opposed worlds (where such weapons usually will be added *very* discreetly), the turrets and bays from pp. GT151-158 can be purchased and weapons installed. For downports, hardpoints are constructed out of reinforced concrete, but the price is the same.

Highports often need the space that would be allotted to turrets and bays for external cradles (see p. 103), anyway. A downport can simply add small buildings dedicated to housing weapons. Rarely will actual turrets or bays be added to a downport terminal.

Example: *Mertactor has no weapons installed at either port.*

Armor

Starports usually are armored. This deters terrorist attacks, offers some protection from star pilots with better confidence than judgment, and keeps the random mishap from becoming a tragedy and Imperial incident. Generally, minimum DR will be 100, but it can reach much higher figures for starports at the edges of Imperial space.

Armor is purchased normally per p. GT152.

Highport Example: *Mertactor is situated in a particularly dangerous portion of Imperial space, though not right at the laserburned edge. We decide to give the highport a DR of 300. This armor masses 35,700 tons and costs MCr428.4.*

Downport Example: *Armor isn't as important on the surface installations, since the primary threats to security on this world would manifest as hostile starship fleets. We decide to give the passenger terminal DR 200, at a cost of MCr33.6, and the cargo terminal DR 100 at a cost of MCr16.8.*

Other Surface Features

Sealing: Almost all installations should be sealed, just in case. This is purchased normally per p. GT152.

Highport Example: *Sealing the highport's hull costs MCr23.8.*

Downport Example: *Sealing each of the downport's buildings costs MCr2.8.*

Sensor Masking: Starports very rarely incorporate these options, although theoretically a highport in dangerous space with its own maneuver drives could benefit from being able to sneak out of orbit in times of war. In practice, this would be nigh impossible to accomplish – the port would never be unobserved long enough to break free of visual tracking. Cloaking devices for downport installations would verge on the silly.

Bridges

Highports have bridges proper; downport buildings generally have a control room that serves the same function. These shouldn't be confused with traffic control resources, which will be installed below. These almost always qualify as command bridges at Class II or larger ports.

Highport Example: *We install two bridges in Mertactor's highport (one as a backup), requiring 10 spaces with a mass of 41.8 tons and cost of MCr19.2.*

Downport Example: *The two downport buildings each get a single control room requiring 5 spaces and costing MCr9.6.*

Engineering

Each highport or downport building will usually have at least one engineering module. Any given structure could have more than one such module, representing two or more reactors providing power requirements. The "slices" of fusion plant that will be added on to these with additional modules can be judged to be divided evenly between them, or unevenly distributed. This backup system does not mean that, should one reactor fail, the other reactors can make up for the lost power generation. But a highport with two engineering modules (and thus two reactors) could survive failure of one reactor indefinitely by shutting down non-critical power consumption to the point that the remaining reactor can meet demand.

SPA policy is to provide onsite power generation at each major downport building. Minor buildings can draw power from a major building through underground power lines. (This can create some minor ***GURPS Traveller*** design-system breakdowns. For instance, one of the aforementioned downport weapons bunkers might incorporate a laser that the GM intends to draw power from the main terminal. The problem is that the additional reactor components required to provide the laser's energy will be installed in the bunker with the weapon, not in the site housing the reactor to which they belong. GMs who won't be happy with this misallocation of resources can consult ***GURPS Vehicles*** and shift the appropriate power-plant components back to the proper building. For others, the effect will be minor and can be safely ignored.)

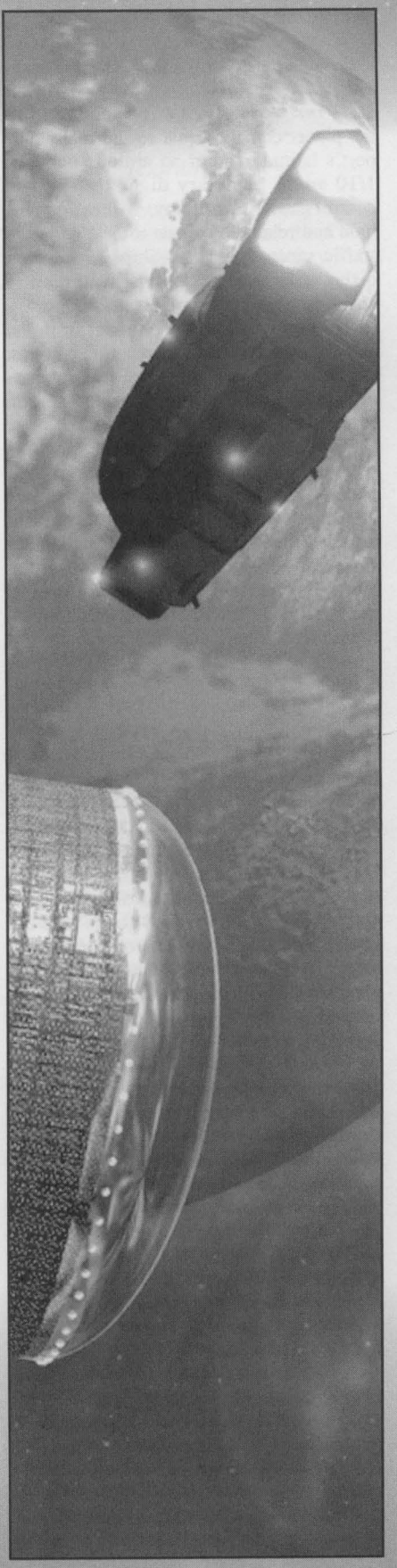
Downports can be assumed to be hooked up to the local power grid, as well. Most Imperial downports use their own power-generation resources, turning to the local supply only at times of reactor failure.

Highport Example: *We install two engineering modules in the highport, representing two fusion reactors. These take up 2 spaces, mass 8 tons, and cost MCr0.64. We decide that the reactors will be of equal size, each providing half of the highport's energy needs.*

Downport Example: *The two downport buildings each require a single engineering module, taking up 1 space in each building and costing MCr0.32 each.*

Traffic Control

Each highport or downport requires 1 traffic-control module (see p. 104) per 25,000 displacement tons of weekly traffic, rounded up. A port can get by with fewer modules, representing the traditional overworked and harried traffic-control staff, at -1 to related skill rolls per missing module. Ports pay 3 times the list cost for traffic-control modules; the other 400% investment pays for navigation satellites, landing beacons, etc.



Standard Orbits

A standard orbit is defined as a circular orbit from west to east (*prograde*), with an inclination to the planet equator equal to the main starport's latitude and at an altitude between 1/10 and 1 planetary diameter. Traffic control authorities (if any) will assign altitude and relative position to best maintain traffic separation. Even ships proceeding directly to the surface will intercept a standard orbit to begin their descent.

This convention is a remnant from the days when starships used reaction engines, and the extra velocity gained from operating in the direction of planetary rotation resulted in important cost savings.

Other, non-standard orbits are possible and may be requested when filing a flight plan. Polar orbits, with an inclination near 90 degrees, are useful for mapping because they cover more of the planet's surface. Retrograde (east to west) orbits are sometimes useful for maintaining more frequent (but brief) contact with parties on the surface.

Leaving the Port – The XT Line

The border between the Imperial extrality zone and the rest of the host planet is called the extrality or XT line. XT lines are usually designed to prevent smuggling contraband goods onto the planet, in defiance of local customs laws. On particularly repressive worlds, the planetary side of the line may be designed instead to keep the inhabitants in – a 57th-century Berlin Wall.

The XT line can be divided into two sections. First are the actual *access points*, where traffic (ground or grav) can move from one side to the other. Air, water, and space traffic will generally be met by customs officials where it lands, but security arrangements and level of scrutiny will be similar.

The rest of the XT line is called the "*fence,*" whatever its physical arrangement. Physical security measures will be similar to, but less strenuous than, those at the crossing points. Sensors will concentrate on area coverage to detect and locate a breach. At a minimum, there will usually be a literal fence or other physical barrier, even on planets with CR 0 – it prevents the inhabitants from wandering into the starport by accident.

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Highport Example: *The highport needs 8 traffic-control modules, taking up 32 spaces, massing 59.2 tons, and costing 8 × 3 × 12.66 or MCr303.84.*

Downport Example: *We decide to give the downport only 1 traffic-control module, as a character flaw, giving its traffic controllers a -1 to any skill rolls. This takes up 4 spaces and costs 3 × 12.66 or MCr37.98.*

Holds

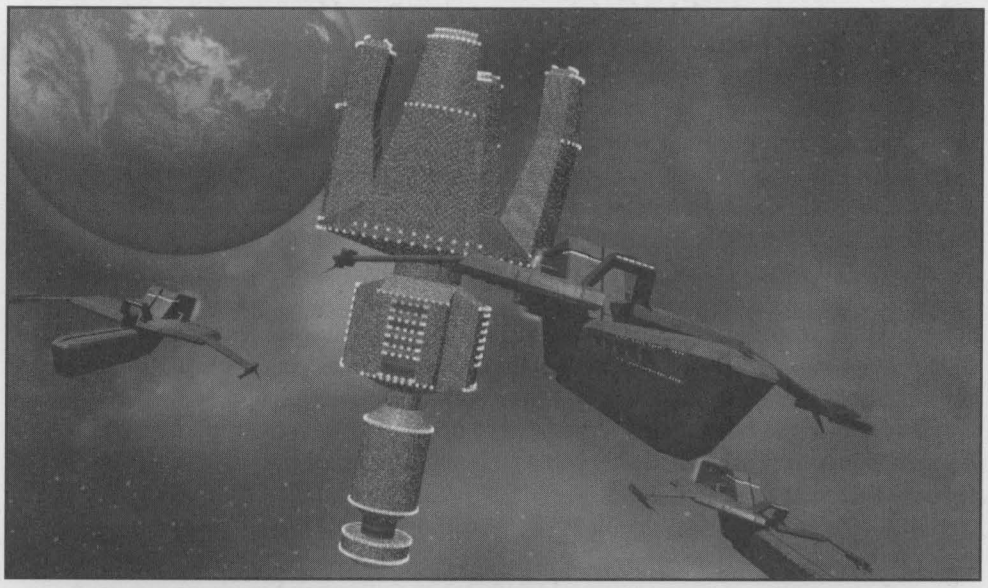
A large proportion of any port facility will consist of storerooms, warehouses, loading docks, transit sheds – holds, in starship terms. HAZMAT warehouses will be mostly holds, usually with just 4 or 8 spaces left over for offices.

The average downport with freestanding berths should have hold spaces equivalent to 0.5 times weekly cargo handled. The average highport, or downport with berths in the main building, should have hold spaces equal to 0.5 times weekly cargo handled *plus* 0.5 times weekly starship displacement tons served.

Ports off the beaten path may want to increase this percentage, to reflect increased turnover times. Assume the average cargo hold will mass 1 ton at any time (most of them will be empty at any given time, since much of this space actually goes to wharfs and similar cargo-handling rather than -storage needs).

Highport Example: *Mertactor is on a main trade route, so goods don't sit on its docks long. The highport needs (0.5 × 96,000 dtons of cargo) + (0.5 × 185,000 dtons of starship) or 140,500 displacement tons of holds, taking up 140,500 spaces and massing on average 140,500 tons.*

Downport Example: *The downport requires 0.5 × 40,000 dtons of hold, taking up 20,000 spaces. We decide that 75% (15,000 spaces) will go in the cargo terminal, with the rest representing luggage and parcel service in the passenger terminal.*



Jump Fuel

Fuel tankage is an important component of starports, since refueling starships is a primary service. The average port should incorporate tankage at least equal to 0.06 times the weekly displacement tonnage of starship served. This will average a three-day supply. Ports in remote locals or with fragile supply lines may need to *greatly* increase this tankage. Military or scout ports always store more fuel than this.

Highports hold fuel stores within their hull, but most downports bury the tankage on a remote corner of their site (preferably in rock), then pump the fuel to individual berths through a system of underground pipes (paid for in the infrastructure improvements assumed in their hull costs). For this reason, fuel-tankage spaces aren't counted against downport structures. Downports also use heavier, cheaper tanks, but given the costs of excavation end up paying the standard costs for tankage given on p. GT155.

Underground tanks are easier to insulate and contain leakage better (though a large escape of liquid hydrogen will create a major frost heave, compounding the problem). Aboveground tanks, suitable for small ports and temporary installations, cost MCr0.05 less per module.

At most minor ports, vessels must be moved to a specified fueling bay.

Class I ports will only have unrefined fuel, if that. Class II rarely offer refined, but rarely lack any fuel at all. Class III and IV ports routinely offer both refined and unrefined fuels, while Class V ports often do not offer to sell unrefined stores. See p. GT121 for more information.

Worlds with very hostile environments require special consideration when it comes to fuel storage of fuel. The GM may increase tankage expense accordingly.

Highport Example: *We decide that Mertactor's highport should incorporate more fuel tankage than normal, to serve as a small strategic reserve for Imperial forces in times of border tensions. The normal stores would be 0.06×185,000 or 11,100 tons. We double this to 22,200 tons. The filled tanks take up 22,200 spaces, mass 28,860 tons, and cost MCr3,552.*

Downport Example: *The downport needs to support 28,300 dtons of shipping, therefore we purchase 0.06 × 28,300 or 1,698 tons of tankage at a cost of MCr271.68.*

Fuel Processors

Major ports almost always take in unrefined fuel and process it themselves, as do minor ports when they offer refined fuel at all. Working full time, a fuel-processing module will refine the average fuel needs of 9,000 dtons of weekly shipping. Most SPA starports will boast processing sufficient to sell refined fuel to all visitors.

Downport fuel processors generally are placed underground, close to the fuel depot. Excavation costs and certain environmental concerns that starships and highports can ignore raise the per-module cost to MCr1.

Highport Example: *With 185,000 dtons of weekly traffic, the highport needs 21 fuel processors, taking up 21 spaces, massing 23.1 tons, and costing MCr17.85.*

Downport Example: *Limiting our investment to 3 fuel processors will still provide refined fuel for (3×9,000)=27,000/28,300, or 95% of weekly traffic. Since that's probably a far higher percentage than will be seeking refined fuel, we decide that's enough and invest the required MCr3.*

Fuel Collection

On water-rich worlds, starports can simply tap into local resources and ferry up the highport's needs. On worlds with restrictions on using water for fuel (usually any with a hydrographic percentage of 40% or less), "oilers" (small craft or non-starships dedicated to carrying fuel) will have to be purchased to mine local gas giants. Some of these will need to be able to transport fuel to the downport.

If neither source is available, liquid hydrogen may have to be imported from a nearby system, which will add Cr400 per dton to its cost! (The GM should note that a system with no fuel source would not be likely to generate enough trade to warrant a large starport; he should rule that *some* source exists if the system has a major port.) Oilers for downport service will be needed.

Imperial starports generally use the 800-dton oiler from p. T:FT137 to shuttle fuel between highport and downport. Each MCr113.7 oiler can shuttle enough fuel to service 125,000 dtons of weekly traffic. Each requires a crew of five, 25 for full-time service. The 40-dton fuel skimmer (p. GT140) serving 3,000 dtons or a 50-dton modular cutter with fuel skimmer (p. GT142) serving 4,500 dtons can be substituted for lesser needs.

Gas-giant mining varies widely depending on proximity (if the system's main world orbits a gas giant, the 800-dton oilers can be used). For longer trips, robotic "fuel blimps" (non-starships up to 10,000 dtons with no hull armor) are deployed. The GM should simply assign a small-craft cost of MCr0.001 to MCr1 (averaging MCr0.01) per dton of total weekly starship traffic, depending on how difficult the process is and lengthy the round trip. The blimps will require no crew, but will require highport-based technicians.

Leaving the Port – The XT Line

[Continued]

Physical security and strength will increase with both the TL and the CR of the host planet. Height of barriers will be at least 10′ divided by local gravity; planets with extensive air traffic will rely more on sensors (and in extreme cases anti-aircraft weapons) to enforce XT line restrictions.

The design sequence on p. 69 merely provides an abstract cost for erecting the XT line's physical features. When the XT line comes into play, the GM can get a better idea of just what it incorporates using the following tables:

Physical Security Measures

CR	XT Fence	Access Points
0	Single fence	Open gate
1	Single fence	Gate with gatehouse
2	Cleared buffer zone	Guards
3	Anti-intrusion fence	Random ID/ manifest checks
4	Double fence; sensors	100% ID/ manifest checks
5	Non-lethal traps; patrols	Random search
6	Lethal traps; deadly force	100% physical search

Higher level measures may be added during times of heightened alert.

Physical Security Technology

TL	Sensors	Barrier DR/HP
0-4	Mk. 1 eyeball; unaugmented hearing	4/10
5	Searchlights.	8/20
6	Radar; metal detector, microphone, rad counter	12/30
7	LLTV, thermograph, X-ray, geophone, MAD	16/40
8	PESA, AESA, chemsniffer	24/60
9-10	Radscanner	40/100
11	Densitometer, biosniffer	60/150
12	Neural activity sensor	100/250

Casinos

Gambling presents a special set of opportunities and problems for port administration. *The plus side:* Gambling is a profitable business with an unusually low overhead – you provide the opportunity, and the customers give you their money. *The downside:* Casinos handle a great deal of cash (more often than any other part of the port, including the banks). They attract cheats, thieves, and compulsive gamblers. (Casino management has no reason to discourage the last category until they are broke – at which point they become the port's problem, not the casino's.)

An additional factor is that if people are not given a place to gamble legally, they will find their own places to do it. Because casinos operate within regulations, and have licenses they do not wish to lose, many gamblers believe they are less likely to be cheated at a professional table than in a hotel-room pickup game. When a dispute does arise, the "formal" atmosphere, as well as the presence of casino and port security, means it is less likely to turn violent.

The port director has the final decision on whether to allow casino gambling. Only about 5% of major ports do not, and half of those ban casinos at the request of a nearby military base.

All Imperial starport casinos are concession operations. Locals run some, especially at smaller ports. Three-quarters of the casinos at major ports are operated by large gaming corporations, such as Provace, Firenze Ltd., and Schwarzbuch Recreations, LIC.

In the interest of respecting local laws, residents of worlds where gambling is forbidden are not permitted to own portside casinos. (The SPA cannot prevent them locals from gambling in them, though the casino operator may.) From time to time this rule is challenged, either directly as a matter of free trade law, or secretly, through offworld holding companies. The former case is routinely passed back by the line office to the local government, which may issue or deny a waiver (or change the law) as it sees fit. The second case requires a determination of whether Imperial securities law (which forbids false declarations of ownership) has been violated.

Example: *Mertactor has a 19% hydrographic percentage, so the water's probably off-limits to the Imperial port, and the system has no gas giants! (See p. T:FT131.) We decide that a nearby non-terrestrial world has significant hydrogen in its stew of an atmosphere (since we do have a major port serving the system). Total weekly traffic is 185,000+28,300=213,300 dtons. We assign a fuel-blimp cost of MCr0.005 per dton for a total expense of MCr1,066.5. We also need to shuttle fuel for 28,300 dtons of shipping to the surface. Though an 800-dton oiler costs more than the seven modular cutters that could also do the job, far fewer crew members (35 vs. 105) will be required and the excess capacity may prove handy in an emergency, so we purchase the oiler for MCr113.7.*

Berths/Spacedock Hangars

The single most core component of a starport is its ability to house starships and small craft, therefore a large percentage of its volume will be taken up with spacedock hangars (called berths at a starport).

The average port will have berth space to hold its weekly average traffic, or a little more. Since the average starship remains in port three days, this amounts to more than 200% of average need. There are several reasons for the extra capacity. First, some weeks will see far more traffic than the average. Second, star traffic does not arrive in smooth ratios of small, medium, and large ships; some weeks will see many small ships and others will see a surge of 20,000-dton liners. Third, the port's own small craft and private small craft will be using the smaller berths as available.

The SPA builds berths with capacities of 100, 800, 5,000, or 20,000 dtons. Vessels larger than 5,000 dtons usually call strictly at the highport. Using these standard designs boasts all the advantages of standard configuration (pp. 56-57): No custom design study is necessary, the supplies for a berth are available as a prepackaged "kit" (containing surfacing and wall materials, lighting, landing-beacon components, and wiring), and landing procedures for a specific berth size are also standardized.

The following is the standard SPA formula for determining how many berths of a given size that a given highport or downport needs. They are based on weekly displacement tons served. In certain cases (for instance, a core world that sees a higher proportion of 20,000-dton freighters than the norm, or a frontier world that rarely sees a commercial ship exceeding 800 dtons), this formula should be heavily modified.

BERTHS PER 100,000 TONS SERVED

1	20,000-ton (extra large)
6	5,000-ton (large)
40	800-ton (standard)
180	100-ton (small)

Downports substitute four large berths for each extra-large berth. Use these ratios to nearest 100,000 dtons. For remaining fraction of 100,000, assign berths as evenly as possible.

Highport Example: *We decide that since it serves 185,000 displacement tons, Mertactor's highport needs 2 20,000-ton berths, 11 5,000-ton berths, 70 800-ton berths, and 340 100-ton berths.*

Downport Example: *The downport serves 28,300 displacement tons weekly. At 10 large berths (using the extra-large berth substitution) per 100,000 dtons served, that works out to about 3 large berths needed. We go with that, adding 11 standard berths and 45 small berths to fill out our needs.*

Highports purchase standard spacedock hangars per p. GT154. Not all of them offer true berths for all of the ships they serve. Instead, they berth many ships in external cradles (see p. 103) or orbital berths (see below).

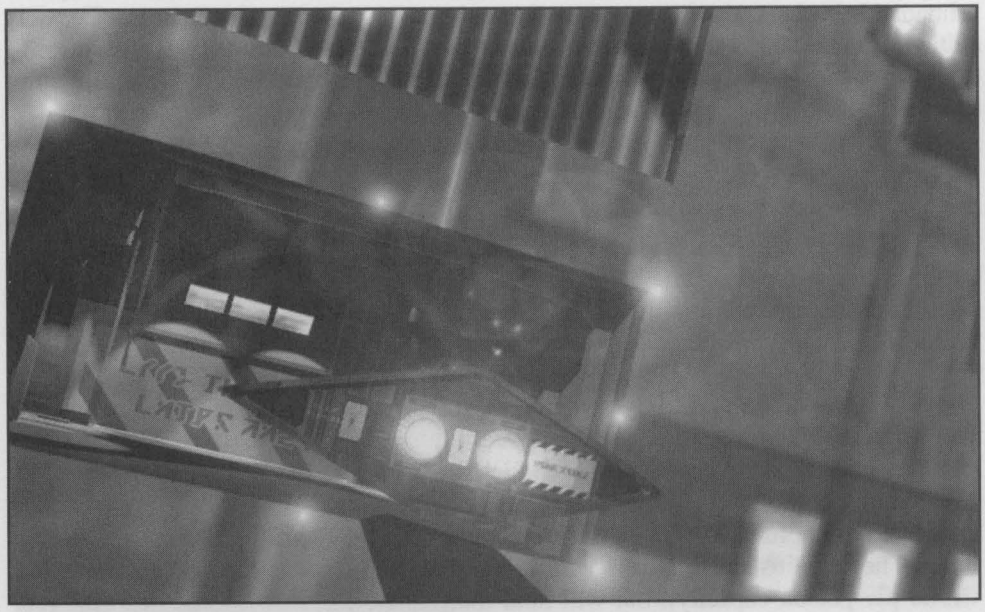
External cradles are preferred over simple airlock-to-airlock connections because the SPA doesn't like to leave large ships "floating" next to their highport hulls. By employing cradles for all external berths, the highport can undergo emergency maneuvers (whether via tug or its own maneuver drives) with minimal notice. Likewise, starship pilots can't attempt unwise close maneuver until traffic control releases their ship from its cradle. Still, many undercapitalized highports resort to airlock-to-airlock external berths if they lack both unfilled cradles or spacedocks, and the transfer craft required to support an orbital berth.

The SPA installs large external cradles to roughly match its standard berth capacities. These have the following characteristics:

CRADLE/BERTH EQUIVALENTS

Size	Spaces	Mass	Capacity (stons)	Cost (MCr)
Small	3 (1)	37.5	375	0.75
Standard	30 (10)	375	3,750	7.5
Large	160 (54)	2,000	20,000	40
X-Large	700 (234)	8,750	87,500	175

Spaces are the number of spaces within the port's hull that the external cradle takes up; most of the cradle is outside the ship's hull. The number in parentheses indicates the number of turrets that can't be installed because the cradle supplants them. *Mass* is the mass of the cradle itself, while *capacity* is the heaviest ship the cradle can hold, as measured in standard tons. Any given cradle can hold any ship lighter than its limit.



The SPA tries to avoid relying on orbital berths, in which the incoming ship is parked in an orbit adjacent to the highport and business is conducted via small craft and lighters. This system increases navigational woes, and small craft are more expensive in the long run than cradles or berths. Regardless, many older highports have seen traffic increase to the point where orbital berths are their only option. Each orbital berth requires the highport to add additional small craft to its transfer-craft fleet to meet the following needs:

ORBITAL BERTH TRANSFER CRAFT NEEDS

Size	Passenger Couches	Cargo Holds
Small	1	1
Standard	3	7
Large	30	75
X-Large	120	300

These figures assume that the transfer craft will simply be added to the pool established on pp. 63-64, and all crafts will serve both normal transfer and orbital-berth needs.

Highport Example: *Our highport hull is a little small for our needs, so we decide to purchase half of our berths as internal spacedocks, half as external cradles. Purchasing 1 extra-large, 6 large, 35 standard, and 170 small internal berths takes up 190,000 spaces, with a mass of 212 tons and cost of MCr1.06. Adding 1 extra-large, 5 large, 35 standard, and 170 small external cradles takes up 3,060 spaces, masses 38,250 tons, and costs MCr765. The cradles take up the hull space that 1,024 turrets normally would; since the highport could wield 5,000 turrets (were we to arm it), this suggests that cradles cover roughly 20% of its surface.*

Public Data/Comm

Imperial starports usually provide (for a small fee) public terminals that tap into the local communication networks. These terminals are typically computers of varying degrees of sophistication. On more primitive worlds, they may be old-fashioned telephones or videophones.

All public communications use their own lines, distinct from those of the starport's internal systems. While information about the starport and its functions is obtainable using these terminals, one cannot directly access any information stored there.

Chapels

Most major ports have at least two religious facilities, known generically as "chapels." One of these is nondenominational, a plain, quiet room where anyone may rest and meditate. The other has a collection of iconic objects and holographic projections representing many faiths, which can be set up, with a couple of hours' notice, to house a particular faith's services.

These two rooms, which typically seat 50-100 persons each, are provided and maintained by the SPA. They are not staffed, though large ports usually have a number of religious officials (minister, priest, rabbi, etc.) available via pager.

Religious organizations are permitted to lease space for dedicated chapels. The rents may, at the director's discretion, be discounted, since it is assumed that the chapel is not a profit-earning enterprise; however, this cheap space will not usually be in a prime commercial area. Leased chapels usually have a minister on duty part of the time.

The port chapel is thought of differently from the other public spaces. Quiet is maintained, and it is considered very bad manners to openly wear weapons inside (there are some fringe world sects that incorporate weapons in their observances, but even these observe the niceties when sharing space with others). It is also bad form to talk about anything non-spiritual, and that especially means conversations with shady contacts.

A chapel is not considered a "sanctuary" in the sense that lawbreakers can take refuge from pursuit. Security will remove such a fugitive with whatever force is necessary. A fugitive who wishes to surrender may choose the chapel to do so peacefully. When there's a serious shooting situation in the corridors, one way of declaring your non-involvement is to take a seat in chapel; the central tenet (i.e., not being shot) is very ecumenical. At the conclusion of the incident outside, enterprising deacons often stand by the exit holding a collection basket; people become surprisingly generous.

People's tendency to congregate in the chapels in emergencies leads some directors to install special safety features such as additional fireproofing or heavier walls.

Traffic Control

Traffic control at Imperial starports usually isn't a hectic, seat-of-the-pants process. Usually.

Traffic control's main tower will be located at the highport (if present), but every downport will also have its own "local" traffic-control tower. The highport tower (which usually is a towerlike extension of the highport's hull, but for security reasons sometimes isn't) has command authority over the downport towers, and senior officials usually will be based at the highport. Their offices usually will be adjacent to the traffic-control centers, often at the base of the tower.

Traffic control is always isolated from other port functions, for reasons of security and to ensure no interruption of its dedicated infrastructure needs (it wouldn't do if a janitor's vacuum cleaner blew a fuse that knocked out the main radar). Public access is always restricted. In addition to failsafe power supplies, traffic control will require a deal of communications equipment, both for speaking to traffic and for receiving data from its network of navigational-aid satellites. This often is located at the traffic-control tower, but also can be elsewhere on port property with a dedicated physical datalink to the tower proper.

Traffic Control Protocol

Imperial starports use a standard system for controlling flight space, depending on port class. All of Imperial space uses a single radio channel for flight control (with two backups for occasions when the main channel suffers interference). Ships arriving in a system administered by the SPA are expected to notify the starport at earliest opportunity. The port will then instruct the starship on any local variances from the standard control system; this data also can be obtained in commercial navigation software or a pilot with the appropriate Area Knowledge may already possess it. Class III or higher ports usually then assign the ship to a different traffic-control frequency, to keep the main channel relatively free of clutter.

Each starport provides the traffic control described for its class and all below it.

Class I: These starports usually possess minimal or no traffic-control sensors, and may not possess any full-time traffic-control personnel. All that they must maintain is an *advisory zone.* This zone usually extends from the planet's surface to 100 AU from the primary star or the orbit of the last charted planet in the system (whichever is greater). Starships maneuvering within this space are supposed to notify the port of their flight data.

The port will try to relay this information to any traffic with obviously converging courses. An advisory zone is considered uncontrolled space.

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Usually, downport main buildings only house a few small berths, for small craft performing transfer duties. At most SPA downports, each starship berth is a freestanding, paved area with a wall around it (for customs and inventory control). The landing starship drops right into the berth, and flies straight up and out when its business is done. These berths usually are located a prudent distance from any main buildings, an equally prudent distance from the XT line, and as far apart from each other as feasible. They generally ring the downport's main building(s), with the usual exception of a corridor that will be left clear for ground traffic.

A standard SPA downport starship berth has two doors in the wall, a small one for personnel and a large one for grav/ground vehicles. Generally, both doors remain locked until customs has cleared the vessel, at which time the starship captain is given control of both portals until his ship departs.

These berths are sufficiently large that the unused space within their walls can be used as a transit shed and staging area for offloading, sorting, and onloading cargo. Many feature retractable roofs that can completely enclose the berth once a ship has landed. Their physical characteristics are:

FREESTANDING STARSHIP BERTHS

Size	Volume (cf)	Diameter (ft)	Cost (MCr)	Size Modifier
Small	150,000	100	1.25/1.51/2.41	+9
Standard	1,200,000	225	4.38/5.26/8.41	+10
Large	7,500,000	450	14.38/17.26/27.61	+12

The first cost is for a basic berth with no roof and DR 25 walls and flooring. The second price is for the same berth with a DR 25 retractable roof. The third figure is for a high-security berth with DR 100 flooring, walls, and retractable ceiling. Berths with roofs can be considered sealed when the roofs and doors are closed.

Most starports should buy at least 5% of freestanding berths in each category with roofs, to be converted into hangars later in this design process.

Freestanding berths use underground leads from a nearby main building for power (for lighting and doors), water, sanitary sewer, and datalink. They almost always are connected to the fuel storage via underground pipes, so that starships can refuel within them. They are insulated; berths with roofs contain no life-support (unless added at Cr500 per person capacity), but will hold their temperature fairly well with the roof closed, and it will take quite some time to use up the air within one.

In a pinch, each larger berth can be used to house four vehicles that would fit into the next smaller berth. A large berth can house four starships up to 800 tons; a standard berth can fit four 100-dton starships. This is rarely done – any cargo (or personnel . . .) left lying about by an existing tenant could well be damaged during takeoff or landing procedures by another ship sharing the facility.

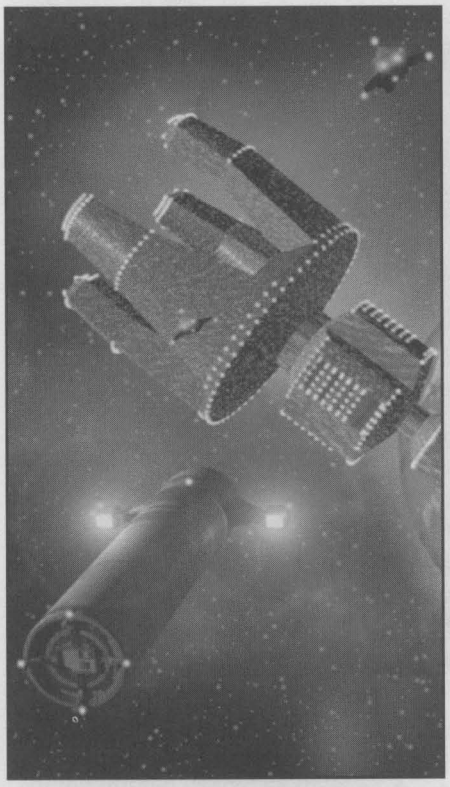
While freestanding berths are the usual style of downport starship support, they are by no means universal. Some downports feature a "dock tower," basically an immense skyscraper with spacedocks stacked one on top of the other and doors that require ships to enter and exit horizontally. (Build this as a massive passenger terminal, with all of the downports berths purchased as spacedocks in the main building.) The SPA tries to avoid this design (and the dozens of variant but similar concepts), because it makes traffic and hazard control much more difficult, but sometimes must yield to local pressures to build a more aesthetically pleasing and imposing downport facility.

Freestanding, scattered berths make traffic control as simple as it can be, and automatically isolate any flight-related disasters. Their major drawback is that same isolation – passengers and cargo must be moved from the berth to their terminals and back again. Some Imperial downports take care of this by linking each berth to the terminal(s) with large underground slidewalks. Others take the initially simpler route of providing a fleet of grav vehicles for passenger and cargo transfer. Usually, even berths equipped with underground slidewalks have personnel and cargo doors opening onto the surface, for emergencies and special cargo-handling circumstances.

A standard underground slidewalk system uses a 15′ by 15′ corridor (regardless of the size of berth to which it is attached), with a slidewalk that moves at 2 yards per

second and that is rugged enough to transport just about anything that could be placed upon it. It costs MCr0.1 per freestanding berth if the downport has 1-12 such berths, MCr0.15 per berth if 13-36 freestanding berths, MCr0.2 if 37-84 berths, MCr0.25 per berth if 85 or more berths. If each berth is to enjoy connections to each of more than one terminal, double the overall system cost for two terminals, triple it for three, etc. More often, a downport with multiple terminals simply connects each terminal with a massive array of slidewalks (costing MCr1 for two terminals, MCr3 for three terminals, MCr6 for four terminals, or MCr10 for five terminals), then connects each freestanding berth to the most convenient of those terminals. Note that the slidewalks will be used only to transport people and small lots of cargo – transfer of large cargo lots is handled by small craft and already figured into the transfer-traffic figures.

Downports with freestanding berths unconnected by slidewalks also use their existing small craft to shuttle large cargo lots, and TL10 utility grav sleds for small lots and people. These sleds carry 12 passengers or 1 displacement ton/5 standard tons of cargo, with statistics comparable to the sled found on p. 74 of ***GURPS Traveller Star Mercs***. (The larger cargo vehicles on pp. 100-101 can be substituted if there's enough traffic to justify them.) The standard sleds cost Cr50,000 each, with a crew of one driver (five drivers, total, to keep them in full-time service). The downport will need one per 3,000 displacement tons of starship served to keep people, small cargo lots, and the mail moving.



Custom berths may be constructed, generally at small private facilities where only one specific vessel (such as a noble's yacht) is expected to land; constructing, say, a 200-displacement ton berth can provide enough space savings over a 800-dton standard design as to be worth the trouble. Large berths are also constructed for specific vessels, mostly by the military; the practical limit is still 5,000 dtons. Larger vessels than this can generally call on a downport only by landing on open water.

Design a custom berth as a starship hull with twice the volume of its stated tonnage, or three times the volume if extensive freight handling is foreseen. A berth with a roof requires the MCr0.005 investment for a spacedock door, and is armored just like a starship. A roofless berth avoids the spacedock cost, and multiplies final armor cost by 0.83 (since the top one-sixth will have no armor).

Yet another alternative, at private ports and cash-tight Imperial minor ports, is the landing pad. A pad is nothing more than a paved area with minimal landing lights and a few mooring rings. A small pad costs MCr 0.25, a standard pad MCr0.87, and a large pad MCr2.87.

Starships can be landed on bare ground in a pinch. Except in the most rocky terrain, repeated landings and takeoffs will chew up the ground, rendering it useless for future landings.

Downport Example: *We decide that each downport terminal will have 5 small berths, for direct small-craft service. These take up 500 spaces and cost MCr0.025 in each terminal. The remaining 3 large, 11 standard, and 35 small berths will be purchased as freestanding berths with retractable roofs, at a cost of MCr162.49. We decide to use the underground slidewalks for moving people and cargo from berths to terminal. With 49 freestanding berths and two terminals, this costs MCr9.8 to link the berths to a terminal each, and MCr1 to link together the two terminals.*

Traffic Control

[Continued]

Class II: True traffic control is operating, with full-time staff and short-range sensors, which are usually ground-based unless the port has an orbital element. Traffic-control staff is divided into tower and ground-control operations.

These ports establish a *starport control zone* that covers the physical extent of the starport (on the surface and/or in orbit) and roughly a 10-mile radius around it in all directions other than below-ground.

The tower maintains *positive control* of all flying craft in the control zone. Positive control means that the vessel should not maneuver without instruction from traffic control. (If it does, without a good reason, the pilot will have to answer for it.) Ground control supervises all non-flying craft, from just after landing to just before takeoff.

Class III: Traffic control becomes much more advanced at this level. Staffing increases substantially, and the port operates at least three low-orbit navigational and meteorological satellites. These ports create an *airspace zone* from the planet's surface to 1/10 the planetary diameter above its surface.

The tower maintains *procedural control* within the airspace zone. Procedural control means that "lanes" are established to enter and exit port airspace, and ships with similar vectors line up for approach in these lanes. During procedural control, even if a pilot has excellent reason for maneuvering without instructions from traffic control, he *will* answer for it. The downport tower also provides weather data for surface operations.

Class IV: Staffing becomes even more extensive. The starport will operate satellites in low, medium, and high orbit. The amount of data being processed would make the job impossible for the most experienced human controller without the support of powerful computers and expert programs. These ports create a *transition zone* extending from the upper limit of the airspace zone to 100 planetary diameters. Procedural control is practiced throughout the transition zone. The airspace zone is under positive control.

Class V: This uses more satellites, even more powerful sensors, and the increased personnel and computer hardware to handle the exponentially increased data. Class V ports establish an *orbital zone* from the upper limit of the airspace zone to 10 planetary diameters above the surface; this is *inside* the transition zone but supersedes it. The tower maintains positive control throughout the orbital zone.

Navigational Aids

The Imperial Grand Survey maintains Imperial navigational charts and primary beacons (see p. T:FI10), but the SPA maintains the laws governing civilian star travel and a host of secondary navigational aids.

Continued on next page . . .

Traffic Control

[Continued]

Most navigational aids are based on satellites, generally called "navsats." Along with a powerful carrier signal, most can transmit verbal messages and respond to orders from their owning agency. Standard navsats include:

Anchor Beacons: These are the navsats maintained by the Imperial Scout Service. Every system with a rated starport will have one to orient starships upon breakout from jumpspace. Their signal incorporates a "time and date stamp," so that starships stranded in interstellar space can more easily fix their position by comparing the relative ages ofsurrounding anchor-beacon signals.

Terminal Beacons: These are the SPA's bread-and-butter navigational beacons. They often are housed on the same satellites that host the SPA traffic-control sensors.

At a Class I port, the terminal-beacon system consists of a single beacon located on or adjacent to the starport proper. Low tech, non-Imperial worlds may substitute other means of identification for a radio transmitter. This may be the only navigational aid of any kind.

Class II and higher ports will retain the port terminal beacons (one for each highport and groundport). Two additional beacons will be placed in the mainworld's orbit, one 60° ahead of and one 60° behind the main world (its Trojan points). These beacons serve to define the plane of the system's ecliptic and locate the mainworld if it is on the far side of the system's primary.

Additional terminal beacons are possible – for example, in orbit near a gas giant designated for fuel skimming.

Global Positioning System (GPS) Constellation: These small satellites (generally 36 in low orbit, to ensure complete coverage and sufficient redundancy) provide not only position data for users on the ground, but also accurate reference data to ships in orbit.

Marker Beacons: Marker beacons provide backup identification of specific navigational points and hazards. They are smaller and lower-powered than terminal beacons, because the required range is proportionally smaller. Placement varies from system to system, but typical uses include initial-approach fix, outer/middle/inner markers on approach, final-departure fix, holding points, floating hulks in orbit, small planetoids, and restricted space stations. A Class V starport may support thousands of marker beacons in its star system.

Data/Comm

Data/Comm is usually dispersed throughout a starport, using several different and mutually redundant nodes. Even within a single department, no one node is always used, except in the case of traffic control.

Continued on next page . . .

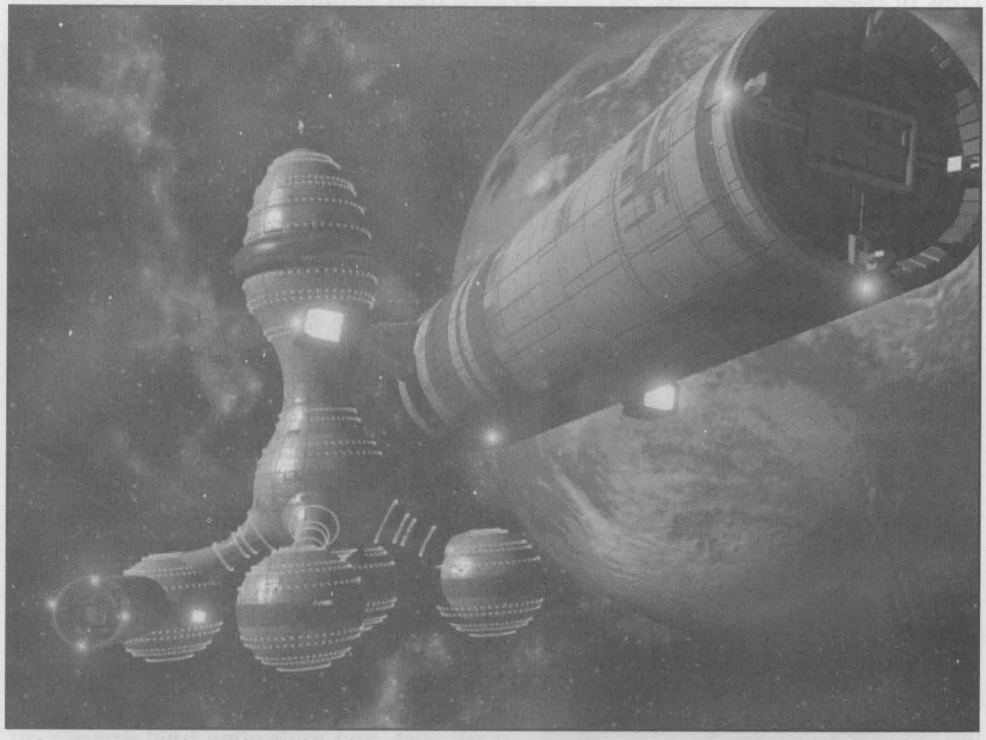
Hangars

In starport parlance, a hangar is a berth (almost always of an enclosed nature) with the necessary equipment for major repairs and refitting of the spacecraft that it houses.

For most maintenance performed in berth, the vessel requires more solid support than its own landing gear. Two kinds of external support are employed for this purpose, scaffolding and work cradles.

Scaffolding consists of lightweight but strong modular frames that can quickly be assembled under and around a grounded vessel. Small hydraulics snug them against the hull and raise the ship slightly, so that its weight is mostly or completely off its landing gear and spread around the scaffold frame. Scaffolding makes the ship very stable, and provides easy access to all parts of the hull for maintenance and repair.

Scaffolding can be moved from berth to berth, so in conjunction with a tool cart (see below) can transform any berth into a hangar. (In doing so, ease of cargo handling is strictly curtailed, since the maintenance gear takes up a great deal of space once set up. It's better to take care of offloading cargo before setting up scaffolding, then onload after the scaffolding is removed.)



It requires 15 minutes per 200 displacement tons to set up scaffolding, half that to take it down. The cost of scaffolding a ship is included in the cost of maintenance, or scaffolding may be rented by do-it-yourselfers for Cr20 per 100 displacement tons per day. A ship may carry its own scaffolding, for use either at ports or in the field.

Scaffolding costs MCr0.125 per 100 displacement tons of capacity. Stowed away, it takes up one cargo-hold space (500 cf) and masses 5 standard tons per 100 dtons capacity. In use, it takes up 25,000 cf per 100 dtons capacity (essentially half again the volume of the ship). Most ports keep enough scaffolding around to convert 10% of their internal or freestanding berths (measured by their maximum ship tonnage held) into hangars.

Work cradles are used when structural alterations to the ship are needed – anything that involves cutting or moving a bulkhead, or removal/change of primary components such as power plants or drives. These are analogous to dry docks: hydraulic frames that firmly support all parts of the vessel. They take all stress off the ship's internal structure, allowing bulkheads and load-bearing members to be relocated or temporarily removed for access.

It requires 12 minutes per 200 displacement tons or fraction to properly secure a vessel in a berthing cradle, and twice that time to release it. Its cost is included in the cost of

maintenance that requires a cradle, or starship crews can pay an extra Cr30 per 100 displacement tons per day to rent a hangar instead of a berth. (This is rarely done because they will still need the appropriate tools for such a large job, and renting a hangar doesn't include access to any SPA tools. The starship crew would have to purchase its own.)

Cradles are strictly located inside enclosed berths; they are not portable. Usually they are fitted within 5% of existing berths, spread as evenly among different berth sizes as possible. A cradle-equipped berth becomes a full-time hangar, used strictly for maintenance. (Cargo could be handled in a work-cradle-equipped hangar, but very inefficiently.) Cradles cost MCr0.25, take up 50 spaces, and mass 10 tons per 100 dtons of capacity. In freestanding berths, they simply supplant cargo-handling space.

Normally only Class IV and V ports install work cradles, and the berths so equipped are located adjacent to (and considered part of) the shipyard facilities (see pp. 80-81).

External cradles for berthing starships automatically fulfill the functions of a work cradle, except that the ship's exterior (and interior if hull integrity is not maintained) will be in vacuum. The necessity to wear vacc suits – and employ premium-salary zero-gee workers – for some or all of the job increases repair cost and time by an average 20%.

Highport Example: *Our highport can hold 95,000 displacement tons of ships in its internal berths, so needs scaffolding for 9,500 tons. This takes up 95 hull spaces when stored (and simply expands into the spacedock excess space when in use), masses 855 tons, and costs MCr11.88. The issue of work cradles is trickier, since theoretically the existing external cradles could fill all needs (though less efficiently since they're not sealed against vacuum). We decide to purchase work cradles for 1 large, 1 standard, and 9 small berths. These take up 3,350 spaces, mass 670 tons, and cost MCr16.75.*

Downport Example: *The downport needs scaffolding for 2,830 tons of shipping. This takes up 29 spaces in storage (we assign 28 spaces to the cargo terminal and 1 space to the passenger terminal) and costs MCr3.54. It doesn't appear that enough 5,000-dton ships are seeking major repairs to warrant a dedicated hangar (this makes sense given the capacities of the highport), so we purchase work cradles for 2 standard and 2 small freestanding berths. (This compensates for having no large work cradles by purchasing an extra standard cradle.) These cost MCr4.5.*

Shop Carts

For flexibility, SPA starports generally store all maintenance and repair tools in "shop carts." A shop cart is a simple grav sled about 15′ long by 5′ wide. It has a rail about 3′ high, custom-fitted to carry one each portable shops for use of the Mechanic, Engineer, Electronics, and Armoury skills. (These are stacked to about 6′ high.) The sled has no motive power; it is towed or hand-pushed to wherever it's needed. It operates for 18.75 hours on an E cell. (In practice this will be modestly lower, because technicians can use the cart's E cell to power equipment when convenient.) After unloading their tools, work crews often use the sled to maneuver heavy starship components; its maximum payload is 5.6 tons. (Note that the normal payload is 5.5 tons, meaning only very-light goof-offs can try to ride a loaded shop cart to work. This is an intentional design element . . .)

Note that a shop cart is not a true workshop – it carries the equipment required to transform any 10 cargo or spacedock spaces into a universal workshop. For jobs on external cradles, the carts are taken aboard the "job" ship and space to set up is found there.

Up to three technicians can work with each of the four kits. Jobs requiring more technicians in any of the four categories will require more shop carts.

In addition to tools, shop carts carry small parts such as fasteners and bearings, as well as a data terminal with access to standard ship plans and diagrams. The terminal also is used to order replacement parts from Central Stores.

SPA shop carts are always TL12, even at TL10 ports, to support all customer needs. Loaded with the portable shops, they cost MCr0.03, mass 5.66 tons, and take up 1.5 cargo spaces each.

Class III starports and above should have at least one shop unit per 2,000 dtons of starship serviced. P/Is have no maintenance, and P/IIs usually have one shop cart and one crew who may or may not be on duty at any time.

Traffic Control

[Continued]

Traffic control almost always boasts the best data/comm in a starport, maintains its own node shared with no one, and only switches to other data/comm linkages should its own suffer catastrophic failure.

Navigational Aids: Anchor or terminal beacons have a range of 100 million miles, and require 0.5 dton, 3 ston, and MCr1.3 each. Marker beacons have a range of 50,000 miles each and come in sets of 20, for MCr0.13 (volume and weight are negligible). A complete GPS constellation costs MCr2.6, takes up 0.5 dton and 0.6 ston as cargo, and must be replaced or re-seeded every 40 years (although some worlds have stretched it well beyond a century, with all of the accompanying problems that diferred maintenance causes). These items are generally provided and maintained by the IISS, who are then reimbursed from the SPA construction budget.

Retail Sales/Services

All ports of Class III and larger have some kind of retail area, usually operated by concessionaires (see p. 21).

The variety of consumer goods and personal services available at a major starport could take pages to list, without much practical purpose. Adventurers do not need to be impressed by the number of retailers in the shopping concourse; they want to know if the particular item they need is for sale.

General guidelines: At a P/V, or P/IV with significant passenger traffic, any consumer item one would expect to find in a shopping mall should be readily available: clothing, luggage, souvenir goods, and so on. From a GM's standpoint, the only reason to deny a character an item is if its lack affects the story. Unusual or rare items – multi-carat diamonds, Sevruga caviar – might cost several times their "normal" prices, especially far from the world of origin.

At a minor port, the necessities of life will be available (occasionally at inflated prices), as well as a few luxuries (always at inflated prices, unless they are "white elephants" the retailer simply wants to get rid of). Most Class I ports have no retail sales. If port/local relations are relaxed, shops will be set up just beyond the gate. These will sell travel essentials and the planet's produce, particularly fresh food.

The availability of services, such as barbers/beauticians, luggage repair shops, and financial services, is driven entirely by customer volume. Again, a major port is likely to have everything one would expect to find at a large hotel or shopping center, while small ports might have a starline ticket office, or nothing at all. An exception is Hardlined ports (see p. 43), where service operators can turn a profit on the trade of port employees.

Parts, and the Parts That They Play

Starport retail offerings for ship's crews are limited, by necessity. A free trader's crew could end up needing any of a *million* items, and even the largest starport can't be stocked for every contingency.

For star crew who need a particular tool or replacement part, roll against Scrounging skill. If the character is in a shop of some kind, Merchant skill may be used instead. Additional skill rolls, such as Language, may be imposed by the GM as appropriate.

- If the item both is commonplace and would normally be found in this location – a screwdriver in a hardware store – success is automatic *except* that on a critical failure, they've "just sold the last one" (which may lead to a chase after whoever bought it), or the last one on the shelf will turn out, later, to be defective.
- If the item is slightly rare or unlikely – a nonconductive 3/8″ Torx driver, or a screwdriver in a grocery – an ordinary success is needed. Both conditions at once put the roll at -2. Critical failure has the same effects as above.
- If the item is exceptionally rare – the *exact* hydraulic door actuator for your 50-year-old scout ship of unknown origin and modifications – a critical success is necessary, and don't even bother rolling if you're not in a service station, or at least a junkyard.

Naturally, the GM may always simply say, "Here it is," or "Nope, nothing like that 'round here." And search rolls should always take into account the plot *function* of the item, by which we don't mean driving screws.

As an example, suppose the party needs to cross a wilderness to continue their adventure, but their ATV has broken down, and they need a new steering linkage to get it going again.

If there's no other way to make the trip, the part is *essential,* and they'll eventually have to be given one, though it could cost a fortune, or require a subadventure.

If there's alternate transportation, by horseback or TL10 river sandals, the part is a *convenience,* and the GM may allow a die roll to find one; this is why characters have skills to use, after all.

Continued on next page . . .

Tools disappear easily. Most starports store shop carts in main buildings, taking them out to remote freestanding berths only on demand.

Highport Example: *The highport requires 93 shop carts, which cost MCr2.79, mass 526.38 tons, and take up 140 cargo spaces. (These cargo holds will be in addition to those designated earlier.)*

Downport Example: *The downport needs 15 shop carts, of which one will be stored at the passenger terminal and the remainder at the cargo terminal. They cost MCr0.45 and require 2 cargo spaces at the passenger terminal and 21 spaces at the cargo terminal.*



The Shipyard

Most major Imperial ports include commercial shipyards. These can build new small craft, non-starships, and/or starships from scratch. They also can supplement the starport's work-cradle-equipped hangars (see pp. 78-79) in serving as depots for major repairs.

Total shipyard capacity in displacement tons usually is equal to weekly trade tonnage divided by 12 at Class IV ports or 8 at Class V ports, then rounded up to the next standard hull size where applicable. Starports sharing a system with a naval base often have double this capacity, or more. The shipyard can produce one vessel at its capacity size per year, or any combination of smaller vessels totaling that tonnage in a year's production. In wartime (or other emergencies), this capacity can be extended by 50% at double standard employment, and used to accommodate military vessels.

Most SPA ports maintain coordinated shipyard facilities at both the downport and highport on host planets of TL10+. The downport specializes in ordering fabrication and parts from local resources, and building smaller ships. The highport orders and distributes any imported parts, and builds the unstreamlined and larger hulls. On lower TL worlds, the shipyard often is concentrated at the highport, since most parts must be imported anyway.

Stocking jump drives is the most costly aspect of shipyard operations. Class IV ports usually do not undertake this expense, and cannot build jump-capable starships.

Non-starship shipyards take up 5 spaces, mass 5 tons, and cost MCr0.2 per dton of capacity. Shipyards capable of producing jump-capable starships take up 6 spaces, mass 6 tons, and cost MCr0.3 per dton of capacity. This includes a spacedock (usually one vast space in which several smaller hulls can be worked on simultaneously if need be), work cradles, and tools. The mass, but not cost, of a proper parts inventory is included. (The cost of parts can be ignored as part of the production cost of goods.)

Since starship construction averages only a 5% profit margin on a rough ship price of MCr0.2 per dton, the average Class V shipyard takes 78 years to truly pay itself off if one anticipates a 3% rate of return on investment. Therefore, few private concerns find themselves attracted to the industry.

Example: *Mertactor starport probably could import many parts from its TL9 host world, thus justifying a downport branch of the shipyard, but we decide to go ahead and place the whole facility in the highport. (Mostly because our theme of old and cramped is filling up our downport buildings more quickly than our highport.) Together, the highport and downport service 213,300 dtons per week, so the shipyard should have a capacity of 17,775 dtons. Going with our theme of being a bit behind the times, we round down to 15,000 dtons, instead of up as would be standard. As a Class IV port, Mertactor will be limited to building small craft and nonstarships (perhaps 150 100-dton shuttles per year, perhaps 18 800-dton lighters, or any combination totaling no more than 15,000 dtons). The shipyard takes up 75,000 spaces, masses 75,000 tons, and costs MCr3,000.*

All worlds with sufficient population and TL are capable of constructing space vessels without a dedicated shipyard; production costs and time are doubled.

Runways

A small craft or starship could be loaded past the point where it can perform true vertical takeoffs or landings. This condition would require a runway for landing at or leaving a downport.

The SPA does not place runways on its downports – ships that don't have full control over their motion are considered far too dangerous to be flying about. Overloaded ships that must reach the surface usually have their cargo offloaded in orbit to make them light enough to perform a vertical descent. For extreme cases, the Starport Authority or local government might maintain a runway in a remote area somewhere, since cases this extreme tend to be emergencies and should be isolated. This runway will usually be very long. Given their designs, once a starship requires a runway, it rapidly requires a *lot* of runway!

Low-tech worlds usually have several airports close – but not *too* close – to the Imperial starport, but this traffic will not be allowed to fly over the starport itself.

Downports do usually have taxiways, to control ground traffic of ships that need to switch berths for whatever reason. (For instance, routine maintenance might reveal a bigger problem, requiring a starship switch from a standard berth to a fully outfitted hangar.) If present, taxiways are assumed to be paid for in the general improvements bought when paying starship hull costs for the ground buildings of a starport.

Maneuver Drives

Downport buildings cannot have maneuver drives. SPA policy is split on the utility of providing highport maneuver drives. A drive providing 0.001 Gs to 0.01 Gs of thrust can be useful for station-keeping. Otherwise, tugs must be used for this task. About two-thirds of Imperial highports feature their own maneuver drives, and most of those being built currently also incorporate them.

Example: *Mertactor's highport does have its own maneuver drives. Figuring that the port will end up massing about 1 ton per displacement ton, or 500,000 tons, we decide to give it 5,000 tons of thrust. Installing 125 spaces of maneuver drive provides this. The drives mass 425 tons and cost MCr20.*



Parts, and the Parts That They Play

[Continued]

If it is the GM's intention that the players cross the plains on foot, or by oxcart, or some other mode less comfortable and speedy than their ATV, the part is a *plot device*, and may simply be declared unavailable. ("You're 8 parsecs from the nearest drop-forge.") Or the price can be set sufficiently high that to pay it takes the story in an unexpected, but interesting, direction. ("I'll take you to a parts stash for all those laser carbines. Folks like you oughta cope without all that firepower.")

There's nothing wrong with allowing travelers to spend all their liquid assets on Stuff, especially since the GM is the ultimate arbiter of whether the Stuff is ever of any use or not. But remember that, just as a disadvantage that doesn't impair the character in play isn't one, a plot obstacle that can be overcome with an item from the ship's locker isn't one, either. And if it can be solved with a cash transfer, it doesn't count unless those credits (which are imaginary to begin with) could have been used for something just as important, like the overdue payment on the starship mortgage.

The Plumbing Factor

Some people find science-fictional restrooms fascinating, possibly because it's an intrusion of the alien into the extremely familiar, and possibly because it seems both a rather naughty and absolutely necessary topic.

Beyond the issue of Just What Do They *Do* In There, interior design for nonhumans extends to everything: lighting, chairs, corridor widths. This could be handled abstractly by the following rule: If a port routinely serves more than three major races, add 5% to the construction cost of all public facilities. This automatically applies to all Class V ports.

Staff Shortages

A port director (Imperial or otherwise) under pressure to reduce costs may decide to cut staff. This can lead to disputes with the laid-off workers (and their union, if any), and, unless the reduction is in response to a drop in traffic, service will suffer eventually.

Customer relations personnel tend to be the first to go, which means that the remaining ones get overloaded, tired, and unpleasant. The job may be taken over by someone from another office who still has that work to do, in which case they tend to go straight to unpleasant with no transition time. Staff providing "comforts," such as cafeteria workers, often go early, which spreads the grouchiness rapidly through the entire workforce.

Administrators traditionally get to hang onto their jobs through a lot of belt-tightening. Sometimes this is for just the reasons you might expect, but it is also true that the paperwork and incoming comms can't be reduced by executive order, and an operation paralyzed at the top is just as stuck as one that's run out of fuel.

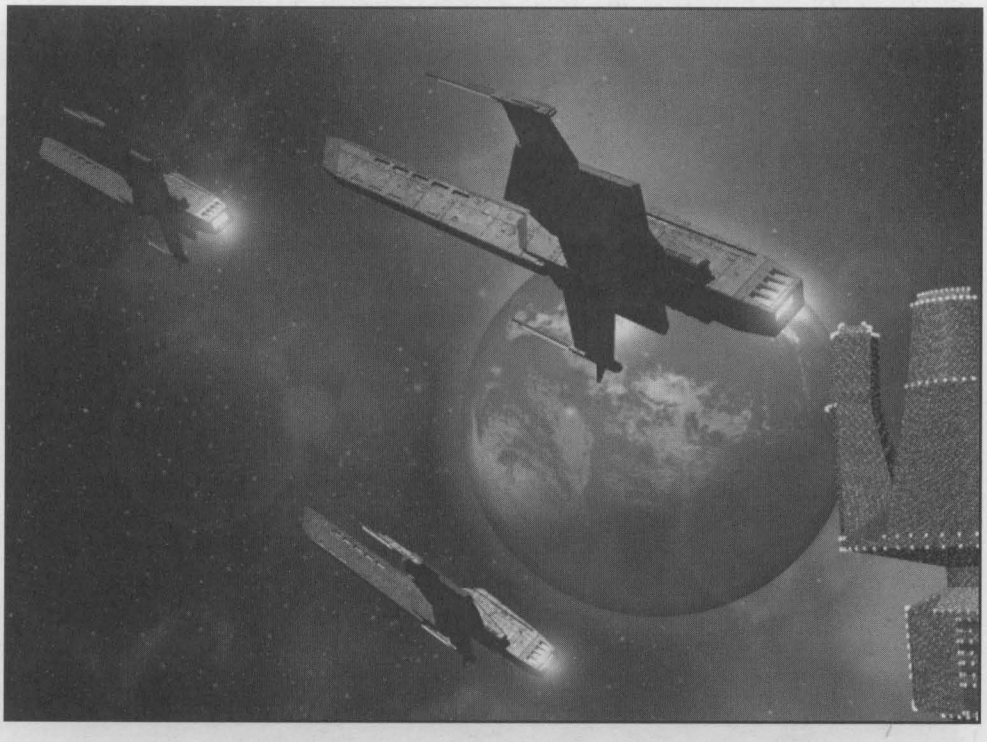
Ship mechanics can usually hold onto their jobs, for two reasons: Servicing is a key source of income for the port, and laid-off technicians are likely to hop the first ship to someplace with an opening, and may not be replaceable when times improve.

This is a second reason for labor shortages: a lack of properly trained personnel, especially in the technical trades. SPA can usually ship in enough brevet executives to cover any emergency, but there are only so many certified ship mechanics to be had.

Sometimes a shortage is due to industrial action. The issue of strikes, and of strikebreaking, may not be something GMs and players wish to deal with, but it can create unusual problems for travelers who thought they were just passing through. (See also *Union Dues* sidebar, p. 31.) Striking mechanics will probably not interfere with a ship's crew who do their own maintenance in a berth – the quarrel is with the port, not with them – but it may call for some polite explanations ("No, this is *our* ship.") and negotiations ("We don't have the right tools. We'd rather not rent them from the port while you people are out. That means we've got to buy them from somebody. Do you mind that?").

Sickbays

SPA ports feature complete medical facilities for port personnel and passengers alike. A sickbay module should be installed for at least every 1,000 weekly passengers and employees housed at each highport or downport building (round up). On worlds with limited medical resources, the SPA often will install larger sickbay complexes in its ports.



Highport Example: *Mertactor's highport has 3,000 employees serving 8,200 passengers weekly. It needs 12 sickbay modules taking up 12 spaces, massing 9 tons, and costing MCr1.92.*

Downport Example: *We decide to split the downport employees roughly evenly between the cargo and passenger terminals, with 1,500 in the cargo terminal and 1,215 in the passenger terminal. (Even though far more cargo comes through than passengers, passengers require a great deal more service, and many of the administration offices will be in the passenger terminal.) The cargo terminal needs 2 sickbay modules, taking up 2 spaces and costing MCr0.32. With 1,215 employees and 8,200 passengers, the passenger terminal needs 10 modules, taking up 10 spaces and costing MCr1.6.*

Utilities

Purchase these normally for highports, as well as downports that need to improve gravitational conditions.

Example: *The highport needs 1,000 utility modules, taking up 1,000 spaces, massing 11,500 tons, and costing MCr300. With a local gravity around 0.2 Gs, the downport (at least the passenger terminal) could stand to have utility modules as well, but we decide the need doesn't quite justify the expense.*

Meson Screens and Nuclear Dampers

Highports and downport buildings often have nuclear dampers installed, even if the last armed threat to the facility took place a century ago. The dampers work just as well against radioactive HAZMAT incidents as they do against warheads.

Meson screens are less common – an effective DR for installations as large as a highport would cost a great deal – but the Starport Authority has been known to justify the expense at certain key ports in the Spinward Marches. A common cost-cutting measure is to install meson screens for just critical nodes at the port.

These systems can be installed even at TL10 ports – the SPA retains access to TL12 components even when building at a lower TL, of course.

Highport Example: *Mercator can't really justify the expense of meson screens; each point of DR for the highport would cost about MCr0.26 and there's little cost-effectiveness in buying less than thousands of points of DR. We do install nuclear dampers, taking 1 space, massing 10 tons, and costing MCr4.*

Downport Example: *One nuclear-damper module protects a 10-mile radius, more than enough to cover all of the downport grounds. We install it in the passenger terminal at a cost of 1 space and MCr4.*

Vehicle Bays

Ports don't often incorporate vehicle bays; flexibility usually proves more important than saving space. Still, a major port built in an area with very regular starship schedules could realize substantial space savings by building custom bays rather than berths for regular customers.

More often, corporate tenants will sign a long-term lease for a given amount of space at the highport, then convert it to vehicle bays custom-fitted to their own craft. Starship lines with uniform fleets can enjoy substantial savings in port expenses using this strategy.

Example: *Neither the Mercator highport nor downport utilizes vehicle bays.*

Lab Modules

SPA ports rarely have any use for these, but other varieties of port may install vast laboratory complexes.

Example: *Neither the Mercator highport nor downport has lab facilities.*

Cockpit Systems, Low Berths, Jump Drives, and Passenger Couches

None of these starship and small-craft components usually have any place in a starport facility. Theoretically, a highport could mount a jump drive, but the practically nonexistent need would never justify the expense.

Naval highports sometimes incorporate great banks of low berths full of "frozen watch" personnel in times of crisis.

Stores and Supplies

Parts and logistical support for an entire year cost 0.5% of total starport revenue, and require 1 cargo hold (that will mass 1 ton when filled) for every MCr0.02 in value. These stores may be spread in any ratio among the port's various highports and downport buildings (to fill odd spaces that may begin creeping up at this point in the design process), though every installation should have at least 5% of the storage to fill immediate needs.

Example: *Mertactor's port needs MCr1,143× 0.005 or MCr5.72 in stores and supplies that will take up 286 hold spaces. We place 15 spaces worth in each of the highport and downport passenger terminal, with the remainder at the cargo terminal.*



Duty Free

"Duty free" shopping has puzzled travelers for centuries. It can be an outrage to buy a dozen bottles of good liquor on a trip only to be charged import duty on arrival at home.

What "duty free" means is that since the goods are intended to be consumed or used outside the country in which they are sold – indeed, they are only for sale to people who can prove they are about to leave the country – they are exempted from local use taxes. In many cases, the goods originate in another country, but since they have only been brought to the port, no import tax has been paid. In theory, this results in a lower price than the buyer would have to pay at retail.

Duty-free stores exist where local taxes (or outright bans) make them profitable. This is a matter both of the tax bite and the type of demand. If there is a 30% planetary luxury tax on fine wines, a portside store can sell bottles to departing travelers at the base price, or even 10% above, and do good business. This presumes that the wine will be drunk on the trip. If the tax were on, say, cameras, an item popular with leisure travelers, one would sell them only to people not expecting to return to this world – since local Customs would charge the tax anyway when the tourist got home. (The storekeeper might, of course, allow the tourist to buy the "cheap" camera without mentioning the homecoming surprise.)

There is no special advantage to duty-free shopping on worlds without import duties charged when leaving the port; thus they are never found on Imperial worlds.

Duty-free stores are usually owned by planetary locals, as most worlds do not charge import duty on money (corporate taxes are another matter). Others are run by interstellar, or at least off-world, corporations. Non-Imperial ports often operate duty-free for their own benefit (resulting in the curious situation of a government profiting from both its high import taxes and helping people to evade them).

The people who get the most out of duty-free shopping are starship crew members, who may go for years without ever crossing an XT line.

The Life of a Starport

Starports undergo a maturing process, reflecting the growth of the surrounding city, from an initial colony to a well-established facility with a history. This is true regardless of the size and type of port. This evolution follows five distinct stages; separate sections of the same port may be at different stages at the same time.

Development

When the starport is new, it has a raw, open vitality like nothing else. Every facility is either temporary or newly built, and construction is constant. People have to improvise and make do until full capabilities come online. Colony worlds grow up around the first (main) starport; the port city dominates growth in the early years and usually becomes the planetary capital in the end. The town outside the gate, therefore, is as raw and new as the port – entertainment is bound to be a little rough (the beginnings of Startown), but essentially open and not entirely unhealthy. This phase itself is temporary, but may be repeated in part at the groundbreaking of each new facility.

Maturity

As the city grows up, so does the starport. Construction is completed; eventually berthing capacity becomes saturated. The center of commercial and social activity in the city moves away from the old core around the starport. Outside the gate, the city gives way to purely starport-oriented businesses: warehouses, chandlers, freight consolidators, and an expanding Startown. The tone of the starport is businesslike and work proceeds with the utmost concern for efficiency. This is a stable phase, and many starports remain at their peak for centuries.

Decay

Eventually, the starport passes its peak. Perhaps demand exceeds the capacity to meet it, and a new facility is built, farther out from the city center. As the port ages, perhaps it becomes more economical to open a new facility than to continue to maintain the old one. Perhaps public perception of the port as seedy and run-down simply turns into self-fulfilling prophecy, as the former business of the port goes elsewhere. In its place come the marginals: old freighters, looking for a break on berthing costs; free traders who can no longer compete with the big liners at the main ports; and those whose business can least stand the scrutiny of the authorities.

Continued on next page . . .

Public, Staff, and Commercial Space

To this point, the port has everything it needs except "people space" – the facilities for passengers, SPA staff, and commercial tenants to go about their business. We'll add the essentials first, then leave the remaining space (if there *is* any remaining space, in the case of our cramped example port) for additional commercial exploitation.

Concourses

Concourses are the large passageways through which passengers move to reach their shuttle's or ship's gates, the nearest restroom, the baggage claim, etc. They tend to have high ceilings and are lined with rented-out retail outlets (bars, snack bars, newsstands, etc.). They also include departure lounges, though most passengers immediately board their ship and begin unpacking prior to departure. (Starships can't wait till the last minute to board everyone.)

Among the concessions, large starlines often have lounges reserved for the exclusive use of their passengers. All major ports have a VIP lounge for the use of any passenger requiring additional security: nobles, politicians, or sometimes criminals in custody.

Use the plaza habitat module (see p. 103) to represent concourses. Each major port should have 1 concourse per 5,000 weekly visitors, rounding up. (Alternatively, the GM may install fractions of a habitat module.)

Minor ports usually do not have concourses. They instead install 1 empty space (500 cf) per weekly visitor, representing hallways, probably a single waiting area, etc. Any retail presence will have to be installed individually for a minor port (whereas major ports can assume a certain number of shops are provided for in each concourse).

Highport Example: *Serving 8,200 passengers per week, the highport needs 2 plaza modules, taking up 20,000 spaces, massing 60,000 tons and costing MCr2.*

Downport Example: *Here's where our outmoded buildings begin to show their age. The passenger terminal doesn't have enough room left to fit the 2 concourse modules that it should have. For now we won't bother installing a fractional module; we settle for just one (leaving our downport passengers jostling elbow to elbow at the moment, but see p. 86). It takes up 10,000 spaces and costs MCr1.*

Offices and Work Areas

Every starport has a substantial percentage of administrators, many of whom only work the local equivalent of the "9 to 5" shift and leave an untended desk during other shifts. In addition, these modules suffice to represent more general work areas – employee cafeterias and dining halls, Security wardrooms, janitor's closets, and whatnot. In all, each major building must have 1 office module (see p. 103) for every 10 employees on site, including flight personnel,

Highport Example: *The highport employs 3,000, so it needs 300 office modules that take up 1,200 spaces, mass 1,062 tons, and cost MCr5.4.*

Downport Example: *We divided our downport employment pool into 1,500 at the cargo terminal and 1,215 at the passenger terminal on p. 82. The cargo terminal needs 150 office modules taking up 600 spaces and costing MCr2.7. The passenger terminal needs 122 taking up 488 spaces and costing MCr2.2.*

Equipment

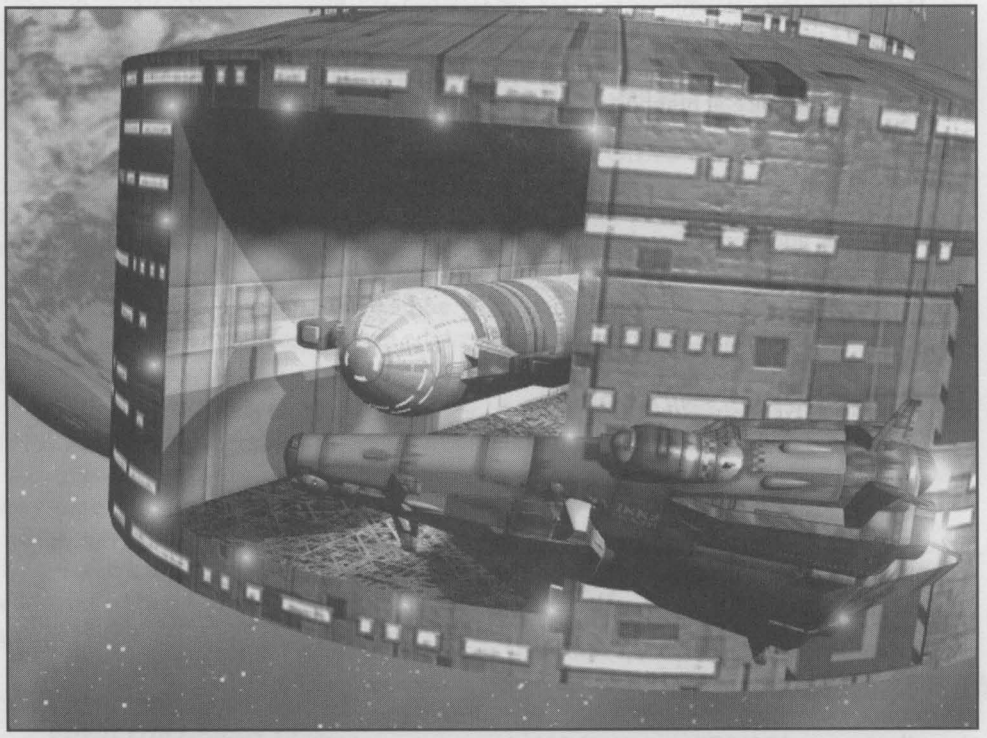
Starport staffs need the right equipment to do their jobs, from autobrooms for janitors to grav cruisers and sidearms for Security. Several examples of this gear can be found in Appendix A. Some equipment already has been purchased – most notably the small craft and non-starships needed to conduct starport business, and the tools port mechanics need to service visiting starships. Some equipment can be assumed to be present with the appropriate modules, but other examples won't be. For instance, a sickbay module will include "crash kits" and staple medical supplies, but a cargo module doesn't include a forklift.

Rather than catalog each additional item needed, the GM should spend 50% of annual revenue on general equipment. It has no volume, being stored in the already

purchased work areas when not in use. (For grav vehicles, work area becomes converted into a suitable berth area as appropriate.) Much of the heavy stuff (grav vehicles in particular) will be at the downport, so highport mass increases only 1 ton per MCr2 spent.

The GM may feel free to purchase actual inventory items from this fund, should he desire. Beyond this book, ***GURPS Traveller: Far Trader*** in particular describes useful stuff, as do the two ***Ultra-Tech*** books.

Example: *The Mertactor starport spends MCr571.5 on general equipment. This increases highport mass by 285.75 tons. All of the exoskeletons and ambulances, cookpots and laser pistols, will have to come from this fund.*



Detention Cells

Some starports will have cells for unruly patrons; some don't bother, contracting with local authorities to hold arrested personnel. Any existing cells are purchased as brig modules (see p. 103).

Example: *The Mertactor highport has two cells (8 spaces, 22.8 tons, MCr0.1).*

Housing

Highports that house staff (or others) on the grounds must provide housing. Most starports offer apartments purchased as starship staterooms at 8× normal volume. Starports with tight space offer small apartments treated as staterooms at 4× normal volume. Most downports, and those highports that can afford it, offer housing purchased as a housing habitat module (see p. 103) and are *very* popular with veteran SPA personnel.

Example: *The Mertactor starport includes no housing.*

Parks

Well-funded starports might offer a park to relieve traveler stress and anxiety. These are purchased as park habitat modules (see p. 103). Downports need not use interior space for the park unless on a hostile world.

Example: *The starport has no parks.*

The Life of a Starport

[Continued]

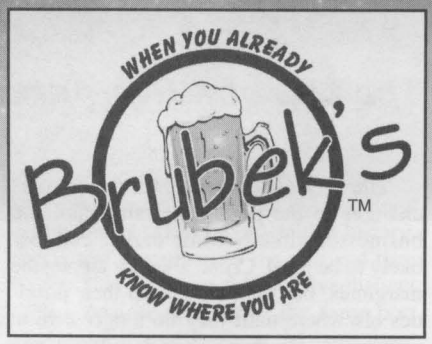
The city outside the gate reflects the changes in the port. Entertainments and businesses alike become darker and less likely to be legal. Crime abounds among the marginals, but the police keep their priorities elsewhere until they no longer dare to venture into the streets they abandoned long ago. This is the classic picture of startown, and the climax of its growth. This is also a stable state, and startowns have lasted unchanged long enough to become institutions in themselves.

Transition

Other, more legitimate but equally poor, elements move into the area eventually, seeking freedom and affordable infrastructure. Artists and students are the classic examples, but any marginal subculture might benefit. Whatever the motivation, the method is the same: Take over abandoned commercial property (perhaps even illegally, by squatting) and turn it into something new. Warehouses become studios, art galleries, and theaters; offices become funky little boutiques. The Startown begins to show a healthier side again – first at night, later in street festivals and open-air markets. As the light returns to the area around the port, the dregs move on to find the safe darkness again.

Renewal

The transition phase never lasts long – rarely even a single generation. As word spreads from the subculture to the mainstream, the investors and the imitators come. The startown becomes gentrified – the clubs and the shops are still there, but the real talent behind them is gone, driven out by rising property values, or co-opted. Now the old port receives back the life that it gave to the startown; investors restore the port, either to a facsimile of its "former glory" or to some wholly new vision. The "quaint, romantic" oldport becomes the principal passenger terminal in the starport complex. The rich and trendy board their private yachts, vacationers debark excursion shuttles from their orbiting liners, close to the new cultural center of the city. Small, general-purpose cargo vessels (read "free traders") may be diverted to the oldport when pads at the new commercial terminal are filled with larger (and more profitable) customers. This final stage may be stable as well, or may be followed by successive cycles of decay, transition, and renewal. This is especially the case when there are two or more competing "oldports."



Brubek's: "When You Already Know Where You Are"

Brubek's is a chain of starport taverns, located in Class V, IV, and a few III ports. Of the 200 units, half are in Solomani space, 20 in the Sword Worlds, and the rest scattered through the Imperium.

Along with food and drink, Brubek's sells familiarity. Every unit looks just like every other: same decor (dark wood, leather, and brass), same view (a holographic panorama of a Generic Big City by Night, on the wall to the left of the front door), same menu, same bottles behind the bar. It is a recreation of a romantic ideal . . . a neighborhood joint from the near-mythical pre-spaceflight days of Old Terra. Even the floorplan is always the same (see p. 87). The only difference is that some high-traffic locations get a slightly bigger Brubek's; the "modular expansion section" in the middle is repeated once or twice. Each module adds about 14′ of depth, giving room for four more tables and four more booths. But no Brubek's is ever *very* big. Behind the scenes, things will look different; the manager's office and the warehouse must fit into whatever space is available. Sometimes there's even a private room for very favored customers, maybe even with its own unmarked exit to the spaceport concourse. But most regulars not only don't know that, but wouldn't believe it unless they saw it.

All but a few of Brubek's employees are Human, and most of those are Solomani. There is no rule about this; it just reflects the "homeworld bar" nature of the place.

Brubek's brews its own beer (light, amber, dark, and porter) and ships it as a relatively stable concentrate. Patented machinery ensures precise reconstitution on-site; the device is backed up by the regulars (and Brubek's only has regulars) who know what the beer is supposed to taste like and will let everyone around know if it's "off."

The menu is basic: burgers with the usual options, skin-on fries, onion rings, and "bowl of red" chili (mild, hot, and fusion-core). There's also a green salad, but they don't serve many of them.

The clientele is mainly Solomani, with some other Humaniti and a number of Vargr (not surprising, given all that red meat).

Continued on next page . . .

Commercial Space

At this point we've completed our official needs for the starport. Whatever space is left will be available for tenants' commercial usage. Normally, this will be between 20% and 40% of the volume available in the highport hull and downport buildings.

If they wish, GMs can stop here, and assume an additional 2 stons highport mass per dton of commercial space. Or they can go ahead and figure out what commercial services are offered. Regardless, the SPA won't be paying the improvement costs, so the only concerns are volume and (at highports) mass.

Some common tenants and design notes about them:

Hotels

Hotels purchase starship staterooms, at 4× normal volume for standard fare, 8× normal volume for luxury suites, or half for slotshops. They may add bars, restaurants, conference rooms, swimming pools, etc. from the selection of modules on pp. 103-104. Hotels usually only rent space at highports, preferring to locate just off the downport site.

Warehouses

The SPA already offers long-term leases on the hold space already installed at each port, but additional freight storage taken from the commercially available space is not unknown. This usually consists of hold spaces and maybe one or two office modules. Particularly secure installations may add extra-tough walls and security systems; just add an appropriate mass (to represent the extra armor) to the highport mass.

Theaters/Entertainment

Stages and auditoriums may be purchased (and pooled if need be) on p. 104.

Factories

The SPA rarely places factories in its starports, other than shipyards, but many tenants do. The tenant would purchase these as factory habitat modules.

Highport Example: *The highport has 43,229 of its 500,000 spaces remaining. Hotel rooms numbering about 1,000 beds would be in order, so we add 900 standard rooms (14,400 spaces, 2,160 tons) and 100 luxury suites (3,200 spaces, 240 tons). A 10-module swimming pool (70 spaces including the precautionary spacedock modules described on p. 104, 270 tons) and 500 theater seats (100 spaces, 10.5 tons) will help entertain the guests. A factory habitat module (10,000 spaces, 50,000 tons) leased by a local consortium allows zero-gee manufacturing. An additional plaza module (10,000 spaces, 30,000 tons) will be dedicated solely to use as a shopping mall. The remaining 5,459 spaces will be rented out to the odd private shuttle service, warehouser, etc.*

Downport Example: *The cargo terminal has 3,087 spaces remaining and the passenger terminal 3,473. We decide that a single tenant has a partial factory habitat module installed at the cargo terminal, under a sweetheart deal agreed to by the local government to make duty-free export goods for Imperial Navy purchase. The commercial space in the passenger terminal will be filled with a partial plaza/concourse module, meeting some of the public-space needs we shortchanged on p. 84.*

Non-SPA Starport Needs

The proportions of various components in this chapter will vary at other starports, such as naval or scout bases, and some equipment not normally seen at commercial ports will be in place (see the modules list on pp. 103-104 for examples). The GM should freely adjust ports' contents to reflect their mission.

Step 9 – Proof Design vs. Budget

The starport does not need to meet its budget precisely, though any port well out of proportion to its budget will be a strain on SPA resources. Those under their budget will be a welcome relief, though one too far under suggests that it is underserving its system.

Example: *The Mercator highport ended up with a cost of MCr8,602.63. (And, incidentally, a mass of 479,095.53 tons.) The downport cargo terminal cost MCr46.57 and the passenger terminal MCr107.13. Various small crafts, non-starships, and other general expenses cost MCr2,496.95. The total is MCr11,253.28, or GCr11.25. Since our construction budget was GCr14.29, we're well under – but a major port on a relatively low-tech world* ***should*** *be well under, because it'll have to subsidize the same size of port on a higher-TL world.*

Step 10 – Allocate Personnel

Now that the physical port is finished, personnel can be distributed among the various departments. In doing so, usually the crew requirements for starship modules can be safely ignored – port personnel assigned to that function will greatly exceed the numbers given for safe starship operation. Still, these can be referenced as minimum staffing numbers should conflicts arise. Staffing can vary considerably, but in general each department has the following percentages of personnel:

Administration 8% (Executive 1%, The Line Office 0.5%, Concessions 1%, Legal 0.3%, Financial 1%, Personnel 1%, Labor Relations 1%, Records and Data Processing 0.2%, Public Relations 0.3%, Commercial Liaison 1%, Military Liaison 0.1%, Employee Residence 0.1%, and Contracting 0.5%).

Traffic 10% (Traffic Control 6%, Ship Registrar 0.3%, and Vehicular Control 3.7%).

Ship Services 25% (Berthing 1.5%, Fueling 0.5%, Stores and Provisioning 2%, Maintenance and Repair 4.5%, Housekeeping 1%, Certification 0.3%, Hiring Hall 0.2%, and Shipyard (if present) 15%).

Cargo 20%(Freight Handling 15%, Warehousing 4.5%, HAZMAT Storage 0.1%, Brokerage Office 0.3%, and Special Handling Unit 0.1%).

Passenger Services 12% (Hospitality 0.1%, Passenger Assistance 0.1%, Baggage 10%, and Passenger Transport 1.8%).

Security 2% (Tac teams vary widely and aren't often full time; Customs is separate service).

Medical 0.5%.

Emergency Services 0.5%.

Flight Operations 10%.

Physical Plant 12% (Engineering 5%, Power 2%, Data/Comm 1%, Transport 1.5%, Central Stores 1.5%, Commissary 0.5%, and Housekeeping 0.5%).

Example: *We can spot-check some numbers given what we already know of needs from our staff of 5,715. We've already kept a tally of flight crews, since they're best kept track of as the various small craft are purchased. We needed 485 personnel for transfer craft, 30 for employee shuttles, and 35 for the oiler that services the downport, for a total of 550 people. Comparing that to the formula's 10% of 5,715 suggests 572-550=22 personnel maintain the fuel blimps that supply the highport, which may be a bit low. Our nine traffic-control modules average needing six people each ×5 for full-time operation, or 270 people. The formula gives us 343, so 73 probably could be used elsewhere should the numbers appear low there.*

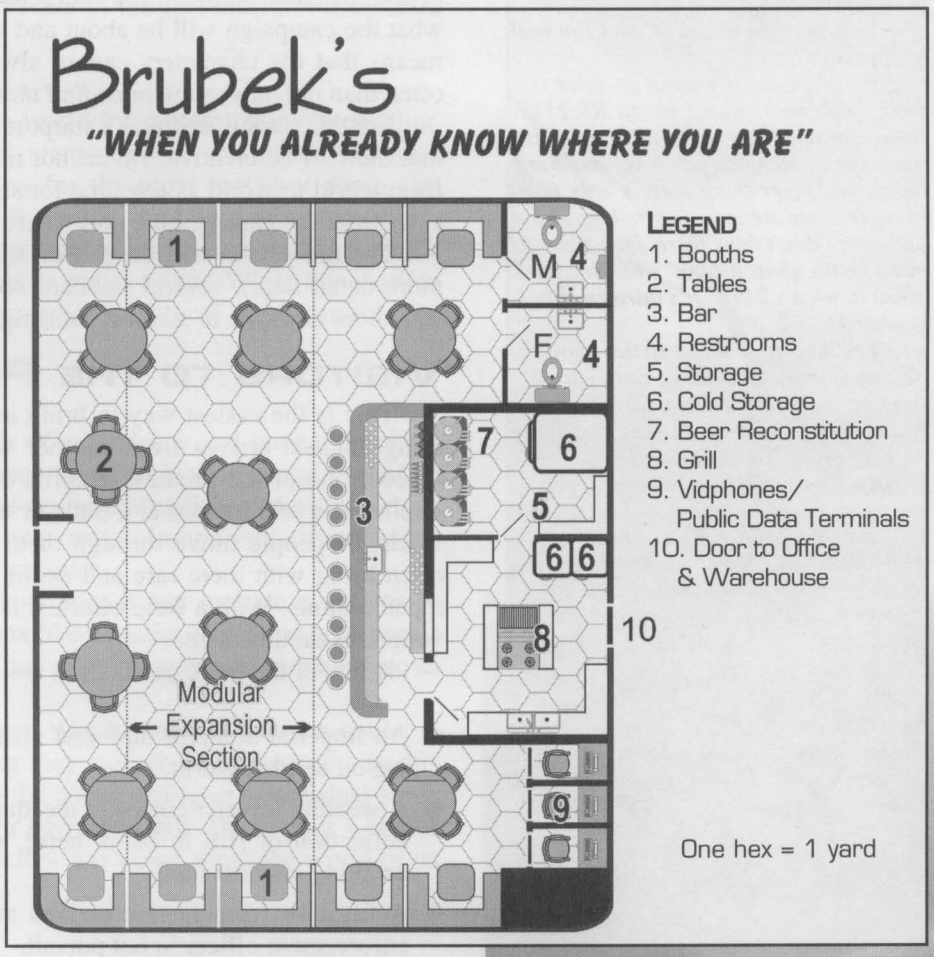
Brubek's

[Continued]

Weapons are tolerated in Brubek's, but violence is not, not even the typical starport-bar "brawling." People go there to relax; there are plenty of taverns one can visit for a fight. Lucky violators of this rule will be ejected by the staff; unlucky ones will get the bum's rush from the customers.

Because of this calm atmosphere, Brubek's is an excellent place to meet contacts or patrons. The bartenders hear a great deal of gossip – probably more than the average, since the customers feel more "at home" than at less familiar places – and while they're expected to politely keep secrets, they'll normally cooperate with legitimate investigators, or adventurers in a sufficiently noble cause.

For free traders, a contract to supply Brubek's branches (the "Brubek's Brew and Burger Bus") can be a good way to pay the bills; a typical major-port unit uses 500 gallons of beer concentrate and 1,000 pounds of ground beef a week (1 dton/month). Because of the standard nature of the units, a complete facility, including furniture, carpets, and the beer machinery ("Bek's in a Box"), can be shipped to a new franchise site in two 20′ 4C containers (8 displacement tons and 36 standard tons total).



Starport/Starship Components

Much of the following starship or small craft components will be found in use at Imperial starports.

Cutter/Modular Components

Base Station Module: This module is designed to be carried by a standard 50-dton modular cutter (see p. GT142).

One of these modules is the minimum configuration for a Class I starport. The module contains three staterooms, an office module (see p. 104), and a power/control room containing a fusion power supply, controls for landing lights and other external equipment, and a transmitter. It has unlimited endurance as long as food stores hold out. The general manager has single-occupancy quarters; any other officers take single or double as required. Unused staterooms are used for additional storage, and one may be removed for more living/working space. The other is usually retained for use by "visiting firemen" (scouts, couriers, and so on).

- **Crew:** None in flight. At least one in ground service.
- **Design:** 30-dton SL Hull, DR 100. Modules, 1 Basic Bridge, 1 Engineering, 4.5 Cargo.
- **Statistics:** EMass 47, LMass 70, Cost: MCr4.9, HP: 6,000. Size Modifier: +7.
- **Performance:** When attached to modular cutter, Accel 3.3 Gs, Air Speed 2,353.

Habitat Modules

In addition to starports, some large vessels (such as colony ships and space stations) contain large urban or green areas inside them. Each module described below is about the size of a city block and includes lighting, temperature control, air recycling, and a "slice" of power plant.

Housing

This module contains one or more apartment buildings or a few dozen houses, plus grounds, walkways, etc., providing long-term accommodation for up to 100 people (half that many in luxury, twice that many in cramped conditions).

Factory

A large industrial park, capable of operating efficiently with a few dozen workers or robots. Contains warehouses, minifacs, etc.

Farm

An acre or so of open space with a few buildings devoted to agriculture and food processing. Up to 10 people or robots can work it effectively; each worker can grow food to feed 10 people. Using crop rotation, the farm can serve as total life support (providing air, food, and water) for about 100 people.

Park

A landscaped green space, possibly with entertainment or exercise facilities (pool, stream, swings, etc.). In a pinch, it can provide camp grounds for about 100 people.

Plaza

A mall or concourse area, with about a dozen medium establishments, plus open space for several hundred people to congregate.

TL	Module	Space	Mass	Cost (MCr)
10+	Farm	10,000	20,000	0.5
10+	Factory	10,000	50,000	10.1
10+	Housing	10,000	40,000	1.0
10+	Park	10,000	20,000	0.2
10+	Plaza	10,000	30,000	1.0

Editor's Note: The habitat modules are based upon those in ***GURPS Space***, pp. 124-125. The above include "power-plant slices" to make them conform to ***GURPS Traveller*** needs, however. The relatively tiny increase in mass has been ignored, and the equally small volume requirements are assumed to be taken from existing access space. The cost of power requirements has been added where it applies.

Standard Modules

Brig: This is an ordinary stateroom equipped with reinforced walls and door (DR 200), restraints, and a high-security alarm and observation system. It normally holds 1-2 people. Up to 50 could be crammed in for a limited time, but this will overwhelm the two-person life support. A ship or starport with one or two brigs usually will monitor them from the bridge. A larger number of brigs probably will have its own dedicated security station.

Bunkroom: Bunks for 16 personnel, with life support, under very cramped conditions. Imperial protocol is to load only four passengers per bunkroom, except for missions of very short duration or emergencies.

Communications: A scout-base staple, this TL12 module contains a single massive laser communicator, with 10 million miles transmission range and 10 times that in reception. There are three hardened, high-capacity mainframe computers, 50 terabytes of hardened data storage with double backups, and an energy bank with five hours operational capacity. The module is designed for high redundancy, with the three computers all checking the others' results and the three sets of data stored in different locations. The laser communicator is used for its very high bandwidth. Even with the usual high level of encryption and error-correction on the signal, the module can upload or download its entire storage capacity in about an hour. The equivalent TL10 module has the same size and cost, but carries only 500 gigabytes of data.

External Cradle: These are placed on the hull of a starship or starport. Each module clamps 125 standard tons of another vehicle onto the hull. Modules can be combined to form larger cradles, or installed in 0.5-displacement ton increments for smaller versions. Vehicles carried this way aren't counted against the ship's internal spaces, but must still be included in any jump-drive requirements. They are not protected by the ship's armor.

Hall, Bar, or Conference Room: A large room with tables. Usable as a restaurant, bar, conference room, etc. It can comfortably accommodate 100 people per module (smaller lounges and conference rooms are included in stateroom volume). Weight and cost include furnishings.

Information Center: A TL12 high-tech military-style operations room for 10-20 people, this is often found in Imperial Navy starports. Has workstations, a sophisticated array of electronic mapping and display tables (which function as a fire direction center), plus several dozen digital cameras for video teleconferencing. The module also includes a hardened Complexity 8 macroframe computer and 10 terminals for running high-end analysis programs like Expert (Tactics), Transmission Profiling, and Traffic Analysis.

Morgue: This includes space for 20 sets of battledress and accessories such as flight packs, with room for maintenance and loading.

Office: Each office module holds four offices, with room for three visitors each, *or* 16 cubicles with no room for visitors. Includes full life-support for 16 and space for conference rooms, office-supply storage, etc.

Small-Craft Bridge Add-On: This module can be used *instead* of an engineering module on craft equipped with a basic bridge. Includes fusion-power startup, full life support for five, and a two-main airlock. The TL12 version also includes one bunk.

Stage: A 20′×20′ stage area with high ceilings, usable for dancing, plays, nightclub acts, and so on. Includes sophisticated lighting and sound systems. Normally attached to a hall or theater containing the audience.

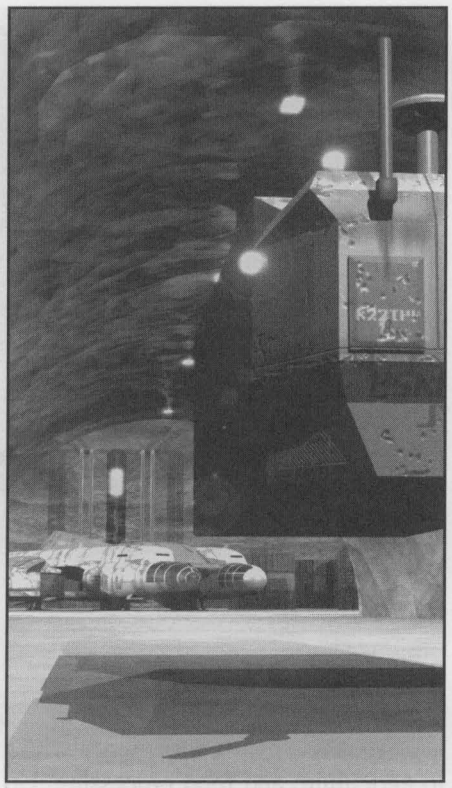
Swimming Pool: Starports and large commercial ships will often have swimming pools. Includes 100 sf of pool (10′ deep), 100 sf of deck area, and overhead clearance. Multiple modules can be combined to make larger pools. Finished design should add one spacedock module per complete pool, to contain the water in case of loss of artificial gravity.

Theater: A small auditorium with 100 roomy seats for the audience, a large holoprojector, and an operator's workstation. Can be used for entertainment, for presentations, or as a briefing or situation room. The holoprojector can be stowed, if desired, but a stage is not included.

Traffic Control: This module contains four sets of astronomical instruments, four high-resolution planetary survey arrays, a mainframe computer, eight roomy crew stations with computer terminals, and a "traffic center" with sophisticated holographic-projection devices. This allows the traffic controllers to create visualizations of incoming data.

MODULE TABLE

Type of Module	Spaces	Mass	Cost (MCr)	Crew
Brig (1-2 occupants)				
TL10	4	11.4	0.052	†
TL12	4	5.6	0.03	†
Bunkroom				
TL10	4	4.8	0.018	0
TL12	4	1.92	0.018	0
Communications	12	138.1	3.83	0-1
External Cradle	1*	12.5*	0.25*	0
Hall, Bar, Conference	10	0.2	0.003	†
Information Center	4	3	2.8	10-20
Morgue	1	28.75	0	0
Office				
TL10	4	3.54	0.018	†
TL12	4	1.92	0.009	†
Small-Craft Bridge Add-On				
TL10	0.5	1.96	0.32	0
TL12	0.5	1.4	0.16	0
Stage	16	0.5	0.004	†
Swimming Pool	6	27/1.5**	0.031	†
Theater	20	2.1	0.015	†
Traffic Control				
TL10	4	7.4	12.66	4-8
TL12	4	5.4	7.63	4-8



* per 125 standard tons of ship to be carried. External cradles count against the turret-mounted weapons limit at a rate of 3 modules per 1 turret.

** First figure is filled mass; second is empty. Should have 1 spacedock module per pool module in highport or starship.

† varies and/or GM's discretion. Many of these modules are passenger services, and usually the GM can safely rule that a ship's standard complement of stewards fulfills the crew needs. (For instance, a passenger liner with a swimming pool will require a lifeguard, but those swimmers would be requesting some other service if they weren't swimming. In terms of personnel needs, it's a wash.) In other circumstances, bartenders, actors, and such will need to be added to the standard ship's personnel, particularly on ships that normally carry only a handful of stewards.

Chapter One

Starships

Consider how often we take the parameters of interstellar technology for granted. It's true that the workings of the jump drive are so perplexing that very few civilizations have ever developed it independently. Aside from that obstacle, however, almost everything about interstellar travel is easy. Once the jump drive is known, it can be built by relatively primitive cultures. It requires no extraordinary skill to maintain or use. It can be installed in ships small and simple enough to be operated by a single crewman. Its operating costs are well within the reach even of individual entrepreneurs.

As a result, interstellar travel is within the reach of common individuals everywhere in Charted Space. We can afford to use it for the most prosaic purposes: warfare, trade in basic commodities, migration, even idle tourism.

There's no obvious reason why this had to be the case. Suppose interstellar travel cost the equivalent of billions of credits per ton-parsec, could not be accomplished by ships smaller than flying mountains, and required skills only a tiny fraction of Humans could master. History would have been utterly different – assuming that an interstellar civilization could be built at all, under such circumstances.

– Sir Shamash Thomas,
An Overview of Imperial History

Starships bind the Imperium together. Millions of starships are registered within Imperial space, carrying cargo and passengers, protecting the trade lanes, helping Imperial citizens go about their business. Most citizens will never travel from one world to another – but starship stories fill the Imperial news and entertainment channels, giving every citizen a picture of what life aboard is like. Every citizen knows *something* about the ships that carry goods and passengers, protect the trade routes, or explore new worlds. Starships are romantic, promising the freedom to travel widely, visit exotic places, take part in a millennia-old tradition, and make one's personal fortune.

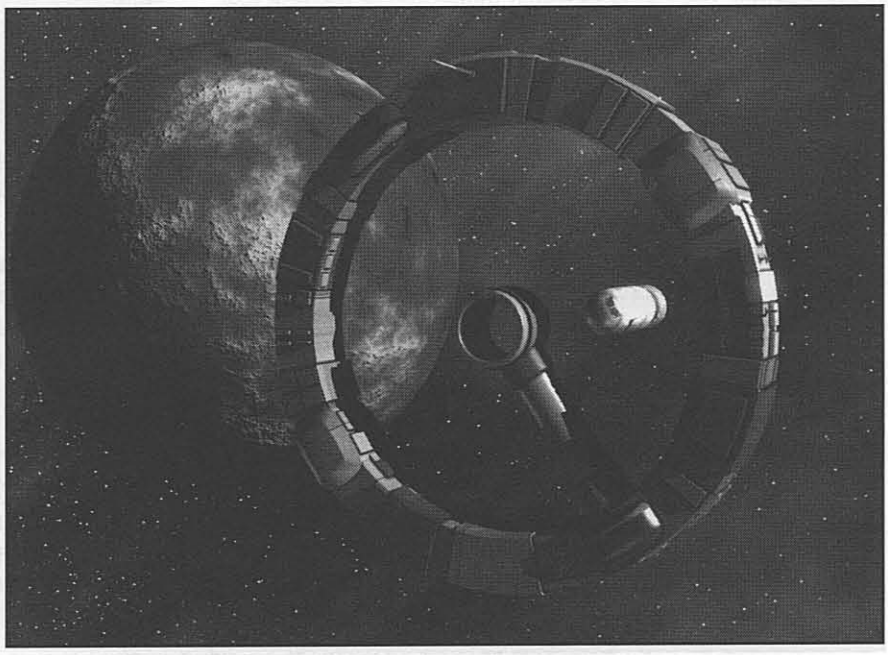
Traveller revolves around starships. Almost every adventuring party will spend much of its time making its way from one world to the next via starship. Perhaps only one member of the group will own a ship (or at least *control* it, in the case of a detached Scout). Or the adventurers may be part owners in a merchant starship. Or the GM may turn the acquisition of a ship into an adventure, making would-be starfarers earn their wings.

Adventuring without a ship is possible, but the campaign takes on a radically different nature (which some players may prefer). The focus changes from interstellar to interplanetary (or single-planet) situations, and the group tends to linger in one system or on one world. The group can take passage on NPC-operated starships, stow away, or otherwise arrange to travel from world to world – but this cannot always be done freely, at the will of the adventurers.

The Starship Environment

In ***Traveller***, a starship is defined as a spacecraft capable of faster-than-light travel. Because there is only one means of FTL travel in ***Traveller***, this specifically means any spacegoing vessel that has a jump drive. Slower-than-light generation ships can engage in interstellar travel, but are not called starships because they do not use jump drives. Such vessels are obsolete. Battle riders are large, extremely powerful ships of the line, but they have no jump drive, and thus are not starships.

A starship presents an artificial environment which spends much of its time utterly isolated from the wider universe. Crewmen and passengers coming aboard for the first time will find much of it unfamiliar, despite efforts to make it safe and comfortable.



Size Range

A starship must displace at least 100 dtons (see p. 12) in order to use a jump drive. The most common starship of this size is the *Suleiman*-class scout/courier, used by the IISS and by detached scouts throughout the Imperium and beyond. Coming in a close second is the 100-dton express boat (Xboat).

The upper limits of starship size have yet to be reached, but current theory places the maximum size of a starship between 1.5 million and 2.5 million dtons – although some engineers claim that there is no real upper limit.

Starship Structure

Every starship has a *hull*, a main body or shell which acts to contain the ship's components and payload. The hull always carries some armor to protect against meteor impact and other natural hazards. It may or may not carry extra armor to protect against combat damage.

The hull is internally divided into *compartments*, each of which contains some of the ship's components or provides space for payload. Compartments are separated by *bulkheads*, *decks*, and *partitions*. Decks are usually perpendicular to the onboard artificial gravity's "down" axis, while bulkheads and partitions are parallel to it. More intuitively, one walks on the decks and opens doors set into the bulkheads and partitions.

Bulkheads are structural elements of the ship and can withstand differences in air pressure on either side. A compartment which is sealed by bulkheads will maintain its internal environment even if there is a hull breach in an adjacent area. Bulkheads are used to surround very important or dangerous areas of the ship, such as the bridge, the engineering compartment, or the block of crew quarters. Bulkheads cannot be moved around the ship without a significant amount of work at a shipyard.

Partitions are simple walls, serving to divide compartments without being airtight. They can easily be moved from place to place by a mechanic-and-electrician team. As a result, different ships (even of the same class) can have different internal arrangements.

Common Ship's Systems

A variety of equipment and systems will be found inside the hull of any starship, all designed to provide basic support to the vessel and help fulfill its intended function. Each ship's internal design is different, but certain systems are common to almost all starships.

Almost all starships will have one or more *power plants*. In the present-day Third Imperium, these are usually reliable, long-lasting fusion installations. There may be backup power plants or energy banks using other technologies. The power plant is the basic energy source for all other ship's systems.

Most starships will have a *maneuver drive*. This system permits the vessel to travel under power through normal space. Maneuver drives can make use of a variety of technologies (see Chapter 4), but most Imperial starships use reactionless thrusters. Thrusters require no fuel, instead converting energy from the ship's power plant directly into motive thrust.

By definition, all ***Traveller*** starships will have a *jump drive*. The jump drive is the key to interstellar travel. It permits starships to traverse interstellar distances in reasonable time, by taking "short cuts" through an alternate dimension called *jumpspace*. Jump drives use power-plant energy, but they also use hydrogen fuel which is expended in the course of the jump. Jump drives are rated according to their operating range; a jump-1 drive can move its starship one parsec at a time, while a jump-6 drive can make six-parsec jumps. A controlled jump of more than six parsecs is theoretically impossible, although starships occasionally jump further as a result of "misjump" accidents. High-rated jump drives are very expensive and use vast quantities of fuel, so only courier and military vessels routinely use higher than jump-3.

Starships usually mount *communications* and *sensor* equipment. Most of this equipment uses very old technology for manipulating the electromagnetic spectrum: radios, communication lasers, telescopes, radar, and so on. More exotic electronics, such as meson communicators and gravitic sensors, are available on high-technology worlds. In ***Traveller***, all sensors and communications in normal space are restricted to lightspeed; as a result, interstellar communication is usually handled by courier starship.

Many starships are armed. Starships can use a variety of beam weapons such as laser cannon, particle accelerators, meson guns, plasma guns, or fusion guns. Many starships also use missiles. Small weapon systems can be mounted in *turrets* on a starship's hull. Large warships are often designed around *spinal mounts*, gigantic beam weapons that are aimed by turning the entire ship.

To defend against attack, starships use a variety of techniques. *Sandcasters* can be used to fill nearby space with prismatic particles, providing some protection against laser weapons. At high levels of technology, a ship can use force screens such as *meson screens* or *black globes* to protect against beam weapons. Ships' beams weapons also can be used in a defensive role, to shoot down any incoming missiles. Very advanced ships can use *repulsors* to deflect missiles or *nuclear dampers* to prevent nuclear explosives from working.

Many starships carry smaller craft on board as auxiliary vehicles. Auxiliaries give a starship greater flexibility, permitting cargo, fuel, or passengers to be carried where the starship itself can't go. Some starships (such as fighter-wing carriers) are designed entirely around their carried craft.

Internal Appearance

In Imperial starships, most spaces have carpeting on the floor; some have carpet on the walls as well (for greater comfort, and for safety in case of violent maneuvers). This carpet is usually in a neutral color, and is always designed to be easy to clean. The carpeting in crew or passenger living areas will usually be softer and more plush. Compartments which normally contain heavy machinery or cargo (especially the engineering compartment) will have gratings or bare deck plating, instead.

Living quarters will usually have "programmable walls," large vision screens that can display any pattern or image desired. The default setting for such walls may be "bare deck plating," but they can also simulate wood paneling or other attractive surfaces if desired. Programmable walls are tied into the Ship's Information System (p. 8) and can serve as elaborate display systems for games or passive entertainment. They also serve an important function during ship emergencies, displaying critical information or evacuation directions.

Most spaces have light panels recessed into the ceiling, providing soft indirect light. Emergency lights are also set into the ceiling, ready to activate using internal battery power should the ship's power grid shut down. A few compartments are normally set to "low lights," in order to make holographic imagery stand out more clearly.

Most compartments on any starship are kept bare and uncluttered – a messy area is inefficient, and can become a safety hazard in an emergency. Living areas will usually have a few pieces of furniture, often permanently fixed to the walls or floor. Some starships provide small hanging baskets, potted plants, aquaria, or other items to give a sense of nature amid the blatantly artificial environment. These are often affixed to stable surfaces using adhesive patches which have the strength of welds until released with a specific tool.

Noise

Starships are inherently noisy places, especially when certain areas are busy (such as cargo bays, flight decks, or weapons compartments). A ship's drives are particularly loud. In the drive compartments, engineers and mechanics normally wear soundproof ear protection with active noise suppression and built-in communications gear. Elsewhere in the ship, baffling and soundproofing tend to deaden the noise of the drives; experienced crew and passengers can still tell something of how the ship is maneuvering if they listen carefully.

Smells

Although life-support systems at TL10 and up are quite good, the problem of providing clean air is never-ending. Providing the proper gas mix is relatively easy, and the gas mix can even be varied from one airtight compartment to the next, if necessary. Making sure the ship *smells* pleasant can be much harder. No matter how much the air is filtered, no matter how well crew and passengers observe cleanliness rules, stale and unpleasant smells tend to build up throughout a voyage. Some ship classes (notably the *Suleiman*-class scout ship) are notorious for this, while others (especially passenger liners) are designed to minimize the problem.

A few ships use special measures to keep the air pleasant. Plant hangings and hydroponics equipment can provide some "natural" recycling. Some ships (notably those with K'kree crews) use artificial scents. Others use ionizers to push negative ions into the circulating air; most oxygen-breathing sophonts, especially Humans, find that this makes the air more bracing and agreeable to breathe.

Viewports

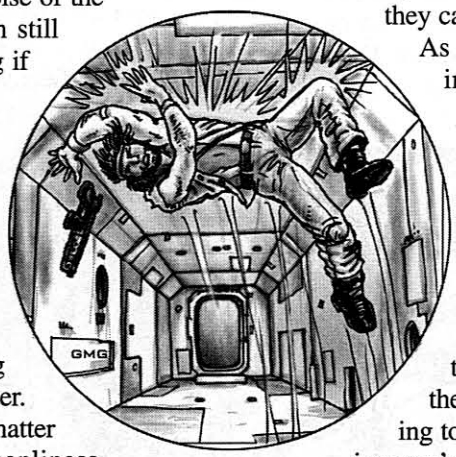
Many civilian ships include viewports, constructed of a high-strength polymer designed to be almost as resistant to damage as the hull (DR 80). This material is not strong enough to equal the protective armor used by military starships. All viewports are installed with opaque shutters, so that they can be closed while the starship is in jump space. Exterior displays in passenger compartments are usually electronic (and on some vessels are prerecorded in case weather conditions do not allow a perfect view of the takeoff).

On military vessels, viewports are unnecessary and dangerous weak spots in the vessel's hull. Views of the outside are provided by electronic displays, instead.

Gravity

All modern starships use artificial gravity plates in the decking. These systems can be very finely controlled, to the point of permitting every compartment to set the strength of its own gravity field. Most ships rarely make much use of this feature; indeed, crew and passengers are discouraged from changing gravity settings frivolously.

Sudden changes in gravity can be extremely dangerous. In fact, they can be used as a weapon in shipboard combat. Boarders or hijackers can be injured or effectively immobilized by being intermittently pulled to the floor, ceiling, and walls (this is sometimes called "grav pong" by Marines). Of course, if boarders gain control over ship's gravity, they can use the same tactic against the crew. As a result, the artificial gravity controls in each compartment usually include safety interlocks to prevent rapid changes in setting. These can be overridden from the bridge or other crew strongpoints, but the overrides themselves are carefully protected by access codes.



Merchant ships will often slowly adjust the internal gravity during the week of a voyage, matching that of the world of departure at first, then moving to match that of the destination world at journey's end. Imperial military ships usually maintain a consistent 1 G field at all times.

Shipboard Information Service

Every starship is run by computer, from the powerful mainframes that act as the ship's "main computer," to the swarm of small dedicated processors that are built into every workstation and stateroom. All of these computers are networked, and the entire network supports a software structure called the "Shipboard Information Service."

The SIS is a set of protocols and software applications that permit flexible information interchange among computers, crew, and passengers. Using it, those on board can call up a tremendous variety of information: systems readouts "echoed" from the bridge or engineering compartment; text or voice messages from other crewmen or passengers; information about scheduled events, entertainment programs, library data, or correspondence courses; and so on.

Whether the starship is a vast Imperial dreadnought or a small tramp trader, the SIS is a vital part of ship operations. It acts as a primary interface for ship's controls – but more importantly, it has a significant effect on crew and passenger morale. It can help a ship's inhabitants form a viable community. It can also *keep them occupied*, a critical factor when a dozen (or a thousand) sophonts are forced to live with one another in a tiny container for a week in jump space.

Compartments

A new crewman aboard any starship will soon learn how to find his way around. Within the Imperium, even the smallest starships use an alphanumeric system to "name" individual compartments, corridors, and other spaces. This system originates in the Imperial Navy, but is also maintained by the Imperial Ministry of Commerce as a standard for privately owned starships. As a result, even a new spacehand will soon find himself able to glance at a wall or door plate, determine where he is, and guess how to get to where he needs to be.

On any starship, many of the compartments are "generic" in nature, corridors or spaces that serve only as storage or as a means of moving around inside the hull. Other compartments serve special purposes of their own.

Bridge

The *bridge* is the primary control center of the starship, the place where all orders regarding the ship's movements and routine originate. It contains workstations for the pilot, astrogator, sensor officer, communications officer, and possibly a variety of other officers depending on the ship's size and function. (For instance, military starships often will have at least one weapons officer on the bridge.) The ship's computer and almost all of its important instruments will all have controls on the bridge.

When a starship is underway, the captain will spend most of his time on the bridge. When he can't be there, he will usually designate a watch officer (or "officer of the deck") to keep an eye on the controls and readouts. Other officers may be present, depending on the ship's current situation and how many workstations must be manned full-time (see *Watchbills*, p. 113).

Access to the bridge is often restricted. On large or military ships, non-watch crewmen must usually request permission to enter the bridge. Small private vessels are sometimes less formal, but even they usually avoid having too many unnecessary people on the bridge at any one time.

The captain usually maintains an office somewhere on the starship, either adjacent to the bridge or near (or in) his own quarters. On large ships, other senior staff will also have their own offices. Ordinary crewmen who don't have business on the bridge are more likely to seek out the senior officers in their offices.

While in theory the bridge functions could be decentralized, fast personal communication in emergencies outweighs any advantage of a decentralized nervous system. Large starships may decentralize somewhat by installing *auxiliary bridges*, either as a backup to the main bridge or to serve similar command-and-control functions. Large warships designed as command vessels may have a *flag bridge,* from which the admiral in command of a whole formation can work. Some ships also have a *combat information center* where large amounts of tactical information can be gathered, processed, and handed on to the captain or admiral in command.

At any time when a starship is manned but not under way, the bridge may be left empty while control shifts to another part of the ship. In such cases, a *quarterdeck* is defined – a marked-off area which is manned by the current watch officer and his staff.



Workstations

Every starship has one or more *workstations* on board. Critical ship's systems are controlled from workstations on the bridge and in the engineering spaces. Large starships may have workstations in many different compartments.

A workstation consists of a single acceleration couch and a set of displays and control panels, permitting a crewman to operate one or more ship's systems. Most workstations will be found in control areas like the bridge, auxiliary bridges, weapons stations, and the drive compartment. Large ships may have workstations dedicated to minor functions that are not treated independently on smaller ships.

Dynamic Configuration

Most starship workstations in the Imperium (at TL9 and up) use *dynamic configuration*. Such workstations do not have actual buttons or switches; instead, the entire control panel is a touch-sensitive pad, layered over a back-lighted display on which individual controls are marked. Some control areas or displays can also be projected holographically above the control panel. The placement of controls is managed by the workstation's local dedicated computer, and can be changed at will.

Under this system, each workstation panel has a default configuration, but each crewman can rearrange the controls and telltales to suit his own preferred work style. The goal is to make the controls as intuitive as possible for the crewman involved, minimizing mistakes and permitting him to watch the displays instead of his hands. Personal (or racial) preferences can easily be accommodated. Each configuration can be stored and called up at a moment's notice.

For example, the communications board may normally have radio tuning controls on the left, transmission controls in the center, and aiming controls for a laser communicator on the right. Regardless, the communications officer can rearrange things to suit his preferences. He could push the laser controls down to a lower "layer" of the display, making them invisible except when he actually needs them. Meanwhile, the radio-tuning and -transmission controls could be expanded to cover the entire panel, and rearranged to place the most-used controls under the officer's hands.

Dynamic configurations even allow workstation functions to be "shared," so that ship's systems can be controlled from different workstations as needed. In theory, the pilot could work from any workstation on the ship. Two or three major functions could be pushed onto a single workstation and handled by a single officer. In practice, such rearrangements are rarely used except in emergencies (such as when a ship is badly undermanned).

Engineering

Every starship's engineering department is responsible for maintenance and repair of systems all over the ship (and even outside the hull). As a result, many of a ship's compartments may be designated as "engineering spaces." The working heart of any starship, however, is the compartments containing maneuver-drive, jump-drive, and power-plant components. There can be several of these compartments, especially on large starships which may have multiple maneuver drives or power plants. All of them are under the control of the engineering department, and share similar features.

Drive and power-plant compartments are quite austere. Instead of carpeting, there will be bare deck plating or grillwork, with plenty of panels providing access to machinery in the decks themselves. There will be ladders and catwalks, giving access to hard-to-reach parts of the drive or power plant. The lighting will be bright and harsh, in comparison to the soft, indirect lighting found elsewhere on board. Aside from any workstations which are present, there will be no place to sit or lie down, and no extraneous furniture. The walls will be thick bulkheads, with soundproofing to help reduce noise; they will be broken up by tool bays, storage for spare parts, fire extinguishers, vacc suit lockers, and other utilitarian items.

Like the bridge, the drive compartments are usually off-limits to personnel who have no legitimate business there. The chief engineer (and his senior mates, on ships with large engineering crews) will maintain offices somewhere on the ship for routine business. On large starships, the engineering department will have whole compartments devoted to electrical shops, machine shops, and so on. These compartments will normally be more accessible to casual visitors.

Cargo Hold

Cargo holds are also very spartan places. The decks are bare plating, marked with guide lines for the placement of cargo containers. Ceilings are usually lattice-work, with lighting panels well inset so that mishandled cargo will not crush them. There will be plenty of mechanical fixture points, permitting cargo containers to be firmly locked to the deck or walls. An empty hold is a large space, full of echoes as sounds reverberate from the bare surfaces. A full hold is occupied by rows (or even stacks, on large freighters) of standardized cargo containers, each bearing its own corporate logo, handling markings, and manifest pad.

Each cargo ship usually has at least one "cargo office," placed close to the most likely entry point for cargo containers. This small office will contain a workstation, permitting the cargomaster to register cargo and plan how to place it in the hold. The cargo office is often designated as the quarterdeck (p. 8) when a ship is in port and the bridge has been left unmanned. In this case, the most critical readouts from the bridge are "echoed" to the cargo-office workstation, so that the captain or watch officer can deal with situations as they arise.

Cargo holds are rarely placed off-limits to any crew. Indeed, new apprentices on a merchant ship are likely to spend more time there than they would like!

Freshers

On most Human-designed starships, a "fresher" will be present in each stateroom, off each crew or passenger lounge, and in some other compartments, as well. A standard starship fresher is remarkably compact. Although it provides all the necessary equipment for a full-body shower or the relief of biological needs, it is rarely bigger than a coat closet. One person in a fresher will feel cramped. Two will feel crushed.

Although most Imperial starships have superb water-recycling systems, their water-*storage* capacity is limited. Freshers are usually engineered to use as little water as possible. Long, hot showers are usually possible, but actual bathing is out of the question except on the most luxurious (and expensive) passenger liners.

Crew Quarters

Crew members will spend almost all their off-duty time in crew quarters. In the Third Imperium, only the most cramped military starships will require crew to use bunkrooms. Most enlisted or apprenticed crewmen will live two to the stateroom, while senior officers will have their own staterooms (often with attached office space). On large ships, crewmen who work in the same department and are at about the same rank are usually assigned to bunk together.

In a crew stateroom, each crewman will have a single bed with a storage locker built into the base, and a computer terminal that can be used either for entertainment or for authorized access to ship's systems. (Of course, authorization varies widely depending on the crew position held.) There will be no loose furniture, but there may be at least one chair bolted to the floor, and there will probably be fold-down tables and locking cabinets set into the walls. Every crew stateroom will have a locker with vacc suits and other emergency gear.

Even a small starship will usually have at least one crew lounge, with tables, chairs, entertainment consoles, and exercise gear. Crew lounges are critical for crew morale, and often provide the best venue for formal meetings. If there is more than one crew lounge, each may be dedicated to a specific subset of the crew – an officers' lounge, a petty officers' lounge, an engineering department lounge, and so on. On military vessels, the largest officers' lounge is usually called the *wardroom.*

On small ships, a crew lounge may have an attached kitchen area. On larger ships, whole compartments are set aside for food storage and galley equipment. Away from the crew lounge, crewmen can still get small snacks or drinks, as needed. For example, the bridge and engineering spaces will often include small refrigerators and drink-making equipment for the convenience of crewmen on duty.

All but the smallest ships have a sickbay, usually attached to the crew quarters. If a starship has a bank of low berths, these are usually close to the sickbay (or to the crew lounge if there is no sickbay).

As one might expect, access to crew quarters is almost unrestricted. This is the crew's living space, and aside from the basics of onboard protocol, few social restrictions apply. Even passengers may be invited into crew quarters under certain circumstances.

Passenger Quarters

Passenger quarters are like crew quarters, but *more* – more spacious, more elegantly decorated, more devoted to entertainment, containing more storage space and more furniture. Instead of a pair of single beds, many passenger staterooms contain a single larger bed for the convenience of traveling couples.

The passenger lounge is the social center of any small starship, and is the space most often customized. Even if the crew lounge has no more than a small kitchenette, the passenger lounge will usually have a full galley. Large passenger ships may set aside large spaces for passenger entertainment and comfort: theaters, game rooms, exercise rooms, even swimming pools.

Access to passenger quarters is also unrestricted. Indeed, starships that carry passengers often encourage crewmen to visit the passenger spaces (although they insist that crew members present a good appearance and behave with courtesy when they do).



Culture and Naval Architecture

The fundamentals of naval architecture are a constant throughout Charted Space. Cultural traits can't change the laws of physics, so any civilization which manages star travel will build starships loosely similar in structure and appearance. On the other hand, the aesthetic values of a given culture will have an effect on the details of starship design.

Aslan Starships

The unique Aslan aesthetic shows clearly in their starship design. Aslan ships tend to be highly rounded, with almost no visible sharp angles or edges. Hull sections tend to be oval or circular in shape, and many designs make use of pods. Inside, the effect is even more pronounced. Almost all internal spaces are rounded and cave-like. Crew quarters are divided among many small spaces, so that every crew member can have his own enclosed room. Internal spaces tend to be more austere than on Imperial ships, although even workstations and wall space will sport subtle decoration.

Droyne Starships

Droyne ships tend to resemble those of their neighbors; Droyne ships in the Imperium follow Human conventions, in the Aslan Heirate they tend to mimic Aslan designs, etc. The main difference in internal arrangement involves the living quarters. Droyne ships have fewer staterooms, but they are up to three times the size of the Imperial standard stateroom, and several Droyne live in each. Quarters are arranged around a central area, which serves as both working area and crew lounge. All of these spaces will be connected with doors, even permitting Droyne to go directly from one stateroom to the next. These features are comfortable to the gregarious Droyne, but bother visitors who prefer privacy.

Hiver Starships

Hive Federation ships exhibit an aesthetic opposite that of the Aslan. They tend to be blocky, even cubistic, and very utilitarian in appearance. Unlike most other major races, Hivers tend to place control stations as deep in the hull as possible – the bridge will be in the center of the ship, not exposed at one end. Likewise, weapons will be fired from the bridge, not from turret stations close to the hull.

Inside, Hiver ships are very comfortable, but not ornately decorated. The cubic aesthetic continues, as most compartments will have straight walls meeting at strict 90° angles. Some observers find this peculiar, given that dirtside Hiver settlements are usually full of rounded buildings, tunnels, and chambers; the cubist design of Hiver starships may reflect a concern for efficiency.

K'kree Starships

K'kree starships are probably the most unusual in Charted Space, due to the oddities of Centaur psychology. First, they are *big*. Centaurs are physically large, hate traveling except in groups, and tend toward claustrophobia. All of this means that they need a *lot* of internal space, far more than a Human crew with the same number of individual members. The smallest of their manned starships is 1,000 dtons, and most are much larger. Almost all of them are built on a flattened-disk shape.

The entire working space of a K'kree starship is one big chamber, with consoles and equipment arranged around the rim. The crew lives and works in this space at all times, and uses robots if there's any need to work alone or in enclosed spaces. The working chamber is usually equipped with smart walls, holographic generators, and scent in the air circulation, all to give the illusion of being outdoors on a pleasant K'kree world.

Solomani Starships

Solomani Confederation ships are very close to the Imperial norm. They lack Vilani influences in their internal design and sometimes show Aslan touches, although they are always arranged to be comfortable for Humans. Solomani ships are rich with security features, and many of them have extensive internal-monitoring equipment.

Vargr Starships

Vargr starships have been described as "like Human ships, but with spiky bits." Although Vargr culture is too diverse to make general statements, most Vargr shipyards do tend toward angular designs, with plenty of radiator fins or sharp-edged projections. This is especially common in corsair or military vessels, which are intended to project an image of ferocity. Internally, Vargr ships can have widely varied arrangements and aesthetic styles, although they tend not to be too outrageous to a Human perspective.

Vilani Starships

Starships built to traditional Vilani designs have an aesthetic (or a lack thereof) all their own. Vilani starships look as if they were designed by engineers, not architects. They are blocky and solid-looking, and are considered ugly by most non-Vilani. Efficiency is the primary consideration, not attractiveness or comfort.

Internal spaces are close to the Imperial norm. A clear class distinction will be visible in staterooms and lounges. Passenger spaces are likely to be quite comfortable and well-appointed, while crew quarters will if anything be more austere and uncomfortable than in most Imperial ships.

Zhodani Starships

Zhodani ships are not far from the Imperial norm in design or aesthetics. Internally, they tend to be designed for greater comfort for crew and passengers (and most spaces have higher ceilings given typical Zhodani heights). The most significant difference is subtle – the presence of psionic switches in most of the ship's simple fixtures. A trained telepath of even modest power can use these switches to open and close doors, control lights, activate small items of equipment, and so on.

Chapter Two

Starship Design and Construction

Working the Yards

"Okay, now, listen up! I don't know where you came from, and I don't care. You're working at the Mora yards now, and we do things a little differently here.

"My name is Eirene Sennit, and for the next 30 days I'm your mother, father, and best friend. You may call me 'ma'am.' You may also call me 'sir' if you were in the military or think you've got the hackles to back up your attitude. If you're lucky enough, and good enough, you can call me Eirene when your orientation period is over. If not, you won't be around to call me anything.

"I know what you're thinking – 'What a hardcase!' You're right, and there's a reason for it. Look out that window, and what do you see? Girders. Forges. Deck plates. Work pods. The skeletons of starships. Looks like God's own erector set just went critical all over the place. This is the big league, boys and girls.

"You think you can build starships? Maybe you can, but that's old news. We don't build starships here, we ***produce*** *them. They're a commodity, a crop we harvest from asteroids and comets, the moons, and Mora herself. We give birth to dreadnoughts, freighters, fighters, SDBs – we crank out more copies of some designs in* ***one year*** *than some yards do in a decade.*

"Just because we can crank out the hulls does ***not*** *mean we skimp on quality! You will be a part of the best-trained, best-equipped, most professional shipbuilding team this Imperium has ever seen. We build ships that will outlive me, you, your kids, their kids – I fully expect some of our battlewagons to be in service when the next millennium rolls over. Your work is your legacy to the Imperium – make sure you give your best!*

"Once your orientation period is over, you will be assigned to your own work crews. You might get assigned to a destroyer squad, or one of the far-trader teams. We rotate assignments once every six months, so you won't get bored, and you'll gain experience working on every major design we produce here. We need well-rounded workers, girder monkeys who can lay a keel on any design in our inventory. You might pull duty on a specialty hull, a one-shot for some rich hunter or hush-hush corporate project. If you do, count yourself lucky. If not, we'll keep you so busy you won't notice.

"One thing – your head had better be screwed on tight 100% of the time. Out here, there's no margin for error. The workload is beyond anything most of you have ever experienced, and there are accidents all the time. There are no ***minor*** *accidents here. If you screw up, you* ***will*** *die, and I don't have time for that kind of paperwork.*

"There's no place to rest on your butt except the hardpoints on the construction gantries – those are for the architects and BuShip busybodies. Don't be surprised if they emerge from their caves every once in a while and peer over your shoulder. No matter how strong the urge, do ***not*** *use your torch to give them an attitude adjustment. If you do, you're liable to end up baby-sitting a bunch of newbies for 30 days."*

This chapter presents a comprehensive set of tools for designing and constructing vessels of virtually any type found within the Third Imperium and its predecessors. (The peculiarities of alien naval architecture are covered in their respective sourcebooks; see the ***GURPS Traveller: Alien Races*** series.)

Shipbuilding

Centuries of starfaring tradition have created a rather distinct set of definitions for some terms that are used in a much more general sense outside of the starship-building world.

Terminology

Vessel: Any spacecraft.

ston: A measure of weight and (conventionally) mass: a short ton; 2,000 pounds.

Displacement: Based on long-standing tradition dating back to the Ramshackle Empire, spacecraft are customarily recorded in official documents by their hull's "displacement." This refers to how many short tons of liquid hydrogen (the most common fuel) they would displace. One short ton of liquid hydrogen has a volume of 500 cf, which is referred to as one displacement ton, or dton. In this and other ***GURPS Traveller*** books, the word "ton" is used when the context makes it obvious that dtons are being discussed.

To avoid confusing these tons with the more familiar measures of mass and weight, these rules will call displacement tons "dtons." A short "ton" in this book generally refers to *stons,* above.

Note that a "space" in ***GURPS*** terms is also assumed to be about 500 cubic feet. The common names of ships often include the nomenclature *100-ton*, like the *Kugashin*-class 400-ton lab ship. In this example, the *Kugashin* has a displacement (or *hull class* – see below) of 400 dtons (but the ship's total mass is considerably more than 400 stons).

Total Displacement: The total volume of the ship, including the volume of all external stores (but not turrets and external bays) and vessels carried in cradles.

Hull Class: The volume of the main hull itself. Often simply called "displacement." Vessels are normally classified and referred to by their hull class, as in 200-ton *Beowulf*-class free trader.

Ship: A vessel of hull class 100 or larger.

Small Craft: A vessel of hull class below 100.

Starship: Any ship with a jump drive.

Non-starship: A vessel lacking a jump drive. Small craft are also non-starships.

cf: cubic foot or cubic feet.

Cr: A credit, the unit of currency in the Imperium. Dollar costs in ***GURPS Vehicles*** convert to credits on a 1-for-1 ($1 = Cr1) basis at the TL of the design. See p. T:FT48 for exchange rates between differing TLs. KCr is a thousand credits; MCr is a Megacredit, or a million credits. Because space vessels cost so much, they usually are priced in MCr.

HPs: Abbreviation for "hit points."

MW: A megawatt, or a thousand kilowatts; MJ is megajoule or megawatt-second (MWs); a thousand MW is a gigawatt (GW); a thousand megajoules is a gigajoule (GJ) also known as a gigawatt-second (GWs). Similarly, a million megawatts is a terawatt (TW); a million megajoules (a million million joules) is a terajoule (TJ). These last terms are normally used only in the description of extremely powerful ship's weapons.

Power Slice: Part of a power plant included in a module to simplify the design process.

Turret mount: A turret-mount weapon is a weapon built into a turret with a universal mounting system. It has a 180° arc of fire, though the turret itself allows a full 360° arc. This combination allows a full hemisphere to be covered.

Hull mount: A hull-mount weapon is a weapon built into the hull but with a casemate swivel-mount system. It has a 90° arc of fire (45° to either side). All weapons except spinal mounts can be hull-mounted.

Fixed mount: A fixed-mount weapon is a weapon built into the hull, with a 15° arc of fire. The only fixed-mount weapons in the *Module Tables* are spinal mounts as they are typically the only weapons to use this mounting system. See *Spinal Mounts*, p. 19, for more information.

Shipyard Facilities

All worlds with sufficient population and TL are capable of constructing space vessels within their industrial sector; such vessels cost double, due to limited production. Worlds with Class IV and V starports have shipyards attached to them, capable of turning out vessels in quantity (or at least able to take advantage of standardized production methods to keep costs down). Shipyards are also extensively used for annual maintenance, refits, upgrades, and overhauls (see p. 106).

Starports and their respective facilities are listed below. For more detail, see ***GURPS Traveller: Starports***.

Class V Starport

Installation of excellent quality. Annual maintenance overhaul available. Shipyard is capable of constructing starships and non-starships.

Class IV Starport

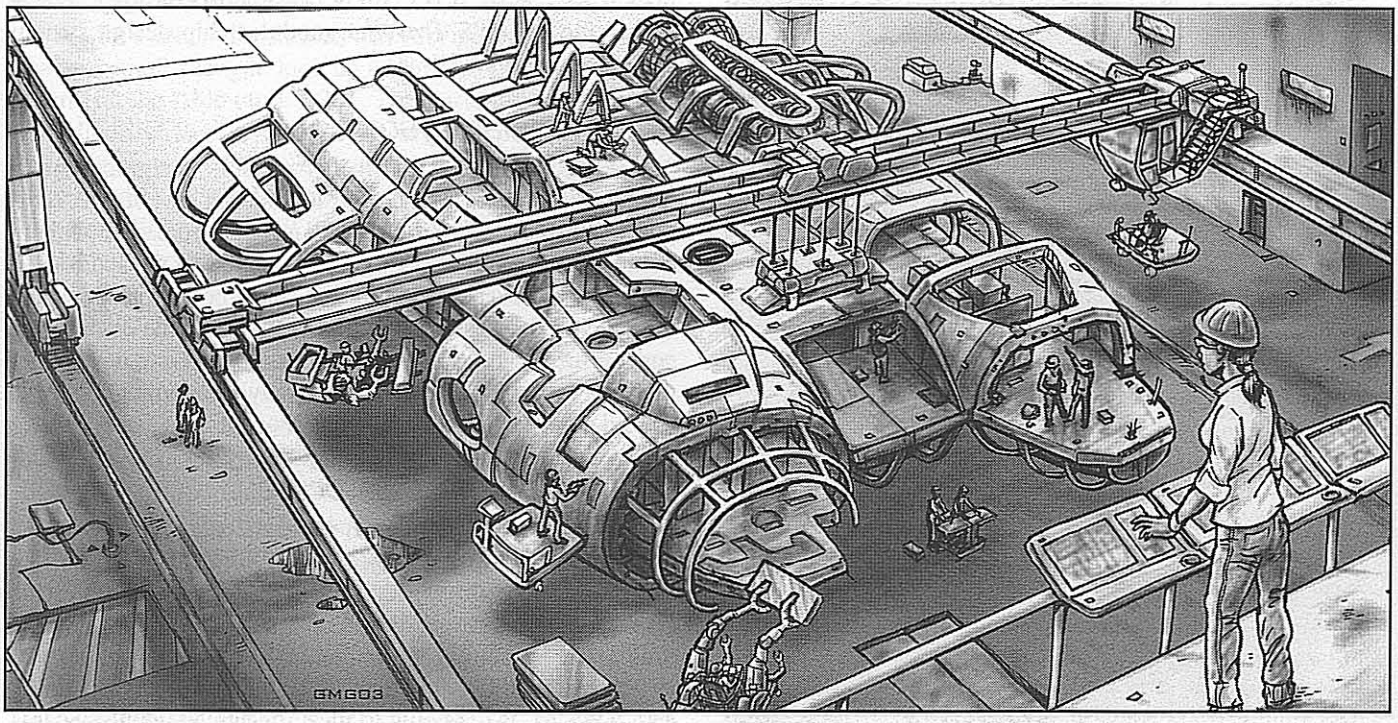
Installation of good quality. These also offer annual maintenance-overhaul services. Shipyard is capable of constructing non-starships.

Class III Starport

Shipyard facilities are standard or average. Reasonable repairs can be accommodated.

Class II, I, 0 Starports

No repair or shipyard facilities are present.

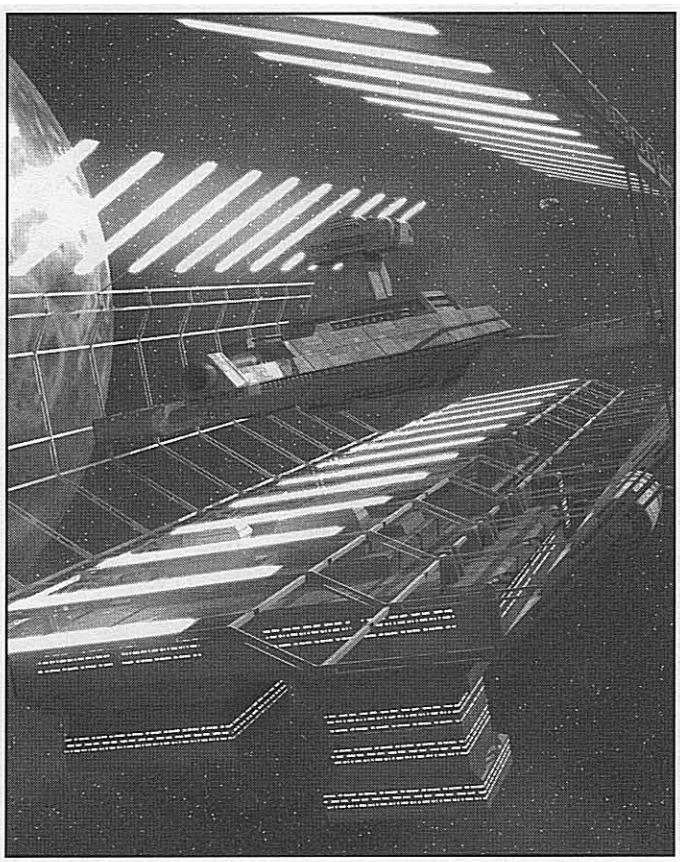


Standard Designs

Most starships are built to order from existing hull plans. Many standard classes (scouts, free traders, far traders, etc.) are centuries old and their designs are in "the public domain." These are included in the Imperial Data Package of industrial standards provided to member worlds. If the requirements are neither outlandish nor locally illegal, a builder can usually find plans for an appropriate ship; a set of plans would be about a 1 gig database costing Cr1,000. Some shipyards offer use of *their* standard plans, at a discount.

Buyers may specify reasonable variations from the plans on armor, surface features (stealth may be decreased or removed, but not improved), weapons, and non-vital interior components. Changes in hull size or drives should add considerably to the cost, at the GM's discretion.

The usual time to build a ship at a Class V port is calculated as (hull surface area in sf/2,000 days) with a minimum of six months due to ordering, lead time, and shipyard configuration. GMs may rule that if the vessel is common and produced locally, it takes a minimum time of one month. Both the actual and minimum construction times can be reduced by paying extra: doubling the price divides these times by 2, tripling it divides these times by 3, and so on. The absolute minimum time is 1/4 the standard time (never less than 6 weeks unless produced locally), costing four times the standard price and working around the clock. Military shipyards on a war footing use this speed; civilian shipyards require a reaction roll of Very Good or better (using influence and bribery as necessary). Anything not available locally must be imported, and special items might take extra time to install. For really radical new design concepts, refer to p. VE201.



Smaller shipyards also take longer. A Class IV port will take twice as long on any hull class over 400 and three times as long on anything over 2,000 dtons (if they will handle it at all). A Class III port isn't really equipped for shipbuilding at all. It can build a craft of up to 20 dtons, but takes four times as long. It can't build larger vessels.

The price for a ship built to standard plans is simply the sum of the prices of all its systems and components, plus labor.

Building Better Ships From the Ground (Clearance) Up

Why have construction guidelines? Few (if any) naval vessels are produced by a single designer working in isolation, without constraints on resources or fitness for purpose. Instead, they are designed by teams, to specifications drawn up by committees, to meet conflicting requirements of mission, flexibility, lethality, survivability, and cost. Creating an entirely new class of vessel requires extensive space trials to identify and to fix problems (see pp. VE201-202); even so, there is a limit to how much testing any organization will tolerate. Every vessel flying is the result of hundreds of compromises, large and small.

These guidelines represent the procurement standards published by the Imperial Navy's Bureau of Ships (BuShips). BuShips expects new ship designs that are offered in response to Requests for Proposals to adhere to these standards. Designs that do not meet these standards are considered "inadequate." Anything more is likely to be rejected as "excessive" or "not cost effective."

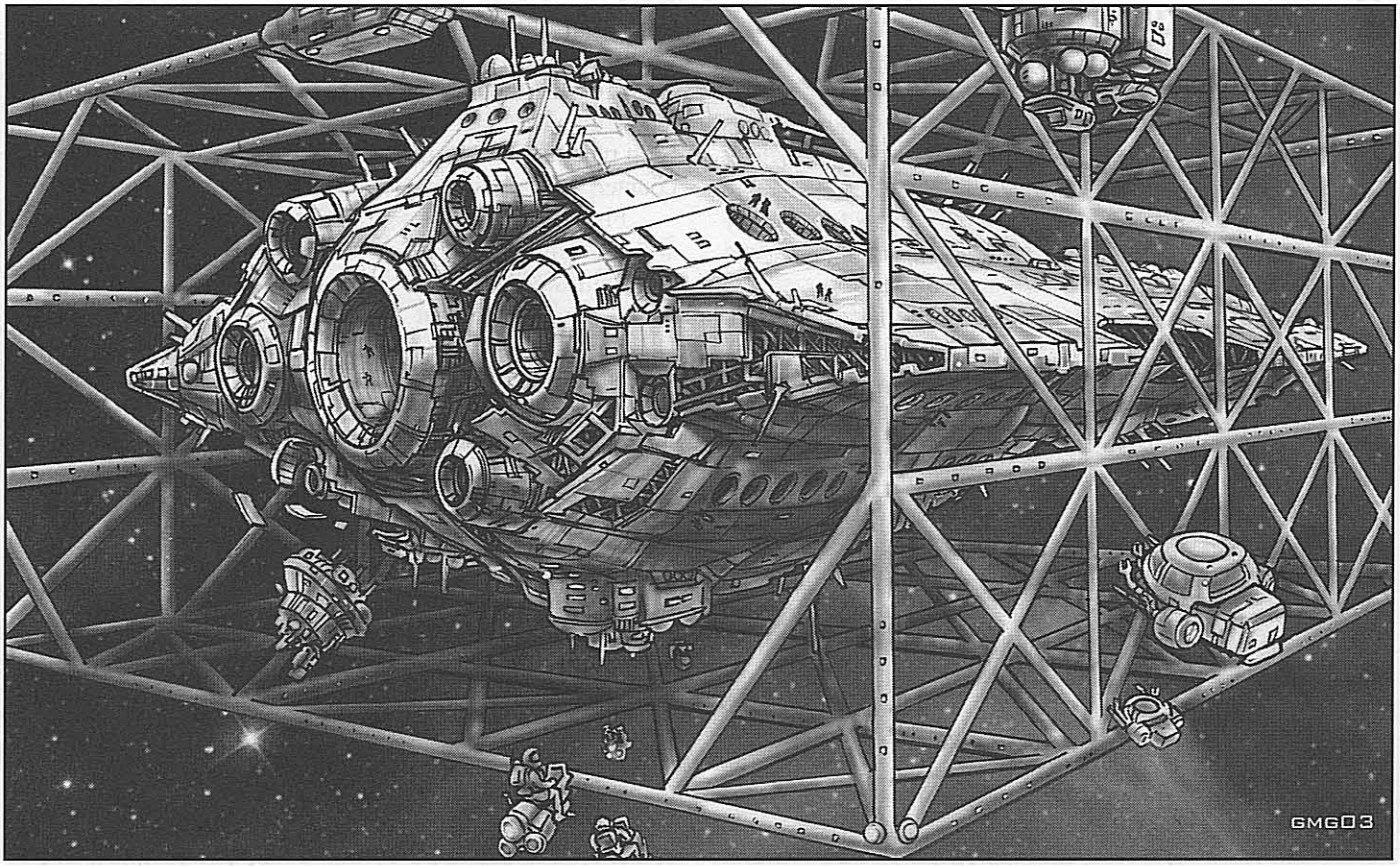
In game terms, this keeps the balance between naval weapons and armor within playable bounds, making for a faster, more interesting game. GMs are free to construct vessels with the modular design system that *exceed* these guidelines if they wish. It is entirely possible to construct vessels within the ***GURPS Traveller*** modular ship design system exceeding these guidelines.

The Modular System

While the ***GURPS Traveller*** starship design system is modular, in most cases the *ships* it produces are not. The components forming a specific module might be spread throughout a ship, rather than forming a compact bundle of the appropriate volume. The reverse is true of the ship's power plants, which are specific devices with controls in the requisite engineering compartment, but their volume is incorporated into many other modules for bookkeeping purposes only. That errant volume is termed a "power slice" or simply, "slice."

Hull and Armor Materials

The various classification societies (e.g., Lloyd's Register, Traveller's Aid Society, etc.) have determined through long experience that "Medium Frame, Standard Materials, Expensive Metal Armor" is the optimal combination of safety, utility, and economy for a particular TL. Anything more gets expensive, though some designs justify their cost. Anything less, however, is not going to meet the agreed-upon standards



(i.e., HP and structural HT). Bank financing will be nearly impossible to obtain, insurance rates will be astronomical, and government charters will be unavailable for such a shoddy operation. (Substantive differences between TLs are already factored into the exchange rates.) This sort of conservative approach is entirely consistent with the slow rate of technological progress within the Imperium and its neighbors.

How Big Is My Hull?

A ship's actual dimensions can vary greatly. For a rough idea of the hull's length, look up its Size Modifier in the Size column on the table on p. B201. This assumes a fairly average cylindrical ship, or a collection of disks, pods, and cylinders. Length varies from 1.5 to three times that in yards if it is long and skinny, dart-like, or a flattened disk or wedge. Diameter will be 2/3 that if the ship is ovoid or spherical. For examples, refer to *Suggested Hull Sizes,* p. S108.

How Big Is My Reactor?

When drawing deck plans, it is sometimes difficult to visualize just how large the reactor is. After all, you have all these neat modules but no information on just how large the power slice is other than a MW rating.

- Add up the total power (in MW) consumed by all modules included in the ship design.
- Determine the TL of the reactor (it's the same as the ship's overall TL unless specified otherwise).
- Multiply the total power (in MW) by the appropriate factor: TL7 = 0.96, TL8 = 0.48, TL9 = 0.12, TL10+ = 0.024.

The final answer is the reactor size in dtons. 1.5 dtons for TL7, 1/2 dton for TL8/10+, and 2.5 dtons for TL9 reactors should be added per core (there is one included in the Engineering modules, see p. 36). If a ship has more than one reactor core of the same TL, this final answer can be divided amongst them in any fashion desired to represent redundancy. Sometimes it is useful to include a secondary power core without the other elements of a complete engineering system. Installing a power plant core from a TL different from the ship's primary TL allows mixing systems from both TLs, for example. If a vessel has two reactor cores of different TLs, the power requirement for each TL must be determined separately.

Custom Building

If plans are not available, it will take (the square root of the final cost in MCr) days to draw up complete documents (regardless of ship size – although a very complex design may take more time, at the GM's option). The fee for this is usually Cr1 per dton of final displacement, with a minimum of Cr10,000. Triple the cost if the designer will not have the right to sell the plans as "standard" after he finishes.

New plans can be produced with Shipbuilding (Starship) skill. A shipbuilding program (see p. 70) will help! The GM makes a single skill roll. A failure wastes the effort for the time calculated above, but designers can start over. A critical failure produces a plan so subtly flawed that the builders won't notice . . . but the GM can provide a catastrophe as soon as the ship is first used.

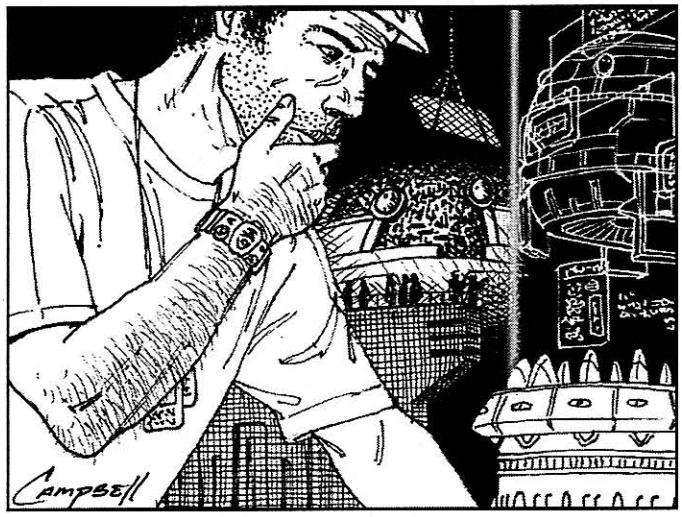
An advantage of custom-built ships is their anonymity; one cannot judge their capability from casual observations. A successful roll on Shipbuilding (Starship) skill will allow a determination of capacity and a good guess about power plant and weapons.

Starship Design Sequence

GURPS Vehicles offers a complete design system suitable for all types of vehicles including starships, but it is complex. To make ***GURPS Traveller*** more accessible, this book expands upon the modular-design system in ***GURPS Traveller,*** enabling players to assemble ships from standard hulls and components.

A starship "module" represents a collection of components usually scattered throughout the entire vessel. The "power slice" will actually be in the engine room, control stations might be located in the bridge, and so forth. They are not necessarily homogenous systems found in the same location on a vessel.

These hulls and modules were all created using ***GURPS Vehicles*** or ***GURPS Ultra Tech,*** so experienced GMs may use those books to design their own modules or to create custom-built designs, but see *Building Better Ships From the Ground (Clearance) Up,* p. 14, for some important considerations.



Design Overview

The next several pages provide a systematic spacecraft-design process. Calculations are simple and can be easily done on scrap paper. A calculator is useful but not essential. Many of the steps below have a corresponding chapter in this book to explain more details.

Step 1: Decide on the ship's concept and TL.
Step 2: Design the hull and record its characteristics.
Step 3: Designate turrets and/or bays.
Step 4: Select armor. Calculate mass, cost, DR, and PD.
Step 5: Select surface features.
Step 6: Fill all internal spaces with systems.
Step 7: Add turret and bay weapons (optional).
Step 8: Calculate basic statistics.
Step 9: Calculate performance and finalize the design.

As design choices are made, keep a running total of the vessel's weight (in stons), cost (in MCr) and power requirements (in MW). Power requirements are very useful if deck plans are to be created, but are not integral to the design process itself.

Naval Ship Classes

The starships operated by the navies of the galaxy range from 100 to 1 million dtons. There are no known ship designs larger than that, but that doesn't mean that they don't exist. Ship types of one TL tend to be smaller than their higher TL counterparts, sometimes by as much as 20% per TL.

Five broad types of warships are registered in service with the Imperial Navy: Scouts, Escorts, Cruisers, Carriers, and Battleships.

Scouts: The Scout Service controls a wide variety of craft up to cruiser class, but scouts proper are vessels up to 200 dtons designed for exploration, survey, and courier work. In times of war, such ships are pressed into military service but have negligible combat value except in reconnaissance.

Escorts: Escorts are small ships of up to 5,000 dtons and are meant to be light support craft for larger ships, primarily cruisers. Escorts are also widely used for convoy protection and commerce raids.

Cruisers: Cruisers are the smallest ships to carry the large spinal weapons needed to cause serious damage to armored ships. Most are too lightly armored to withstand heavy battle action. They form the cadre of task forces that raid commerce and provide fire support for planetary invasions. Hull sizes range from 20,000 to 100,000 dtons. Cruisers serving with a battle fleet are generally grouped in cruiser squadrons of four to eight ships, while individual ships or pairs of cruisers are used to form scouting or raiding teams.

Carriers: Carriers are designed to transport large numbers of combat boats (termed either "fighters" or "system defense boats"). The small ships are used in the screen of the battle fleet or in support of a planetary invasion. Given the limited weaponry of fighters and light boats, they are little more than a distraction in a major fleet action, but they can be extremely effective against ships of cruiser class or less.

Battleships: As their name suggests, battleships are jump-capable vessels, which are, due to their armament and protection, capable of standing in the line of battle. Also often called "dreadnoughts" (because their crews theoretically dread no opponent . . .), battleships generally have little better in the way of primary armament than cruisers, but their extensive secondary batteries render them virtually immune to missile and small-craft attack; their bulk also provides tremendous damage absorption, allowing considerable endurance in pressed attacks and long battles.

Other Naval Vessels

A wide variety of supporting ships and boats of the Imperial Navy are deployed in the Spinward Marches. Many don't fit into the five categories presented above, and they are commonly classed as auxiliaries. A battle rider is a non-jump-capable combatant generally carried on a large (up to 1 million dtons) fleet tender. A typical tender carries a complete battle squadron (BatRon) of six to eight vessels.

Commercial ships of 50,000 dtons or more are unknown in the Spinward Marches as of 1120, although 10,000- and 20,000-ton bulk carriers are fairly common.

Cruisers (including carriers) and battleships together are considered *capital ships*, a designation with historical and

social, as well as tactical, significance. Battleriders may or may not be considered capital ships, depending on who is doing the considering . . .

Step 1: Concept and Tech Level

First, come up with a general concept and mission for the vessel. Who's building it and for what purpose? Is it an interplanetary craft or a starship? A merchantman or a warship? This design system can also be used for space stations and satellites; just read "ship" as "station" and do not install maneuver or jump drives.

Next, decide on the vessel's TL. The design system presented here allows vessels to be designed at any TL from 7 to 12, with some items of TL13 supertechnology included for GM use. Crude and limited spacecraft are possible under special circumstances at TL5-6; these are best approached on a case-by-case basis using ***GURPS Vehicles***. Higher TLs are the realm of Ancient artifacts and alien superscience: GMs are encouraged to refer to ***GURPS Space*** or use their imagination.

When designing the vessel, do not install components higher than the vessel's TL without good reason (e.g., a TL10 hull upgraded with TL12 electronics and weapons); be sure to include an engineering module or a power core for the additional TL.

The strangest ship design I ever saw was some wealthy loon who wanted a yacht that duplicated a Terran surface ship named ***Henry Grace a Dieu****. The inside was normal (as much as any spaceship with black powder cannons can be called "normal"), but the outside had masts and sails with internal wires so they "billowed."*

– Loni Watt-Tukera,
Principles of Starship Design

TL7 Vessels

Generally homegrown for local conditions, TL7 vessels might service nearby markets or serve as an alternate to depending on foreign imports. TL7 will support routine space operations, but each vessel must normally be optimized for its specific role and/or mission profile due to the tight constraints imposed by the less robust technology base. Fission reactors are most often used to provide power.

TL8 Vessels

TL8 vessels are markedly more capable and versatile than TL7, primarily because they employ gravitic technology – contragravity (p. 40) – and reactionless thrusters (p. 37), but they are constructed for the same reasons. Fission power is standard.

TL9 Vessels

These ships use fusion power and are capable of mounting jump drives. The fusion power plants are crude and expensive, however; the capabilities and prices of TL9 vessels follow suit.

Naval vessels at TL8 and early TL9 are often equipped with dual maneuver drives: reactionless thrusters for long-haul operations, and reaction thrusters (or even reactionless thrusters powered by energy banks) for short-duration, high-thrust maneuvers (i.e., takeoffs and landings, and combat).

Historically, the First (Vilani) Imperium was TL9 for its entire history, as were the early Terran Confederation (-2431 to -2210) and the few remaining starfaring planets and polities during the Long Night (-1776 to -150).

TL10 Vessels

TL10 vessels are average for the present-day Imperium, often used by merchant lines, independent traders, and planetary and subsector navies. Many TL7-9 worlds also use TL10 designs, ordering them (and spare parts) from shipyards elsewhere in their sector, just as Third World nations of Terra's 20th century ordered ships from Europe, Russia, or the United States.

The Terran Confederation's achievement of jump-3 (early TL10) in -2210 was the edge they needed to finally defeat the Vilani Imperium and establish the Rule of Man (Second Imperium). After the technological regression of the Long Night, the Sylean Federation (precursor to the Third Imperium) was able to re-establish TL10 by around -150 and was fully TL10 following the upheavals of the Civil War (604 to 622). Empress Arbellatra (then still Regent) used the new jump-4 capability to establish the Xboat network (624 to 718).

TL11 Vessels

These ships are more advanced with improvements over TL10 in several areas. They serve as the "front line" vessels for most of the Imperium's potential adversaries: the Zhodani Consulate, the Solomani Confederation, top clans in the Aslan Hierate, and exceptionally well-equipped Vargr corsairs.

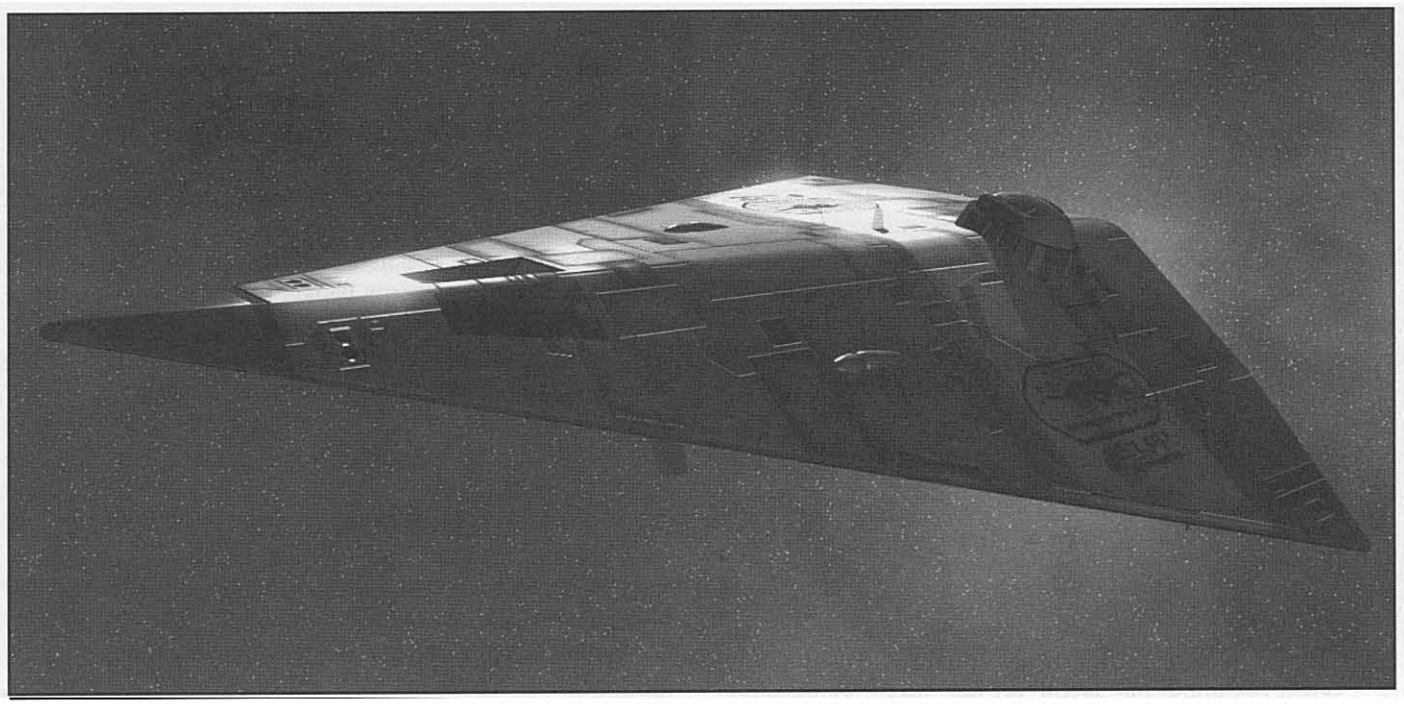
TL12 Vessels

These represent the cutting edge of naval architecture. The Imperial Navy is equipped at TL12, with a few TL10-11 vessels in service in backwater areas or as auxiliaries. Shipping lines and corporations use TL12 vessels as fast couriers and liners.

The Solomani Rim War (990 to 1002) provided the impetus the Imperium required to develop TL12.

Streamlining

Streamlining specifies how much attention was paid to airflow over the hull, and affects the ship's performance in an atmosphere. Although many different configurations and streamlining options are available, spacecraft streamlining can be grouped into three broad categories: streamlined, unstreamlined, and other (dispersed structure and planetoid hulls).



Streamlined

Atmospheric performance and airflow over the hull were prime considerations in the design of the hull. All protuberances were kept to a minimum and aerodynamic lifting and control surfaces are incorporated into the hull. The spacecraft has full atmospheric maneuverability, and generates lift so it can take off from worlds with a surface gravity greater than its G-rating. Streamlined hulls may skim gas giants for hydrogen fuel and can safely re-enter any atmosphere.

Unstreamlined

Airflow over the hull was considered as an afterthought, if at all. Sharp edges were rounded off and protuberances may have been covered by fairings. However, the hull does not generate lift and no aerodynamic control surfaces have been provided. Unstreamlined ships can skim for fuel and can enter a world's atmosphere but they do not have landing gear or any other facilities to relieve the stresses on the hull when set on the ground. This typically means that they can land once – and stay there indefinitely.

Other Hulls

Dispersed structure hulls are not designed to operate in an atmosphere. Sharp edges, antennae, bracing, and all kinds of other things stick out from the frame at various places. These hulls are extremely vulnerable to wind turbulence; they should never land on any planet and should never enter an atmosphere greater than trace (0.1 atmosphere), even with contragravity.

Planetoid hulls are not stable enough for atmospheric operations and are not normally designed for any type of planetary landing, but can land on airless worlds in extreme circumstances. Hulls intended for planetary landing are normally equipped with contragravity units.

Dispersed structure and planetoid hulls may not skim gas giants under any circumstances.

Step 2: Hull Design

The hull is the frame of the ship, but it is more than just a metal shell. It includes decks, cables, stress bracing, and other elements.

Streamlining

Decide whether the ship is streamlined (SL), unstreamlined (USL), planetoid (PL), or dispersed structure (DS). *Streamlined* ships are sleek lifting bodies (often dart-, teardrop-, wedge-, or disk-shaped) and may fly within a planetary atmosphere. *Unstreamlined* ships are usually cylindrical, spherical, or some other non-aerodynamic shape. *Planetoid* hulls are nickel-iron asteroids, hollowed out and mounted with ship systems. *Dispersed structure* hulls are open tubular frameworks, with some components in separate subhulls.

Hull Classes

Select a standard hull class from the Hull Table on p. 28 or design a custom hull (p. 29). See *How Big is My Hull?* (p. 15) to approximate ship dimensions. Multiply the listed weight, cost, and hit points by the factors shown under *Options,* p. 29. Record hull mass, hull cost, and Size Modifier (SM; p. B201). Hull areas and volume are for reference and will figure in later calculations.

Spaces

Calculate the vessel's *internal spaces.* An unstreamlined vessel has spaces equal to its hull class. A streamlined vessel has spaces equal to the volume factor (from the *Streamlining Table*) × hull class. Standard hulls with Very Good streamlining have spaces equal to 0.8 × hull class. Internal spaces will be used up by equipment and other options. Keep a running total of how many spaces remain; when they are all gone, nothing else can be installed in the vessel.

Step 3: Turrets, Bays, and Spinal Mounts

Decide how many turrets and/or bays the vessel has. Their mass, cost, and internal spaces are shown on p. 131. As with the hull, mass varies by TL and cost varies depending on whether the hull is streamlined or not.

See *Batteries,* p. 24, for a way to increase firepower by linking turrets or hull-mounted weapons. Batteries should be considered *after* the actual weapons are installed.

Turrets

Turrets are standard mounts for shipboard weapons. They have the most flexibility in terms of arc of fire because the entire turret is turned to aim it, along with all the weapons mounted in it, of course. They have effectively unlimited arcs of fire – as long as the ship's hull or appendages aren't in the way, the turret can fire at any target, independent of the attitude of the ship. For most configurations, that means the arc of fire is 180° in any direction – a complete hemisphere. For game purposes, assume turrets can fire at any vessel within range.

In ordinary 1-second combat turns, weapons in turrets may not fire on targets on the opposite side of the ship, and may be further restricted by the configuration of the hull (GM's decision). ***GURPS Traveller*** space-combat rounds (see p. GT163) represent 20 minutes, so GMs may ignore this targeting restriction due to ship maneuvers in zero gravity during that time scale.

A ship can have a maximum of one turret per 100 dtons of hull class, or it can have fewer or none at all. A small craft of at least 3 dtons may have one turret.

Instead of a turret, weapons can be built directly into a hull. A vessel can have 3 spaces of turret weapons installed in hull mounts in place of one turret. Hull-mounted weapons have reduced range of tracking due to the lack of a turret mechanism. Since they are inside the hull's armor belt, the degree of protection is greater than for turrets, but they can only fire on targets within a 45° arc to either side of the direction the mount is facing. Each hull-mounted weapon must be installed on one of the six faces of a ship (forward, aft, port, starboard, dorsal, or ventral).

The figures in the Module Tables (p. 124) are for medium frame, standard materials, with very good streamlining (VGSL) and unstreamlined (USL) prices (the two most common). Multiply turret *weight* by the same frame and material factors used to design the vessel's hull. To select a streamlining level other than VGSL, multiply the USL turret *cost* by the appropriate factor (3.6 for SSL, 6 for ESL, or 12 for RSL). Then multiply this cost by the same frame and material factors used to design the vessel's hull. (Use the USL cost if the turret is unstreamlined.)

Optionally, turrets purchased as unstreamlined can be placed on streamlined hulls, but they make the vessel unstreamlined as a result. Turrets on planetoid hulls may use any materials and have a frame strength equal to the hull. Turrets have 800 sf of surface area each and must be armored separately (see Step 4).

Pop Turrets

Pop turrets are identical to ordinary turrets, except they can be fully retracted into the hull when not needed. They are only protected by the hull's armor while retracted, but may still be separately armored. Pop turrets are often used on planetoid hulls to preserve the appearance of a natural asteroid. If a pop turret takes more than half of its HP in damage, it is locked in whatever its position was before the damage was inflicted. (It may still rotate.) Pop turrets are treated as hull-mounted when not extended.

Weapon Bays

Weapon Bays are large weapon mounts. They come in two varieties: external or internal. External bays are treated exactly like turrets, above (though they have the same surface area as a vessel of their size; see p. 28). Internal bays are treated exactly like hull-mounted weapons, as above. Bays on planetoid hulls are usually internal. Weapon bays may *not* be grouped as batteries.

Bays are available in large and small sizes (for 100-ton and 50-ton weapons, respectively). Bays must be installed during construction (though their weapons may be installed later). Weaponry in internal bays is easily removed and replaced at a suitable shipyard or spacedock as the need arises. It takes about two hours to replace a small internal bay weapon; double this time for large bays, and triple it for external bays. The 50-ton bay is the bay in the ***GURPS Traveller*** core book. It is referred to as a 50-ton or small bay here to prevent confusion with the 100-ton or large bay.

Empty internal bays may store cargo or hold small craft. *External* bays may not store cargo or craft – they are only capable of holding weapons due to a honeycomb structural arrangement designed to hold either missiles for the multiple missile racks or the components used to build energy weapons.

Vehicles and craft may be carried in otherwise unused internal bays at 50% space wastage (a 100-ton bay holds 50 dtons of vehicle or craft); a bay may launch one craft per turn (see p. 64).

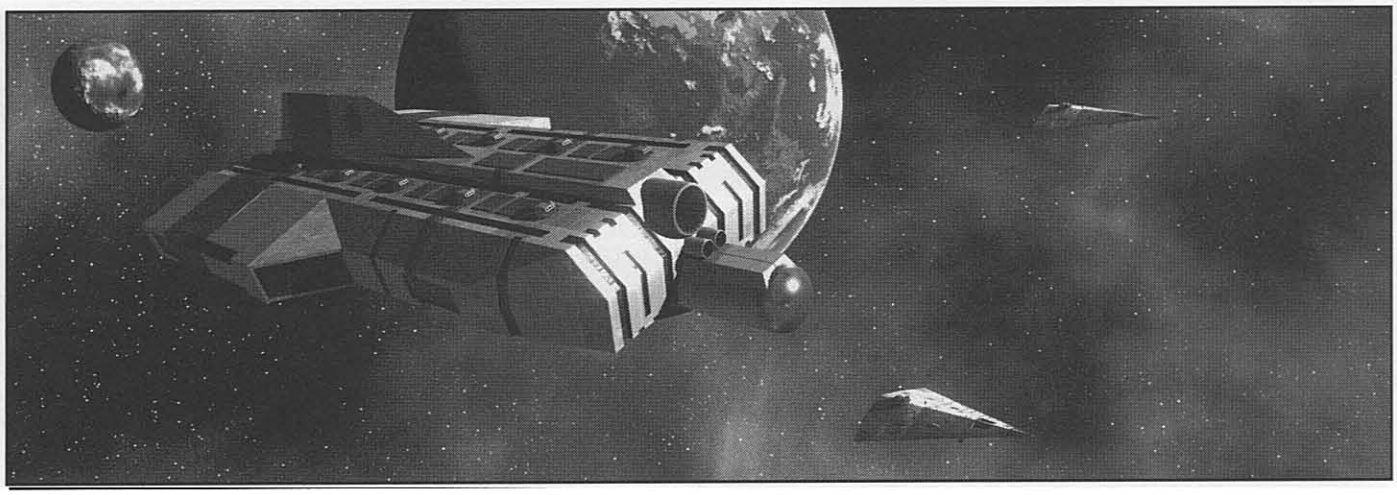
An internal bay may carry deadfall ordnance (p. 53); such a bay is useless in battle, but is used to bombard worlds.

A ship can install one bay for every 10 turrets *not* installed. For example, a ship with Hull Class 10,000 may have up to 100 turrets, but the designer could instead install 80 turrets and two bays. This effectively limits bays to ships of 1,000 dtons and larger.

Spinal Mounts

Spinal mounts are large enough to require special planning; they are considered fixed-mount weapons and basically become the main structural member for the ship. They have limited arc of fire – no more than 15° to either side of the direction the vessel is facing. Spinal mounts require that the entire ship be pointed in order to aim the weapon, but they have no overhead for mounting.

Spinal weapon mounts reduce the number of turrets possible by 1 for every 100 dtons they occupy. Other surface features (external grapples, etc.) also affect the number of turrets and bays that can be mounted; see p. 31.



Evolution vs. Revolution

Warships are expensive investments, especially large warships. This simple fact drives much of the design conservatism for which navies are notorious. Any officer who suggests radical design changes is placing his career on the line (especially after a victorious war). Navies tend only to adopt new technologies after they have been thoroughly proven and tested on smaller, less expensive vessels. It is a common naval paradigm that more than 25% novelty in a new design will lead to disaster. Therefore, new designs should be evolutions of older vessels rather than revolutions in design practice. Assume Imperial Navy ships last 80-100 years before undergoing a major overhaul/refit, and then are good for another 80-100 years before retirement. There will be instances where some ships last longer and some retire quite quickly, but on average, 180 years is the life expectancy of a warship due to HT loss (see below).

Aging Ships

So what happens at 180 years? Does the ship spontaneously combust? Not likely, but its chances of being fully operational are slim. When making a Structural HT check, make an *extra* check for every 50 full years that the ship has been in continuous service. This means that a ship 50 years old makes two HT checks, one 100 years old makes three HT checks, etc. Reset this to one check if the ship has had a major rebuild (see p. 106).

For every 200 years of service, a ship's HT permanently drops by 1; ships of that vintage are normally retired or used for light duties. TL13+ ships multiply the intervals by TL-10. However, regardless of how many times a ship is rebuilt, overhauled, prayed for, or glued back together, the maximum theoretical lifespan is 60 years at TL7 and doubled every TL after that. This puts a TL10 vessel at around 500 years and a TL12 vessel at around 2,000 years.

How Much Armor Do I Need?

Armor in ***GURPS Traveller*** can be divided into four types: Recommended Minimum (DR 100), Turret Invulnerable (can ignore hits from standard turret-mounted weaponry), Bay Invulnerable, and Spinal Mount Invulnerable. What is invulnerable at one TL may *not* be at the next. Depending on a ship's mission, it may only need enough to keep the dust off. When designing a warship, make a determination as to what class of weapon this type of vessel will be able to ignore or shrug off.

Step 4: Armor

Vessels are armored to protect against cosmic rays, micrometeors, and enemy weapons. Adding heavy armor will slow a ship down (due to the extra mass) but make it more "survivable." Choose both armor material and DR.

Most starships use expensive armor. Bulk transports and ore carriers may use cheaper materials as an economy measure, while prototypes might use advanced materials.

To figure out how much armor is needed, calculate the ship's *Total Surface Area:* This is the number shown in the area column of the *Hull Table* (p. 28) plus the surface area of all turrets and *external* bays. Each turret has an area of 800 sf. Each external bay has an area of 6,500 sf (small) or 10,000 sf (large). Internal bays, hull-mounted weapons, and spinal mounts do not take up surface area.

The minimum armor for manned vessels is generally considered DR 100 – military starships will have considerably more. As a rule of thumb, a light military vessel will be able to withstand a hit by turret lasers of its TL at 1/2D range, while a ship of the line will be completely impervious to turret beam weapons – and will frequently shrug off bay particle and plasma/fusion weapon hits as well! See *How Much Armor Do I Need?*, above.

Optionally, armor for the turrets may be calculated separately from hull armor. Turrets and bays are often designed with lighter armor than the hull itself. For a fast way to design this, just add *half* the turrets' and external bays' area to the vessel's area; afterward, they can be assumed to have half the DR the hull has. Military vessels also have suggested minimum and maximum armor requirements for turrets. The ***GURPS*** rules don't normally track armor volume because it is negligible, but placing huge amounts of DR on a relatively tiny turret will use up the space for weaponry (and would slow rotation speeds below the standards assumed in the space-combat system). To reflect this, turrets have maximum DR. They should have an absolute minimum of DR 100, and not exceed DR 250 at TL7, doubled every TL after that, or half the ship's armor, whichever is less.

Passive Defense (PD). Armor PD depends on DR, as follows: 1 if DR 1, 2 if DR 2-4, 3 if DR 5-15, 4 if DR 16+.

Step 5: Other Surface Features

Sealed: Vessels must be sealed. Dispersed structure hulls are unsealed; instead, individual subhulls are sealed separately. GMs may wish to ignore the cost of sealing on large, high-TL vessels, as it is so low as to be negligible.

Sensor Masking: Warships are usually the only vessels to use sensor masking. A ship may optionally be given *stealth,* making it harder to detect by active sensors (like radar), and/or *emission cloaking* to mask it from passive sensors (like infrared). Each type comes in three levels: "Modest," "Basic," and "Radical." A third type of sensor masking, *sound baffling,* is used only when in an atmosphere.

Step 6: Component Modules

A component module is a set of components grouped together into a system, like a bridge or a jump drive. Each module is rated for the *spaces* it takes up. Select modules whose total spaces are sufficient to fill the ship's hull spaces. Weapons and magazines are placed in turret spaces unless hull-mounted. Keep a running total of remaining space; when it's gone, no more modules can be installed inside the hull.

Cargo Space in Turrets

Although turrets aren't designed to carry cargo, they can – with great difficulty. Maintenance hatches must be removed, exposing wiring and conduits, and the cargo must be carried by hand. Safety regulations prohibit the use of turret access space for cargo storage. Players choosing to ignore safety regulations can store small cargo in them. This requires dismantling the turret from the hull side and most cargo in standard shipping format can't even be put in there without a major engineering chore. This is also backbreaking labor – imagine stowing cargo in the front seat of a hatchback, going in through the trunk – and the GM should roll for mishaps which may result in anything from static on the intercom to leaks in the turret's jump field causing jump fluctuations.

Carrying cargo in turrets is not normal practice. If crew members do risk the difficulties and the malfunctions, customs inspectors might decide to examine *every* access hatch and crawlspace, which could easily take days. GMs take note: While the volume of turrets is not counted as part of a ship's total volume when calculating jump, that is a simplification for accounting, *not* a loophole through which ships can get an extra 3% external cargo space "for free." Just the opposite, in fact: Starship owners often pay the price when stuffing things into areas where they don't belong.

So I get settled on the ship and the pilot calls me up to the bridge to sign autographs for the crew. While I'm there, I notice that one of the buttons has a light that says "Press to Test." I resist for about ten minutes, then I press it, and the light changes to "Release to Detonate."

Everybody's a comedian.

– Anton Wilson Peale

Every ship should have a bridge and an engineering or a cockpit/systems module. Other modules are more or less optional, although drives and quarters should be installed in nearly all vessels.

Where modules are available at different TLs, the TL is given after the name; for instance, "Maneuver Drive/10" means a TL10 maneuver drive. If no TL is given, assume the system is available at TL7+. If a series of modules tops out at a TL lower than the vessel's TL, assume the highest TL module is available at the vessel's TL. Modules are also rated for other statistics:

Spc: The spaces the module takes up.

Mass: The module's mass in stons.

Cost: The module's price in MCr.

Pwr: The module's power requirement in MW.

In some cases, a module is partially designed by the ship's builder: select a size in spaces, which then determines mass and cost. Some modules have additional statistics like thrust, power output, and fuel consumption; see the individual description for details.

Balanced Arrays

A balanced array of one missile rack, one laser, and one sandcaster per turret is normal for commercial vessels. On average, two sandcasters will buy a ship an additional laser hit before it takes major damage. Lasers are useful offensive/defensive (anti-missile) weapons, while missiles are the most effective purely offensive weapon. Because small ships in combat rarely have urgent tasks for all five bridge crew stations (the Pilot and Gunner certainly will be busy, and the Sensors station also should be, but a distinct Communications station and the Navigator may have time available), one useful technique is to hand off missiles after they are fired to another crew station, using the bridge's lasercomm for guidance and allowing gunners to concentrate on anti-missile/anti-ship fire.

Step 7: Turret and Weapon Bay Armament

Add each weapon's mass and cost to the running total of vessel mass and cost. Turret weapons may occupy a turret space (up to three spaces per turret) or take up space inside the hull (up to three spaces per turret not installed).

Bay weapons may occupy an entire external bay or take up space inside the hull (in an internal weapon bay).

Spinal mounts always take up space inside the hull.

See *Module Tables,* p. 124, for more information.

Step 8: Statistics

Once the various components that make up a vessel have been added together, it will be necessary to figure out what they can *do* . . .

Payload

Payload is:

- The weight of cargo carried. Assume 5 stons per dton of cargo hold (i.e., about 20 lbs./cf) unless you want to recalculate every time these vary. Exceptionally dense cargo may weigh up to 25 stons/dton; this is the maximum the holds can handle without special reinforcement.
- The mass of vessels carried in spacedocks, vehicle bays, and external grapples.
- The mass of all ordnance: missiles, sand canisters, etc.
- The mass of all non-jump fuel.

Total Empty Mass

Total the mass of hull, turrets/bays, armor, surface features, chosen modules, and weapons. This is the vessel's empty mass.

Total Loaded Mass or Weight (LWt.)

This is equal to empty mass plus payload.

Volume

This is the volume of the vessel in dtons, excluding turrets and external bays.



Maintenance Requirements

For any complete module (drop tank, cargo pod, etc.) that is unpowered and has no systems requiring power, an annual maintenance overhaul is usually sufficient to ensure peak performance. However, starships and small craft have different maintenance requirements. Starships require maintenance in an ongoing fashion, while small craft and non-starships not normally in continuous operation require maintenance only on a periodic basis.

To calculate a starship's maintenance requirement, use:

Maintenance = 4.8 × original purchase price in MCr / (square root of actual purchase price in MCr).

The result is number of man-hours per day required for maintenance.

To calculate the maintenance requirement for a small craft and non-starships in temporary service, use:

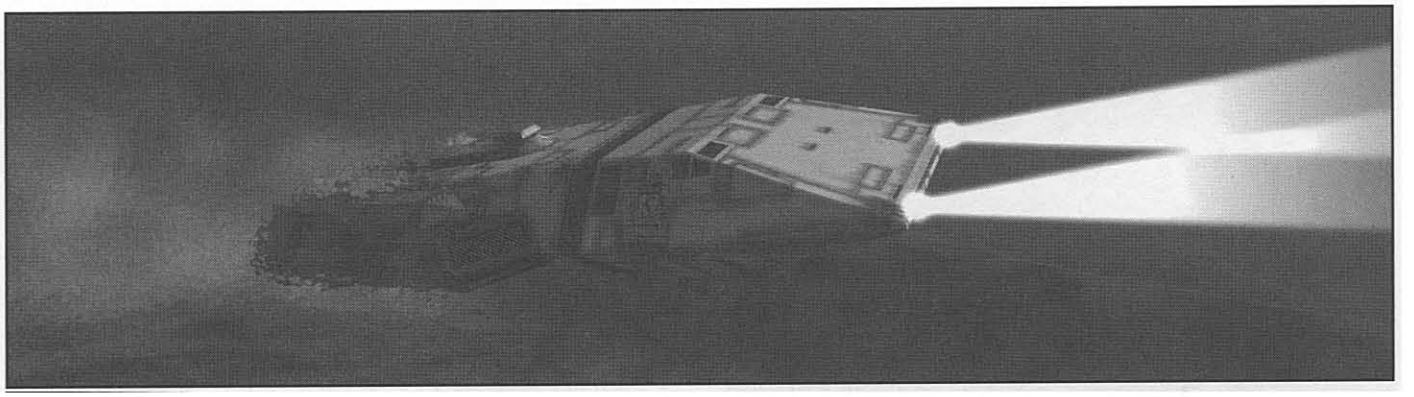
Maintenance = 20 × (square root of actual purchase price in MCr) / original purchase price in MCr.

The result is the maintenance interval, or the number of operating hours between 4-hour maintenance check-ups.

Customized Maintenance Requirements

Some ships also require more maintenance than other ships. Some require less. For every percentage more maintenance required by a vessel, increase its original purchase price by an equal percentage in the above formula. The reverse is also true. For every percentage less maintenance required, decrease the original purchase price of the vessel by an equal percentage in the above formula. *Note that the actual purchase price remains unchanged for purposes of use in the formula.* If the point system is used via the *Ship's Patron* advantage from ***GURPS Traveller: Far Trader***, increase or decrease the ship's point cost by the same amount, rounding *up*. Note that some shipyards (or even whole polities) may produce ships that require more or less maintenance than normal. Terran ships from early in the Interstellar Wars are known to have required 20% more maintenance.

Example: A particular shipyard produces ships that are known for their low maintenance. The GM decides these vessels require only 95% the normal routine maintenance. The team decides they want one of these vessels – it costs MCr25 as per the design sequence in this book. Using the formula above, 4.8 × (25 × 0.95) / (square root of 25) = 22.8 Man-Hours per day of maintenance. Normal maintenance on a ship costing MCr25 is 24 man-hours per day. GMs may also decide to increase the cost the players have to pay for a ship such as this, but the original purchase price and the actual purchase price must be based on what the ship normally costs as per the rules in this design system.



Total Cost or Price

Add together hull, turret/bay, streamlining, armor, surface features, modules, and weapon costs to get the vessel's cost.

Fitted-Out Cost or Payload Cost.

This is equal to the final cost of the ship once it has been fitted out (p. 26).

Structural Health (HT)

Ships in ***GURPS Traveller*** have a structural Health (HT) statistic to reflect their general condition and resistance to wear, fatigue, and breakdowns. Used ships may have reduced HT due to age and wear (see p. 20). If the purchase price was discounted to 50% or less, reduce HT by 1; 10% or less, reduce by 2.

A ship's basic HT is [75 × (internal space in dtons / loaded mass in stons)] + 5, rounded to the nearest whole number. Maximum HT is 12 or the ship's overall TL, whichever is higher. Multiply "internal space in dtons" by 0.1 for super-light frame, 0.25 for extra-light frame, 0.5 for light frame, 1 for medium frame, 2 for heavy frame and heavy asteroid frame, 4 for extra-heavy and extra-heavy asteroid frame, and 8 for super-heavy asteroid frame. See p. T:FT75 for more information.

Hit Points

Record hit points for the hull and each bay or turret. A hull, bay, or turret's hit points are its area × 1.5. Multiply this result by 0.1 for super-light frame, 0.25 for extra-light frame, 0.5 for light frame, 1 for medium frame, 2 for heavy frame and heavy asteroid frame, 4 for extra-heavy and extra-heavy asteroid frame, and 8 for super-heavy asteroid frame.

Damage Threshold

This is the point at which the ship takes major damage. Vessels designed with medium frames suffer a Major Damage result every time cumulative damage to the hull reaches a multiple of 10% of their hull points (HP), as per p. GT169. For vessels with other frame strengths, this "damage threshold" is different. It is equal to the hull's HP multiplied by 1 for super-light frame, 0.4 for extra-light frame, 0.2 for light frame, 0.1 for medium frame, 0.05 for heavy frame and heavy asteroid frame, 0.025 for extra-heavy and extra-heavy asteroid frame, and 0.0125 for super-heavy asteroid frame.

Step 9: Performance and Design Finalization

The final step in starship design involves computing performance and miscellaneous statistics. These bits of information will be handy during game sessions, where pilots will need them to fly their vessel!

Jump Number, Air Speed, and Space Acceleration

These statistics are determined as on p. GT159. To determine drag for airspeed calculations, divide surface area by 10 for superior streamlining, 20 for excellent streamlining, or 40 for radical streamlining.

Space Acceleration and Reaction Drives

If a vessel uses a reaction drive, it can only accelerate for a limited amount of time before running out of fuel. The accounting unit used to determine how long a vessel can accelerate is called a G-Round, or GRd for short. Calculation of GRd formulae is only necessary if a vessel uses a reaction drive; most vessels use reactionless thrusters. The GRd formulae determine the average acceleration over the complete burn time afforded by the available fuel on board. See *G-Round Calculations*, below, for the formulae used to calculate GRds.

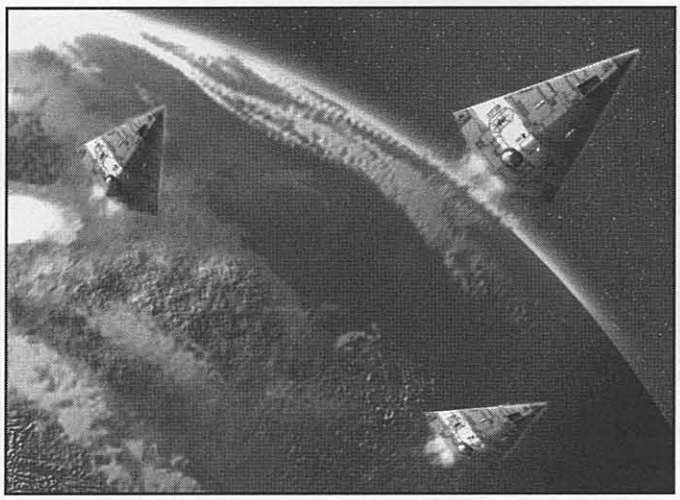
G-Round Calculations

For reaction-drive ships only, this statistic measures how long a ship can accelerate without running out of fuel. The format is *A G R GRds*. *A* is the vessel's maximum space acceleration in gravities; *R* is the number of gravities of acceleration that can be used before the vessel runs out of fuel.

A is reaction drive thrust in stons divided by (ship loaded mass in stons minus half the mass of reaction drive fuel in stons). This reflects the fact that drive fuel will be burned away as the ship accelerates, and thus gives an average result without much complication.

R is the spaces of fuel carried for the reaction drive divided by the drive's fuel consumption in spaces per hour, multiplied by *A* times 3.

Each space combat round, subtract the acceleration in G used by the ship from its remaining G-Rounds. When G-Rounds reach zero, the ship is out of reaction drive fuel and can no longer accelerate.



Example: A ship has a reaction drive with a thrust of 54 stons and a fuel consumption of 188 spaces/hour; the ship has a loaded mass of 600 stons. It carries 282 spaces of hydrogen fuel for its reaction drive; hydrogen masses 1 ston per space, so the fuel masses 282 stons.

A is 54 divided by [600 – (282/2)] = 0.12 G.

R is 282 (fuel spaces) divided by 188 (fuel consumption per hour) times 0.12 (A) times 3 = 0.54.

Its GRd statistic is written as 0.12 G 0.54 GRds. If the vessel accelerates at 0.1 G for two rounds, its GRds drop to 0.34.

Missiles are also rated in GRds; instead of fuel, they use electricity stored in power cells.

Underwater Performance

There may be occasions where the underwater performance of a spacecraft will be relevant (System Defense Boats hiding deep in the ocean, for example). In ***GURPS Traveller***, ships with vectored reactionless thrusters capable of more than 2 G of thrust, very good or better streamlining (see p. 29), and total compartmentalization (see p. 30) are assumed to have the equivalent of a submersible hull. A submersible hull is required for most underwater operations, but ships without one may still be able to function in this environment. For more information, see *Submerged Performance,* p. VE132.

There are two key parameters for underwater performance: Maximum Speed and Crush Depth.

To calculate Maximum Speed underwater (uSpeed), first determine:

Hydrodynamic Drag = 944 × cube root of (Total Displacement × Total Displacement).

Then:

uSpeed in MPH = 76 × cube root (Thrust/Drag).

Total Displacement is in dtons and Thrust is in stons.

Crush depth in yards is 10 plus the DR of the hull or turrets (whichever is lower), multiplied by 0.75 for super-light frames, 1.5 for extra-light frames, 3 for light, 6 for medium, 12 for heavy, and 24 for extra-heavy. Divide this final result by the size modifier of the ship (p. 28). If the ship does not have a submersible hull or the equivalent, divide again by 2. In ***GURPS Traveller,*** this supersedes the formula on p. VE133.

Underwater Action

UV and rainbow lasers have 1/500 their listed range underwater, X-ray lasers 1/1,000, and plasma and fusion guns are useless. TL8+ missiles use their uSpeed statistic as calculated above and can travel for one hour (though their crush depth is quite shallow). If combat occurs in this environment, ***GURPS Traveller: Ground Forces*** is recommended for the shorter combat rounds and distances involved.

Batteries

Up to 10 turrets, or 30 spaces of hull-mounted weapons, may be linked together to form a *battery,* aimed and fired by a single gunner. This is normally done to increase firepower and reduce crew requirements. All turrets must be on the same side of the ship and carry the same weapons. Each time the number of *weapons* is doubled, the battery's effective rate of fire is increased by 1. Battery assignments may be changed at will, so long as sufficient gunners are available. Batteries may not mix turrets and hull-mounted weapons. Weapon bays may not be grouped as batteries.

Directions and Numbering

Directions on shipboard can be both relative ("forward of bulkhead 30") and absolute ("the aft airlock").

Direction Terminology

Drive Axis – the principal direction on a ship is its drive axis, a line from the center of thrust of the primary drives through the center of mass of the ship. Some ships may have both a primary and a secondary drive axis if they have more than one drive configuration; if so, the primary drive axis is almost always meant.

Deck Orientation – Ships are defined as *belly-landers* if their main deck is parallel to the drive axis, or *tail-landers* if perpendicular. Belly-lander designs are common among freighters; this configuration maximizes the area for cargo hatches in proximity to a dock. Belly-landers are also suited to lifting-body designs for streamlining. Military and scientific vessels, and those designed purely for zero gravity, are often tail-landers (e.g., the Laboratory Ship, p. GT145, and Mercenary Cruiser, p. GT139).

Fore and Aft – Forward (fore) is in the direction of the drive axis (toward the nose); after (aft) is in the opposite direction, toward the "tail" of the vessel.

Port and Starboard – The left and right sides of the ship, respectively, always determined while facing forward. The term "port" refers to the Solomani custom of placing the primary airlock (and hence, access to the starport) on that side; Vilani-influenced designs show no particular preference.

Dorsal and Ventral – the top (back) and bottom (belly) of the ship, while facing forward and with port to the left. On tail-landers, port is arbitrarily defined by the location of the main airlock; ventral, starboard, and dorsal subsequently are defined from there.

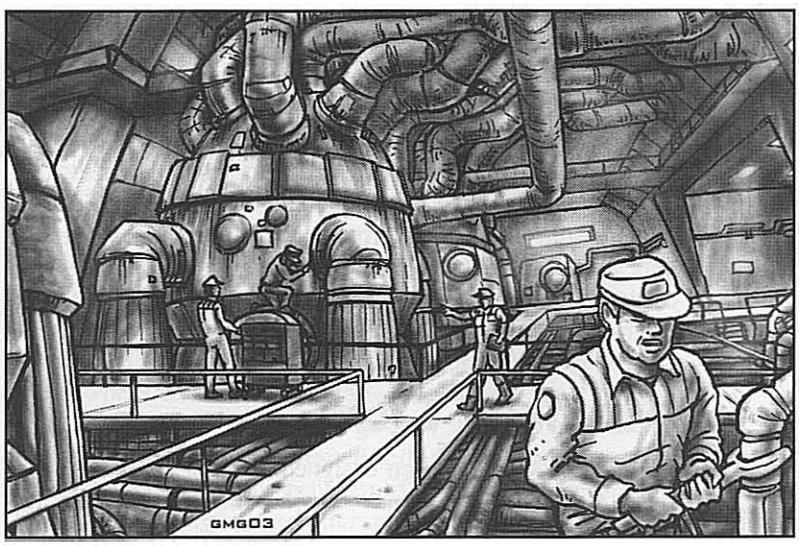
Outboard and Inboard – Outboard is away from the drive axis; inboard is toward the drive axis.

Numbering

Starships have many identical components located throughout the hull; when it is important to distinguish them clearly, a standard numbering system is used. Odd numbers are used on the port side, even numbers on the starboard. Numbering is consecutive, in order from inboard to outboard, fore to aft, dorsal to ventral. Items on the drive axis are numbered after any others of the same type.

For example, the cabins on a *Beowulf*-class free trader (pp. GT132-134) are numbered thusly: starting on deck 1, from top to bottom on the deck plan, numbers 1-3-5 on the left (port) side and 2-4-6 on the right (starboard). On deck 2, the captain's cabin on the port side is #7, while the double occupancy cabin is #8 and the remaining crew cabin #10 (the low berth compartment could be called #9). The two drive units are #1 on the left and #2 on the right; the dorsal turret is #1, the ventral turret #2.

Different ships may have slightly different conventions, and all components should be clearly labeled in any case to prevent confusion. But when the chief engineer tells a crewman to "cut off power to the #3 drive, and hurry!" he should at least know where to look!



Crew and Passengers

All (non-sentient) starships require a crew to operate and maintain the ship. In general, the crew of the ship must provide enough personnel to operate all machinery and man all weaponry. The actual number of crew personnel required for the ship is based on the drives, weaponry, and other equipment carried by the ship. If the ship is under 1,000 dtons, then the rules on pp. GT149-150 should be followed. For vessels 1,000 dtons and over, see *Crews on Large Ships,* below.

In general, crew should have a skill level of at least 12 in the skill(s) appropriate to their positions. Good computers can make up for a lot (especially at high TLs); a luxury yacht may be capable of interstellar travel even though nobody aboard knows anything about piloting, astrogation, or the engine room!

If the GM feels a ship is under-crewed, he should assess penalties to appropriate skill rolls, especially in stressful situations when one spacer has to be in three places at once. See p. GT165 for rules on penalties due to additional duties.

Crews on Large Ships

Typical crew requirements are given below, but these are *averages;* actual requirements can vary a great deal. Military ships will have larger crews to allow for multiple shifts and to replace losses in combat. Transports often run with a bare minimum of crew to save money. A civilian yacht might not have anyone with the titles listed below, but somebody needs to do the job. Ships with minimal crews call for talented people since several jobs are doubled up.

Command Section

The ship should have a commanding officer, an executive officer, a computer officer, two navigation officers, and a communications officer. The section should also have some support personnel, ratings equal to 50% of the total officers in the section. On ships over 20,000 dtons, the number of personnel in the command section should amount to five per 10,000 dtons of ship.

Engineering Section

Engineering crew requirements are listed in the descriptions of each drive and power module. Additional mechanics and technicians (life support, electronics, etc.) may be required to meet maintenance man-hour requirements (see p. 106). The section should include a knowledgeable chief engineer, a second engineer, and several petty officers. There should be 10% officers and 20% petty officers.

Gunnery Section

The ship should have a chief gunnery officer and at least one petty officer for each type of weapon aboard. A spinal mount should have a crew of one per 100 dtons of weapon (round to the nearest whole number); bay weapons should have a crew of at least two; turret weapons should have a crew of at least one per battery. The gunnery section should have 10% officers and 30% petty officers.

A weapon cannot be fired in combat unless it has an operator. However, this may be a gunner, a non-gunner operating at default, or a computer. Some weapons may be manned by ship's troops during combat operations.

Flight Section

If the ship has any small craft, it should have a flight-control officer, crew for each craft, and at least one technician per craft. Launch tubes should have a crew of at least 10, which will include a flight-supervision officer and a preponderance of petty officers.

Stewards on passenger liners are often given minimum certification as lifeboat operators for emergency evacuations.

How Many Medics Do I Need?

If a ship is 1,000 dtons or larger, see *Medical Section*, below. For smaller ships, here is a review of the different rules and guidelines.

- ***GURPS Traveller: Far Trader*** says one Certified Medical Technician is required for ships 200 dtons or larger and carrying paying passengers.
- ***GURPS Traveller*** states one Sickbay is required for every 120 staterooms, rounded up. It is recommended that the first Sickbay have two medics and then one medic for each additional one.
- ***GURPS Traveller*** states a medic with First Aid should be carried on ships without Sickbays but carrying passengers. This medic may be a steward with the required training.
- ***GURPS Traveller*** states a medic with Electronic Operations (Medical) at 10+ should be carried on ships to oversee cryogenic freeze capsule (low berth) operations. This may be a steward with the required training.

To sum up: If a ship is carrying paying passengers (awake or in low berth) and the ship is 200 dtons or larger, a certified medical technician is required with Electronic Operations (Medical) at 10+. If the ship doesn't have a Sickbay (or Emergency Aid Station) this medic can also be a steward. One full-time medic for each 60 people aboard is highly recommended. Automeds and chrysalis machines (p. S91) can replace medics, but a ship should retain at least one live medic per sickbay, military sickbay, or per two Emergency Aid Stations (see p. 65).

Medical Section

A chief medical officer, plus one full-time medic or assistant per additional 50 people aboard. Automeds and chrysalis machines (p. S91) can replace medics, but a ship should retain at least one sophont medic per sickbay or military sickbay, or per two Emergency Aid Stations (p. 65).

The rate at which low-berth passengers can safely enter or awake from cold sleep is critically dependent on the number of skilled medics available: one medic at Physician 10+ or Electronic Operations (Medical) 10+ can assist the entry of 12 or revival of 16 passengers per hour (p. GT108). Passenger ships with large numbers of low passengers often cross-train stewards to minimum standards to expedite this process.

Service Crew

The ship itself may have a requirement for additional sections which provide basic services including shops and storage, security (especially if there are no ship's troops aboard), food service, and other operations. Allow two per 1,000 dtons of ship or 100 other crew, whichever is more; three per 1,000 dtons or 100 crew if there are no ship's troops.

Luxury liners often have extensive housekeeping and service staffs for the comfort of passengers; see p. 56.

Ship's Troops

Most ships 1,000 dtons and over have a marine (or military) contingent aboard which ranges in size from a squad to a regiment. The size of contingents can range from three per 1,000 dtons of ship to three per 100 dtons. Such forces are organized according to the standards of the service from which they are drawn, but are assigned to the ship; their equipment should be consistent with the TL of the ship. Ship's troops often fill the role of security forces aboard the ship and are used for military exercises by the ship's commanding officer. They are also used for damage-control parties, manning of some weapons, and boarding actions.

Ship's troops often get bunkroom accommodations, though this is avoided whenever possible. They also require approximately one armory per 20 troops, in addition to special facilities for storing battledress (p. 55) if so equipped.

Specialists

Large ships, especially military vessels, will have full-time officers and specialists for intelligence, liaison, electronic warfare, etc. There may also be science crew, cargo specialists, etc.

Optional Crew

Entertainers of various sorts will be found on luxury liners – sometimes more entertainers than passengers. They may or may not have any actual "crew" skills.

Frozen Watch: If low berths provide enough places for a 50% overage in personnel (including ship's troops, if any), then the ship may have a "frozen watch." Fresh personnel are kept available in low berths for continuous replacement of casualties and battle losses; between battles, the frozen watch can be revived and used to restore lost crew.

Fitting Out

Once a ship has been designed, it is far from ready for flight. A variety of consumable supplies must be acquired, first.

Additional Expenses

Vessels may require these additional expenses not included in their cost:



- Computer programs (p. 70).
- Missiles (p. 52).
- Sand canisters (replacements cost Cr400).
- Spare parts: assumed at 0.1% of original purchase price of vessel per year.
- Berthing costs: Cr100 × hull class per week (or fraction thereof) to land or dock at any starport. For more detailed costs, refer to ***GURPS Traveller: Far Trader***.
- Fuel: depends on required type. See the table below:

Fuel Type	*Cr/dton*	*Abbreviation*
Refined LHyd	350	H
Unrefined LHyd	50	H
Hydrogen/Oxygen	333	HO
Jet Fuel	10,000	J
Metal/Oxide	50,000	MOX
Rocket Fuel	6,667	R
Water	0	W

- Fresh provisions: cost Cr60+ per person per week; required for high-passage accommodations. Also refer to p. 59.
- Annual maintenance: costs 0.1% of original purchase price and two weeks at any Class IV or V starport. See p. 106.

Outfitting the Ship

A starship costs tens of millions of credits, yet some owners will begrudge a few tens of thousands to keep their investment in top shape. Here are a few points to consider when outfitting a new ship.

Auxiliary Equipment

Auxiliary equipment includes every item not part of the ship's basic design. Freight-handling equipment (p. 62) is an investment – a self-sustaining ship is one that can make a profit where others can't. Environmental gear for the ship's locker (see p. 61) and survival gear for the crew and passengers (especially sufficient rescue balls in every compartment) can make the difference between life and death (see p. 116). Finally, buy shotguns and snub pistols enough to equip the crew, for repelling boarders and hijackers *without* frying the bulkheads (see p. 105).

Parts and Stores

Spare parts cost 0.1% of the ship's original purchase price per year; their volume is included in engineering. This is in addition to parts required for annual maintenance (p. 106).

Although ships' life-support systems can produce edible food from algae and mycoprotein, it is not too tempting; the product is a bland-tasting, dry, flaky paste or cake, often gray or brown. Flavor additives (100 single-meal packs weigh 5 lbs. and cost Cr 50) make it more palatable. Vats that produce fauxflesh (a product of artificial tissue-engineering technology) provide real animal protein, but ships with less than 50 staterooms may have room to grow only one variety ("Beef *again*? I'd kill for lamb!").

Fresh provisions are the alternative of choice, and a necessity on any ship intending to carry high passengers. Preserved provisions are 2 lbs., 0.04 cf, and Cr6 per person per man-day. Fresh *real* food ranges from two to four times the price (and up, although at the high end the quality of the product depends more on the Cooking skill of the chef), and has twice the weight and volume. Both are carried as cargo: 2,000 man-days of preserved provisions or 1,000 man-days of fresh food per dton; fresh provisions are also perishable.

Ammunition

Not all merchant ships need to be armed; in the core sectors of the Imperium, armed turrets are not only a waste of space, but attract unwanted attention as well. Ships operating on the fringes or contracted to carry mail, however, need some form of armament. Some captains elect not to buy ammo while they pray their weapons alone will act as a deterrent. Others swap out weapons in bays and turrets when available at starports or planetside.

There is no magic formula for how many missiles and sandcasters to buy. In general, the ship with the most ammo wins; buy as much as possible.

Cash

Don't forget to maintain a cash reserve. Ideally, this should be enough for three months' expenses – but no one ever manages to save that much. Just set something aside for quick speculations, battle-damage repairs, unforeseen equipment requirements, "contributions" to local economies and their officials, and so on.

Hiring Crew

As in most business ventures, personnel can represent the single top expense of a starship operator.

Salaries and Shares

Crew members must be paid monthly, usually at the first port of call each month. Non-player characters must be paid according to the Job Table on p. GT106. Player characters may bargain for better pay rates or elect to accept worse. In addition, crew members may participate with the owners and accept shares in the proceeds of the ship's activities in lieu of all or part of their salaries. Salaries (and shares) should be noted next to names on the crew manifest, though this detail might be neglected on pirate ships.

Working Passage

A starship captain with a crew shortage may fill the vacancy by offering passage instead of wages. Working passage may not continue for more than three jumps or the individual is considered "hired" for standard salary – retroactive to the date he joined the ship. Crew members that work for passage do not sign the ship's Articles; instead, an entry is made in the ship's log detailing the circumstances and terms of the contract. In order to sign on for working passage, the individual must have some expertise in the position for which he is hired (but might not be fully certified). Baggage totaling 2,000 lbs. or one dton is allowed. Working passage costs the individual nothing; he receives passage, room, and board in lieu of salary.

Chapter Three

Hulls

There are four types of hull: streamlined, unstreamlined (the hull type that ***Traveller*** calls "partially streamlined"), dispersed, and planetoid.

Standard hulls are constructed according to the hull tables below; custom hulls make use of several options for more efficient or specialized design.

Streamlined and Unstreamlined Hulls

Many vessels previously seen in the ***GURPS Traveller*** universe used standardized hull designs, either TL10 or TL12 medium frames with standard materials, and either a non-streamlined hull or very good streamlining with a lifting body.

Standard Hull Sizes

The following table is for TL10, non-streamlined hulls:

Hull Class (dtons)	Volume (CF)	Area (SF)	Hit Points	Mass (stons)	Cost (MCR)	Size Mod
10	5,000	2,000	3,000	2	0.1	+6
20	10,000	3,000	4,500	3	0.15	+6
25	12,500	3,500	5,250	3.5	0.175	+7
30	15,000	4,000	6,000	4	0.2	+7
40	20,000	5,000	7,500	5	0.25	+7
50	25,000	6,500	9,750	6.5	0.325	+7
60	30,000	7,000	10,500	7	0.35	+7
80	40,000	8,000	12,000	8	0.4	+8
90	45,000	9,000	13,500	9	0.45	+8
100	50,000	10,000	15,000	10	0.5	+8
200	100,000	15,000	22,500	15	0.75	+8
300	150,000	20,000	30,000	20	1	+9
400	200,000	25,000	37,500	25	1.25	+9
600	300,000	30,000	45,000	30	1.5	+9
800	400,000	40,000	60,000	40	2	+10
1,000	500,000	45,000	67,500	45	2.25	+10
1,200	600,000	50,000	75,000	50	2.5	+10
2,000	1,000,000	60,000	90,000	60	3	+10
3,000	1,500,000	80,000	120,000	80	4	+11
4,000	2,000,000	90,000	135,000	90	4.5	+11
5,000	2,500,000	110,000	165,000	110	5.5	+11
10,000	5,000,000	170,000	255,000	170	8.5	+12
15,000	7,500,000	230,000	345,000	230	11.5	+12
20,000	10,000,000	280,000	420,000	280	14	+12
30,000	15,000,000	360,000	540,000	360	18	+13
50,000	25,000,000	510,000	765,000	510	25.5	+13
60,000	30,000,000	580,000	870,000	580	29	+13
70,000	35,000,000	640,000	960,000	640	32	+14
75,000	37,500,000	660,000	990,000	660	33	+14
80,000	40,000,000	700,000	1,050,000	700	35	+14
90,000	45,000,000	760,000	1,140,000	760	38	+14
100,000	50,000,000	810,000	1,215,000	810	40.5	+14
110,000	55,000,000	870,000	1,305,000	870	43.5	+14
120,000	60,000,000	920,000	1,380,000	920	46	+14
130,000	65,000,000	970,000	1,455,000	970	48.5	+14
140,000	70,000,000	1,020,000	1,530,000	1,020	51	+14

Standard Hull Sizes (Continued)

Hull Class (dtons)	Volume (CF)	Area (SF)	Hit Points	Mass (stons)	Cost (MCR)	Size Mod
150,000	75,000,000	1,070,000	1,605,000	1,070	53.5	+14
175,000	87,500,000	1,180,000	1,770,000	1,180	59	+14
200,000	100,000,000	1,290,000	1,935,000	1,290	64.5	+14
250,000	125,000,000	1,500,000	2,250,000	1,500	75	+14
300,000	150,000,000	1,690,000	2,535,000	1,690	84.5	+15
400,000	200,000,000	2,050,000	3,075,000	2,050	102.5	+15
500,000	250,000,000	2,380,000	3,570,000	2,380	119	+15
750,000	375,000,000	3,120,000	4,680,000	3,120	156	+15
1,000,000	500,000,000	3,780,000	5,670,000	3,780	189	+16
1,250,000	625,000,000	4,390,000	6,585,000	4,390	219.5	+16
1,500,000	750,000,000	4,950,000	7,425,000	4,950	247.5	+16
1,750,000	875,000,000	5,490,000	8,235,000	5,490	274.5	+16
2,000,000	1,000,000,000	6,000,000	9,000,000	6,000	300	+16
3,000,000	1,500,000,000	7,860,000	11,790,000	7,860	393	+17

Custom Hull Sizes

Hulls can be constructed to any size. If a hull class falls between two classes on the table, treat it as the larger class for area, hit points, cost, mass, and size modifier. The volume (in cf) of the new hull is calculated by multiplying the Hull Class (dtons) by 500 (the number of cubic feet assumed to be in a space).

Options

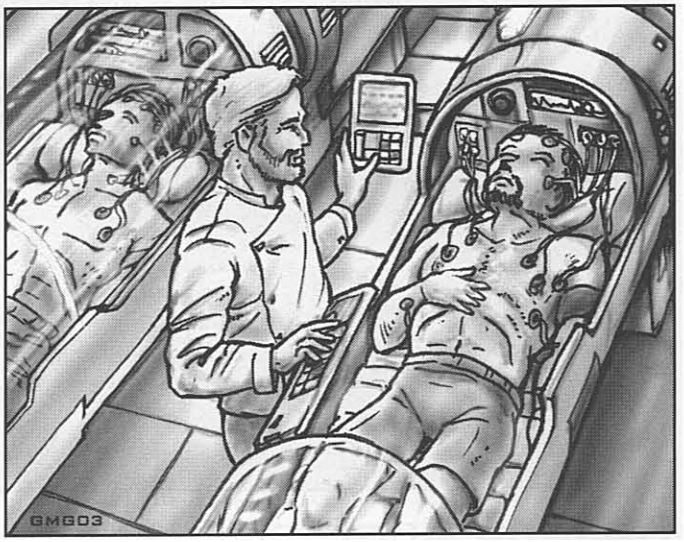
The naval architect can vary several structural factors, depending on the vessel's intended purpose.

Frame: Most ***GURPS Traveller*** vessels use medium frames, but other types are possible: racing vessels are often super-light, while warships are frequently reinforced. Multiply cost, mass, and HP by the values on the table. Ships with high accelerations, external cradles, or other abnormal loads should have heavy or extra-heavy frames to handle the additional stress this places on their hulls if gravitic compensation is below the acceleration the engines can provide. Hit point thresholds for determining major damage is not affected by frame strength (this means vessels with heavier frames will typically take more major damage before becoming disabled). See Chapter 2.

Materials: Most ***GURPS Traveller*** vessels use standard materials, which represent the optimum balance between mass and cost. Where one of these factors is overwhelmingly important, different materials can be used. Multiply mass and cost by the values on the table. All starports have standard materials readily on hand and are tooled to work with them. Starports may not have other options available; it will add to the construction time (and thus cost, at GM's discretion) if they have to retool for it.

TL: Improving materials technology reduces structural mass, as indicated on the table. TL10 hulls are the standard against which all others are measured.

Streamlining: Standard ***GURPS Traveller*** vessels have either no streamlining or very good streamlining. All streamlined vessels are lifting bodies (like the Space Shuttle or "flying wings" – see p. VE11). Better streamlining increases



a vessel's atmospheric speed. Multiply hull cost and internal spaces by the values from the table.

Tech Level

	7	8	9	10	11	12+
Mass	3	2	1.5	1	0.75	0.5

Frame

	Super Light	Extra Light	Light	Med	Heavy	Extra Heavy
Cost	0.1	0.25	0.5	1	2	5
Mass	0.1	0.25	0.5	1	1.5	2
HPs	0.1	0.25	0.5	1	2	4

Materials

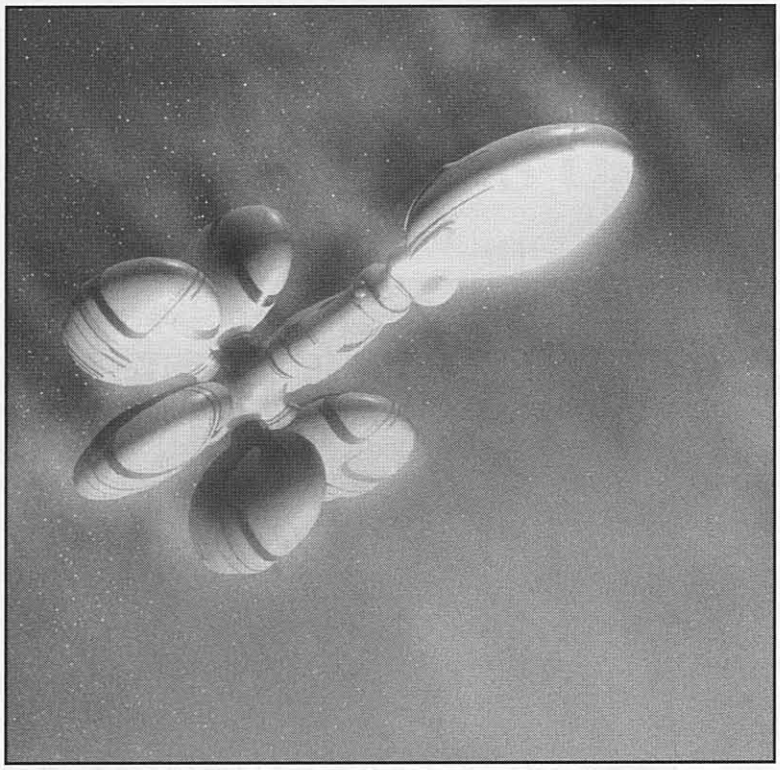
	Cheap			Exp.		Advanced
	Very Cheap		Standard		Very Exp.	
Cost	0.2	0.5	1	2	5	10
Mass	2	1.5	1	0.75	0.5	0.375

Streamlining

	Unstream.		Superior		Radical
		Very Good		Excellent	
Cost	1	2.4	3.6	6	12
Spaces	1	0.8	0.77	0.74	0.71

Compartmentalization

Vessels are already divided into airtight compartments with interior walls and pressure doors. For extra weight and cost, vehicles can have Heavy Compartmentalization (adds 10% of hull mass to total weight) or Total Compartmentalization (adds 20% of hull mass to total weight). Either type costs MCr0.01 per ton of weight added. Effects of compartmentalization are outlined on p. 31.



Robotic Ships

For a ship that can be run completely by computer, double hull cost (cumulative with the above modifiers) to include the necessary systems and internal data highways to enable the vehicle to be controlled entirely by a robot brain (see pp. VE61-63). A robotic ship still requires routine maintenance which can be performed by a human crew or with a crew of generic tinker-bots as described in ***GURPS Robots***.

Robotic vessels are severely restricted by Imperial safety regulations (starships cannot legally be operated on interstellar flights without a crew, for instance). There is nothing to prevent robotic provisions being added to a *crewed* ship, however; this represents a high degree of automation in the ship's systems. Robotic ships are commonly used as in-system gas and ore haulers on routine runs.

Other major powers and most independents have similar restrictions. The Hiver Federation is the notable exception: Hivers make extensive use of robotic vehicles and spacecraft.

In situations where a crew is required on a robotic ship, add up the total crew required to operate the maneuver drive as per the individual modules. The number of crew needed is the square root of the total, rounded up to the nearest whole number. This should also be done for the jump drive and the combination gravitics system if installed.

Dispersed Hulls

A dispersed hull is a structure with a minimum of open frame armor, to which components are attached. The hull itself cannot be sealed or pressurized; instead, separate sub-hulls are constructed and attached to the frame to provide pressurized environments. Dispersed hulls are common at low TLs (to save weight) and for military and commercial jump tenders, because a dispersed hull can launch and recover all carried craft at once.

Select a hull from the hull table; this provides the framework. Dispersed hulls cannot be streamlined or have any sensor masking or radiation shielding.

A maximum of (DR 100 × structural hit point factor) of "open-frame" armor may be added. Open-frame armor protects normally against collisions but provides no protection against explosions, beams, bullets, or other small projectiles (optionally, there is a 2 in 6 chance of hitting the frame). Open-frame armor has 20% of normal weight; since cost is based on weight, this makes it 20% as expensive.

All inhabited portions of the ship (bridge, engineering, staterooms, and any component with a power requirement) must be installed in pressurized sub-hulls. Turrets and weapon bays need not be included, as they already constitute separate compartments. Total all pressurized systems and design a single "hull" to contain them. This "hull" is framed (often of super-light strength), armored, and sealed normally. Total Compartmentalization allows this "hull" to be divided into as many sub-hulls as desired. The sub-hulls may be stealthed and cloaked at basic or lower levels (though it is pointless because the rest of the hull cancels any benefits gained). Sub-hulls may not have any other external surface features (hardpoints, external cradles, etc.) or streamlining, as they are contained within the primary hull. This sub-hull is still considered part of the overall vessel and not removable. It therefore does not require any special mounting hardware.

Planetoid Hulls

A planetoid may be used as a hull; they are available for the finding in any system with an asteroid or planetoid belt.

Planetoid hulls must be sealed, but may not be streamlined, nor have any sensor masking above basic. The inexpensive nature of planetoid ships would appear to be their major attraction, but they do provide other benefits, such as relatively inexpensive (though bulky) armor protection.

Hull: Select a hull from the hull table (or design a custom hull) using Medium Frame, Standard Materials. Multiply by the following factors:

Frame	Heavy	Extra Heavy	Super Heavy
Mass	18	24	36
HPs	2	4	8

Super-heavy frames are only available for planetoid hulls. They represent a hull that is mostly solid nickel-iron with compartments hollowed out of it.

Armor: Multiply DR by (surface area × 0.00035) to get armor weight in stons; planetoid armor is free. Minimum DR is 100; maximum DR = surface area.

Alternatively:

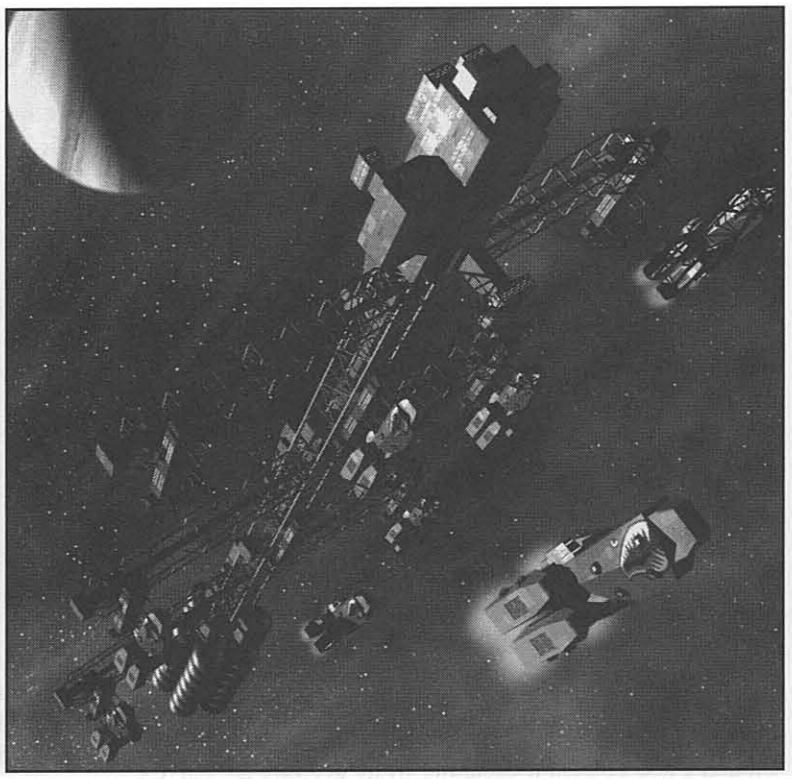
Planetoid DR = (armor weight in stons × 2,857) / surface area.

Planetoid hulls must still be sealed.

Cost: Starports charge a higher fee for "wrangling" a suitable planetoid, especially if it is located in a remote or dangerous system. Finding and moving a planetoid can kick off an adventure revolving around ship construction! Cr100 per space for hollowing, plus Cr2.5 to Cr40 per space for bringing in the planetoid.

Compartmentalization: Heavy Compartmentalization weighs 10% of hull mass; Total Compartmentalization weighs 20%. These don't have to be hollowed out (obviously), but they do count against the transportation cost. Their weight counts against the empty weight of the ship.

Volume: Unlike most vessels, the structural framework, armor, and compartmentalization of a planetoid hull are too bulky to ignore. Add up the total weight of the frame plus compartmentalization, divide by 125, and round up to get the number of *internal spaces* occupied by solid nickel-iron; these spaces are not available for other systems. Divide the total weight of armor by 125 to find its volume in spaces. Again, these spaces are not available for other systems.



Armor

Standard ***GURPS Traveller*** vessels use expensive metal armor. Select the DR level and material for the vessel's armor, then calculate the mass and cost. Metal armor is assumed to occupy no volume; planetoid armor is treated differently (see p. 31).

Armor Type at TL	Expensive		Cheap		
	Advanced		Standard		Mass
Steel or Aluminum Alloy	–	–	7	8	0.00025
High-Grade Steel or Aluminum Alloy	–	7	8	9	0.0002
Titanium Alloy	7	8	9	10	0.000125
Durasteel	8	9	10	11	0.000075
Crystaliron	9	10	11	12	0.00005
Superdense	10	11	12	13	0.00003
Bonded Superdense	11	12	13	–	0.00002
Cost (MCr/ston)	0.04	0.012	0.004	0.002	

Tech Level: The TL shown on the table is the TL at which each type of armor is considered Advanced, Expensive, Standard, or Cheap, respectively. A dash "–" means the armor is not available at that TL.

Mass: Multiply the figure in the table by total surface area and desired DR to get total mass of armor.

Cost: Multiply the cost factor for material and TL by total mass to get cost.

Surface Features

Surface features are components and options applied to the outside of the hull. They generally do not consume internal space, but almost always add to the vessel's cost and often add to weight.

Sealing

Vessel hulls must be sealed to retain internal atmosphere; crew and passengers will require vacc suits and their own oxygen supply in the very few classes of vessel that do not possess this feature. Multiply total surface area by MCr0.00004 to determine cost. Halve this cost at TL8 and halve it again at TL9+.

Sensor Masking

Warships are generally the only vessels to use sensor masking. A ship may be given *stealth* making it harder to detect by active sensors (like radar) and/or *emission cloaking* to mask it from passive sensors (like infrared). *Infrared cloaking* is an earlier version of emission cloaking. It is effective only against infrared, thermograph, or a PESA using thermograph mode but *not* any other type of PESA. Each type comes in three levels: "Modest," "Basic," and "Radical."

Stealth systems at TL8+ may incorporate, at no extra cost or mass (GM's discretion), a color-changing liquid crystal coating centrally controlled by the ship's computer. Civilian ships sometimes add this feature to their hulls separately and use it for camouflage (-2 to Vision rolls), decoration, or advertising.

Sensor Masking Feature	Mass	Cost	Power
Modest Infrared Cloaking/7	0.0005	0.00003	0
Basic Infrared Cloaking/7	0.001	0.0003	0
Radical Infrared Cloaking/7	0.002	0.003	0
Modest Stealth/7	0.0005	0.00003	0
Basic Stealth/7	0.001	0.0003	0
Radical Stealth/7	0.002	0.003	0
Modest Emission Cloaking/8	0.0005	0.00003	0
Basic Emission Cloaking/8	0.001	0.0003	0
Radical Emission Cloaking/8	0.002	0.003	0
Modest Sound Baffling/7	0.0005	0.00001	0
Basic Sound Baffling/7	0.001	0.0001	0
Radical Sound Baffling/7	0.002	0.001	0
Liquid Crystal Skin/8	0.0001	0.00004	Neg

Weight and cost are each equal to the vessel's total surface area times the number shown on the table above. Weight and cost are halved the TL after the system's introduction, and halved again 2 or more TLs after introduction. A vessel may not have two different versions (i.e. basic and radical) of the same feature.

Each level of cloaking, stealth, or sound baffling has a bonus associated with it. Modest is (TL-4) / 2 (round up). Basic is (TL-4). Radical is 2 × (TL-4). The bonuses for IR Cloaking and Emission Cloaking while in space are halved.

Infrared (IR) Cloaking subtracts its bonus from rolls to determine the success of IR sensor scans. Emission Cloaking subtracts its bonus from rolls to determine the success of passive sensor scans. IR and Emission Cloaking have no effect on vessels propelled by fusion air-rams or any other rocket.

A vessel with modest stealth has rudimentary smooth contours, but can pass as an ordinary design. A vessel with basic stealth has more smooth contours, but can also pass as an ordinary design. One with radical stealth always *looks* stealthy; think of a contemporary B-2 bomber or F-117 strike fighter. Either kind of stealth loses its effectiveness if the vessel has loaded external hardpoints (although empty hardpoints are fine); the vessel regains its stealth bonus after dropping its load. Stealth subtracts its bonus from rolls to determine the success of active sensor scans.

A vehicle with sound baffling is less noisy – system defense boats (SDBs) acting underwater or in a gas giant and atmospheric fighters often have sound baffling to make them harder to detect, but it can also reduce noise pollution! Sound baffling represents a variety of internal and surface measures to reduce the vehicle's noise level. Care is taken to mask sounds emitted from the vehicle, especially those of the engines. Equipment is carefully mounted so its vibrations are reduced. A vehicle with sound baffling may have modest, basic, or radical levels. Radical sound baffling is even more obsessive in its quest for noiselessness: the vehicle's surface may be covered with special tiles designed to degrade sonar detection. At higher TLs, the vehicle surface may actually be shaped to absorb sound. Sound baffling subtracts its bonus from rolls to hear the vehicle or detect it with any form of microphone, sound detector, or passive sonar. Radical sound baffling also subtracts TL-4 from attempts at active sonar sensing.

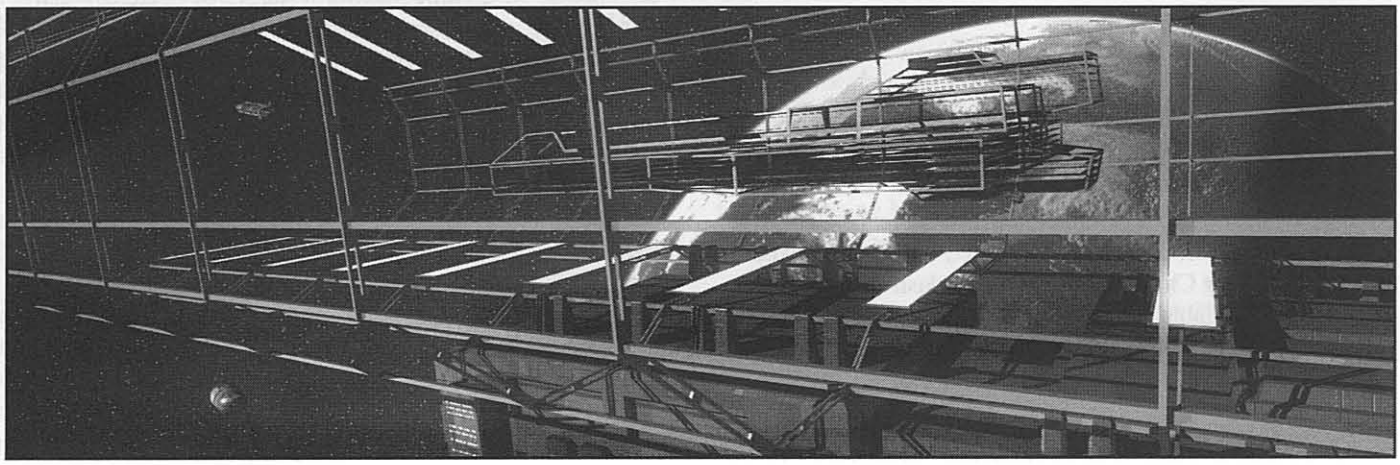
Each of these Sensor Masking options produces the ship's Detection Modifier. If a vessel is attempting to scan a ship with AESA (or another active sensor), its Detection Modifier is its Stealth Modifier. Likewise, its Detection Modifier against passive sensors is its Emission Cloaking Modifier.

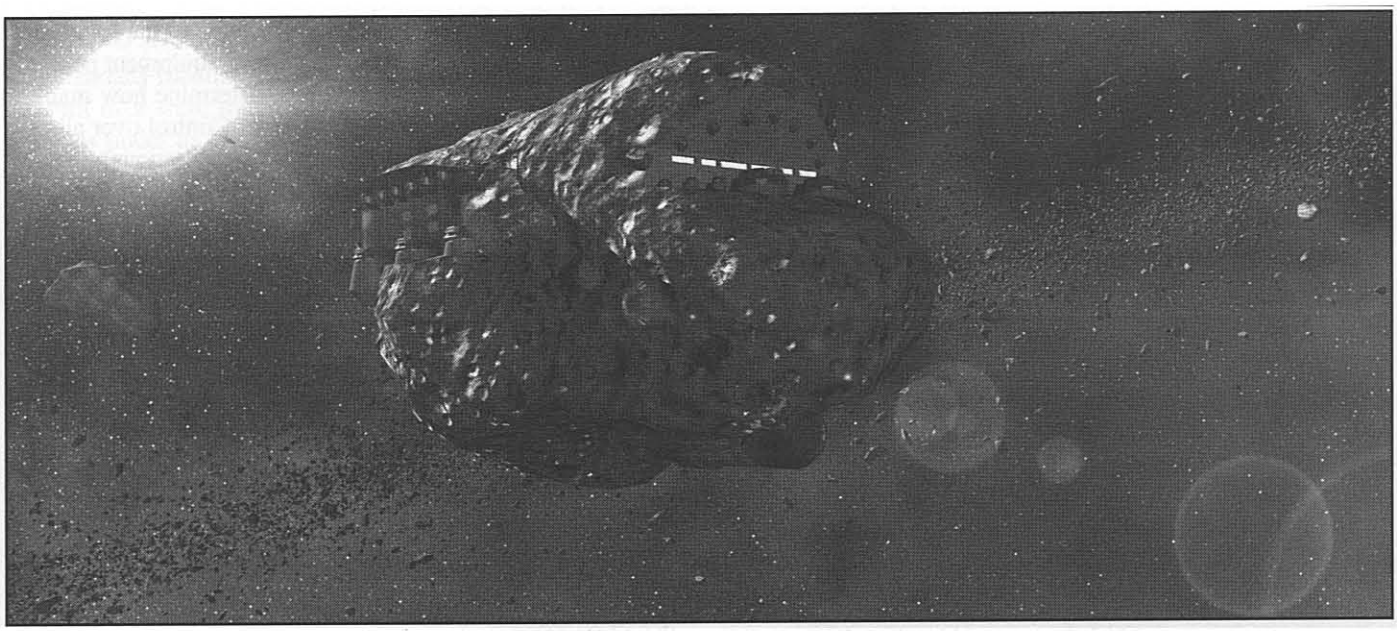
Typically, sensor masking can only be installed when the ship is designed. However, GMs may rule that *Modest* levels of sensor masking can be retrofitted to existing designs. This includes enhancements such as radar-absorbing paint, smoothing out some edges, and various tune-ups to the ship's systems.

Additional Shielding

Vessels likely to face certain hazards may have additional shielding installed. Alternatively, individual compartments may be shielded (brigs, bridges, staterooms, etc.). Find the surface area of individual compartments using the formula (spaces × 500) raised to the 2/3 power, multiplied by 6. The following types are available:

Electrified Surface: This feature is used to keep animals away or discourage people from tampering with the vessel. Conductive wires are embedded in the vessel's hull. The system can be set for "stun" or "kill." When turned on, any uninsulated object touching or touched by the outside of the hull takes 2d damage (if set to "stun") or 10d damage (if set on "kill"). Complete metal armor protects with only DR 1 against electrocution. A HT roll is required if any damage penetrates DR and the victim is still conscious; failure means he passes out for 25-HT turns (seconds). Electrical damage is covered more fully on pp. CII138-139.





Turning an electrified surface on or off can usually be accomplished from the bridge or main security station; it can be disabled from engineering or when the vessel loses power. An electrified surface can be designed to activate when an alarm system detects tampering with the locks or (if appropriate) by an operational Anti-Hijack program.

Radiation Shielding: Radiation shielding is typically ignored in ***GURPS Traveller*** but included here as an option. Detailed radiation rules are given on pp. S104-106. A vessel's hull has a natural radiation protection factor (PF). This is based on the DR of the hull facing the radiation. DR less than 100 gives PF 2. DR 100 gives PF 10 and every doubling of DR after that increases PF by a factor of 10 (e.g., DR 800 gives PF 10,000). In addition, double the PF if the vessel has superconducting armor, and the radiation is primarily X-rays, UV, or gamma rays.

Additional radiation shielding may be added if desired. PF for one layer is 10 at TL7, 100 at TL8, 1,000 at TL9-10, 10,000 at TL11-12, and 100,000 at TL13+, which adds to the natural PF above. Architects can add as many layers of shielding as desired, subject to the limitations of weight and cost.

Psi Shielding: Interferes with the use of telepathy (friendly or hostile) through the hull of the ship. Psi shields protect exactly as if it were a Mind Shield used by a telepath with a skill of 3 and a Power of (TL-2) × 2 (see p. B167).

Thermal Superconductor Armor: This coating may only be added over armor. It doubles DR up to an additional +DR 250 against shaped-charge (HEAT and HEDP) explosive warheads, lasers, X-ray lasers, and high-energy (plasma and fusion) weapons.

Shielding Feature	Mass	Cost
Electrified Surface	0.0001	0.00001
Radiation Shielding	0.001	0.00003
Psi Shielding/8+	0.00005	0.0001
Thermal Superconductor Armor/11+	0.000125	0.00025

Multiply mass and cost by the total surface area of the vessel. Weight and cost are halved 1 TL after the system's introduction, and again 2 or more TLs after introduction.

Turrets

Turrets come with a roomy built-in crew station (seat and console) with computer terminal and a Heads-Up Display/Weapon Aiming Computer (HUDWAC); at TL8+ they include a pupil scanner. Note that even though batteries of turrets (p. 24) do not require crew stations, naval experience has shown it is prudent to include them, anyway. If centralized battery control falls victim to battle damage, the only thing that might save a warship is crew members rushing to the turret stations and manning the weapons the old-fashioned way . . .

Turrets have three spaces available for weapons external to the main hull and consume one space internally for rotation room and the crew station. Pop turrets consume four spaces internally and three spaces externally when extended.

See p. 19 for more information on turrets. Turrets are Size Mod +5.

Weapon Bays

Weaponry in bays may be of five different types: meson guns, particle beams, high-energy weapons (plasma and fusion guns), repulsors, and missile racks. Bays don't come with crew stations – these crew stations are built into the actual weapons installed in the bay.

Small external bays have 50 spaces available for 50-ton bay weapons external to the main hull and consume 10 spaces internally for rotation space. Large external bays have 100 spaces available for 100-ton bay weapons external to the main hull and consume 20 spaces internally for rotation space.

If used as a sort of pop turret, small external bays consume 60 spaces internally (weapon space plus rotation space) and 50 spaces externally when extended. Large external bays consume 120 spaces internally and 100 spaces externally when extended.

Small internal bays have 50 spaces available for 50-ton bay weapons and consume 50 spaces internally. Large internal bays have 100 spaces available for 100-ton bay weapons and consume 100 internal spaces.

See p. 19 for more information on weapon bays. Weapon bays have a Size Mod equal to that of a vessel of their volume.

Modular Sockets

A modular socket is a space *in* a vessel designed to accept different component modules, and to allow them to be changed as needed without a shipyard facility or extensive reconstruction. A modular socket is rated for the exact volume of the module it can accept. It has no weight but costs MCr0.25 per dton. Its volume is exactly equal to its capacity. Modular sockets are available in half-space increments. The modular component (what fits in it) costs 20% more than its base cost.



External Store Mountings

External stores are anything carried outside the main hull and not stored in turrets or external bays. If a vessel does not have grav compensation, install enough mountings to hold the expected "weight" of the stores. This is determined by multiplying the mass of the stores by the expected acceleration of the vessel. This could result in small cradles capable of fitting large stores if the vessel is quite slow.

Hardpoints

Hardpoints are reinforced points on the exterior of a vessel's hull to which external stores such as drop tanks, missiles, or equipment pods are attached and jettisoned.

Each hardpoint (which is actually a set of related fittings) is rated for the maximum weight it can carry – its load capacity. Within these weight limits, a single hardpoint can be loaded with *one* drop tank, weapon, or equipment pod.

If a vessel will have hardpoints, determine how many it will have and the load capacity of each. Control over all of a vessel's hardpoints (which includes firing weapons) must be assigned to one of the vessel's crew stations, typically the pilot's.

The total weight of all hardpoint loads may not exceed (0.01 × the ship's hit points) in stons. Each hardpoint weighs 0.05 stons and costs MCr0.0002 per ston of load capacity. Hardpoints are assumed to be "tapped," allowing the vessel to draw liquid hydrogen from drop tanks and provide power to pods containing electronics.

Performance (jump number, acceleration) for ships with hardpoints must be calculated separately with and without external stores. Each 100 spaces of external stores on hardpoints obscures the arc of one turret. Each 1,000 spaces obscures the arc of one bay or 10 turrets. In either case, the weapons may be hull-mounted in lieu of losing their arcs completely.

Because hardpoints are generic and can carry any store within their weight limit, the stresses associated with atmospheric flight are unknown. Ships mounting loaded hardpoints may not enter an atmosphere without destroying the hardpoint and the stores attached. For atmospheric flight with external stores attached, see *Modular Couplings*, *Intrinsic Couplings*, and *External Cradles/Grapples*.

Modular Couplings

Modular couplings are linkages commonly used to affix a module to a modular craft. These linkages are simple connectors, far less elaborate and expensive than the robotics found in an external grapple. Conversely, modular couplings are not automated; a freight handler usually performs manual attachments and detachments. Modular couplings are also "dedicated" – only a module of the same "standard" can be attached to a given modular coupling. The most common standard in the Imperium is the "cutter coupling," used by the 30-ton modules for the modular cutter. Coming in a distant second is the "freight coupling" used by the standardized containers described on pp. T:FT56-57.

Modular couplings are designed exactly as *hardpoints* except they are dedicated to a specific external store.

Any couplings installed on a small craft take up the space normally available for a turret (but see *Intrinsic Couplings*, p. 35) due to the strengthened mechanical connection. For ships of 100 dtons or greater, each 100 stons of modular coupling *capacity* takes up the space usually available for one turret.

The standard coupling includes data and power leads. A "dead" coupling can be installed for half the cost of a linked coupling. For double cost, a linked coupling can be *remote-controlled*, allowing the modular ship operator to detach (but not attach) a module from his crew station. A linked coupling can be made *explosive* for 5 times normal cost; this allows the module to be released by remote control, though this disables the coupling until it is repaired.

The modules themselves require no extra cost or weight to fit a given coupling standard.

Intrinsic Couplings

Standard modular couplings simply tack the module to the hull of a ship, much like a TL7 fighter plane attaches weapons under its wings. An intrinsic coupling makes space for the module within the general outline of the modular ship itself; the module is "inserted" into its coupling like a battery into a radio.

Intrinsic couplings *quadruple* the weight of module a given coupling can carry because the module is held more snugly by the hull of the ship carrying it.

Several factors offset this advantage. First, an intrinsic coupling must be rated for dtons as well as stons of capacity. Thus, the standard modular cutter's intrinsic coupling must carry a 30-ton module. Modules of smaller size may be carried, but the coupling will have only one-quarter its usual weight capacity.

Second, a ship with intrinsic couplings may have restrictions placed on its sAccel rating when it is not carrying modules. The ship's structural integrity is just as dependent on the module as the module's fastening is dependent on the ship's structural integrity. To determine the sAccel limit of a ship with intrinsic couplings, divide the dton capacity of all intrinsic couplings by the displacement of the ship before the couplings are added. Look up the result on the table below:

dton Ratio	sAccel Limit
0.01 or less	None
0.011-0.5	3
0.51-1	2.5
1.01-1.5	2
1.51-2	1.5
2.01-2.5	1
2.51 or more	0.5

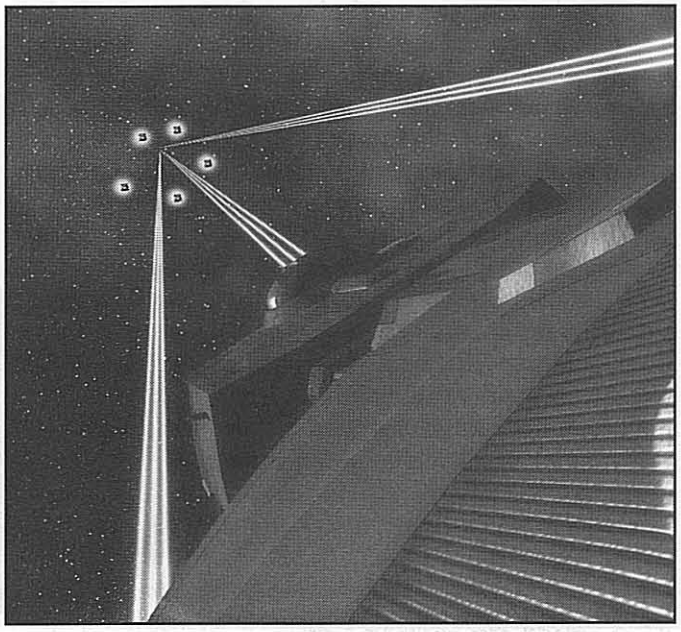
Each time the vessel exceeds its sAccel limit, the pilot should make a Piloting roll at -3, with a further -1 per 0.2 G over the limit. Roll once per hour for extended periods of high acceleration. Every failed roll does 6d×50 damage to the vessel's hull, bypassing armor.

Ships with two or more intrinsic couplings will have several sAccel limits, depending on whether all or some modules are missing. Modules in place count as host-vessel displacement when comparing empty intrinsic capacity to host-vessel displacement.

Third, in almost all circumstances ships with intrinsic couplings are considered to displace their own hull displacement *plus* the displacement of their intrinsic couplings. Therefore, the 50-ton modular cutter rates as 50 dtons of small craft when carried by another ship, whether or not the cutter is carrying a module. Standard Imperial practice is to even call the ship by this expanded displacement.

Intrinsic couplings must be added when a ship is designed; they cannot be retrofitted. They do not displace turret capacity as do standard modular couplings.

Example: The 50-ton module cutter is designed as a 20-ton small craft. This gives it 4,500 hit points. Its maximum intrinsic-coupling capacity in weight is up to (4,500/100×4) or 180 stons. We calculate that its intrinsic coupling will have the maximum 180 stons of capacity with (of course) 30 dtons of volume capacity. The coupling adds 2.25 stons to the cutter's weight and MCr0.009 to its cost. The craft now will be designated as a "50-ton" modular cutter, even though in combat it will be targeted as a 20-ton vessel (the 30-ton module would be targeted separately, unless using the alternate rules from ***GURPS Vehicles,*** p. 177). Dividing its 30 dtons of module capacity by its 20 dtons of hull size gives a dton ratio of 1.5, which limits sAccel to 2 G when a module is not carried. The cutter also takes up space as a 50-ton craft in all circumstances, unless a generous GM allows crafty space hands to stack cargo carefully around its odd configuration.



External Cradles/Grapples

These are multi-functional grapples capable of holding a wide variety of items – asteroids, small craft, cargo containers, etc. (for external craft in recessed vehicle bays, see p. 63). Each cradle consists of strong electromagnets, gravitics, or soft clamps attached to cables and winches, matched with articulated buffers to protect the hull. One cradle module holds an object of up to 125 stons on the outside of the ship's hull; total cradle capacity can be divided among as many actual cradles as desired but a cradle assembly can only hold one object. Cradle systems can be installed in increments of 1/2 space. Objects in cradles are not counted against the ship's internal spaces, but must still be included in jump drive requirements. They are also not protected by the ship's armor.

Grapples can also be used remotely, launched by a low-powered gas jet and attached to their target using Professional Skill (Grapple Operator). This provides rated force to pull objects toward the ship. Acceleration is pulling force divided by the mass of the smaller object (thus it is rarely necessary to have more capacity than the weight of the ship on which grapples are mounted); maximum speed is 4 yards/second. Stopping the grappled mass in zero-g is another matter, requiring the cradle's buffers or (for properly aligned, streamlined vessels) landing gear.

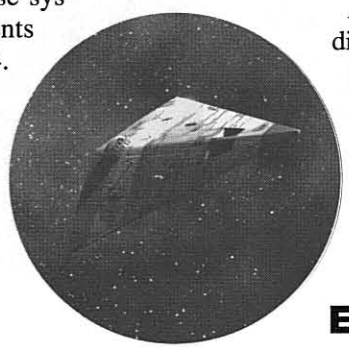
External cradle systems count against the turret-mounted weapons limit at a rate of one turret per three spaces.

Chapter Four

Propulsion, Power, and Fuel

Propulsion systems are the heart of any vessel – without them, a hull is just a cold, immobile hulk. Drives move the ship through space (or jump space). The power plants in engineering provide energy in the form of electricity; engineering and life-support systems also maintain a habitable environment inside the ship. Fuel systems collect, process, and store fuel used for jump and maneuver drives.

The number of engineering personnel on a vessel depends on the quantity and type of these systems installed. Specific crew requirements are noted in the *Module Tables*, p. 124. Add up all requirements (retaining fractions) and then round up to the next whole number. For systems that come in half-sized or small versions, divide all statistics by 2 unless otherwise noted and round any fractional spaces to the nearest 1/2 space.



Engineering Component Modules

Engineering systems package the basic requirements for power and life support into a single module. The power-plant and life-support cores are only the beginning, however. In the modular ship-design system, every module includes a "slice" of power plant sufficient to meet its own energy requirements (crew and passenger accommodations include a similar "slice" of life support). These power-plant slices must be taken into account when computing the total size of a ship's engineering spaces if designing deck plans. See *How Big Is My Reactor?* on p. 15.

Engineering Modules

All ships require a single engineering system (or equivalent); naval vessels often have more than one for redundancy and to allow for maintenance. Each system has a power core (the base "startup" weight, cost, and volume for a power plant) appropriate to the TL, total-life-support core, full fire-suppression system, and a six-man airlock. Included with the airlock is an inflatable 100'-passage tube (armored to DR 20) that can be erected in 30 minutes to connect two airlocks for passenger boarding, cargo transfer, and so on. Some smaller vessels have the same power requirements as larger vessels but have a much more limited volume requirement for their airlocks. The *small* modification (see *Module Tables*, p. 124) reduces the six-man airlock to a one-man version.

Airlocks

All TL13+ modules containing airlocks are assumed to have membrane airlocks to add a bit of a "wow" effect (see *Future Developments*, p. 72). Membrane airlocks are cell-like "curtain" membranes made of bioplastic that are selectively permeable to atmosphere. They work like normal airlocks but take only 2 seconds to cycle. GMs who feel this is too futuristic may assume standard airlocks, instead.

Any airlock rated for more than one person may be divided up into smaller units as needed. For example, a six-man airlock could consist of two three-man airlocks or one two-man airlock and four one-man airlocks. These divisions must be specified at design time (or when designing deck plans) if this level of detail is desired.

Small-Craft Bridge Add-Ons

This system includes a startup power plant, full life support for five, and a two-man airlock. The TL12+ version also includes one bunk. The design is compatible with the hardened bridge option (p. 42). It uses some of the waste space in the bridge systems. A craft with one of these add-ons still requires a Basic Bridge, but does not need an engineering system; this replaces the engineering module.

Power-Plant Cores

These modules are used when installing modules of different TLs in a single ship. The engineering module will, of course, provide the power-plant-core needs of whatever other modules are installed at the same TL as it, but a power-plant core will be required as the basis for the alternate-TL energy sources for other modules of higher or lower TL.

Each module includes one power core appropriate for the TL (fission at TL7-8 and fusion at TL9+) with long-term access space. The TL10+ versions may contain two cores for twice the cost and mass, with no additional volume.

Power Plant Slices

This module contains a power-plant slice of the type appropriate for the TL (fission at TL7-8 and fusion at TL9+) with long-term access space. They are used when a larger plant than the one built by adding the various modules to a ship is desired. A power-plant core of the same TL as this module must be installed. This core comes from either the engineering module or a power-core module.

Naval designers may install extra power capacity for several reasons, including emergency backup capacity, but usually this is done to improve the performance of lasers or other energy weapons. The higher a weapon's RoF, the better chance it has of hitting a target. Each doubling of the RoF increases hit probability by +1 without loss of range or damage capabilities (however, see *Double Fire* program, p. 72). The simplest way to determine how much extra energy is required is to add up the power requirements for each weapon and multiply by the desired RoF doubling. No RoF may be faster than 1/2.

Example 1: To take a 250-MJ Turret Laser from RoF 1/60 to RoF 1/30 (a single doubling), its energy bank requires recharging twice as fast. P. GT157 points out that the usual 60-second recharge takes 11.1 MW, so doubling will require 11.1 × 2 = 22.2 MW. The weapon already has a power slice rated at 11.1 MW, so it requires an additional one rated at 11.1 MW (22.2 – 11.1).

Example 2: To take a 250-MJ Turret Laser from RoF 1/60 to RoF 1/8 is a triple doubling (from 1/60 to 1/30 to 1/15 then finally 2/15, which rounds to 1/8). An energy bank requires recharging eight times as fast: 11.1 × 8 = 88.8 MW. The weapon already has an energy bank rated at 11.1 MJ, so it requires another one rated at 77.7 MW (88.8 – 11.1).

Energy Banks

A rechargeable energy bank is used to provide energy to systems whose transitory power requirements far outstrip the capacity of ordinary power plants. Energy banks are also used to store excess energy that is absorbed by black globes (see p. 50). Ships with any of these systems should be built with energy banks. Energy banks are available in full- and half-sized versions.

Jump Drives (TL9)

A ship requires a jump drive to make interstellar jumps. Each system includes the jump-drive machinery and power slices. Decide on the ship's Jump Drive number to a maximum of jump-1 at early TL9, jump-2 at late TL9, jump-3 at early TL10, jump-4 at late TL10, jump-5 at TL11, and jump-6 at TL12.

The number of jump-drive modules required is based on the ship's total displacement. See *Terminology*, p. 12, for information on total displacement. Whenever the total displacement changes (when jumping without craft carried externally or without other external stores, for example) the jump number must be recomputed based on the new displacement. The number of jump drive modules required is:

number of jump drive modules = 0.01 × total displacement × (jump number+1).

In some circumstances, this formula indicates a fractional value. Round up to the nearest space in those cases.

Short-Term Systems

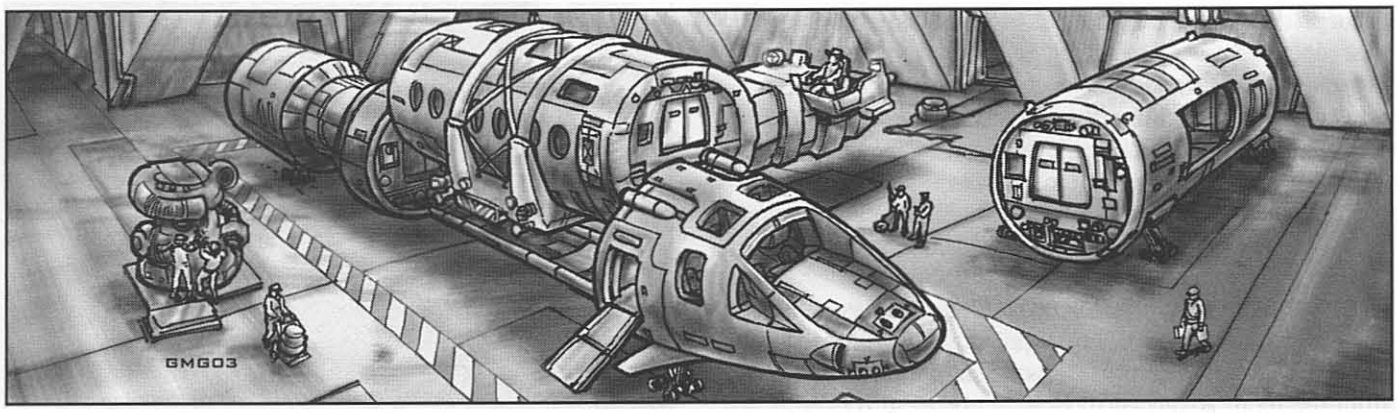
Small craft are generally used solely as short-duration vessels. Short-term modules utilize short-term access space instead of long-term access space. Vessels built with these modules are only serviceable groundside or from within a spacedock, and only when the craft is *not* in use – there is not enough access space within the vessel to get to the required systems. Small craft *do not* have to be built with these systems. They can be (and usually are) built with the normal long-term access modules, instead. Short-term systems start with "ST" to differentiate them from the long-term systems (see *Module Tables*, p. 124).

Reaction and Maneuver Drives

There are two kinds of normal space drives: reaction drives and reactionless maneuver drives. A vessel needs some type of normal space drive to adjust its course through space; even "immobile" space stations and platforms will often have weak drives to make small corrections in their orbits. All normal space drives are available with long-term access and most are available with short-term access for use with small craft.

Maneuver Drives

A maneuver drive (M-Drive) is a reactionless thruster that produces thrust without fuel or reaction mass. Each module has a vectored reactionless thruster and a power-plant slice to run it. Install as many M-Drive modules as desired. Short-term and half-sized modules are available, as well. See *Ships Without Vectored Thrust Engines*, p. GT174, for more information.



Solar Sails

The solar sail, though not really a standard maneuver drive, is a low-thrust space drive that uses the pressure of light (usually sunlight) for propulsion. Its main advantage is it requires no fuel. A solar sail is essentially a very large, ultra-thin steerable mirror. Unlike normal sails, it does not require a mast subassembly.

Light pressure is very slight and varies inversely with the square of the distance from the system's star. As such, a solar sail is most useful within the inner part of a star system. A solar sail can maneuver and propel the vessel in any direction, by tilting the sail and using stellar gravity to assist in changing course.

Solar sails are very fragile. A ship with an unfurled sail cannot use any other form of thrust without damaging the sail, nor can it come within 200 miles of any world with an atmosphere. Furling or unfurling a solar sail is a difficult maneuver requiring one hour to accomplish. A successful Piloting (Solar Sail) roll will cut this time to 15 minutes.

Reaction Drives

The reactionless maneuver drive is the most common form of slower-than-light propulsion in the ***Traveller*** universe, but far from the only one. At low TLs, reaction drives (rockets) of various sorts may be a better option or the only option available. Short-term modules are available for all except the HEPlaR drives and Solid Rocket Boosters. The Solid Rocket Booster has no access space, as it is disposable.

"Reaction drive" is a general term for any drive that involves throwing something out the back of the ship to make it go forward. The limiting factor on reaction drives is reaction mass – the material ejected as exhaust. A drive that uses a lot of reaction mass has limited acceleration, since carrying the reaction mass itself slows down the ship. But a ship which uses little mass, or which can pick up more while traveling, could in time accelerate to speeds approaching light speed.

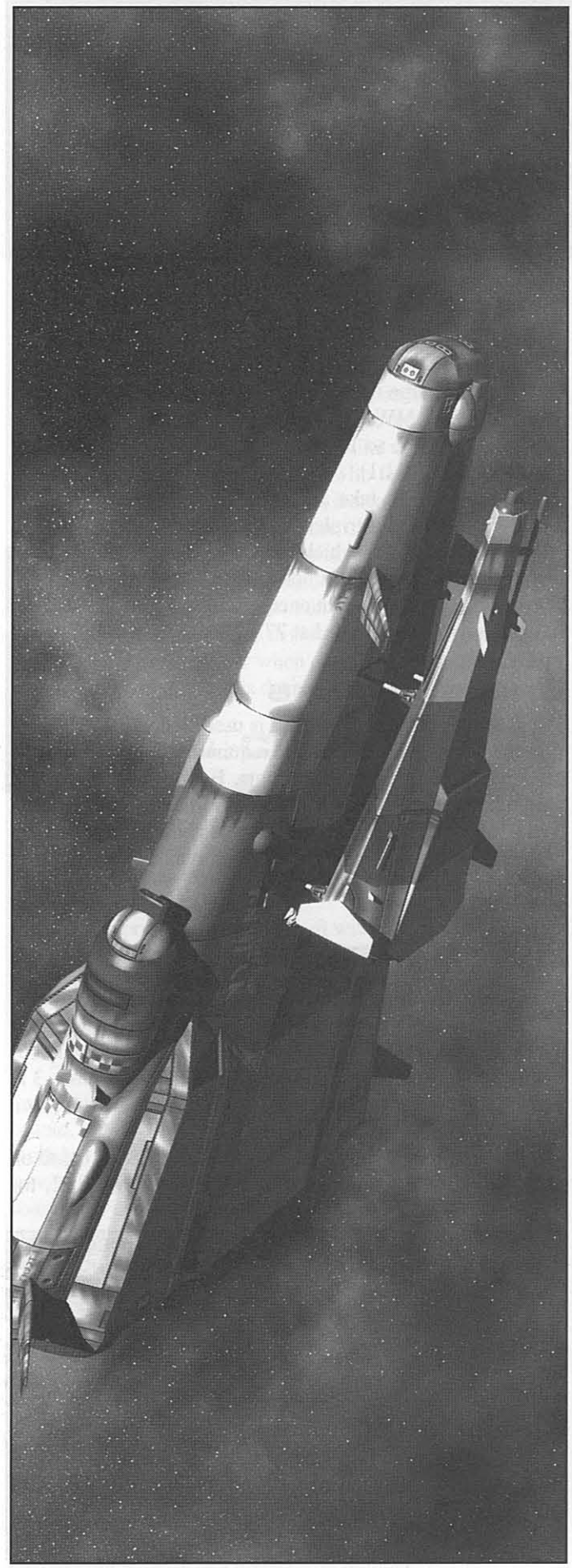
GMs that feel reaction drives are too archaic or too realistic may choose to ignore them completely. Alternatively, they may feel reactionless thrusters are too "super-science" and decide to use reaction drives exclusively (though this can substantially change the flavor of a ***Traveller*** campaign). Early discussions of campaign style can avert the use of inappropriate technologies.

Thrust, mass, cost, and fuel consumption (in dtons per hour) are *per module* of drive. All drives are *vectored thrust* (except the Bussard ramjets). Most are already in half-space increments.

Liquid Fuel Rockets are rocket engines that burn a mixture of fuel and oxidizer, and expel the resulting hot gas exhaust to create thrust. Liquid-fuel rocket engines are quite lightweight, but they are extremely fuel-thirsty.

Fission Rockets utilize a built-in fission reactor optimized to heat reaction mass and expel it to produce thrust. They are heavy and expensive. Their exhaust is also somewhat radioactive. Fission rockets require a Power Core appropriate for the drive TL (see p. 36).

Solid Rocket Boosters (SRBs, or solid fuel rockets) differ from the more advanced models of chemical rocket in that



the fuel is part of the rocket engine. Each module installed either adds 20 minutes burn time or the rated thrust (in stons). Alternatively, the thrust may be doubled, halving burn time. In either case, once the rocket fuel has burned away, the rocket is useless. The remaining weight of the rocket casing is 15% of the fueled rocket and is usually jettisoned. SRBs may be externally mounted in any of the available external mountings (see p. 34). Cradles are generally not used because guidance of the rocket requires control connections. Hardpoints may be mounted on a larger assembly containing the SRBs, to hold the actual spacecraft itself.

Example: If a ship is using a TL8 SRB (providing 7 stons of thrust for 20 minutes) and it requires 14 stons of thrust, cut the burn time of the booster by 10 minutes or add another SRB module. If a thrust of 28 tons (4×) is required, cut burn time to 5 minutes (1/4×) or add three more SRB modules.

HEPlaR drives (High Energy Plasma Recombustion) are an advanced and efficient fusion drive. They add a heat exchanger/recombustion chamber to any existing fusion power plant. Hydrogen injected into the chamber is heated to a plasma state, and then magnetically accelerated further to produce a high-velocity stream of reaction mass. HEPlaR thrusters *do* require input power. They are not available in short-term versions. They incorporate crude, first-generation elements of the technology that eventually becomes reactionless thrusters.

Total Conversion Rockets are a total conversion drive; see *Reaction Drives Table,* p. S117. They convert fuel directly into energy. It is marginally "harder" science than a reactionless thruster, since it does not violate the conservation of energy or momentum. It also requires ships to refuel occasionally even when the jump drives are not used.

Metal/Oxide Rockets burn a watery mixture of metal powder in liquid oxygen (Metal/LOX). The performance is substantially lower than other types, but they are sometimes used because fuel can be obtained by processing asteroids or lunar rocks.

Metal/LOX fuel (MOX) is a cryogenic slurry – the metal element may vary, though aluminum and magnesium perform about equally and are common in asteroids. It is a tricky fuel to burn, requiring tougher pumps and engine parts to resist abrasion from both the metal powder and the exhaust, which is essentially hot, fine sand. The advantage of Metal/LOX is that it can be produced from material commonly available on waterless vacuum moons and asteroids, where hydrogen is scarce.

Atmospheric Drives

Atmospheric drives are typically used at lower tech levels to allow spacecraft access to ground facilities. They are not able to function in a vacuum, so are only useful on worlds with an atmospheric pressure of 0.5 or higher. Short-term modules are available.

Turbo-Ramjets are turbojets with variable geometry inlets allowing them to function as ramjets once the vehicle is moving faster than sound, considerably increasing their thrust. TL8+ turbo-ramjets include turbo-scramjets (supersonic combustion ramjets, designed to operate at very high speeds).

Hyperfans are advanced, hydrogen-burning turbofans. They are common in places where petroleum-based jet fuel is unavailable or too expensive.

Fusion Air Rams are fusion rockets that suck in air, heat it using fusion reaction, then expel it as reaction mass. They operate for 2.5 years on an internal fuel supply. While they only work in an atmosphere, its type or density (beyond a mere trace atmosphere) is irrelevant. The air-ram includes a high-efficiency fusion reactor that serves only to power the engine.

Gravitic Systems (TL8)

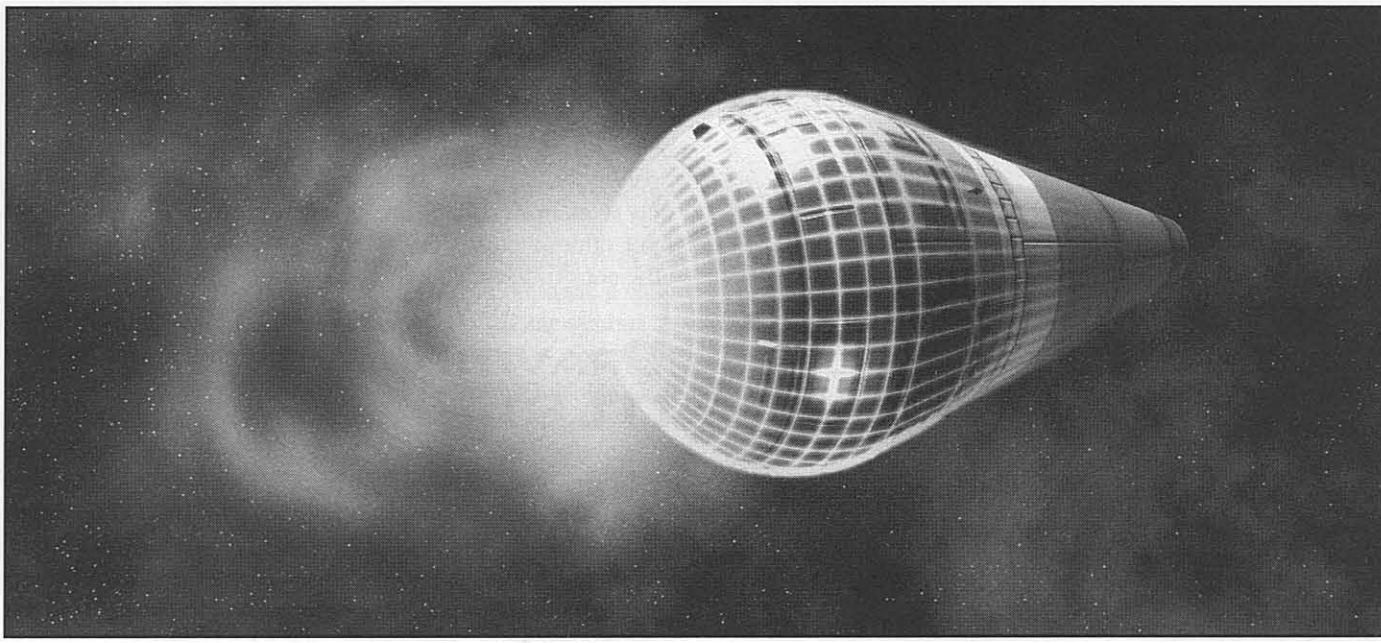
Gravitic systems are the product of scientific insight into the nature of the force of gravity, and the technical ability to manipulate the gravitic force to achieve specific effects, particularly counteracting the felt effect of high-G acceleration.

Maneuvering Without Grav Compensation

GURPS Traveller vessels, if equipped with artificial gravity, are assumed to have compensation for transient high-G maneuvers (see p. GT107). This relieves many of the stresses on the structure of a vessel, allowing it to perform at the fantastic accelerations found in the ***Traveller*** setting. But what happens when a ship suddenly loses this capability? Typically, external stores (cradles, drop tanks, and cutter modules) are at the highest risk as their mountings are usually only sized for the mass of the carried item under 1-G acceleration; exceed this and the mounting has to hold more "weight" than it was designed for. Cargo and stored vehicles may also suddenly "fall" against a bulkhead. The hull can also be affected (dented or even crushed) if acceleration is too high. Crew members may find it difficult to operate, as they are thrown against bulkheads and/or hit with "falling" objects.

A few guidelines:

- Can the crew operate under the high G? G-seats and G-suits help to reduce the effect of high-G maneuvers. See pp. CII131-132 or pp. VE152-155 for more information.
- Each time the vessel exceeds its "safe acceleration limit" (as imposed by the external mountings, p. 34), the pilot should make a Piloting roll at -3, with a further -1 per 0.2 G over the limit. Roll once per hour for extended periods of high acceleration. Every failed roll does 6d×50 damage to the external mountings, bypassing armor. Note this assumes a fully loaded mounting. Once HP have been reduced to 0, the mounting breaks and its payload is lost. The GM should determine if there is further damage caused as it bounces down the hull. External mountings are assumed to have a volume equal to mass/50 unless otherwise specified. Use the method under *Additional Shielding,* p. 32, to determine surface area, then multiply by 1.5 to get HP. Assume cargo containers and vessels stored in spacedocks or hangars are mounted with clamps that can hold twice the "weight" of the item contained; then apply the penalties above, if necessary. Should the item break free, treat this as a collision between the item and any bulkheads that it hits.



● The ship's structure itself has limits on how much stress it can take. The actual calculations and theory are quite intense and not appropriate for this book. As a guideline, if a crew can endure the acceleration, then the vessel can, as well.

Utility Systems (TL8)

This is an artificial-gravity generator that can vary gravity from 0 G to 3 G over a 500-dton volume via deck plating and other similar means. Artificial-gravity units include automatic compensation for transient high-G accelerations (separate "grav compensators" aren't needed) to 3 G at TL8-9, 6 G at TL10-12, and 9 G at TL13+ throughout the same volume. It also includes a two-person airlock. Utility systems are also available in half-sized, or *small*, versions, covering half the rated volume and only including a single airlock. Small craft normally omit utility systems, though there are also short-term versions presented covering 120 dtons (300 dtons at TL13) with a one-man airlock.

The grav compensation covers the total volume capacity of the module, permitting no more than 1 G of stress on structures fitted to the hull. This allows cradles, hardpoints, etc. to be rated at a minimum of 1 G without fear of undue stress from high acceleration. (See p. 39 for information on ship performance without grav compensation). Certain designs will still have other limits, such as those with *Intrinsic Couplings* (see p. 35).

Contragravity Systems (TL8)

Contragravity systems cancel out all natural gravitational forces acting on an object up to their rated lifting capacity, as discussed on pp. GT107 and S120. In ***GURPS Traveller***, where reactionless thrusters are common, such technology is available but only necessary in very specialized applications.

Each module counteracts 450 stons of weight at TL8, 1,500 stons at TL9, and 5,000 stons at TL10+. The module provides no lateral thrust.

Can My Vessel Really Fly?

For extra detail, a ship required to fly in an atmosphere must have enough lift to compensate for its weight. This lift can come from three different locations: the hull (via streamlining), contragravity, or vectored drives. One or both of the latter two are required if unstreamlined ships want to move around in an atmosphere – they don't get any lift from the hull (see *Streamlining*, pp. 17 and GT119).

The minimum required surface area to keep a *streamlined* ship in the air if its contragravity and/or vectored drive cannot totally compensate for the weight is 10 × LMass × square root of (LMass / Thrust), where LMass and Thrust are in stons. This formula indicates how much surface area is needed to stay in the air given the thrust of the vessel in one Earth atmosphere. If the CG or vectored drives can't keep it in the air and the hull's surface area is below this value, the design needs a bigger hull or to add more CG or drives.

Combination Gravitics Systems (TL8)

These systems combine contragravity, artificial gravity, and grav compensation in one module. These can be substituted for standard utility modules on most existing designs to provide contragravity lift on a 2-for-1 basis (two of these replace one existing *Utility Module*, above). Each module covers 250 spaces and provides 400 stons of lift at TL8. This decreases to 300 stons at TL9 (where each individual module becomes more compact, see above), then increases to 450 stons of lift at TL10+.

Fuel Tanks

These systems consist of a tank and appropriate pump mechanisms. They store the liquid hydrogen (H) used by jump drives and the reaction mass used by reaction drives. Strictly speaking, tanks should be required for all bulk liquid or gaseous cargoes, as well.

A ship with a j-drive requires a volume of H equal to its total displacement × jump number × 0.1. Typically, ships have enough fuel tanks to accommodate this volume.

Jump-Fuel Tanks

Ultralight self-sealing internal tanks permanently installed as part of a ship's design, these are available in half-sized versions. If the tank is designed to carry hydrogen, it includes the cryogenic equipment required; if the tank is carrying something other than hydrogen, this additional mass and cost is required to strengthen the tank structurally. Jump-fuel tanks are assumed to have fuel scoops for frontier refueling whether installed in a streamlined or unstreamlined vessel. Mass includes 1 ston of hydrogen fuel, so be sure to subtract it before using other fuel sources.

Collapsible Tanks

A 400,000-gallon collapsible self-sealing tank made of light folding polymers, this expands into an empty Hold or Spacedock module (which are required, to provide support and stability). It holds 120 dtons (and only 120 stons) of fuel when full. It can be installed in half-sized increments. A full tank will rupture and spill during maneuvers at least 1.5 G greater than that compensated by the utility systems.

Fuel from collapsible tanks must be pumped into the normal fuel tanks before it can be used; thus, a jump made with collapsible tanks may not use more fuel than the capacity of the normal interior fuel tanks. Pumping fuel before a jump takes about three hours. A typical use for collapsible tanks is to allow a short-jump ship to cross a long-jump "gap" in two or more jumps.

Demountable Tanks

Additional tankage can be installed or removed from cargo holds or space docks as required; the process takes 10 man-hours per dton at a suitable maintenance facility, at a cost of Cr10 per man-hour. Unlike the collapsible tanks, fuel stored here does not require pumping to the main tanks before use.

Drop Tanks

Disposable fuel tanks may be added to the ship. These jump-fuel tanks are fitted to the outside of the ship on hardpoints (see p. 34). The result is more interior space available for cargo and passengers, or increased jump number for military vessels. Such tanks may either be retained throughout jump or jettisoned just before jump (assign a -2 penalty to all jump checks if they are jettisoned, due to jump-field interference). Jettisoned tanks can only be replaced at a starport, base, or spacedock, so this operation is only practical on runs to civilized areas or for naval operations.

Drop tanks are constructed as sub-hulls; choose a hull from the hull table (or design a custom hull) and fill it with internal jump-fuel tanks. They need not be armored, but are very vulnerable to damage if not; military drop tanks normally carry at least DR 100. Drop tanks are often constructed for half price (using the "Cheap" quality option) if designed to be disposable. (The tanks themselves may be recovered, but are often irreparably damaged during the drop operation.)

Because drop tanks must be attached to hardpoints to jettison properly, there is a built-in limitation on the amount of fuel carried this way. This limit is highly dependent on the mass of the tank. See *Hardpoints*, p. 34.

Reaction Mass

A ship that uses a reaction drive requires fuel tanks in addition to those required for the jump drives.

To determine how many hours a particular reaction drive will operate, add up the total consumption of the drive in dtons and multiply it by the desired duration in hours. This is the total size of the fuel tank required (see *Module Tables*, p. 124). To increase the drive's endurance, add additional tankage. Liquid hydrogen from a starship's jump-fuel tanks can be used as reaction mass (and vice versa), but using too much may mean the ship cannot jump!

R-Mass Type	Cr/dton	ston/dton	Fire	Abbrev.
Refined LHyd	350	1	13	H
Unrefined LHyd	50	1	13	H
Jet Fuel	10,000	10.8	13	J
Metal/Oxide	50,000	20	13	MOX
Rocket Fuel	6,667	16.7	13	R
Water	0	15	0	W

Fire is explained under *Damage Control*, p. 116.

Fuel Collection and Purification

The hydrogen that starships use in their jump drives may be the most common element in the universe, but it isn't always the most accessible. Specialized equipment is often necessary to procure liquid hydrogen for a jump, or to refine it to remove destabilizing impurities.

Fuel Processors

This module purifies raw fuel (skimmed from a gas-giant atmosphere or from another source), turning it into refined fuel. Fuel processors use catalytic grids and molecular filters to extract the hydrogen from gas-giant atmospheres. Each system can process 1 dton (TL8), 3.5 dtons (TL9), or 8 dtons (TL10+) of raw gas-giant atmosphere every hour. Half-sized versions are available.

Some ships install combination electrolysis/processor modules that can more efficiently "crack" water and ice. Each module cracks 1/3 dton of water into 1/2 dton of liquid hydrogen (H) and 1/4 dton of liquid oxygen (LOX) and it refines 3 dtons of unrefined fuel per hour (1 dton at TL8). When finished, the ship should jettison the water or the hydrogen – or store each in separate fuel tanks.

Dedicated fuel-electrolysis systems are also available, though they are not as common as fuel processors except at low TLs due to their power consumption. Each module cracks 2/3 dtons of water into 1 dton of H and 1/2 dton of LOX.

Each system also includes necessary power components.

Chapter Five
Controls, Sensors, and Electronics

Spacecraft require sensors, controls, computers, and communicators. For safety, most spacecraft carry three redundant computer systems; these are included in Bridge and Cockpit components. Select the required electronics from this section and add them to the design.

Bridge Systems

The vessel's control, navigation, sensor, and communication systems are in the Bridge. All ships require at least one bridge system; larger vessels sometimes have an auxiliary bridge. Three types of bridge system are available: Cockpit/Systems, Basic Bridge, and Command Bridge.

Cockpit/Systems

A Cockpit/Systems component module is used on small craft instead of separate Bridge and Engineering modules. It provides two crew stations with computer terminals and HUDWACs, compact fire suppression, two advanced radar/laser detectors, one laser communicator, one radio communicator, a flight data recorder, one IFF, one inertial-navigation system, three microframe computers (Complexity TL-4), precision navigation instruments, active and passive sensors, a radscanner on all TL9+ versions, power startup, and a one-person airlock and two man-days limited life support.

The *Command* version is used on long-range fighters; it includes one hardened computer (Complexity is TL-2) and two hardened backup computers (Complexity is TL-3). It also has sensors and communications as listed for a Command Bridge of the same TL, except that it has only *one* communicator of each type. Full life support for two and two bunks are included for extended-patrol missions.

The *Light* version is a smaller, cheaper cockpit, with reduced sensor ranges. It is designed for short-duration commercial roles where sensor ranges and long-term pilot activity are not a key factor (e.g., orbital interfaces, runabouts, lifeboats, small private crafts). It occupies a niche between grav vehicles and full spaceships, as normal cockpits tend to cost far too much for private ownership of spacecraft.

Basic Bridges

A Basic Bridge is typical of civilian ships. It includes five crew stations with computer terminals and HUDWACs, full fire suppression, two advanced radar/laser detectors, one laser communicator, two radio communicators, a flight data recorder, two IFFs, two inertial-navigation systems, three mainframe computers (Complexity is TL-3), precision navigation instruments, and active and passive sensors. A radscanner is included at TL9+; one meson communicator is part of the system at TL11+.

Command Bridges

Some ships, especially military ships, will install a larger and better-equipped Command Bridge. It includes 10 crew stations with computer terminals and HUDWACs, full fire suppression, two advanced radar/laser detectors, four laser communicators, 10 radio communicators, two flight data recorders, two IFFs, two inertial-navigation systems, three macroframe computers (Complexity TL-2), precision navigation instruments, and active and passive sensors. At TL9+, the Command Bridge includes a radscanner; at TL10+, one meson communicator is included.

Bridge Options

Throughout the Imperium and beyond, there are many different bridge configurations. Below are just a few.

Compact: Bridges can be made more compact by removing crew stations. This is often done with command bridges on smaller military vessels to save space. For every *two* crew stations removed, reduce the size of the bridge by 0.5 spaces and the mass by 0.04 stons. There is no reduction in cost. If desired, bridges can add additional seating by increasing space and mass at the same rate.

Thermograph/LLTV: This option replaces the PESA sensor system in any of the above (except Command Cockpit/Systems) with Thermograph and LLTV of the same rating. This modification is common on low-end commercial ships.

Thermographs are high-resolution infrared sensors. Treat a thermograph as Infravision (p. B237) but there is no -1 penalty for night combat (or the darkness of space) and an extra +1 to Tracking bonus.

Dumb: This reduces complexity of all computers by 1.

Genius: This increases the complexity of all computers by 1. As this is an expensive option, it is typically only used by the military for high-precision targeting systems.

Hardened: All bridge/cockpit computers can be "hardened" (e.g., fiber-optic backup), making them immune to radiation (see *Radiation Shielding*, p. 33, and *Turret Particle Beam Weapons*, p. 48). The higher the TL, the more resistant even unshielded electronic gear becomes, though. Rad levels equivalent to an EMP kill are as shown:

TL	Rads
7	100
8	200
9	500
10	2,000
11+	10,000

Bridge Systems Modifications Table

System	Th./LLTV Mass	Th./LLTV Cost	Dumb Cost	Genius Cost	Hard Mass	Hard Cost
Cockpit/7	0	0	-0.114	2.28	0.6	0.48
Cockpit/8	-0.2	-1.63	-0.228	4.56	0.3	0.96
Cockpit/9	-0.187	-1.14	-0.057	1.14	0.3	0.24
Cockpit/10	-0.188	-0.838	-0.029	0.57	0.15	0.12
Cockpit/11	0.125	-0.375	-0.029	0.57	0.15	0.12
Command Cockpit/10+	0	0	0	49.4	0	0
Light Cockpit/7	0	0	-0.114	2.28	0.6	0.48
Light Cockpit/8	-0.017	-0.235	-0.114	2.28	0.6	0.48
Light Cockpit/9	-0.02	-0.294	-0.057	1.14	0.3	0.24
Light Cockpit/10	-0.019	-0.293	-0.029	0.57	0.15	0.12
Light Cockpit/11	0.013	-0.127	-0.029	0.57	0.15	0.12
Basic/7	0	0	-0.48	11.4	1.5	2.4
Basic/8	-0.338	-2.17	-0.48	11.4	1.5	2.4
Basic/9	-0.375	-1.68	-0.24	5.7	0.75	1.2
Basic/10	-0.425	-1.38	-0.12	2.85	0.375	0.6
Basic/11	0.187	-0.512	-0.12	2.85	0.375	0.6
Basic/12	0.188	-0.512	-0.12	2.85	0.375	0.6
Command/7	0	0	-4.8	114	12	24
Command/8	-0.525	-2.7	-4.8	114	12	24
Command/9	-0.9	-2.76	-2.4	57	6	12
Command/10	-0.937	-2.99	-1.2	28.5	3	6
Command/11	0.662	-1.47	-1.2	28.5	3	6
Command/12	0.65	-1.47	-1.2	28.5	3	6

Auxiliary Control Stations (Duplicate Controls)

This is a simple auxiliary control station with duplicate controls and a one-person airlock, but no fusion startup, navigation, nor independent life support. Various uses include:

- As another piloting position, similar to a cockpit, for docking the craft or other delicate maneuvers.
- As a security station.
- As a training/auxiliary workstation used to provide training on, or extra assistance with, an already installed module (e.g., Engineering).

Information Centers

A high-tech military-style operations room for 10-20 people, this has workstations, a sophisticated array of electronic mapping and display tables (which function as a fire direction center, p. VE58), plus several dozen digital cameras for video teleconferencing. The system also includes a hardened Complexity TL-2 macroframe computer and 10 terminals for running high-end analysis programs like Expert (Tactics), Transmission Profiling, and Traffic Analysis. It may also be called a *Command Center* or *Tactical Command Center*.

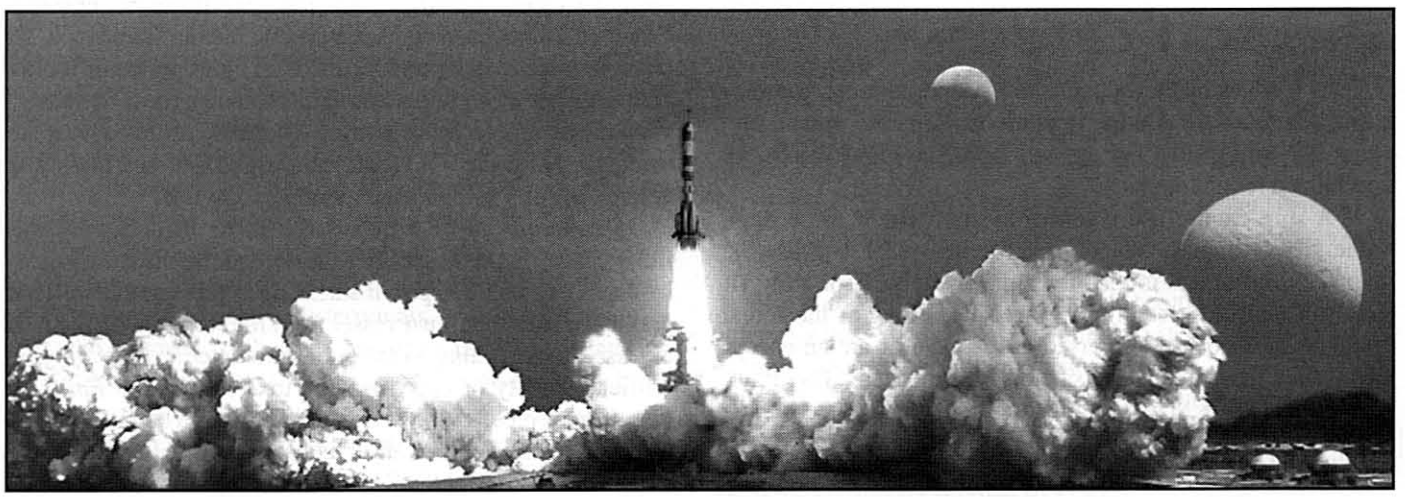
Comm Systems

All Bridges include a standard package of basic communications equipment, adequate for routine operations. Separate communications systems are available for applications with specialized requirements. The Underwater Electronics System (see p. 45) also has a radio.

Communications Suites

Communications suites are designed for vessels requiring additional communications longer-ranged than those included in the Bridges or Cockpits. These are generally found on warships (particularly carriers and flagships) but also have civilian applications.

Communications suites come in *enhanced* and *advanced* packages, and require that some form of bridge be installed on the vessel, as well. The bridge contains the crew stations, which the communications suites lack.



A maser is also known as a tight-beam radio. This is an ultra-high-frequency directional signal or an actual microwave beam. Only receivers within a 20° cone can pick up the signal. Maser signals are often sent up to satellites and then relayed down again. They also have military uses where a radio signal sent in all directions is not desirable.

Communications Systems

Module/TL	Number of Sets/Range (Millions of Miles)			
	Radio	Maser	Laser	Meson
Enhanced Comms/7	3/0.3	1/3	1/0.6	–
Enhanced Comms/8	5/1	2/10	2/2	–
Enhanced Comms/9	5/10	4/100	5/20	–
Enhanced Comms/10	5/50	2/500	1/100	1/1
Enhanced Comms/11	5/50	4/500	3/100	1/1.5
Enhanced Comms/12+	10/50	6/500	6/100	1/2
Advanced Comms/10	10/50	9/500	9/100	1/10
Advanced Comms/11	10/50	9/500	9/100	1/15
Advanced Comms/12+	10/50	9/500	9/100	1/20

Communications Modules (Xboat)

This system consists of a single massive laser communicator, three hardened computers, hardened mass-data storage capacity with double backups (5 TB at TL7, 50 TB at TL8-10, and then ×10 per TL after that), and an independent energy bank (5-hour supply). It is designed for high redundancy: the three computers check each other's results and three sets of data are stored in different locations. The laser communicator is used because of its very high bandwidth. Even with the usual high level of encryption and error correction on the signal, the system can upload or download its entire storage capacity in about an hour. It is used on the Xboat couriers of the Imperial Interstellar Scout Service as well as related ground and space-support installations. See ***GURPS Traveller: First In*** for further details.

The TL10+ versions have Imperial-grade high-security encryption systems. Reduce volume by 1.5 cf, mass by 12.1 stons, and cost by MCr2.44 for systems without the encryption equipment.

Sensor Systems

All Bridges include a package of standard sensory equipment, adequate for routine operations. Separate sensor systems are available for vessel applications that have specialized requirements.

A ship cannot use a sensor system which has a Scan value greater than the ship's Size Modifier +36, because the ship isn't big enough to mount a large enough sensor array. (It may still *install* a system this powerful, as long as the actual lesser Scan is noted.) Dispersed hull structures are an exception – they may mount any size of sensor system. The drawback is that their Size Modifier is increased to (Scan value -36) for detection purposes, due to the inclusion of booms, masts, or periscopes required by the oversized sensors.

Sensor Suites

Sensor suites contain a full array of sensors that extend the capabilities of standard bridge equipment. Some of these systems have a crew requirement that can be filled by regular bridge personnel, instead.

Enhanced and *Advanced* sensor suites each contain large PESA, AESA, and radscanner sensors. They are used to supplement the systems on existing bridges.

Survey Module/Traffic Control contains four sets of 10,000× astronomical instruments, four high-resolution planetary-survey arrays (medium resolution at TL7), a macroframe computer available at TL7-9, a mainframe computer at TL10+, eight crew stations with computer terminals, and a "survey center" featuring sophisticated holographic-projection devices (small movie screens at TL8-). This allows survey specialists to create elaborate visualizations of incoming data. Use of the survey system is detailed in ***GURPS Traveller: First In*** and the traffic-control system in ***GURPS Traveller: Starports***.

Planetary Survey Add-on modules contain one medium-resolution planetary survey array at TL9- or high-resolution at TL10+. Both fit within the waste space of a sensor system.

Astronomical Add-on contains one 200× astronomical-instrument array that fits in the waste space of a sensor system.

Long-Range Sensors (TL8)

These are military-grade sensors typically used on picket ships (vessels that patrol the edges of a fleet). Scan rating and nominal range in miles (divide by 10,000 to get number of combat hexes) is given for each. The PESA and Radscanner systems require negligible power, so they include nothing but the sensor. The AESA systems have the listed sensor and a slice of power plant. They are not mounted in a turret; thus, the ship must be pointed in the direction that they will scan.

Densitometers (TL11)

This device uses gravitic-imaging technology to map the interiors of objects. Effective range is 500 miles at TL11, 1,250 miles at TL12, and 2,500 miles at TL13. A successful Electronics Operation (Sensors) roll is required to make a clear scan, which takes 1 second per 27 cubic feet (18.5 seconds per dton). Failure means the scan must be repeated. When an object has been scanned, the data is stored as a 3D plan on standard computer media (0.037 gigs per cubic foot or 1.85 gigs per dton) accessed via a computer for a "cutaway" view of the object. More powerful versions of this device are available. For each +6 to scan, multiply range, cost, mass, and volume by 10. Power consumption is negligible.

Densitometers are very susceptible to disruption by artificial gravity fields (especially those under constant manipulation). They require special shielding to prevent the artificial gravity field in their *own* vessel from interfering with them. If a vessel is attempting to foil a densitometer scan by varying artificial gravity or contragravity, treat it as *Basic Emission Cloaking* (see p. 31) for defensive purposes. They are considered passive sensors for all practical purposes, but other densitometers can detect their use at 20× range.

Legitimate users might be very interested in a civilian ship carrying such equipment. Some GMs may opt to disallow densitometers in their games as they might too easily detect important clues in an adventure.

Underwater Electronic Systems

This component includes one active sonar system with the active/passive option, one passive system with the towed array option, one passive dipping array with the active/passive option, one roomy crew station, one hardened macroframe computer (a mainframe instead at TL9-), and one computer terminal.

A receive-only very-low-frequency (VLF) radio is also included. Ranges are 300,000 miles at TL7, 1 million miles at TL8-9, 5 million miles at TL10+. Divide ranges by 10 during atmospheric use. Divide ranges by 1,000 during underwater use and decrease capability to 10 characters per second. Typical operations call for the base station to send out a request for a communications link. The underwater craft then initiates a link when conditions permit, via either meson comms or tight-beam laser.

Each module also has a reactor slice to power it and a power cell permitting 5 hours of silent running at TL7-8 increased by 2.5 hours at each successive TL.

System	Range Active/Passive/Towed	Scan Active/Passive/Towed
Sonar/7	21/42/140	19/20/23
Sonar/8	24/48/160	19/21/24
Sonar/9	27/54/180	20/21/24
Sonar/10	30/60/200	20/21/25
Sonar/11	33/66/220	20/21/25
Sonar/12	36/72/240	20/22/25
Sonar/13+	39/78/260	20/22/25

Ranges are in miles.

Electronic Warfare Systems

Space combat takes place in more dimensions than simply the physical plane. Naval vessels must be able to attack and defend themselves from enemies using the electromagnetic spectrum. Electronic-warfare suites provide a wide range of offensive and defensive capabilities. At the ranges of most space battles, the effects of these systems are largely ignored. Let one side neglect its preparation in this arena, however, and their opponents will be quick to exploit the error.

Each suite consists of advanced radar/laser detectors, area jammers, blip enhancers, hardened macroframe computers (Complexity TL-2) with terminals, radio direction finders, radio jammers, 24-hour rechargeable power cell, and two crew stations. The listing for area jammers gives jammer rating/range in miles; the other listings are range in miles. See p. VE59 for further information on electronic-warfare systems. All area-jammer ranges are divided by 50 for use in an atmosphere; other ranges are divided by 10. See the table below for a list of what is included in each module. All ranges are in miles.

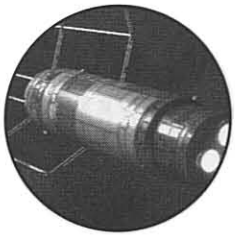
Electronic Warfare Systems Tables

System	TL7-8	TL9	TL10+
Adv. Radar/Laser Detector	1	1	2
Area Jammer	1	1	2
Blip Enhancer	1	1	2
Macroframe Computer	1	2	2
Radio Direction Finders	2	4	4
Radio Jammer	1	2	2

System	Area Jam. Rating/Range	Radio DF Range	Radio Jam. Range
Electronic Warfare/7	2/7.5	30K	300
Electronic Warfare/8	4/75	10M	1,000
Electronic Warfare/9	6/750	10M	10,000
Electronic Warfare/10	7/2,250	50M	50,000
Electronic Warfare/11	7/2,250	500M	50,000
Electronic Warfare/12	7/2,250	500M	50,000
Electronic Warfare/13	7/2,250	500M	50,000

Jammer Systems

This component is a smaller version of the Electronic Warfare module. While the general Electronic Warfare component can extend its protection to other vessels, the jammer unit is designed to cloak the carrying vessel alone. It contains a laser/radar detector, area radar jammer, deceptive radar jammer, chaff-decoy discharger (with 40 decoys), infrared jammer, and batteries. See p. VE59 for further information on area jammers. All area jammer ranges are divided by 50 for use in an atmosphere; other ranges are divided by 10. See the table below for specific information on capabilities. All ranges are in miles.



System	Duration Hours	All Jammers Rating/Range
TL7	1.5	6/1,500
TL8	3	6/1,500
TL9	6	7/2,250
TL10	12	7/2,250
TL11	18	7/2,250
TL12	24	7/2,250
TL13	28	7/2,250

Computer Systems

High-speed, high-complexity computer systems are at the heart of any naval vessel, particularly its fire-control network. This is common in large ships, which have a lot of weapons to control and want to be able to run numerous advanced targeting programs. Sophisticated computer systems are also vital to cutting-edge research and numerical analysis.

This system contains eight high-capacity (+50% to number of programs) computers for use in ships requiring more computing resources than the bridge can provide. Complexity of the computers is equal to TL-2.

Chapter Six

Weapons and Defenses

The universe is a dangerous place, and most ships mount some form of armament.

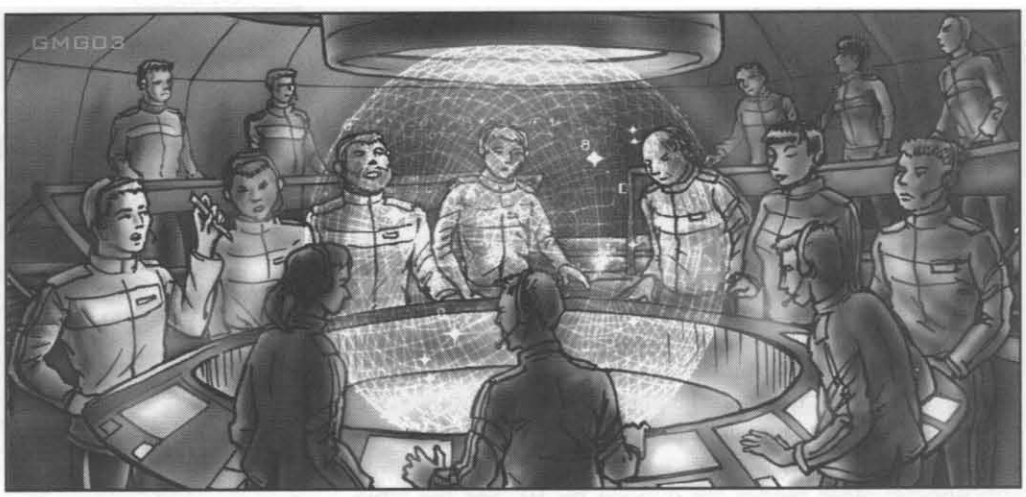
Each ship's turret has room for up to three spaces of turret weapons. Each bay has room for a single bay weapon of the same size; a 50-ton bay mounts a 50-ton bay weapon. Mounting a smaller 50-ton bay weapon in a 100-ton bay is feasible, but the remaining 50 dtons are lost due to the additional bracing required to hold the smaller weapon in place. The "portable" design of bay weapons just doesn't allow the possibility of mounting two 50-ton bay weapons in a 100-ton bay.

Armament need not be specified when a vessel is designed, as shipyards can leave turrets or bays empty for the owner to customize. Merchant ships in safe subsectors or on a tight budget may have empty turrets or mount only one or two rather than the full three weapons. (Crews often find creative uses for the unused 500-1,000 cf, like illicit stills.)

Hull-Mounted Weapons: Turret and bay weapons can be built directly into the hull. Such a hull-mounted weapon takes up space just as if it were a component module. If it is a turret-sized weapon, it is fired from the bridge/cockpit crew stations (often by the pilot). Hull-mounted turret and hull-mounted bay weapons (also called Internal Bays) are assumed to be installed in casemate swivel-mounts enabling them to fire in a 90° arc on one side of the ship (specified during construction).

Spinal Mounts: Spinal mounts are huge weapons built into the centerline of the vessel (sometimes called a fixed mount). They are limited to firing directly forward, and aimed by pointing the ship. A ship can only have one spinal-mount weapon (but multiple fixed-mount weapons).

Pulse Mode: A beam weapon's gunner can use a special computer program called *Double-Fire* to adjust the pulse rate of his weapon to fire at a higher rate at lower power. This "pulse mode" gives an increased chance of hitting a target, at the expense of decreased range and damage. There are three additional rates of fire available beyond the default 1/60; 1/30 (RoF Bonus +8) for 2/3 damage and range, 1/15 (RoF Bonus +9) for 1/2 damage and range, and 1/8 (RoF Bonus +10) for 1/3 damage and range. The last rate is mainly used for point defense. All fractional values are rounded down. Each weapon firing in pulse mode requires a running copy of the program *Double-Fire* (see p. 72). If pulse mode is used for the entire round (instead of just for point defense), the pulse rate must be specified at the beginning of the round.



Turret Weapons

Turret weapons are the universal tools of space combat. Even on large vessels, they still fulfill valuable point defense and close-defense roles vs. missiles and small vessels.

The Imperial Navy, in an attempt to make battlefield swaps between partially damaged and inoperative ships easier, has made 1,500-cf (3-ton) turrets their standard size. Imperial ships only mount turrets of those sizes, and most weapons manufacturers follow suit by only producing weapons to fit the standard Imperial sockets. Custom designs are possible using ***GURPS Vehicles***.

Missile Racks

Missiles are launched from standardized launchers; 250mm missiles are launched from 250mm tubes, while heavy missiles (500mm) are launched from 500mm tubes. These are Imperial standards, and there is no reason to expect other polities to use the same weapons. An easy way to represent this is to decide that a Vargr world (for example) uses 253mm missiles – these are functionally identical to their Imperial counterparts, but will not fit in Imperial launchers (and vice versa, of course). However, the actual diameter of the launch tube itself does not affect its mass, cost, or volume. The same statistics could easily be used to represent a Vargr missile rack of a different diameter.

250mm Missile Racks

A slow autoloading launch tube, rated to fire 250mm, 700-pound, 6 cf (0.35 stons, 0.012 dtons) missiles. Missiles as light as 290 lbs. can be launched from the launcher. The system also includes a laser communicator used to control operator-guided missiles, plus magazine space for 70 missiles at TL7, 75 at TL8, 76 at TL9, and 77 at TL10+. Range of the launcher's laser communicator is six hexes at TL7, 20 hexes at TL8, 200 hexes at TL9, and 1,000 hexes at TL10. Divide ranges by 10 for use in an atmosphere and by 1,000 for use underwater.

Reloading missile racks on any ship smaller than 800 tons is a chore, as the missiles are 11' long. Military vessels, if expected to carry reloads, are usually designed with the cargo hold near the missile magazine to facilitate the transfer of the missiles. Civilian ships usually restock missiles when grounded dirtside or docked at an orbital facility.

The 250mm Missile Rack is the missile rack as described in the ***GURPS Traveller*** core book.

500mm Missile Racks/ EW Drone Launchers

A slow autoloading launch tube, rated to fire 500mm, 4,000-pound, 30 cf (2 stons, 0.06 dtons) missiles. Missiles as light as 2,000 lbs. can be launched from the launcher. The system also includes a laser communicator used to control operator-guided missiles, and magazine space for 10 missiles (8 at TL7). As these missiles are 15' long, the restrictions on reloading 250mm missiles usually apply here, as well. Range of the laser is the same as on the 250mm missile rack. The 500mm missile rack and missile are Legality Class 0 within the Imperium.

This module also doubles as an Electronic Warfare (EW) Drone Launcher. Any number of 500mm missile racks may be grouped together as a dedicated *EW Drone Control Center* – if used as such they are *not* counted as hull-mounted weapons and cannot be used as such. If used in a turret, the 500mm rack may double as a combat launcher and drone controller, but not both simultaneously.

Energy Weapons

Lasers emit powerful beams of coherent light. Most ships mount them as a missile defense; they are the most common weapons on civilian ships due mostly to their long range and high penetration. All versions are available in standard (1 dton) and heavy (3 dton) versions.

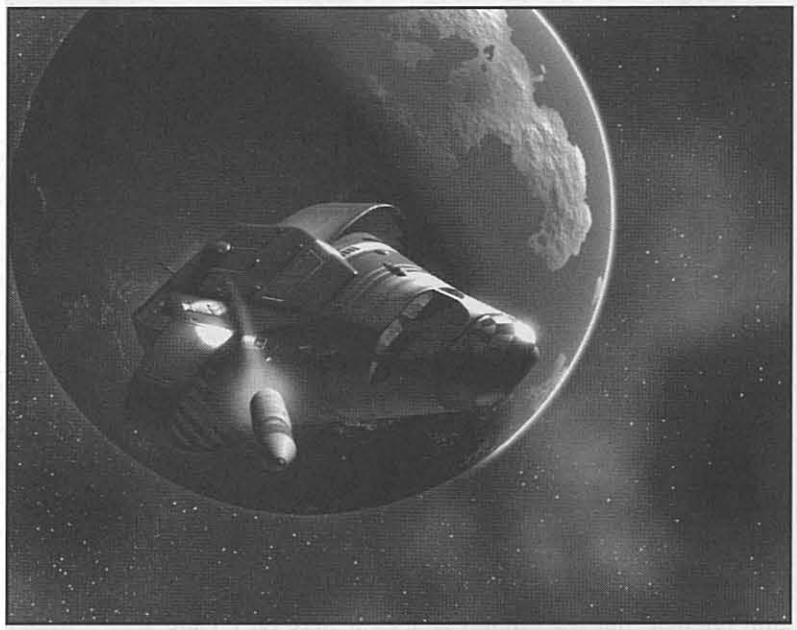
Turret Laser Weapons (TL8)

All turret laser weapons are constructed with a cyclic rate of 1/2 and the extreme-range option. A rechargeable power cell provides power for each shot while fusion-reactor components (fission at TL8) generate the power required to maintain the listed rate of fire. The laser is fully stabilized and installed in a universal mount (for turrets) or a casemate mount (if hull mounted). Turrets can fire in all directions, the casemate only to the side on which it is mounted.

Most weapons take up 1 space; the Imperial Navy also uses 3-ton "Heavy" Lasers on some ships to provide more power, range, and damage.

The UV Laser is one of the first ship-mounted energy weapons developed. Its range is very short by ***GURPS Traveller*** standards, being able to reach only 2,800 miles before its full energy dissipates by half. Most TL8 planetary navies mount lasers only as point-defense weapons because missiles are more effective as offensive armaments.

At TL9, lasers are designed to adjust their wavelength for optimal performance in various conditions such as adverse planetary atmosphere, dense fog, obfuscatory smoke, and even underwater. Such lasers are known as "rainbow" lasers. These become the first truly effective starship laser weapons. Their ranges measure in tens of thousands instead of just thousands of miles.



At TL10, lasers capable of X-ray wavelengths are developed. X-Ray lasers are able to penetrate through most conditions that hinder lasers at lower tech levels such as smoke, fog, bad weather, etc. X-Ray lasers can penetrate armor at least twice as thick as armor that can absorb a rainbow laser's damage, which makes them formidable weapons and the standard for most modern vessels.

At TL11, advances in optics technology produce a more powerful beam, and the costs of production are reduced; compact components become reliable and economically viable. TL11 lasers were used extensively by the Zhodani during the Fifth Frontier War, although they were not known to use the "heavy" versions adopted by some fleets in the Imperial Navy. The TL12 lasers used by the Imperial Navy utilize advanced optics and compact components so that they are the most powerful turret-mounted lasers in the Imperial arsenal. A few merchant companies and civilians who can afford them have been mounting TL12 lasers on their ships as well. The heavy version of this weapon is reserved exclusively for the Navy and is not for sale to civilians (Legality Class 1).



Turret High-Energy Weapons (TL9)

High-energy weapons are incredibly powerful. Plasma guns fire bolts of superheated gas, contained in a magnetodynamic "bottle." Fusion guns are similar but heat the plasma until it is actually fusing – getting touched by a fusion bolt is like skimming a star! Although their magnetic containment decays in a relatively short time, making them viable only as defensive weapons, the powerful bolts are strong enough to blow any missile or drone into slag. They are also very useful in ground attacks – some of these weapons could even give a grav tank a rough time.

Plasma and fusion guns do *Spcl* damage (burn with no damage modifier) to anything they hit. In addition, anything within two yards takes one-quarter the listed damage from splattering hot plasma, and flammable objects will usually catch fire. (This usually isn't a concern on the scale of starship combat, but for ground attacks it may be.) They are identical to the plasma blaster weapons described on p. UT58, except when the output is below 6,400 kJ, the cost multiplier jumps from ×1.5 to ×15.

Turret Particle Beam Weapons (TL8)

This development at TL8 places a particle-beam weapon in a turret or casemate mount. The purpose of this weapon is to provide heavy firepower to patrol or escort craft. Particle beams have the ability to disable electronics (like unhardened computers) due to the radiation they produce. Unhardened electronics are automatically disabled (EMP Kill) when they receive too many rads of radiation. The rads delivered are equivalent to the damage done by the weapon. See *Radiation Shielding*, p. 33, and *Hardened Computers*, p. 42, for more information. The main drawback to this weapon is its short range when compared to lasers of the same tech level.

These particular weapons come standard at 3 tons. However, at TL9+, they may be reduced to 1.5 tons by cutting power, volume, mass, cost, and price in half, cutting damage and distance by 1/3, and dropping Accuracy by 1. This series of modifications was implemented on the *Gazelle*-class close escort, but tests revealed the weapon was rather ineffective except at extremely close ranges.

Particle beams accelerate hydrogen nuclei to relativistic velocities, strip them of their charge, and fire them. P-beams have less range but are more powerful than lasers; plus, sandcasters don't affect them. *Neutral* particle beams are absorbed by atmospheres; particle beams that have been configured to fire *charged* beams aren't absorbed, but will dissipate in space. This makes p-beams useless as orbital bombardment weapons – except against vacuum worlds!

Sandcasters

Sandcasters launch tiny reflective/ablative crystals, commonly called "sand," as a defense against lasers. These crystals are distant relatives of the tiny transparent spheres used to make street signs, reflective paint strips, and the like. Such a sphere will bounce a beam of light back in the direction of the source with a small amount of spread. The advanced crystals used in "sand" work similarly. When the laser first hits the crystal, part of the energy is reflected back in the general direction of the firing ship and the rest is absorbed. As the beads absorb more of the pulse, they heat up and melt quickly. However, in free fall a liquid will keep its spherical shape, so the liquid bead continues to reflect a portion of the energy away. Eventually, the bead will start boiling, the energy absorption jumps dramatically, and it flashes into vapor. This vapor continues to absorb more of the laser pulse until it ionizes and forms plasma. How much the vapor absorbs, and how easily it ionizes, will depend on the composition of the bead.

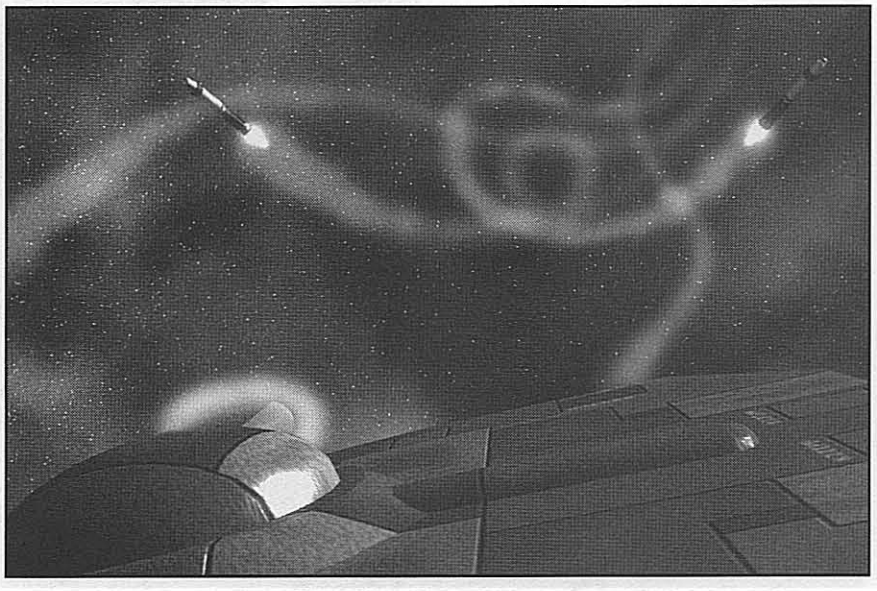
Once it becomes a plasma, it may be very transparent or very absorbent depending on the composition and the laser wavelength. Proper selection of crystal composition causes the plasma to be very opaque at common weapon-grade-laser wavelengths. At higher TLs, the efficiency of the sand continues to increase.

The crystals are shot out of the sandcaster so that a cloud is placed between the ship and enemy vessels that might fire on the ship. A single canister of sand provides the listed "effective DR" against laser attacks coming from a single enemy ship; defending against multiple ships requires multiple clouds of sand. As the sand absorbs an attack, its DR is reduced until it's gone. After each attack, the defender may choose to replenish the sand.

An enemy ship must be detected to be able to properly position the sand cloud. If the enemy isn't located before shooting, the ship won't be able to have sand in place. However, after the first hit, the defenders should know where the enemy is and be able to launch sand to protect against subsequent attacks.

Sandcasters must be targeted vs. a particular enemy vessel (or a group of vessels in *very* tight formation). A sandcaster adds an extra DR 400 vs. all laser fire originating from the targeted vessel, cumulative with armor DR. X-ray laser fire halves sandcaster DR just as it halves the DR of ordinary armor. Multiple sandcasters can concentrate on a single vessel's fire, but each extra 'caster only adds +50 DR. Each sandcaster holds 200 sand canisters.

Sandcasters also have useful melee applications. A sandcaster is treated as a grenade (albeit, a very large one) and does 10d fragmentation (cutting) damage to anyone in range – 300 yards, 30° cone. The base attack roll at point blank range (in front of the nozzle) is 24, -1 per hex distance.



Bay Weapons

Besides the weapon, power supply, and any ammunition, each bay weapon also includes a pair of roomy crew stations for two gunners (though the weapon can be fired by only one person), two hardened and dedicated mainframe computers (Complexity TL-3), a computer terminal, and a HUDWAC with pupil scanner. One of the mainframe computers runs a TL-2 Targeting program, the other runs a skill TL+5 Gunner program (pp. 71 and GT162).

Missile Bays

250mm Missile Bays

A 50-ton bay weapon housing 50 250mm missile racks plus magazine space for 3,500 missiles at TL7; 3,700 at TL8; 3,800 at TL9+. The missile bay can launch and control 50 250mm missiles per turn. This is the missile bay from ***GURPS Traveller***.

500mm Missile Bays

A 100-ton bay weapon housing 100 500mm missile racks plus magazine space for 800 500mm missiles at TL7; 1,000 at TL8-9; and 1,100 at TL10+. The 500mm missile bay can launch and control 100 500mm missiles per turn.

Energy Weapons

Bay weapons come in small (50-ton) and large (100-ton) varieties. Typically, only particle beams, plasma guns, fusion guns, meson guns, and repulsors are mounted in bays.

Particle Beam Bays (TL8)

This is a much bigger version of the turret particle-beam weapon (see p. 48). This powerful weapon is used on most large military ships to support their spinal weapons.

Particle beams were one of the first bay weapons to be deployed in space combat before the advent of meson guns. They are available starting as early as TL8 and improve continuously until TL11, where levels reach their peak and compact components are used to pack more weapon into a smaller space

Plasma Gun Bays (TL9) and Fusion Gun Bays (TL11)

High-energy-weapon bays hold larger, bay-mounted versions of the high-energy plasma and fusion guns. See p. 48.

Meson Gun Bays (TL12)

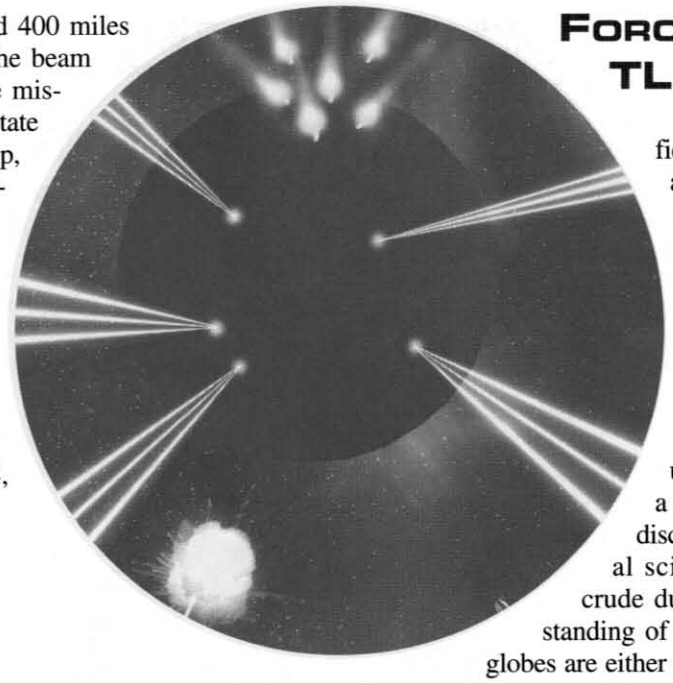
Meson guns use nuclear-damper and particle-beam technology to generate and aim a beam of high-energy mesons (subatomic particles that carry nuclear force). Mesons pass harmlessly through normal matter, but soon decay explosively in a storm of other energetic particles – with precise calculation a meson beam may be created and aimed so this explosion occurs inside an enemy vessel.

Repulsor Bays (Late TL9)

In order to supplement sandcasters and point-defense lasers, some large ships mount repulsor bays for point defense. These bays generate a beam of gravitic energy that can knock missiles off course. Repulsors are bay-mounted weapons and are capable of dispatching multiple missiles in a single round.

When the missile is around 400 miles away, the controller activates the beam and uses it to press against the missile. The missile is forced to rotate and thrust at an angle to the ship, causing it to bypass the defenders. These beams are only effective in the Collision and Point Defense Phase of the combat turn, as their range is extremely limited.

Repulsors are built as a ***GURPS Vehicles*** deflector screen, but their use is slightly different. See *Combat,* p. 104, for information on repulsor use.



Spinal Weapons

The most powerful beam weapons are mounted along the spine of a vessel – in many cases, the ship is literally built around the weapon. Spinal weapons are aimed by pointing the entire vessel, which may limit movement options (see p. 19). Spinal mounts include the weapon, a power slice (usually quite large), a rechargeable power cell (also quite large), one roomy crew station, a HUDWAC with pupil scanner, and two dedicated and hardened macroframe computers. One macroframe runs a TL-1 Targeting program; the other runs a skill TL+6 Gunner program (pp. 71 and GT162). Spinal particle beams are introduced at TL8, while spinal meson guns are introduced at TL10.

Screen Systems

In addition to targeted defenses like sandcasters and repulsors, large warships mount screens that protect against all attackers.

Nuclear Dampers (TL10)

A nuclear damper focuses a field that subtly interferes with the strong nuclear force, causing nuclear warheads to fail to detonate. A spacecraft damper field protects a 10-mile radius, increased by 5 miles each time the number of modules installed is doubled. A nuclear damper system requires four crew members to operate, regardless of the number of modules installed.

Meson Screens (TL10)

A meson screen disrupts incoming high-energy mesons. The system includes a screen generator and fusion-power components. The vessel's DR *vs. meson guns only* is 20.8 million times the number of meson-screen modules divided by its total surface area in sf. A meson screen requires four crew members regardless of the numbers of modules installed.

Force Fields (Late TL12)

Classic science fiction "force fields" or defensive screens come about at high tech levels because of an increased ability to manipulate subatomic particles and forces. Force-field generators project an energy-absorbing shell around a ship, and are known as *black globes.* The Third Imperium didn't acquire force-field technology until the late 11th century, when a cache of Ancient artifacts was discovered. Based on those, Imperial scientists were able to generate crude duplicates and gain some understanding of the technology involved. Black globes are either artifacts installed on a makeshift basis or temperamental experimental models installed on TL12 Imperial warships. The acquisition of any force-field generator is probably the result of a lucky find on the part of a government, individual, or corporation.

Since a black globe absorbs all energy, a ship with its field on is protected from all fire. Black globes store this energy in a capacitor bank. Unfortunately, the force field works in both directions; the ship may not fire, maneuver, or even see anything beyond the opaque darkness (except a few feet of light from the vessel if the GM thinks it's pertinent). These limitations would make the black globe of limited value in battle if not for the ability of the field generator to flicker – switch the field on and off many times per second – giving the ship part-time protection while still allowing it to fire, maneuver, and track enemy ships during the "off" intervals.

Using a black globe: Choose a flicker rate in multiples of 10%, up to the maximum listed for the globe installed. When flickering, the vessel can see normally, but sAccel is reduced by a percentage equal to the flicker rate. A flickering black globe increases the vessel's PD against all attacks, including meson guns, by (flicker rate/10%). If the globe's PD is responsible for an attack missing the vessel, the attack strikes the globe instead. See p. 104 for information on using a globe in combat.

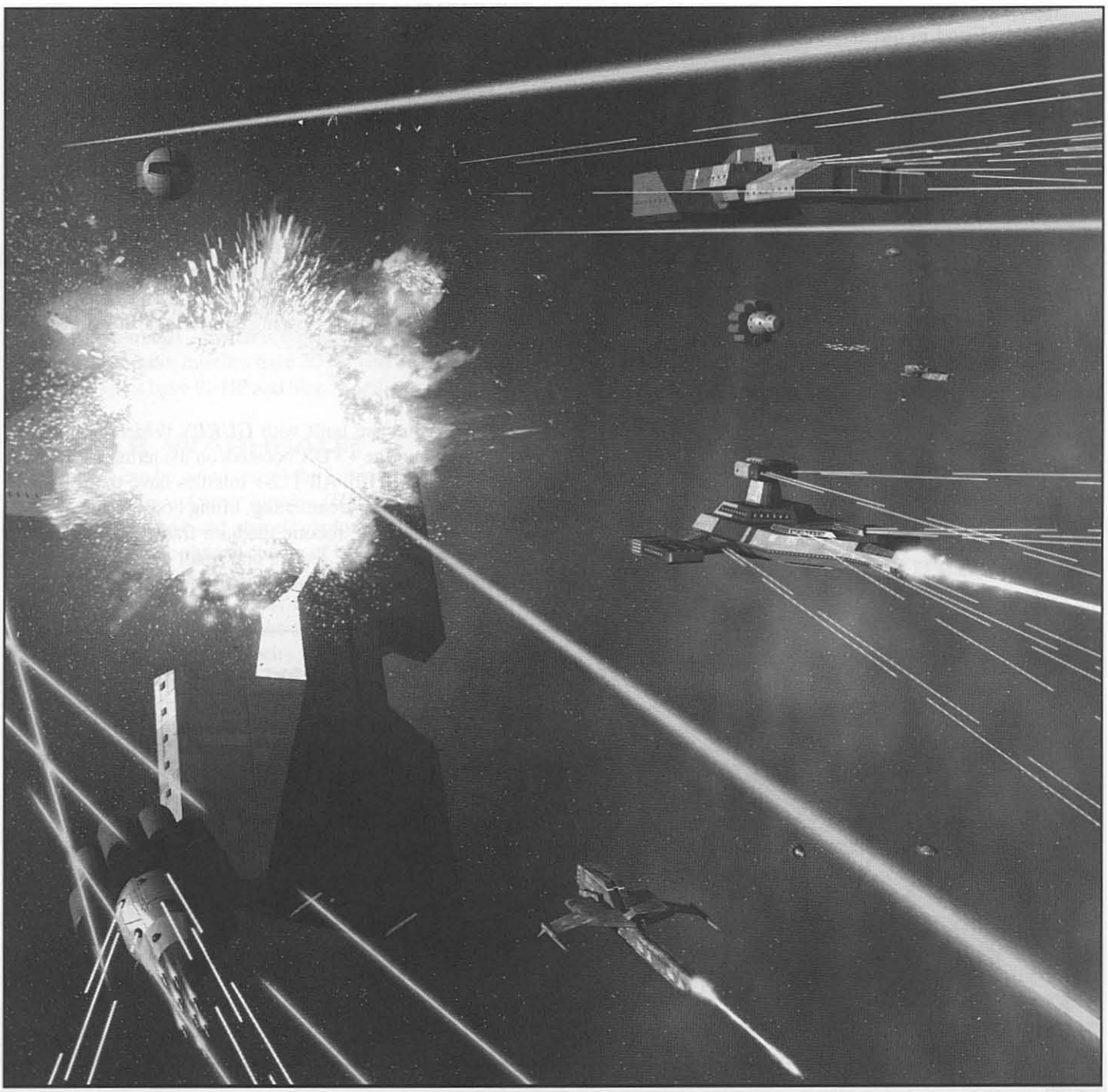
Damage points from attacks that strike the globe are absorbed by the globe's capacitors as hit points. The size of the capacitor bank is critical, as the globe will discharge catastrophically when it overloads. Stored hit points may be drained and converted to energy and stored in other energy banks or used to power the ship's systems (see *Energy Banks,* p. 37). Maximum conversion rate is 1% of capacity per second (240,000 HP or 960 MJ per dton per turn. See *Power Plant Slices*, p. 36, for information on increasing an energy weapon's RoF). Ships that do not have separate energy banks may use their jump accumulators. Each jump-drive module includes accumulators capable of storing 24 GJ (or 6,000 HP). Black globes come with a rudimentary capacitor bank able to store 10,000 HP worth of energy.

If the capacitors ever absorb more HP than their capacity, they discharge, releasing all their accumulated hit points at once against the ship as damage. Hull DR does not protect! The black globe and capacitor bank are automatically destroyed in the explosion.

Invisibility: Since a black-globe field absorbs all energy, a ship with its field turned on *without flicker* is, at any range over a few miles, effectively invisible. In battle, this will have little immediate effect, since a ship that suddenly disappears from enemy sensors in this way will have its current course predicted with 100% accuracy based on its last known position, speed, and facing. If the defenders maneuver to confuse the enemy, it is up to the GM as to how or when attacking ships can detect them. (Of course, the black globe would still show up visually if it had a backdrop of the system's main star, a planet, or even a particularly dense star cluster.)

However, the advantages to a team that has not yet been detected by the enemy are immense. Suppose that a task force were to jump into a system with its black globes on. It could drift unseen past an enemy fleet and drop its screens at a preplanned moment, to bombard a planet or to engage enemy squadrons by surprise. (Of course, this would require some precise pre-jump navigation that the GM might rule is particularly risky to pull off, in order to keep this from becoming a standard tactic.)

Quick Play Option: The preceding expands upon the description of black globes found in ***Alien Races 3***, p. 117. It adds more detail to use this cutting-edge technology. In so doing, it converts the globe's DR value to an ability to absorb hits of damage. GMs who don't desire this extra detail may continue to use the "quick and easy" version of the rules described there.



Chapter Seven
Launched Ordnance

Launched ordnance includes a variety of small, usually unmanned spacecraft. Other than as missiles, these also are used for roles in which larger vessels are unsuitable.

Missiles

The TL10+ 250mm missiles described in this book are usually only found in the hands of the military. All 500mm missiles are reserved exclusively for the Imperial Navy and are not for sale to civilians (Legality Class 0). The missiles from the ***GURPS Traveller*** core book (see pp. GT158-159) are legal for civilian usage within the Imperium.

All TL9+ missiles are semi-autonomous vehicles guided to their target by a gunner to within the range where the terminal guidance system takes over (anywhere from 400 miles to 1,000 miles depending on TL). TL7-8 missiles are handled as on p. GT169. While fire-and-forget missiles are possible, the technological limitations and sheer size of the required sensor system make a guided missile more practical than a completely robotic one. Missiles can cause damage by either exploding close to the target or by impacting the target at a high relative velocity. While some missiles are designed only for impact (or *kinetic*) kills, most missiles contain an explosive charge, giving the gunner two ways of causing damage – this flexibility outweighs the slight performance advantage of a purely kinetic-kill missile. (See pp. VE115-116 for more information on "terminal guidance.")

Missiles at TL7 use reaction thrusters and only have one round of thrust; at TL8+ they use reactionless thrusters and have three rounds of thrust.

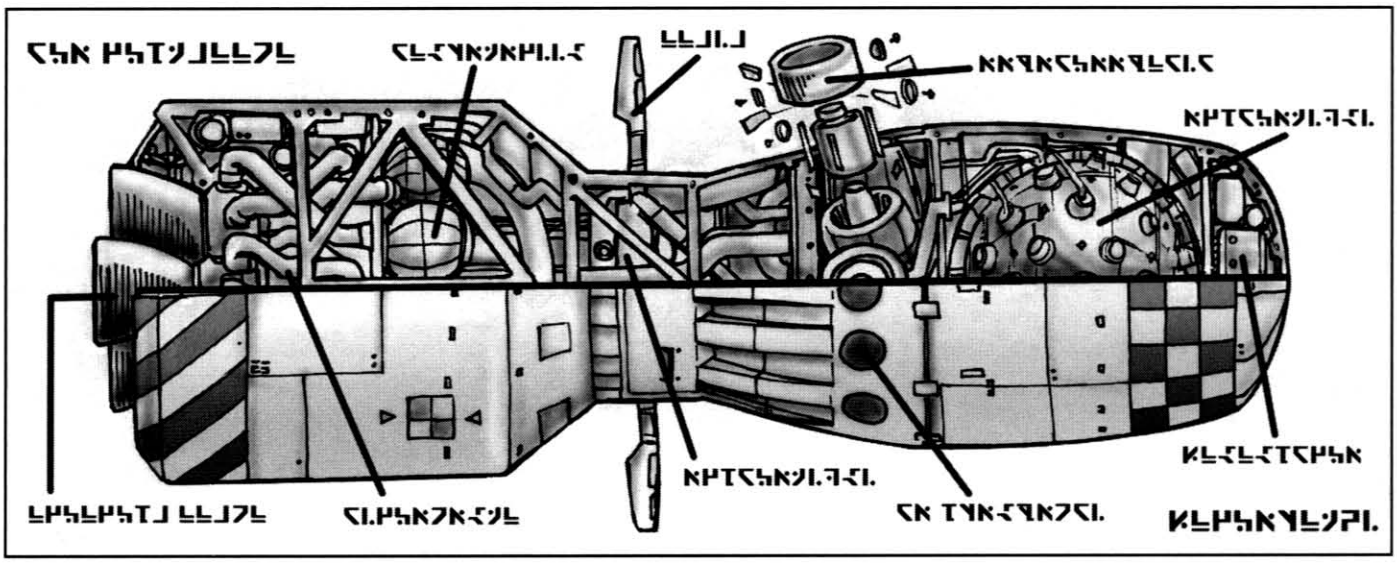
Extra missiles can be carried as cargo. Missile ammunition loaded as cargo will not be accessible during combat, but can be reloaded into missile launchers between battles (this takes about one man-hour per eight 500mm or 20 250mm missiles). Stored as cargo, each 250mm missile takes up about 9 cf (55 per dton of cargo), and each 500mm missile takes up 45 cf (11 per dton).

Missile Design

Missile design has evolved over the last few thousand years. Although there are more highly optimized designs, the designs presented in this book have proven to be the most effective. They are cheap enough to be a viable weapon either singly or in mass quantities, and their performance statistics are optimized in order to accomplish their mission: killing the enemy. However, most importantly, the specifications are generic enough to be built on nearly any planet in the Imperium. This doesn't mean there aren't other designs available. Keep the following guidelines in mind when designing custom missiles:

Nuts and Bolts

All missiles are built with ***GURPS Vehicles*** rules with the exception of the +3 DX boosters on the terminal guidance systems (see p. R10). All TL8+ missiles have the following options: Very Good streamlining, lifting body, standard metal armor and materials, robotic medium frame, basic emission cloaking, basic stealth, sealed, one small dedicated hardened robot-brain computer, one long-range receive-only laser



communicator, a rechargeable power cell for one hour of operation, and a vectored-thrust, reactionless thruster. TL7 missiles are identical except they use IR cloaking, a short-range laser, an advanced battery, and a 20-minute solid-fuel rocket. Missiles are either 250mm or 500mm. TL7-10 missiles use small High Explosive Armor-Tapping (HEAT) warheads; TL11-12 use modest HEAT; TL13 uses normal HEAT. All warheads have the self-destruct option.

All TL9+ missiles have terminal guidance systems consisting of two small hardened robot-brain computers (one with a +3 DX reflex booster) running Electronics Operations (Missile Sensors) and Piloting (Missile), and a cheap Passive Radar Homing (PRH) guidance system. One copy of each program must be purchased for the ship (then copies are downloaded to the missiles) if the terminal guidance system is to be used (program TL must match missile TL). Otherwise, the missiles must be guided manually (p. GT167). The combined programs cost: Cr6,000 at TL9-10, Cr10,500 at TL11, Cr43,000 at TL12, and Cr123,500 at TL13.

Standard Missiles

In the ***GURPS Traveller*** space-combat system, standard missiles maneuver like spacecraft under the control of the firing gunner. In a 20-minute combat round, a missile rack can fire and control one missile; a small missile bay may control as many as 50 missiles, while a large bay can control as many as 100.

When a missile ends its turn in a target vessel's hex, it may intercept and ram the target (doing impact damage) or detonate its warhead – which is typically an explosive-shaped charge. The 250mm missiles have 30 HP and Size Modifier 0; 500mm missiles have 90 HP and Size Modifier +1.

Missile Warheads

Missiles can be given one of the following warheads:

High-Explosive Armor-Tapping (HEAT) (TL7): This is a specially constructed and shaped explosive-charge warhead. It consists of a cone-shaped charge of high explosive which – detonated moments before impact by means of a remote control, fuse, or probe on the tip of the round – will explode in such a way that it transforms the metal liner of the round into a pencil-thin jet of hyper velocity metal traveling at up to the 25 times the speed of sound. The kinetic energy of this jet enables it to penetrate deep into very tough armor. Although the penetrating jet's diameter is very small, it is lethal by virtue of setting fire to fuel or ammunition, boring through vital components, or killing crew members. All missiles come equipped with HEAT warheads by default. Use the base cost on the *Module Tables*, p. 124.

Kinetic (TL9): A basic space-missile warhead; this is simply a dense rod that smashes into a target. A kinetic missile relies on the high relative speed gained from its own motor or from the launching ship's maneuvering. If reactionless thrusters are not available, kinetic weapons get *most* of their speed from the launching ship's maneuvering; their own drives are used mainly for steering. All TL9+ missiles come equipped with kinetic-kill capability in addition to any other warhead installed.

Nuclear (TL8): A fission, fusion, or antimatter explosive (the latter are not strictly nuclear, but possess equivalent effects), nuclear weapons are usually fused for proximity bursts. Typical yields are in the 10-kiloton range (250mm warhead) or 1-megaton range (500mm warhead). Nuclear weapons are of limited utility against capital ships equipped with nuclear dampers. Against smaller vessels (and spreads of missiles), their "one hit, one kill" capability can be devastating. Add MCr0.042 per 250mm missile, or MCr0.064 per 500mm missile to the base costs.

Concussion damage at the point of detonation for conventional nuclear munitions is 12d×20,000 for a 250mm warhead, and 12d×2 million for a 500mm warhead. In an atmosphere, quarter damage for every 256 yards (250mm) or 1,024 yards (500mm) from the point of detonation. In space, divide damage by the square of the distance to the target in *yards*.

X-ray Laser (TL9): These warheads detonate a small nuclear weapon in order to energize an X-ray laser beam – in fact, this is the only way such weapons can be built in the foreseeable future. The warhead consists of a nuclear bomb, an array of beam-generating laser rods, and a targeting system. Instead of physically intercepting the target, the missile stands off at a distance of several hundred miles, orients itself on the target, and detonates. The nuclear blast destroys the missile but also pumps energy into the laser array; as the rods vaporize, they produce powerful X-ray laser beams directed at the target. Consequently, X-ray laser warheads free missiles from having to close on their target and risk being shot down by point-defense weapons or suppression by nuclear dampers. This warhead is only available for 500mm missiles; add MCr0.11 at TL9, MCr0.064 at TL10, or MCr0.041 at TL11+.

X-ray laser warheads do 5d×200 (2) at TL9, 7d×200 (2) at TL10, and 9d×200 (2) at TL11+.

Nuclear and X-ray laser warheads are very hard to find (Legality Class -3) within the Imperium, but their use is not prohibited outright if restricted to space-to-space combat.

Deadfall Ordnance

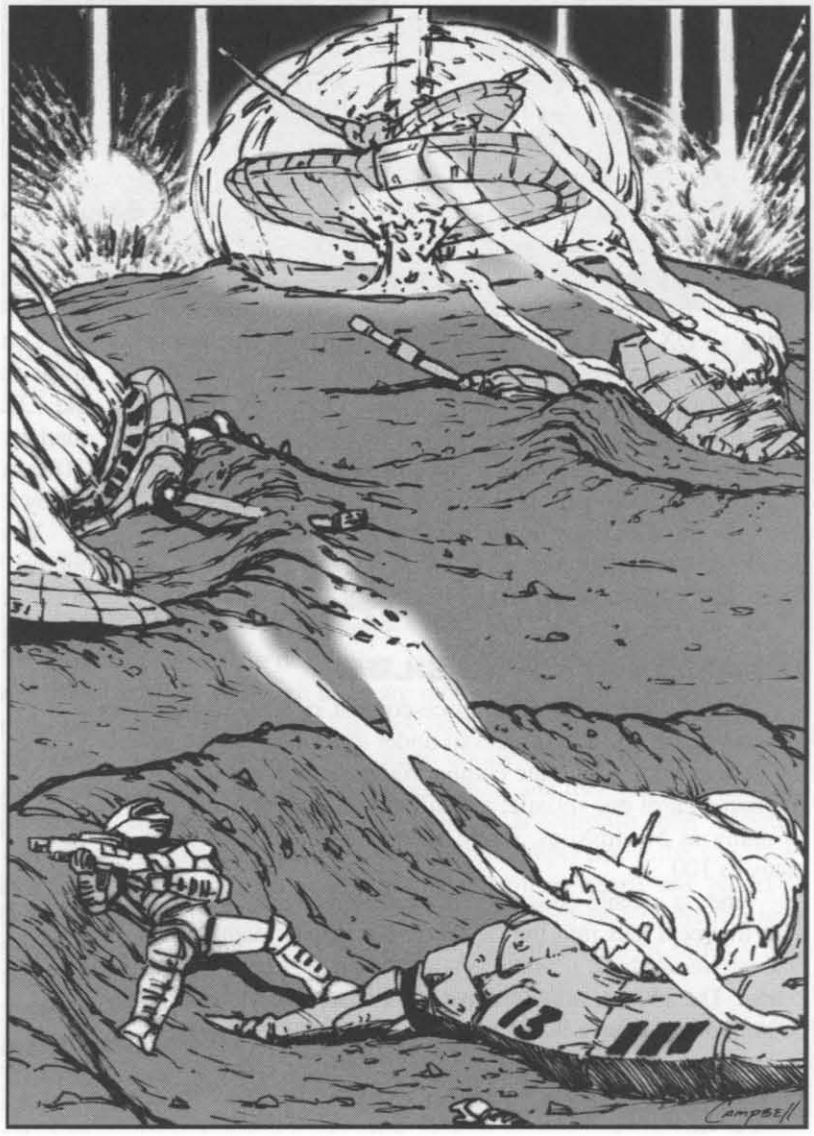
Missiles for planetary bombardment have different requirements than those intended for space combat. (For worlds with vacuum or trace atmospheres, use regular space combat missiles and rules.) Because they depend on some combination of gravity and aerodynamic braking, they are collectively referred to as *deadfall ordnance*.

Spike Submunitions (SSM)

Spikes are "smart" bombs – narrow (80mm) depleted uranium, superdense penetrators with a guidance package and steering fins strapped to their back. They are launched in clusters of seven (250mm) or 38 (500mm) using a standard space-combat missile as a delivery vehicle. The gunner maneuvers the missile to the release point, burns out its rocket motor to accelerate it toward the designated target area, and releases the spikes. The spikes fall the rest of the way to the target using their onboard sensors to lock onto and attempt to hit particular targets.

Guidance: Spike submunition missiles are laser command guided to their release point; they maneuver in the same manner as space-combat missiles. Standard spikes come equipped with infrared or optical homing sensors. Other options are available at additional cost (per missile, 250mm/500mm): imaging infrared (+MCr0.004/0.019), semi-active laser homing (+MCr0.021/0.12), or neutrino homing (TL10+, +MCr0.019/0.10).

Procedure: The launching vessel must be in low or high orbit over the target world. The gunner aims at a point on the ground called the *target reference point* or TRP. He attempts to fly the missile to a position 11 miles (20,000 yards) above the TRP, and releases the submunitions; this takes one space-combat turn (20 minutes). He rolls against his Gunner (Missile) skill (p. B116) to hit, adds the target size modifier as well as the weapon accuracy modifier and subtracts -23 for range. If the attack is successful, the submunitions are distributed around the desired TRP. If the attack missed, refer to the *Size and Speed/Range Table* (p. B201). Take the amount by which the attack roll was missed and look it up on the Speed/Range column, then read over to the adjacent Linear Measurement column. This is the distance by which the spread of submunitions will scatter from the TRP, to a maximum of 9,000 yards. For example, a miss by 16 would be a -16 on the speed/range column, and hence a miss by 1,000 yards. Determine scatter direction randomly (p. B119). Once the submunitions are released, each one may make one attempt to lock on targets according to the homing-missile rules (p. VE193), starting from the point to which they scattered. If the lock is successful, the spike will maneuver to impact the target. If not, it will impact the ground somewhere within a radius around the scatter point: 1,000 yards for 250mm missiles, 3,000 yards for 500mm.



Glide Bombs

Glide bombs are precision munitions. They are designed to be launched from the 250mm or 500mm missile launchers of a ship in close orbit, using a small booster motor to enter the upper atmosphere. Once there, the missile automatically glides to the target area, aerobraking all the while to kill its considerable orbital velocity. The aerobraking phase ends with the missile in a near-vertical descent over the TRP at an altitude of 5,000 yards. The missile then activates its onboard sensors and searches for a target as it continues to fall.

What happens in the terminal phase depends on the type of missile. *Kinetic kill* (KK) missiles fire a terminal rocket motor, accelerating to their maximum velocity in a matter of seconds before impacting on the target. *Explosive* and *nuclear* munitions use steering fins and a small motor to maneuver to the target, where they detonate. In either case, ground range is 8 miles (14,000 yards) from the original target reference point.

Guidance: All glide bombs are "brilliant" (p. T:GF119 or p. VE195) and use inertial guidance (p. VE195) to reach the target area. Standard glide bombs come equipped with either infrared or optical homing sensors. Other options are available at additional cost: semi-active laser homing (+MCr0.02), PESA homing (TL8+, +MCr0.03), or neutrino homing (TL10+, +MCr0.015).

Procedure: The missile must be launched from a vessel in low or high orbit. The selected target reference point must be 1/4 of the planet's circumference (3/4 planetary diameter) ahead of the vessel along the vessel's ground track (the path its orbit traces over the ground) at the time of launch, plus or minus 500 miles in range and 250 miles left or right of ground track.

The flight time of the missile is one space-combat turn (20 minutes). (See p. VE193 for rules on "homing missiles.")

Nuclear Ordnance: Nuclear warheads may be substituted on HEAT missiles, as discussed above (p. 53). At TL7-8, add MCr0.042 per 250mm missile or MCr0.064 per 500mm missile. Halve this extra cost at TL9-13.

Saturation Nuclear Cluster (SATNUC) munitions are also available at TL9+. Add MCr0.5 per 250mm missile, or MCr2 per 500mm missile.

Probes/Drones

An IISS long-range probe is a 6-cf missile with an instrument package instead of a warhead. They are used for many purposes: soundings of planetary atmospheres, close-range photographic sweeps of planetary surfaces, asteroid flybys, and wide-aperture astronomy.

Stealth Surveillance Drone (TL12)

This is the most common orbit-to-ground drone used by IISS exploration vessels. It comes with robot brain (Complexity 6), acute vision +3, night vision, peripheral vision, telescopic zoom (16×), thermograph, super-hearing, long-range radio, radiation shielding, intruder chameleon system, stealth and IR cloaking, flashlight, self-destruct device with 1 lb. of explosive, and inertial compass. A rechargeable D cell powers all systems, with endurance of 10 hours.

Statistics: Design weight 20.58 lbs., total volume 0.275 cf, price Cr7,745, aSpeed 77 mph, PD 4, DR 20 laminate armor, 5 HP, and Legality Class 2.

Electronic Warfare (EW) Drone (TL9)

An EW drone is a small robotic jammer node that runs alongside a larger vessel, projecting an area-effect jamming field. EW drones are based on the 500mm missile, with the warhead and power cell replaced by smaller engines, an area jammer, and a nuclear power unit (NPU). Drones are typically no faster than the ships of their respective TL. The jammer rating is 3 at TL9, 4 at TL10, 5 at TL11-12, and 6 at TL13. (See pp. VE59, VE171, and T:GF112 for further information on "area jammers" and "radar.")

Any 500mm operator-controlled missile launcher can launch the drone. There's no benefit to having more than one drone jamming the same area.

Short-Range Probe (TL12)

This probe is based on an advanced variant of the SIM-12 missile (p. GT159) with the warhead removed and an improved sensor suite added. A modular socket carries custom-built scientific packages. It comes with a receive-only, very-long-range laser communicator (1 million miles), passive electromagnetic sensor array (PESA) (20-mile range), an inertial navigation system, a modular socket with 0.2 cf capacity, and radiation shielding. Additionally, a rechargeable E-cell supplies enough power for one hour of operation.

Statistics: Ewt. 265 lbs., usual payload is 70 lbs., lwt. 335 lbs. (0.17 stons), volume 6 cf, Size Mod +0, price MCr0.070, HT 12, PD 4, DR 120, and 30 HP.

Water Performance: wSpeed 150 mph, wAccel 180 mph/s, wMR 1, wSR 4, wDecel 5 mph/s (100 mph/s), and draft 0.63 feet.

Aerial Performance: aSpeed 740 mph, aAccel 180 mph/s, aMR 6, aSR 3, and aDecel 24 mph/s.

Space Performance: sAccel 9 G.

Probe Launchers

This system is designed for the launch and control of short-range probes (but it is not an EW drone). A probe-launcher system consists of three launchers, each including a launch tube, laser communicator, computer terminal, and crew station for probe control. There is storage space for 13 probes, and 40 modular instrument packages. Depending on the exact composition of the load, the module with a full complement of probes would weigh roughly 4 stons and cost MCr2. This module may also be placed in a turret and operated remotely.

*Why **do** they call it a morgue anyway?*
– Anton Wilson Peale

Jump Troop Systems

Jump troops are lightly armed infantry equipped with *Reardon* medium battledress (T:GF86) and either PGMP-11 plasma guns or FGMP-11 fusion guns (p. GT110).

Their purpose is to assault from orbit, penetrating planetary defenses in small, one-man drop capsules.

Standard Drop Capsule

This is a generic, disposable atmospheric-reentry capsule. It has a compartment for 10 cf of specialized equipment including ECM gear or cargo; this equipment must be designed to fit the limited space. With additional buffers and padding, just about any size battledress can also be used in it, turning it into a meteoric assault capsule. There is an additional 5 cf (250 lbs.) of space for generic cargo. The standard drop capsule includes primitive controls and has Fair streamlining. (See p. T:SM62 for the "assault capsule" statistics used by the Imperial Marines.)

Capsule Racks

This module stores up to 16 capsules (with mass of up to 2,000 lbs. each) in ready racks with room for maintenance and (machinery for) launcher-loading operations. The component statistics do not include the mass or cost of the capsules.

Drop-Capsule Launchers

A pair of 700mm missile launchers in a fixed mounting. Rate of fire is 1/10 each, so in one space-combat phase the pair can launch 240 capsules. This system can also function as a pair of one-man airlocks.

Battledress Ready Rooms ("Morgues")

This module includes space for 20 sets of battledress (weighing up to 1,000 lbs. each) and accessories such as flight packs, with room for *minor* maintenance and loading equipment. The component statistics do not include the weight or cost of the carried suits.

Chapter Eight

Crew and Passenger Accommodations

When creating a ship, the designer must consider how many beings the ship will carry, and how much space and luxury they need. Quarters are not strictly *necessary*, even for long voyages – if there is sufficient life-support capacity, passengers can be carried in the hold. This is uncomfortable, and illegal within the Imperium. Captains only resort to this in emergencies or when shipping refugees, slaves, or animals. Most of the time, passengers travel in a combination of the modules described in this chapter.

For systems that come in half-sized or small versions, divide all statistics by 2 unless otherwise noted and round any fractional spaces to the nearest 1/2 space.



Modules for Crew and Passengers

There are many different ways in which the various sophonts of the Imperium travel. Everything from steerage to palatial multiroom suites are available – for a price. Typically, there are only three different levels of comfort: low, middle, and high passage. See ***GURPS Traveller: Far Trader*** for the various costs and requirements associated with these different modes. In addition to staterooms, there are also recreation facilities: gyms, swimming pools, large lounges and bars, and theater entertainment. Only the larger liners are capable of maintaining anything other than a simple lounge.

Life Support

Limited Life Support provides basic lights, air conditioning, heating and also provides additional "bottled" oxygen and water for as long as power and supplies last. This is the most common kind of life system on small craft. Its endurance is measured in man-days; i.e., 100 man-days of endurance sustains one man for 100 days, two for 50 days, three for 33.3 days, etc. Life support can be turned on or off, thus conserving it when not needed; a shuttle flying through a breathable atmosphere would have no need for it. At TL11+, these systems become obsolete in favor of full life support.

Full Life Support is a self-regenerating oxygen and water purification plant typically found on long-duration non-starships with minimal crew requirement. Full life support does not provide food, so supplies must be carried if the sophonts are to eat.

Total Life Support has all the benefits of full life support but also provides food (see *Parts and Stores*, p. 27). This is the standard aboard all starships and large non-starships in the Imperium.

Alien Environment Suites

This is an individually controlled environment designed for the comfort of up to two passengers (or livestock) with exotic atmospheric requirements. It includes a full life-support system for two (four at TL11+, with half of the standard capacity as backup), separate from and independent of the starship's main life system; a two-man airlock; and 24 hours of battery power (as a backup) to keep the occupants alive should repairs be required. As *total* life support is not provided, rations sufficient for the journey will have to be carried as cargo. At TL10 or less, two man-days of *limited* life support is provided, instead.

Note that alien races with different metabolisms, such as the Inheritors (see ***GURPS Traveller: Alien Races 3***), would consider quarters designed for humans to be "alien environment suites."

Bunkrooms

This type of room has bunks for six personnel at TL7; nine at TL8; 14 at TL9; and 16 at TL10+. All include total life support. Conditions are very cramped. Imperial protocol is to only load up to 25% capacity per bunkroom, except for missions of very short duration or emergencies.

Small-Craft Cabins

Also known as "small-craft staterooms," cabins are much like staterooms (see p. 58), but more basic and spartan – some would say cramped. In the Imperium, cabins are not considered suitable for passengers or crew on interstellar vessels (including Imperial Navy starships) due to these "cramped" conditions, but are often employed on interplanetary vessels and small craft (however, see *Traveling*, below).

Traveling

Aside from the bridge, the cargo deck, and engineering, passengers are normally allowed the run of the ship during the week in jump, although smaller vessels encourage them to remain in the staterooms or in the passenger lounge. Food service is provided as part of the passage, and is served in the lounge.

Low Passage is the fiscal and social equivalent of traveling steerage in a 19th-century passenger liner. Low passengers spend the entire trip in suspended animation, and thus have no life-support requirement other than a trickle of power to run the low berth (see below).

Middle Passage is a step up from low passage, and is substantially more expensive. On large passenger liners, middle- and high-passenger staterooms are segregated on different decks, each with separate lounge areas, galleys, and so on. Smaller vessels often mix the two types of passengers on the same level.

High Passage is more expensive than middle passage, and is virtually identical except for a higher standard of service and food. On large liners, high passengers have their own decks, lounges, and food service. Some ships give high passengers larger, more luxurious staterooms. On smaller ships, the main difference is in the quality of food and the behavior of the stewards. Converting middle-passage accommodations to high passage usually involves simply upgrading the fittings. Luxury fittings are available for just about any crewed compartment at 5× cost.

Some ships also have much more room than others. Some are crowded. To determine exactly how much room your vessel has for the crew, perform the following calculations. Divide the total number of dtons devoted to a crew's comfort (staterooms, bunkrooms, rec facilities, etc.) by the total crew not in low berths. Spartan accommodations are 2 to 2.25 dtons per person, average is 2.26 to 3, above average is 3.01 to 4, and luxurious is over 4. Anything below 2 dtons per person is considered cramped and results in a -1 penalty to all shipboard operations. For passengers (including troops) not in low berths, divide the total number of dtons devoted to passengers' comfort (staterooms, bunkrooms, rec facilities, etc.) by the total passenger count. Use the same descriptions as above.

Note that luxurious high passage may demand a higher price than average high passage . . .

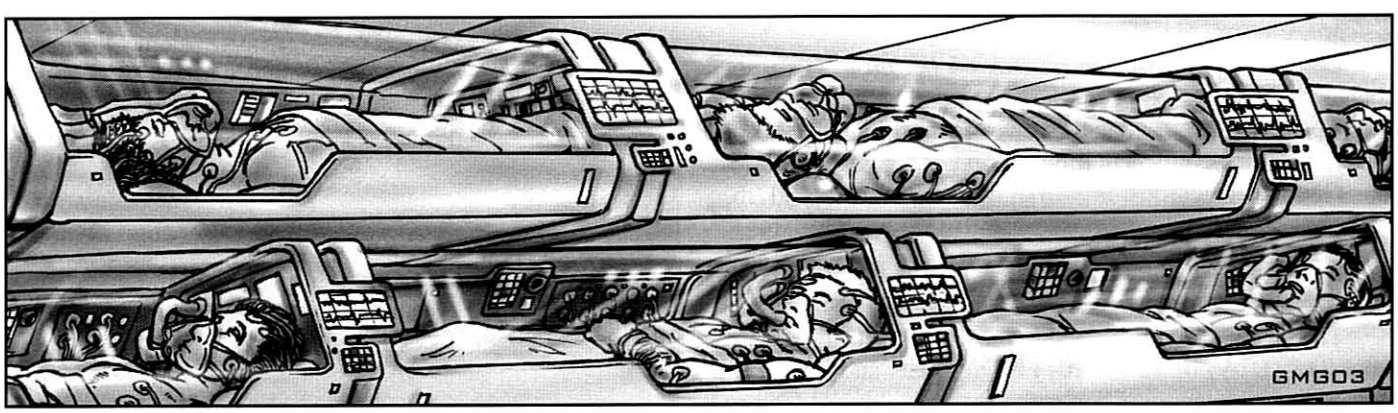
Low Berths (TL9)

A low-berth system contains four cryonic freeze capsules, each containing power components, and capable of holding one person in suspended animation ("low passage") and 10 cf of personal belongings. See pp. UT103, S91, or BIO115 for detailed rules. Low berths are often used to carry replacement crews (see *Frozen Watch*, p. 26) aboard naval vessels, or as emergency life support for disaster survivors or severely injured crew members. Also see *Low Berths*, p. GT108.

To convert a Low Berth to an Emergency Low Berth, add MCr0.004 at TL9 or MCr0.003 at TL10+ and 0.01 stons to the mass for both. It has an integral radiothermal generator or "RTG" (see p. VE85) providing enough power for 14 years. The RTG is usually refurbished during the annual maintenance overhaul. Each module also includes four dedicated, hardened, small computers to control the immersion procedure, allowing an occupant to enter unassisted at assisted speed (5 minutes). Emergency low berths do not have storage space for personal belongings.

Another form of low berth is used to transport livestock. Instead of four capsules, there are only two. Each is rated for 1,000 lbs. (1/2 stons). No supervision is required to put the animals in cryo-sleep, but anesthesia might be a good idea depending on circumstances. Animal Empathy or Animal Handling should give bonuses, if appropriate. Reviving livestock is the responsibility of the colony's veterinarians (usually recruited as professionals). Revival is very similar to the process for standard cryonic freeze capsules, but failure indicates that the livestock is dead (all occupants share the same revival roll). Whether the results of a failed revival are still suitable as food is left to the GM.

When sizing livestock berths, determine the mass of animals to be transported and refer to the following table.



That's Entertainment

"My best advice if you want to be a shipboard entertainer: don't. You're in for long hours of high-stress performance with no chance of getting away from your audience, even if they hate you – and believe me, after a week in jump some will. Still, nobody ever listens to that little nugget of wisdom, so here's my next-best advice.

"First, make sure you're doing it for the right reasons. ***Don't*** *do it just because you want to travel – though you need to like traveling – and don't do it for the money. Do it because you like meeting new people and making them happier.*

"Second, generalize. It doesn't matter if you're not the best singer in the Marches or the funniest comedian, so long as you can do a bit of both and half a dozen other things, and make them all entertaining. A week is a long time in jump space, and you can't get away with the same act every night.

"Third, know your audience. Check the manifest before launch; it'll tell you how many family groups you'll be dealing with, what races are on board, things like that. You don't want to be making Aslan jokes in front of one! Mingle during the flight to jump point and try to gauge the mood. Pick up every scrap of information you can.

"Fourth, make friends with the crew. Help them out and they'll come to your rescue when things get rough.

"I could go on, but those are the most important points. There's always too many of them and not enough of us, no matter how big the ship is – the only thing you can do is practice. Or quit.

"Don't say I didn't warn you."

– Enli Rivera, in an interview for the ***Spinward Times****, 137-1119*

Livestock Stowage Table

Size	Mass	Live	Cold	LS	Examples
Very Large	10,000	0.5	n/a	15	Elephant
Large	1,000	2	1	3	Horse, Cow, Camel
Medium	100	15	10	0.7	Pig, Goat, Dog
Small	10	30	100	0.1	Chicken, Duck, Cat
Very Small	1	160	1,000	0.03	Rat, Quail, Dove

Mass: Given in pounds.

Live: Animals that can be stowed per dton when not transported in a low berth.

Cold: Animals that can be stowed per low berth.

LS: Human-equivalent life-support needs per animal.

Generic livestock is worth approximately Cr1/lb. (Cr2,000/ston), but this may vary greatly (see pp. B140-145).

Passenger Couches

This system is only available for small craft. It incorporates 11 (TL7-9) or 12 (TL10+) roomy seats and one man-day limited life support per passenger, plus the necessary power components to operate the life-support system. All seat bottoms can be used as a flotation device in case of water landing or as a rescue bubble in the case of a vacuum evacuation. All seats fold up into the bulkhead, reducing their volume by 50%, and allowing the passenger compartment to be used as an ad-hoc cargo hold (at 20 cf stowed per seat). For systems without the added safety/fold-up features, divide cost by 10. Half-Sized versions are available; round down the number of passengers.

Staterooms

Staterooms are the long-term quarters called for by interstellar flight; they include 50% additional space for access and other facilities (galleys, rec areas, etc.). Standard passenger comfort demands a certain level of amenity in the stateroom. In order to meet this standard, staterooms are self-contained living areas which need never be left during a voyage. The stateroom contains a bed, a fresher, entertainment consoles, a small kitchen, and miscellaneous furniture. All basic items in the stateroom retract into the floor, wall, or ceiling when not in use.

Staterooms provide a standard bed which folds into the wall at a command. Grav plates (from a utility module, p. 40) can be adjusted to provide a range from 0 to 3 G for personal comfort, plus an intercom and controls for light and heat.

Meals may be taken on a collapsible table and storable chair. The stateroom is large enough for four people to eat around the table comfortably. Meals must be delivered by hand from the galley; there is no automated delivery system. A small refrigerator stores snacks and a small quantity of food for immediate availability. See *Ship's Galley*, p. 60, for another design option on vessels that have more than 20 staterooms.

Sanitary necessities are handled by the fresher, which includes a multifunction shower, a toilet, a sink, and a small washer/dryer (for the benefit of middle passengers). All components fold unobtrusively out of the way when not in use.

Storage of personal necessities is handled by several collapsible compartments and cabinets. Passengers can store up to 10 cf of baggage in their staterooms; high passengers can store an additional 500 cf in the cargo compartment. Note that stowage in cargo and access thereafter requires the assistance of the crew.

Install enough staterooms for the estimated crew and passengers – crew or middle-passage passengers often endure double-occupancy; high-passage passengers and (some) officers should have a room of their own. The staterooms themselves take up only about 50% of the rated volume; the rest is used for common areas (lounges, kitchen, meeting rooms, etc.), total life support, a power slice, and access ways. Staterooms are not available on small craft unless the craft is designed with bridge and engineering systems – not a cockpit/systems module.

Offices

Each office module holds four offices, with room for three visitors each, or 16 cubicles with no room for visitors. Includes full life-support for 16 and space for conference rooms, office supply storage, etc.



Life Support and Provisions

A manned ship should have at least one space of life support if it is intended to operate for more than a couple of days – unless it contains other systems that include life support (i.e., staterooms). Thus, short-range shuttles or fighters do not require life support.

A life-support system can be overloaded if necessary. Roll 3d after each day of overloading, at +1 per full 10% by which the number of people aboard exceeds current capacity. On an adjusted roll of 13 or more, the system begins to break down, losing 10% of its *current* capacity for each point by which the roll was missed. A Mechanic (Life Support) roll can be attempted once per day; if it succeeds, it will restore 10% of *full* capacity. Once the life-support system begins to fail, the effect snowballs. If the ship remains overloaded, life support will eventually reach 0% and fail. At that point, all the oxygen in the air will be used up within a few hours, and everyone will die. Those in cold sleep are unaffected if life support fails . . . as long as the power stays on.

Life-Support Module

This module contains extended accommodations for craft equipped with bridges but no staterooms. Includes full life support for five personnel, one folding bunk at TL7-8, two folding bunks at TL9, two bunks at TL10+, the associated power plant slice, and 9.5 cf of storage for personal gear.

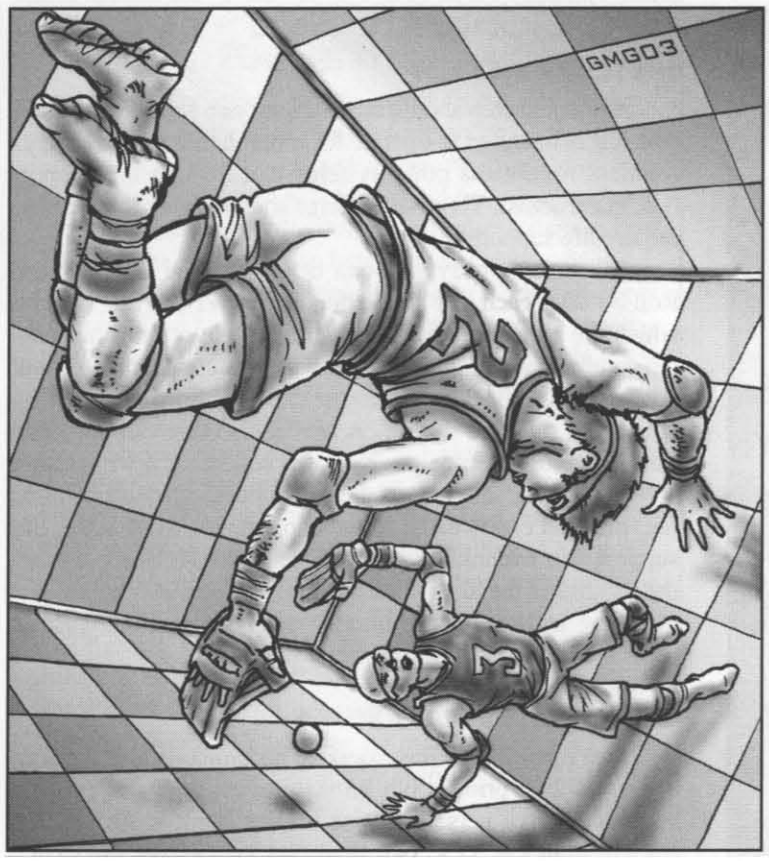
Luxury Fittings and Entertainment Facilities

Leisure activities are considered a necessary part of stateroom life. They relieve the boredom of long jump voyages by providing entertainment, research facilities, and computer access. The wide range of entertainment activities includes holographic theatrical productions, video shows, interactive drama, and audio programming. There are also games (played against a computer or against other passengers). The computer terminal also allows access (on a restricted basis) to the main computer for data processing, word processing, and library data inquiries.

While the phrase "entertainment facilities" conjures images of passenger liners, these modules are also useful in military vessels. The value of exercise rooms and shooting ranges are obvious, but even theaters have their place – not only for entertainment, but as briefing rooms and a place to stage activities between combat.

Gymnasiums/Exercise Rooms

A gym usually contains a wide variety of exercise machines and facilities for both strength and aerobic training. The standard gym can be used by up to four people at once. Gyms aren't necessarily a luxury – long voyages cooped up in a small starship can cause a significant loss of conditioning. Exercise is also a good way to relieve stress and deter psychological problems. Military ships usually have sufficient gym facilities to support 5% of the crew at once.



Halls, Bars, or Conference Rooms

A large room with tables that can serve as a restaurant, bar, conference room, casino, etc., this can comfortably accommodate 50 people per module (smaller lounges and conference rooms are included in stateroom volume). Weight and cost include furnishings.

Holoventures (TL9)

Civilian: A 1,200-square-foot holoventure zone with a roomy operator's crew station. The computer terminal at the station runs holoventure programs on a dedicated mainframe computer. It includes a fusion power slice to run it.

Military: As above, but with DR100 composite armor for training with live ammo.

Shooting Ranges

A 25-yard sighting/training range for two men with a single computer terminal. It is armored to DR100 and is most often used with plastic bullets. Troop ships use it to provide traveling soldiers some time on the trigger. Combining multiple ranges could provide a longer range or even a mock village for rehearsing house-clearing and hostage-rescue missions.

Stages

A 20'×20' stage area for dancing, plays, nightclub acts, and so on, this includes sophisticated electric lights and sound systems. Normally attached to a Hall or Theater containing the audience.

Swimming Pools

Large commercial ships (or those catering to aquatic sophonts) will often have swimming pools. Includes 100 square feet of pool (10' deep), 100 square feet of deck area, and overhead clearance. Multiple modules can be combined to make larger pools. The finished design should add one Space Dock system (1 ston, MCr 0.005) per complete pool, to contain the water in case of loss of artificial gravity. The module only weighs 1.5 stons when empty.

Theaters

A small auditorium with 100 seats for the audience, a large holoprojector (can be stowed), and an operator's workstation. Can be used for entertainment, for presentations, or as a briefing or situation room. A stage is not included – a Stage module may be attached if needed.

Null-G Handball Courts (TL8)

While artificial-gravity generators eliminate the need for space travelers to experience zero-G conditions, some travelers nevertheless like the challenge of experiencing those conditions for recreation. Null-G handball is typical of any number of null-gravity games that have become popular in most space-faring cultures. It is played in a court 20'×20'×40' by either two persons or two two-person teams. Players wear a lightly padded and webbed glove extending their reach by several inches, with which they strike a small resilient ball. The object of the game is to bounce the ball off of any three surfaces of the court (walls, floor, or ceiling) without the opposing player or team touching it. The Null-G Handball Court includes separate artificial-gravity generators to maintain the zero-G environment, a locker room with shower and facilities for the players, and a gallery for an audience of 12 (larger audiences require Theater seating).

Ship's Galleys

A compact food-preparation area with capacity for up to 770 lbs. of food (385 man-days if a life-support system is installed, 64 otherwise). Mass and cost both assume a full pantry at the appropriate TL. Each module provides cramped but usable space for preparation of up to 28 meals at a time. Exact features will depend on TL and may include rough-weather options for low-tech ocean vessels, zero-G options for pre-CG space vehicles, and/or refrigerators and freezers. Galley modules may be stacked to create a much larger facility.

This module should only be purchased for ships requiring more food preparation area than is included in staterooms (see p. 58). A galley may be consolidated from the total kitchen space provided by multiple staterooms. If a ship is designed and built in this manner, the "galley" is considered a common area separate from the staterooms. It would take 20-40 staterooms to make such a galley, depending on level of service and spaciousness desired.

Chapter Nine

Accessories and Unusual Items

In addition to all the equipment crew and passengers see just walking through the ship, ships require many more systems to operate smoothly and/or fulfill its mission: everything from cargo holds to weapon-storage lockers to medical systems is needed.

Cargo

Virtually every starship needs some cargo space. Even the most optimized military vessel will have a ship's locker to store equipment.

Cargo Holds

Each Hold module has space for 500 cf (18.5 cubic yards) of cargo. Multiple modules may represent a single large hold or a number of smaller holds. Holds in half-size increments (250 cf) may also be installed. Holds normally carry 5 stons per dton; maximum rated load is 25 stons per dton. See pp. 57-58 for information on transporting livestock.

Smuggler's Holds

If a vessel has cargo space, some or all of it may be divided into one or more concealed compartments (called *smuggler's holds*, after their most common use). If someone searches the vessel, a smuggler's hold can be found on a roll vs. Holdout or Shipbuilding (Starship) skill, whichever is *lower*. Subtract 10 from skill; add +1 for every 2% of the ship's hull class hidden. Smuggler's holds cost MCr0.005 per 1/2 dton.

Ship's Lockers

The Ship's Locker is a catchall name for the miscellaneous stores and supplies a ship maintains to support its operations and crew. On small ships, it may be a physical locker; on larger ships, it is a storeroom or hold. Contents of a ship's locker may include environmental and survival gear, personal convenience items and consumables for the crew (the *slop chest*), and medical supplies. Most equipment is issued as needed and remains the property of the ship's locker.

Slop chest items (junk food, mild recreational drugs and alcohol, toiletries, entertainment or education chips, T-shirts and even uniforms sometimes) are purchased in bulk by the Purser and sold to the crew at cost or charged against their unpaid salaries. On small merchant ships or those carrying only a few passengers in addition to their cargo, the passengers may have access to the slop chest through the Purser, but on a cash-only basis. Large liners run separate concessions for the convenience of their passengers.

See *Zero-Space Systems*, pp. 68-69, for more information on Ship's Lockers.

Weapon Storage

Small arms and most other conventional weapons are easily stored in cargo holds or the ship's locker. However, some weapons and accessories require special handling and storage if a vessel is to remain safe from accidents and terrorists. Nuclear warheads, antimatter warheads, and even conventional explosives all pose a serious risk to a ship's integrity if not handled correctly.

Anti-Blast Magazines

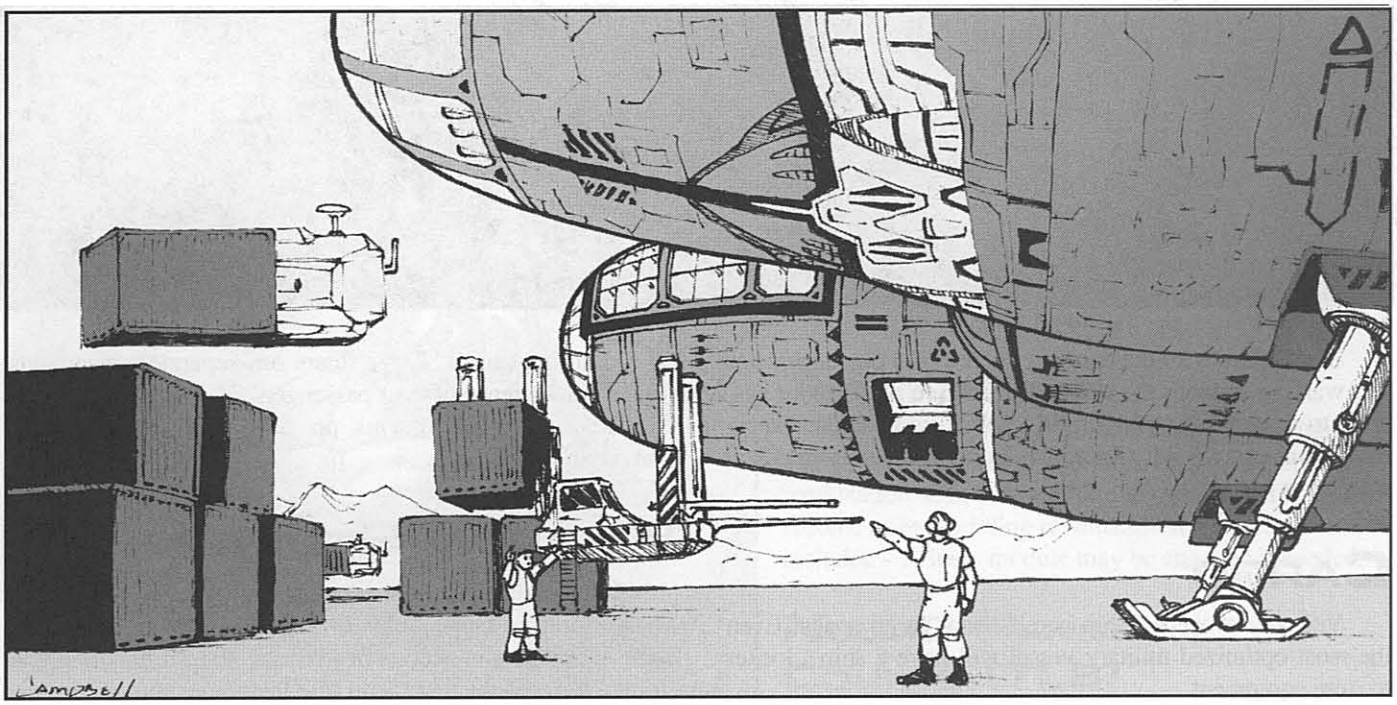
These magazines are special compartments used to store missiles and other hazardous goods. They are designed to channel the blast of an ammunition explosion away from other internal systems, reducing the severity of accidents. A magazine holds 55 250mm missiles, 11 500mm missiles, or 500 cf of other weapons. They should be installed near the outer hull of the ship to operate effectively.

Damper Boxes (TL11)

Damper boxes prevent radioactive decay of unstable isotopes. They weigh 80 lbs., take up 1.6 cf, cost kCr40 and require 0.16 MW for *each* cf of cargo capacity that they possess at TL11. Halve all attributes at each higher TL. The *Module Tables* contains a TL11, TL12, and TL13 box capable of holding 55 250mm or 11 500mm missiles equipped with nuclear warheads; each provides a nuclear power unit (NPU) to run it, allowing containment even when the ship loses power. Smaller units (holding no more than a couple of warheads) should be constructed using the *Zero Space Modules* (see pp. 68-69).

Antimatter Bunkers (TL12)

Antimatter cannot be produced or stored in useful amounts until TL12, and is not used in engines or reactors until late TL13. Antimatter bunkers (or "traps") each hold up to 50 grams of antimatter (usually anti-hydrogen). Since antimatter is worth several million credits per gram (assuming one could find it on the open market), larger bunkers are rarely required. They include a dedicated internal nuclear power unit; containment will be maintained even if the vessel loses power.



An antimatter fuel bunker will explode on a roll of 16 or less if it or the vehicle location containing it is disabled or destroyed. It can be made to self-destruct by turning off the containment system. Failsafe systems, each with the volume, mass, and cost of the original system, can be added. These backups make a damaged trap less likely to explode (-1 to explode per extra module). Damage from a bunker explosion is equal to 6d×25 million points *per gram* – enough to vaporize any ship in ***GURPS Traveller*** and pose a significant hazard to vessels nearby. (The crew's personal armor does protect normally if they are wearing it . . .)

Cargo-Handling Gear

All but the most primitive starports have equipment and facilities for loading and unloading cargo, available for a price. Large ships, or ships designed to access primitive starports, may include their own cargo-handling equipment. Usually, this will consist of winches and hoists, but very advanced ships may choose to include gravitic manipulators (see below).

External Cradles/Grapples

See *Surface Features, External Cradles/Grapples*, p. 35.

Gravitic Manipulators (TL11/13)

These devices generate a gravity field at a distance, pulling objects toward or pushing them away from the ship.

Repulsor Beam (TL11): Each repulsor-beam system generates a ST 8,500 repulsive force. Multiple systems can work together, adding their ST together.

Tractor Beam (TL13): As the repulsor beam, but generates a ST 8,500 attractive force, instead. Multiple systems can work together, adding their ST together.

Combination Beam (TL13): Usable as either a tractor beam or a repulsor beam, but not as both simultaneously. In either mode, the beam generates a ST 8,500 force. Multiple systems can work together, adding their ST together.

Mass Catchers (TL8)

A large cargo net and arrestor system designed to catch up to 625 stons of mass (typically shot by the *Mass Driver*, p. 64) as long as it is less than 1,500 spaces in size and traveling at less than 600 mph. Multiple units will either increase the speed, mass, *or* volume (choose one per additional unit).

It is designed for zero-G operations by producing a strong counter-force (usually thrusters) to catch a load without moving off its stationary position and axis. This system must be mounted on some other structure (at a minimum, a 2,000-ton vessel or platform of some type), as it is not a stand-alone unit.

Optional Detail: Hatches and Openings

Any ***Traveller*** campaign taking advantage of the cargo-handling equipment described here may benefit from information on standardized cargo hatches in the Imperium. Cargo vessels with 7 dtons of cargo space or less have a small cargo hatch, which is 12' wide by 12' high. Larger ships have one standard hatch per 25 dtons (or fraction) of cargo space; standard hatches measure 24' wide by 12' high. Very large ships may combine several hatches into a single opening that is a multiple of these dimensions.

Alien or unusual ship designs may have radically different cargo hatches, requiring some on-the-scene thinking for quick loading or offloading of cargo.

Additional Equipment

While too minor to be individually purchased or inventoried in the starship-design process, the following items are commonly found at starports or in large cargo vessels throughout the Imperium. See pp. T:SP102 and T:FT77 for more information. Any starport employee should know where to find one, and they'll often be lying about in the cargo-handling areas. Travelers should be able to get their hands on most of these without much difficulty.

Hand Truck: A two-wheeled dolly that carries up to 1,000 lbs. or 4 cf of breakbulk product. The speed at which it can be pushed depends on the user, but the weight is normally divided by 10 or 20 (see p. B89) for encumbrance purposes. $50, 30 lbs.

Dock Cart: A four-wheeled cart than can hold up to 4,500 lbs. or 180 cf of breakbulk product. The speed at which it can be pushed depends on the user, but the weight is normally divided as per the hand truck, above. $100, 300 lbs.

Bulk Liquid Pump: A rugged pump used to move liquids such as water, gasoline, milk, etc. For double cost and weight, a heavy-duty version can move cryogenic fuels. For quadruple cost and weight, increase transfer rate by 50%.

A TL7 unit can move 3,000 gallons per hour at a distance of up to 150 feet (multiply rate by 1.5 per TL after TL7). Multiple pumps may be connected in-line to move a liquid a longer distance. There are usually 4-6 of these pumps operating during shipboard cargo operations. The pump's price includes a short-range communicator and a dedicated computer so operators can control the pump at a distance.

The pump with hose weighs 185 lbs., costs $600, and takes up 5 cf. Both pump and hose have DR 5, HP 5.

The pump uses a D cell (or equivalent advanced battery at TL7) for every 12 hours of operation. It takes 15 minutes and a Freight Handling skill roll to set up.

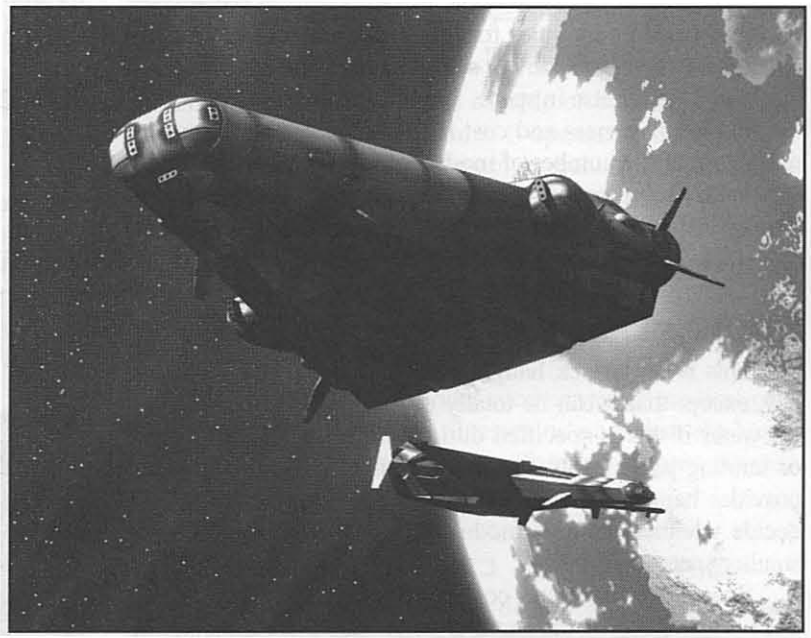
Dry Bulk Auger: As above, but uses a screw mechanism to move bulk dry goods like beans, wheat, rice, etc. A TL7 unit can move about 4,000 cf of bulk product per hour at a distance of up to 50' (multiply rate by 2 per TL after TL7). Multiple augers can be connected in-line to move a product a longer distance. These are often used during shipboard cargo operations. The auger's price includes a short-range communicator and a dedicated computer so operators can control the auger at a distance. An auger with hose weighs 320 lbs., costs $1,700, and takes up 10 cf. Both auger and hose have DR 5, HP 15.

The auger uses a D cell (or equivalent advanced battery at TL7) per 6 hours of operation. It takes 15 minutes and a Freight Handling roll to set up.

Conveyor Belt: A 15'×2' (or a multiple thereof) motorized conveyor belt. A TL7 unit can move up to 625 cf of breakbulk or bulk product per hour (multiply rate by 2 per TL after TL7). There are usually four to six of these conveyors operating during shipboard cargo operations. The conveyor's price includes a short-range communicator and a dedicated computer so operators can control it at a distance. Non-powered roller conveyors are half weight and one-tenth cost, but are obviously limited in utility.

The conveyor weighs 70 lbs., costs $500, takes up 3 cf, and has DR 5, HP 15. It uses a D cell (or equivalent advanced battery at TL7) per 12 hours of operation.

Portable Hydrogen Fueling Unit: This handy unit often supplements or replaces starship-standard fuel-processing modules for starport fuel-refining needs. Each unit produces its rated gallons per hour × 1.58 in liquid hydrogen and its rated gallons per hour × 0.76 in liquid oxygen. The TL7 unit uses a 4C55/7 container and the TL8 uses a 4C55/8 container (see p. T:FT57 for information on standard cargo containers). The TL9+ units each use a 4D55/8 container. The TL7-8 versions use a fission reactor, the TL9 version uses a NPU, and the TL10+ versions use a fusion reactor. A cutter can carry two HFUs (one at TL8-) and eight empty 4A70/8 fuel tanks in one trip.



Vehicle Storage

Starship designers have several options for storing smaller vessels within a larger one.

Vehicle Bays

A vehicle bay is custom-designed to snugly hold a single, specific small craft within the skin of the ship. It is not usable for other sorts of vehicle, except an externally identical variant of the original small craft.

To simulate the way that many small craft were carried in ***Traveller***, vehicle bays may be considered partially recessed into the hull. The full volume is still subtracted from available volume. The mass of any craft carried in this recessed vehicle bay plus any external stores still may not exceed the limits as imposed by hardpoints (see p. 34). Total volume of all recessed vehicle bays may not exceed 20% of hull class due to structural limitations. Use intrinsic modular couplings instead (p. 35) to overcome that limitation.

Example: A 100-ton ship has 12,150 HP and a recessed 20-ton vehicle bay. The external-store limit is 121.5 stons, therefore, the vehicle bay can only store a craft that does not exceed that mass. There would be no limit if the vehicle bay was fully enclosed.

Vessels in vehicle bays can only have maintenance performed that can be accomplished from within the vessel itself – since these vehicles often are short-duration small craft, that means they often cannot have large repairs made except at a starport or other dock facility.

Hangar Bays

A vehicle can be given a large bay in which other smaller vehicles can be stored, ready for instant launch. Unlike a vehicle bay, a hangar bay is not specific to a single vehicle type; any vehicle can be carried in it. The weight of a hanger bay includes all necessary elevators or ramps to move the vehicle or vehicles into launch position. Each module provides hangar space for 500 cubic feet (1 hull class) of vessel; decide if multiple modules form one large or several smaller hangars. Hangar bays are *not* sealed against vacuum and thus have very limited use in space.

Hanger bay mass and cost is paid only once per hangar, regardless of the number of modules from which it is formed – it mainly represents the mass and cost of the elevators and ramps. Hangar bays may be purchased in half-sized increments, but cost and mass remain unchanged.

Spacedocks

This is an airlock hangar bay; it is treated as a hangar bay, except that it can be totally evacuated or filled with air (or water if this is specified during construction) with doors or landing-pad elevators opening into space. Each module provides hangar space for 250 cf (1/2 hull space) of vessel; decide whether multiple modules form one large or several smaller spacedocks.

Spacedock mass and cost is paid only once per spacedock, regardless of the number of modules forming it – it mainly represents the mass and cost of the hangar doors and air pump. Spacedocks may be purchased in half-sized increments, but cost and mass remain unchanged.

Launch Tubes/ Mass Drivers (TL8)

A launch catapult (electromagnetic or gravitic) can be installed in any vessel intended to launch spacecraft (such as a carrier). They allow the fast deployment of fighters or other craft (40 per 20-minute space combat turn); see p. GT169 for information on recovering small craft. (The craft does not fly back into the launch tube, but is instead docked in its appropriate storage location.) Craft launched from one of these may use their full acceleration on the turn they are deployed (e.g., a 5-G fighter's vector is 5 hexes longer than the vector of its launching ship). One Launch Tube module is required for every 25 stons of the heaviest craft to be launched from the facility, then add enough spacedock/vehicle bay modules to contain the largest craft accommodated by the launch tube to make a complete launch tube. This additional bay is used to store the vessel until launched and contains the feeding mechanism to move the second and subsequent vessels into the launcher. When a vessel is launched, another vessel is moved into the bay.

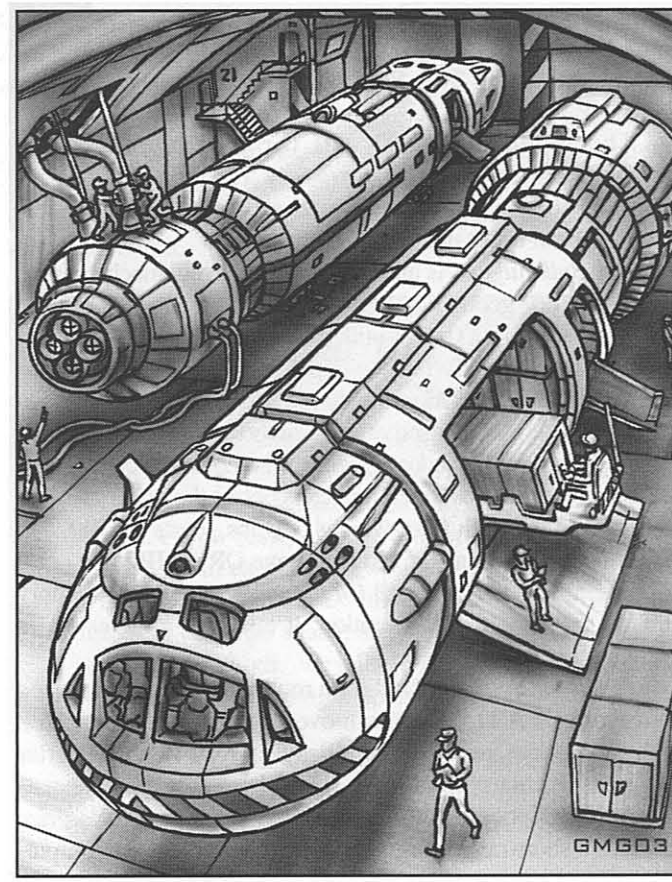
If used as a mass driver, the tube can launch up to 25 stons per module at 60 mph. Multiple modules will either increase the speed by 60 mph or increase the maximum mass that the tube can launch by 25 stons. Usually, a mass driver is designed for use in conjunction with a *Mass Catcher* (p. 62). Their performance should reflect one another's capabilities.

Labs and Workshops

A laboratory provides workspace and equipment for scientific research. A workshop includes workspace, tools, diagnostic equipment, raw stock, and bench parts for performing minor repair and construction work. Small parts can be made from scratch and medium-sized parts can be repaired or modified.

Laboratories

A laboratory dedicated to one scientific skill (e.g., Geology) as well as room for one or two scientists to work. For larger teams, multiple labs are a necessity! It gives +2 to skill in situations where the lab equipment would be beneficial; the GM can also rule a lab is required for a task – it gives no bonus, but work would be impossible without it. Physics laboratories are identical, but also include provisions for the increased power requirements of high-energy research.



Isolation Laboratories

A large, sealed laboratory with an airlock and other equipment certified to provide P4 protection (see p. BIO21). There is room for up to five people to work. It can be used for any sort of dangerous experiment: genetic engineering, chemical warfare analysis, psionics, nanotechnology, and so forth. Only in extreme cases (almost always the result of skilled sabotage) would any contamination spread beyond the lab.

Simulation Labs (TL9)

In scientific research and engineering design, the ability to visualize and manipulate data is often key to understanding and solving problems. The Simulation Lab is designed to assist in this visualization. It consists of a stand-alone holographic-imaging tank, a powerful macroframe computer (Complexity TL-2) to run it, and an operator's terminal. Although it can create images directly using data coming from onboard sensor systems, it is intended to accept and integrate large amounts of data from numerous science labs or design teams, and display it in a coherent, fully realized 3-dimensional picture. Multiple Sim Labs can be combined to create a much larger holographic-display volume (and more workstations) or enhanced displays may be added (see *Computer Lab*, below).

Computer Labs

These modules are designed for applications where reliable high-capacity number-crunching is needed. With a large number of associated workstations, they may also be used for archive and library functions. Each trio of macroframe computers is built as Compact, Genius, and Hardened with one level of High Capacity. Complexity is TL-1. Only dedicated scientific installations routinely use this costly module.

The *Enhanced Display* option consists of a 100 sf holoventure zone used to display the data instead of using flat screens (terminals are still included). These displays may be used with any of the listed laboratory modules as long as it has access to a computer of Complexity 7+. The required holographic program is included in the cost of the display system. Enhanced Displays may be also be used with Sensor Suites or Sim Labs to increase the display volume.

Workshops

Starships intended for long-range operation need to be somewhat self-sufficient, able to manufacture their own spare parts from found materials. The complete workshop contains all the tools needed for the Armory, Electronics, Engineering, and Mechanic skills, plus storage space. Workshops all have the same statistics though higher-TL shops will have better equipment. Up to three people can work in the workshop at the same time; one workshop should be provided for every 60 maintenance personnel onboard. Two of these workshops together make up the Logistics Module from p. T:FI35. Mini-workshops are similar, but not as capable; they are designed for vessels where space is at a premium (such as small craft).

Each complete workshop provides a +2 to repairs, while a mini-workshop negates the penalty for *not having* a workshop when making repairs.



Shipyards (TL7/9)

A shipyard or dry dock is capable of building or repairing 100 dtons of vessel at a time. It operates efficiently with 100 workers or robots and contains warehouses, workshops, offices, minifacs, etc., as well as a power element. There are two versions of this module, one for non-starships at TL7 and one for starships at TL9.

Medical Facilities

A normal sick bay provides workspace for medical personnel to treat wounds and illnesses on an outpatient basis. Other versions are dedicated to performing surgery, providing intensive care, or boarding inpatients.

Emergency-Aid Stations

Emergency-aid stations are designed for use in small ships where a full sick bay is not needed or space is at a premium. At TL7, it includes two bunks and a stretcher; at TL8, two bunks with emergency support units (ESUs) and a stretcher; and at TL9-13 one automed, one diagnosis table, one ESU, and one stretcher. All systems have a computer terminal and reactor slice to power it. See pp. UT94 or S87 for medical-equipment statistics. On ships without sick bays, one of these should be installed for every 60 staterooms or fraction thereof not covered by *Sick Bays*, below.

Sick Bays

Sick bays vary considerably by TL, as medical science advances. At TL7, each module consists of two beds, one operating table, and one stretcher; at TL8, an operating table and two beds equipped with ESUs; at TL9 and higher, an operating table, a diagnostic table, and either two (TL9-10) or three (TL11-13) automeds. All models include a computer terminal and sufficient power components to run all features. Ships should have one sick bay per 120 staterooms or fraction thereof.

Military Sick Bays/ Aid Stations

Naval vessels are often depressurized, either deliberately or because of battle damage. In order to maintain a habitable volume, military sick bays come with their own life support. This system is a sick bay as above (except the operating rooms are fully stabilized), with two 6-man airlocks, radiation shielding (PF 10 at TL7, ×10 for each additional TL), room for 10 ambulatory or two litter patients, and limited life support and energy banks for 15 man-days. A full fire-suppression system is included to augment those in the engineering spaces. Military sick bays are used individually as aid stations (often carefully placed along main corridors to act as blow-out shelters), or added to conventional sickbays to form a larger ward.

Evacuation Bays

Basic: Contains 12 stretchers and 12 Emergency Support Units (TL8+) with plenty of access space to move people in and out of them. Also includes 12 man-days of limited life support and a power slice. It is mostly used by small craft for medevac to a waiting starship.

Advanced (TL9): This contains 12 automeds and plenty of access space to move people in and out of them. Also includes 12 man-days of limited life support (*full* at TL11+) and a fusion power slice. Mostly used by small craft for medevac to a waiting starship.

Operating Theaters

This contains two complete, fully stabilized operating tables, two Emergency Support Units, 50 cf of storage space for medical supplies, and two computer terminals.

Habitat Modules

Some large vessels (such as colony ships and space stations) contain large urban or green areas inside them. Each module described below is about the size of a city block and includes lighting, temperature control, air recycling, and a power slice to run it.

Housing: This module contains one or more apartment buildings or a few dozen houses, plus grounds, walkways, etc., providing long-term accommodation for up to 100 people (half that many in luxury, twice that many in cramped conditions). Life support is not included. It should be supplied by a farm module (below).

Factory: A large industrial park capable of operating efficiently with a few dozen workers or robots. Contains warehouses, minifacs, etc.

Farm: An acre or so of open space with a few buildings devoted to agriculture and food processing. Up to 10 people or robots can work it effectively; each worker can grow food to feed 10 people. Using crop rotation, the farm can serve as total life support (providing air, food, and water) for about 100.

Park: A landscaped green space, possibly with entertainment or exercise facilities (pool, stream, playground, etc.). In a pinch, it can provide camping grounds for about 100 people.

Plaza: A mall or concourse area with about a dozen medium establishments, plus open space for several hundred people to congregate.

Null-G Handball Arena: Like a Null-G Handball Court (see p. 60) but represents either multiple courts or larger courts for bigger games (most often aboard stations rather than ships). For example, grav-ball (played by teams of seven armored players) uses a court 120'× 60'×60' (i.e., 27 handball modules, 20,000 Seats, 900-person Hall).

Security Systems

Civilian vessels require security measures against theft; exactly how many and what type will depend on the owner's paranoia and Imperial liability laws (no system is completely error-free). Warships often have lethal security measures, especially when on duty.

Electrified Surface

See *Surface Features*, pp. 31-35.

Locks, Alarms, and Security Systems

See p. 69.

Cells/Armories/Safes

This is a single cabin with reinforced walls (DR 200), restraints, and barred door – a place to hold unruly passengers, crew, etc.

The same module can be used to construct an armory for secure storage of small arms and ammunition, or a safe for high-value cargo. These versions are not interchangeable, however, and their use must be specified at the time of construction. All versions include an independent high-security alarm and an observation camera. Each module normally holds 1-2 people (up to 25 for a limited period), 4,000 lbs. of racked weapons and ammunition, or 400 cf of valuables.

Dedicated mail carriers should install as many safes as required for the service.

Brigs

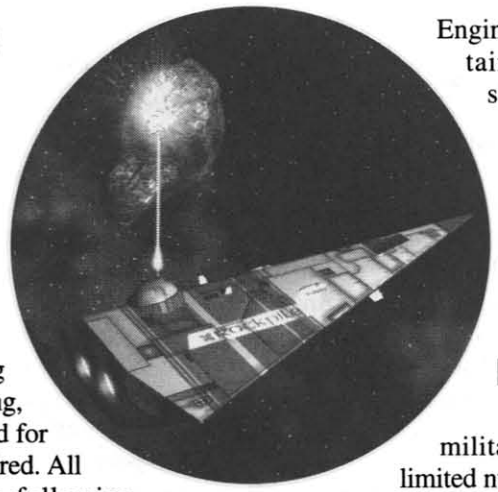
This is an ordinary stateroom equipped with reinforced walls and door (DR 200), restraints, and a high-security alarm and observation system. It normally holds 1-2 people. Up to 50 could be crammed in for a limited time, but this will overwhelm the two-person life support. A ship or starport with one or two brigs usually will monitor them from the bridge. A larger number of brigs probably will have its own dedicated security station (see *Auxiliary Control Station/Duplicate Controls,* p. 43).

Double-Cell Brigs

As per the brig, above, but does not contain the security station. Multiple double-cells are usually installed together with one or two security stations to form a much larger secure area or prison.

Miscellaneous Systems

These round out the many equipment needs of a starship, though many are useful only in specialized applications.



Turreted Mining Lasers (TL8)

This is a powerful mining or cutting laser used by ultra-tech mining, engineering, and rescue vehicles. Mining lasers are sized for continuous fire, so no energy bank is required. All mining lasers are constructed with the following options: close range, universal mount (or casemate if hull-mounted), energy drill, and no stabilization. All TL11+ mining lasers are built with the *compact* option to represent the advances in laser technology found in normal shipboard weapons. See p. B125, *Attacking Inanimate Objects,* for more information.

Although the mining laser can be used as a shipboard weapon, it is impractical to do so because damage is so low and range is so short. If a mining laser is used as a weapon, damage is calculated somewhat differently; the target is no longer a big dumb rock, but is theoretically trying to avoid being hit. All damage ratings are divided by 4 and the RoF becomes 4, subject to the laser-autofire rules. More damage is *not* possible; indeed, just the opposite, as all four shots must hit to do listed damage. The modified damage ratings thus become 6d at TL8, 12d at TL9, 5d×5 (2) at TL10, 7d×5 (2) at TL11, 9d×5 (2) at TL12, and 5d×10 (2) at TL13.

Ore Processors

This is a multi-stage facility for extracting valuable materials from raw ore and concentrating it for transportation or further processing. Fed a steady stream of ground rock, it produces bars of metal, glass rods or fibers, and tanks of condensed volatiles for storage. The system's power plant is self-contained for greater efficiency, and hold space for several hours' feedstock is provided.

Capacity is in dtons of ore processed per hour, for hard rock. For soft rock, rate is doubled. Products depend on concentrations present in ore: multiply input volume by concentration, and reduce by 10% for wastage.

Crew is per shift; three shifts are required for full-time operations.

Passage Tubes

This flexible tube connects the airlocks of two ships in space. It holds pressure, permitting occupants to move between the vessels without space suits. A standard tube is 600' long and 8' in diameter, and hooks to generic fittings around external airlocks. It normally takes an hour or so to rig in free fall (30 minutes with two or more people working) – this requires a Mechanic (Starships) roll. A standard tube has PD3, DR 12; the armored tube increases to DR 20. Engineering and entry modules each contain a 100' armored passage tube as standard equipment.

Entry Modules

An entry module consists of a 100' armored passage tube and either a four- (small module) or eight-man (large module) airlock.

Escape Capsules

Escape capsules are common on military vessels, which typically have a limited number of ship's boats and a crew difficult to assemble under combat conditions (commercial vessels use lifeboats, instead). Each capsule holds four crew members at TL7, six at TL8, eight at TL9, or nine at TL10+ and provides three days of limited life support at TL7-9, four days at TL10, or full life support at TL11+. They have 0.03 G and 0.003 GRds of thrust at TL7, 0.05 G at TL8, 0.6 G at TL9, 0.8 G at TL10, and 1 G at TL11+. A capsule also provides contragravity for landing at TL8+, plus survival packs as defined on p. T:FT70.

Escape capsules are installed under panels in the vessel's hull; to launch, explosive bolts blow the panel clear and the thrusters accelerate the capsule away from the ship (rockets at TL7). Reconditioning and reinstalling escape capsules is only possible at a shipyard or spacedock; they are used only in emergencies! There are normally 25% more seats provided in the capsules than a ship's regular personnel capacity not otherwise provided for in the ship's small craft or lifeboats.

Boarding Clamps

This is an advanced grapple designed to latch onto an enemy ship for boarding purposes. It differs from an ordinary grapple in its reach (12'), strength (ST 800), and the method in which it attaches to the target vessel. The boarding clamp does significant damage to the hull of the target vessel, whereas normal grapples are designed to attach without damage.

Survival Shelters

Survival shelters are reinforced and shielded rooms intended to protect occupants from environmental dangers (such as sudden decompression, fire, radiation, and extreme temperature). Each shelter provides limited life support and power for its rated number of occupants: eight days at TL7, 20 days at TL8, 25 days at TL9, 30 days at TL10, and unlimited duration at TL11+. A medium-range radio is provided to contact rescue personnel. In addition, at TL8 every multi-person shelter has a number of ESUs. At TL9-13, these ESUs are replaced with automeds.

Model	Capacity	Airlock Size	ESU/Automed
Locker	1	1	0
Small	4	2	1
Medium	8	4	2
Large	25	6	5

Optional: Zero-Space Systems

The modular ship-design system presented in this book is intended to be simple; efficiency is a secondary consideration. In particular, many modules contain varying amounts of empty space to bring them up to half- or full-space size. It is certainly possible to simply ignore this fact and assume the extra space makes ***GURPS Traveller*** starships more roomy and livable. It is also possible to infer that some of this space is taken up by items that, by their nature, are too small to add up to even half a dton on any but the largest ships, but are nevertheless important enhancements of the ship's capabilities.

This section details a selection of such items. On small ships – generally less than 1,000 dtons – one zero-space system (about 10 cf) can be added per dton of internal space *not* devoted to cargo holds, fuel, or vessel storage, at additional cost and mass but no extra volume. Remember that streamlining reduces internal volume.

This option is completely at the GM's discretion, however, due to its potential for abuse. Most systems are rated for the number of "units" that will fit in a 10-cf "zero space" or a 250-cf half-space module. Larger vessels should simply purchase these systems in half-space lots. The GM can justifiably insist that small ships do so, too.

Ship's Lockers

Normally, the ship's locker (or *slop chest*) should be separate from the ship's cargo holds. It contains things that the crew may need during flight or in an emergency, but aren't used every day. The cargo holds are inconvenient to dig through during an emergency and may be entirely inaccessible depending on the nature of the problem. The ship's locker usually contains small tools, vacc suits, equipment, survival gear, hull patches, etc. On small ships without an armory, it may also serve as a storage space for weapons, although it is not intended to be secure. (It's supposed to be easy to get into, for emergencies.) Each ship's locker is 10 cf, and holds up to 200 lbs. of gear.

Emergency Life-Support Packs

This is a portable air-supply apparatus. It provides 2 hours of air, weighs 10 lbs., and costs Cr100 (1 hour, 30 lbs. at TL7). One hour of oxygen-nitrogen, or ordinary compressed air, weighs 4.2 lbs., so most of the weight is the compressed air.

For game purposes, assume all adults breathe at the same rate and children under 12 use half as much. Thirty units will fit into 10 cf. See p. S61 for more information.

Tool Kits

Basic tool kits are described on p. GT116. These are normally installed behind panels in any workspace with the appropriate type of equipment. Mechanic or engineer tool kits are 15 cf, 300 lbs., Cr800. Armory or electronic tool kits are 7 cf, 100 lbs., Cr1,200. A half-space module contains five tool kits of each type, for a total of 20.

Damage-Control Lockers

A damage-control locker contains the various equipment used to perform emergency repairs to the ship: hull patches, environment suits, testing and sensing gear, emergency-power conduits, short-range radios, portable emergency-power generators, fuses, etc. An unstocked damage-control locker might as well be used for cargo; it won't help the crew at all in an emergency.

A standard damage-control locker is 50 cf, weighs 1 ston stocked, and costs MCr0.25 in equipment and parts, which must be replenished for every 2,000 HP restored. See pp. 106-107 for information on repairs.

Survival Kits

Imperial safety regulations require commercial ships to carry one survival kit per passenger in lifeboats designed for surface landings. They are a good idea on any craft that may be forced down on a planet with a (more-or-less) breathable atmosphere. Survival kits are standardized at TL10; any vessel in the Imperium will use the same type, regardless of TL. Their contents are described in detail on pp. T:FT69-70. Nine kits are 10 cf, 450 lbs., and cost Cr24,300.

Computer Terminals

Each crew workstation includes a computer terminal; each cabin or stateroom also comes with a monitor and keyboard to access the ship's computer (though access is typically restricted to library, communications, and entertainment functions). Additional terminals may be added for redundancy or to facilitate certain types of research. Five terminals are 10 cf, 200 lbs., and Cr5,000 at TL7-8; this becomes 10 terminals at TL9, and 20 at TL10+.

Heavy-Duty Fire-Suppression

A fully automatic array of extinguishers or hoses mounted inside the vehicle, this uses inert gases to put out fires in milliseconds. This system has the equivalent capability of both a full and compact fire-suppression system in one, giving an *additional* +5 bonus to putting out fires (Engineering, Cockpit, and Bridge modules each already contain a fire-suppression system; see pp. 42-43, p. 36). Each system is 5 cf, 250 lbs., and Cr5,500. See ***GURPS Vehicles***, p. 185, for information on fire suppression. Particularly on large vessels, the GM may rule that each of these systems only benefits a particular section of the vessel.

Security Systems

All ships come with electronic locks. Some starship owners install after-market intruder defenses (including digital cameras, motion sensors, and weapons) and a high-security alarm system (Cr3,000; effective skill 20).

All vessels also come equipped with an internal communications and security system, consisting of a microphone, loudspeaker, optical-data cable jack, and short-range radio repeater in each compartment. Each compartment also has its own pressure, temperature, smoke, and radiation detectors; these are connected through the communications system to the bridge. The microphone and radio pickups can be activated from the bridge, providing some additional information on events in other parts of the ship. Each door, including the external airlocks and sensitive-area access panels, has an electronic lock opened by a keypad, electronic card, or biometrics sensor (chosen before construction).

Communications and security systems are installed on the basis of one "unit" per compartment (room). For ships without detailed deck plans, a good rule of thumb is three compartments per crewman (quarters, workspace, and corridor), not including ship's troops or frozen watch.

The electronic locks cannot be picked. Bypassing the security system requires a contest of skills vs. the security system's skill of 15, using Electronics Operations (Security Systems)/TL or Traps/TL, with modifiers as per Lockpicking skill (p. B67). If the roll fails, the ship's computer alerts the crew and takes other actions as programmed.

Hardened Communications: Military vessels are normally equipped with a fiber-optic backup communications network. This can be assumed (at negligible weight and cost) unless the ship is low-tech or very large. Twenty-five units are 10 cf, 50 lbs., and Cr20,000 at TL7; 100 units are 10 cf, 100 lbs., and Cr16,000 at TL8. This becomes 200 units at TL9 or 400 at TL10+ at 10 cf, 50 lbs., and Cr800.

Basic Security: Internal sensors can be added for additional security. The basic security package upgrades the ship's intercom and internal sensors to include monocular color, low-light television (1×) and imaging ladar. An integral rechargeable B cell provides (TL-6)×360 uses for the ladar in the event of loss of ship's power. The security system's skill is improved to 20. The additional sensors allow the use of the Anti-Hijack program (see p. 71).

The basic package also includes a spray tank, capable of creating a cloud of any standard gas or liquid chemical 3 yards in diameter at a range of 10 yards. The spray automatically hits and lasts for 2 minutes in atmosphere (less in vacuum). Sprayers are normally loaded with sleep gas (p. S78: LC 2, Cr75 per unit for 20 shots; Cr45,000 per 600 units); this cost is not included with the security package.

Twenty units are 10 cf, 230 lbs., and Cr115,000 at TL8; 10 cf, 190 lbs., and Cr57,000 at TL9. Twenty-five units are 10 cf, 220 lbs., and Cr38,000 at TL10; Cr20,000 at TL11+.

Advanced Security: Advanced security systems are designed to actively resist hostile boarding actions and hijacking attempts, even if isolated from the ship's central computers. In addition to all the systems listed for the basic package, each unit incorporates a hardened, high-capacity, Complexity 4 robot brain running Targeting, Gunner, Internal Security, and Optical Recognition programs and a concealed snub revolver (p. GT110) on a retractable mount. Each chamber can be loaded with a different type of ammunition (ammo cost and mass is not included) and individually selected for firing. Sixteen units are 10 cf, 200 lbs., and Cr470,000 at TL9; 20 units are 10 cf, 220 lbs., Cr70,000 at TL10; or 10 cf, 190 lbs., and Cr28,000 at TL11+.

Automated defenses are of dubious legality within the Imperium (LC 0 or worse). Under laws modeled on the Shadusham Accords (p. GT59) and common throughout the Imperium, the owner of such a system is responsible for its actions as if he had performed them himself.

Window Boxes

These are greatly scaled-down versions of *Total Life Support* (see p. 56), designed to provide some greenery aboard ship as well as supplemental fresh vegetables and herbs for the galley, or to support a small pet (up to 2 lb.). Each window box (sometimes called a *terrarium*) includes an underpressure filter kit to prevent airborne contaminants from escaping into the general ship's environment. One window box is 10 cf, 100 lbs., and Cr1,000.

Beacons

A small sphere dotted with solar panels, a beacon holds a tiny battery/capacitor and transmitter. It is designed to emit a 1-second pulse each 10 seconds at 1 AU from a standard star, with both pulse length and interval varying if the beacon is closer or farther. Along with basic data on the local star, this yields the beacon's location; a receiver can intersect signal direction with indicated orbital path. (Technically, a receiver farther out than the beacon has *two* potential locations to choose from, but a skilled radio operator usually can determine which is correct by signal quality.)

A beacon can be set to transmit on emergency or standard navigation radio channels. They come in two sizes: small and large. The range depends on the size of the beacon and the TL at which it is built.

Size/TL	Lbs.	Cf	Cr	Range
Small Beacon/7	219	4	4,076	3
Small Beacon/8	108	2	2,040	10
Small Beacon/9	53.7	1	1,021	100
Small Beacon/10	26.7	0.5	519	500
Small Beacon/11	26.3	0.5	519	500
Small Beacon/12+	25.9	0.5	519	500
Large Beacon/7	2,091	40	12,315	30
Large Beacon/8	1,040	20	6,170	100
Large Beacon/9	518	10	3,090	1,000
Large Beacon/10	257	5	1,578	5,000
Large Beacon/11	256	5	1,578	5,000
Large Beacon/12+	254	5	1,578	5,000

Range is in Space Combat Hexes.

Computers and Programs

This section expands upon the computer rules on p. GT161, describing new programs and explaining what programs are usually used. A *dedicated* computer may only run one program, the one for which it is designed.

Using Programs

All ships in ***GURPS Traveller*** have bridges or cockpits; each has *three* computers. These computers run everything on board from the environmental controls to the weapons to the drives. Experienced captains know that it doesn't pay to skimp on good programs! A complete package for a free trader costs KCr240 (at TL10), and consists of three Datalink programs (one for each communicator), three Targeting (skill +8; one for each turret and one for a missile fire director on the bridge), Damage Control with ship's specifications in a database, Autopilot (normal space, skill of 12, Cr 2,000, Complexity 2), Astrogation (Jump-1), and Library Database. Add a Limited (Cr 2,000, Complexity 4) or Full (Cr 5,000, Complexity 5) Personality Simulation to make the ship more user-friendly, if desired.

There are four different types of programs that run on shipboard computers:

Utility Programs are used to perform many of the day-to-day operations of the ship. They usually require no input from the user and run autonomously in the background, consuming minimal resources. They are not scalable, but they can be tied to RVO programs or Bonus Programs (see below) to swap and/or enhance data. Only the ubiquitous programs or the ones most likely to be interfaced with the crew are included.

Routine Vehicle Operation (RVO) Programs are the programs that actually operate the ship and perform the "day-to-day" operations. They are scalable; more advanced versions of the programs are available, but at higher cost and higher computer complexity requirements. For each increase in skill level above the base level, double the base cost of the program and increase Complexity by 1.

Example: Anti-Hijack has a base Complexity 5 and Criminology-14. If the owner wants a skill level-16 program (an increase of two levels), he pays 4× the cost and increases the complexity of the program by 2.

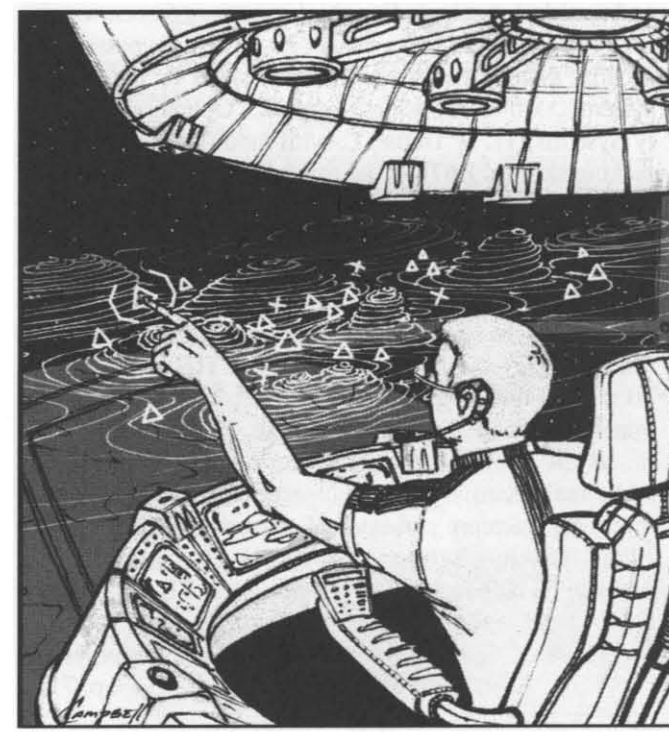
RVOs do not enhance a user's skill. If equipped with a database, they can also be used as an Expert System, but take twice as long to arrive at a solution as a human being would and are subject to the same flaws (e.g., incorrect assumptions). They also are not very good at "thinking outside the box." Databases can be shared between programs that are running concurrently. For more information on RVO programs, see pp. VE63 and T:FT68.

Skill Bonus Programs add a bonus to some skill a user possesses. Skill bonus programs, like RVO programs, are scalable. For each increase in bonus above the base level, double the base cost of the program and increase Complexity by 1. GMs are advised to prevent these programs from generating bonuses that may be too high.

Example: A Targeting program gives a +1 bonus to a human gunner. If he wants a +2 bonus (1 extra level) he pays 2× the cost and adds 1 to the Complexity.

Robot Skill Programs are used by ships equipped with robotic hulls and robotic brains. Considering their rarity in the ***Traveller*** universe, they are not described in detail here. See p. VE63 for more information.

GMs should be advised to not let RVO programs do the work of robot skill programs. The line between them is fine but distinct. The major difference between robot skills and RVOs is RVOs are a lot less forgiving if they encounter a situation even slightly outside their programming. For example, an Autopilot skill program will fly a fairly straight course, making minor corrections to ensure it arrives at a predetermined spot. In an emergency, it is capable of landing or docking the ship, but simple failure results in a mishap, and critical failure results in disaster. Wilderness landings are typically outside the range of "known circumstances" for autopilots, for example. Meanwhile, a robot piloting program is treated as a sophont pilot. Almost any RVO program can also be a robot skill program and vice versa – just remember the differences in capabilities.



GMs should also be advised not to let RVOs do the work of good, old-fashioned die rolls against the adventurers' skills. Anybody trusting his ship's Astrogation (Jump) program without checking the results first is asking for trouble.

All programs have a base TL. This is the earliest TL at which the program is available. For instance, a jump-5 Astrogation program is not available until TL11, whereas a jump-1 program is available at TL9.

The cost of all TL6-8 programs is halved at TL9 and halved again at TL10+.

The cost of all TL9-10 programs is halved at TL11 and halved again at TL12+.

The cost of all TL11-12 programs is halved at TL13+.

Utility Programs

Program	TL	Cost	Complexity
Astrogation (Jump-1)	9	10,000	2
Astrogation (Jump-2)	9	20,000	3
Astrogation (Jump-3)	10	30,000	4
Astrogation (Jump-4)	10	40,000	5
Astrogation (Jump-5)	11	50,000	6
Astrogation (Jump-6)	12	60,000	7
Astrogation (Normal)	7	3,000	2
Cartography	7	5,000	3
Computer Navigation	7	500	2
Datalink	7	400	1
Double-Fire	8	1,000	1
Library Data	7	100,000	1
Personality Sim (Full)	8	20,000	5
Personality Sim (Ltd.)	8	8,000	4
Transmission Profiling	7	8,000	3

RVO Programs

Program	TL	Cost	Complexity	Skill
Anti-Hijack	8	10,000	5	14
RVO Astrogation (J-1)	9	10,000	2	12
RVO Astrogation (J-2)	9	20,000	3	12
RVO Astrogation (J-3)	10	30,000	4	12
RVO Astrogation (J-4)	10	40,000	5	12
RVO Astrogation (J-5)	11	50,000	6	12
RVO Astrogation (J-6)	12	60,000	7	12
RVO Astro. (Normal)	7	3,000	2	12
Autopilot (Jump Space)	9	8,000	2	12
Autopilot (Normal)	8	8,000	2	12
Autopilot (Tactical)	9	200,000	3	12
Gunner	7	45,000	4	12
RVO Routine Skill (E)	8+	3,000	2	12
RVO Routine Skill (A)	8+	6,000	3	12
RVO Routine Skill (H)	8+	12,000	4	12
RVO Routine Skill (VH)	8+	24,000	5	12

Skill Bonus Programs

Program	TL	Cost	Complexity	Bonus
Damage Control	8	2,000	2	+2
Fire Direction	6	2,000	1	+2
Targeting	7	1,000	1	+2
Routine Skill (E)	8+	3,000	2	+1
Routine Skill (A)	8+	6,000	3	+1
Routine Skill (H)	8+	12,000	4	+1
Routine Skill (VH)	8+	24,000	5	+1

Anti-Hijack: This program constantly monitors conditions within the starship and automatically locks the access doors to the bridge and controls when a hijacking occurs (usually by accessing the various utility programs controlling the different subsystems). Because this system is not foolproof, would-be hijackers may gain access in spite of the program. Whenever a situation arises where the program must act or notices "suspicious activity," it alerts the captain. It requires the Basic Security package (see p. 69).

Astrogation (Jump Space): This program comes in two different versions. The RVO program is needed if the computer is to plot an interstellar jump course. The Utility program is required if the navigator is doing it himself. This is similar to the Navigation program in ***Traveller***.

Astrogation (Normal Space): This program comes in two different versions. The RVO program is needed if the computer is to plot a normal space course. The Utility program is required if the navigator is doing it himself. This is similar to the Generate program in ***Traveller***.

Autopilot (Normal Space): This RVO program enables the ship's computer to control the vessel in normal operations, especially en route to/from the jump/breakout point. The program will avoid obstacles and respond to simple instructions from traffic control, but will not perform dangerous maneuvers, "push the edge," or Dodge in combat. If a situation arises beyond its capacity to handle or at preset intervals or events, the program will sound an alarm and rouse the pilot to take over.

Autopilot (Tactical): This RVO program is a much more advanced version of the Autopilot (Normal) program. In addition to the basic version's capabilities, it *will* perform dangerous maneuvers, "push the edge," and Dodge in combat. If a situation arises beyond its capacity to handle, the program will attempt to flee, engaging targets with any weapons given it to control (via the gunner programs) if they try to prevent it from leaving the area; it has Tactics (3D) equal to its skill level. It borders on a true robot program and is Legality Class 0.

Autopilot (Jump Space): Needed for the computer to pilot the ship into jump.

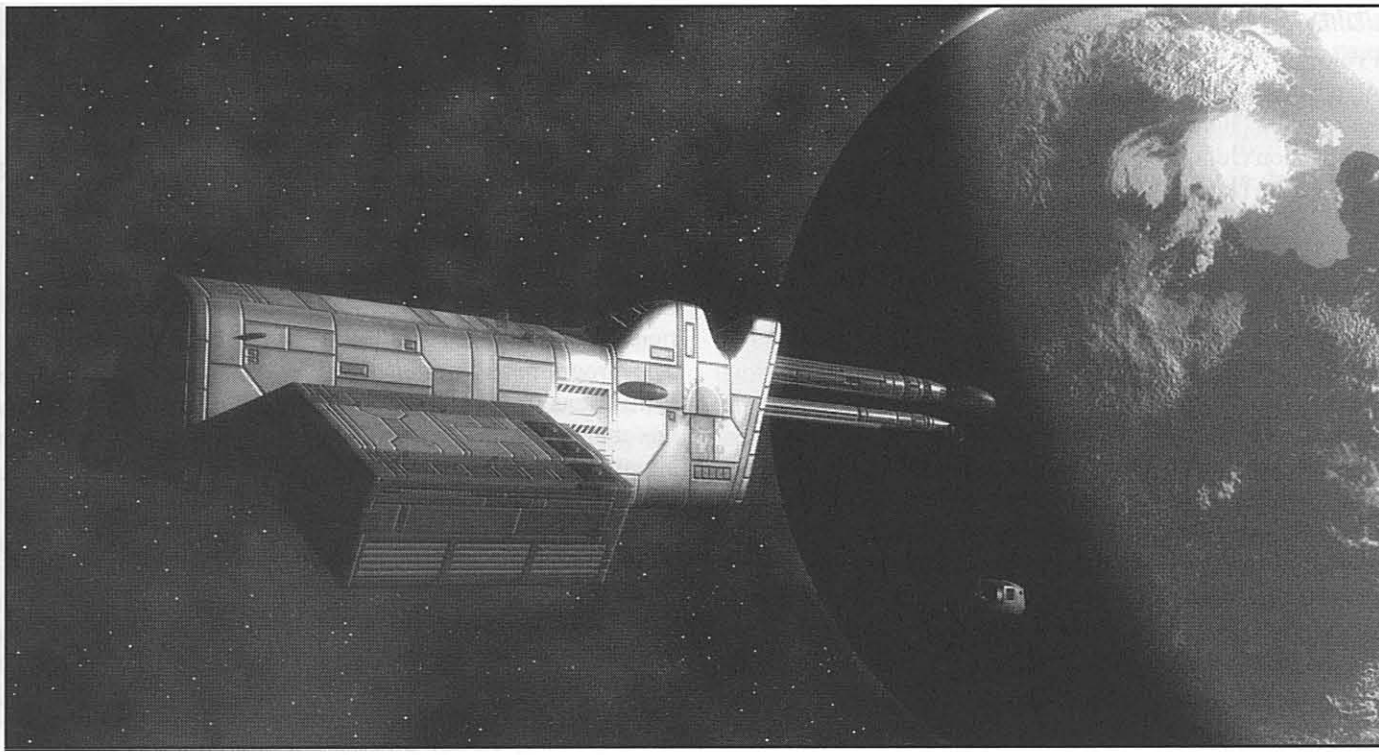
Gunner: In conjunction with a Targeting program (required), it lets the computer act as a gunner. The bonus to skill is *not* cumulative with a Targeting program – use the *lower* of the Targeting bonus or Gunner program skill. One program is required per gun or battery.

Routine Skill: This is a placeholder for any skill program not covered. It comes in four different levels of complexity, depending on the ***GURPS*** skill it is emulating: E for easy, A for average, H for hard and VH for very hard. This program comes in two different versions; the RVO program is needed if the computer is to perform the skill itself, while the skill-bonus version provides a bonus to a sophont using the skill.

Damage Control: Monitors systems status and gives bonuses to repairing ship damage. One is required per damage control (DC) party performing repairs. Also requires ship blueprints (1 gigabyte and Cr1,000 per ship). Multiple DC programs may share the same blueprint database.

Fire Direction: This is used to calculate trajectories for indirect-fire weapons, enabling more accurate aiming of artillery barrages or naval gunfire. This program is typically only found on ships carrying ballistic-type weapons (see ***GURPS Traveller: Ground Forces*** for more information). One copy per gun or battery is required.

Targeting: Predicts target positions and helps aim weaponry, adding a bonus to a gunner's skill equal to the program's Complexity+1. One is needed per human or computer gunner. Due to the long ranges at which spacecraft engage their opponents, a targeting program giving a +7 to +10 bonus is *strongly* recommended for all armed spacecraft!



Cartography: This is a package enabling aircraft equipped with radar or planetary survey arrays to map areas over which they fly. It also allows spaceships or satellites to produce entire planetary maps if orbiting within sensor range, provided they make enough orbits. See ***GURPS Traveller: First In*** for more information on mapping and surveys.

Computer Navigation: This software allows a computer to determine its position by comparing input from a high-resolution sensor with a map database of the region. It requires a LLTV, radar, ladar, AESA, thermograph, or PESA (if underwater, a ladar or active sonar), plus an accurate map database of the local terrain. Combined with a robot brain, this allows the vehicle to pilot itself to a specified location on the map automatically.

Datalink: Used to share real-time data with other computers, sensors, missiles, etc. One is required per active communicator (e.g., laser, radio, missile laser, maser, meson).

Double-Fire: This program allows any energy weapon to be fired at a much higher RoF. See *Pulse Mode*, p. 46. One copy must be running for each weapon so configured.

Library Data: An encyclopedia program containing detailed non-classified information on the Imperium. Not always up to date for all worlds, but licensed owners can often download supplementary data at local starports. 100 gigs.

Personality Simulation: A "persim" enables the ship's computer to simulate emotions, quirks, etc., and use highly idiomatic speech. The "limited" version gives the computer a simple personality (up to five quirks and a single mental disadvantage are appropriate). The "full" version gives the computer a simulation of a real or made-up personality with the same behavior (and quirks and mental disadvantages) as the person it simulates.

Transmission Profiling: This program takes input from a communications receiver, radar detector, or radscanner and compares it with a database to determine what sort of equipment produced the signal. This can be fairly detailed if the GM desires – e.g., "The transmitter is a Zloukalev Industries 500-kW Air Search Radar, from a lot with model numbers beginning with XJ3K4. It isn't using the frequency-shift pattern used by the Zhodani, which means it is probably one of the four sold to the Sword Worlds." Of course, information is critically dependent on the database!

Future Developments

"These aliens are just as fragile as we are. You just have to work through their technology, which is, I'm sad to say, far in advance of our own."

– anonymous scientist from old Solomani 2D movie

Most people assume the Ancients had technology bordering on magical. In reality, Ancient technology is far in advance of the best the Imperium has to offer. One Imperial think-tank, upon being tasked with determining the Imperium's chances of resisting an incursion by a TL13 society, responded after much deliberation, "*A full TL13 society is not to be trifled with.*" GMs should be aware of the extremely game-unbalancing effects of introducing even one of these higher tech fields into the game. ***GURPS Vehicles***, ***GURPS Space***, ***GURPS Ultra-Tech***, and many world books all contain many different technological marvels not common to the ***Traveller*** universe. That doesn't mean they don't exist . . .

TL13+ components (if they are available at all) could be artifacts, experimental prototypes, or in limited production; many are classified. Their prices should be increased by 100-400% to reflect this. Components purchased on the black market will cost at least 500% of this *increased* price.

Here are some guidelines for introducing TL13+ vessels into an existing campaign. In general, most ships are 50-100% faster, weapons do 50-100% more damage, and

metallurgical sciences have produced lighter armor and structural materials (or perhaps vessels don't use metal at all; new plastics or "living ships" may be the norm). Of course, the computers are much more powerful as well, enabling and controlling this new technology while changing many aspects of shipboard life, as well. Medical technology is capable of rebuilding a person from just a few scattered brain cells (see *Chrysalis Machine*, p. S91). The Emergency Aid Station/13, Sickbay/13, and Evacuation Bays/13 are built using these machines. GM may freely ignore these and use the TL12 versions of the modules, instead.

Aside from the typical "wow" effect surrounding TL13+ equipment, there is also the issue of survivability and endurance. The only fleet known to possess TL13 ships belongs to the Darrians in the Spinward Marches, and they are not new designs. The Imperium does not expect any of its TL12 warships to remain in service nearly as long as the Darrians' ships, even with heavy maintenance. The Darrian TL13 starships apparently have very advanced characteristics for survivability and endurance that are currently unknown to the Imperium.

Reactors and Energy Banks

There isn't much improvement in fusion reactors past TL11 other than less maintenance. However, at TL14 antimatter reactors become available (see below) and possibly cosmic power or total conversion at TL16. Both of these halve the size of most power-hungry modules.

Energy banks at TL13 and each successive TL pack more power in them for the same mass and volume but other differences are negligible.

Antimatter

Antimatter plants generate energy through the mutual annihilation of matter and antimatter (usually anti-hydrogen). A gram of anti-hydrogen powers a 1-MW plant for 2.5 years and costs MCr0.001 at TL14 (though in a TL10 society like the Imperium, 1 gram can run into the millions of credits). At TL15+, 1 gram powers the plant for 5 years. It is more expensive to run an antimatter power plant, but they are slightly smaller and cheaper to build. They are much more deadly to the crew if the reactor is injured.

Antimatter bombs (or warheads) are something to be feared; anyone with a magnetic bottle and a gram or two of antimatter is a threat to the safety of everyone and everything around him for miles. Antimatter bombs are simple to build – so simple in fact, that they tend to go off during their construction and are thus rarely used.

Megathrusters (Late TL13)

At late TL13, megathrusters come into being. The Darrians, being an early TL13 society, have yet to stumble onto the megathruster secret. Past TL13, GMs should feel free to make them even more efficient (requiring less power) with each successive TL.

Weapons

Meson-weapon technology tops out at TL14. Other possibilities are grasers and disintegrators at TL13. Missiles become so deadly and move so fast that ships of lower TL don't stand any chance of shooting them down or surviving more than a few hits. The late TL13 versions presented move at 55 G. Sensors may not even detect them until too late.

Turret Meson Gun, 1.39-GJ (TL13): An experimental weapon design based on the TL11 particle-beam turret weapon. This weapon was developed in order to produce small ships and fighters with meson capability. Results from testing the prototype have been favorable so far. It is rumored a few megacorps have produced a top secret "advanced" fighter using this weapon as its main gun. This unit consists of a TL13 meson gun with a 1,390-MJ output, cyclic rate 1/2, extreme range, and the compact option. A TL12 2,780-MJ rechargeable power cell provides the energy for each shot, and TL12 fusion-reactor components generate the 46.3 MW required to fully recharge it every minute. The weapon is fully stabilized and installed in a universal mount (for turrets) or a casemate if hull-mounted.

Teleporters (Late TL13)

Teleporters in the ***Traveller*** universe are based on "circumvention," using an alternate dimension or pocket universe to bridge the gap between two points. Circumvention does not violate the law of conservation of energy, but usually the pocket universe used for the transport contains a large mass, capable of absorbing or providing the extra energy. See pp. T:ARIII114-116 for more information about teleportation and portals. A portal is a circular frame, ranging from about 1-10 yards across. Portals are connected in a network of between two and 60 portals, all attached to the same pocket universe. Transport is allowed only between these portals. There is a control pad on each portal to select the destination portal. Changing the portal destination takes 1 minute.

Once connected, the portals remain open, allowing traffic in either direction. At TL13, the pocket universe is unstable, requiring a vast expenditure of energy to recreate it. The pocket universe lasts for a few days, never longer than one week. The generator module contains a fusion-power slice (antimatter at TL14) to recharge the power cells in 1 day. Generating the pocket universe requires 1 hour and a full power-cell charge. Charging the power cell takes a full day, and cannot be done while the portal is open; the pocket universe is inaccessible during cell recharges.

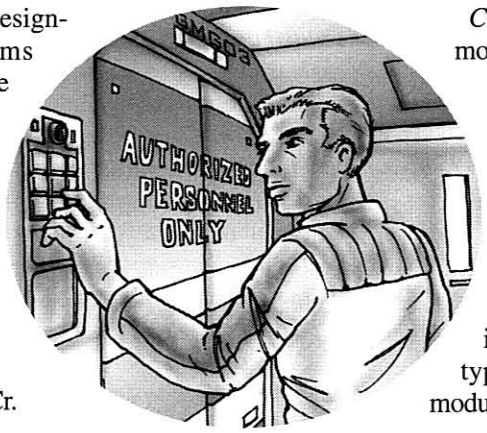
At TL14, the pocket universe is stable, no longer requiring the expensive generator modules. The stable pocket allows 95% of the portal machinery, including power supply, to be located in the pocket universe, but the remainder must be located on the ship or station where the portal is located. The remaining 5% is subsumed in the cost of the portal.

Item	Capacity (cf)	Range (miles)
Teleport Portal, Personal	1	200,000
Teleport Portal, Small Cargo	500	200,000
Teleport Portal, Large Cargo	5,000	200,000

Appendix A

Module Tables

The following tables provide the design-system data for the spaceship systems described in this book. Each general type of module begins with a paragraph giving page references elsewhere in this book for more detailed descriptions of the listed modules and their functions.



Key

Spaces is the number of spaces (dtons) taken up in the hull.

Mass is the mass in stons.

Cost is the cost in megacredits, or MCr.

Crew is the number of personnel that the module requires.

Power is the rating of the power slice in the module in MW. This is used to determine the final size of the reactor when designing deck plans. If deck plans are not being drawn for your vessel, you may ignore this column.

Special circumstances for other table values will be explained in the introductory paragraph for any general type, or in a special endnote for specific module types.

Engineering and Power Plants

See pp. 36-37 for descriptions of these systems that form the core of a vessel's ability to function.

Name	Spaces	Mass	Cost	Crew	Power
Engineering/7	3.5	16.6	4.42	0-1	0
Engineering/8	1.5	6.6	0.624	0-1	0
Engineering/9	3.5	13.4	5.02	0-1	0
Engineering/10	1	4	0.32	0-1	0
Engineering/11-12	1	3.6	0.16	0-1	0
Engineering/13	1	2.85	0.17	0-1	0
Small Mod./7-12	-0.5	-1.25			
Small Mod./13	-0.5	-0.625			

Name	Spaces	Mass	Cost	Crew	Power
Small-Cr. Bridge Add-On/7	3.5	15.2	4.49	0	0.05
Small-Cr. Bridge Add-On/8	1	4.85	0.629	0	0.05
Small-Cr. Bridge Add-On/9	2.5	11.4	5.02	0	0.05
Small-Cr. Bridge Add-On/10	0.5	1.96	0.32	0	0.05
Small-Cr. Bridge Add-On/11	0.5	1.65	0.155	0	0.001
Small-Cr. Bridge Add-On/12	0.5	1.40	0.16	0	0.001

Name	Spaces	Mass	Cost	Crew	Power
Power Core/7	2.5	10	4.4	0-1	0
Power Core/8	0.5	2	0.6	0-1	0
Power Core/9	2.5	10	5	0-1	0
Power Core/10	0.5	1	0.3	0-1	0
Power Core/11	0.5	1	0.15	0-1	0

Name	Spaces	Mass	Cost	Crew	Power
Power Plant Slice/7	0.5	2	0.8	0	0.5
Power Plant Slice/8	0.5	2	0.4	0	1
Power Plant Slice/9	0.5	2	0.8	0	4
Power Plant Slice/10	0.5	2	0.2	0	20
Power Plant Slice/11	0.5	2	0.1	0	20

Fuel Tanks

See pp. 40-41 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Collapsible Tank/7	1	20	0.4	0	0
Collapsible Tank/8	1	10	0.4	0	0
Demountable Tanks/7	1	0.33	0.64	0	0
Demountable Tanks/8	1	0.15	0.64	0	0
Jump Fuel/7	1	1.3	0.16	0	0

Gravitic Systems

See pp. 39-40 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Utility/8	8	101	5	0	10
Utility/9	2	15.5	2.2	0	10
Utility/10	1	11.5	0.30	0	10
Utility/11-12	1	11.5	0.25	0	10
Utility/13	1	11.3	0.254	0	10

Name	Spaces	Mass	Cost	Crew	Power
ST Utility/8	1.5	22.5	1.11	0	2.22
ST Utility/9	0.5	4.69	0.653	0	2.96
ST Utility/10	0.5	6.36	0.168	0	5.56
ST Utility/11-12	0.5	6.36	0.14	0	5.56
ST Utility/13	0.5	6.24	0.141	0	5.56

Name	Spaces	Mass	Cost	Crew	Power
Contragravity/8	0.5	2.26	0.385	1/6	0.9
Contragravity/9	0.5	2.56	0.616	1/17	3
Contragravity/10	0.5	3.51	0.15	1/25	10
Contragravity/11	0.5	3.51	0.101	1/50	10
Contragravity/12	0.5	3.51	0.101	1/100	10

Gravitic Systems (Cont.)

Name	Spaces	Mass	Cost	Crew	Power
Comb. Gravitics Sys./8	4	48.6	2.66	1/6	5.43
Comb. Gravitics Sys./9	1	7.65	1.14	1/80	5.23
Comb. Gravitics Sys./10	0.5	5.66	0.154	1/500	5.53
Comb. Gravitics Sys./11	0.5	5.66	0.126	1/1,000	5.53
Comb. Gravitics Sys./12	0.5	5.66	0.126	1/2,000	5.53
Comb. Gravitics Sys./13	0.5	5.54	0.127	1/2,000	5.53

Name	Spaces	Mass	Cost	Crew	Power
Repulsor Beam/10	1	10.4	0.107	0	8.5
Repulsor Beam/11	1	10.4	0.065	0	8.5
Tractor Beam/13	1	10.4	0.065	0	8.5
Comb. Beam/13	1	10.4	0.068	0	8.5

Energy Banks

See p. 37 for descriptions of these systems. Early TL7 is lead-acid battery, late TL7 and early TL8 are advanced battery, and all others are rechargeable power cells.

Name	Spaces	Mass	Cost	Crew	Power (MWs)
Energy Bank/Early 7	1	50	0.125	0	50,00
Energy Bank/Late 7	1	25	0.5	0	10,000
Energy Bank/Early 8	1	12.5	0.75	0	25,000
Energy Bank/Late 8	1	25	5	0	450,000
Energy Bank/9	1	25	5	0	675,000
Energy Bank/10	1	25	5	0	900,000
Energy Bank/11	1	25	5	0	1,125,000
Energy Bank/12	1	25	5	0	1,350,000
Energy Bank/13	1	25	5	0	1,565,000

Hydrogen-Fueling Units

See p. 41 for descriptions of these portable systems.

Name	Spaces	Mass	Cost	Crew	Power	Notes
Hyd. Fueling Unit/7	4	47.2	17	0	7.7	550 gph
Hyd. Fueling Unit/8	4	47.2	8.8	0	19.6	1,400 gph
Hyd. Fueling Unit/9	2	35.8	12.9	0	31.5	2,250 gph
Hyd.Fueling Unit/10	2	13.1	1.36	0	56	4,000 gph
Hyd. Fueling Unit/11	2	18.8	1.13	0	70	5,000 gph

Misc. Engineering Systems

See p. 41, p. 65 for descriptions of these systems.

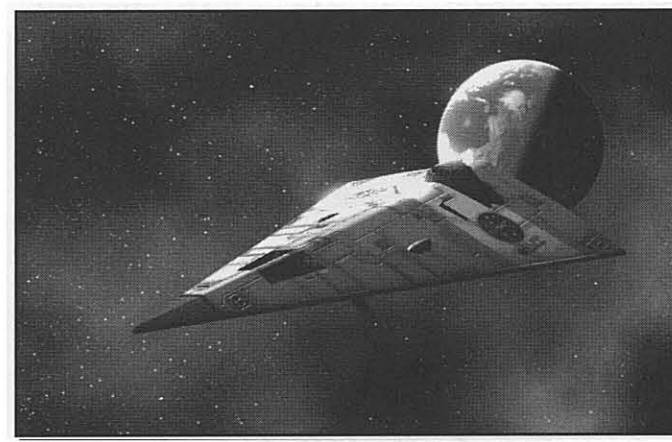
Name	Spaces	Mass	Cost	Crew	Power
Mini-Workshop/8	1	5.26	0.02	0	0
Complete Workshop/7	2.5	15	0.06	0	0

Name	Spaces	Mass	Cost	Crew	Power
Starship Shipyard/9	600	600	30	100	0
Non-starship Shipyard/7	500	500	20	100	0

Name	Spaces	Mass	Cost	Crew	Power
Fuel Processor/8	1	3.67	0.733	0	1
Fuel Processor/9	1	4.67	1.28	0	3.5
Fuel Processor/10	1	1.1	0.85	0	8

Name	Spaces	Mass	Cost	Crew	Power
Fuel Electrolysis/7	30.5	129	48.3	0	29.5
Fuel Electrolysis/8	15.5	64.4	12.3	0	29.5
Fuel Electrolysis/9	4.5	17.4	6.17	0	29.5
Fuel Electrolysis/10	1.5	5.59	0.559	0	29.5
Fuel Electrolysis/11	1.5	5.59	0.411	0	29.5

Name	Spaces	Mass	Cost	Crew	Power
Comb. Fuel Electro./Proc./8	8.5	35.8	6.91	0	15.8
Comb. Fuel Electro./Proc./9	3	12.7	4.19	0	17.8
Comb. Fuel Electro./Proc./10	1	4.35	0.56	0	17.8
Comb. Fuel Electro./Proc./11	1	4.35	0.471	0	17.8



Security

See p. 69 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Brig/7	4	34.1	0.177	0	0.02
Brig/8	4	27	0.122	0	0.02
Brig/9	4	17.4	0.081	0	0.02
Brig/10	4	11.4	0.052	0	0.02
Brig/11	4	8.04	0.04	0	Neg.
Brig/12	4	5.60	0.030	0	Neg.
Brig/13	4	4.44	0.026	0	Neg.

Name	Spaces	Mass	Cost	Crew	Power
Double Cell/7	2	33.1	0.17	0	Neg.
Double Cell/8	2	26	0.115	0	Neg.
Double Cell/9	2	16.4	0.074	0	Neg.
Double Cell/10	2	10.4	0.045	0	Neg.

Name	Spaces	Mass	Cost	Crew	Power
Double Cell/11	2	7.04	0.033	0	Neg.
Double Cell/12	2	4.64	0.023	0	Neg.
Double Cell/13	2	3.44	0.019	0	Neg.

Name	Spaces	Mass	Cost	Crew	Power
Cell/Armory/Safe/7	1	21	0.096	0	Neg.
Cell/Armory/Safe/8	1	17	0.073	0	Neg.
Cell/Armory/Safe/9	1	11	0.048	0	Neg.
Cell/Armory/Safe/10	1	7	0.031	0	Neg.
Cell/Armory/Safe/11	1	5	0.023	0	Neg.
Cell/Armory/Safe/12	1	3.4	0.017	0	Neg.
Cell/Armory/Safe/13	1	2.6	0.013	0	Neg.

Security Station: See *Auxiliary Control Station/Duplicate Controls*, p. 43, p. 133.

Quarters and Life Support

See pp. 56-59 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Life Support/7	1	4.86	0.088	0	0.05
Life Support/8	0.5	2.51	0.028	0	0.05
Life Support/9	0.5	1.14	0.018	0	0.05
Life Support/10	0.5	1	0.008	0	0.05
Life Support/11	0.5	0.345	0.003	0	0.001

Name	Spaces	Mass	Cost	Crew	Power
Bunkroom/7	4	6.84	0.103	0	0.06
Bunkroom/8	4	5.58	0.046	0	0.09
Bunkroom/9	4	4.27	0.043	0	0.14
Bunkroom/10	4	4.80	0.018	0	0.16
Bunkroom/11	4	1.92	0.018	0	0.002

Name	Spaces	Mass	Cost	Crew	Power
Stateroom/7	4	4.08	0.044	0	0.02
Stateroom/8	4	3.04	0.02	0	0.02
Stateroom/9	4	2.41	0.016	0	0.02
Stateroom/10	4	2.4	0.012	0	0.02
Stateroom/11	4	2	0.012	0	Neg.

Name	Spaces	Mass	Cost	Crew	Power
Small-Craft Cabin/7	2	3.08	0.037	0	0.02
Small-Craft Cabin/8	2	2.04	0.013	0	0.02
Small-Craft Cabin/9	2	1.41	0.009	0	0.02
Small-Craft Cabin/10	2	1.4	0.005	0	0.02
Small-Craft Cabin/11	2	1.04	0.005	0	Neg.

Medical

See pp. 65-66 for descriptions of these systems. *Beds* is the number of patients that a medical module can handle at once. Some of these "beds," such as operating tables, might not strictly be proper facilities for long-term care. Also, actual staffing of medical modules can vary considerably from the listed norm.

Name	Spaces	Mass	Cost	Crew	Power	Beds
Low Berth/9	0.5	2	0.22	0	Neg.	4

Name	Spaces	Mass	Cost	Crew	Power	Beds
Emerg. Aid Station/7	0.5	0.245	0.001	1/2	Neg.	2
Emerg. Aid Station/8	0.5	0.345	0.061	1/2	Neg.	2
Emerg. Aid Station/9	0.5	0.51	0.078	1/2	Neg.	2
Emerg. Aid Station/10	0.5	0.455	0.07	1/2	Neg.	2
Emerg. Aid Station/11-12	0.5	0.405	0.07	1/2	Neg.	2
Emerg. Aid Station/13	0.5	0.755	0.17	1/2	Neg.	2

Name	Spaces	Mass	Cost	Crew	Power	Beds
Sickbay/7	1	0.372	0.052	1	0.001	2
Sickbay/8	1	0.471	0.112	1	0.001	2
Sickbay/9	1	0.86	0.163	1	0.001	2
Sickbay/10	1	0.75	0.16	1	0.001	2
Sickbay/11-12	1	0.85	0.21	1	0.001	3
Sickbay/13	1.5	1.91	0.512	1	0.001	3

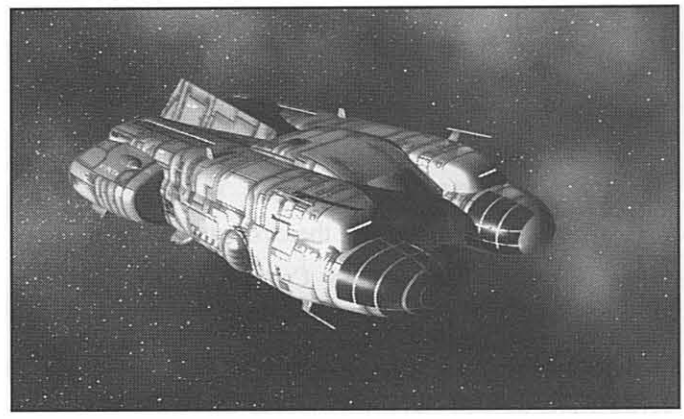
Name	Spaces	Mass	Cost	Crew	Power	Beds
Operating Theater/7	1	0.319	0.109	0	0.001	2
Operating Theater/8	1	0.417	0.167	0	0.001	2
Operating Theater/9	1	0.396	0.136	0	0.001	2
Operating Theater/10	1	0.385	0.121	0	0.001	2

Name	Spaces	Mass	Cost	Crew	Power
Alien Environ. Suite/7	4	10.3	0.184	0	0.021
Alien Environ. Suite/8	4	4.29	0.067	0	0.021
Alien Environ. Suite/9	4	3.28	0.047	0	0.021
Alien Environ. Suite/10	4	3	0.039	0	0.021
Alien Environ. Suite/11-12	4	2.54	0.024	0	Neg.
Alien Environ. Suite/13	4	2.29	0.026	0	Neg.

Name	Spaces	Mass	Cost	Crew	Power
Passenger Couch/7	1	1.34	0.201	0	0.006
Passenger Couch/8	1	1.06	0.088	0	0.006
Passenger Couch/9	1	0.773	0.077	0	0.006
Passenger Couch/10	1	0.54	0.075	0	0.006
Passenger Couch/11	1	0.54	0.073	0	0.001

Name	Spaces	Mass	Cost	Crew	Power
Office/7	4	10.6	0.274	0	0.16
Office/8	4	6.32	0.082	0	0.16
Office/9	4	3.68	0.050	0	0.16
Office/10	4	3.54	0.018	0	0.16
Office/11	4	2.16	0.009	0	0.002
Office/12	4	1.92	0.009	0	0.002

Name	Spaces	Mass	Cost	Crew	Power
Luxury Modifications			×5		



Name	Spaces	Mass	Cost	Crew	Power	Beds
Evacuation Bay, Basic/7	2	1.52	0.023	1	0.006	12
Evacuation Bay, Basic/8	2	1.81	0.37	1	0.007	12
Evacuation Bay, Basic/9	2	1.5	0.189	1	0.007	12
Evacuation Bay, Basic/10	2	1.2	0.097	1	0.007	12
Evacuation Bay, Basic/11	2	1.02	0.097	1	0.002	12

Name	Spaces	Mass	Cost	Crew	Power	Beds
Evacuation Bay, Adv./9	4	4.2	0.61	1	0.007	12
Evacuation Bay, Adv./10	4	3.3	0.61	1	0.007	12
Evac. Bay, Adv./11-12	4	2.52	0.607	1	0.002	12
Evacuation Bay, Adv./13	4	6.72	1.81	1	0.001	12

Name	Spaces	Mass	Cost	Crew	Power	Beds
Military Sickbay/7	3	7.54	0.181	1	0.008	4
Military Sickbay/8	3	5.16	0.173	1	0.008	4
Military Sickbay/9	3	5.15	0.209	1	0.008	4
Military Sickbay/10	3	4.66	0.205	1	0.008	4
Military Sickbay/11-12	3	4.52	0.252	1	0.002	5
Military Sickbay/13	3	4.07	0.564	1	0.002	5

Recreation Facilities

See p. 60 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Hall/Bar/Conf. Room/7	10	0.2	0.003	0	0

Name	Spaces	Mass	Cost	Crew	Power
Civilian Holoventure/9	30	4.14	1.41	0	0.022
Civilian Holoventure/10	30	3.66	0.61	0	0.013
Civilian Holoventure/11	30	3.64	0.302	0	0.012

Name	Spaces	Mass	Cost	Crew	Power
Military Holoventure/9	30	34.1	1.71	0	0.022
Military Holoventure/10	30	23.7	0.81	0	0.013
Military Holoventure/11	30	15.6	0.422	0	0.012
Military Holoventure/12	30	11.6	0.384	0	0.012
Military Holoventure/13	30	8.63	0.351	0	0.012

Name	Spaces	Mass	Cost	Crew	Power
Shooting Range/7	10	40	0.451	0	Neg.
Shooting Range/8	10	25	0.301	0	Neg.
Shooting Range/9	10	15	0.201	0	Neg.
Shooting Range/10	10	10	0.15	0	Neg.
Shooting Range/11	10	6.01	0.11	0	Neg.
Shooting Range/12	10	4.01	0.09	0	Neg.
Shooting Range/13	10	2.51	0.075	0	Neg.

Name	Spaces	Mass	Cost	Crew	Power
Null G Handball Court/8	35	7.17	0.3	0	0.593
Null G Handball Court/9	35	2.13	0.135	0	0.593
Null G Handball Court/10	35	1.89	0.022	0	0.593

Name	Spaces	Mass	Cost	Crew	Power
Stage/7	16	0.5	0.004	0	Neg.
Theater/7	20	2.1	0.015	0	Neg.
Ship's Galley/7	0.5	1.93	0.005	0-1	Neg.
Gymnasium/7	2.5	0.5	0	0	0
Swimming Pool/7	6	27/1.5	0.031	0	0

For swimming pools, the first mass value is when filled, the second when empty. Space vessels with pools should install one spacedock module per pool module to evacuate the water on demand.

Name	Spaces	Mass	Cost	Crew	Power
Luxury Modifications			×5		

Survival Shelters

See p. 67 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Locker Survival Shelter/7	0.5	4.5	0.079	0	0.001
Locker Survival Shelter/8	0.5	3.51	0.062	0	0.001
Locker Survival Shelter/9	0.5	2.82	0.058	0	0.001
Locker Survival Shelter/10	0.5	1.95	0.06	0	0.001
Locker Survival Shelter/11	0.5	0.963	0.04	0	Neg.
Locker Survival Shelter/12	0.5	0.776	0.04	0	Neg.
Locker Survival Shelter/13	0.5	0.651	0.041	0	Neg.

Name	Spaces	Mass	Cost	Crew	Power
Small Survival Shelter/7	1.5	12.4	0.203	0	0.002
Small Survival Shelter/8	1.5	10.4	0.194	0	0.002
Small Survival Shelter/9	1.5	8.71	0.209	0	0.002
Small Survival Shelter/10	1.5	5.92	0.216	0	0.002
Small Survival Shelter/11	1.5	2.3	0.131	0	0.001
Small Survival Shelter/12	1.5	1.93	0.131	0	0.001
Small Survival Shelter/13	1.5	2.03	0.233	0	0.001

Name	Spaces	Mass	Cost	Crew	Power
Med. Survival Shelter/7	3	22.9	0.363	0	0.004
Med. Survival Shelter/8	3	19.4	0.355	0	0.004
Med. Survival Shelter/9	3	16.5	0.39	0	0.004
Med. Survival Shelter/10	3	11.2	0.404	0	0.004
Med. Survival Shelter/11	3	4.1	0.231	0	0.001
Med. Survival Shelter/12	3	3.5	0.231	0	0.001
Med. Survival Shelter/13	3	3.7	0.435	0	0.001

Name	Spaces	Mass	Cost	Crew	Power
Large Survival Shelter/7	8.5	64.8	1.02	0	0.013
Large Survival Shelter/8	8.5	55.7	0.983	0	0.013
Large Survival Shelter/9	8.5	47.1	1.08	0	0.013
Large Survival Shelter/10	8.5	31.4	1.12	0	0.013
Large Survival Shelter/11	8.5	9.7	0.578	0	0.003
Large Survival Shelter/12	8.5	8.2	0.578	0	0.003
Large Survival Shelter/13	8.5	9.2	1.08	0	0.003

Habitats

See p. 66 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Null-G Arena/8	5,000	591	10.1	0	16
Null-G Arena/9	5,000	455	5.65	0	16
Null-G Arena/10	5,000	448	2.61	0	16
Null-G Arena/11	5,000	448	2.53	0	16

Name	Spaces	Mass	Cost	Crew	Power
Farm/7	10,000	20,000	0.5	10	0
Park/7	10,000	20,000	0.2	0	0

Name	Spaces	Mass	Cost	Crew	Power
Factory/7	10,000	50,000	26	12	10
Factory/8	10,000	50,000	14	12	10
Factory/9	10,000	50,000	12	12	10
Factory/10	10,000	50,000	10.1	12	10

Name	Spaces	Mass	Cost	Crew	Power
Housing/7	10,000	40,000	1.16	0	0.1
Housing/8	10,000	40,000	1.04	0	0.1
Housing/9	10,000	40,000	1.02	0	0.1
Housing/10	10,000	40,000	1	0	0.1

Name	Spaces	Mass	Cost	Crew	Power
Plaza/7	10,000	30,000	1.16	0	0.1
Plaza/8	10,000	30,000	1.04	0	0.1
Plaza/9	10,000	30,000	1.02	0	0.1
Plaza/10	10,000	30,000	1	0	0.1

Miscellaneous Systems

See p. 67 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Boarding Clamp/7	3.5	40	36.7	0	0.4
Boarding Clamp/8	2.5	26	24.2	0	0.4
Boarding Clamp/9	1.5	19	18.1	0	0.4
Boarding Clamp/10	1	12.1	12	0	0.4
Boarding Clamp/11	1	9.34	9.02	0	0.4
Boarding Clamp/12	0.5	6.06	6	0	0.4

Name	Spaces	Mass	Cost	Crew	Power
Large Entry Module/7	1	3	0.011	0	0
Large Entry Module/13	0.5	2	0.019	0	0
Small Entry Module/7	0.5	2	0.007	0	0
Ext. Cradle/Mag. Grap./7	1	12.5	0.25	0	0

Name	Spaces	Mass	Cost	Crew	Power
Passage Tube/7	0.5	3	0.006	0	0
Pas. Tube, Armored/7	0.5	6	0.018	0	0

Name	Spaces	Mass	Cost	Crew	Power
Launch Tube/M. Driver/8	2	21	0.4	10	0.5
Launch Tube/M. Driver/9	2	20.3	0.3	10	0.5
Launch Tube/M. Driver/10	2	20.1	0.205	10	0.5

Name	Spaces	Mass	Cost	Crew	Power
Mass Catcher/8	0	5.83	3.02	0	Neg.

Name	Spaces	Mass	Cost	Crew	Power
Vehicle Bay/7	1.05	0.5	0.003	0	0
Hangar Bay/7	1.5	1	0.005	0	0
Spacedock/7	1	1	0.005	0	0

Mass and cost are only paid once for the two bays; after that, empty space at mass and cost 0 is added at the given volume for each 1 dton of vehicle stowed. The same applies to the spacedock, except that *two* modules are required for each 1 dton of vessel stowed.

Name	Spaces	Mass	Cost	Crew	Power
Hold	1	0	0	0	0

Jump-Troop Systems

See p. 55 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Drop Capsule Ready Rack/7	1	4	0.05	0	0
Drop Capsule Ready Rack/8	1	3	0.05	0	0
Drop Capsule Ready Rack/9	1	2.5	0.05	0	0
Drop Capsule Ready Rack/10	1	2	0.05	0	0
Drop Capsule Ready Rack/11	1	1.75	0.05	0	0
Drop Capsule Ready Rack/12	1	1.5	0.05	0	0

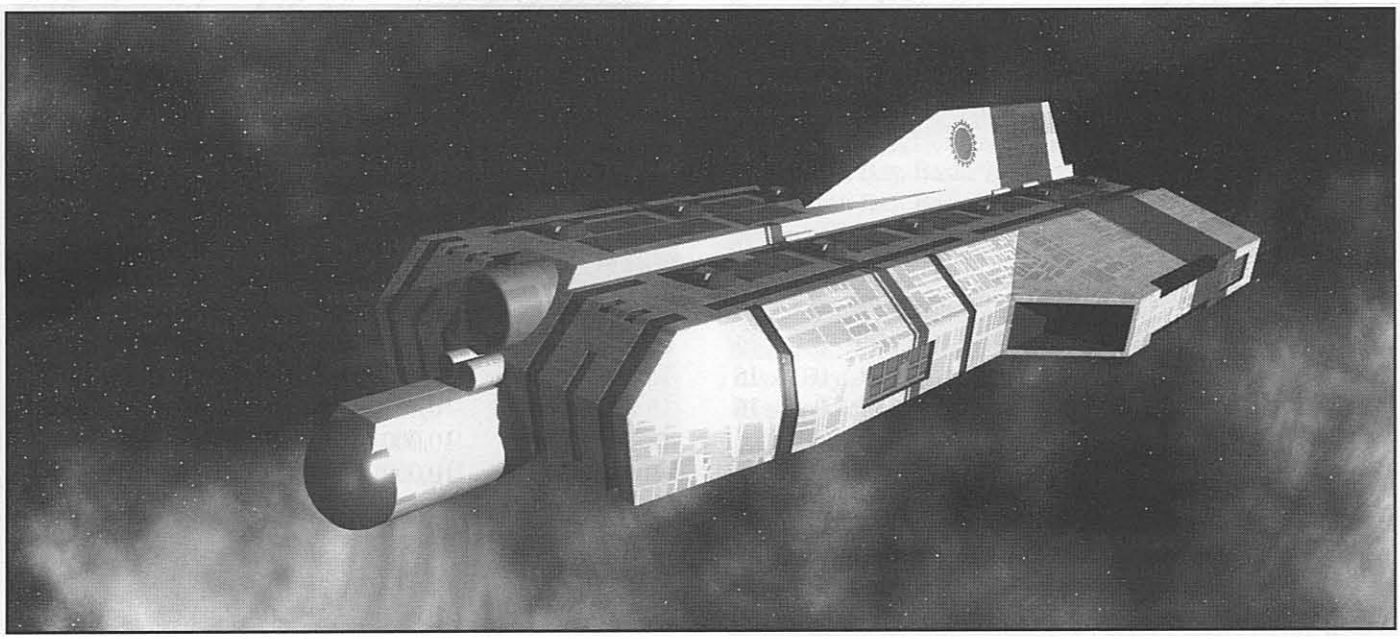
Name	Spaces	Mass	Cost	Crew	Power
B. Dress Ready Room/7	1	4.75	0	0	Neg.
B. Dress Ready Room/8	1	3.5	0	0	Neg.
B. Dress Ready Room/9	1	2.88	0	0	Neg.
B. Dress Ready Room/10	1	2.25	0	0	Neg.
B. Dress Ready Room/11	1	1.94	0	0	Neg.
B. Dress Ready Room/12	1	1.63	0	0	Neg.

These are also commonly called "the Morgue."

Name	Spaces	Mass	Cost	Crew	Power
Drop Capsule Launcher/7	1	12	0.519	0	Neg.
Drop Capsule Launcher/8	1	12	0.604	0	Neg.
Drop Capsule Launcher/9	1	12	0.302	0	Neg.
Drop Capsule Launcher/10	1	12	0.150	0	Neg.

Name	Spaces	Mass	Cost
Drop Capsule/7	0.034	0.925	0.012
Drop Capsule/8	0.034	0.517	0.009
Drop Capsule/9	0.034	0.353	0.008
Drop Capsule/10	0.034	0.269	0.007
Drop Capsule/11	0.034	0.203	0.007
Drop Capsule/12	0.034	0.169	0.007
Drop Capsule/13	0.034	0.145	0.006

Volume is *not* counted against ship's volume; the Drop Capsule Ready Rack module includes space for stowage. Mass and cost *do* count toward ship's loaded mass and fitted cost.



Ore Processors

See p. 67 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power	Capacity
Ore Processor/7	400	2,230	325	15	200	0.4 dtons/hr
Ore Processor/8	400	2,120	162	10	400	0.8 dtons/hr
Ore Processor/9	400	2,180	247	6	1,200	2.4 dtons/hr
Ore Processor/10	400	2,350	39.3	5	3,600	7.2 dtons/hr
Ore Processor/11	400	2,350	21.1	4	3,600	7.2 dtons/hr

Teleporters

See p. 73 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
T. Portal, Personal/13	1.5	9.6	1.68	1	16
T. Portal, Sm. Cargo/13	12	88.9	15.6	2	148
T. Portal, Lg. Cargo/13	116	889	156	4	1,480

Name	Spaces	Mass	Cost	Crew	Power
T. Poc. Univ., Personal/13	0	0.155	0.015	0	0
T. Poc. Univ., Sm. Cargo/13	0.5	1.44	0.14	0	0
T. Poc. Univ., Lg. Cargo/13	2.5	14.4	1.4	0	0

Name	Spaces	Mass	Cost	Crew	Power
T. Portal, Personal/14	0	0.4	1.6	1	16
T. Portal, Sm. Cargo/14	0.5	3.7	14.8	2	148
T. Portal, Lg. Cargo/14	4	37	148	4	1,480



Escape Capsules

See p. 67 for descriptions of these systems.

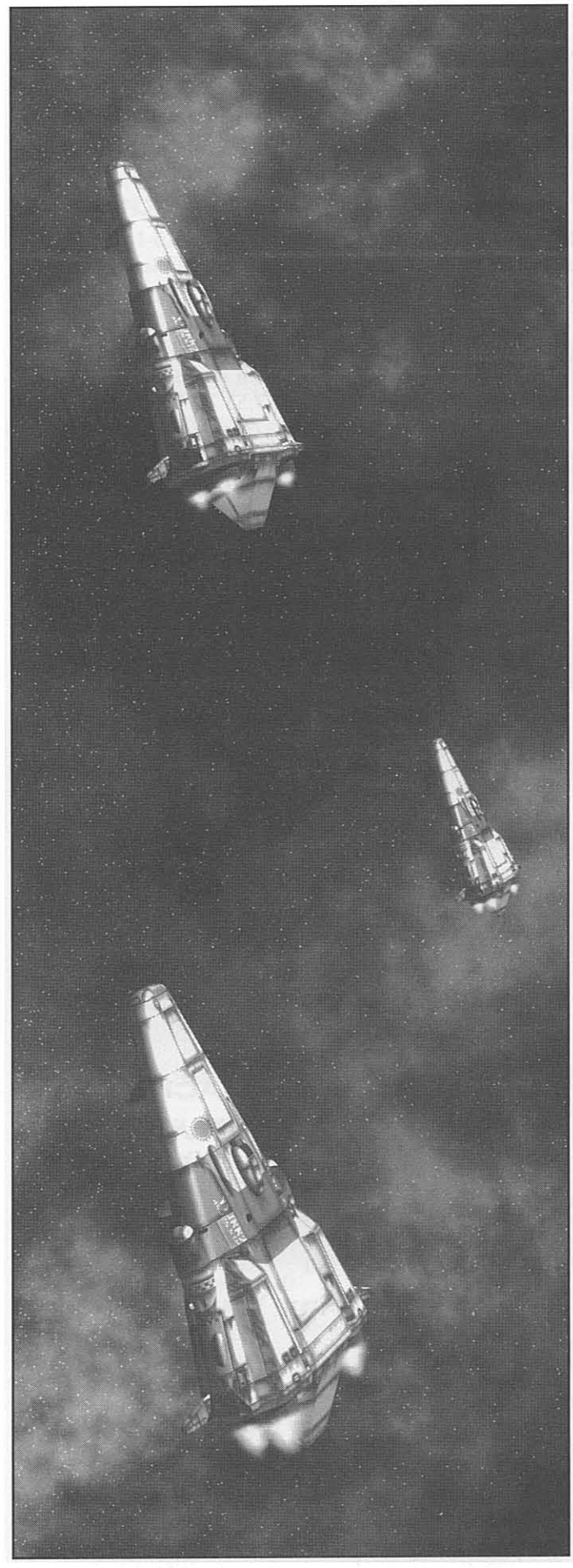
Name	Spaces	Mass	Cost	Crew	Power
Escape Capsule/7	0.5	8.82	1.05	0	0
Escape Capsule/8	0.5	5.4	0.297	0	0
Escape Capsule/9	0.5	3.56	0.17	0	0
Escape Capsule/10	0.5	2.51	0.13	0	0
Escape Capsule/11	0.5	1.29	0.112	0	0
Escape Capsule/12	0.5	1.14	0.111	0	0
Escape Capsule/13	0.5	1.07	0.11	0	0

Beacons

See p. 69 for descriptions of these systems.

Name	Spaces	Mass	Cost	Notes
Small Beacon/7	1	6.82	0.253	62 per case
Small Beacon/8	1	6.76	0.255	125 per case
Small Beacon/9	1	6.71	0.255	250 per case
Small Beacon/10	1	6.66	0.260	500 per case
Small Beacon/11	1	6.56	0.260	500 per case
Small Beacon/12	1	6.46	0.260	500 per case

Name	Spaces	Mass	Cost	Notes
Large Beacon/7	1	6.12	0.074	6 per case
Large Beacon/8	1	6.24	0.074	12 per case
Large Beacon/9	1	6.48	0.077	25 per case
Large Beacon/10	1	6.44	0.079	50 per case
Large Beacon/11	1	6.39	0.079	50 per case
Large Beacon/12	1	6.35	0.079	50 per case



Weapons

See p. 46 for descriptions of these systems. Note that ships often mount turrets with no weapons installed; purchasing and installing turret weapons after construction is relatively simple.

Turret Lasers

See p. 47 for descriptions of these systems.

Standard Lasers

Name	Spaces	Mass	Cost	Crew	Power
Tur. Laser, 43-MJ/8	1	6.69	0.875	0	1.43
Tur. Laser, 101-MJ/9	1	8.63	1.42	0	3.79
Tur. Laser, 250-MJ/10	1	8.3	0.82	0	11.1
Tur. Laser, 390-MJ/11	1	7.53	1.16	0	17.3
Tur. Laser, 405-MJ/12	1	7.8	0.68	0	18
Tur. Laser, 420-MJ/13	1	8.1	0.713	0	18.7
Tur. Graser, 390-MJ/14	1	8.46	1.3	0	19.5

Heavy Lasers

Name	Spaces	Mass	Cost	Crew	Power
Tur. Laser, 130-MJ/8	3	20.2	2.63	0	4.33
Tur. Laser, 303-MJ/9	3	25.9	4.25	0	11.4
Tur. Laser, 810-MJ/10	3	27.6	2.71	0	36
Tur. Laser, 1.3-GJ/11	3	25.1	3.8	0	57.7
Tur. Laser, 1.3-GJ/12	3	25.1	2.18	0	57.8
Tur. Laser, 1.3-GJ/13	3	25.1	2.18	0	57.8
Tur. Graser, 660-MJ/13	3	14.3	2.18	0	33
Tur. Graser, 1.18-GJ/14	3	25.6	3.88	0	59

Mining Lasers

Name	Spaces	Mass	Cost	Crew	Power
Tur. Mining Laser, 2.6-MJ/8	3	10.4	2.08	0	5.2
Tur. Mining Laser, 10.2-MJ/9	3	11.6	4.6	0	23
Tur. Mining Laser, 40-MJ/10	3	10.9	1.09	0	107
Tur. Mining Laser, 46.5-MJ/11	3	12.6	0.648	0	124
Tur. Mining Laser, 46.5-MJ/12	3	12.6	0.634	0	124
Tur. Mining Laser, 46.5-MJ/13	3	12.6	0.634	0	124

Turret Missile Racks

See pp. 46-47 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
250mm Missile Rack/7	1	1.88	0.1	1	Neg.
250mm Missile Rack/8	1	1.45	0.065	1	Neg.
250mm Missile Rack/9	1	1.45	0.033	1	Neg.
250mm Missile Rack/10	1	1.45	0.018	1	Neg.

Name	Spaces	Mass	Cost	Crew	Power
500mm Missile Rack/7	1	6	0.307	1	Neg.
500mm Missile Rack/8	1	4.5	0.23	1	Neg.
500mm Missile Rack/9	1	4.25	0.115	1	Neg.
500mm Missile Rack/10	1	4.13	0.058	1	Neg.

Turret Sandcasters

See pp. 48-49 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew
Sandcaster/7	1	5	0.25	0

High-Energy Turret Weapons

Name	Spaces	Mass	Cost	Crew	Power
Tur. Plasma Gun, 225-MJ/9	1.5	11.3	3.04	0	7.5
Tur. Plasma Gun, 430-MJ/10	1.5	15.8	1.7	0	14.3
Tur. Fusion Gun, 700-MJ/11	1.5	14	2.5	0	23.3
Tur. Fusion Gun, 700-MJ/12	1.5	14	2.5	0	23.3

Name	Spaces	Mass	Cost	Crew	Power
Tur. Par. Beam, 160-MJ/8	3	16	2.9	0	5.33
Tur. Par. Beam, 450-MJ/9	3	22.5	4.16	0	15
Tur. Par. Beam, 860-MJ/10	3	31.6	1.59	0	28.7
Tur. Par. Beam, 1.4-GJ/11	3	28	3.5	0	46.7

Name	Spaces	Mass	Cost	Crew	Power
Tur. Meson Gun, 1.39-GJ/13	3	27.8	3.47	0	46.3

Bay Weapons

See pp. 49-50 for descriptions of these systems.

50-ton Bay Weapons

Name	Spaces	Mass	Cost	Crew	Power
Plasma Gun Bay, 7.4-GJ/9	50	371	99.3	2	247
Plasma Gun Bay, 12.81-GJ/10	50	470	50.4	2	427
Fusion Gun Bay, 23.3-GJ/11	50	467	82.3	2	777
Fusion Gun Bay, 23.3-GJ/12	50	467	82.3	2	777

Name	Spaces	Mass	Cost	Crew	Power
Particle Beam Bay, 2.65-GJ/8	50	266	48.1	2	88.3
Particle Beam Bay, 7.4-GJ/9	50	371	68.4	2	247
Particle Beam Bay, 12.81-GJ/10	50	467	23.2	2	427
Particle Beam Bay, 23.3-GJ/11	50	467	58	2	777

Name	Spaces	Mass	Cost	Crew	Power
Meson Gun Bay, 12.81-GJ/12	50	467	21	2	427
Meson Gun Bay, 23.3-GJ/13	50	467	58	2	777

100-ton Bay Weapons

Name	Spaces	Mass	Cost	Crew	Power
Plasma-Gun Bay, 14.9-GJ/9	100	746	200	2	497
Plasma-Gun Bay, 28.5-GJ/10	100	1,050	112	2	950
Fusion-Gun Bay, 46.7-GJ/11	100	936	165	2	1,560
Fusion-Gun Bay, 46.7-GJ/12	100	935	165	2	1,560

Name	Spaces	Mass	Cost	Crew	Power
Part.-Beam Bay, 5.34-GJ/8	100	535	96.4	2	178
Part.-Beam Bay, 14.9-GJ/9	100	746	138	2	497
Part.-Beam Bay, 28.5-GJ/10	100	1,050	52.6	2	950
Part.-Beam Bay, 46.7-GJ/11	100	936	116	2	1,557

Name	Spaces	Mass	Cost	Crew	Power
Meson-Gun Bay, 28.5-GJ/12	100	1,050	52.6	2	950
Meson-Gun Bay, 46.7-GJ/13	100	936	116	2	1,557

Repulsors

Name	Spaces	Mass	Cost	Crew	Power	Notes
Lt. Repulsor Bay/9	100	400	344	2	720	+1 Dodge
Hv. Repulsor Bay/10	100	460	536	2	3,600	+3 Dodge

Repulsors (Continued)

Name	Spaces	Mass	Cost	Crew	Power	Notes
Md. Repulsor Bay/11	50	205	134	2	1,800	+2 Dodge
Hv. Repulsor Bay/11	100	410	268	2	3,600	+3 Dodge
Md. Repulsor Bay/12	50	193	71.6	2	1,800	+2 Dodge
Hv. Repulsor Bay/12	100	385	143	2	3,600	+3 Dodge
Hv. Repulsor Bay/13	50	193	71.6	2	1,800	+3 Dodge
Ehv. Repulsor Bay/13	100	385	143	2	3,600	+4 Dodge

Dodge bonus is vs. missiles only. See *Combat*, pp. 104-105.

Missile Bays

See p. 49 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
250mm Missile Bay/7	50	94.8	5.43	2	0.05
250mm Missile Bay/8	50	60.9	3.68	2	0.05
250mm Missile Bay/9	50	48.8	1.84	2	0.05
250mm Missile Bay/10	50	45.9	0.85	2	0.05

Name	Spaces	Mass	Cost	Crew	Power
500mm Missile Bay/7	100	601	31.1	2	0.10
500mm Missile Bay/8	100	451	23.4	2	0.10
500mm Missile Bay/9	100	425	11.7	2	0.10
500mm Missile Bay/10	100	413	5.85	2	0.10

Missiles

See pp. 52-54 for descriptions of these systems, including the magazine capacity for racks at different TLs.

Item	Spaces	Mass	Cost	Pilot	Performance
250mm Missile/7	0.012	0.32	0.02	–	0.15 G 0.15 GRds
250mm Missile/8	0.012	0.25	0.02	–	0.33 G 1 GRds
250mm Missile/9	0.012	0.23	0.03	12	5 G 15 GRds
250mm Missile/10	0.012	0.22	0.03	14	6 G 18 GRds
250mm Missile/11	0.012	0.18	0.04	15	8 G 24 GRds
250mm Missile/12	0.012	0.18	0.04	17	10 G 30 GRds
250mm Missile/13	0.012	0.24	0.20	18	55 G 165 GRds

Item	Spaces	Mass	Cost	Pilot	Performance
500mm Missile/7	0.06	1.45	0.07	–	0.2 G 0.2 GRds
500mm Missile/8	0.06	1.48	0.08	–	0.33 G 1 GRds
500mm Missile/9	0.06	1.26	0.08	12	5 G 15 GRds
500mm Missile/10	0.06	1.08	0.07	14	6 G 18 GRds
500mm Missile/11	0.06	1.59	0.15	15	8 G 24 GRds
500mm Missile/12	0.06	1.30	0.14	17	10 G 30 GRds
500mm Missile/13	0.06	1.33	1.02	18	55 G 165 GRds

Item	Spaces	Mass	Cost	Pilot	Performance
SIM-10 Missile	0.012	0.15	0.032	–	6 G 18 GRds
SIM-12 Missile	0.012	0.15	0.022	–	10 G 30 GRds

EW Drones

See p. 55 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew
EW Drone/9	0.06	1.48	0.27	0
EW Drone/10	0.06	0.99	0.16	0
EW Drone/11	0.06	1.74	0.27	0
EW Drone/12	0.06	1.18	0.17	0
EW Drone/13	0.06	1.34	0.55	0

Sand Canisters

See p. 48 for a description of this system. A standard sandcaster holds up to 200 canisters of ready ammunition.

Name	Spaces	Mass	Cost
Sand Canister/7	0.0048	0.06	0.0004

Weapon Storage

See p. 61-62 for descriptions of these systems. Note that the various missile platforms and sandcaster already include storage capacity in their integral magazine.

Name	Spaces	Mass	Cost	Crew	Power
Damper Box/11	4.5	35.6	26.1	0	0.079
Damper Box/12	2.5	13.9	11.5	0	0.04
Damper Box/13	2	6.93	5.74	0	0.02
Anti-blast Magazine/7	1	6.25	0.125	0	0
Anti-matter Bunker/12	0.5	12.5	0.25	0	0

Turrets

See p. 46 for descriptions of these systems. These standard turrets each hold up to 3 spaces of turret weaponry.

Name	Spaces	Mass	Cost (USL/VGSL)	Crew
Turret/7	1	2.45	0.046/0.11	1
Turret/8	1	1.64	0.043/0.103	1
Turret/9	1	1.23	0.042/0.101	1
Turret/10	1	0.825	0.041/0.097	1
Turret/11	1	0.625	0.041/0.097	1
Turret/12	1	0.425	0.041/0.097	1

50-ton External Bays

See p. 19 for descriptions of these systems.

Name	Spaces	Mass	Cost (USL/VGSL)	Crew
50-ton External Bay/7	10	19.5	0.325/0.78	0
50-ton External Bay/8	10	13	0.325/0.78	0
50-ton External Bay/9	10	9.75	0.325/0.78	0
50-ton External Bay/10	10	6.5	0.325/0.78	0
50-ton External Bay/11	10	4.88	0.325/0.78	0
50-ton External Bay/12	10	3.25	0.325/0.78	0

100-ton External Bays

See p. 19 for descriptions of these systems.

Name	Spaces	Mass	Cost (USL/VGSL)	Crew
100-ton External Bay/7	20	30	0.5/1.2	0
100-ton External Bay/8	20	20	0.5/1.2	0
100-ton External Bay/9	20	15	0.5/1.2	0
100-ton External Bay/10	20	10	0.5/1.2	0
100-ton External Bay/11	20	7.5	0.5/1.2	0
100-ton External Bay/12	20	5	0.5/1.2	0

Internal Bays

See p. 19 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew
50-ton Internal Bay/7	50	0	0	0
100-ton Internal Bay/7	100	0	0	0

Spinal Mount Weapons

See p. 50 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Spinal P-Beam, 250-GJ/8	4,460	22,424	4,488	45	8,333
Spinal P-Beam, 420-GJ/8	7,492	37,668	7,536	75	14,000
Spinal P-Beam, 670-GJ/8	11,951	60,085	12,020	120	22,333
Spinal P-Beam, 1-TJ/8	17,837	89,677	17,938	179	33,333

Name	Spaces	Mass	Cost	Crew	Power
Spinal P-Beam, 670-GJ/9	3,910	26,558	6,152	40	22,333
Spinal P-Beam, 920-GJ/9	5,369	36,467	8,447	54	30,667
Spinal P-Beam, 1.8-TJ/9	10,503	71,345	16,524	106	60,000
Spinal P-Beam, 3.1-TJ/9	18,088	122,870	28,457	181	103,333

Name	Spaces	Mass	Cost	Crew	Power
Spinal P-Beam, 569.5-GJ/10	1,513	15,126	1,035	15	18,983
Spinal P-Beam, 870-GJ/10	2,292	22,868	1,568	23	29,000
Spinal P-Beam, 1.7-TJ/10	4,478	44,783	3,063	45	56,667
Spinal P-Beam, 2.7-TJ/10	7,111	70,966	4,865	72	90,000

Name	Spaces	Mass	Cost	Crew	Power
Spinal P-Beam, 530-GJ/11	911	7,858	1,307	10	17,667
Spinal P-Beam, 840-GJ/11	1,443	12,454	2,071	15	28,000
Spinal P-Beam, 1.6-TJ/11	2,749	23,720	3,945	28	53,333
Spinal P-Beam, 2.8-TJ/11	4,810	41,509	6,903	49	93,333

Name	Spaces	Mass	Cost	Crew	Power
Spinal Meson Gun, 820-GJ/10	2,160	21,554	4,038	22	27,333
Spinal Meson Gun, 1.4-TJ/10	3,688	36,798	6,894	37	46,667
Spinal Meson Gun, 2.3-TJ/10	6,058	60,453	11,325	61	76,667
Spinal Meson Gun, 3.4-TJ/10	8,955	89,364	16,740	90	113,333

Name	Spaces	Mass	Cost	Crew	Power
Spinal Meson Gun, 670-GJ/11	1,765	17,603	1,792	18	23,333
Spinal Meson Gun, 1.1-TJ/11	2,897	28,900	2,941	29	36,667
Spinal Meson Gun, 2.3-TJ/11	6,057	60,425	6,149	61	76,667
Spinal Meson Gun, 3.1-TJ/11	8,164	81,442	8,287	82	103,333

Name	Spaces	Mass	Cost	Crew	Power
Spinal Meson Gun, 570-GJ/12	1,512	15,119	939	16	19,000
Spinal Meson Gun, 870-GJ/12	2,291	22,851	1,420	23	29,000
Spinal Meson Gun, 2.1-TJ/12	5,530	55,156	3,426	56	70,000
Spinal Meson Gun, 2.9-TJ/12	7,636	76,167	4,731	77	96,667

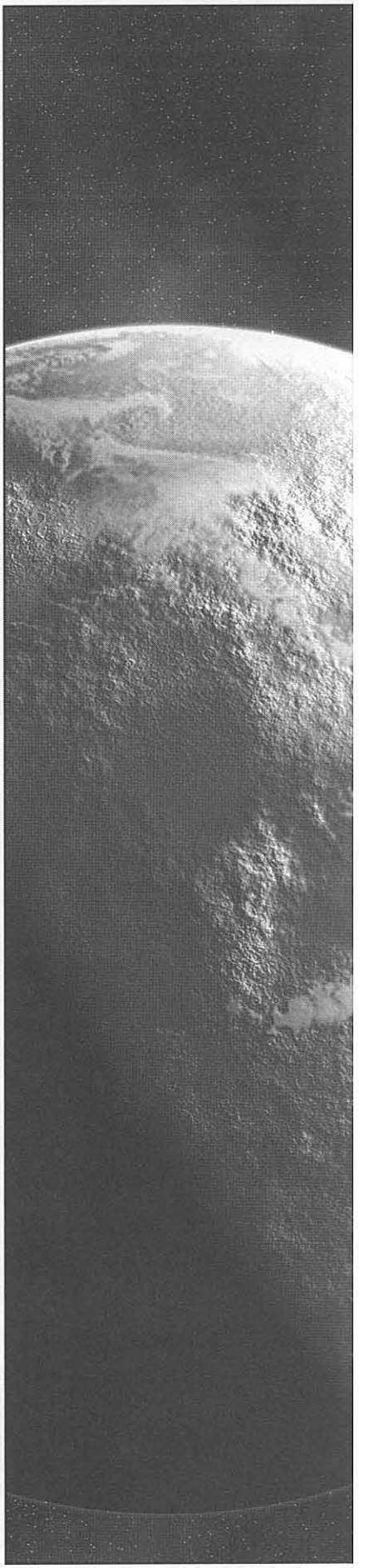
Name	Spaces	Mass	Cost	Crew	Power
Spinal Meson Gun, 870-GJ/13	1,495	12,888	2,143	15	29,000
Spinal Meson Gun, 2.3-TJ/13	3,950	34,070	5,665	40	76,667
Spinal Meson Gun, 2.9-TJ/13	4,980	42,957	7,142	50	96,667
Spinal Meson Gun, 3.4-TJ/13	6,869	59,250	9,851	69	133,333

Cockpits and Bridges

See pp. 42-43 for descriptions of these systems. *Scans* ratings are passive/active/radscanner.

Name	Spaces	Mass	Cost	Crew	Power	Scans
Cockpit/Systems/7	3.5	15.2	6.06	1-2	0.227	31/33/–
Cockpit/Systems/8	1	4.45	3.69	1-2	0.127	31/33/–
Cockpit/Systems/9	3	13.4	7.62	1-2	0.502	33/37/23
Cockpit/Systems/10	1	4.9	2.5	1-2	1.25	35/39/29
Cockpit/Systems/11	1	4.7	2.3	1-2	1.75	37/40/31

Name	Spaces	Mass	Cost	Crew	Power	Scans
Command Cockpit/7	5.5	30.5	31.3	1-2	0.773	32/36/–
Command Cockpit/8	2.5	14.6	27	1-2	0.773	34/38/–





Cockpits and Bridges (Cont.)

Name	Spaces	Mass	Cost	Crew	Power	Scans
Command Cockpit/9	5	28.9	24.5	1-2	2.52	37/41/31
Command Cockpit/10	2.5	19.1	11	1-2	4.79	39/42/32
Command Cockpit/11	2.5	17.3	10.2	1-2	6.02	41/43/38
Command Cockpit/12	2.5	16.9	10	1-2	6.02	41/43/38

Name	Spaces	Mass	Cost	Crew	Power	Scans
Light Cockpit/Systems/7	3	11.5	5.57	1	0.024	25/27/–
Light Cockpit/Systems/8	1	3.03	1.22	1	0.014	25/27/–
Light Cockpit/Systems/9	3	11.1	5.88	1	0.051	27/31/23
Light Cockpit/Systems/10	0.5	1.94	0.94	1	0.127	29/33/23
Light Cockpit/Systems/11	0.5	1.9	0.589	1	0.177	31/34/25
Light Cockpit/Systems/12	0.5	1.89	0.589	1	0.177	31/34/25

Name	Spaces	Mass	Cost	Crew	Power	Scans
Basic Bridge/7	2.5	11	4.78	1-5	0.355	31/34/–
Basic Bridge/8	2.5	8.07	5.21	1-5	0.505	33/37/–
Basic Bridge/9	2.5	11.6	6.1	1-5	1.75	35/40/29
Basic Bridge/10	2.5	8.6	4	1-5	2.51	37/41/31
Basic Bridge/11	2.5	7.55	3.22	1-5	3.76	38/42/35
Basic Bridge/12	2.5	7.3	3.1	1-5	3.76	38/42/35

Name	Spaces	Mass	Cost	Crew	Power	Scans
Command Bridge/7	7	34.5	12.8	1-10	0.788	32/36/–
Command Bridge/8	5.5	21.9	12.2	1-10	0.788	34/38/–
Command Bridge/9	5.5	23.7	12.4	1-10	2.54	37/41/31
Command Bridge/10	5	20.9	9.6	1-10	3.80	39/42/32
Command Bridge/11	5	20	8.96	1-10	5.05	41/43/38
Command Bridge/12	5	19.2	8.8	1-10	5.05	41/43/38

Name	Spaces	Mass	Cost	Crew	Power	Scans
Compact, Basic or Command only	-0.5	-0.04	0	-2		

Electronic Systems

See p. 43 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Aux. Control Station/Dup. Controls/7	0.5	0.355	0.013	0-2	Neg.
Aux. Control Station/Dup. Controls/8	0.5	0.355	0.004	0-2	Neg.
Aux. Control Station/Dup. Controls/9	0.5	0.335	0.003	0-2	Neg.
Aux. Control Station/Dup. Controls/10-12	0.5	0.300	0.003	0-2	Neg.
Aux. Control Station/Dup. Controls/13	0.5	0.200	0.004	0-2	Neg.

Name	Spaces	Mass	Cost	Crew	Power
Information Center/7	4	7.66	10.5	10-20	0.01
Information Center/8	4	7.63	10.3	10-20	0.01
Information Center/9	4	4.51	5.28	10-20	0.01
Information Center/10	4	3	2.8	10-20	0.01

Sensor Systems

See pp. 44-45 for descriptions of these systems. *Scans* ratings for multifunction sensor suites are given as passive/active/radscanner values.

Name	Spaces	Mass	Cost	Crew	Power	Scans
Enhanced Sensor Suite/7	4	32.9	11.8	1	1.5	37/38/–
Enhanced Sensor Suite/8	4	31.2	16.1	1	3.25	37/41/–
Enhanced Sensor Suite/9	4	39.7	27.6	1	5	41/43/33
Enhanced Sensor Suite/10	4	41.2	27.3	1	11.3	43/45/37
Enhanced Sensor Suite/11	4	38.7	26.9	1	25	45/47/39

Sensor Systems (Continued)

Name	Spaces	Mass	Cost	Crew	Power	Scans
Advanced Sensor Suite/7	8	69.8	20.1	1	2.25	40/39/–
Advanced Sensor Suite/8	8	65.8	39.2	1	6.23	40/43/–
Advanced Sensor Suite/9	8	78.4	53.6	1	11.3	43/45/34
Advanced Sensor Suite/10	8	82.4	56.8	1	25	45/47/38
Advanced Sensor Suite/11	8	77.1	56.5	1	50	47/49/40

Name	Spaces	Mass	Cost	Crew	Power	Scans
Densitometer/11	1	12.5	6	1	Neg.	–/27/–
Densitometer/12	1	12.5	5.4	1	Neg.	–/29/–
Densitometer/13	1	12.5	5.2	1	Neg.	–/31/–

Screens

See p. 50 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Nuclear Damper/10	1.5	32.4	16	4	2
Nuclear Damper/11	1	16.4	8	4	2
Nuclear Damper/12	1	10	4	4	2
Nuclear Damper/13	0.5	4.4	2	4	2

Name	Spaces	Mass	Cost	Crew	Power
Meson Screen/10	2	12.5	9.05	4	72.8
Meson Screen/11	1	6.24	4.34	4	36.4
Meson Screen/12	1	5	2.26	4	36.4
Meson Screen/13	1	4.29	1.22	4	36.4

Name	Spaces	Mass	Cost	Crew	Power
Black Globe Capacitor/12	1	25	5	0	24 million HP
Black Globe-1/12	10	20.5	51	4	0.00001
Black Globe-2/12	15	41	102	4	0.00001
Black Globe-3/12	20	82	204	4	0.00001
Black Globe-4/12	25	164	408	4	0.00001

Volume, mass, cost, and power are per 8,200 sf of vessel protected for black globes *only*.

Electronic-Warfare Systems

See p. 45 for descriptions of these systems.

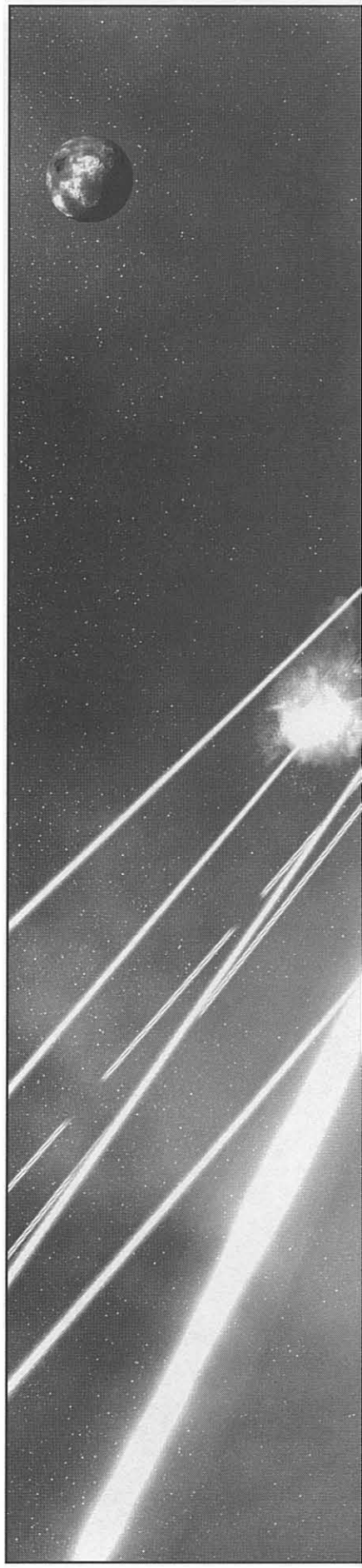
Name	Spaces	Mass	Cost	Crew	Power
Jammer/7	33	378	60.1	0	21
Jammer/8	6	31.5	13.8	0	10.4
Jammer/9	3	26.8	18.2	0	15.7
Jammer/10	1	14.5	11.3	0	7.88
Jammer/11	1	15.2	10	0	7.73
Jammer/12	1	16.5	10.3	0	7.73
Jammer/13	1	16.6	10.3	0	7.73

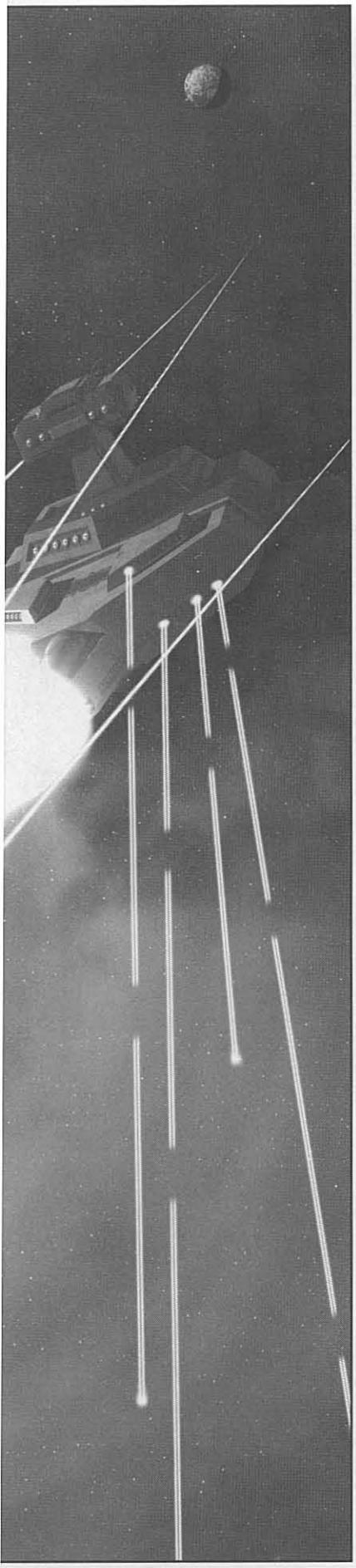
Name	Spaces	Mass	Cost	Crew	Power
Electronic Warfare/7	3	56.2	11.4	2	0.22
Electronic Warfare/8	3	33.6	11.4	2	1.02
Electronic Warfare/9	3	27.7	14.4	2	5.02
Electronic Warfare/10	3	43.7	13	2	15
Electronic Warfare/11	3	44.9	11.4	2	15
Electronic Warfare/12	3	40.4	10.5	2	15
Electronic Warfare/13	3	37.1	9.85	2	15

Long-Range Sensors

See p. 44 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power	Scan/Range in miles
FLt. Radscanner/9	2	25	10.1	0	Neg.	Scan 35, Range 10k
MLt. Radscanner/9	3	37.5	15.1	0	Neg.	Scan 36, Range 15k
ULt. Radscanner/9	4	50	20.1	0	Neg.	Scan 37, Range 20k
SLt. Radscanner/9	6	75	30.1	0	Neg.	Scan 38, Range 30k





Long-Range Sensors (Continued)

Name	Spaces	Mass	Cost	Crew	Power	Scan/Range in miles
ELt. Radscanner/9	9	113	45.1	0	Neg.	Scan 39, Range 45k
Lt. Radscanner/9	14	175	70.1	0	Neg.	Scan 40, Range 70k
Md. Radscanner/9	20	250	100	0	Neg.	Scan 41, Range 100k
Hv. Radscanner/9	30	375	150	0	Neg.	Scan 42, Range 150k
EHv. Radscanner/9	40	500	200	0	Neg.	Scan 43, Range 200k
SHv. Radscanner/9	60	750	300	0	Neg.	Scan 44, Range 300k
UHv. Radscanner/9	90	1125	450	0	Neg.	Scan 45, Range 450k

Name	Spaces	Mass	Cost	Crew	Power	Scan/Range in miles
ELt. Radscanner/10	2.5	28.1	11.3	0	Neg.	Scan 39, Range 45k
Lt. Radscanner/10	3.5	43.8	17.5	0	Neg.	Scan 40, Range 70k
Md. Radscanner/10	5	62.5	25	0	Neg.	Scan 41, Range 100k
Hv. Radscanner/10	7.5	93.8	37.5	0	Neg.	Scan 42, Range 150k
EHv. Radscanner/10	10	125	50	0	Neg.	Scan 43, Range 200k
SHv. Radscanner/10	15	188	75	0	Neg.	Scan 44, Range 300k
UHv. Radscanner/10	22.5	281	113	0	Neg.	Scan 45, Range 450k

Name	Spaces	Mass	Cost	Crew	Power	Scan/Range in miles
Md. Radscanner/11	1	12.5	5.01	0	Neg.	Scan 41, Range 100k
Hv. Radscanner/11	1.5	18.8	7.51	0	Neg.	Scan 42, Range 150k
EHv. Radscanner/11	2	25	10	0	Neg.	Scan 43, Range 200k
SHv. Radscanner/11	3	37.5	15	0	Neg.	Scan 44, Range 300k
UHv. Radscanner/11	4.5	56.3	22.5	0	Neg.	Scan 45, Range 450k

Name	Spaces	Mass	Cost	Crew	Power	Scan/Range in miles
FLt. PESA Array/8	2.5	30	49.6	0	Neg.	Scan 42, Range 150k
MLt. PESA Array/8	3.5	40	65.6	0	Neg.	Scan 43, Range 200k
ULt. PESA Array/8	5	60	97.6	0	Neg.	Scan 44, Range 300k
SLt. PESA Array/8	7.5	90	146	0	Neg.	Scan 45, Range 450k
ELt. PESA Array/8	11.5	140	226	0	Neg.	Scan 46, Range 700k
Lt. PESA Array/8	16	200	322	0	Neg.	Scan 47, Range 1M
Md. PESA Array/8	24	300	482	0	Neg.	Scan 48, Range 1.5M
Hv. PESA Array/8	32	400	642	0	Neg.	Scan 49, Range 2M
EHv. PESA Array/8	48	600	962	0	Neg.	Scan 50, Range 3M
SHv. PESA Array/8	72	900	1442	0	Neg.	Scan 51, Range 4.5M
UHv. PESA Array/8	112	1400	2242	0	Neg.	Scan 52, Range 7M

Name	Spaces	Mass	Cost	Crew	Power	Scan/Range in miles
ULt. PESA Array/9	2.5	30	48.8	0	Neg.	Scan 44, Range 300k
SLt. PESA Array/9	4	45	72.8	0	Neg.	Scan 45, Range 450k
ELt. PESA Array/9	6	70	113	0	Neg.	Scan 46, Range 700k
Lt. PESA Array/9	8	100	161	0	Neg.	Scan 47, Range 1M
Md. PESA Array/9	12	150	241	0	Neg.	Scan 48, Range 1.5M
Hv. PESA Array/9	16	200	321	0	Neg.	Scan 49, Range 2M
EHv. PESA Array/9	24	300	481	0	Neg.	Scan 50, Range 3M
SHv. PESA Array/9	36	450	721	0	Neg.	Scan 51, Range 4.5M
UHv. PESA Array/9	56	700	1121	0	Neg.	Scan 52, Range 7M

Name	Spaces	Mass	Cost	Crew	Power	Scan/Range in miles
ELt. PESA Array/10	3	35	56.4	0	Neg.	Scan 46, Range 700k
Lt. PESA Array/10	4	50	80.4	0	Neg.	Scan 47, Range 1M
Md. PESA Array/10	6	75	120	0	Neg.	Scan 48, Range 1.5M
Hv. PESA Array/10	8	100	160	0	Neg.	Scan 49, Range 2M
EHv. PESA Array/10	12	150	240	0	Neg.	Scan 50, Range 3M
SHv. PESA Array/10	18	225	360	0	Neg.	Scan 51, Range 4.5M
UHv. PESA Array/10	28	350	560	0	Neg.	Scan 52, Range 7M

Name	Spaces	Mass	Cost	Crew	Power	Scan/Range in miles
Md. PESA Array/11	3	37.5	60.2	0	Neg.	Scan 48, Range 1.5M
Hv. PESA Array/11	4	50	80.2	0	Neg.	Scan 49, Range 2M
EHv. PESA Array/11	6	75	120	0	Neg.	Scan 50, Range 3M
SHv. PESA Array/11	9	113	180	0	Neg.	Scan 51, Range 4.5M
UHv. PESA Array/11	14	175	280	0	Neg.	Scan 52, Range 7M

Long-Range Sensors (Continued)

Name	Spaces	Mass	Cost	Crew	Power	Scan/Range in miles
ULt. AESA Array/8	5.5	37.5	10.6	0	7.5	Scan 44, Range 300k
SLt. AESA Array/8	8.5	56.3	15.9	0	11.3	Scan 45, Range 450k
ELt. AESA Array/8	13	87.5	24.6	0	17.5	Scan 46, Range 700k
Lt. AESA Array/8	18	125	35.1	0	25	Scan 47, Range 1M
Md. AESA Array/8	27	188	52.6	0	37.5	Scan 48, Range 1.5M
Hv. AESA Array/8	36	250	70.1	0	50	Scan 49, Range 2M
EHv. AESA Array/8	54	375	105	0	75	Scan 50, Range 3M
SHv. AESA Array/8	81	563	158	0	112.5	Scan 51, Range 4.5M
UHv. AESA Array/8	126	875	245	0	175	Scan 52, Range 7M

Name	Spaces	Mass	Cost	Crew	Power	Scan/Range in miles
ELt. AESA Array/9	4.5	35	12.3	0	17.5	Scan 46, Range 700k
Lt. AESA Array/9	6	50	17.6	0	25	Scan 47, Range 1M
Md. AESA Array/9	9	75	26.3	0	37.5	Scan 48, Range 1.5M
Hv. AESA Array/9	12	100	35.1	0	50	Scan 49, Range 2M
EHv. AESA Array/9	18	150	52.6	0	75	Scan 50, Range 3M
SHv. AESA Array/9	27	225	78.8	0	113	Scan 51, Range 4.5M
UHv. AESA Array/9	42	350	123	0	175	Scan 52, Range 7M

Name	Spaces	Mass	Cost	Crew	Power	Scan/Range in miles
Md. AESA Array/10	3.5	31.9	9.78	0	38	Scan 48, Range 1.5M
Hv. AESA Array/10	4.5	42.5	13	0	50	Scan 49, Range 2M
EHv. AESA Array/10	6.5	63.8	19.5	0	75	Scan 50, Range 3M
SHv. AESA Array/10	9.5	95.6	29.3	0	113	Scan 51, Range 4.5M
UHv. AESA Array/10	15	149	45.5	0	175	Scan 52, Range 7M

Name	Spaces	Mass	Cost	Crew	Power	Scan/Range in miles
EHv. AESA Array/11	4.5	35.6	9.77	0	75	Scan 50, Range 3M
SHv. AESA Array/11	6.5	53.4	14.6	0	113	Scan 51, Range 4.5M
UHv. AESA Array/11	9.5	83.1	22.8	0	175	Scan 52, Range 7M

Special Sensors and Add-ons

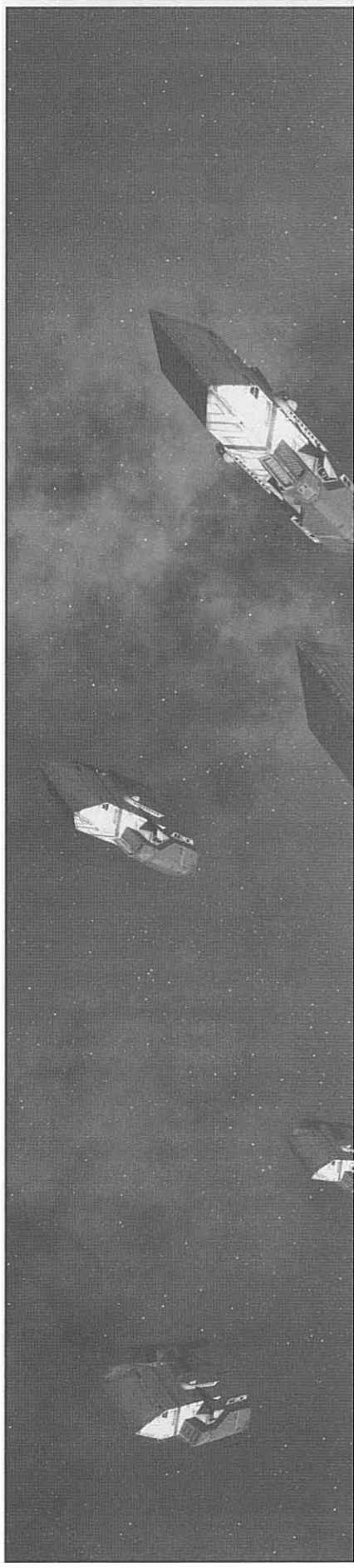
See pp. 44-45 for descriptions of these systems.

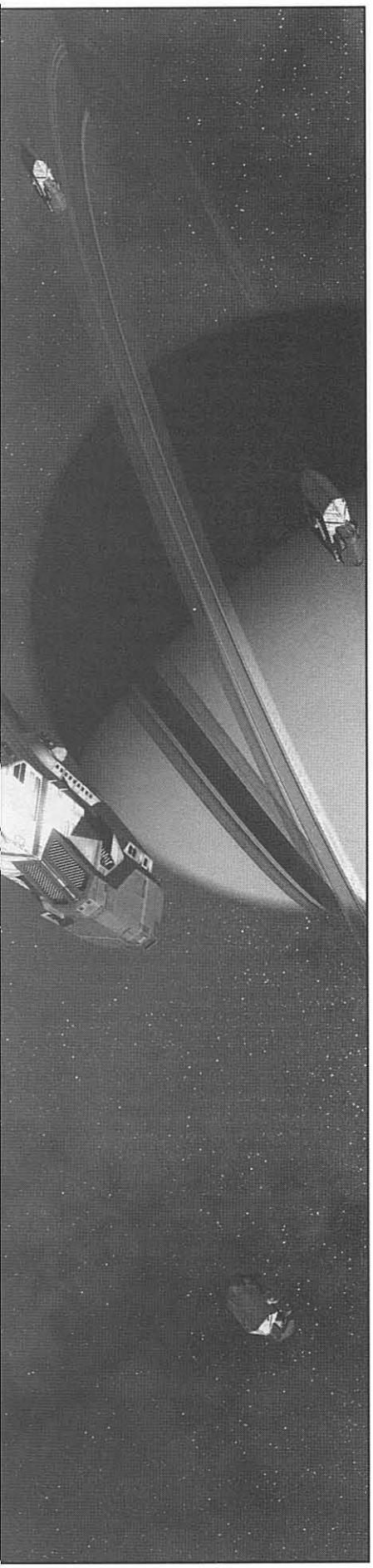
Name	Spaces	Mass	Cost	Crew	Power
Survey Module-Traffic Control/7	5	31.3	409	4-8	0.016
Survey Module-Traffic Control/8	4	21.8	124	4-8	0.034
Survey Module-Traffic Control/9	4	11.1	62.1	4-8	0.031
Survey Module-Traffic Control/10	4	5.31	30.6	4-8	0.022

Name	Spaces	Mass	Cost	Crew	Power
Underwater Electronics/7	1	7.83	4.05	1	0.106
Underwater Electronics/8	0.5	4.13	1.88	1	0.121
Underwater Electronics/9	0.5	2.89	1.45	1	0.136
Underwater Electronics/10	0.5	4.2	3.53	1	0.160
Underwater Electronics/11	0.5	4.47	3.63	1	0.175
Underwater Electronics/12	0.5	4.73	3.73	1	0.19
Underwater Electronics/13	0.5	4.99	3.84	1	0.205

Name	Spaces	Mass	Cost	Crew	Power
Astronomical Instruments/7	0	0.138	2.03	0	Neg.
Astronomical Instruments/8	0	0.055	0.51	0	Neg.
Astronomical Instruments/9	0	0.028	0.255	0	Neg.
Astronomical Instruments/10	0	0.014	0.128	0	Neg.

Name	Spaces	Mass	Cost	Crew	Power
Planetary Survey/7	0	0.25	0.5	0	0.001
Planetary Survey/8	0	0.125	0.25	0	0.001
Planetary Survey/9	0	0.063	0.125	0	0.001
Planetary Survey/10	0	0.5	1.25	0	0.005





Communications Suites

See pp. 43-44 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Enhanced Comms/7	1.5	18	0.257	0	0.006
Enhanced Comms/8	1.5	17.5	0.245	0	0.011
Enhanced Comms/9	1.5	18.8	0.268	0	0.024
Enhanced Comms/10	1.5	18.1	2.1	0	0.017
Enhanced Comms/11	1.5	14.4	1.09	0	0.026
Enhanced Comms/12	1.5	16.3	0.67	0	0.04

Name	Spaces	Mass	Cost	Crew	Power
Advanced Comms/10	13.5	168	6.25	0	0.084
Advanced Comms/11	7.5	93.1	3.25	0	0.084
Advanced Comms/12	4.5	55.6	1.75	0	0.084

Name	Spaces	Mass	Cost	Crew	Power	Notes
Comm. Module (Xboat)/7	81.5	1,010	13.6	0-1	0.023	60k/6M mi range
Comm. Module (Xboat)/8	41.5	514	12.8	0-1	0.023	200k/20M mi range
Comm. Module (Xboat)/9	20.5	252	3.38	0-1	0.023	2M/200M mi range
Comm. Module (Xboat)/10	12	138.1	3.83	0-1	0.023	10M/1B mi range

Computer and Scientific Systems

See p. 45 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power
Computer System/7	4	48.3	120	0	0.08
Computer System /8	4	48.2	120	0	0.08
Computer System /9	2	24	60	0	0.08
Computer System /10	1	12	30	0	0.08

Name	Spaces	Mass	Cost	Crew	Power
Computer Lab/7	2	18.2	900	1	0.03
Computer Lab/8	2	18.1	900	1	0.03
Computer Lab/9	1.5	9.08	450	2	0.03
Computer Lab/10	1.5	4.59	225	6	0.03

Name	Spaces	Mass	Cost	Crew	Power
Enhanced Display/9	2.5	0.3	0.1	0	0.001
Enhanced Display/10	2.5	0.3	0.05	0	0.001
Enhanced Display/11	2.5	0.3	0.025	0	0.001

Name	Spaces	Mass	Cost	Crew	Power
Simulation Lab/9	5	11.4	2.1	2	0.014
Simulation Lab/10	5	10.9	1.55	2	0.014
Simulation Lab/11	5	10.9	1.53	2	0.014

Name	Spaces	Mass	Cost	Crew	Power
Physics Lab/7	2.5	11.2	1.48	1	0.3
Physics Lab/8	2.5	10.6	1.12	1	0.3
Physics Lab/9	2.5	10.2	1.06	1	0.3
Physics Lab/10	2.5	10	1	1	0.3

Name	Spaces	Mass	Cost	Crew	Power
Isolation Lab/7	20	100	10	1	0.03
Lab/7	2	10	1	1	0.003

Name	Spaces	Mass	Cost	Crew	Power
Probe Launcher/Control/7	1	4.13	0.223	0-3	0.003
Probe Launcher/Control/8	1	2.38	0.132	0-3	0.003
Probe Launcher/Control/9	1	1.59	0.066	0-3	0.003
Probe Launcher/Control/10	1	1.2	0.033	0-3	0.003

Drives

See pp. 37-39 for descriptions of these systems. *Thrust* is measured in stons. *Fuel* is measured in dtons per hour (where applicable); see pp. 38-39 for fuel-type abbreviations.

Reactionless Thrusters

See pp. 37-38 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power	Thrust
Maneuver Drive/8	1	4.13	0.825	1/3	1.5	1.5
Maneuver Drive/Early 9	1	4	1.3	1/10	5	5
Maneuver Drive/Late 9	1	3.75	0.69	1/17	3	30
Maneuver Drive/10	1	3.4	0.16	1/60	4	40
Maneuver Drive/11	1	4	0.65	1/50	10	100
Maneuver Drive/12	1	4	0.65	1/100	10	100
Maneuver Drive/13	1	4.03	4.38	1/25	35	350

Reaction Drives

See pp. 38-39 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
Liquid Fuel Rocket/7	0.5	2.07	0.104	0	0	115	86.3 R
Liquid Fuel Rocket/8	0.5	2.1	0.105	0	0	140	92.4 R

Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
Fission Rocket/7	0.5	2.1	0.419	0	0	4.3	1.29 W
Fission Rocket/8	0.5	2.08	0.416	0	0	9.25	0.555 W

Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
Solid Rocket Booster/7	1	25.2	0.25	0	0	6	–
Solid Rocket Booster/8	1	25.2	0.25	0	0	7	–

Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
HEPlaR/9	0.5	0.85	0.75	0	Neg.	3.75	0.0033 H
HEPlaR/10	0.5	3.7	0.16	0	Neg.	14	0.0125 H
HEPlaR/11	0.5	3.7	0.09	0	Neg.	14	0.0125 H

Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
Rocket Drive/8	0.5	2.1	0.42	0	0	2.8	0.000336 H
Rocket Drive/E9	0.5	2.1	0.42	0	0	7	0.00084 H
Rocket Drive/L9-10	0.5	2.1	0.084	0	0	28	0.00336 H
Rocket Drive/11-12	0.5	2.1	0.42	0	0	70	0.0084 H
Rocket Drive/13	0.5	2.1	16.8	0	0	1,400	0.168 H

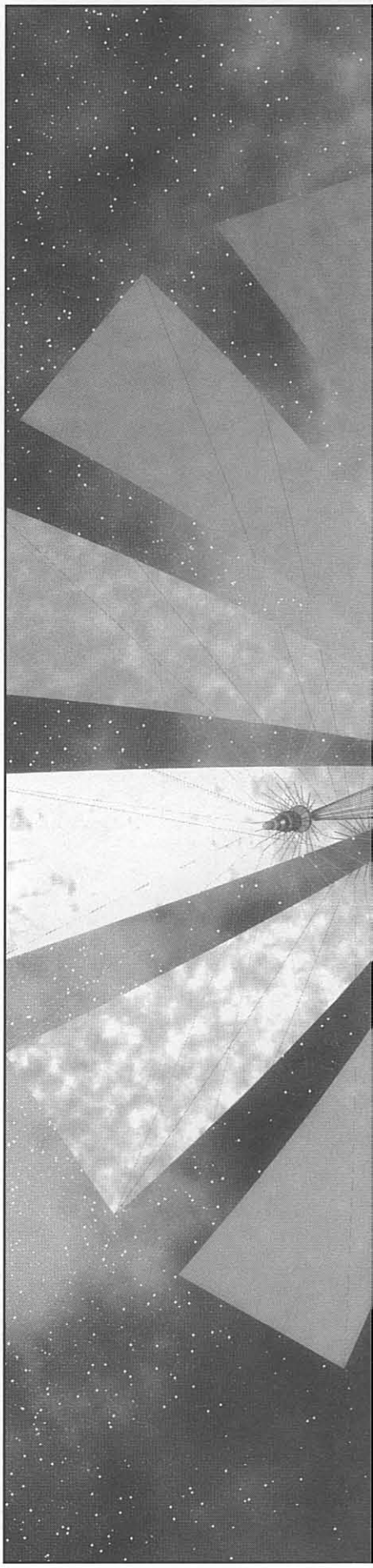
Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
Metal/Oxide Rocket/8	0.5	2.06	0.412	0	0	55	35.6 MOX

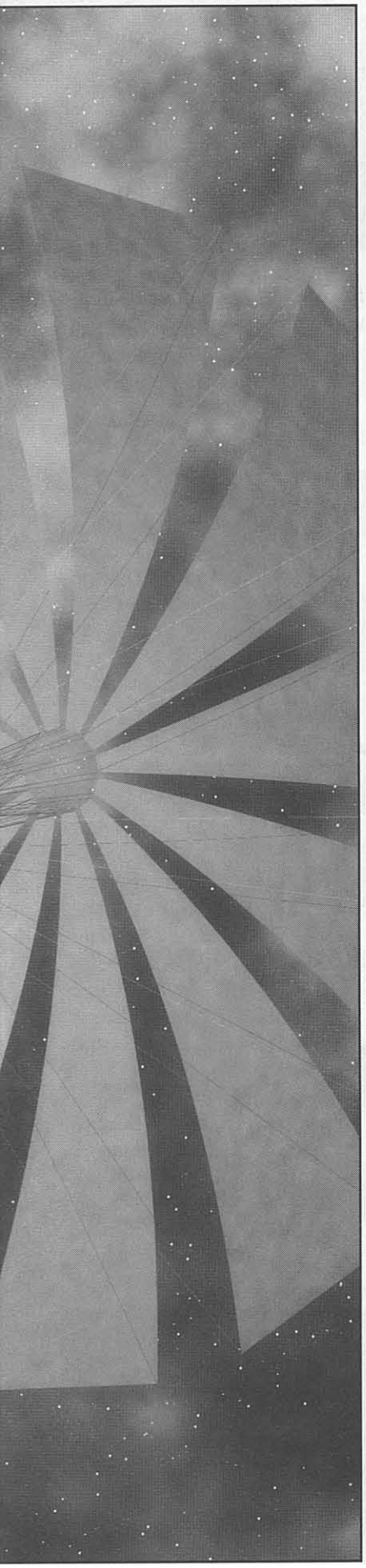
Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
Bussard Ramjet/9	1	4	3.2	0	0	0.65	–
Bussard Ramjet/10	1	4	3.2	0	0	6.5	–

Atmospheric Drives

See p. 39 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
Turbo-Ramjet/7	1	4.16	0.833	0	0.35	17.5	0.525 J
Turbo-Ramjet/8	1	4.13	0.825	0	0.42	21	0.567 J
Hyperfan/9	1	4.16	0.416	0	0.55	27.5	3.3 H
Fusion Air Ram/9	1	4.2	0.84	0	0.55	27.5	–
Fusion Air Ram/10	1	4.16	0.833	0	1.1	55	–





Short-Term Reactionless Thrusters

See p. 37 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power	Thrust
ST Maneuver Drive/8	0.5	3.03	0.605	1/5	1.1	1.1
ST Maneuver Drive/E9	0.5	2.8	0.91	1/14	3.5	3.5
ST Maneuver Drive/L9	0.5	3.13	0.575	1/20	2.5	25
ST Maneuver Drive/10	0.5	2.98	0.14	1/70	3.5	35
ST Maneuver Drive/11	0.5	3	0.488	1/66	7.5	75
ST Maneuver Drive/12	0.5	3	0.488	1/133	7.5	75
ST Maneuver Drive/13	0.5	2.88	3.13	1/40	25	250

Short Term Reaction Drives

See pp. 38-39 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
ST Liquid Fuel Rocket/7	0.5	3.15	0.158	0	0	175	126 R
ST Liquid Fuel Rocket/8	0.5	3.15	0.158	0	0	210	138.6 R

Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
ST Fission Rocket/7	0.5	3.07	0.614	0	0	6.3	1.89 W
ST Fission Rocket/8	0.5	3.15	0.63	0	0	14	0.84 W

Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
ST Rocket Drive/8	0.5	3	0.6	0	0	4	0.00048 H
ST Rocket Drive/E9	0.5	3	0.6	0	0	10	0.0012 H
ST Rocket Drive/L9-10	0.5	3	0.12	0	0	40	0.0048 H
ST Rocket Drive/11-12	0.5	3	0.6	0	0	100	0.012 H
ST Rocket Drive/13	0.5	3	24	0	0	2,000	0.24 H

Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
ST Metal/Oxide Rocket/8	0.5	3	0.6	0	0	80	51.8 MOX

Short-Term Atmospheric Drives

See p. 39 for descriptions of these systems. Power generated is *per module*.

Name	Spaces	Mass	Cost	Crew	Power	Thrust	Fuel
ST Turbo-Ramjet/7	0.5	3.04	0.608	0	0.25	12.5	0.375 J
ST Turbo-Ramjet/8	0.5	3	0.6	0	0.3	15	0.405 J
ST Hyperfan/9	0.5	3.04	0.304	0	0.4	20	2.4 H
ST Fusion Air Ram/9	0.5	3.08	0.615	0	0.4	20	–
ST Fusion Air Ram/10	0.5	3.04	0.608	0	0.8	40	–

Solar Sails

See p. 38 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power	Thrust	Notes
Solar Sail/7	0.5	22.4	11.2	0	0	0.003712	1.6-square-mile sail
Solar Sail/8	0.5	24.4	24.4	0	0	0.01886	7.5-square-mile sail
Solar Sail/9	0.5	25	25	0	0	0.3288	125-square-mile sail

Jump Drives

See p. 37 for descriptions of these systems.

Name	Spaces	Mass	Cost	Crew	Power	Notes
Jump Drive/9	2	8	5	1/5	10	Max Jump 2
Jump Drive/10	1	4	3.1	1/25	10	Max Jump 4
Jump Drive/11	1	4	3.05	1/50	10	Max Jump 5
Jump Drive/12	1	4	3.05	1/100	10	Max Jump 6

Appendix B

Weapon Tables

See p. GT158 for an explanation of these weapon combat values. The 1/2 and Max Range values for energy weapons are given in *miles* followed by *hexes*, for ease of use in the ***GURPS Traveller*** space-combat system.

Turret Energy Weapons

Standard Lasers

Name	RoF	Damage	1/2D Range	Max Range	Acc	SS
Turret Laser, 43-MJ/8	1/60	5d×20	2,800/0	8,400/1	28	30
Turret Laser, 101-MJ/9	1/60	4d×40	14,000/1	42,000/4	33	30
Turret Laser, 250-MJ/10	1/60	5d×50 (2)	17,000/2	51,000/5	32	30
Turret Laser, 390-MJ/11	1/60	4d×100 (2)	23,000/2	69,000/7	32	30
Turret Laser, 405-MJ/12	1/60	5d×100 (2)	26,000/3	78,000/8	33	30
Turret Laser, 420-MJ/13	1/60	6d×100 (2)	29,000/3	87,000/9	33	30
Turret Graser, 390-MJ/14	1/60	6d×50 (5)	21,000/2	63,000/6	32	30

Heavy Lasers

Name	RoF	Damage	1/2D Range	Max Range	Acc	SS
Turret Laser, 130-MJ/8	1/60	6d×30	4,900/0	15,000/1	30	30
Turret Laser, 303-MJ/9	1/60	7d×40	25,000/3	75,000/8	34	30
Turret Laser, 810-MJ/10	1/60	5d×90 (2)	31,000/3	93,000/9	33	30
Turret Laser, 1.3-GJ/11	1/60	7d×100 (2)	43,000/4	130,000/13	34	30
Turret Laser, 1.3-GJ/12	1/60	5d×170 (2)	47,000/5	140,000/14	34	30
Turret Laser, 1.3-GJ/13	1/60	5d×200 (2)	51,000/5	150,000/15	34	30
Turret Graser, 660-MJ/13	1/60	4d×100 (5)	28,000/3	84,000/8	33	30
Turret Graser, 1.18-GJ/14	1/60	5d×100 (5)	37,000/4	110,000/11	33	30

Mining Lasers

Name	RoF	Damage	1/2D Range	Max Range	Acc	SS
Turret Mining Laser, 2.6-MJ/8	1	5d×5	22/0	66/0	11	25
Turret Mining Laser, 10.2-MJ/9	1	5d×10	140/0	420/0	16	25
Turret Mining Laser, 40-MJ/10	1	5d×20 (2)	210/0	630/0	15	25
Turret Mining Laser, 46.5-MJ/11	1	7d×20 (2)	250/0	750/0	15	25
Turret Mining Laser, 46.5-MJ/12	1	6d×30 (2)	280/0	840/0	16	25
Turret Mining Laser, 46.5-MJ/13	1	5d×40 (2)	300/0	900/0	16	25

High Energy Turret Weapons

Name	RoF	Damage	1/2D Range	Max Range	Acc	SS
Turret Plasma Gun, 225-MJ/9	1/60	7d×100	1,600/0	4,800/0	27	30
Turret Plasma Gun, 430-MJ/10	1/60	7d×200	2,500/0	7,500/1	28	30
Turret Fusion Gun, 700-MJ/11	1/60	7d×300	3,400/0	10,000/1	29	30
Turret Fusion Gun, 700-MJ/12+	1/60	5d×500	3,700/0	11,000/1	29	30
Turret Particle Beam, 160-MJ,/8	1/60	8d×80	1,400/0	4,200/0	27	30
Turret Particle Beam, 450-MJ,/9	1/60	7d×200	2,500/0	7,500/1	28	30
Turret Particle Beam, 860-MJ,/10	1/60	8d×300	3,800/0	11,000/1	29	30
Turret Particle Beam, 1.4-GJ,/11+	1/60	5d×700	5,200/1	16,000/2	30	30
Turret Meson Gun, 1.39-GJ/13	1/60	6d×550 (!)	5,200/1	16,000/2	30	30

Bay Energy Weapons

50-Ton Bay Weapons

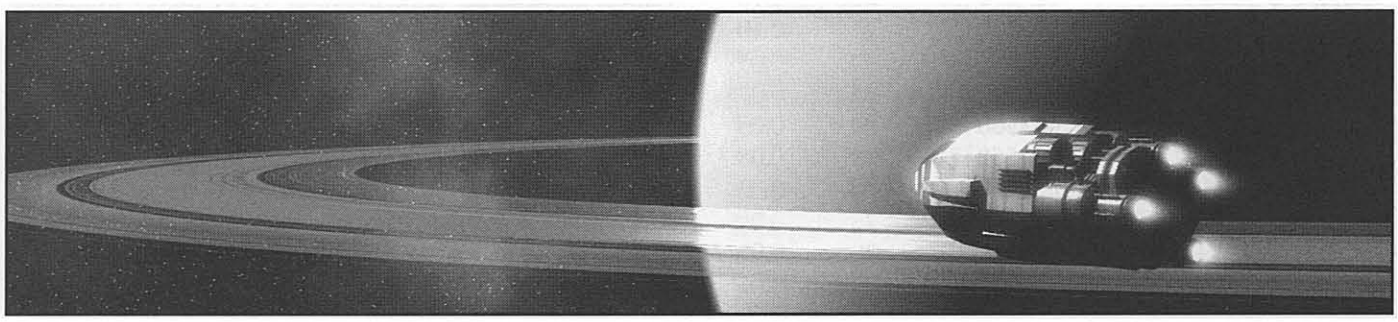
Name	RoF	Damage	1/2D Range	Max Range	Acc	SS
Plasma Gun Bay, 7.4-GJ/9	1/60	6d×500	9,300/1	28,000/3	32	30
Plasma Gun Bay, 12.81-GJ/10	1/60	6d×800	13,000/1	39,000/4	33	30
Fusion Gun Bay, 23.3-GJ/11	1/60	6d×1,200	20,000/2	60,000/6	33	30
Fusion Gun Bay, 23.3-GJ/12+	1/60	6d×1,400	21,000/2	63,000/6	34	30
Particle Beam Bay, 2.65-GJ,/8	1/60	5d×440	5,600/1	17,000/2	30	30
Particle Beam Bay, 7.4-GJ,/9	1/60	4d×1,000	10,000/1	30,000/3	32	30
Particle Beam Bay, 12.81-GJ,/10	1/60	6d×1,000	15,000/2	44,000/4	33	30
Particle Beam Bay, 23.3-GJ,/11+	1/60	8d×1,000	21,000/2	63,000/6	31	30
Meson Gun Bay, 12.81-GJ,/12	1/60	6d×1,000 (!)	15,000/2	44,000/4	33	30
Meson Gun Bay, 23.3-GJ,/13	1/60	4d×2,000 (!)	21,000/2	63,000/6	31	30

100-Ton Bay Weapons

Name	RoF	Damage	1/2D Range	Max Range	Acc	SS
Plasma Gun Bay, 14.9-GJ/9	1/60	4d×1,000	13,000/1	39,000/4	33	30
Plasma Gun Bay, 28.5-GJ/10	1/60	7d×900	20,000/2	60,000/6	34	30
Fusion Gun Bay, 46.7-GJ/11	1/60	9d×1,000	28,000/3	84,000/8	34	30
Fusion Gun Bay, 46.7-GJ/12+	1/60	7d×1,500	30,000/3	90,000/9	35	30
Particle Beam Bay, 5.34-GJ,/8	1/60	7d×400	7,900/1	24,000/2	31	30
Particle Beam Bay, 14.9-GJ,/9	1/60	5d×1,000	14,000/1	42,000/4	33	30
Particle Beam Bay, 28.5-GJ,/10	1/60	8d×1,000	22,000/2	66,000/7	34	30
Particle Beam Bay, 46.7-GJ,/11+	1/60	5d×2,100	30,000/3	90,000/9	35	30
Meson Gun Bay, 28.5-GJ,/12	1/60	8d×1,000 (!)	22,000/2	66,000/7	34	30
Meson Gun Bay, 46.7-GJ,/13	1/60	5d×2,100 (!)	30,000/3	90,000/9	35	30

Spinal Mounts

Name	RoF	Damage	1/2D Range	Max Range	Acc	SS
Spinal P-Beam, 250-GJ/8	1/60	5d×2,000	54,000/5	160,000/16	36	30
Spinal P-Beam, 420-GJ/8	1/60	6d×2,000	70,000/7	210,000/21	37	30
Spinal P-Beam, 670-GJ/8	1/60	7d×2,000	88,000/9	260,000/26	38	30
Spinal P-Beam, 1-TJ/8	1/60	8d×2,000	110,000/11	330,000/33	38	30
Spinal P-Beam, 670-GJ/9	1/60	6d×3,000	97,000/10	290,000/30	38	30
Spinal P-Beam, 920-GJ/9	1/60	5d×4,000	110,000/11	330,000/33	38	30
Spinal P-Beam, 1.8-TJ/9	1/60	5d×5,000	160,000/16	480,000/48	39	30
Spinal P-Beam, 3.1-TJ/9	1/60	6d×5,000	210,000/21	630,000/63	40	30
Spinal P-Beam, 569.5-GJ/10	1/60	7d×3,000	98,000/10	290,000/29	36	30
Spinal P-Beam, 870-GJ/10	1/60	6d×4,000	120,000/12	360,000/36	38	30
Spinal P-Beam, 1.7-TJ/10	1/60	6d×5,000	170,000/17	510,000/51	39	30
Spinal P-Beam, 2.7-TJ/10	1/60	7d×5,000	210,000/21	630,000/63	40	30
Spinal P-Beam, 530-GJ/11	1/60	6d×4,000	100,000/10	300,000/30	38	30
Spinal P-Beam, 840-GJ/11	1/60	7d×4,000	130,000/13	390,000/39	39	30
Spinal P-Beam, 1.6-TJ/11	1/60	7d×5,000	180,000/18	540,000/54	39	30
Spinal P-Beam, 2.8-TJ/11	1/60	7d×6,000	230,000/23	690,000/69	40	30



Spinal Mounts (Continued)

Name	RoF	Damage	1/2D Range	Max Range	Acc	SS
Spinal Meson Gun, 820-GJ/10	1/60	5d×3,000 (!)	98,000/10	290,000/29	38	30
Spinal Meson Gun, 1.4-TJ/10	1/60	6d×3,000 (!)	130,000/13	380,000/38	38	30
Spinal Meson Gun, 2.3-TJ/10	1/60	7d×3,000 (!)	160,000/16	480,000/48	39	30
Spinal Meson Gun, 3.4-TJ/10	1/60	6d×4,000 (!)	200,000/20	600,000/60	39	30
Spinal Meson Gun, 670-GJ/11	1/60	6d×3,000 (!)	97,000/10	290,000/29	38	30
Spinal Meson Gun, 1.1-TJ/11	1/60	7d×3,000 (!)	120,000/12	360,000/36	38	30
Spinal Meson Gun, 2.3-TJ/11	1/60	9d×3,000 (!)	180,000/18	540,000/54	39	30
Spinal Meson Gun, 3.1-TJ/11	1/60	6d×5,000 (!)	210,000/21	630,000/63	40	30
Spinal Meson Gun, 570-GJ/12	1/60	7d×3,000 (!)	97,000/10	290,000/29	36	30
Spinal Meson Gun, 870-GJ/12	1/60	6d×4,000 (!)	120,000/12	360,000/36	38	30
Spinal Meson Gun, 2.1-TJ/12	1/60	8d×4,000 (!)	190,000/19	570,000/57	39	30
Spinal Meson Gun, 2.9-TJ/12	1/60	6d×6,000 (!)	220,000/22	660,000/66	40	30
Spinal Meson Gun, 870-GJ/13	1/60	7d×4,000 (!)	130,000/13	390,000/39	39	30
Spinal Meson Gun, 2.3-TJ/13	1/60	8d×5,000 (!)	210,000/21	630,000/63	40	30
Spinal Meson Gun, 2.9-TJ/13	1/60	7d×7,000 (!)	240,000/24	720,000/72	40	30
Spinal Meson Gun, 3.4-TJ/13	1/60	6d×8,000 (!)	280,000/28	840,000/84	40	30

Missiles

Name	DR	HEAT Damage	KK Damage
250mm Missile/7	1	6d×60 (10)	–
250mm Missile/8	20	6d×60 (10)	–
250mm Missile/9	25	6d×60 (10)	6d×100 (5)
250mm Missile/10	40	6d×60 (10)	6d×100 (5)
250mm Missile/11	80	6d×80 (10)	6d×100 (5)
250mm Missile/12	120	6d×80 (10)	6d×100 (5)
250mm Missile/13	210	6d×100 (10)	6d×100 (5)

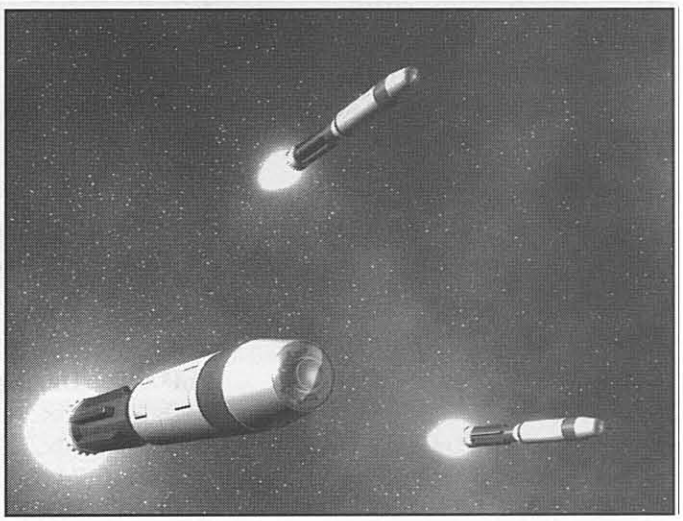
Name	DR	HEAT Damage	KK Damage
500mm Missile/7	1	5d×150 (10)	–
500mm Missile/8	60	5d×150 (10)	–
500mm Missile/9	65	5d×150 (10)	6d×300 (5)
500mm Missile/10	80	5d×150 (10)	6d×300 (5)
500mm Missile/11	300	6d×150 (10)	6d×300 (5)
500mm Missile/12	350	6d×150 (10)	6d×300 (5)
500mm Missile/13	400	6d×200 (10)	6d×300 (5)

Civilian Missiles

Name	DR	HEAT Damage	KK Damage
SIM-10 Missile	40	6d×60 (10)	6d×100 (5)
SIM-12 Missile	120	6d×80 (10)	6d×100 (5)

Deadfall Ordnance

Name	Damage	Skill	Cost
Lt. APDU SSM/10	6d×200 (3)	20	0.02
Lt. APSD SSM/11+	6d×240 (5)	23	0.02
Hv. APDU SSM/10	6d×200 (3)	20	0.10
Hv. APSD SSM/11+	6d×240 (5)	23	0.10
Lt. APDU GB/10	6d×310 (3)	20	0.03
Lt. APSD GB/11+	6d×340 (5)	23	0.02
Hv. APDU GB/10	6d×500 (3)	20	0.08
Hv. APSD GB/11+	6d×550 (5)	23	0.08
Lt. HEAT GB/10	5d×150 (10)	20	0.02
Lt. HEAT GB/11+	6d×150 (10)	23	0.02
Hv. HEAT GB/10	6d×200 (10)	20	0.07
Hv. HEAT GB/11+	6d×200 (10)	23	0.06



Notes

Abbreviations include *SSM:* Spike Submunition, *GB:* Glide Bomb, *APDU:* Armor-Piercing Depleted Uranium, *APSD:* Armor-Piercing Superdense, and *HEAT:* High Explosive Armor-Tapping. *Cost* is per complete missile. *Damage* is per missile for GBs, per submunition for SSMs. Each 250mm SSM carries seven submunitions, each 500mm 38. Also see pp. 52-54 for more information on how these function.

Nuclear Warheads: See p. 53 (and optionally, p. VE187) for damage and other considerations.

SATNUC Warheads: Each SATNUC submunition (seven per 250mm missile, 10 per 500mm) will attempt to attack a vehicle-sized target (size modifier +1 or more) within the burst radius of the round (1,300 yards for 250mm missiles, 3,400 yards for 500mm missiles). Each submunition rolls 3d vs. (warhead's TL + target's size modifier - IR cloaking) to hit. If successful, damage is 6d×2,000. Successful or not, all submunitions will explode on impact. Damage is 6d×200 to everything within the burst radius of the round, and 6d×20 to everything within twice its burst radius. Again, DR is squared against proximity blasts. (See p. VE193 for more information on SATNUCs.)

submersible option. Heavy compartmentalization in body. Roll stabilizers.

- **Hit Points:** Superstructure 876, Body 8,106.
- **Armor:** PD 4, DR 200 standard laminate.
- **Surface Features:** Basic chameleon system, basic sound baffling, electrified surface.
- **Vision:** No view. Vision is only available from the conning platform on the superstructure (if on surface) or via sensors.
- **Statistics:** Empty weight 47,201 pounds. Usual payload 8,879 pounds. Loaded weight 56,080 pounds (28.04 tons). Volume 3,500 cf. Submerged weight 218,750 pounds (109.38 tons). Size modifier +6. Price MCr2.416. Structural HT 12.
- **Water Performance:** Can float. Hydrodynamic drag 293. Aquatic motive thrust 72,000 pounds. Top speed 40 mph. wAccel 25 mph/s. wMR 0.75. wSR 6. wDecel 15 mph/s (27.5 mph/s). Draft 5.1 feet.
- **Submerged Performance:** Can submerge. Submerged hydrodynamic drag 363. Top speed 35 mph. uAccel 5 mph/s. Submerged draft 20 feet. Crush depth 8,400 yards.
- **Space Performance:** sAccel 1.3 G.

Starships

The Scout Fleet consists of an eclectic variety of highly specialized ships. These range from the *Suleiman*-class scout/courier and express boat, all the way up to *Ashanti High Lightning*-class frontier cruisers and *Kokirrak*-class dreadnaughts acquired as surplus from the Imperial Navy. This section covers some of the ships most likely to be encountered in IISS service.

New Modules

Scout Service ships have a number of special systems not often seen on merchant vessels or warships. In particular, the following types are referred to in the starship descriptions later in this chapter. The modules are described at TL12, but TL10 equivalents are given.

Communications Module: This module contains a single massive laser communicator, with 10 million miles transmission range (and 100 times that in reception). There are three hardened, high-capacity mainframe computers, 50 terabytes of hardened data storage with double backups, and an energy bank with enough capacity for five hours of full operation. The module is designed for high redundancy, with the three computers all checking each other's results and the three sets of data stored in different locations. The laser communicator is used for its very high bandwidth. Even with the usual high level of encryption and error-correction on the signal, the module can upload or download its entire storage capacity in about an hour. The module takes up 12 spaces. Mass: 138.1 tons. Cost: MCr3.830. Crew requirement: 0-1. The equivalent TL10 module has the same size and cost, but carries only 500 gigabytes of data.

Logistics Module: Starships intended for long-range operation need to be self-sufficient, able to manufacture their own spare parts from found materials. The logistics module contains two "complete" workshops, with all the tools needed for the Armoury, Electronics, Engineering, and Mechanic skills at the module's TL. Up to 6 people can work in the module at the same time. The module takes up 5 spaces. Mass: 30.0 tons. Cost: MCr0.12. Crew requirement: 0 (ship's engineers and support crew use the module on an occasional basis). The equivalent TL10 module has the same size and cost.

Probe Module: This module is designed for the launch and control of long-range probes (see p. 33). An IISS long-range probe is essentially a standard 0.15-ton missile, with the warhead replaced by some kind of instrument package. A probe module consists of three launch systems, each including a breech-loading launch tube, a very-long-range laser communicator, a computer terminal and a roomy crew station for probe control. There is storage space for 20 probes and 40 modular instrument packages. Depending on the exact load, a full complement of probes and modules would mass about 3 tons and cost about MCr2. The module takes up 1 space in the ship. Mass: 1.2 tons (empty). Cost: MCr0.033 (empty). Crew requirement: 0-3. The equivalent TL10 module has the same size and cost, although different probes may be used.



Survey Module: A survey module contains four sets of astronomical instruments, four high-resolution planetary survey arrays, a mainframe computer, eight roomy crew stations with computer terminals, and a "survey center" with sophisticated holographic-projection devices (built as a 100-sf "holoventure zone"). This allows the survey specialists to create visualizations of incoming data. Use of the survey module is detailed in Chapter 7. The module takes up 4 spaces in the ship. Mass: 5.4 tons. Cost: MCr7.63. Crew requirement: 4-8. The equivalent TL10 module masses 7.4 tons and costs MCr12.66.

Armor	F	RL	B	T	U
Body:	6/16,000 L	4/6,000 L	4/6,000 L	4/6,000 L	4/6,000 L
Tur:	4/16,000 L	4/6,000 L	4/6,000 L	4/6,000 L	
Cup:	6/16,000 L	4/6,000 L	4/6,000 L	4/6,000 L	

Weaponry

2×190mm Tactical ML [Tur:F] (18 each) +2.
4×511-MJ Light Fusion Gun [Tur:F] (64 each) +2.
2×PD Xaser [Cup:F] (388 each) +2.

Equipment

Body: Advanced Avionics, Airlock, 19 Heavy Energy Banks, Safety, 2×HUDWACs. *Tur:* Large AESA, Large PESA. *Cup:* Discharger Pack w/ 20 reloads, 14 Heavy Energy Banks, Large AESA, Large PESA, 3×Small PESAs (R, L, B), HUDWAC.

Statistics

Size: 12′×10′×15′ *Payload:* 4.1 tons *Lwt.:* 203.5 tons
Volume: 3.5 dtons *Maint.:* 4.3 hours *Price:* MCr22.7

HT: 8 *HP:* 3,600 [Body] 2,400 [Tur] 1,500 [Cup]

aSpeed: 600 *aAccel:* 4 *aDecel:* 16 *aMR:* 4 *aSR:* 5
CG lift 2.3 Gs.

Design Notes

Frames are extra-heavy for 2-dton sloped body, 1-dton turret, and 0.5-dton sloped cupola. Fusion plant is Core plus 30 Power. Base price is MCr21.4 prior to purchasing typical missile load described in main text. Missiles are all stored in the turret.

STARSHIPS

Delivering the troops to the fight is one of the most difficult tasks that the Navy faces. To help accomplish this mission, the Navy operates specialized troop transports.

Note that the following troop complements assume a war footing. The troops (and, for that matter, the Navy crews) will be crammed elbow to elbow, clearing just enough space for some exercise and training areas that must be carefully rotated among the platoons and squads.

In peacetime or for long patrols, two to four times as many transports would be used for the same number of troops.

NEW STANDARD MODULES

These modules are used in the following ships, but are not described in ***GURPS Traveller***. Many debuted in other ***GURPS Traveller*** supplements.

Brig: This is an ordinary stateroom equipped with reinforced walls and door (DR 200), restraints, and a high-security alarm and observation system. It normally holds 1-2 people. Up to 50 could be crammed in for a limited time, but this will overwhelm the two-person life support. A ship or starport with one or two brigs usually will monitor them from the bridge. A larger number of brigs probably will have its own dedicated security station.

Bunkroom: Bunks for 16 personnel, with life support, under very cramped conditions. Imperial protocol is to load only four passengers per bunkroom, except for missions of very short duration or emergencies.

External Cradle: These are placed on the hull of a starship or starport. Each module clamps 125 standard tons of another vehicle onto the hull. Modules can be combined to form larger cradles, or installed in 0.5-displacement ton increments for smaller versions. Vehicles carried this way aren't counted against the ship's internal spaces, but must still be included in any jump-drive requirements. They are not protected by the ship's armor.

Gym: An exercise room. Several may be fitted together to form a single, larger facility.

Hall, Bar, or Conference Room: A large room with tables. Usable as a restaurant, bar, conference room, etc. It can comfortably accommodate 100 people per module (smaller lounges and conference rooms are included in stateroom volume). Weight and cost include furnishings.

Morgue: Space for 20 battledress suits and accessories such as flight packs, with room for maintenance and loading.

Shooting Range: A target practice facility, armored so as to protect the rest of the ship, and including pop-up targets and the like. Each module provides 50 downrange yards for eight shooters; several may be combined for longer ranges or more shooters.

Stage: A 20′×20′ stage area with high ceilings, usable for dancing, plays, nightclub acts, and so on. Includes sophisticated lighting and sound systems. Normally attached to a hall or theater containing the audience.

MODULES

Type of Module	Spaces	Mass	Cost (MCr)	Crew
Brig (1-2 occupants)				
TL10	4	11.4	0.052	†
TL12	4	5.6	0.03	†
Bunkroom				
TL10	4	4.8	0.018	0
TL12	4	1.92	0.018	0
External Cradle	1*	12.5*	0.25*	0
Gym	2.5	0.5	0	0
Hall, Bar, Conference	10	0.2	0.003	†
Morgue	1	28.75	0	0
Shooting Range	10	10	0.15	†
Stage	16	0.5	0.004	†
Tactical Command Center	4	3	2.8	†
Theater	20	2.1	0.015	†

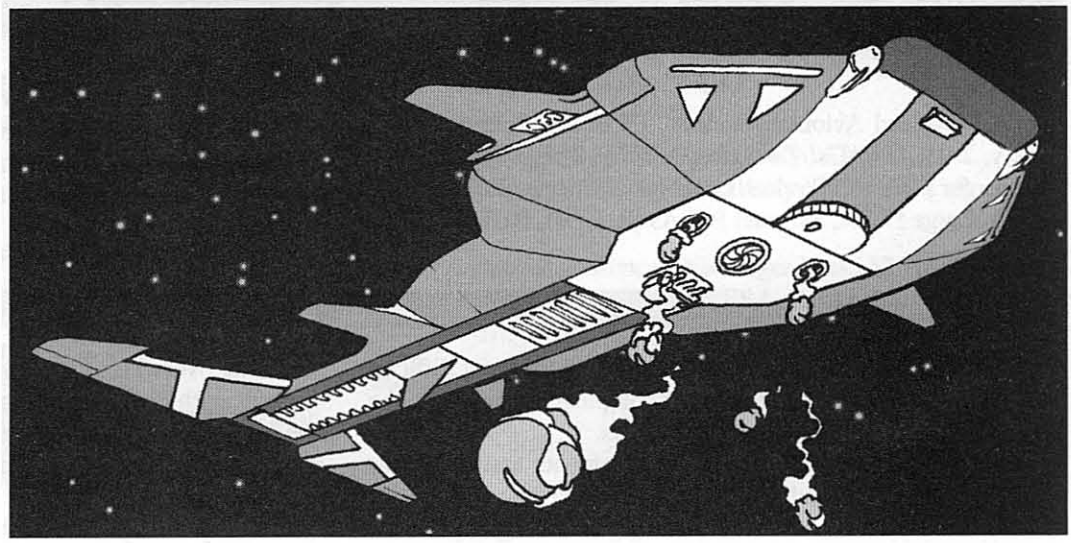
* per 125 standard tons of ship to be carried. External cradles count against the turret-mounted weapons limit at a rate of 3 modules per 1 turret.

† varies and/or GM's discretion. Many of these modules are passenger services, and usually the GM can safely rule that a military ship's standard complement fills the crew needs.

Tactical Command Center: TL12 operations room for 10-20 people. Includes fire direction center with mapping and display tables, dozens of cameras for video conferencing, and hardened Complexity 8 macroframe and 10 terminals.

Theater: A small auditorium with 100 roomy seats, a large holoprojector, and an operator's workstation. Can be used for entertainment or as a briefing or situation room. A stage is not included.

Keith-Class 30,000-ton Transport (TL12)



These giant vessels received their baptism of fire in the Fifth Frontier War, and performed far beyond all expectations. Shipyards are turning out new *Keiths* on a regular schedule, and the High Command hopes to be able to drastically reduce the Army's reliance on the older classes of cold-sleep "reefer" transports.

The heart of the transport is the mammoth central core, almost 900' long. Each of these huge transports can ferry a complete Army light infantry brigade, or a grav tank brigade and a rapid interface battalion.

All but one grav tank battalion of the brigade's vehicles are preloaded onto the transport's *Nakerkh* landers (see p. 97). The *Keith's* spacedock contains room for that grav tank battalion and any one other battalion's vehicles, in case some sort of mid-flight loading adjustment need be made (see below). Often this extra spacedock capacity is used to carry extra supplies.

Imperial doctrine calls for the *Keith* to close to within high orbit of the target world. When carrying a light infantry brigade, the six externally carried landers then disengage and begin a very high-speed descent with the command, three infantry, artillery, and support battalions. The grav tank squadron descends on its own power, since each *Intrepid* is a smaller, tougher target than a *Nakerkh*. When carrying a grav tank brigade, the non-armor battalions descend normally. The brigade commander decides whether to deploy the two *Nakerkh*-loaded grav tank squadrons rapidly in the landers or more safely in the usual dispersed fashion (by simply deploying from the still-moored lander in orbit). The third armor squadron must deploy on its own (or wait to board a returning lander).

Certain circumstances require deploying the landers farther out. In these cases, the undeployed armor squadron waits for a returning lander (or the brigade commander may choose to delay the landing of another battalion, often his support unit).

Keiths are crowded when filled with a full brigade, but the troops have space to train and prepare for their assignments.

The crew includes the captain, pilot, navigator, three sensors operators, three communications specialists, computer officer, 145 engineers, 21 medics, 125 gunners, and 80 frozen watch; the total of 210 staterooms houses up to 395 additional officers and the 230 bunkrooms house up to 3,398 additional NCOs and enlisted.

The *Keith*-class transport features heavy compartmentalization, sealed body, basic stealth, and basic emission cloaking.

Subassemblies: USL Hull +14, 120 Turrets +5, 3 Bays +7.
P&P: 5,100 Maneuver, 1,500 Jump.
Fuel/End: 12,000 Fuel.
Occ: See above. **Cargo:** 6,000 dtons.

Armor	**F**	**RL**	**B**	**T**	**U**
All:	4/2,500	4/2,500	4/2,500	4/2,500	4/2,500

Weaponry

100 Turrets w/ 3×Lasers (1 each) +2.
20 Turrets w/ 3×Sandcasters (200 each) +2.
3×Meson Gun Bays (1 each) +2.

Equipment

Modules: Hardened Command Bridge, Engineering, 30 Low Berths (120 tubes), 60 Utility, 20 Sick Bay, 4 Drop Capsule Launchers, 50 Capsule Racks (800 capsules), 120 Morgues (2,400 battledress suits), 2 Conference Rooms, 4 Stages, 10 Theaters, 5 Shooting Ranges, 7 Tactical Command Centers, 15 Gyms, 1,200-ton Spacedock (holds 600 dtons), 110-space Vehicle Bay (for 2 launches and 3 ship's boats), 926-space Meson Screen (DR 40,506), 10 Nuclear Dampers. *Hull:* 6×9,250-ton external cradles.

Statistics

Dim.: 125'×125'×960' *Payload:* 77,003 tons *Lwt.:* 163,581 tons
Volume: 30,000 dtons *Maint.:* – *Price:* MCr9,618

HP: 540,000 [Hull] 1,200 [each Tur] 9,750 [each Bay]

sAccel: 3.12 Gs/5.89 Gs empty *Jump:* 4 *aSpeed:* –

Design Notes

Data is for ship loaded with grav tank brigade. Lift infantry brigade is Lwt. 157,332, sAccel 3.24 Gs. Price does not include small craft or landers.

Grav Vehicle Modular Design

Sternmetal Horizons grav vehicle dealerships Imperium-wide are pleased to offer our innovative "Vehicle Builder" program where you design the customized Sternmetal Horizons grav vehicle of your choice. Select from an array of pre-designed component plug-ins and let Sternmetal's autofacs do the rest! Your custom-built modularized vehicle ready within 48 hours. (Some exceptions for large or milspec orders. Inquire first.)



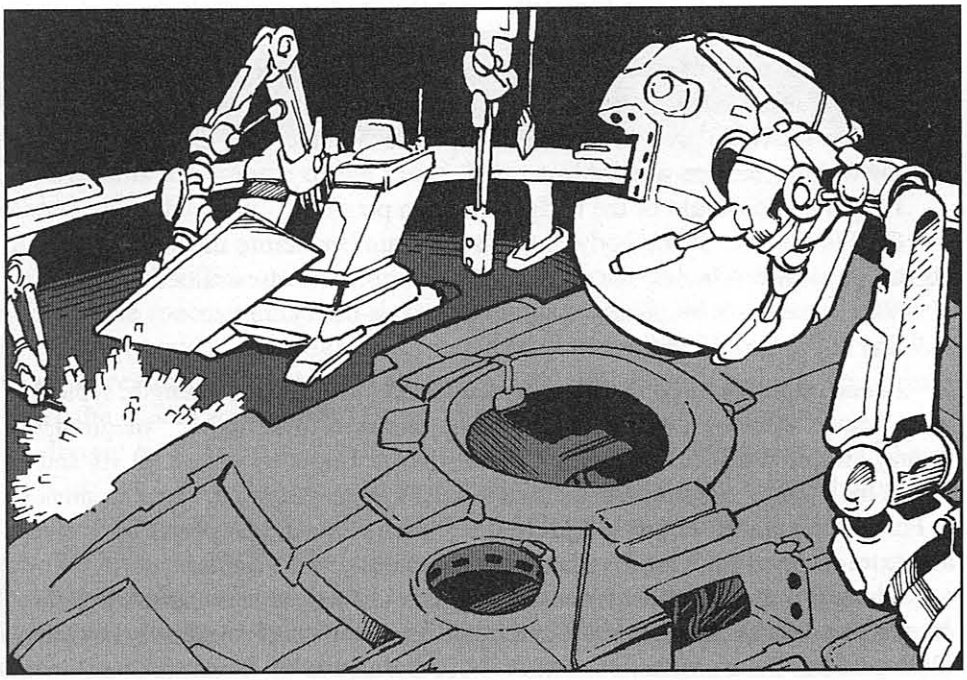
Design Sequence

This design system provides rules for the modular design of grav vehicles at TL9 to TL12, using a method similar to that of the starship design rules in ***GURPS Traveller.*** It is not intended to replace the far more detailed rules found in ***GURPS Vehicles***. Instead, the design rules presented here represent a simplification of ***GURPS Vehicles*** optimized for the ***Traveller*** setting.

To design a vehicle, follow the steps below and the instructions in each step, noting down design choices and keeping track of the cumulative weight (in lbs.), cost (in KCr, units of thousands of credits), and power requirements (in kilowatts, or kW).

Step 1: Concept and Tech Level

Decide what the purpose of the vehicle will be, and whether it will be built at TL9, TL10, TL11, or TL12.



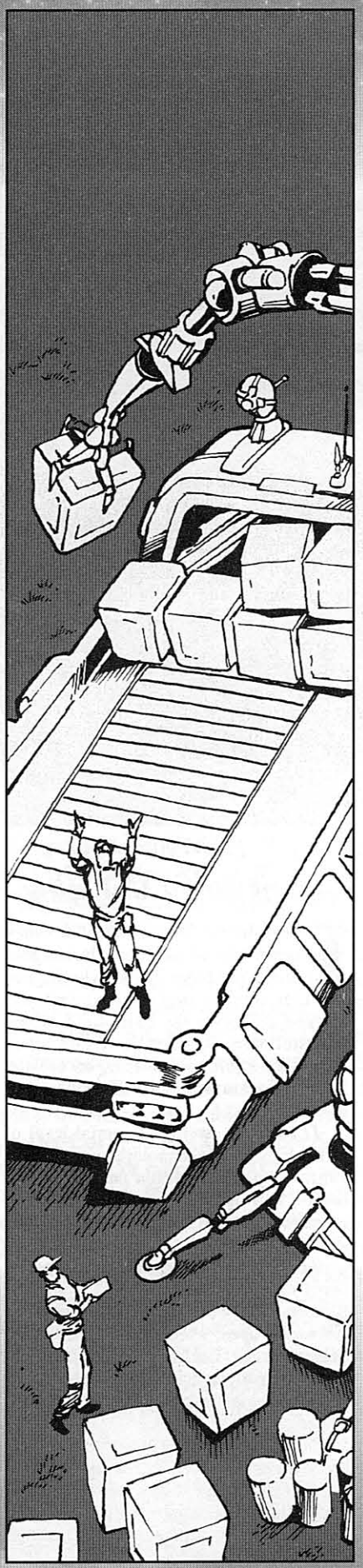
TL of Grav Vehicles

TL9 is the earliest tech level at which modern grav armor is mass-produced, and the TL at which grav vehicles replace most helicopters and tracked AFVs on the battlefield. Some interstellar mercenary units and many PDFs are equipped at TL9, as are the Sword Worlds and some Zhodani Army units.

TL10 is the average Imperial level of technology. New technology used in grav vehicles includes meson comms, X-ray lasers, and nuclear dampers. Most star merc forces are TL10, as is most of the Zhodani Army.

TL11 is an above average Imperial level of technology. At TL11, sensor, thruster, and fusion-power technology reaches its apex, while fusion guns replace plasma guns. The majority of Imperial Army formations are equipped with TL11 vehicles, as is the elite Zhodani Consular Guard.

TL12 is the peak of Imperial technology. Meson accelerators are now small enough for practical use in artillery grav vehicles. The Imperial Marines and a few Imperial Army units are equipped at TL12.



Step 2: Vehicle Body

First, pick one of these three configurations:

Normal: An ordinary vehicular body, typical of grav trucks, air/rafts, and some light armored vehicles.

Sloped: Body with radical front sloping, typical of the majority of grav tanks and grav APCs.

Streamlined: Body with very good streamlining, typical of speeders, fast-attack sleds, and sub-orbital interceptors.

Then select the body size from the table below. Size is given in displacement tons (dtons). As a rough guide, most air/rafts and grav cars are 0.1 to 0.5 dtons, a typical utility grav truck or g-carrier is 0.5-2 dtons, a light tank or APC is 0.5-1.5 dtons, a medium tank or APC is 2-4 dtons, while a heavy APC or tank is 6-15 dtons. Sizes can *substantially* decrease as TL advances (components get smaller).

VEHICLE BODYS

			weight						
DTons	Area	VSP	TL9	TL10	TL11	TL12	Cost	HP	Size
0.1	100	10/8	600	400	300	200	25/50	600	+2
0.15	125	15/12	750	500	375	250	31.25/62.5	750	+2
0.2	150	20/16	900	600	450	300	37.5/75	900	+2
0.3	175	30/24	1,050	700	525	350	43.75/87.5	1,050	+3
0.5	250	50/40	1,500	1,000	750	500	62.5/125	1,500	+3
0.7	300	70/56	1,800	1,200	900	600	75/150	1,800	+4
1	400	100/80	2,400	1,600	1,200	800	100/200	2,400	+4
1.5	500	150/120	3,000	2,000	1,500	1,000	125/250	3,000	+4
2	600	200/160	3,600	2,400	1,800	1,200	150/300	3,600	+4
3	800	300/240	4,800	3,200	2,400	1,600	200/400	4,800	+5
4	1,000	400/320	6,000	4,000	3,000	2,000	250/500	6,000	+5
5	1,200	500/400	7,200	4,800	3,600	2,400	300/600	7,200	+5
6	1,500	600/480	9,000	6,000	4,500	3,000	375/750	9,000	+5
10	2,000	1,000/800	12,000	8,000	6,000	4,000	500/1,000	12,000	+6
15	2,500	1,500/1,200	15,000	10,000	7,500	5,000	625/1,250	15,000	+6

Volume is the volume in cubic feet.

DTons is the volume in starship "displacement tons" (spaces) of 500 cf. Thus, a 0.5-dton vehicle has a volume of 250 cubic feet.

Area is the surface area in square feet.

VSP is the number of "vehicle spaces" of components that can be installed. The number after the slash applies to streamlined or sloped vehicles, which have less usable internal space. One VSP is equal to 5 cubic feet, exactly 1% of the volume of a "space" on a starship.

Weight is the weight of the body's frame in pounds.

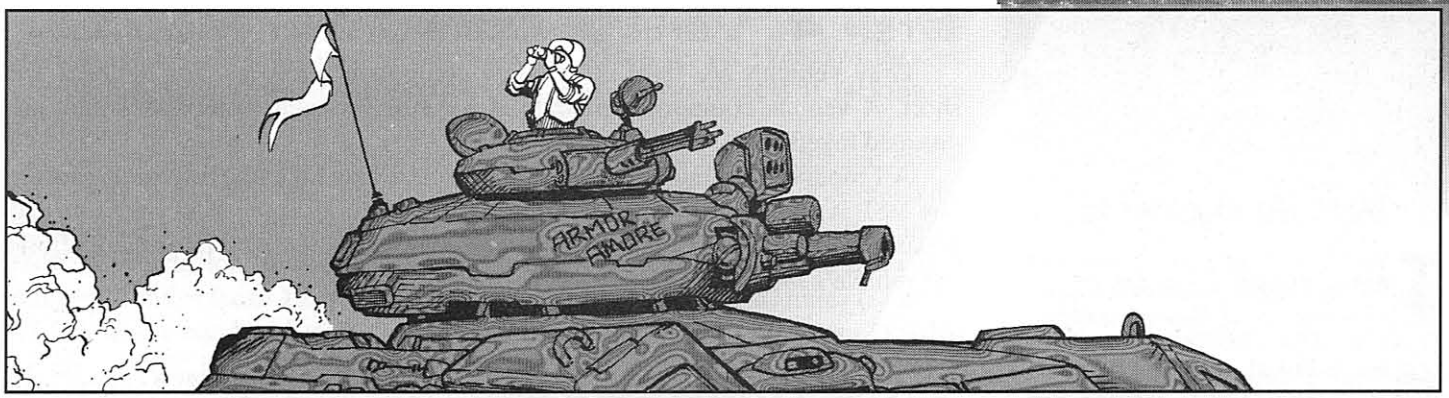
Cost is the cost of the body, in KCr. The number before the slash applies to normal or sloped vehicles; the number after it applies to streamlined vehicles.

HP are the body hit points, assuming an extra-heavy frame.

Size is the Size Modifier of the body.

Frame Options: The table assumes an extra-heavy frame strength, typical of most heavy tanks and APCs. This may be changed to a "light," "medium," or "heavy" frame if desired. For a light frame, divide weight by 4, cost by 10, and hit points by 8. For a medium frame, divide weight by 2, cost by 5, and hit points by 4. For a heavy frame, divide weight by 1.5, cost by 2.5, and hit points by 2. Heavy and extra-heavy frames are very common in grav armored vehicles.

Compartmentalization: For extra weight and cost, vehicles can have "heavy" compartmentalization (masses 10% of body mass) or "total" compartmentalization (20% of body mass). Either costs KCr 0.005 per pound of weight added. A compartmentalized vehicle is harder to depressurize and less vulnerable to fires.



Step 3: Add a Turret

A turret is optional, but is useful for mounting weapons or sensors. Several turret sizes are available. Select one or more turrets, but all turret volumes combined must be smaller than the body volume.

Decide whether the turret is attached to the top or underside of the vehicle. (A turret may be mounted atop another larger turret; the upper turret is then known as a cupola.) Turrets of 0.05 dton or larger size may also be *sloped*, sacrificing volume for an angular front face offering better defense.

VEHICLE TURRETS

			weight						
DTons	Area	VSP	TL9	TL10	TL11	TL12	Cost	HP	Size
+0.01	18	1	108	72	54	36	4.5/9	108	0
+0.02	30	2	180	120	90	60	7.5/15	180	0
+0.05	60	5/4 (-1)	360	240	180	120	15/30	360	+1
+0.1	100	10/8 (-2)	600	400	300	200	25/50	600	+2
+0.15	125	15/12 (-3)	750	500	375	250	31.25/62.5	750	+2
+0.2	150	20/16 (-4)	900	600	450	300	37.5/75	900	+2
+0.3	175	30/24 (-6)	1,050	700	525	350	43.75/87.5	1,050	+3
+0.5	250	50/40 (-10)	1,500	1,000	750	500	62.5/125	1,500	+3
+0.7	300	70/56 (-14)	1,800	1,200	900	600	75/150	1,800	+4
+1	400	100/80 (-20)	2,400	1,600	1,200	800	100/200	2,400	+4
+1.5	500	150/120 (-30)	3,000	2,000	1,500	1,000	125/250	3,000	+4
+2	600	200/160 (-40)	3,600	2,400	1,600	1,200	150/300	3,600	+4
+3	800	300/240 (-60)	4,800	3,200	2,400	1,600	200/400	4,800	+5
+4	1,000	400/320 (-80)	6,000	4,000	3,000	2,000	250/500	6,000	+5
+5	1,200	500/400 (-100)	7,200	4,800	3,600	2,400	300/600	7,200	+5

DTons is the volume of the turret. It is expressed as an addition to the displacement of the body.

Area is the area of the turret in square feet.

VSP refer to the spaces available in the turret. The number after the slash refers to the spaces available if the turret was sloped. The number in parenthesis is the spaces which are *subtracted* from the body for the turret rotation mechanism. *Exception:* in the case of a cupola, subtract spaces from the turret atop which the cupola is mounted.

Weight by TL is the weight of the turret in pounds, varying at different TLs.

Cost is the cost of the turret on an unstreamlined or sloped vehicle before the slash, or cost on a vehicle that is streamlined after the slash.

HP is the hit points of the turret.

Frame: As with the body, the turret is assumed to have an extra-heavy frame, but can be given a light, medium, or heavy frame to reduce weight and cost, at the expense of fewer hit points. Multipliers to weight, cost, and hit points are identical; see p. 108.

Vehicle Crew Requirements

A grav vehicle in combat should have the following crew (civilian needs will vary, of course):

Pilot: A vehicle requires one pilot with Piloting (Contragrav) skill. On vehicles with only one crew member, he may also act as gunner and commander, but will usually be too busy to be completely effective.

Commander: Most combat vehicles have a commander, who is in charge of the vehicle. Useful skills are Tactics and Leadership; the commander usually also handles sensors and communications using Electronics Operation (Sensors) and (Communications) and may act as gunner for a secondary weapon.

Gunner: An armed vehicle should have one gunner per weapon intended to be used simultaneously. Note that vehicles may have multiple weapons, but only use a couple at a time. The relevant skill usually is Gunner.

Less common crew requirements include:

Fire Direction Centers: A vehicle with an FDC should carry two fire-control officers per battery it will coordinate at once. They need Electronics Operation (Communications) skill.

Medics: Ambulances (vehicles with stretchers and/or ESUs) will usually have one or more often two medics assigned to them. The most useful skills are Diagnosis, First Aid, and Electronics Operation (Medical).

Nuclear Damper Operator: A vehicle with a nuclear damper should have one damper operator with Electronics Operation (Force Shields) skill.

Workshop Technicians: Vehicles with a workshop should have one mechanic or technician per workshop module, with appropriate skills. Otherwise, technicians are rarely necessary as (unlike starships) grav vehicles usually operate near garages or logistics bases. Even so, military vehicle crews often have modest skill levels in Armoury, Electronics Operation, and Mechanic skill to perform routine maintenance.

Vehicle Systems

This section provides additional details of some avionics, sensor, and crew/passenger module components.

AESA, PESA, Radscanner: These sensors are described on p. GT162. Aside from being shorter ranged, vehicular sensors are identical. Ranges of AESA and PESA sensors are multiplied by 10 if used to detect targets in space. Note that if AESAs (active sensors) are turned on, they can be used as range finders and provide a +2 bonus to hit.

Computer: All vehicles incorporate computers and computer terminals for each crew member. See p. GT161 for computer rules. Basic avionics systems do not use *hardened* computers; they are vulnerable to electromagnetic pulse from nuclear weapons. See ***GURPS Space*** or ***GURPS High-Tech*** for EMP rules.

Crashweb: An advanced "smart" airbag that reduces whiplash damage suffered by seated vehicle occupants involved in crashes or collisions, providing an effective DR equal to its TL against such damage. An activated crashweb will prevent the user doing anything until he gets free (DX-2 roll to do so each turn). If a collision is expected and the occupant is not worried about surviving it, he can turn off the crashweb.

Full Life Support: Provides air, water recycling, and temperature control (but not food) for as long as the vehicle has power.

GPS: A global positioning system receiver, designed to receive real-time satellite navigation data from friendly GPS satellite constellations (if any have been installed). Normal version accurate to +/-25 yards, military version to +/-5 yards.

IFF: An "identify friend or foe" system intended to prevent fratricide, warning the user if he is targeting or detecting a friendly target (provided that individual or vehicle has IFF as well). Brilliant missiles and drones are normally programmed to attack anything that does not give a proper IFF response.

Inertial Navigation System: Gyroscopic system used for "blind" navigation and fixing the vehicle's position. Adds (TL-2) to Navigation skill.

Continued on next page . . .

Step 4: Vehicle Component Modules

Grav vehicles are built in "vehicle component modules," or modules for short. A vehicle component module is a set of vehicular components that are grouped together.

All modules are rated for the internal space they take up (in vehicle spaces; one VSP is 5 cubic feet), along with their weight (in pounds), cost (in KCr), and power (in kW). Select precisely a number of modules with a total space that fills the vehicle's internal space.

Internal Space

A vehicle's internal space is equal to the vehicle body's VSP (minus any subtraction for turret rotation). In addition, components may also be placed in turrets/cupolas, which have their own VSP. If the vehicle has one or more turrets or cupolas, be sure to note which components are there, rather than in the body.

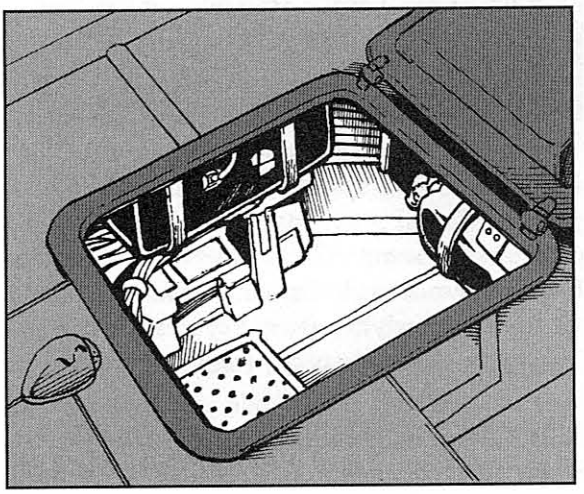
Required Modules

Certain modules are required for all vehicles. Specifically, every vehicle must take one or more Crew or Exposed Crew modules, one or more Thruster (or Ducted Fan) modules, and one or more Light, Medium, Heavy, or Extra Heavy CG modules. Vehicles must also have sufficient power modules (NPU Core, NPU Power, or Fusion Power) to power their other modules.

Lift: Grav vehicles are buoyed up by contragravity (CG) systems, allowing them to fly without wings or rotors, regardless of a planet's atmosphere or lack of one. CG modules are rated for how much *lift* they provide. To fly, the vehicle's final loaded weight (its basic weight in 1 gee times the local gravity) must not exceed contragrav lift. For most civilian vehicles, a single Light CG module is more than enough to ensure all necessary lift in most gravities, but if a great deal of armor or heavy cargo is added, a vehicle may need one or more Medium, Heavy, or Extra-Heavy CG modules.

Module Descriptions

These modules are commonly installed in grav vehicles. (For more details of Avionics and Crew/Passenger modules, refer to the *Vehicle Systems* sidebar).



Advanced Avionics: Instruments and electronics typical of heavy grav tanks or command vehicles. It includes computerized controls and three hardened microframe computers (complexity of TL-4), one scrambled extreme-range radio, four scrambled long-range radios, four long-range laser comms, and (at TL10+ only) one medium-range meson comm. Navigation systems are two terrain-following radars, a military global positioning system (GPS), two inertial navigation systems, and two IFFs. Sensors consist of a band of four PESAs with 5-mile range (scan 15) around the vehicle and a radscanner with range of 100 miles (scan 23, TL9), 200 miles (scan 25, TL10), or 1,000 miles (scan 29, TL11+).

Airlock: A pressurized chamber sealed with hatches or iris valve large enough for one man to enter or exit without spilling its air. (Vehicles that are compartmentalized will only depressurize part of the vehicle if lacking an airlock.)

Basic Avionics: Instruments and electronics typical of air/rafts and utility grav sleds. It has computerized controls, a mini computer with TL-5 complexity, a long-range radio, a terrain-following radar, a transponder, a GPS, and a radar/laser detector. Sensors are a low-res imaging radar (non-targeting) with a range of 5 miles (scan 15, TL9), 10 miles (scan 17, TL10), or 20 miles (scan 19, TL11+) and a band of four PESAs around it with a range of 0.5 miles (TL9-10) or one mile (TL11+).

Cargo: Five cubic feet of cargo space. Multiple cargo modules can be combined to form a single larger cargo hold. Cargo modules with fractional spaces are also possible.

Crew: A crew station is necessary for each desired crew member. It includes a roomy seat (cramped if used by someone in battledress) with a crashweb, and a computer terminal. It is enclosed within the vehicle and has life support (one man-day's worth at TL9-10, indefinite at TL11+).

Diagnosis Table: A computerized table equipped with scanners that adds +5 (TL9) or +6 (TL10+) to a medic's Diagnosis skill when examining a patient lying on it.

Discharger Pack: A pack of five dischargers for defensive launch of smoke, hot smoke, anti-laser "prism" aerosol grenades, or decoys such as chaff. Additional Reload Packs may be carried with 20 reloads. Effects are identical to the appropriate warheads (see sidebar, pp. 116-117); the grenades can be fired to burst at a point within 20 yards, affecting a burst radius of 20 yards for smoke/hot smoke/prism or 100 yards for chaff.

Drone Missile Bay: A small vehicle bay for launch of contragrav drone missiles (see sidebar, p. 123).

Ducted Fan: A low-tech alternative to reactionless thrusters, this is a vectored-thrust ducted fan assembly similar to that used in hovercrafts. It generates 1,500 lbs. (0.75 tons) of vectored thrust. It is only effective in a thin (or denser) atmosphere. It is sometimes used at TL8-9 in preference to reactionless thrusters for vehicles that do not have to operate in all planetary environments.

ESU: An emergency support unit capable of sustaining life in one mortally wounded stretcher casualty. (See p. VE68 for detailed rules.) Requires a Stretcher module.

Exposed Crew: A crew station is necessary for each desired crew member. This includes a roomy seat (cramped if someone in battledress is using it) with a crashweb, and a computer terminal. It is in an open-topped compartment exposed to the elements with partial side and no overhead cover.

Exposed Passenger: A roomy passenger seat (cramped for battledress) for one person in an open compartment (see *Exposed Crew*, above).

External Cradle: A large exterior grapple for attaching other craft to the exterior of the vehicle. The cradle is sized per ton of loaded mass of the other craft, so to carry a 5-ton vehicle, mount five external cradle modules. Do not forget to include the weight of the carried craft in the final loaded weight of the vehicle!

Extra Life Support: Increases the duration of the limited life support in the TL9-10 crew and passenger modules. Each Extra Life Support module adds 2.5 man-days of life support at TL9, or five man-days at TL10. Not needed at TL11+.

Extra-Heavy CG: A very powerful contragravity unit (suitable for a heavy grav tank) with 480,000 lbs. (240 tons) of lift.

Vehicle Systems

[Continued]

Laser Comm: A line-of-sight laser communicator; see p. GT160.

Limited Life Support: If the vehicle is sealed up, this system provides air for one man-day per crew or passenger module so equipped. (For example, if a vehicle has two crew and six passenger modules, it would have eight man/days of air, enough for one person to breath for eight days, or 16 people to breathe for 12 hours).

Low-Res Imaging Radar (no targeting): A radar capable of discerning and displaying the general shape of an object detected. It works like an AESA functioning in radar mode. It does not provide a targeting bonus for weapons.

Meson Comm: A meson communicator; see p. GT160.

Radio: A radio communicator. A long-range radio has (at TL10+) a 500,000-mile range, a very-long-range radio has 5 million-mile range, while an extreme-range radio has a 50 million-mile range. Radio use can be detected and located via radscanner; vehicles often transmit on lower-power, shorter-range settings as a result. *Scramblers* are transmission encryption systems (basically unbreakable at TL9+). A scrambled radio signal can still be detected, but its content is unknown.

Radar/Laser Detector: Warns if vehicle is being scanned by radar or ladar (from AESA) at up to twice the system's range, but, unlike a radscanner, does not locate the scanning system.

Terrain Following Radar: A radar or ladar that is slaved to altitude controls, assists the pilot in flying at high speed just above the ground without accident or fatigue. The ladar/radar pulses are very short range and (unless someone is directly below the vehicle) will not be detected by radscanners.

Transponders: An electronic beacon. If turned on, it automatically identifies the vehicle to allied civilian traffic-control systems or military sensors.

Gunnery Made Easy

A grav armor gunner firing at a target will have a *lot* of modifiers. To prevent play bogging down as the player or GM adds everything up, it is a good idea to calculate each gunner's adjusted skill beforehand with the weapons they are likely to use. Adjusted skill should be recorded as two numbers separated by a slash: the first for snap shots, the second for aimed shots. For snap shots, adjusted skill is equal to Gunner skill plus any bonus for Targeting programs used. For aimed shots, adjusted skill is equal to the snap shot adjusted skill plus half the weapon's Acc bonus (which may not exceed the gunner's base skill before targeting programs are added).

Accuracy is halved to reflect battlefield realities, as described on p. VE182. This can be ignored, if desired.

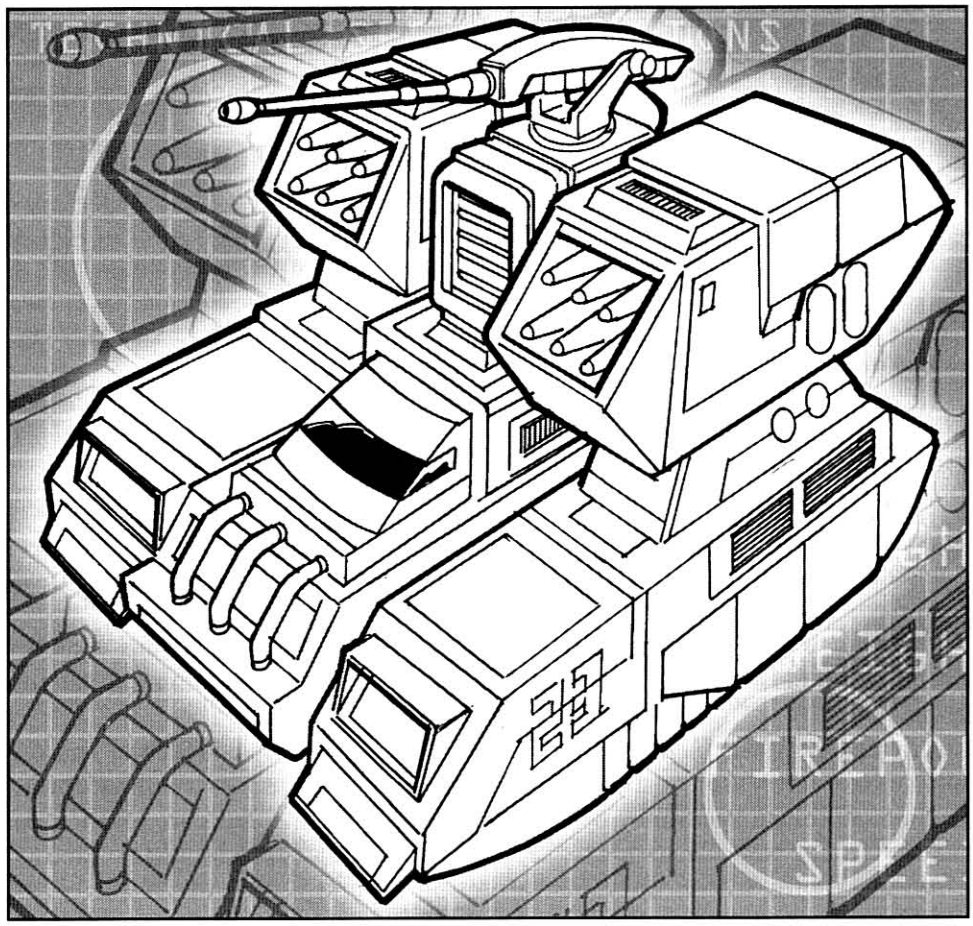
Example: *Sergeant Vlad Yakovich is a gunner on the Ace of Swords, a grav tank. He has Gunner (Beams)-14. Using the tank's 945 MW plasma cannon (Acc 24) and targeting program bonus (+7) his adjusted skill when firing a snap shot is 14 (skill) +7 (program) = 21. With an aimed shot, it is 21 + the Accuracy bonus. The plasma cannon has Acc 24, halved to 12; this Acc does not exceed Vlad's basic skill 14, so added to 21 it gives an adjusted skill of 33. Record this as (945 plasma) 21/33.*

Battlefield Scale

Various grav tanks can fly at 600 mph and feature weapons that can reach out to destroy targets miles away. For this reason, neither the one yard to a hex scale suggested in ***Basic Set*** nor the 5 yards/hex scale for ground vehicle combat (see ***GURPS Vehicles***) are easy to use. GMs are encouraged to either use abstract resolution (keeping track of ranges and locations on paper or in their heads) or to adopt a larger scale if using a hex grid.

As an alternative, a suggested hex map scale of 50 yards to a hex is recommended. At this scale, a small platoon level action can be played out on three or four ordinary ***GURPS*** hex grid maps (such as those included with the ***Basic Set.***). If using large-scale maps for combat, remember that ***GURPS*** is not a war game, and the emphasis should always be on the actions of the PCs. The GM should describe events from the perspective of the player-characters – use hex maps as spatial aids, not as a substitute for graphic description of what the troopers sense, hear, smell, and see.

If utilizing a 50-yard hex in combat, a quick way to calculate ranges is to mentally knock off two zeros, then double the remainder. Thus, a weapon with 1/2D range of 700 yards becomes 1/2D range 14 hexes.



FDC: A fire direction center with specialized map displays and systems for coordinating artillery fire. Adds a +4 bonus to any indirect fire plotted through it. An FDC requires minimum crew of two per battery it directs. Install the crew modules in addition to the FDC.

Fusion Core: The heart of a fusion reactor. It does not generate power, but one Fusion Core is a necessary prerequisite for installing any number of Fusion Power modules. The fusion reactor will function for 200 years on internal fuel.

Fusion Power: Generates 125 kW (TL9) or 625 kW (TL10+) of power output. The vehicle must have a reactor core, but only needs one such core regardless of how many Fusion Power modules are installed.

Heavy CG: A powerful contragravity unit with 230,000 lbs. (115 tons) of lift, suitable for a medium tank or APC.

Heavy Energy Bank: A set of 25 rechargeable E power cells storing 6,750 megawatt-seconds (MWS) at TL9, 9,000 MWS (TL10), 11,250 MWS (TL11), or 13,500 MWS (TL12). One MWS is 1,000 kWS.

Jammer: A battlefield or tactical-area electronic warfare device, this module affects a 60-mile radius and subtracts 12 from all rolls for radio communication and radar (not ladar) detection or lock-ons in the area, whether by friend or foe. It is only effective vs. radars of equal or lower TL. Location of the jamming field (but not what is in it) is detected automatically by any radar within 20 times the jamming range.

Large AESA: An active electromagnetic sensor array with active targeting (+2 bonus to hit) and search radar, imaging radar, and ladar capabilities – see p. GT161. The AESA must be mounted to look in one direction; for complete coverage, place it in a turret or install one facing in each compass direction. Its range is 750 miles (scan 28) at TL9, 1,500 miles (scan 30) at TL10, or 3,000 miles (scan 32) at TL11+.

Large PESA: An advanced passive electromagnetic sensor array including thermal imaging, passive radar (detection of low-level millimetric-band emissions), and a low-light television camera (see p. GT161). Range is 500 miles (scan 27) at TL9, 1,000 miles (scan 29) at TL10, or 2,000 miles (scan 31) at TL11+. The PESA must be mounted to look in one direction; for complete coverage, place it in a turret or install one facing in each compass direction.

Light CG: A modest contragrav generator with 30,000 lbs. (15 tons) of lift, suitable for a light grav vehicle.

Light Energy Bank: Contains a bank of five rechargeable E cells storing 1,350 MWS (TL9), 1,800 MWS (TL10), 2,250 MWS (TL11), or 2,700 MWS (TL12).

Medium CG: A contragrav generator with 80,000 lbs. (40 tons) of lift, suitable for a heavy grav truck, light tank, or APC.

Improved Avionics: Instruments and electronics typical of the majority of light and medium grav armor. It has computerized controls, one hardened computer (complexity of TL-5), one scrambled very-long-range radio, a laser comm, four long-range radios, two terrain-following radars, one military GPS, two inertial navigation systems, and two IFFs. Its sensors consist of a radscanner with a range of 10 miles (TL9), 20 miles (TL10), or 100 miles (TL11+) and a band of four PESAs with range of 1 mile (scan 11, TL9-10) or two miles (scan 13, TL11+) around it.

NPU Core: The core of a Nuclear Power Unit (an advanced radiothermal generator or micro-fusion reactor) plus power-generating components. Its output varies by TL; see *Vehicle Module Table*, pp. 114-115. The NPU will function for 1 year (TL9), 2 years (TL10), 5 years (TL11), or 10 years (TL12) on internal fuel before requiring replacement.

NPU Power: A vehicle that possesses an NPU Core that requires additional power output may add extra NPU Power units to the core. See above for duration. Output varies by TL; see *Vehicle Module Table*, pp. 114-115.

Nuclear Damper: This is a nuclear damper (p. GT51) capable of being focused to prevent nuclear fission or fusion detonations. Multiple modules increase area of effect; maximum range is a 5-mile radius times number of modules installed. It will require one crew member serving as the nuclear damper operator. It is available only at TL11+. See also *Nuclear Dampers*, sidebar, p. 122.

Open Cargo: Ten cubic feet of cargo space, in an open cargo bed (see *Exposed Passenger*, p. 111). Multiple cargo modules can be combined to form a single larger cargo hold, or fractional modules can be installed.

Passenger: A roomy passenger seat (cramped if used by battledress) with a crashweb and (optionally) a window. It is enclosed within the vehicle, and has life support (one man-day's worth at TL9-10, indefinite at TL11+).

Safety: Contains a fire-suppression system that senses fires and then floods the burning compartment with inert gas to extinguish them.

Small AESA: As Large AESA, but with a range of only 75 miles (scan 22, TL9), 150 miles (scan 24, TL10), or 300 miles (scan 26, TL11+). This is typical of systems mounted on light or medium grav armor. Civilian vehicles typically rely on the sensors built into the Basic Avionics module, instead.

Small PESA: As Large PESA, but range is only 50 miles (scan 21) at TL9, 100 miles (scan 23) at TL10, or 200 miles (scan 25) at TL11+. As with Small AESA, typical of light or medium grav armor, but most civilian vehicles just rely on Basic Avionics.

Stretcher: As per Passenger module, but contains a stretcher pallet (removable) for one casualty instead of a seat.

Other Attack Roll Modifiers

Vehicles take the usual modifiers for ranged fire (see p. B201). In addition, the following will often apply:

AESA: If activated, an AESA feeds targeting data to the gunner and thus adds +2 to hit with all weapons built into the vehicle.

Firing while Moving: As all built-in vehicular weapons are fully stabilized, vehicles suffer no penalties for firing "on the move." However, someone firing a hand weapon from a moving grav vehicle will suffer a -1 penalty, or a -5 if trying to hit another flying target.

Terrain and Concealment: Ground targets, or a grav vehicle that has landed or is flying "nap of the earth" can be concealed by terrain or poor visibility. Typical modifiers are:

- Target obscured by light woods -2
- Target obscured by dense forest or jungle -4
- Target in built-up area -4
- Target obscured by smoke, hot smoke, or prism -5
- Target has instant chameleon system -3, or -6 if stationary

Fire beyond 1/2D Range: Fully stabilized vehicle-mount weapons do not drop to zero Accuracy when performing direct fire at targets beyond 1/2D range. Unless noted, all weapons are fully stabilized.

Battlefield Scale Speed/Range Table

If using battlefield scale, use this table for speed/range modifiers. It is identical to the table on p. B201, except that distances are divided by 50 for ease of use. Equivalent distances are shown in yards for reference.

Speed/Range Modifier	*50-yd hexes*	*Linear yards*
-6	0	20
-8	1	45
-10	2	100
-11	3	150
-12	4	200
-13	5-6	300
-14	7-9	450
-15	10-14	700
-16	15-20	1,000
-17	21-30	1,500
-18	31-40	2,000
-19	41-60	3,000
-20	61-90	4,500
-21	91-140	7,000
-22	141-200	10,000

Indirect Fire

Indirect fire means the gunner is firing projectiles in a ballistic arc, like an artillery shell. Only guns or unguided rockets may use indirect fire. (Guided missiles may be fired in a high ballistic arc with similar effects – see *Inertial Guidance*, sidebar, p. 121). The target need not be in line of sight, provided the weapon has the range to shoot over it. The firing weapon should have a universal or high-angle mount, but in a pinch any gun can be sited for indirect fire by having it fire while on an upward slope or the like. Indirect fire multiplies the range of a gun by 2.5 and a rocket or missile by 5.

To attempt indirect fire, the gunner must be able to observe the target, or be in communication with a forward observer or fire direction center that can provide accurate target coordinates. Indirect fire is aimed at an area, not an individual. Indirect fire relies on having accurate map references and knowing the relationship of the weapon to the target area. For proper accuracy a vehicle should be fixed and sited – that is, stopped with its position precisely located on maps or via navigation systems. It takes a vehicle one minute to do this after moving, or 10 seconds if it has an inertial navigation system.

It takes a forward observer 2d+5 seconds to relay coordinates (2 seconds if datalinked) assuming absolutely ideal conditions. This assumes he is already in contact and the battery commander is ready and waiting for him to transmit the coordinates. In practice, a "call for fire" will usually take more like 10-60 seconds. After receiving coordinates or observing the target for himself, the gunner can fire an aimed shot at the target. Only range modifiers (not size or speed) apply as the target is firing at an area. Indirect fire is *always* treated as "beyond 1/2D range." For this reason, weapon Accuracy does not come into play. Instead, these special modifiers apply:

- Fire direction center coordinating +4
- Firing weapon fixed and sited +2
- Relying on observer to see target 0*

* Plus a bonus equal to the amount by which the observer makes a Forward Observer skill roll (see p. B243; use IQ-5 if the observer lacks this skill). If directing fire from multiple weapons on the same target, roll only once.

If a hit is achieved, it means the shot fired came in over the target hex (or burst above it, as appropriate). Given that weapon Accuracy bonuses are not added, the more likely result is a miss. If the attack missed, it will land elsewhere; use the *scattering* rules, p. VE176.

Continued on next page . . .

Thruster: A reactionless thruster system with vectored thrust that generates 160 lbs. (0.08 tons) vectored thrust at TL8, 1,600 lbs. (0.8 tons) at TL9-10, or 4,000 lbs. (2 tons) at TL11+.

Winch: A motorized winch. It can lift one ton (ST 100) at up to 4 yards/second or tow much greater weights.

Workshop: A portable repair shop, including spares and tools, allowing one person to work on one of Armoury, Electronics, Engineer, or Mechanic skill tasks. Each type of skill task requires its own shop.

Sensor Note: Sensors (except radscanners, which are omnidirectional) are assumed to face forward out of the turret or body unless otherwise specified. If installing PESAs or AESAs to face a different direction, specify this.

VEHICLE MODULES

Type of Module	TL	VSP	Wt.	KCr	Pow.
Adv. Avionics	9	9	2,201	711	-3.46
Adv. Avionics	10	6	1,416	597	-3.46
Adv. Avionics	11	5	1,233	384	-3.46
Adv. Avionics	12	5	1,205	333	-3.46
Airlock	7+	10	500	1	neg.
Basic Avionics	9	0.2	42.5	25.7	-2.54
Basic Avionics	10	0.1	31	22.8	-5.04
Basic Avionics	11+	0.1	30	22.3	-5.04
Cargo	0	1	0	0	0
Crew	9	9	165	1.2	-0.5
Crew	10	9	105	0.95	-0.5
Crew	11+	9	75	0.95	-0.1
Diagnosis Table	9+	16	250	12	neg.
Discharger Pack	6+	1	100	0.5	0
– 20 reloads	6+	1	100	(0.4)	0
Drone Missile Bay	12	0.16	7.5	0.01	0
– Heavy Drone Missile	12	–	(66)	(19.7)	0
Ducted Fan	8+	1	252	18	375
ESU	9	1	100	15	-1
ESU	10+	1	100	7.5	-1
Exposed Crew	9	5	65	0.7	neg.
Exposed Crew	10+	5	55	0.45	neg.
Exposed Passenger	10+	5	45	0.2	0
External Cradle	1+	0.8	200	2	0
Extra-Heavy CG	9+	1*	250	2.9	-480
Extra Life Support	9	1	250	1.25	0
Extra Life Support	10	1	250	2.5	0
FDC	7+	40	2,000	250	neg.
Fusion Core	9	160*	20,000	5,000	0
Fusion Core	10	16*	2,000	300	0
Fusion Core	11+	16*	2,000	150	0
Fusion Power	9	1*	125	25	+125
Fusion Power	10	1*	125	6.25	+625
Fusion Power	11+	1*	125	3.125	+625
Heavy CG	9+	0.5*	125	1.65	-230
Heavy Energy Bank	8+	1	500	50	0
Imp. Avionics	9	1	254	130	-0.58
Imp. Avionics	10	0.5	155	88.7	-0.58
Imp. Avionics	11+	0.5	152	88.2	-0.58
Jammer	9	2	500	100	-600
Jammer	10+	1	250	50	-300

Type of Module	TL	VSP	Wt.	KCr	Pow.
Large AESA	9	5	1,125	625	-187.5
Large AESA	10	5	1,125	500	-375
Large AESA	11+	5	1,125	437.5	-750
Large PESA	9	4	1,000	1,600	0
Large PESA	10	4	1,000	1,200	0
Large PESA	11+	4	1,000	1,000	0
Light CG	9+	0.1*	25	0.65	-30
Light Energy Bank	8+	0.2	100	10	0
Medium CG	9+	0.2*	50	0.9	-80
NPU Core	9	1*	250	50	+102.5
NPU Core	10	1*	250	50	+205
NPU Core	11	1*	250	50	+580
NPU Core	12+	1*	250	50	+1,205
NPU Power	9	1*	250	50	+125
NPU Power	10	1*	250	50	+250
NPU Power	11	1*	250	50	+625
NPU Power	12+	1*	250	50	+1,250
Nuclear Damper	11	32	8,000	4,000	-1,000
Nuclear Damper	12	16	4,000	2,000	-1,000
Open Cargo	0	1	0	0	0
Passenger	9	9	145	0.75	-0.5
Passenger	10	9	95	0.75	-0.5
Passenger	11+	9	65	0.7	-0.1
Safety	7+	1	200	5	0
Small AESA	9	0.5	112	187.5	-18.75
Small AESA	10	0.5	112	162.5	-37.5
Small AESA	11+	0.5	112	100	75
Small PESA	9	0.5	100	400	0
Small PESA	10	0.5	100	400	0
Small PESA	11+	0.5	100	280	0
Stretcher	9	9	155	0.75	-0.5
Stretcher	10	9	105	0.75	-0.5
Stretcher	11+	9	75	0.7	-0.1
Thruster	8	1*	120	2.4	-80
Thruster	9-10	1*	120	2.4	-80
Thruster	11+	1*	120	12	-200
Winch	8+	1	250	1	-0.5
Workshop	5+	27	3,000	4	-0.5
– if electronics	5+	22	1,500	7	-0.5

Module Type: The type of component module.

TL: Minimum tech level at which the module becomes available. Vehicle designs *may* mix modules of various TLs.

VSP: The vehicle spaces the module takes up. An * after spaces indicates that the module may only be installed in the body, not in turrets.

Wt. The weight of the module in pounds.

Cost: The cost of the module in KCr.

Pow: The power requirement (if a minus sign) or output (if a plus sign) of the component. The vehicle should be designed with a neutral or positive power output. Neg. means negligible power – as long as the vehicle has any power plant, the component will work.

Values in parenthesis are consumables; they are not counted toward empty weight and base cost of vehicle, but do count toward loaded weight or equipped cost.

Indirect Fire

[Continued]

Once an initial shot has fallen, fire can be corrected if the fall of shot can be observed. This takes the same time as aiming at a new target, but is made at +4 bonus for the first shot, +8 for the second, and a further +2 for later ones, up to a limit of the weapon's Accuracy.

Meson Guns: Meson guns can be used for indirect fire, but in this case the gun is firing *through* the ground or other obstacles. When a meson gun fires at an unseen target spotted by another observer, treat as indirect fire. The weapon's range is not increased, but no special mounting is required.

Open Cargo, Exposed Crew, and Passenger Seats

These provide no overhead cover, so cargo and occupants will also take damage (separately from the vehicle and unprotected by its PD/DR) if exposed to indirect fire, explosion, ICM, SATNUC, or (except from below) fragmentation damage. This includes "backblast" from plasma and fusion gun hits against the vehicle.

Angle of Fire

This depends on how the weapon was mounted; see *Weapon Module Descriptions*, p. 116. Usual mounts in this system are:

Universal Casemate in Body: A casemate is a trainable mount installed in a vehicle's body. A weapon in a casemate has a 180° vertical and horizontal arc of fire; i.e., it can be swiveled to fire up to 90° to either side, or up and down off the direction it is facing (usually forward).

Universal Casemate in Turret Atop Body, or Cupola Atop Turret: The turret can be rotated to fire in any direction except immediately below the vehicle. (And a grav vehicle can fire below itself by tilting nose downward.) Reverse this if the turret/cupola is mounted below the vehicle. Turrets are power-driven and can rotate in under a second, but the turret's facing at the end of the turn should be specified. Normally one crew member (gunner or commander) will control the rotation.

High Angle Casemate in Body/Turret: As above, but can't depress. Can only fire at targets above the vehicle, or in indirect fire.

Warheads

Guns, rockets, and missiles may fire munitions with warheads whose effects require various special rules. Warheads are indicated on weapon tables by cryptic abbreviations for the ammunition used, such as HE or ICM.

HE: High explosive warheads inflict explosive concussion effects as per p. B121. The area of large explosions is greater: if damage is 120d or more (e.g., 6d×20), the increment at which damage is quartered is 4 rather than 2 yards. If 1,200d or more, it is 8 yards. If 12,000d or more, it is 16 yards, etc. Sealed vehicle armor protects vs. explosive concussion damage with the square of its DR, but occupants of open-crew, open-passenger, or open-cargo spaces are unprotected and take damage separately. The warhead also scatters fragments over the area; see p. B122. Fragment damage for HE warheads is given in brackets after concussion damage, for example, 6d [2d] means 6d explosive concussion damage and 2d cutting fragmentation damage.

HEC: High explosive concussion warheads use the same rules as HE, but have a light non-rigid casing that does not inflict fragmentation damage.

HEAT: High explosive anti-tank warheads are shaped charges that inflict full damage on anyone directly hit (sealed armor is *not* squared) plus armor protects at one-tenth DR. In addition, they have the same effect as an HEC warhead on anyone nearby (sealed armor DR *is* squared against this secondary damage).

CHEM: Chemical warheads burst and spread whatever chemical agent (options include smoke, nerve gas, etc.) they were filled with over the radius of effect listed under damage. CHEM rounds usually persist for 300 seconds divided by wind speed in mph. As dumping offensive chemicals on targets is normally frowned on, the most popular CHEM warheads are:

Continued on next page . . .

Weapon Module Descriptions

The following weapon-module options are commonly available for grav vehicles at the TLs described. All weapons are fully stabilized, allowing fire while moving.

AutoRLs and MRLs are in high-angle mounts, and drills in standard mounts. All other weapons except the meson accelerator are in universal mounts (if in turrets or cupolas) or casemate mounts (if installed in the body). As with sensors, a weapon is assumed to face forward out of the turret or body in which it is placed. If installed to face a different direction, specify this.

Guns

4mm VRFGG: A very rapid fire Gauss gun. Its typical role is anti-personnel, but it can chew up poorly armored vehicles and has some utility as a point-defense weapon. Available in TL9 and TL10 versions. Use Gunner (Gauss gun) skill.

20mm ETC CG: A TL9 electrothermal chaingun ("ETC" guns use an electric charge to boost the efficiency of a chemical propellant). This is a typical auto-cannon designed for engaging infantry and light armor, normally firing armor-piercing discarding sabot (APDS) ammo. Use Gunner (Cannon) skill.

75mm EMC: A TL10 75mm electromagnetic ("Gauss") cannon firing depleted uranium (TL10) or hyperdense (TL11) darts at very high velocities. It is an alternative to a medium fusion cannon, with better penetration but a slower rate of fire. Use Gunner (Railgun) skill.

80mm RF Howitzer: A TL10 light rapid-firing electromagnetic gun-mortar artillery piece used for direct or indirect fire support. Use Gunner (Mortar) skill.

80mm 6-barrel Massdriver: A large six-barrel electromagnetic cannon. The Imperial Army calls its version the "Solar Wind." Use Gunner (Railgun) skill.

All guns also require ammunition modules. Anti-blast magazines are available for the 80mm howitzer and massdriver to reduce risk of ammunition explosions. If so, one should be installed per 200 howitzer or 39 mass-driver rounds carried.

Artillery Rocket Launchers

These are missile launchers mounted on high angle mounts for indirect fire. Along with meson accelerators, they are the mainstay of the Imperial Army's artillery batteries.

A frequent tactic is to precede bombardment with a lead volley of missiles with hot smoke, prism, and chaff warheads to degrade the effectiveness of point defense. Depending on guidance systems, following missiles' accuracy may suffer as well.

AutoRL: The automatic rocket launcher is a magazine-fed autoloading missile launcher designed for rapid sustained missile fire. The example included is the 160mm AutoRL built to fire the 160mm "Sunray" missile (the standard Imperial Army artillery missile). Anti-blast magazines are available for it; install one per eight missiles.

MRLs are artillery multiple rocket launchers with 20 (200mm) or 36 (160mm) launch tubes, some or all of which can be fired simultaneously in a devastating barrage. The disadvantage is that it takes a long time to reload them. MRLs are in high-angle mounts, suitable only for indirect artillery fire (see *Indirect Fire* sidebar, pp. 114-115).

All rocket launchers require ammunition modules. Use Gunner (Rocket launcher) if firing unguided rockets, or Gunner (Guided missile) if firing guided missiles.

Tactical Missile Launcher

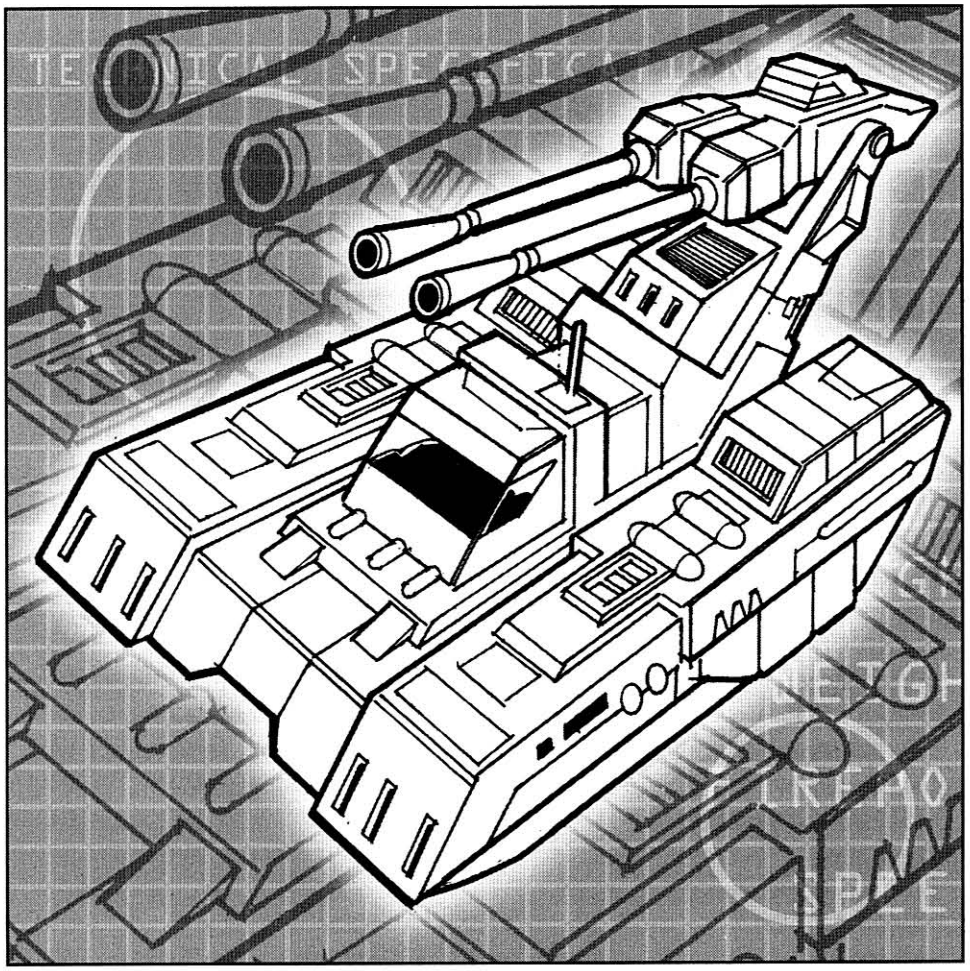
The TML is a standard direct-fire tactical missile launcher weapon. It requires an ammunition module, and needs Gunner (Guided missile) skill to fire.

Lasers and X-Ray Lasers

All lasers and X-ray lasers use Gunner (Beam) skill.

Laser Drill: A 2-megajoule rainbow laser energy drill used for mining operations or as a cutting torch for quickly opening up damaged vehicles to rescue their personnel.

PD Laser: These are rapid-fire "rainbow" (multi-frequency) laser weapons designed to shoot down incoming missiles or shells in point defense, but also effective against other lightly armored targets.



PD Xaser: A PD laser using a more powerful X-ray laser beam.

AD Laser, AD Xaser: A long-range "rainbow" laser or X-ray laser intended for theater aerospace defense against orbital bombardment, long-range missiles, and approaching aerospace craft.

Plasma and Fusion Guns

These high-energy weapons are the standard armament of grav AFVs, as their combination of high penetration and explosive area effect makes them ideal for engaging both point and area targets. Use Gunner (Beam) skill.

Rapid-Fire Plasma: Light weight, rapid-pulse energy weapons that fulfill a role similar to the 20mm autocannon. Their high rate of fire makes them good for killing infantry and intercepting missiles. They are often mounted on grav APCs.

Warheads

[Continued]

- *Smoke:* Obscures the area with dense but harmless chemical smoke. Infrared (included in PESA) and radar (in AESA) can see through it; otherwise, there is a -5 to vision and attack rolls. Takes five seconds to form.
- *Hot Smoke:* As smoke. Also impairs IR and thermograph sensors (including PESA). Lasts half as long as normal smoke.
- *Prism:* Prismatic anti-laser aerosol smoke. Same effect as ordinary smoke, but forms instantly and the shimmering cloud is impenetrable to TL7-9 lasers (including weapons, ladar, laser comms, etc).
- *Blackout:* Dense opaque cloud that combines effect of prism and hot smoke, with *double* penalties to normal vision.

CHAFF: Conductive strips that confuse radar returns. Covers a radius five times greater than that listed for a normal CHEM round. Gives a -10 penalty on radar detection into or through it, but only vs. systems of the same or a lower TL. Persists half as long as a CHEM round.

ICM: Scatters explosive bomblets over the listed radius, doing 6d explosive and 4d cutting fragment damage everywhere. Also, roll 3d for everything important in the area, and on a roll of (5+Size Modifier) or less a bomblet scores a direct hit. Use the same damage, but armor protects at one-tenth DR due to its shaped charge.

ICMTDX: An ICM variant replacing shaped charges with bomblets filled with altitude-fused gravitationally polarized two-dimensional explosive (the TDX described on p. T:SM67). The explosion has a normal radius but occurs in a flat plane, with the bomblets detonating at variable altitudes 2'-4' off the ground! Everyone in the area takes 6d×2 explosive and 4d cutting fragmentation.

SATNUC: An ICM round that scatters small nuclear bomblets! Generally, only interstellar governments will possess these. See pp. VE192-193 for the full, complex effects, or just assume everything in the burst radius takes 6d×200 explosive damage (6d×20 to twice the radius). The ground underneath the burst radius will also be contaminated with 50 rad/day of radiation (10/day out to twice the radius).

Drone Warhead, 160mm: A bus missile that will break up to release seven microdrones. It is designed for light anti-armor and anti-battledress roles, providing the mobile equivalent of land mines. See p. 122 for drone rules.



Light, Medium, and Heavy Plasma: Powerful plasma cannons usually installed as the main turret weapon of light, medium, and heavy grav tanks. They have a slower rate of fire than rapid-pulse weapons, but are more devastating.

Fusion: More powerful fusion guns of all types replace plasma guns at TL11+.

Meson Guns

Meson guns are the ultimate artillery weapons, but do not become compact enough for practical vehicular use until TL12. Use Gunner (Beam) skill.

10-GJ Meson: The standard TL12 battlefield meson accelerator.

WEAPON MODULES

Guns

Type of Module	TL	VSP	Weight	KCr	PPS
20mm ETC chaingun	9	0.6	144	15	0.12
1,250 rds. APS	9	0.4	200	12	0
4mm VRFGG	9	0.2	46.4	26.3	0.13
12,000 rds. APS	9	0.05	(25)	(1.5)	0
4mm VRFGG	10	0.25	46.4	13.3	0.13
12,000 rds. APS	10	0.05	(25)	(1.5)	0
75mm electromag cannon	10	33	8,160	586	95
45 rds. APFSDSDU	10	1	(495)	(68)	0
80mm RF howitzer	10	2	464	54.1	0.96
200 rds. HE	10	1	(500)	(12*)	0
anti-blast magazine	11	–	125	1.25	0
80mm 6-barrel massdriver	10	101.4	25,344	2,554.4	115.2
39 rounds HE	11	1.5	(750)	(5.8)*	0
anti-blast magazine	7	–	125	1.25	0

Launchers

Type of Module	TL	VSP	Weight	KCr	PPS
200mm MRL	9	12	2,580	60.55	0
20 rockets	9	16	(4,000)	(156/64*)	0
20 missiles	9	16	(4,000)	(796/64*)	0
200mm MRL	10	12	2,580	43.175	0
20 rockets	10	16	(4,000)	(156/64*)	0
20 missiles	10	16	(4,000)	(596/64*)	0
190mm TML	11	2.6	640	34.4	0
6 missiles	11	4.8	(1,200)	(201/6.6*)	0
anti-blast magazine	11	–	600	6	0
160mm AutoRL	10	3.7	915	14	0
8 missiles	11	12.4	(2,425)	(160/5.25*)	0
8 stealth missiles	11	12.4	(2,425)	(1,373/5.25*)	0
anti-blast magazine	7	–	1,250	12.4	0
160mm MRL	10	18.4	4,200	30	0
36 stealth missiles	11	44	(11,000)	(6,180/23.5*)	0
36 missiles	11	44	(11,000)	(722/23.8*)	0

Lasers

Type of Module	TL	VSP	Weight	KCr	PPS
Rainbow Laser Drill	9	23	0.09	6.45	4.5
PD Laser/9	9	1	240	24.65	3.6
PD Xaser/10	10	2	400	123	6
PD Xaser/12	12	1.5	320	29.2	3.84
50-MJ AD Laser	9	97	4,830	236	112.5
360-MJ AD Xaser	10	43	10,720	1,873	900

Plasma Guns

Type of Module	TL	VSP	Weight	KCr	PPS
141-MJ Lt. Plasma Gun	9	14	3,520	384	281.25
562-MJ Md. Plasma Gun	9	38	9,440	985	1,125
878-MJ Hv. Plasma Gun	9	59	14,560	1,500	1,757
10-MJ RF Plasma Gun	10	4.5	1,120	75	20
540-MJ Lt. Plasma Gun	10	18	4,480	952	1,080
945-MJ Med. Plasma Gun	10	30	7,520	782	1,800
1.35-GJ Hvy. Plasma Gun	10	45	11,200	2,177	2,700

Fusion Guns

Type of Module	TL	VSP	Weight	KCr	PPS
10-MJ RF Fusion Gun	11	4.5	1,120	31	20
511-MJ Lt. Fusion Gun	11	11	2,700	465	1,432
2.05-GJ Hvy. Fusion Gun	11	71	17,600	1,801	4,010
708-MJ Lt. Fusion Gun	12	24	5,920	634	1,416
1-GJ Md. Fusion Gun	12	34	8,320	867	2,000
2.3-GJ Hvy. Fusion Gun	12	77	19,200	1,932	4,600

Meson Accelerators

Type of Module	TL	VSP	Weight	KCr	PPS
10-GJ Meson Gun	12	308	77,000	1,770	20,000

Module Type, TL, Spc., Weight, Cost: As for p. 115. Values in parenthesis are ammunition costs and weights; they are not counted toward empty weight and base cost of vehicle but do count toward loaded weight or equipped cost. For missiles and rockets, two costs are given: the first is the cost of the missile/rocket body, the second the warhead; the latter cost may vary by ammo type.

* *Varies by ammo type:* select from HE or HEC (×1 cost), HEDP or HEAT (×1.5 cost), ICM (×3 cost), ICM TDX (×12), or CHEM (varies: ×1 for chaff or smoke, ×2 for prism or hot smoke). If 80mm RF, may also use solid (×0.5 cost) or APFSDSDU (×6 cost). If missiles/rockets, may also use SATNUC (×100 cost) or (for 160mm) APDU (×1.5 cost) or drone (no "warhead" cost, but add cost of seven microdrones).

PPS: The power requirement in MWS for a single shot. Thus, a weapon firing at RoF 20 (for instance) would multiply the PPS by 20. The power is drained from Energy Banks, requiring that the vehicle have Energy Banks installed. Power plants can recharge Energy Banks.

Features, Upgrades, and Options

These systems do not take significant space but may add extra expense. They can also easily be retrofitted.

Emergency Lights and Siren: Typical of police sleds, fire engines, and ambulances. KCr0.05.

Genius Option: Adds +1 to Complexity of computers in Avionics module. Cost is KCr22.5 for a Basic Avionics module, KCr112.5 for an Improved Avionics module, or KCr300 *per computer* for the three computers in an Advanced Avionics module. At TL9, price is *doubled.*

Lights, Doors, Ramps: Included in vehicle cost.

HUDWAC with Pupil Scanner: A head-up display which trains turret- or casemate-mounted weapons in whatever direction that the user looks, applying a -7 to the weapon's SS number. May be added to any gunner's Crew module. KCr1.

Beam Weapons

Plasma and fusion weapons do burn damage (no damage multiplier) to anything directly hit. In addition, anything within two yards takes one-quarter the listed damage from splattering hot plasma, and flammable objects will usually catch fire. Vehicular plasma or fusion weapons can also fire "hot shots" at 4 times PPS energy consumption doing ×1.5 damage.

Lasers fired through rain, heavy snow, or fog do half damage. Damage is also halved for every (1/2D range × 0.2) hexes of smoke (or fraction) that they cross. Lasers cannot penetrate blackout gas or prism clouds at all.

X-ray Lasers (Xasers) are not degraded by environmental conditions, smoke, prism, or blackout gas, and DR protects at half value against them.

Meson weapons do full damage to any target directly hit, and that target's DR does not protect it. They also inflict explosive concussion damage on everything else in the immediate area, just as if they were an HEC warhead with the same damage as the meson gun.

Guided Missiles

Guided missiles use different rules than other weapons. Vehicular missiles are generally "brilliant" semi-autonomous weapons that, once launched, look for targets on their own, or artillery missiles with inertial guidance systems that are fired vs. map coordinates, usually using a form of indirect fire. Some missiles have multiple guidance systems. If so, decide which is used at time of launch.

Brilliant Missiles

Brilliant missiles must be preprogrammed with a course (distance and bearing, up to 90% of its range), a point along its course at which to turn on its terminal guidance to start hunting for targets, and a target category. This programming can be changed before launch (takes 2 seconds; multiple missiles can be programmed with the same targets at once). The target category may be specific ("*Astrin* APC") or general ("any vehicle") provided the parameters are available in a database. Missiles with broad parameters may attack friendly targets, but can be programmed to respect friendly IFF signals.

Continued on next page . . .

Guided Missiles

[Continued]

Launching is an attack maneuver (unmodified Gunner+4 roll). Failure means the missile was misprogrammed and will crash the second after launching; critical failure means it may go after the wrong kind of target. After launch, the missile flies along its plotted course at its rated Speed. At the programmed point, it activates its terminal guidance and tries to lock on to potential targets in its arc of vision each turn, starting with the nearest ones that matches its target category.

One lock-on attempt can be made each turn vs. the nearest potential target in the missile's arc of vision. The missile rolls against the Electronics Operation (Sensors) skill of the programming gunner *plus* the missile's own guidance Skill rating. Apply range to target and target Size (but not Speed) modifiers as per p. B201, but other modifiers depend on the missile's guidance system (Guid.). Some typical guidance systems in use are:

Brilliant Infrared Homing (BIRH): The missile hunts targets with thermal emissions that match its programming. If the target has Emission Cloaking, apply the listed modifiers for it (e.g., subtract TL-6 if Basic Cloaking).

Brilliant Optical Homing (BOH): Uses a computer to recognize the target's silhouette and a night-vision-capable optical sensor for guidance. Apply the normal modifiers for a visually aimed attack (cover, visibility, vegetation, chameleon systems), except that darkness has no effect.

Brilliant Neutrino Homing (BNH): The missile can only track targets which are neutrino sources, but does so at a +4 bonus. Neutrinos are emitted by nuclear power systems (e.g., an NPU, or a powered-up fusion or fission reactor). TL8-9 Emission Cloaking is useless; TL10+ subtracts (TL-9)/2 if Minimal, (TL-9) if Basic, or (TL-9)¥2 if Radical.

Continued on next page . . .

Step 5: Armor

Vehicles are normally armored to provide some protection against accident or fire. Typically, the material used is either high-tech metal alloys (such as crystal iron or superdense) or more costly (but also somewhat more effective) composite laminates of metal alloys, synthetic materials, and ceramics. Decide on the vehicle's body DR and whether it will use metal or laminate armor.

Some typical DR ranges:

Air/raft, utility sled	DR 5-100
Artillery grav sled	DR 50-1,500
Light grav APC	DR 100-1,000
Medium grav APC	DR 200-2,000
Heavy grav APC	DR 500-5,000
Light grav tank	DR 1,000-5,000
Medium grav tank	DR 2,000-10,000
Heavy grav tank	DR 4,000-20,000

Figure armor weight (in pounds) as:

armor weight = body area × DR × M

M depends on the armor's material and TL, as follows:

TL9: 0.15 if metal, 0.1 if laminate.
TL10: 0.1 if metal, 0.06 if laminate.
TL11: 0.06 if metal, 0.04 if laminate.
TL12: 0.04 if metal, 0.025 if laminate.

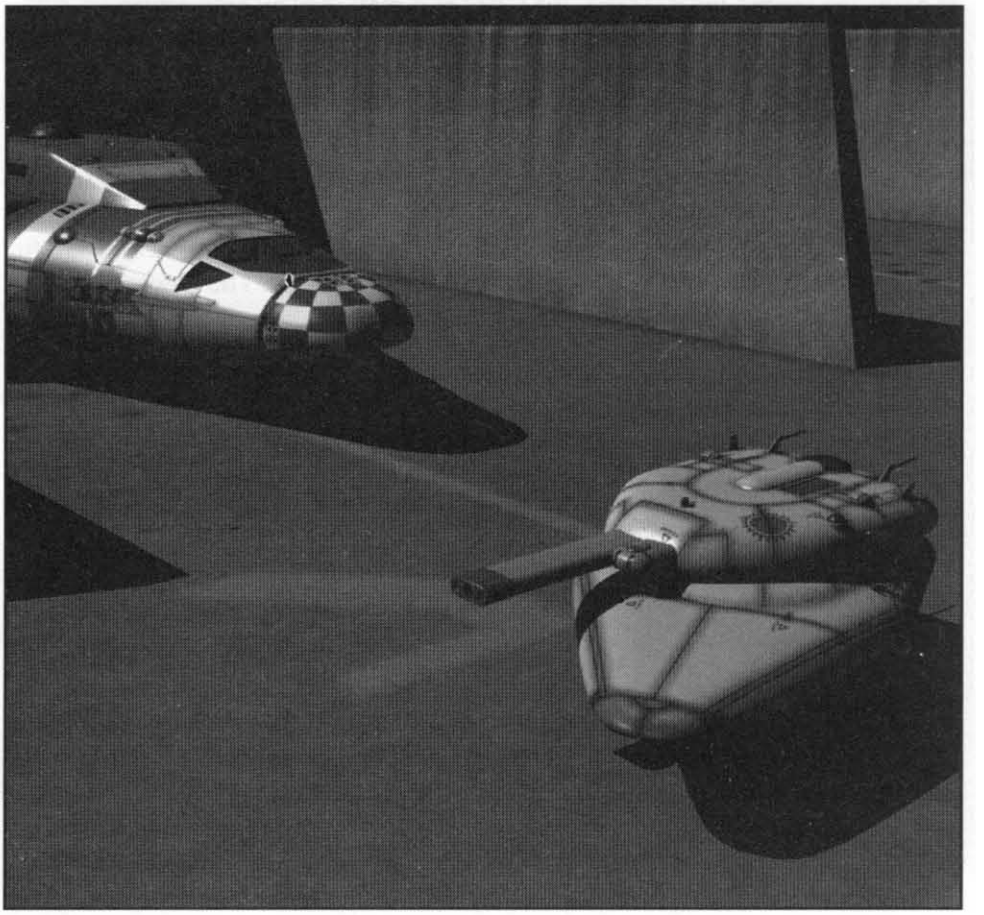
Calculate the armor cost in KCr using this formula:

cost = armor weight × KCr0.006 if metal or KCr0.03 if laminate

TL9-11 vehicles may also be given "advanced" armor. Treat it as one TL higher. Cost is KCr 0.04 for metal, KCr 0.2 for laminate.

It is common to vary the armor values on each face of the vehicle (front, back, right, left, top, underside). For example, a tank may have stronger front armor. If this is desired, multiply DR by 6, then redistribute "DR points" among each of the six sides.

Slope Effects: If the vehicle has a sloped body, its final front face armor DR is doubled to reflect the slope. This does not affect the armor's weight or cost.



Passive Defense: This depends on DR (after slope). DR 1 gives PD 1, DR 2-5 provides PD 2, DR 5-15 PD 3, and DR 16+ PD 4. Add +2 to front body PD if the vehicle is sloped.

Turret Armor

If the vehicle has one or more turrets (or cupolas), use the same procedure as above to armor each turret and calculate PD, with the exception that the turret's area is used rather than the body's area. DR may be the same, more, or less than the body.

If varying the turret armor by face, multiply DR by 5 rather than 6, as the turret face attached to the vehicle is not armored. As with a body, if a turret is sloped, double its front DR and add +2 to its PD.

Step 6: Surface Features

These are features that are added to the surface of a vehicle.

Sealed Vehicles

Sealing protects the vehicle's interior contents from hostile environments, vacuum, contamination, and water. Any vehicle with Crew or Passenger modules (as opposed to Exposed Crew or Passenger) should be sealed.

The cost to seal the vehicle is: KCr 0.01 × the sum of (body + turret area).

Bulldozer or Plow Blade

These are earth-moving blades attached to the front of the vehicle. When the vehicle is flying a foot or two off the ground, they can clear or plow a path as wide as the vehicle. Bulldozer blades or plows weigh 2 lbs. times vehicle body area and cost KCr 0.004 times vehicle body area.

Sensor Masking

A vehicle can be given sensor-masking systems to make it harder to detect.

Stealth protects against active sensors like an AESA's radar or ladar.

Sound Baffling muffles the vehicle's power plant and other noises, making it quieter.

Emission cloaking protects against passive sensors like infrared or a PESA's thermograph.

Each system comes in three levels: Modest, Basic, or Radical. Modest subtracts 0.5×(TL-4) (round up) from rolls to determine the success of appropriate scans or (for baffling) hearing rolls, as well as from lock-on attempts by guided missiles with appropriate guidance. Basic subtracts TL-4, and radical subtracts 2×(TL-4). Weight and cost are calculated as follows:

Type	Weight	Cost
Modest Stealth or Cloaking	0.1	0.03*
Basic Stealth or Cloaking	0.25	0.075*
Radical Stealth or Cloaking	0.5	0.75*
Modest Sound Baffling	0.1	0.01
Basic Sound Baffling	0.25	0.025
Radical Sound Baffling	0.5	0.25

Weight is the weight in pounds. Find it by multiplying the sum of the body and turret area by the number on the table.

Cost is the price in KCr. Find it by multiplying the sum of the body and turret area by the number on the table. Double cost if TL9 (only) emission cloaking.

Guided Missiles

[Continued]

Semi-Active Laser Homing: To track the target, the target must be detected and illuminated by a laser designator or AESA sensor when the seeker activates. If so, lock-on is automatic. Note that blackout gas, dense fog or snowfall, or prism will prevent lock-on.

If a lock-on roll fails, the missile will continue on its course (but may check again next turn, provided a target is still in its arc of vision) until it successfully locks onto something or its endurance (rated in seconds) expires.

If a lock-on roll succeeds, the missile will immediately alter course and attempt to intercept the target, closing on it at its best speed. If it reaches the target's position it hits automatically unless Dodged, in which case it can circle around and attempt an attack on a later turn, if it has sufficient endurance left.

Inertial Guidance

A missile with IG guidance is programmed with specific map reference coordinates (takes one turn, if they're in a database) for a fixed target (a city block, building, area of ground, etc.) and then is fired at them, using an integral inertial guidance system to keep it on course during flight. To determine how close it hits, roll against the gunner's skill and apply the Size Modifier of the target area (maximum +10). If the roll misses, the missile scatters.

The missile can also be fired on an indirect ballistic arc: Multiply range by five, but there is a -10 penalty to hit in addition to other modifiers.

Point Defense

Missiles can be shot at just as if they were other vehicles during a character's turn. In addition, on his turn a gunner may, instead of firing, dedicate himself and a vehicular weapon to point defense of his own vehicle (or some other target). This is essentially a "wait" action that allows him to fire in the missile's turn. If multiple missiles hit his vehicle from the same general direction (ahead, behind, etc.) and he has multiple attacks (due to a high RoF) he can divide his fire among them using the Area Effect rule on p. B121. Assume 10 points of damage is sufficient to deflect or destroy a missile.

Nuclear Dampers

A nuclear damper normally operates in a wide area mode, but is not completely omnidirectional. There's plenty of time to focus it in a 20-minute space-combat round, but in ground combat its use requires an Electronics Operation (Force Shields) skill roll for each nuclear weapon detonating in the area. A failed roll means that the weapon was not damped and instead will detonate. A damper can also be focused precisely on a single area of ground to eliminate residual radiation from a nuclear ground burst, or it can be focused on a single vehicle or building and "sterilize" all nuclear munitions that are carried within it (effectively transforming them into duds). Again, an Electronics Operation (Force Shields) roll is required to do this properly.

Drone Missiles

Drone missiles are semi-autonomous remote-controlled vehicles. Drones can always be directly controlled by an operator. This requires the operator to be in continuous communications with the drone. (For details, see sidebar, p. RO68.)

Operators may give simple commands to the drones, which may be changed at any time. Changing orders requires communication contact with the drone and takes one turn. Drones ordered to act as picket sensors are treated as having Electronics Operation (Sensors) skill of 18. Drones with warheads ordered to attack are treated as guided missiles (see p.00) using a sensor skill of 18 and a guidance skill of 13.

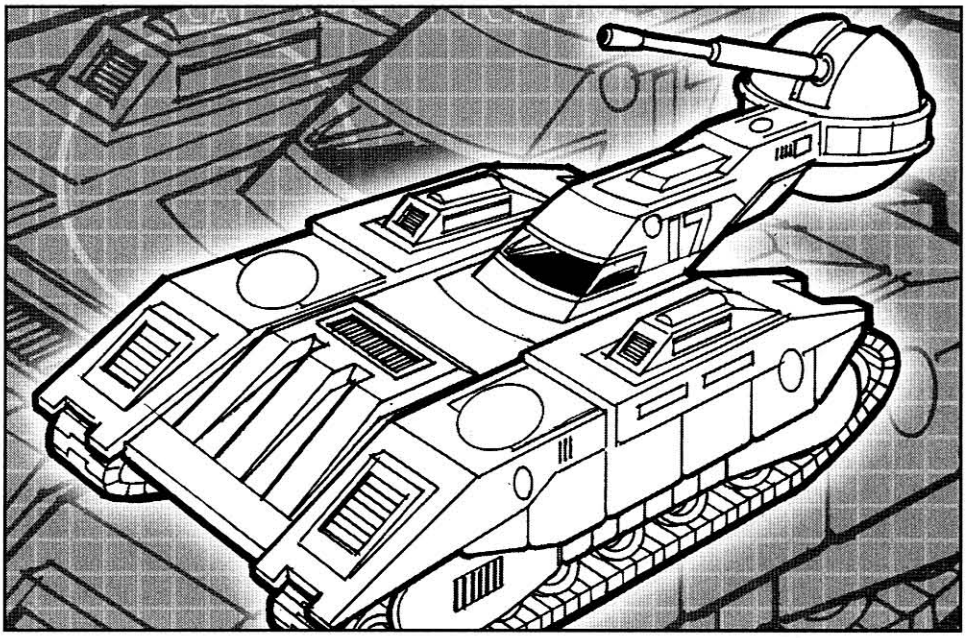
Drone missiles can be deployed via more conventional missiles for swifter delivery, the "carrier" missile warhead breaking apart to release the drones above the intended operational area. The 160mm Sunray missile carries seven microdrones.

Chameleon System

Vehicles may be equipped with chameleon hulls that allow them to electronically alter their color and hue, automatically camouflaging them against the local background. This gives a -6 penalty to rolls made to spot or attack the vehicle, or to detect it with ladar or lock-on with optical homing (OH) missiles; this penalty is reduced to -3 if the vehicle is moving.

Type	Weight	Cost
Instant Chameleon System, TL10	0.25	0.050
Instant Chameleon System, TL11+	0.125	0.025

Weight is the weight in pounds. Find it by multiplying the sum of the body and turret area by the number on the table. *Cost* is the price in KCr. Find it by multiplying the sum of the body and turret area by the number on the table.



Defensive Features

These defend against particular threats to the vehicle. Weight and cost are based on total vehicle area (the sum of the body and turret areas).

Psi Shielding interferes with attempts by psis to use telepathy on anyone inside the vehicle, as if such an effort had to penetrate a Mind Shield with a Power of 2×(TL-7). It weighs 0.025 lbs. and costs KCr 0.025 × total vehicle surface area.

Thermal Superconductor Armor is available at TL11+. It doubles armor DR (to a maximum of an additional DR 250) against laser, microwave, X-ray laser, and graser attacks, as well as plasma and fusion guns. At TL11 it weighs 0.25 lbs. and costs KCr 0.25 × total vehicle area. At TL12 it weighs 0.125 lbs. and costs KCr0.125 × total vehicle area.

Step 7: Statistics

The vehicle has now been designed. Calculate the following statistics for it:

Total Empty Mass (EMass): Add together the weight of body and turret frames, armor, surface features, and chosen modules. Divide by 2,000. This is the vehicle's empty mass in tons.

Total Loaded Mass (LMass): This is equal to empty mass plus these additional categories:

● *Ammunition* – As specified in the various modules lists, some expendable supplies do not count toward EMass but do count toward LMass.

● *Occupants* – Add 0.1 ton per passenger or crew member carried (assuming Human-sized occupants). If occupants are usually in battledress, add the weight of the suits.

● *Cargo* – Add the weight of cargo usually carried. If exact numbers are unknown, assume 0.0025 tons per space of cargo or 0.005 tons per space of open cargo (i.e., about 20 lbs./cf), which can allow for cargo holds that are not fully packed. A weight of up to five times that value is reasonable for vehicles that usually transport substantially heavier loads, such as an ammunition carrier.

● *Other Vehicles* – The mass of vehicles or robots carried aboard.

Total Cost: Add together body, turret, module, armor, and surface-feature costs to get the vehicle's cost in KCr at the TL that produced it.

Size Modifier: Record the Size Modifier for the body and each turret or cupola.

Hit Points: Record hit points for the body and each turret or cupola.

Health (HT): A measure of structural robustness, distinct from Hit Points. Structural HT=(0.1 × body hit points/Loaded Mass in tons) + 5. Max HT is 12.

Maintenance Interval (Optional): Multiply cost in KCr by 1,000, then find the square root. Divide 20,000 by the square root. The result is the maintenance interval in hours. A vehicle will require about 4 man-hours of maintenance by someone with Mechanic-9 or better and a tool kit or workshop every time the interval is passed to stay in peak condition. If a check-up is missed, roll vs. the Mechanic skill of the soldier who made the last checkup (-4 per additional checkup missed). If *that* roll fails, roll vs. the vehicle HT. Failure reduces the vehicle HT by 1 (wear and tear); critical failure also means a serious breakdown of some item of equipment (GM's choice as to what fails and when). Lost health or breakdowns can be regained; treat each point of HT or breakdown as a minor repair (see p. B54).

Step 8: Performance

Calculate the following performance statistics for the vehicle.

Lift: A grav vehicle can fly if the combined lift of its powered CG modules exceeds loaded weight under local gravity.

Top Air Speed: This depends on thrust and drag. If it can fly, a grav vehicle's drag is its total area/5 if streamlined or area otherwise. Add 10 to drag for each Exposed Crew or Exposed Passenger module. Its thrust is the combined thrust – in tons – of all powered Thruster or (in atmosphere) Ducted Fan modules. Its top air speed in mph is the square root of [15 million × (thrust/drag)]. However, top air speed may not exceed 600 mph if the vehicle is unstreamlined! Always round air speed to the nearest 5 mph.

aAccel: A grav vehicle's aerial acceleration rating in mph per second (mph/s) is its thrust (tons) divided by its loaded mass (tons) times 20 mph.

aMR: A grav vehicle's aerial maneuver rating (the number of gravities it can safely "pull" while maneuvering in atmosphere) is (1+TL-Size Modifier)/2. Round to the nearest half or whole number.

aDecel: A grav vehicle's aerial deceleration rating in mph/s is its aMR × 4 mph/s.

aSR: A grav vehicle's aerial stability rating comes into play when a Piloting (Contragrav) roll fails. If the roll fails by more than the aSR, the vehicle not only fails to perform the maneuver but the pilot loses control (no maneuvering next turn). Naturally, this can be hazardous in some circumstances. The aSR is 3 for vehicles under 0.2 dtons, 4 if at least 0.2 dtons but less than 2 dtons, and 5 if 2 dtons but under 20 dtons.

Microdrones

The 60mm microdrones are the smallest semi-autonomous drones used by the Imperium. They are mostly suited to attacking infantry or support vehicles, but within that limited role they are quite effective for their cost.

Subassemblies and Body Features: body with superior streamlining, no subassemblies.

Propulsion: 40-lb. vectored super reactionless thruster.

Weaponry: 60mm "small" self-destruct HEAT warhead – 6d×15 (10) damage.

Instruments and Electronics: short range radio w/scrambler, short range lasercomm receiver, 2-mile LLTV, 0.5-mile radscanner, DX+3 tiny robot brain (Complexity 5).

Programs: Computer Navigation, Datalink, Gunner (Missile)-12, Routine Vehicle Operation (Piloting).

Power: one rC cell sufficient for 45 minutes at maximum power or 4 hours hovering.

Volume: 0.066 cf. Area: 1 sf.

Structure: robotic.

Hit Points: 2.

Armor: front has PD 4/DR 50 expensive laminate; other faces PD 4/DR 20.

Surface Features: sealed, basic stealth, basic emissions cloaking, instant chameleon.

Statistics: Weight 4.98 lbs. Volume 0.066 cf. Size modifier -4. Price KCr1.33 (programs cost extra but may be assumed to not be purchased per missile . . .) ST 1, DX 13, IQ 8, HT 12/2.

Aerial Performance: Stall speed 0. Drag 0.1, Thrust 35 lbs., aMax 1,600 mph, aAcc 150 mph/s, aMR 8, aDec 32.

Space Performance: 8 Gs.

VEHICULAR ARMAMENTS

Guns

Weapon Name	Type	Damage	SS	Acc	1/2D	Max	RoF	TL
4mm VRFGG/9	Cr.	5d×3 (2)	20	14	1,500	7,200	100*	9
4mm VRFGG/10	Cr.	6d×3 (2)	20	15	2,300	9,200	100*	10
20mm ETC CG	Cr.	6d×13 (2)	20	17	3,400	12,000	20*	9
75mm EMC								
w/APFSDSDU	Cr.	6d×120 (3)	30	20	23,000	46,000	1/4	10
80mm RF Howitzer	Cr.	6d×12	20	16	2,500	8,500	4*	10
80mm 6-barrel Massdriver	Cr.	6d×64	30	19	16,100	31,000	25*	11
w/APFSDSDU	Cr.	6d×128 (3)	30	20	24,000	45,000	25*	11
other 80mm:								
w/CHEM	Spcl.	24 yd	var.	var.	var.	var.	var.	10-11
w/HE	Exp.	6d×24 [6d]	var.	var.	var.	var.	var.	10-11
w/HEC	Exp.	6d×32 [6d]	var.	var.	var.	var.	var.	10-11
w/HEAT	Exp.	6d×20 (10)	var.	var.	var.	var.	var.	10-11
w/HEDP	Exp.	6d×20 (5) [6d]	var.	var.	var.	var.	var.	10-11
w/ICM	Spcl.	48 yd.	var.	var.	var.	var.	var.	10-11

Lasers

Weapon Name	Type	Damage	SS	Acc	1/2D	Max	RoF	TL
AD Laser/9	Imp	6d×18	30	28	89,000	267,000	1	9
Laser Drill/9	Imp.	6d×7	22	14	2,900	8,700	1	9
PD Laser/9	Imp.	20d	20	22	8,000	24,000	12*	9
PD Xaser/10	Imp.	6d×4 (2)	20	25	28,000	84,000	16*	10
AD Xaser/10	Imp.	6d×50 (2)	30	32	200mi	600mi	1/2	10
PD Xaser/12	Imp.	6d×5 (2)	20	25	28,000	84,000	20*	12

Plasma Guns

Weapon Name	Type	Damage	SS	Acc	1/2D	Max	RoF	TL
141-MJ Light Plasma/9	Exp.	6d×100	25	21	5,600	17,000	1	9
562-MJ Medium Plasma/9	Exp.	6d×200	30	23	11,000	33,000	1/2	9
878-MJ Heavy Plasma/9	Exp.	6d×250	30	23	14,000	42,000	1/2	9
10-MJ RF Plasma/10	Exp.	5d×40	25	20	3,300	9,900	8*	10
540-MJ Light Plasma/10	Exp.	6d×250	30	25	12,000	37,000	1/2	10
945-MJ Medium Plasma/10	Exp.	8d×250	30	24	16,000	48,000	1/2	10
1.35-GJ Heavy Plasma/10	Exp.	6d×380	30	25	19,000	58,000	1/2	10

Fusion Guns

Weapon Name	Type	Damage	SS	Acc	1/2D	Max	RoF	TL
10-MJ RF-Fusion/11	Exp.	5d×50	25	20	3,600	10,800	8*	11
511-MJ Light Fusion/11	Exp.	6d×300	30	23	13,000	39,000	1/2	11
2.05-GJ Hv. Fusion/11	Exp.	6d×600	30	25	21,000	63,000	1/2	11
708-MJ Lt. Fusion	Exp.	5d×500	30	24	16,000	49,000	1/2	12
1-GJ Med. Fusion	Exp.	6d×500	30	24	19,000	58,000	1/2	12
2.3-GJ Hv. Fusion	Exp.	6d×650	30	25	30,000	90,000	1/2	12

Meson Accelerators

Weapon Name	Type	Damage	SS	Acc	1/2D	Max	RoF	TL
10-GJ Meson	Exp.	8d×900!	30	23	400mi	1,200mi	1/2	12

Malf. for all weapons is Ver.

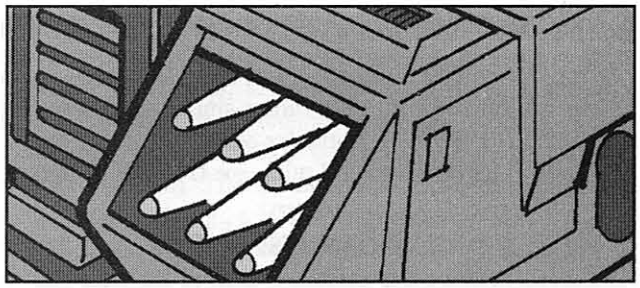
Damage Notes: The number in parenthesis is an armor divisor; divide armor DR by it before applying damage; e.g, (2) means DR is halved. *Exp.* means the attack is an explosion. The effects depend on the type of weapon or warhead. The effects depend on the type of warhead. *!* means a meson gun; it ignores armor DR completely. Base damage and type for 80mm RF/Massdriver is for solid ammunition; see "other 80mm" for options.

RoF Notes: RoF divided by a colon (for instance, 6:8) means the weapon uses multiple launch tubes. The first number is the number of tubes that can fire *simultaneously*; the second number is the time in seconds to reload *each* tube.

LAUNCHERS

Name	SS	RoF	Launches	TL
200mm MRL	25	6:8	200mm rocket or missile	9-10
190mm TML	20	1/5	190mm missile	11
160mm AutoRL	20	1	160mm missile	11
160mm MRL	30	36:8	160mm missile	11

Other statistics depend on the type of missile that is loaded and fired, as shown below:



ROCKET AND MISSILE STATISTICS

Name	Guid.	Type	Damage	Spd.	End.	Max	Acc	Skill
200mm rocket/9	none	Var.	Var.	800	36	28,800	15	–
200mm missile/9	BOH/IG	Var.	Var.	34	Var.	27,200	–	16/IG
200mm rocket/10	none	Var.	Var.	800	54	43,200	15	–
200mm missile/10	BOH/BNH/IG	Var.	Var.	800	53	42,400	–	17/16/IG
200mm warheads:								
w/CHEM	Var.	Spcl.	360 yd.	Var.	Var.	Var.	Var.	Var.
w/Chaff	Var.	Spcl.	1,800 yd.	Var.	Var.	Var.	Var.	Var.
w/HE	Var.	Exp.	6d×750 [12d]	Var.	Var.	Var.	Var.	Var.
w/HEAT	Var.	Exp.	6d×90 (10)	Var.	Var.	Var.	Var.	Var.
w/ICM	Var.	Spcl.	720 yd.	Var.	Var.	Var.	Var.	Var.
w/ICMTDX	Var.	Spcl.	1,080	Var.	Var.	Var.	Var.	Var.
w/SATNUC	Var.	Spcl.	1,440 yd.	Var.	Var.	Var.	Var.	Var.
190mm missile/11	BOH/BIRH/BNH/SALH	Var.	Var.	600	34	31,000	19/19/-/18	Var.
190mm warheads:								
w/HE	Var.	Exp.	6d×640 [12d]	Var.	Var.	Var.	Var.	Var.
w/HEAT	Var.	Exp.	6d×80 (10)	Var.	Var.	Var.	Var.	Var.
w/ICM	Var.	Spcl.	540 yd.	Var.	Var.	Var.	Var.	Var.
160mm missile/11	BOH/BNH/IG	Var.	Var.	1,700	105	178,500	–	19/18/IG
160mm warheads:								
w/APDU	Var.	Cr.	6d×60 (3)	Var.	Var.	Var.	Var.	Var.
w/Chaff	Var.	Spcl.	960 yd.	Var.	Var.	Var.	Var.	Var.
w/CHEM	Var.	Spcl.	192 yd.	Var.	Var.	Var.	Var.	Var.
w/Drone	Var.	Spcl.	7 drone	Var.	Var.	Var.	Var.	Var.
w/HEC	Var.	Exp.	6d×256	Var.	Var.	Var.	Var.	Var.
w/HEAT	Var.	Exp.	6d×64 (10)	Var.	Var.	Var.	Var.	Var.
w/ICM	Var.	Spcl.	192 yd.	Var.	Var.	Var.	Var.	Var.
w/ICMTDX	Var.	Spcl.	288 yd.	Var.	Var.	Var.	Var.	Var.
w/SATNUC	Var.	Spcl.	384 yd.	Var.	Var.	Var.	Var.	Var.

Damage: A number in yards is the burst radius. See the *Warheads* sidebar, pp. 116-117, for special rules for missile warhead effects.

Guid.: The guidance system used. *B* = brilliant, *OH* = optical homing, *NH* = neutrino homing, *SALH* = semi-active laser homing, and *IG* = inertial guidance. If multiple systems, select which to use at launch. See the *Guided Missiles* sidebar (pp. 119-121) for rules and descriptions. Missiles that use OH may be built instead as IRH (infrared homing); cost and skill is the same.

End. is the amount of time (in seconds) that the missile or rocket can fly.

Spd. is its speed in yards per second; double this to get speed in mph.

Max is the maximum range assuming horizontal flight. All artillery rockets (and missiles using IG) guidance can also be fired indirectly, with five times the listed Max range.

Acc/Skill: Rockets (being unguided) have an Acc rating, while missiles (being guided) have a Skill rating. For weapons with both BOH and BNH the first skill rating refers to BOH, the second to BNH. For weapons with BOH/BIRH/BNH/SALH the first skill rating applies to BOH, the second to BIRH, the third to BNH. SALH has no skill rating.

Malf. All missile Malf. numbers are Crit.

The 160mm stealth missile is identical to the 160mm missile but has Basic Stealth (p. 121) which subtracts TL-4 from its chance of being detected by radar, etc.

Grav Armor in Action

This section provides some rules for grav vehicle operations on the battlefield or in adventuring situations. These rules are optimized for ***GURPS Traveller*** vehicle designs created via this system; for more general rules, see ***GURPS Vehicles.***

Fire and Movement

A vehicle moves 1 yard per second for every 2 mph of speed. If using 50-yard hexes (see *Battlefield Scale* sidebar, p. 112) this converts neatly to one hex per 100 mph of top speed. Vehicles slower than 100 mph move one 50-yard hex every [100/top speed] turns; e.g., a vehicle with a 25-mph top speed would move one hex every 4 turns.

A grav vehicle retains its speed and direction of travel from turn to turn unless it accelerates or decelerates (or loses power and falls out of the sky). The pilot can add the vehicle's aAccel to its speed each second, or subtract its aDecel, provided it does not accelerate past its top air speed. The GM is free to ignore acceleration and simply have vehicles whiz about the battlefield at up to their top speed, or he can keep track of speed on scratch paper. Note that often all vehicles in a platoon will be moving at the exact same speed to keep formation; this reduces the recordkeeping.

Grav vehicles can use their vectored thrust to assist in maneuvering rather than accelerate. They can trade 2 mph/s of acceleration for 1 yard of up, down, or sideways movement (retaining its current facing), or add its acceleration to its deceleration.

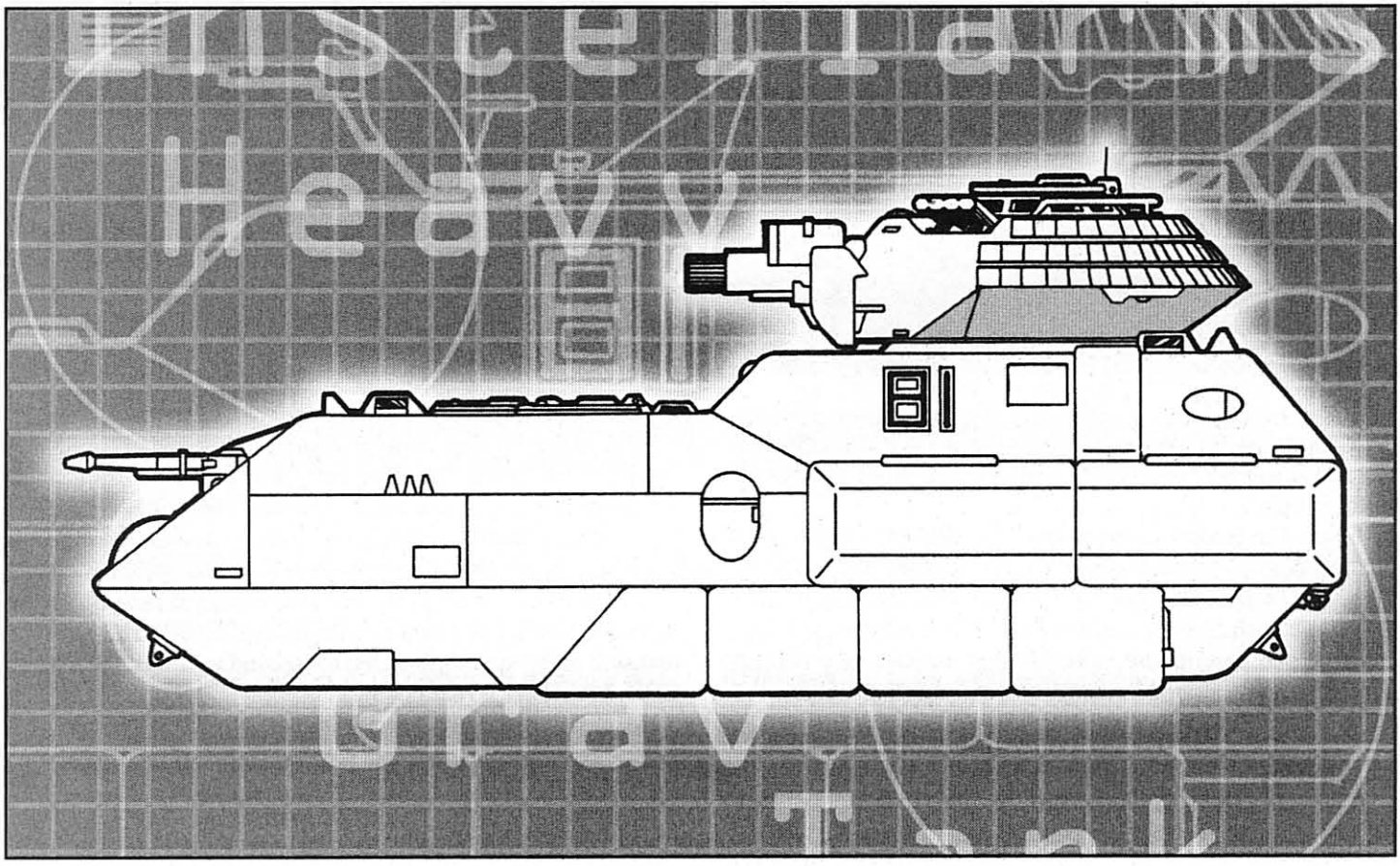
A sudden upward "pop-up" to carry the vehicle over concealing terrain and into a firing position is a common maneuver for high-acceleration vehicles. A grav vehicle can also trade acceleration for aMR: each 5 mph/s unused adds 0.25 to aMR. If the vehicle has decelerated to 0 speed, it can choose to accelerate backward or sideways, but does so at half aMR and cannot exceed 150 mph or half top speed, whichever is less.

A grav vehicle moving at high speed is not able to turn on a dime. The vehicle's aMR is the number of gravities it can "pull" in a turn. The GM can use the precise formula for turning radius found on p. B139 (or for more detail, ***GURPS Vehicles***).

Alternatively, the GM can ignore turn-radius questions and assume that contragravity allows grav vehicles to turn "on a dime" and maneuver much like spacecraft in zero gee, or fictional UFOs. If using the turning rules on p. B139 in conjunction with *battlefield scale* (sidebar, p. 112) 50-yard hexes, the table below shows the number of turns a vehicle must travel in a straight line after making a 1-hexside facing change. (This formula is derived from the turning-radius formula on p. B139.)

Turning Radius

	aMR								
Speed	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**4**	**5**	**6**
At 100 mph:	10	5	4	3	2	2	1	1	1
At 200 mph:	20	10	7	5	4	4	3	2	2
At 300 mph:	30	15	12	8	6	5	4	3	2
At 400 mph:	40	20	15	10	8	7	5	5	3
At 500 mph:	50	25	19	13	11	9	7	5	4
At 600 mph:	60	30	22	15	12	10	8	6	5



Cross-index vehicle speed (round up) with aMR (round down) to find the vehicle's turning radius (the number of hexes it must travel in a straight line after each one-hexside turn).

Example: *Lt. Jen Riisha is driving her grav APC at 212 mph, allowing it to move two 50-yard hexes every second. Her vehicle has aMR 4. Rounding the speed up to 300 mph for this purpose, it means that after announcing a 1 hexside change in facing she must "fly straight" for the two following turns (moving four hexes directly ahead). Only then can she maneuver again.*

The limitations on turning radius show why grav vehicles flying at nap-of-the-earth altitudes (i.e., skimming the ground) will do so at slow speeds. If they don't, they risk being unable to turn in time to avoid ramming into a building or hill.

Crashing and Falling

For detailed rules for falls or collisions, see ***GURPS Vehicles.*** Generally, a vehicle hitting an immovable object (ground, big building, etc.) takes (its own body hit points× collision speed in mph)/200 dice damage, while one smashing into another vehicle *inflicts* damage equal to the above formula based on their relative velocity; the damage it *receives* is based on the other vehicle's results from the above formula.

A vehicle shoves aside the other vehicle if it inflicts twice the damage it took. In addition, anyone in a vehicle that crashed into something it couldn't smash through or shove aside will suffer whiplash or concussion damage if speed was 20 mph or more: 1d-2 crushing per 20 mph. Vehicle or personal armor does not protect, although Toughness and crashwebs do. Double damage for anyone not wearing a safety belt.

Attacking Vehicles

Attacks on a grav vehicle will normally be directed at the vehicle's body on the side facing the attacker. An attacker may choose to target a turret or cupola instead; if so, use the appropriate Size Modifier rather than that of the vehicle body.

Incoming indirect fire generally strikes the top of a vehicle (unless the vehicle is at a very high altitude); if the vehicle has subassemblies, roll randomly to determine the hit's location.

Passive Defense and Dodging: A grav vehicle that has been hit may attempt to Dodge, just like a person, provided it has aMR 1+. Its Dodge score is its pilot's Piloting (Contragrav) skill/3 (round down) plus its PD. If this gives Dodge over 14, treat it as 14. A vehicle that cannot Dodge may still roll vs. PD.

Active Sensors and Dodging: If an attacker is using an AESA or similar active sensor (laser sight, etc.) to aim or fire at a vehicle that has either a radar/laser detector or radscanner, the vehicle's defenses will warn the pilot, allowing him to add +1 to Dodge. Thus, it can be better to turn off the active system.

Damage and DR

A vehicle's DR normally works just like a character's DR, but it may vary depending on location (body, turret, cupola) and facing (front, back, right, left, top, underside) attacked. Some special circumstances also apply:

Armor divisors are present on some weapons, noted as a number in parenthesis; e.g., (10) or (2). Divide DR by the armor divisor. This only applies to direct hits, not any explosive concussion or fragmentation effects from near misses.

Sealed vehicles have their DR *squared* against any explosive concussion damage. This does *not* apply to *direct hits* from HEAT/HEDP warheads, ICM shaped-charges, or plasma, fusion, and meson guns. *Laminate armor* doubles DR against *direct hits* from HEAT or HEDP warheads, and vs. the shaped-charge effects of ICM. This is cumulative with any armor divisors the warhead has; e.g., a HEAT warhead with armor divisor (10) would divide laminate DR by 5. *Thermal superconductor armor* adds DR 250 or doubles armor DR (whichever is less) against laser, X-ray laser, or plasma/fusion gun direct hits.

Effects of Vehicle Damage

Damage is kept track of separately for the body and for each turret or cupola; each of these locations has their own individual hit point totals. If a location's hit points are reduced to 0 or less, it is disabled, but may later be repaired. If reduced to -5 × original hit points it is destroyed, and cannot be repaired.

Disabled/Destroyed Body: When a vehicle's body is reduced to 0 or fewer Hit Points, the entire vehicle is effectively knocked out. All components in it cease to work, including contragrav. If the vehicle is flying, it will begin to fall.

Disabled/Destroyed Turret/Cupola: When a vehicle's turret or cupola is disabled, only those components inside it are knocked out of action.

Unsealing Vehicles: If a sealed location loses 10% of its hit points (20% if it has heavy compartmentalization, 50% if total compartmentalization), it is no longer sealed. This exposes the occupants to any hostile environment outside.

Crew and Passenger Injuries: If a location is occupied and damage penetrates DR, roll 1d per 100 points (or fraction thereof) of penetrating damage. For each 6 rolled, one occupant in the location (determined randomly or by GM fiat) takes either 50 points of damage or half the penetrating damage suffered by the location, whichever is higher. *Exception:* If damage was greater than the location's original hit points, damage is inflicted on a 5-6, and the maximum damage is 100 points.

Fire: If a laser or explosive weapon penetrates vehicle armor, it may cause a fire in the penetrated location. This is automatic if damage is 18 or more points. Otherwise, roll 3d vs. penetrating damage. If a vehicle catches fire, the location takes 2d damage plus a further 2d every 10 seconds; DR is ignored, but heavy compartmentalization subtracts 2 points and total compartmentalization subtracts 4. Any time a fire does 8+ damage (after modifiers) it spawns another fire either affecting the vehicle or setting fire to a person in it (GM's option); if it does less than 4 hits, the fire goes out. A fire will fill a location with smoke (pp. B132-133). A Safety module puts out fires on a roll of TL+6 or less (-1 penalty per extra fire raging) on 3d; check immediately and again every 10 seconds for *each* fire separately. Occupants can take 10 seconds to put out a fire manually (roll 6 or less) or with handheld extinguishers (TL+2 or less); critical failure means they take 2d burn damage.

Ammunition Explosion: If a vehicle location is on fire and has explosive ammunition stored in it, roll 1d: on a 5-6 it "cooks off" and explodes. All ammunition is destroyed; use the damage of 1d shots (or whatever is left) to determine the damage to the vehicle, ignoring its DR. *Exception:* Ammo in an anti-blast magazine will be destroyed, but the explosion is vented safely out of the vehicle on a roll of TL+6 or less.

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