GURPS

VEHICLES

Second Edition

By David L. Pulver



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STEVE JACKSON GAMES

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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 auto-rotate 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."*

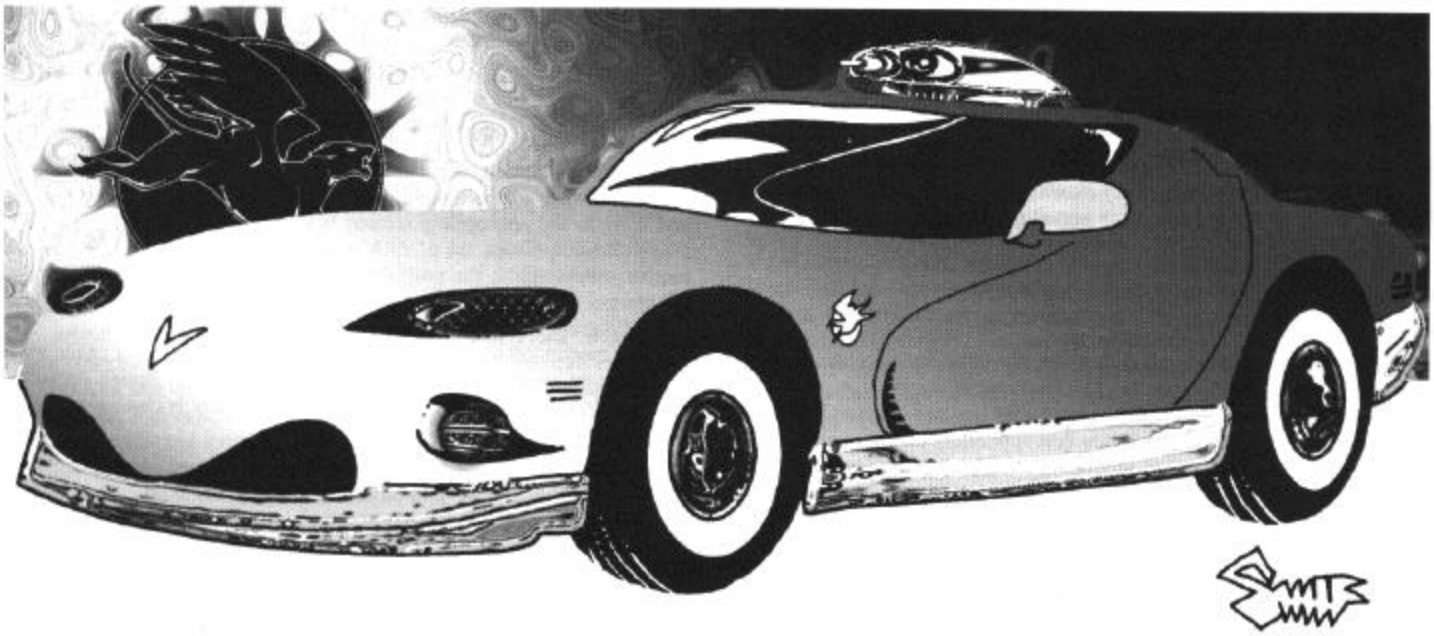
She stood up, took off her sunglasses, and stared deep into Cassidy's eyes, her own blue meeting his.

"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.

EXAMPLE

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

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.

EXAMPLE

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.

Part 1: 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).

EXAMPLE

The Kitty Hawk will have wheels.

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.

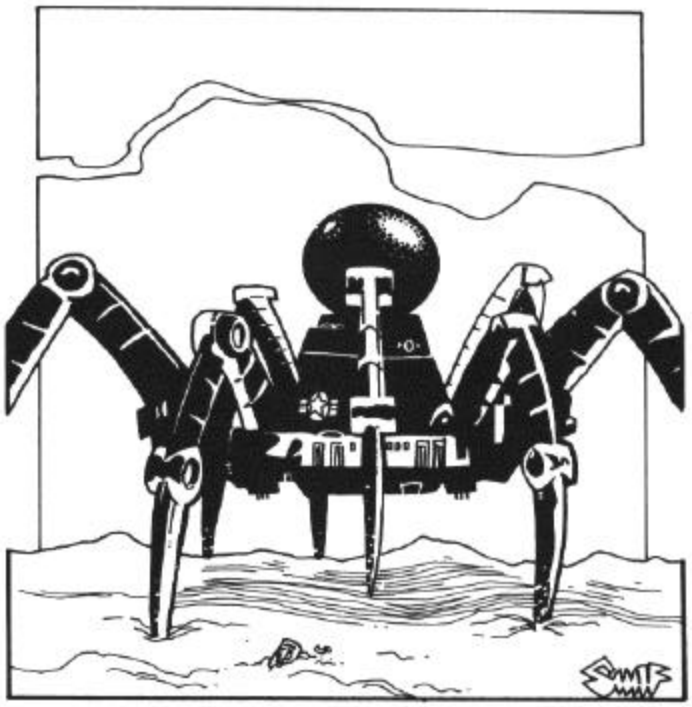
Legs

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.

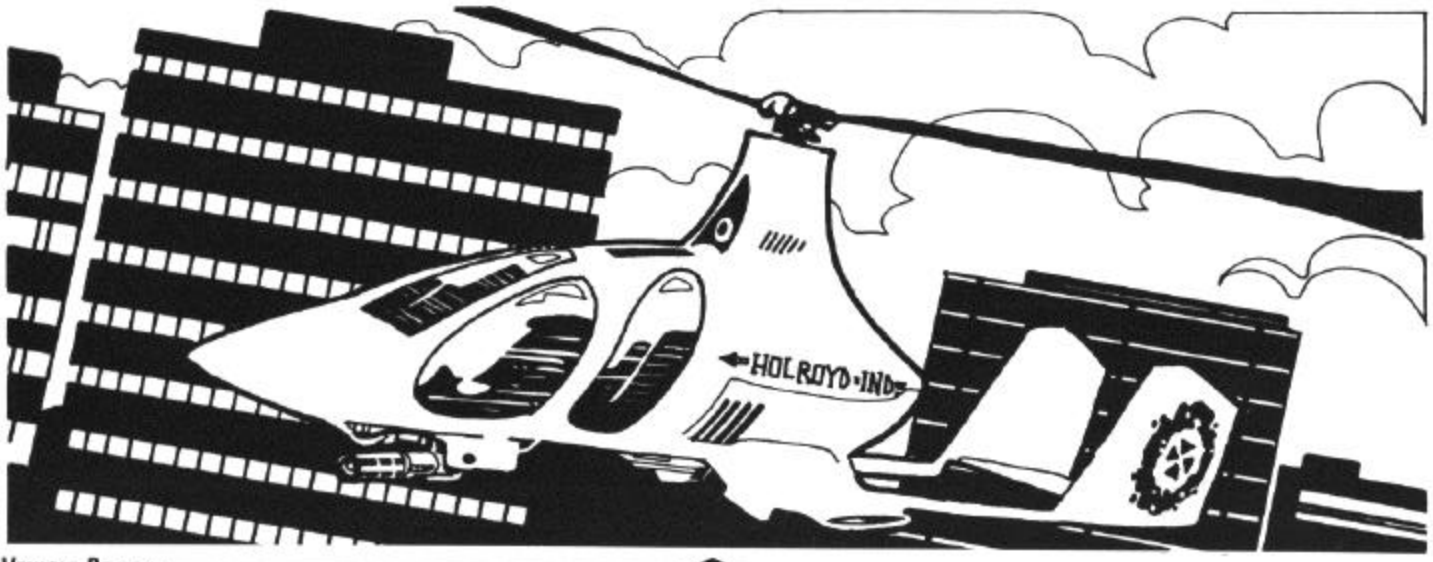
An autogyro is a rotary-wing vehicle whose rotors are unpowered: like an airplane, it has a stall speed and can only fly if the vehicle is moving forward fast enough to create lift. Its advantages over conventional wings are that the rotor is lighter and cheaper, and the stall speed is usually lower. 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.

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.

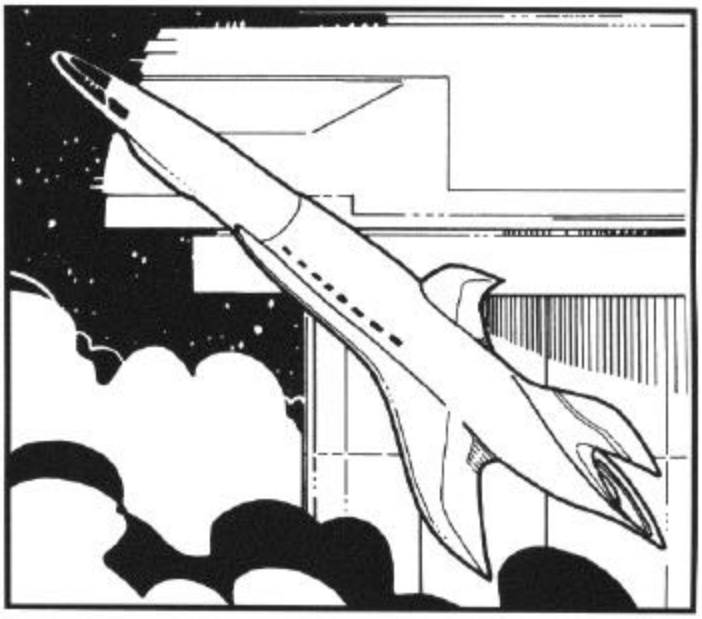
Radical (TL6) is typical of missiles and hypersonic aircraft.

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.

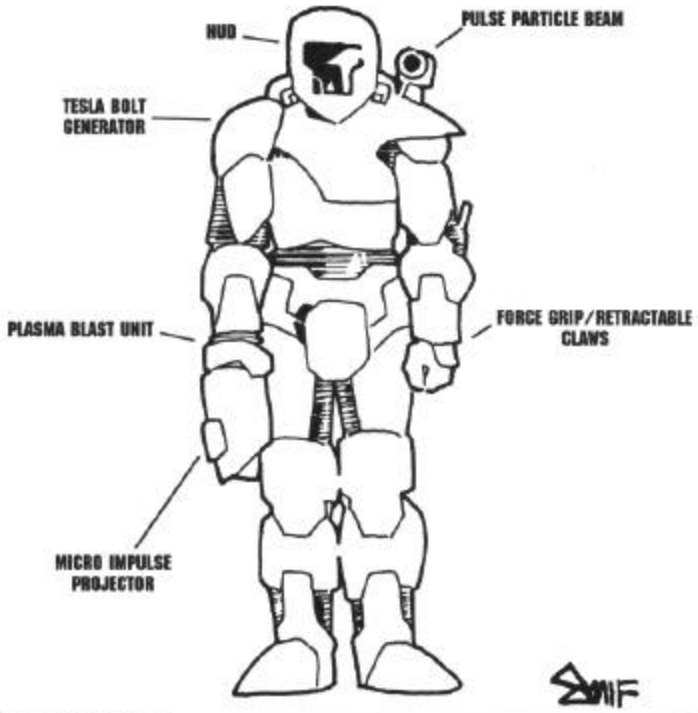
Power is measured in kilowatts. Some components require negligible (abbreviated "neg.") amounts of power. This means they function as long as the vehicle has any kind of working power system. At the GM's option, a negligible power component can be considered to actually require 0.01 kW power.

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.

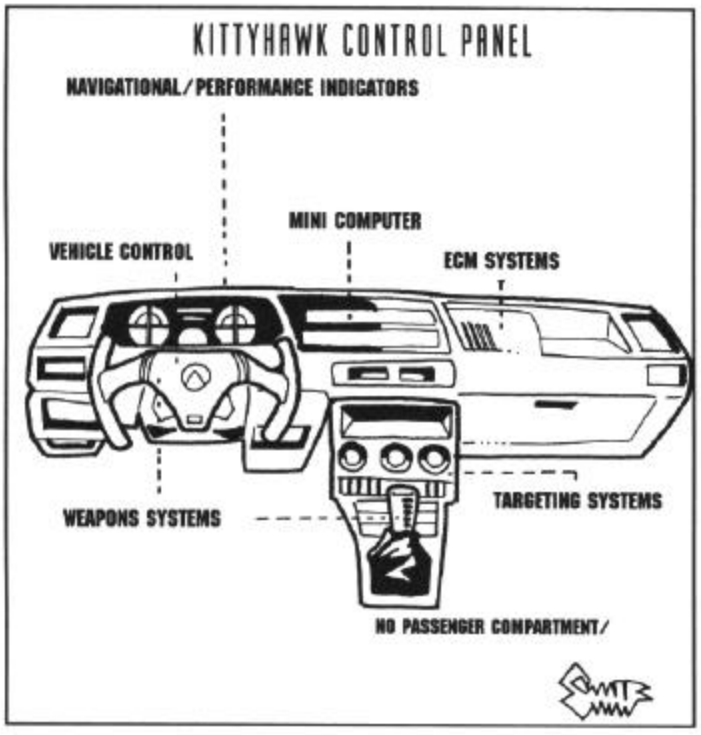
Laboratories and Workshops for conducting research or making repairs, on p. 66.

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

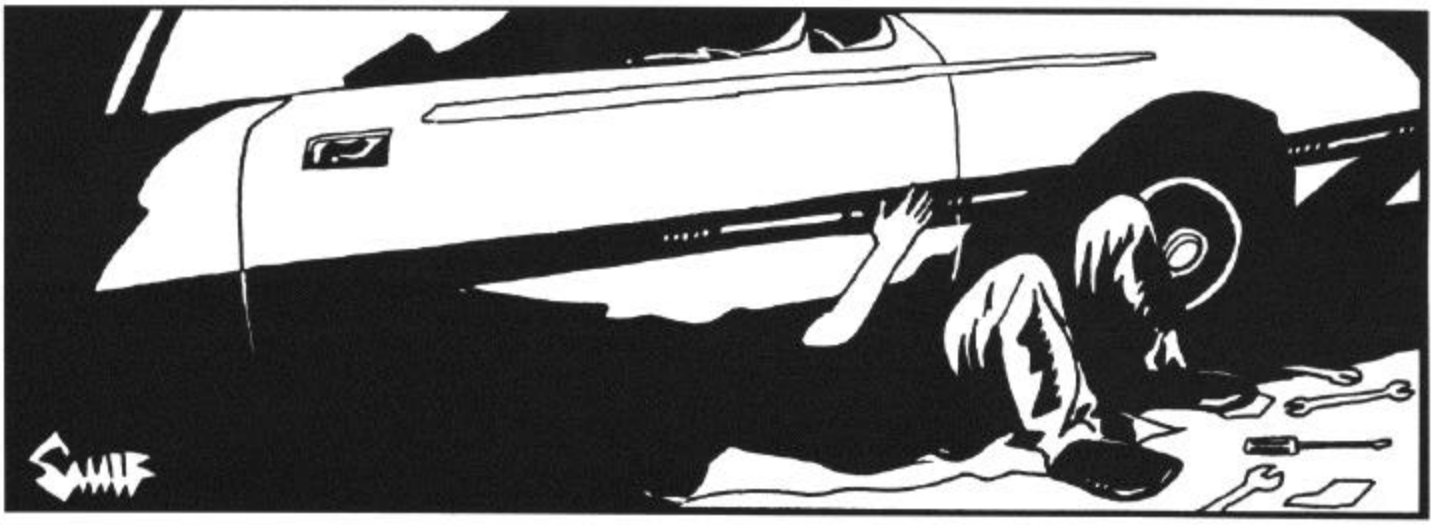
The Kitty Hawk's jet and its gas turbine both use fuel. We install a 60-gallon, light, self-sealing tank. See the *Fuel* section (p. 88) in Chapter 7 for details.

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

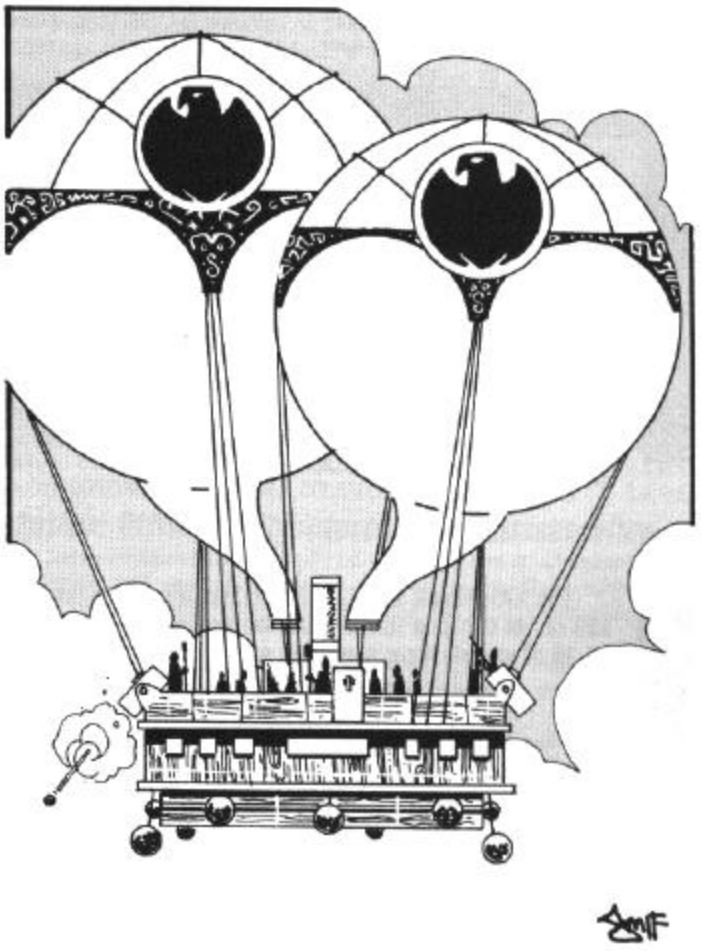
A mast's volume in cf is (height in feet cubed)/10,000.

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

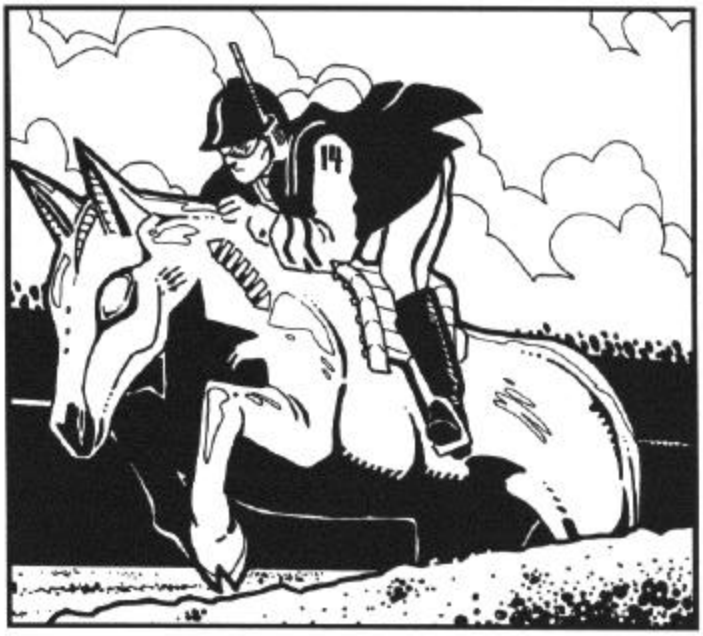
After structural surface area is calculated, the vehicle's internal skeleton and frame – its structure – can be designed. A vehicle's structure can be modified with various structural options, which affect the structure's weight and cost.

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

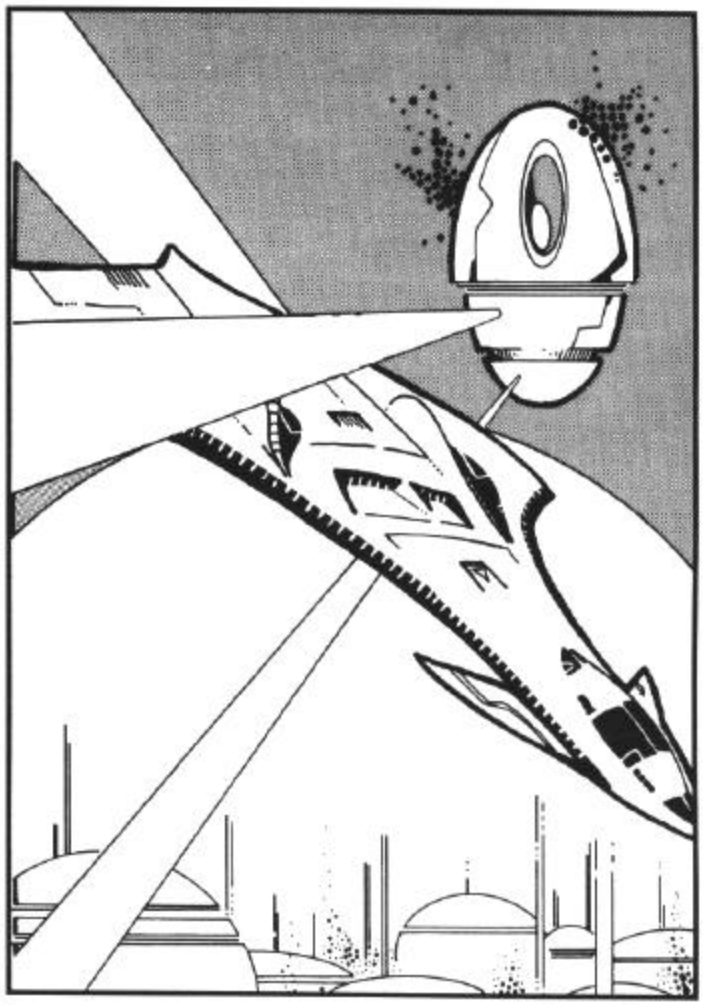
We decide the Kitty Hawk has a light frame built with very expensive materials. The fact that it is submersible and streamlined will also affect its structural weight and cost. Weight is 6 lbs. (TL7 structure) × 0.5 (light frame) × 0.5 (very expensive materials) × 2 (submersible) × 1 (Fair streamlining) × 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).**

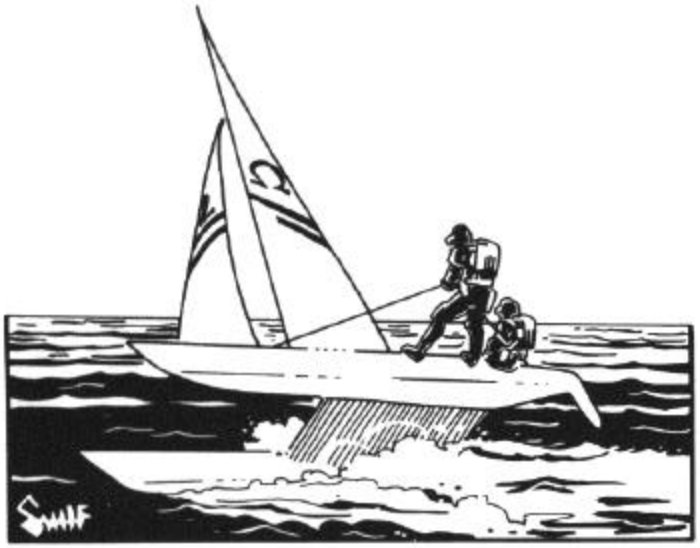
Option: Different Structures for Subassemblies

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	0.0015	$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)

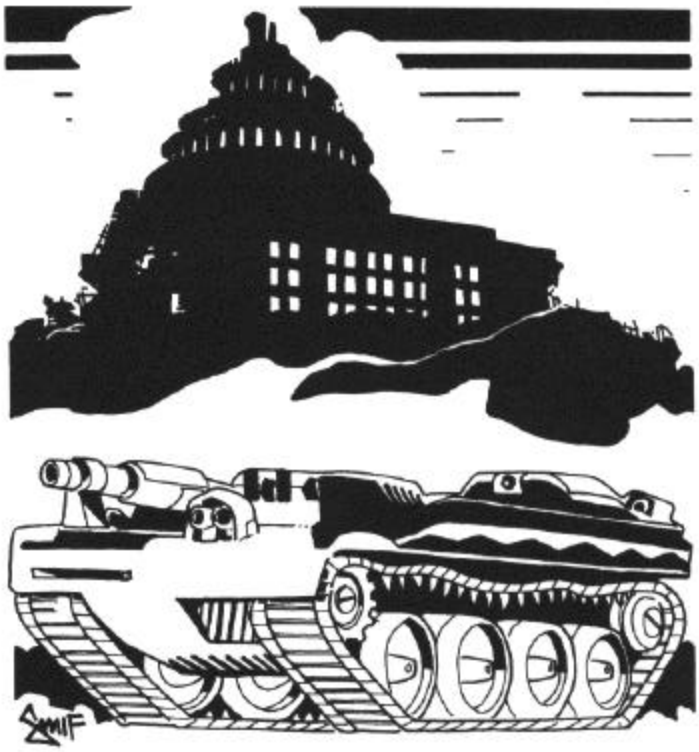
Most large vehicles are divided into several compartments automatically. But a vehicle built at TL5 or higher can optionally be given Heavy or Total compartmentalization. This is most common on carefully-designed warships, but other vessels (such as well-protected space and ocean liners, battle tanks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

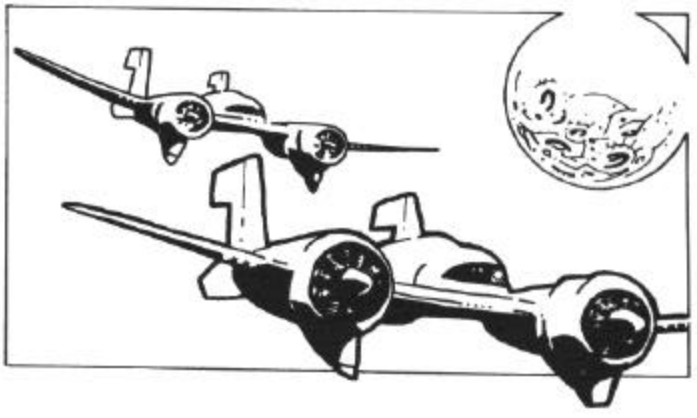
There are several kinds of armor: wood, metal, composite, laminate, ablative, nonrigid and reflex.

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.

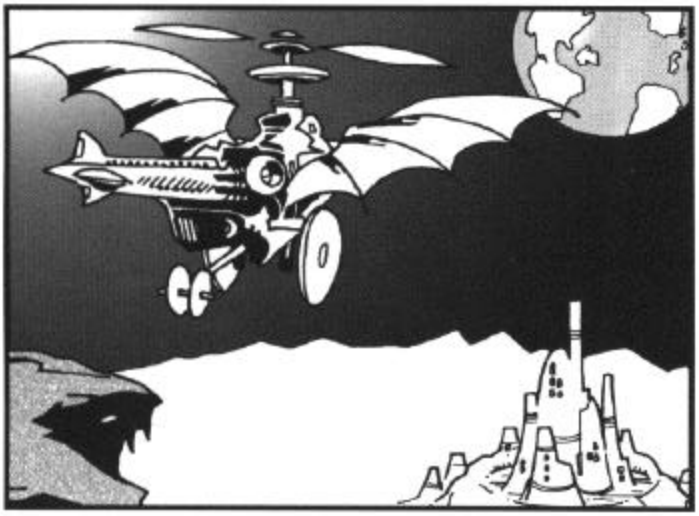
Slope and PD: As well as possibly increasing PD by boosting DR, slope will further increase Passive Defense on the sloped faces, provided that armor is either metal, composite or laminate. PD is increased as follows:

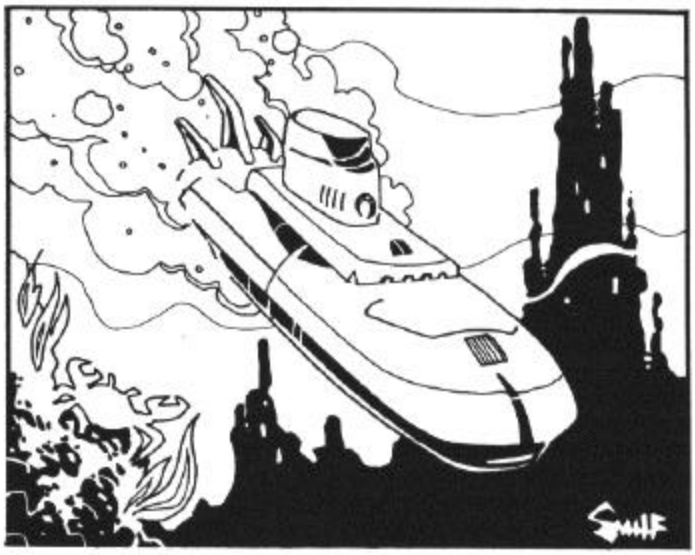
30° slope adds +1 to PD on the face that is sloped.

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.

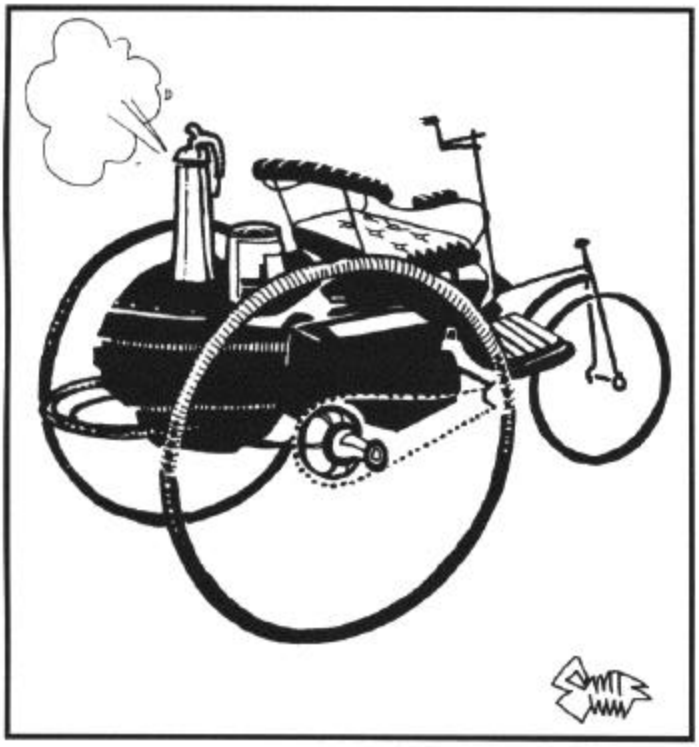
Loaded Mass in Tons: If the weight checks out, find the loaded mass in *tons.* This is used in some performance calculations. Divide the loaded weight by 2,000 to get it. (If the vehicle has hardpoints, calculate two loaded masses.) Round fractional loaded masses to two decimal places.

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 contra-grav 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.

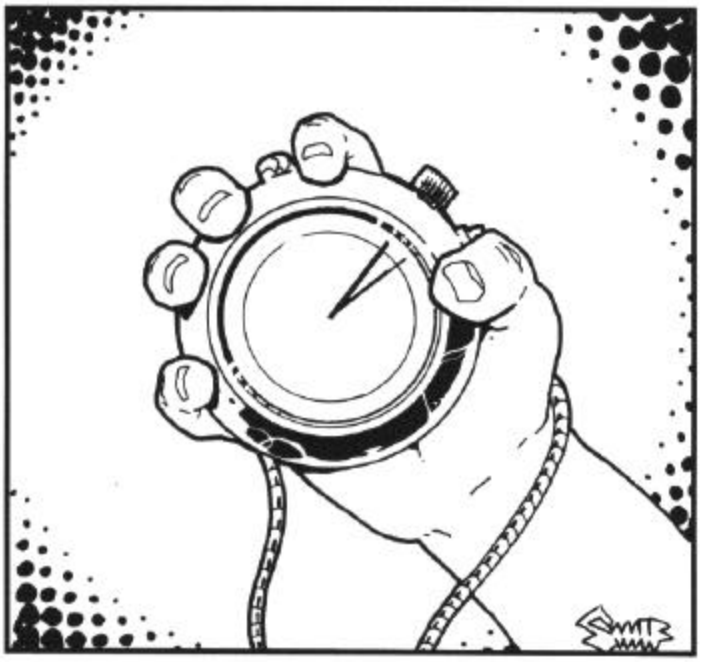
BHP = body hit points. *Lwt.* = loaded weight.

(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.

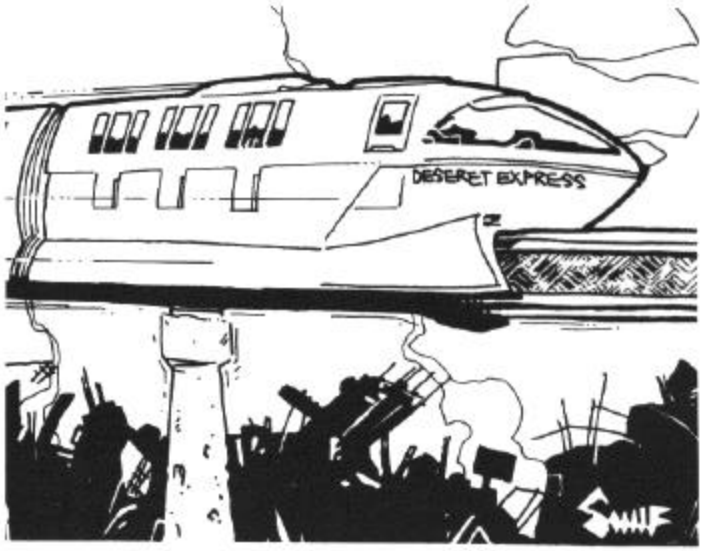
Safety Belts: Safety straps or belts can be assumed to be "free" with seats at TL6+, although not all vehicles have them.

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.

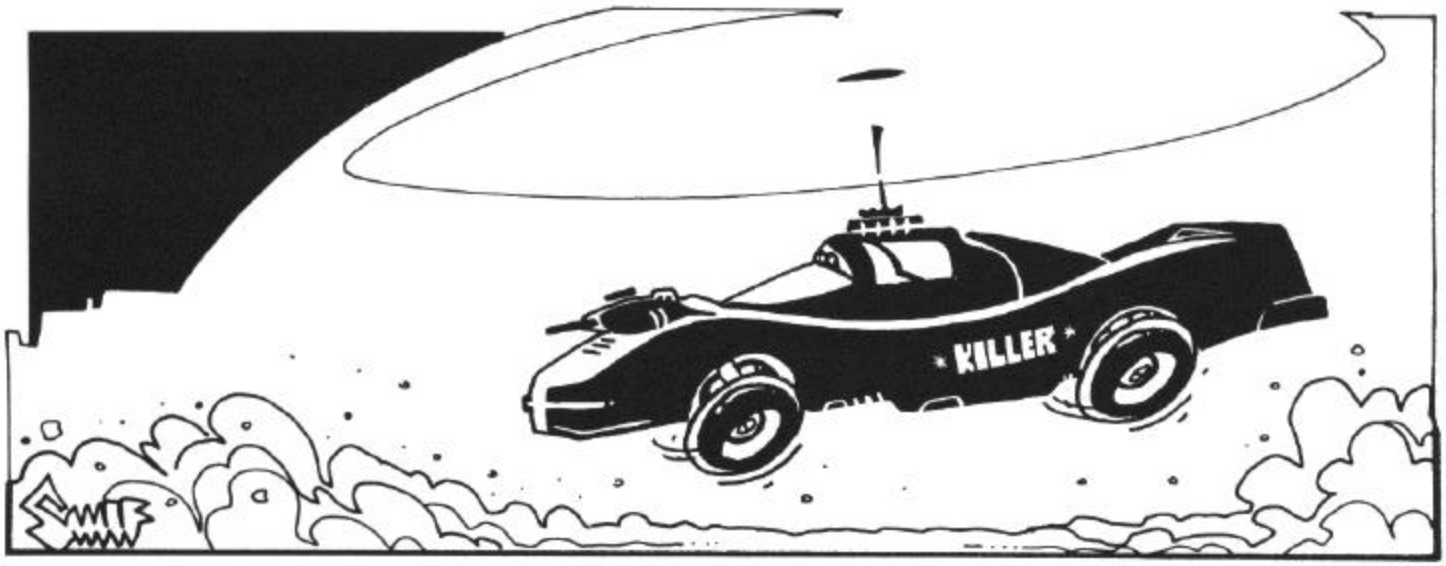
Page is the page where the system is described in detail.

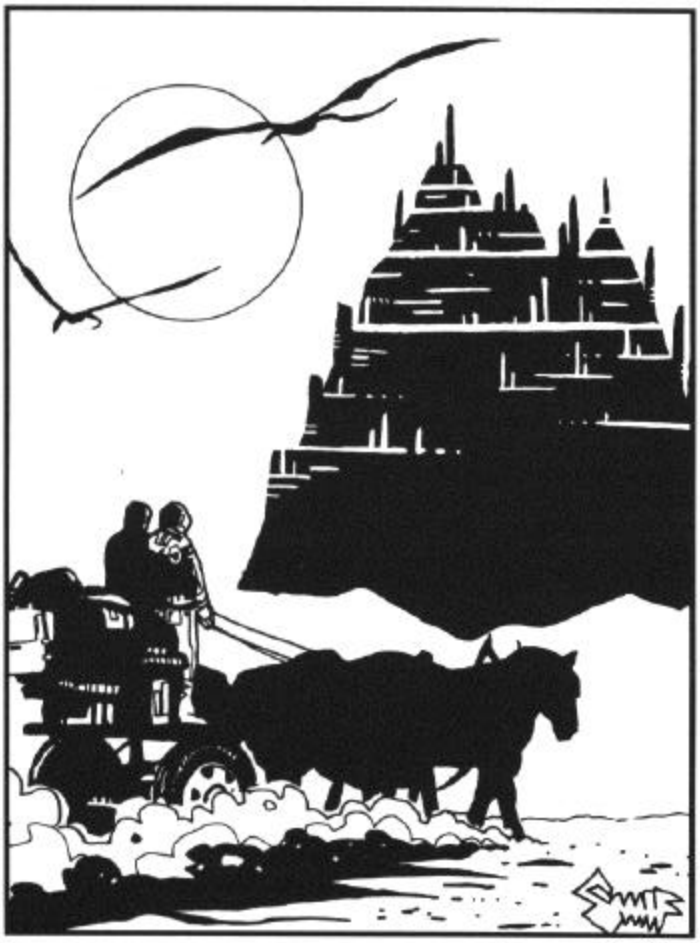
Choose a propulsion system or systems that suit the vehicle's concept, and design their capabilities and statistics.

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

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.

EXAMPLE





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.

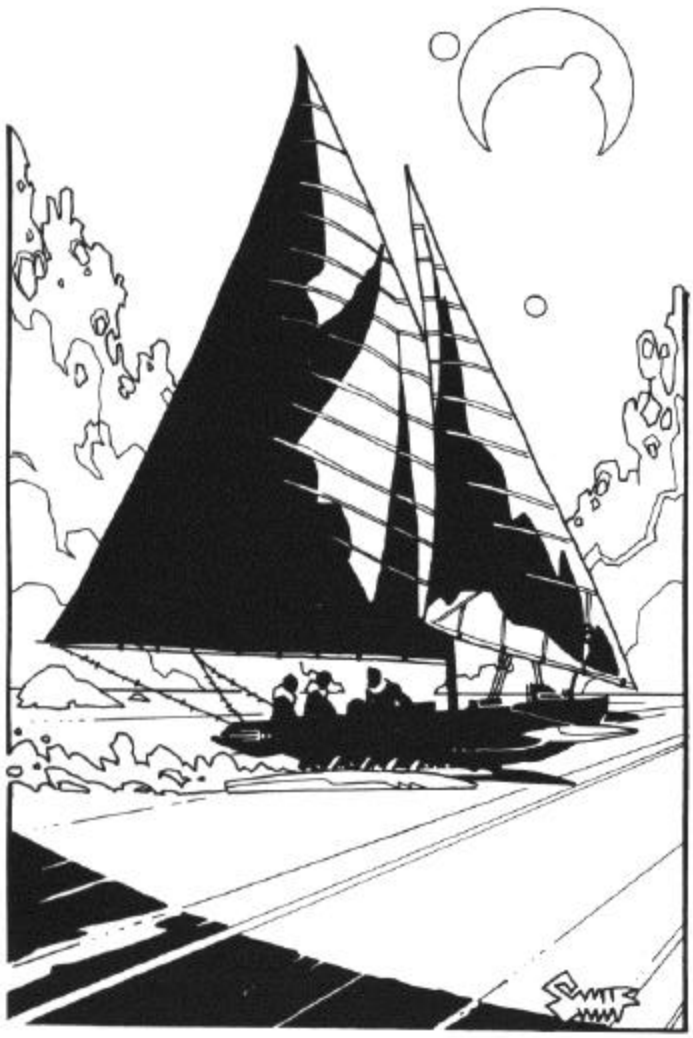
Weight, Volume and Cost per rowing position is shown below. This includes paddles, or oars and oarlocks, and the space to use them but not weight, volume and cost of the seats, which will be covered under *Crew and Passengers*.

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.

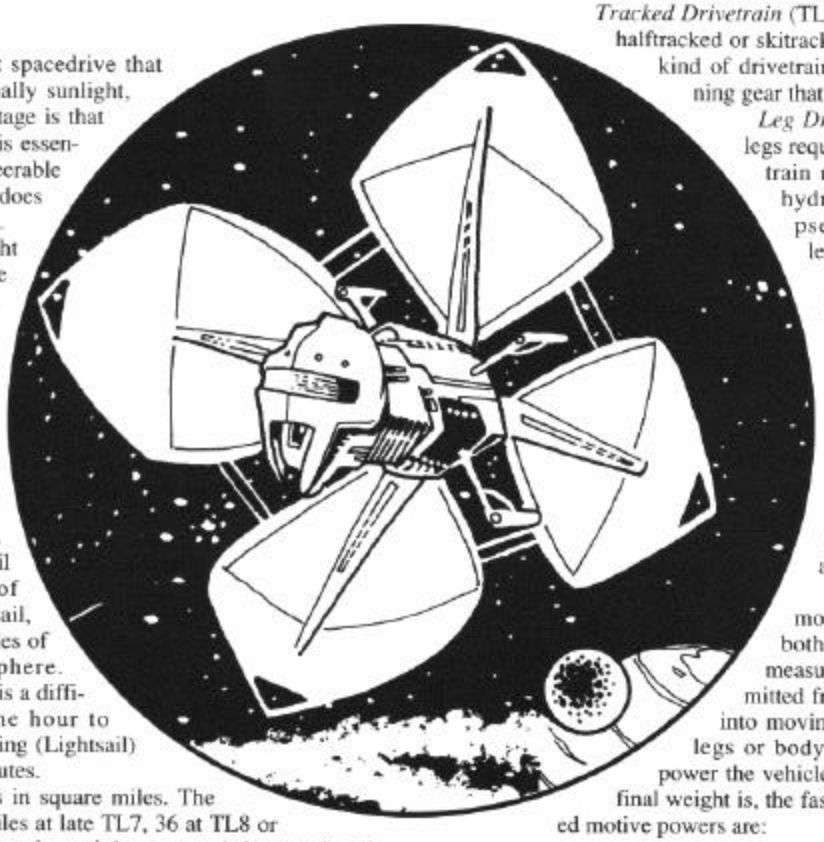
Aerial sails are built exactly like an ordinary fore-and-aft or full rig, but have 1.5 times the area and weight of sail, and twice the cost. They are also usable as normal sails for land or water propulsion, but excess masts and sail that would get in the way must first be removed and stowed. This takes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

TL	Type	Weight in lbs. when Motive Power is under 5 kW	5 or more kW	Aquatic Motive 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

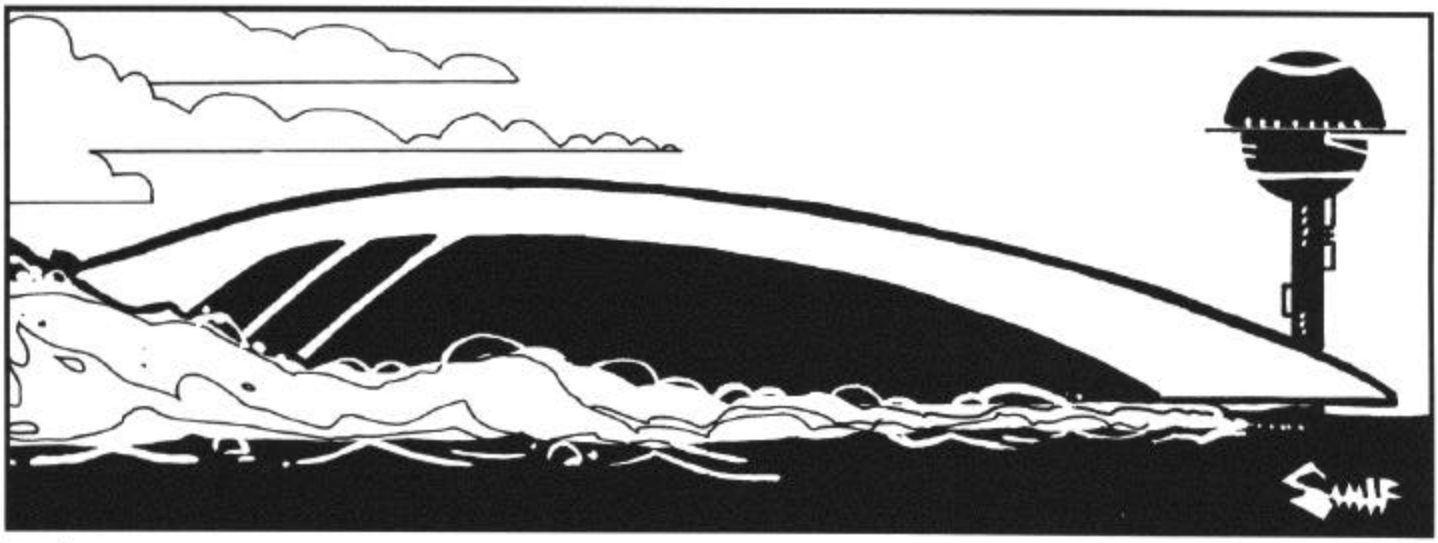
Location: Paddle wheels must go in the body. Propellers and MHD tunnels (see p. 84) may go in either the body or pods. Hydrojets may go in the body, pods, hydrofoils or legs.

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

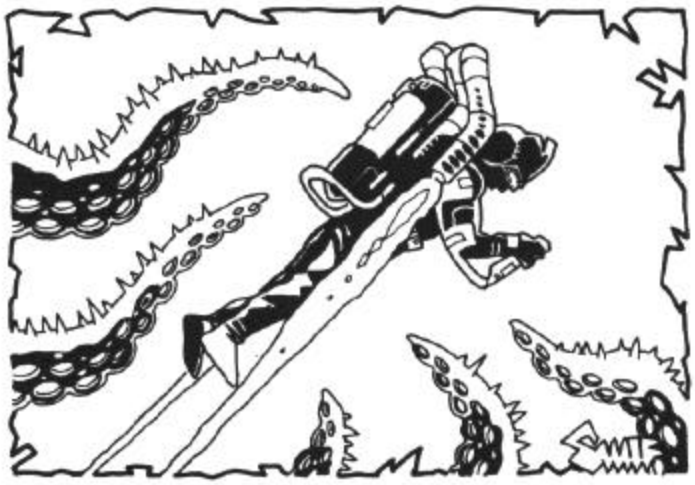
Location: Ornithopter drivetrains may only go in wings.

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!

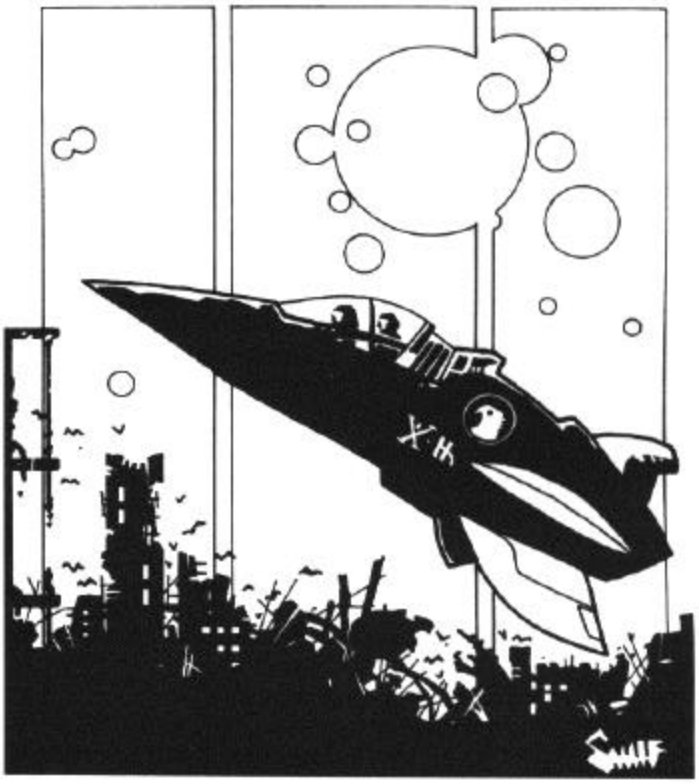
Decide what type of engine the vehicle will use, how many it will have, and what each engine's motive thrust will be. Some typical jet aircraft motive thrusts:

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

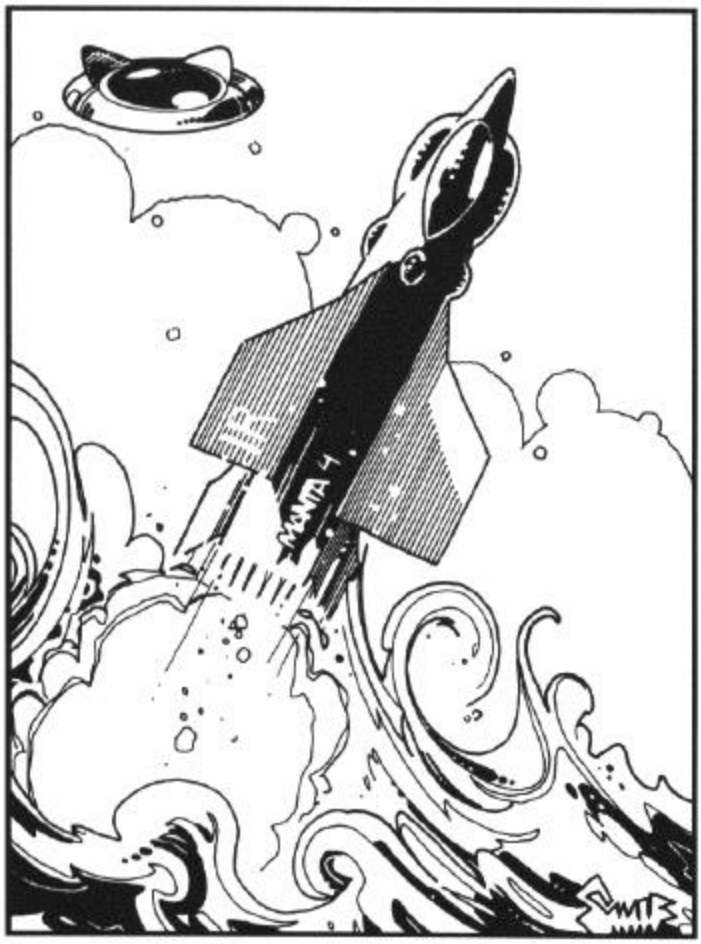
Location: The engine may be placed in the body, wing, pod, superstructure, or leg.

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!

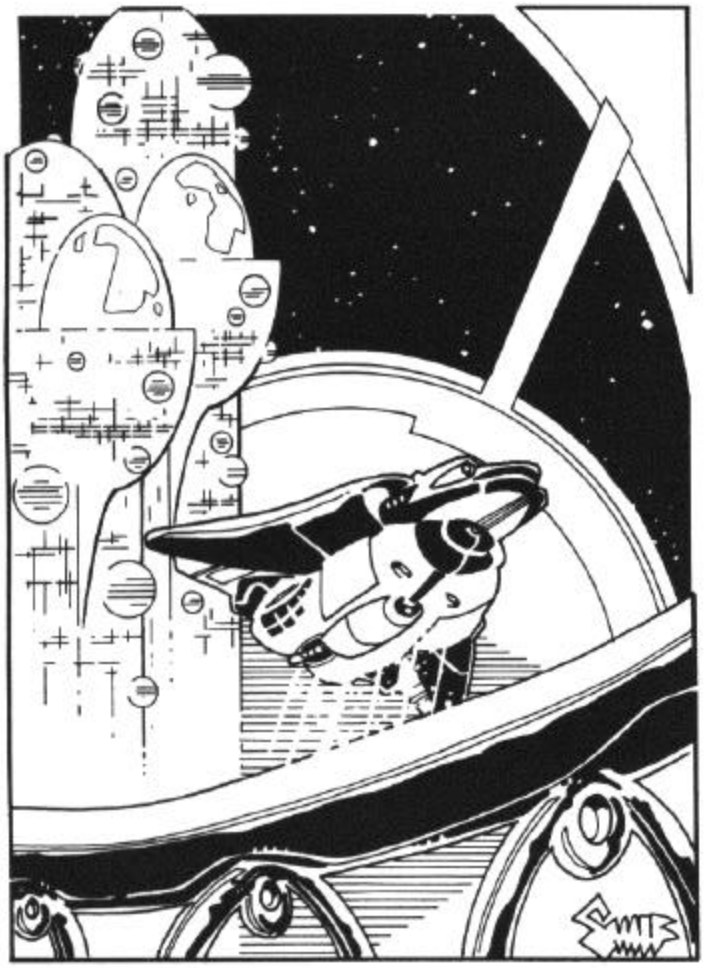
TL9 reactionless thrusters produce considerable waste heat discharge, as much as any rocket of equivalent thrust. TL10 thrusters produce some waste heat discharge, similar to a jet engine. TL11+ thrusters produce no waste heat and are invisible and silent. Most "grav" vehicles use TL11+ reactionless 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:

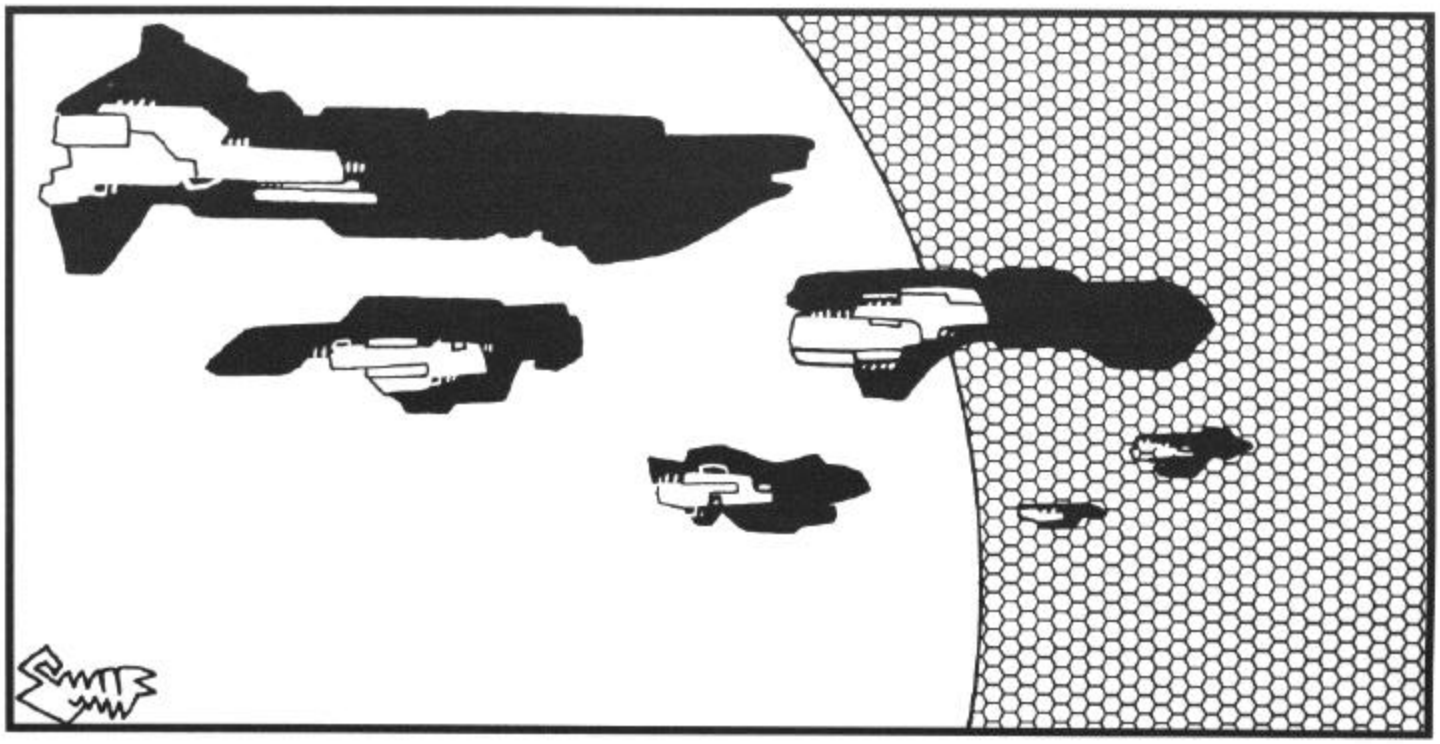
Mag-Lev Lift Table

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-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:

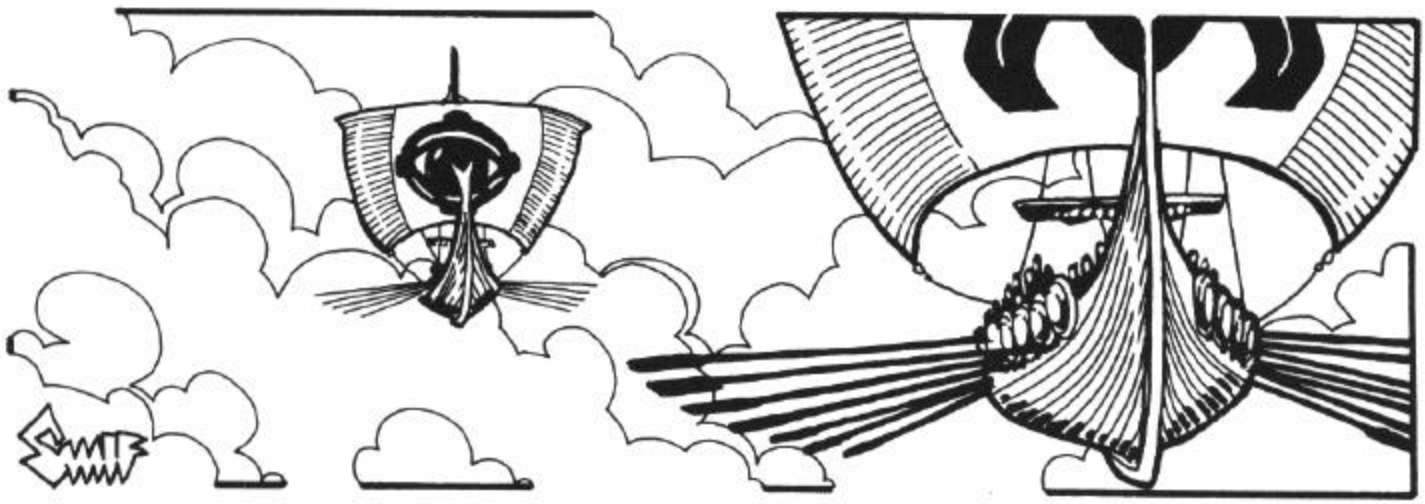
Magic Levitation (TL0): A vehicle body can be enchanted with the Levitation spell, using the same method that is used to create flying carpets (see p. M70). The energy cost is a flat 700 energy per 250 pounds of lift (or fraction thereof).

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

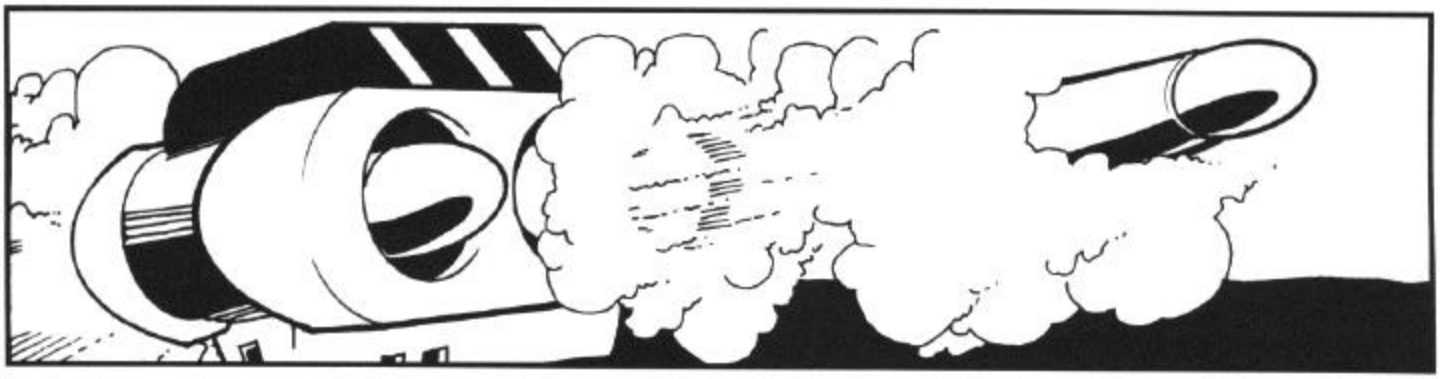
Name	*Malf*	*Type*	*Damage*	*SS*	*Acc*	*1/2D*	*Max*	*RoF*	*Wt*	*Cost*	*WPS*	*VPS*	*CPS*	*Ldrs.*
TL2 Catapults														
Ballista	Crit.	Imp	6d+2	20	6	430	540	1/35	200	$5,200	1.6	0.032	$3.2	2
Onager	Crit.	Cr	13d	30	2	240	300	1/50	2,000	$8,800	10	0.2	$5	3
TL4 Naval Guns														
50mm Swivel	14	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	0.0037	$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]	6d×20(5)	20	11	680	4,500	3	350	$17,000	4.7	0.046	$84	0

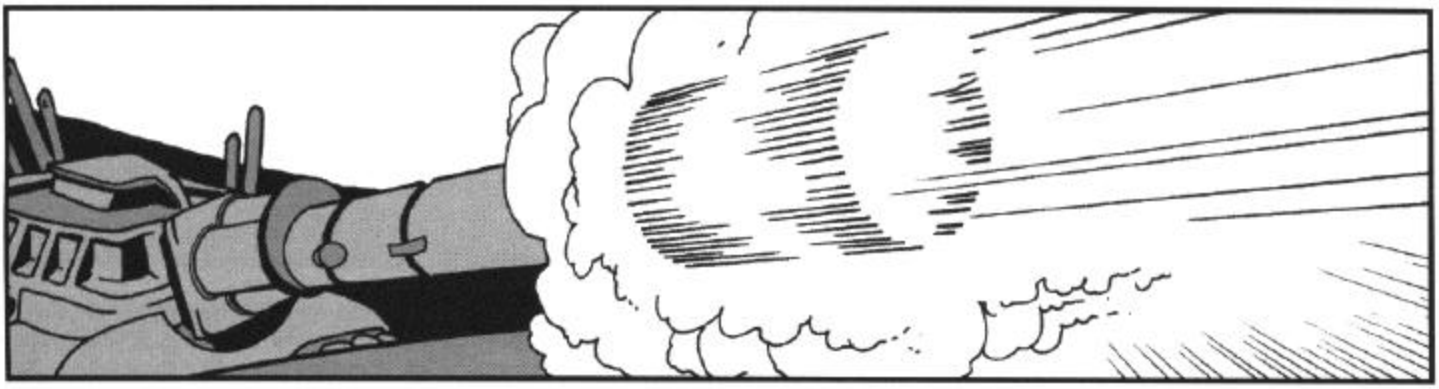
Footnotes:

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

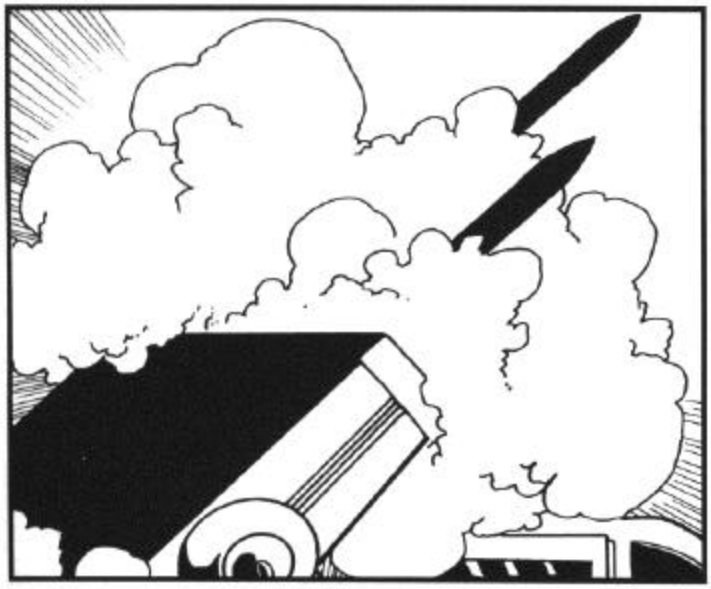
A weapon stabilizer can be added to any vehicular weapon. It gyroscopically stabilizes the weapon, keeping it pointed in the same direction, regardless of the movement of the vehicle. The effect is to reduce the penalties suffered when firing while the vehicle is moving. There are two kinds of stabilization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

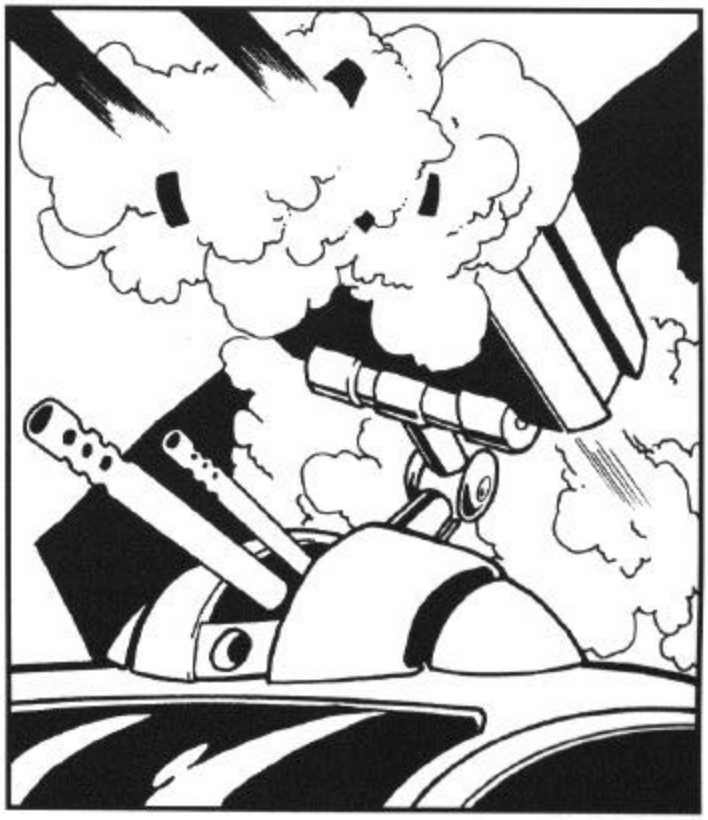
Partial Stabilization (late TL6): The weapon is stabilized in elevation only. Partial stabilization reduces movement penalties by 1.

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.

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.

EXAMPLE

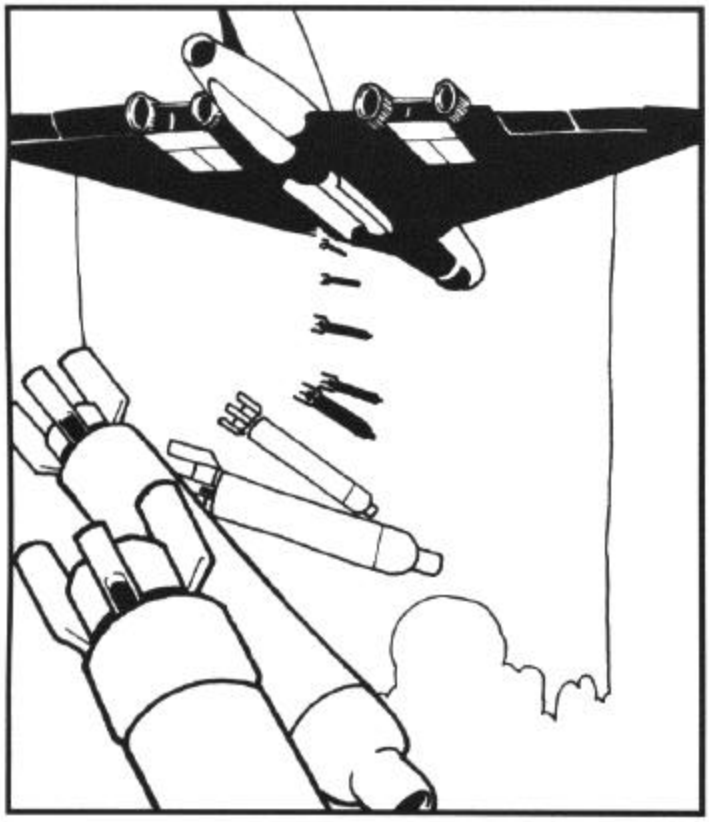
Special Mountings

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.

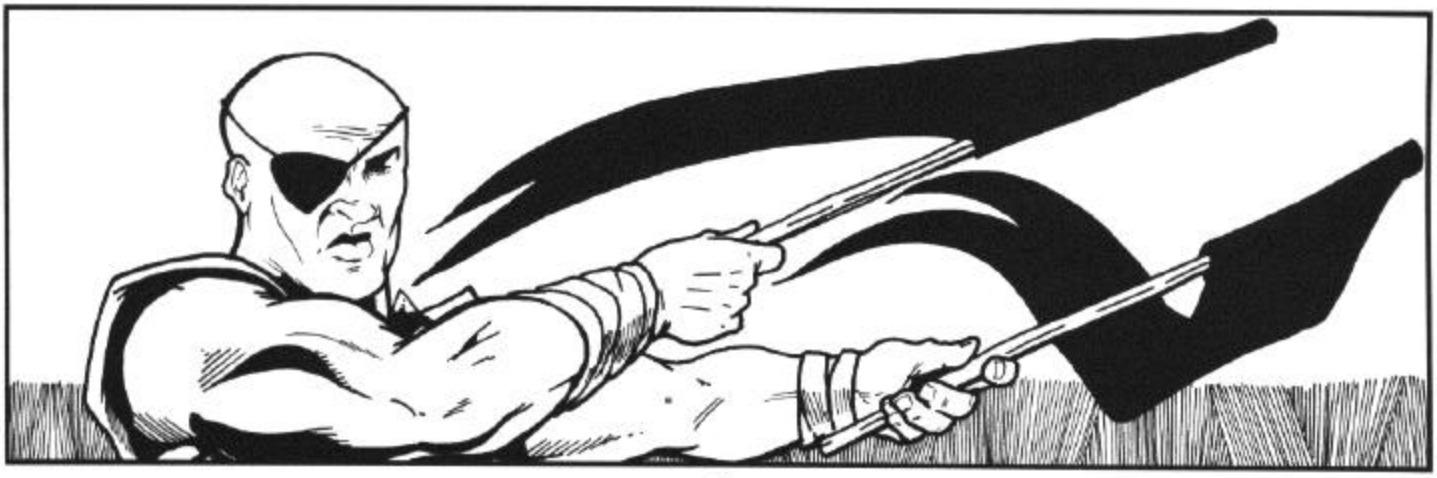
Communications are normally limited to the speed of light (186,000 miles per second). For planetary communications, this is effectively instantaneous, but in space, a lag between sending a message and receiving a reply may be noticeable.

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.

EXAMPLE

The Kitty Hawk has headlights; there is no extra weight, volume or cost.

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:

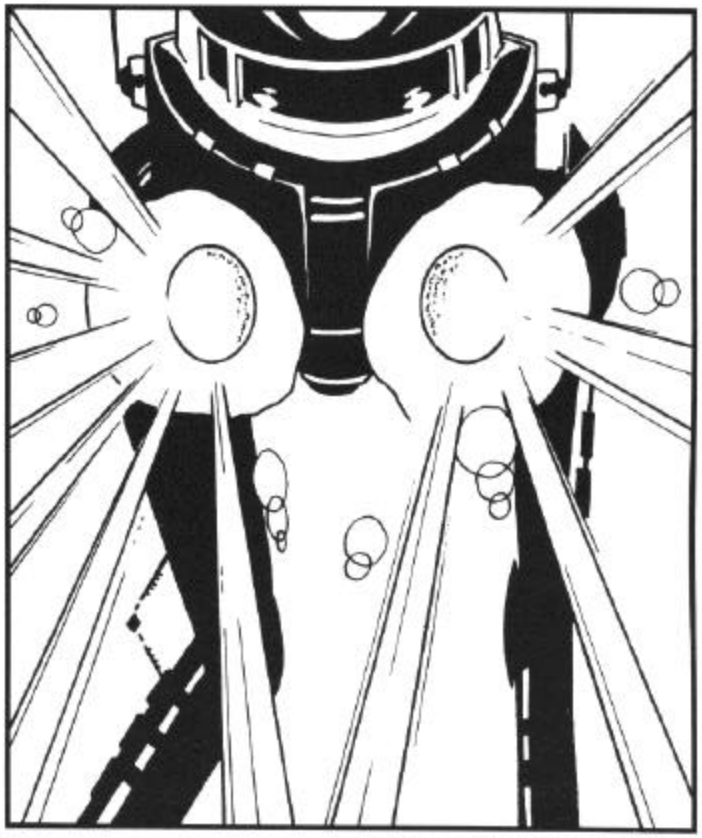
Visual Augmentation Sensors, which enhance the user's vision – telescopes, light amplification and low-light TV.

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.

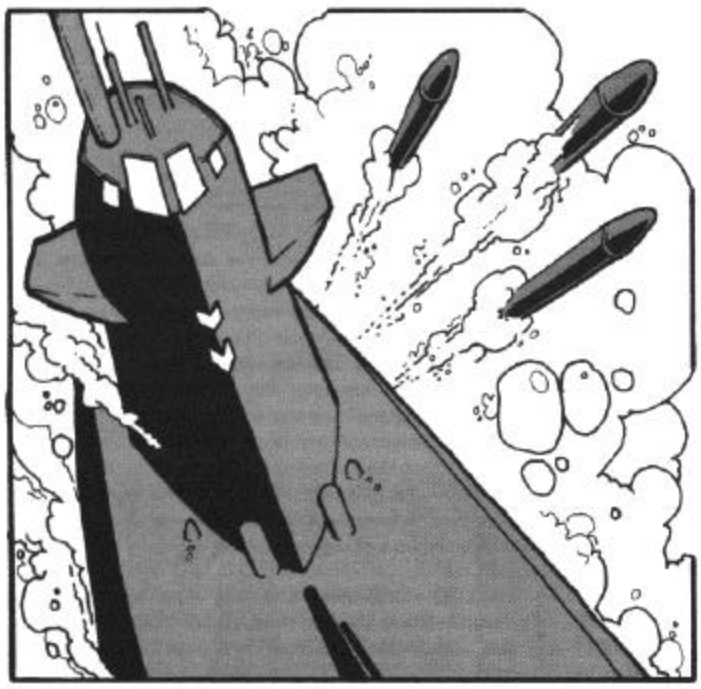
Multiply the range of the sensor in miles by the numbers shown on the table to find its weight, volume, cost and power requirement. *Exception:* If a sensor has over 125 miles range, its cost is the number shown on the table multiplied by [100 + (1/5 its range)].

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.

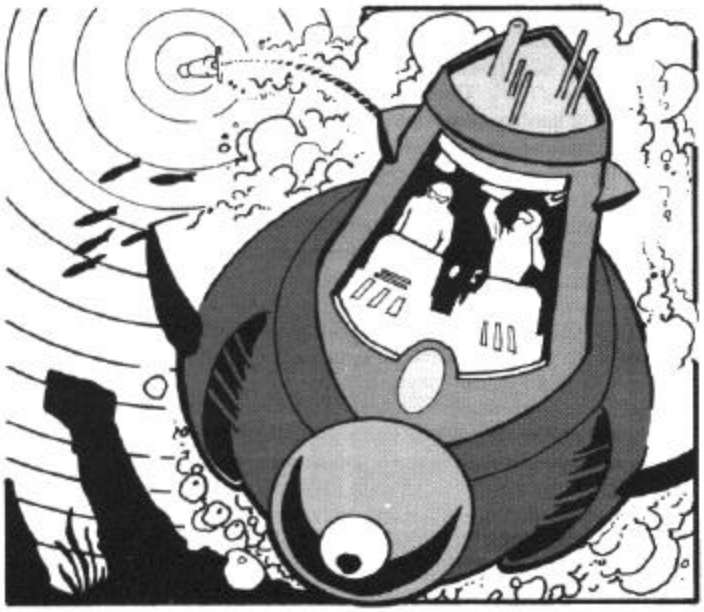
Active sonar can also be used for targeting weapons fire, feeding ranging information to a gunner. This allows a vehicle to attack targets that cannot be seen visually.

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

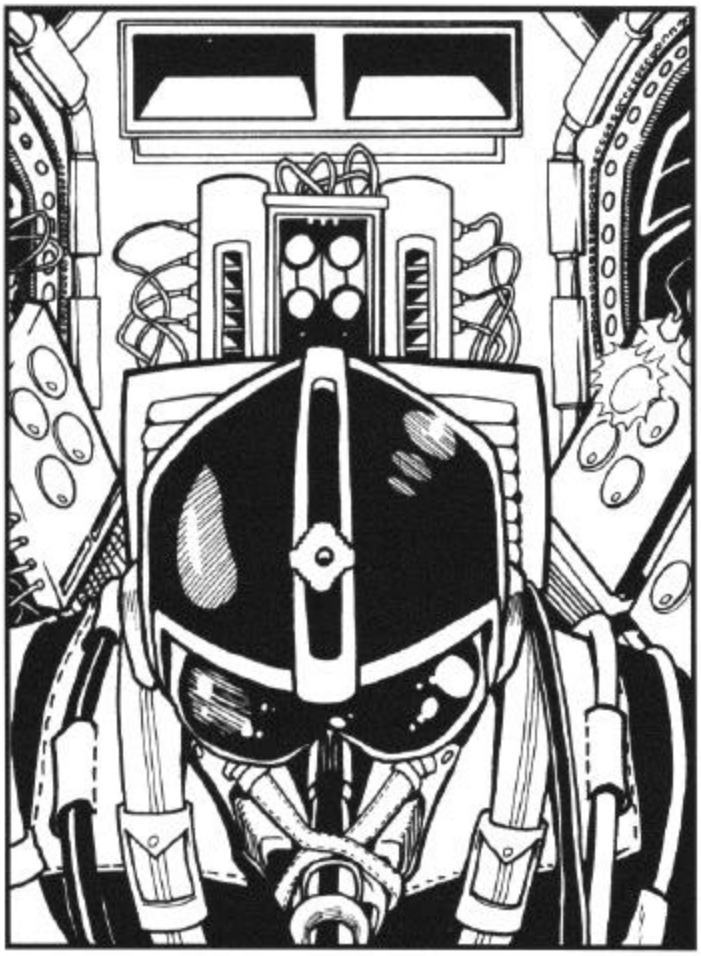
TL	*Type*	*Weight*	*Volume*	*Cost*	*Power*
7	Geophone or MAD	50	1	$50,000	neg.
8	Geophone or MAD	20	0.4	$20,000	neg.
9+	Geophone or MAD	10	0.2	$10,000	neg.
9	Multiscanner	10	0.2	$10,000	neg.
10	Multiscanner	2.5	0.05	$2,500	neg.
11+	Multiscanner	0.5	0.01	$500	neg.
9	Chem-, Rad- or Bioscanner	5	0.1	$5,000	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).

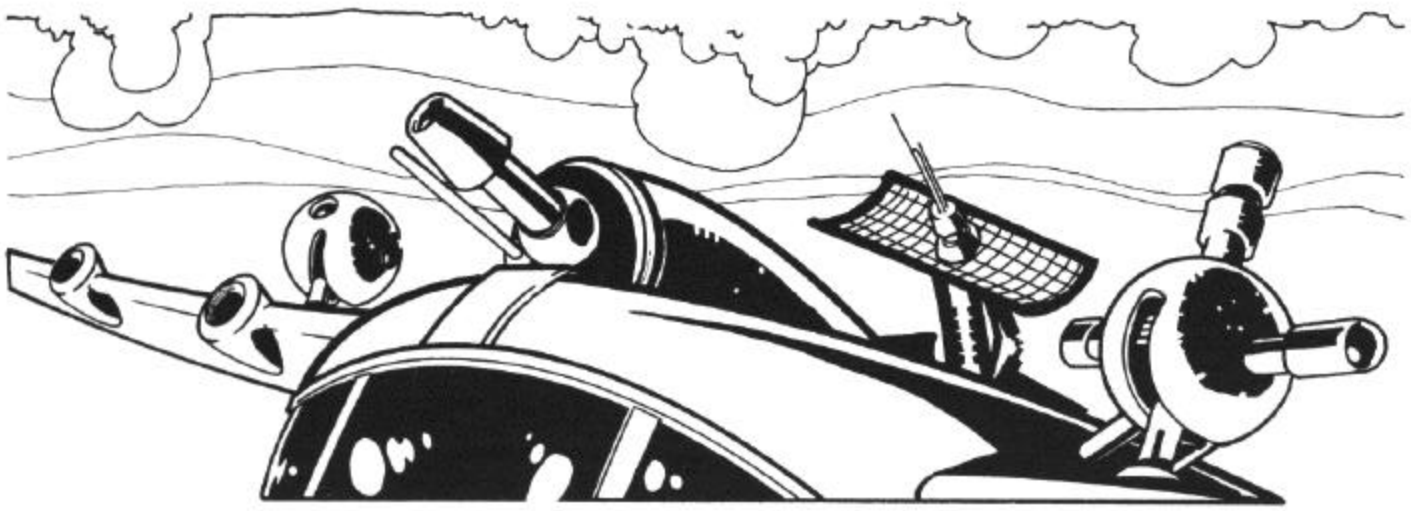
Navigation Systems

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.

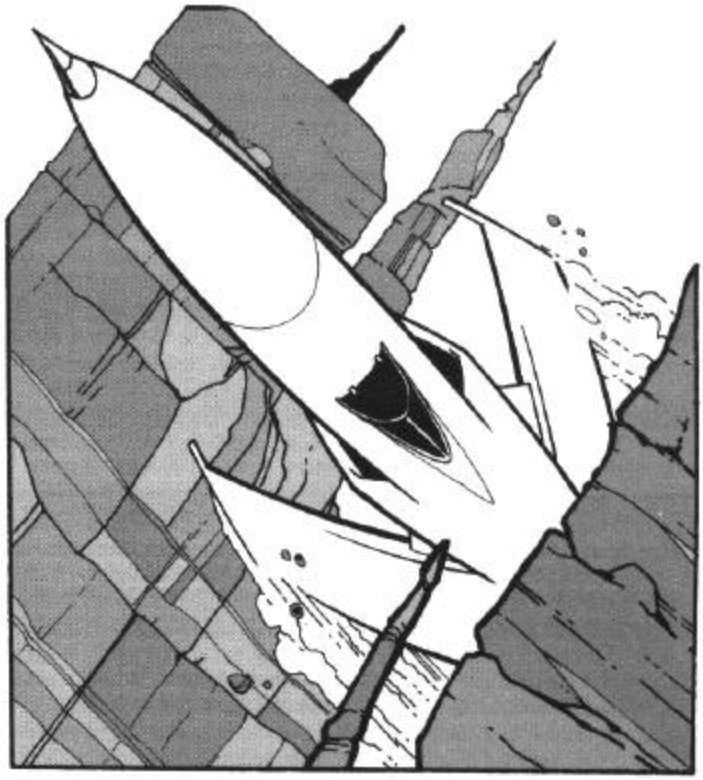
IFF (TL6): This stands for "identify friend or foe." It is a specialized transmitter and receiver unit used to identify vehicles that have been detected but whose identity is in question. A military IFF is programmed with an identification code and a list of current "friendly" codes. The IFF can be triggered 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.

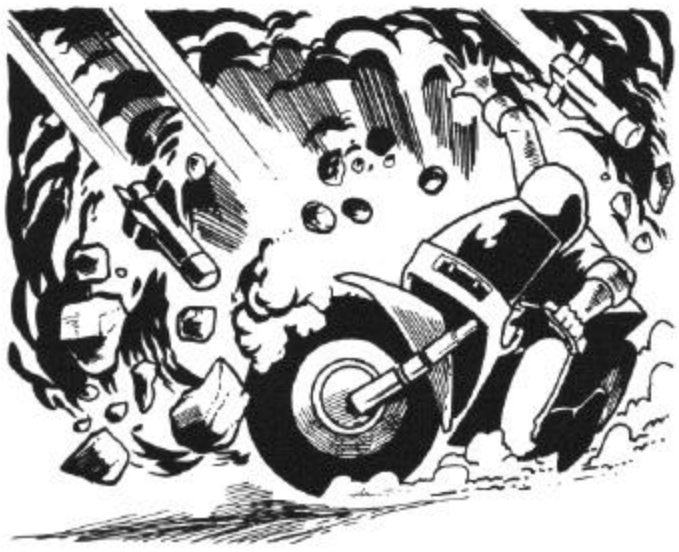
Any HUDWAC may be fitted with a pupil scanner at extra cost. This uses a laser to scan the user's eyeballs, and trains weapons and sensors wherever the user looks. This reduces the SS of any weapon mounted in an arm, turret, open mount, or casemate mount by a *further* 2 points.

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.

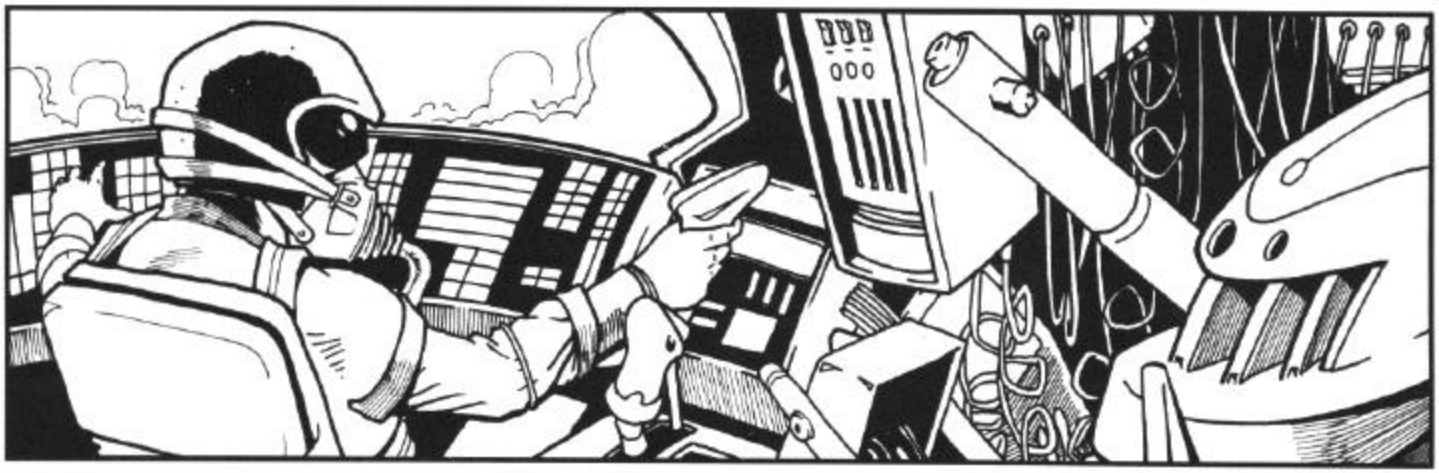
Morgan would love to load the vehicle down with countermeasures, but she's worried about weight. She settles for a TL7 advanced radar/laser detector (body, 30 lbs., 0.6 cf, $3,000, neg. power), and a TL7 decoy discharger (body, 20 lbs., 1 cf, $100) with four chaff, four flare and two sonar decoy reloads (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.

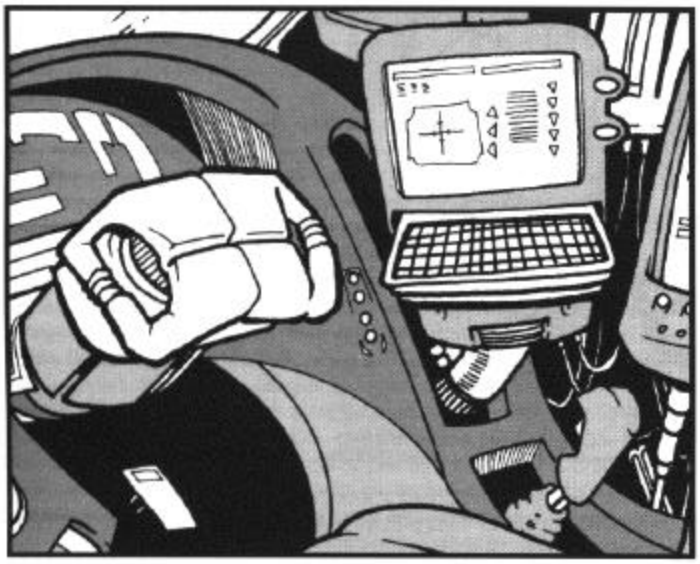
Volume: Just as with weight, if a computer has TL modifiers or options that affect volume, multiply volume by each modifier in turn.

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.

EXAMPLE

We'll add the Kitty Hawk's software later. Morgan will probably write her own or pirate it anyway . . .

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!

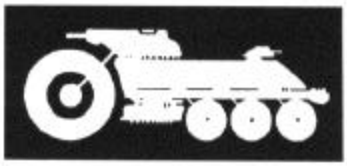
Gunner (late TL7): This is a sophisticated, intelligent target-engagement program, designed to operate autonomously. It lets the computer program act as a gunner with a skill of 12, and reduces SS as if it were equipped with a HUD of its TL. If a human gunner or robot brain skill program (see below) 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

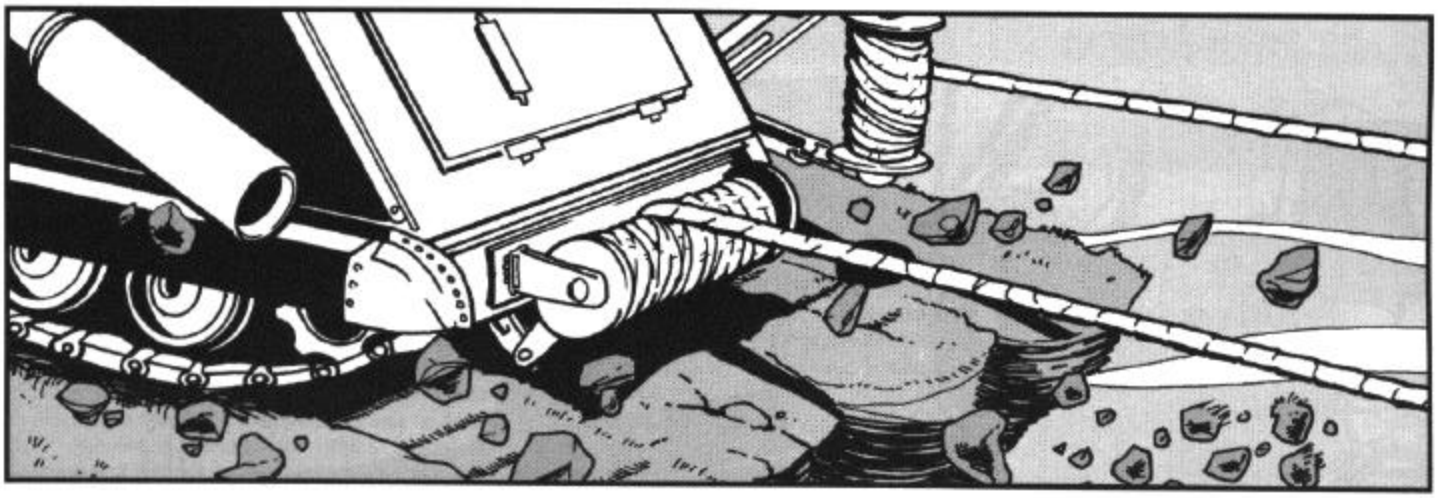
Many vehicles carry extinguishers to help put out fires. The effects of fire extinguishers are described in the rules for *Fire and Explosion*, p. 184. Fires can also be put out manually, using buckets, hand-held extinguishers, and so on.

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

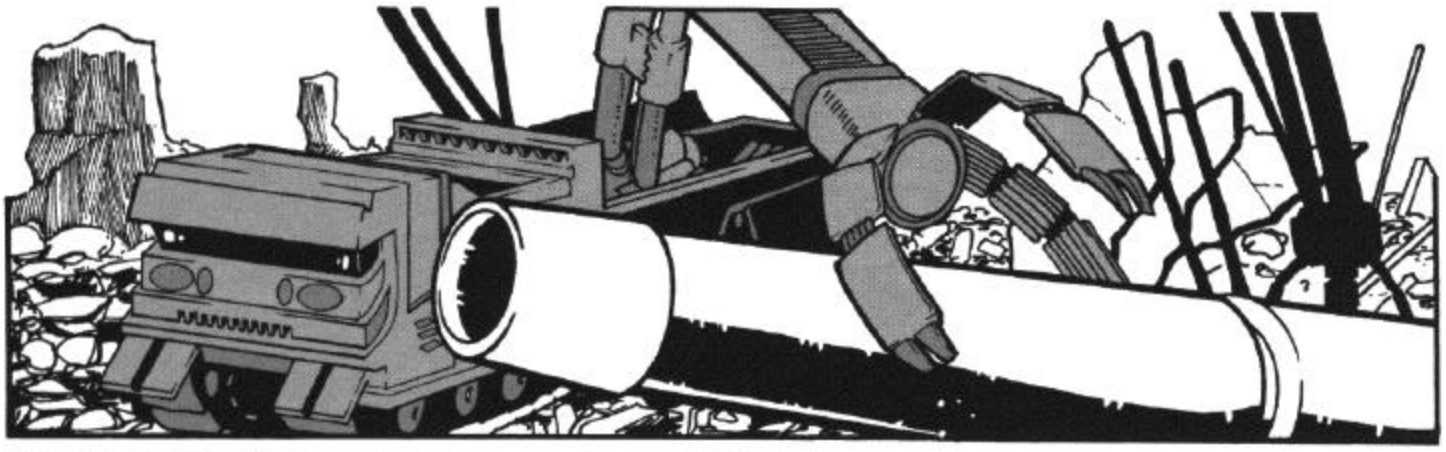
This section describes equipment used for "heavy" tasks such as construction, combat engineering, and loading or launching vehicles.

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*	*

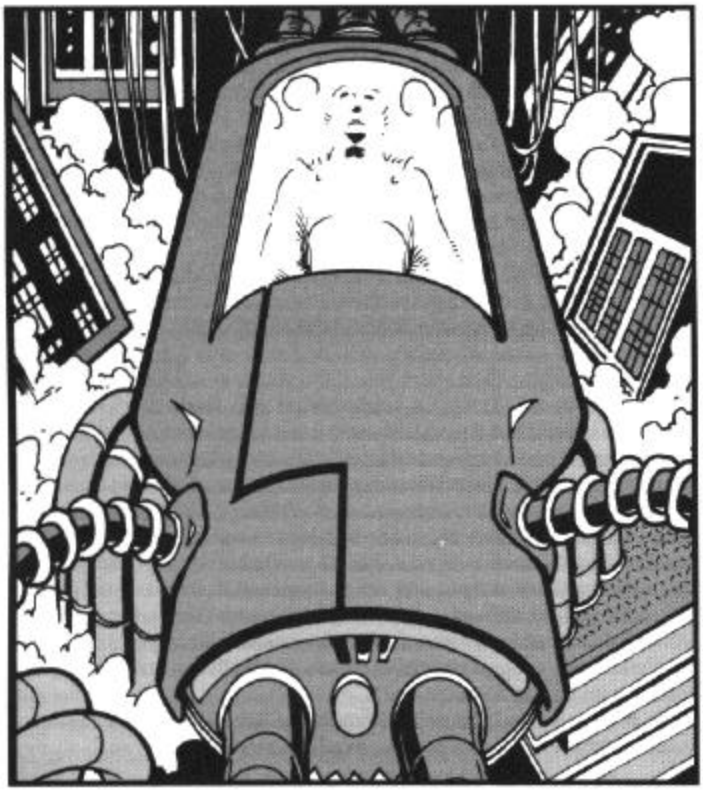
Weight, Volume, Cost and *Power:*

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.

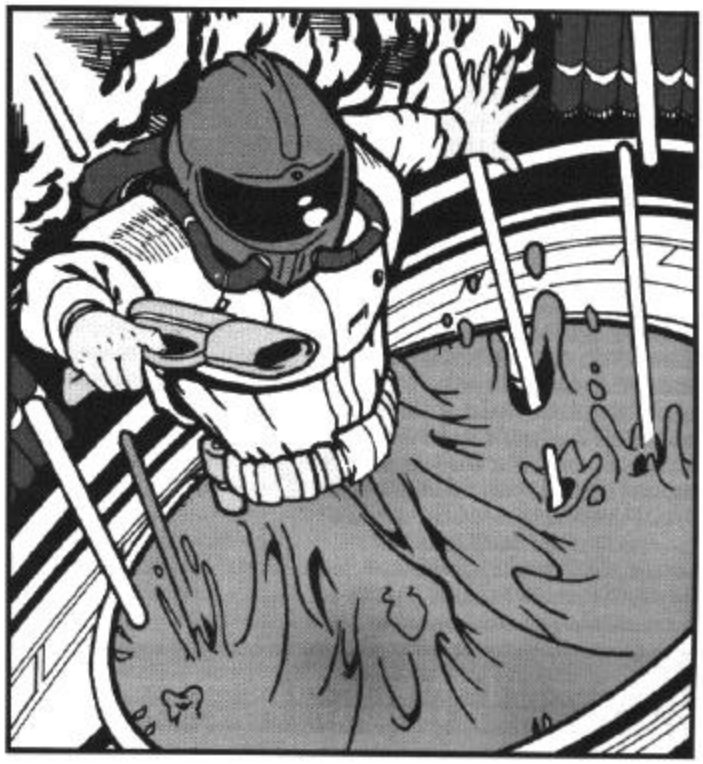
Vehicle Access

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.

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).

EXAMPLE

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

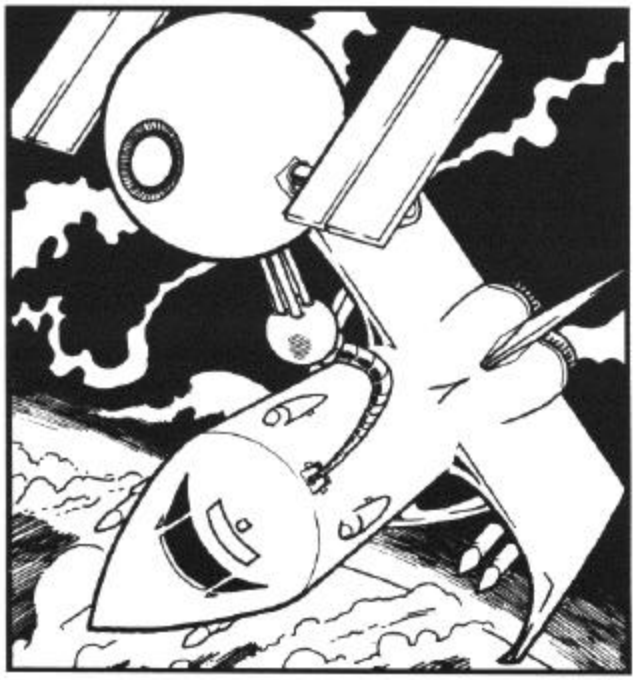
same fuel) or recharge from its energy bank. Unlike a vehicle bay, a hanger bay is not specific to a single vehicle type; any vehicle can be carried in it. The weight of a hanger bay includes any necessary elevators or ramps to carry vehicles onto a flight deck.

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.

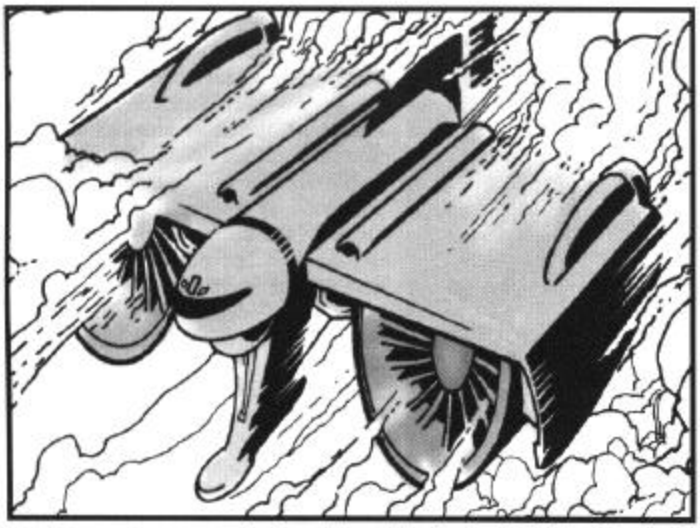
Fuel Transfer and Processing Equipment

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.

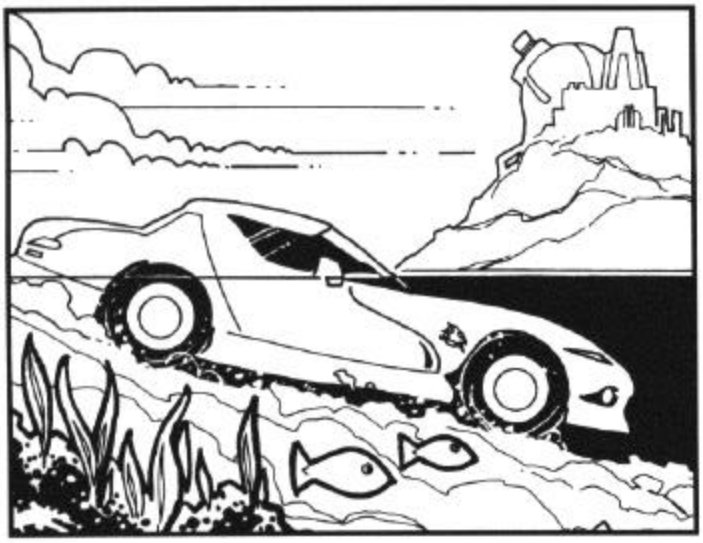
For limited life systems, multiply the weight, volume and cost by the number of man-days the vehicle provides support for, with a minimum of one-quarter man-day per person the vehicle carries. Power is *per person* rather than per man-day.

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

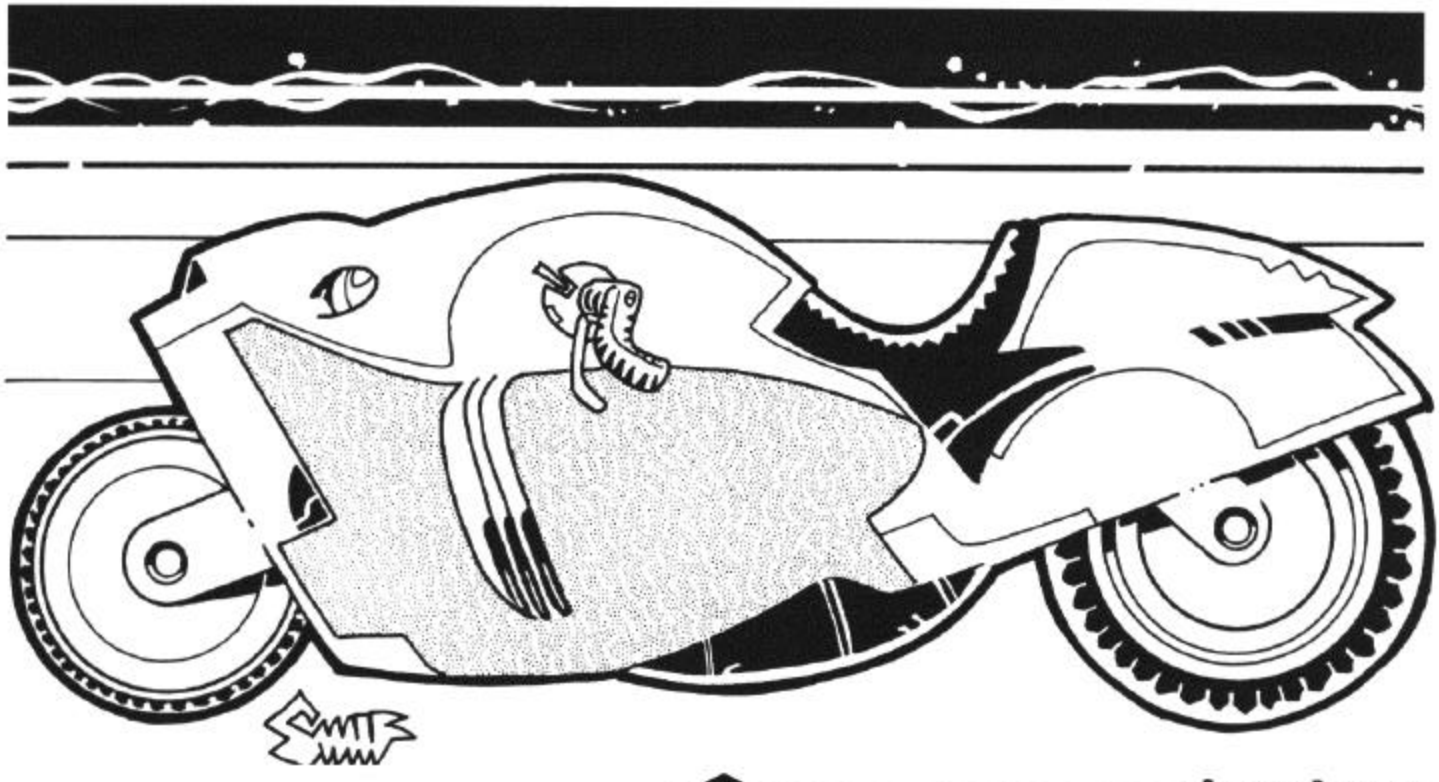
* Weight is 10 lbs. per cf of volume of seat, standing room or quarters so equipped. Volume is weight/50. Cost $50 per pound it weighs.

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.

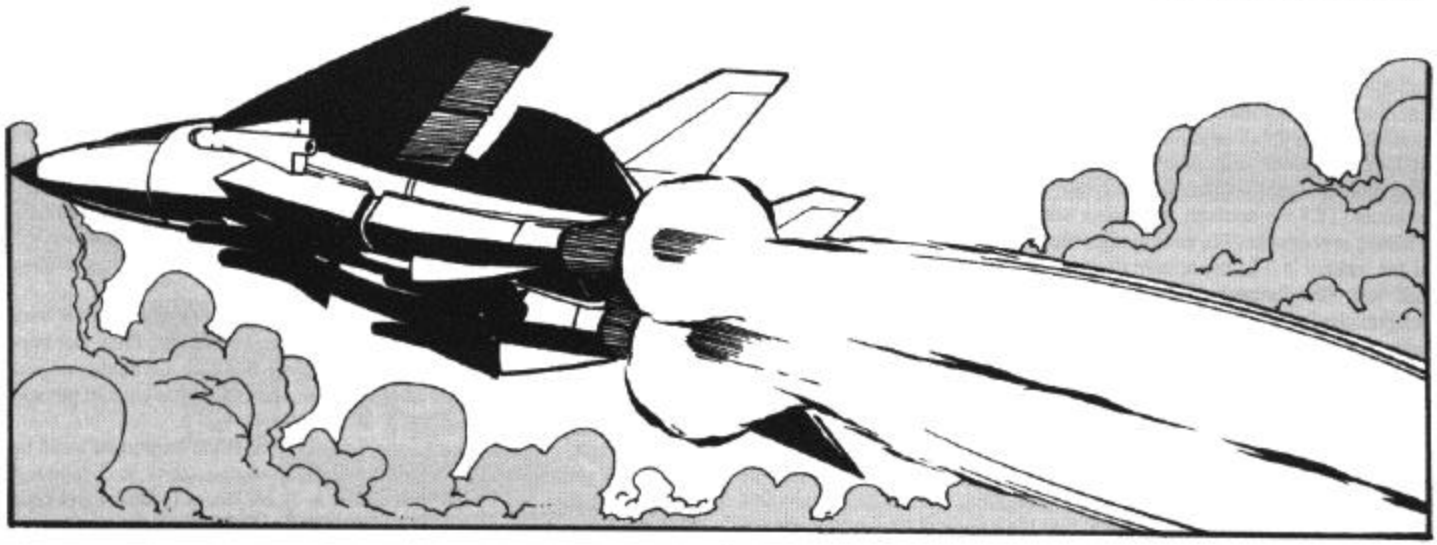
When a power plant or energy bank is installed, indicate what power-using systems it powers. Sometimes this is obvious – a single power plant or energy bank will run everything – but not always. For instance, if a vehicle has a radio using 0.1 kW and a drivetrain that uses 100 kW, it is more elegant 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.

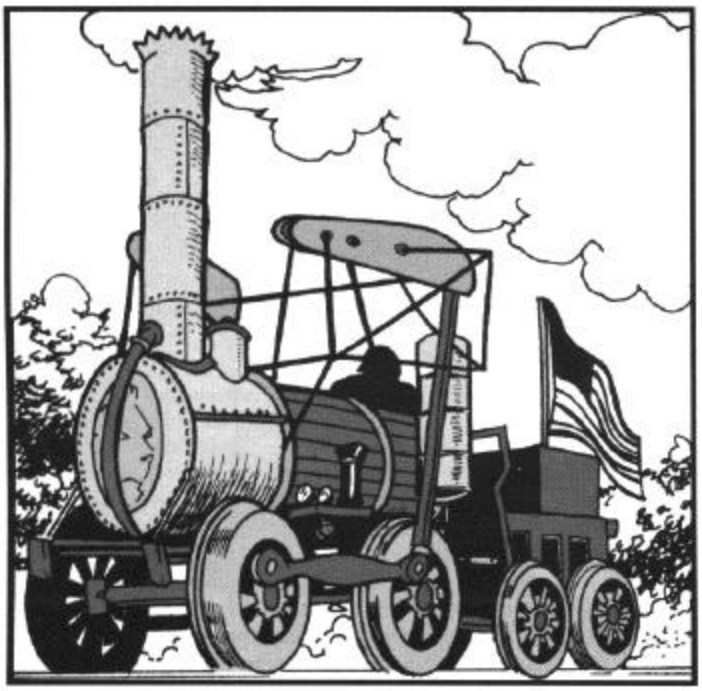
EXAMPLE

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	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.

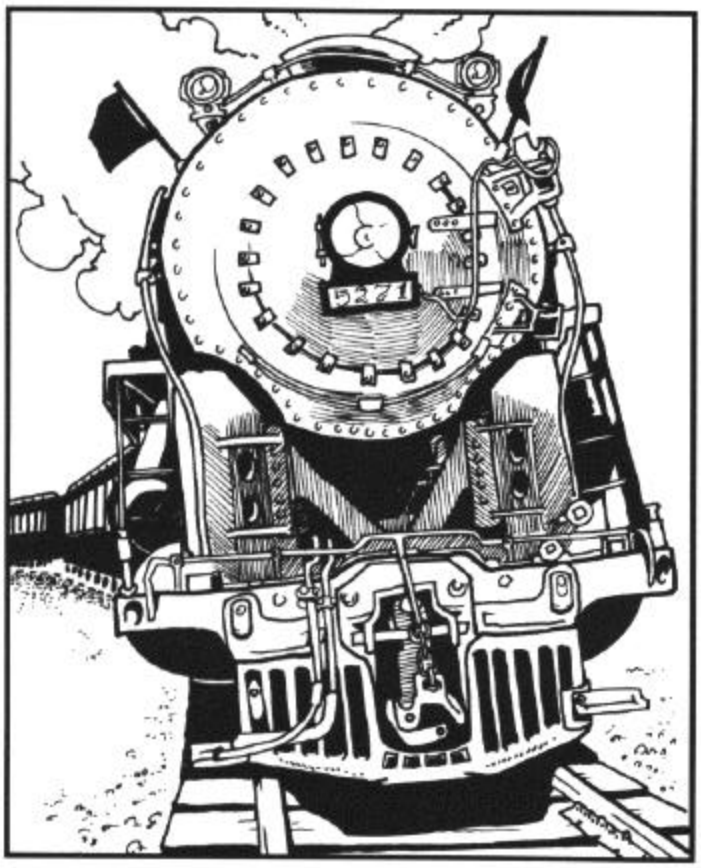
Cost: This is the cost per pound of power plant weight.

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	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

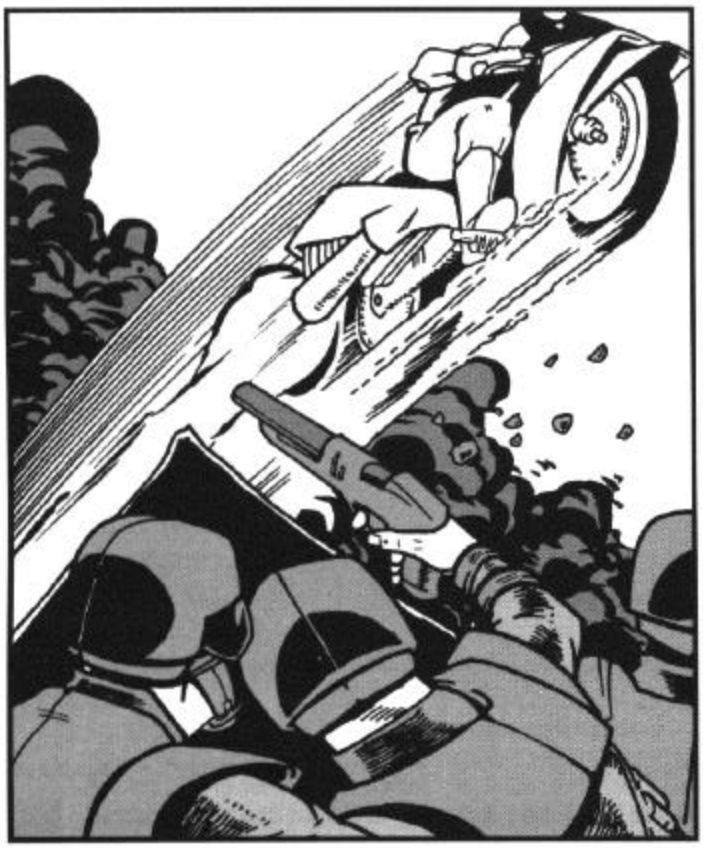
Location: Internal combustion engines can go in the body, pods or wings.

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.

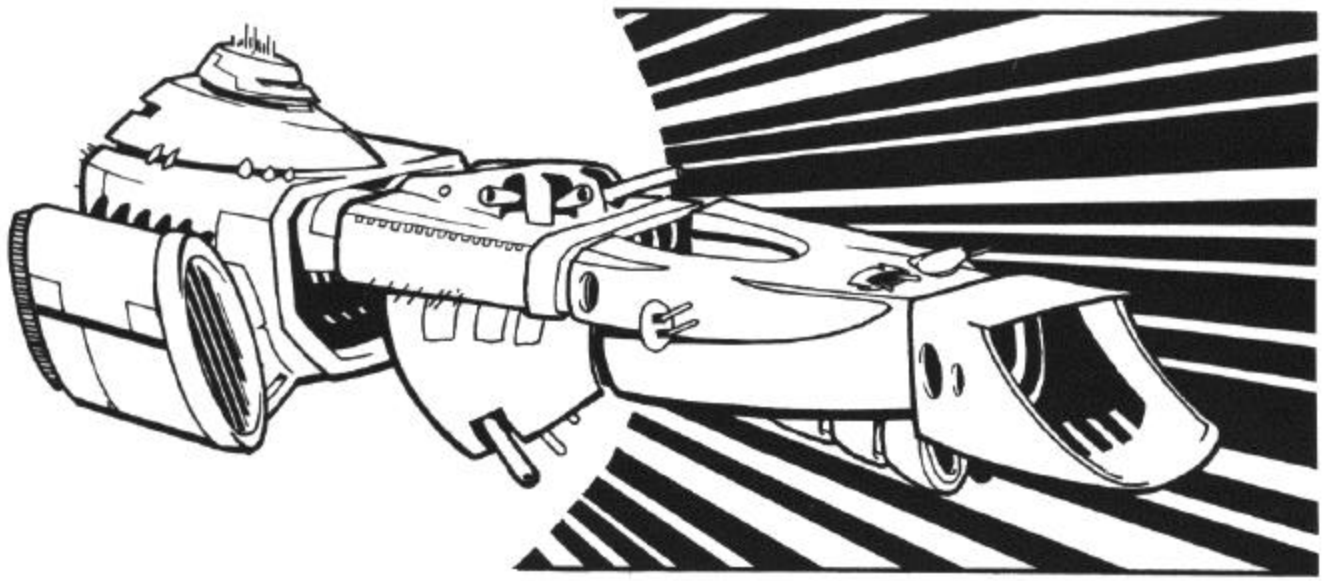
Fusion (TL9) power plants generate energy by fusing hydrogen into helium through a thermonuclear reaction. No refuelling is necessary: the power plant's internal hydrogen fuel tank lasts for 200 years.

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.

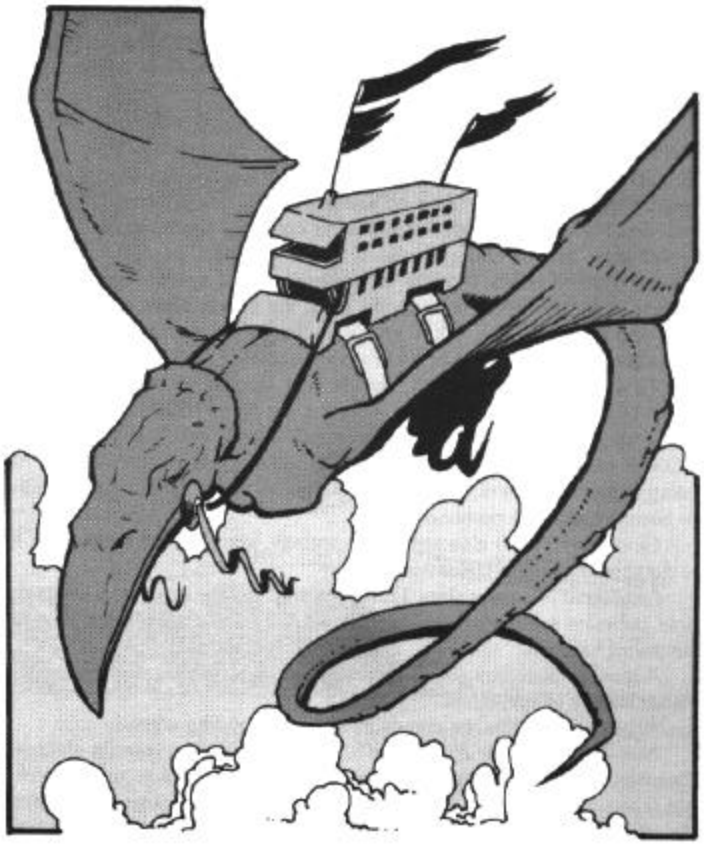
Volume is weight/50 cf.

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.

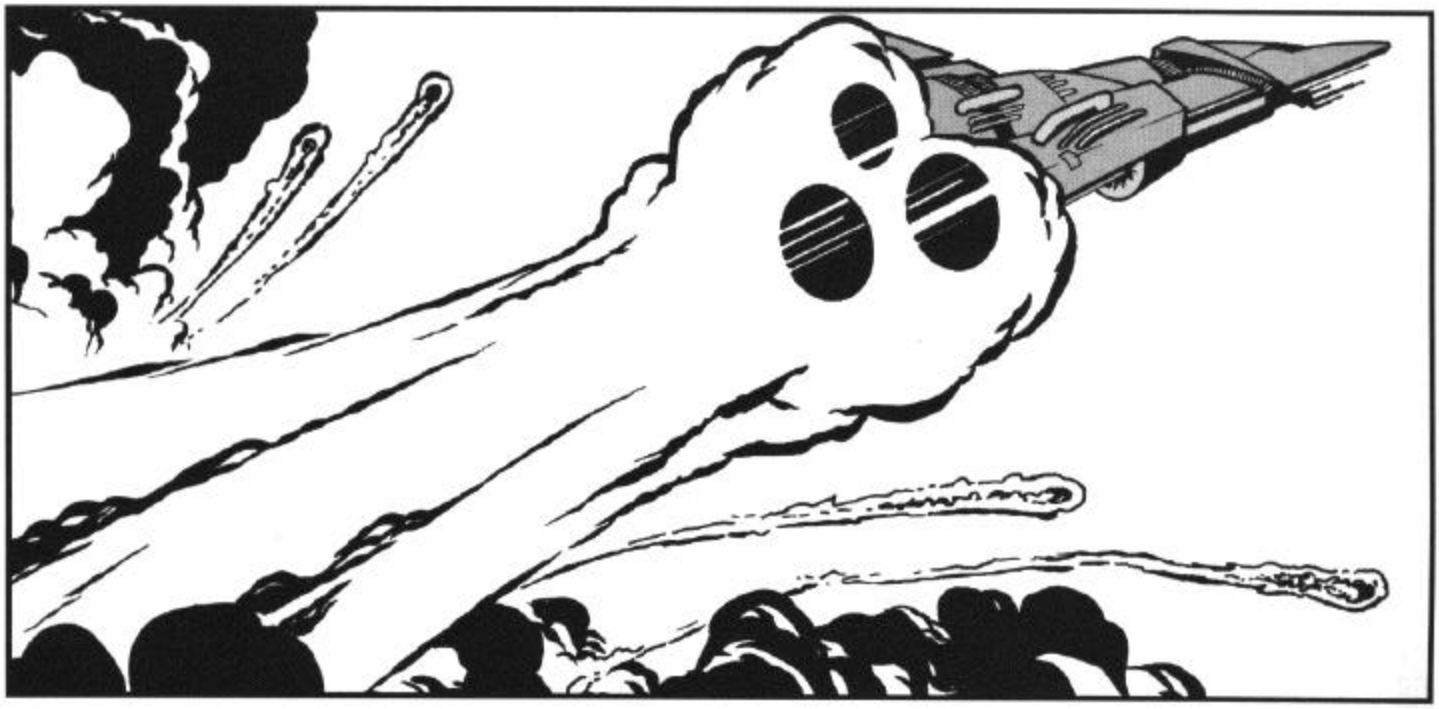
To decide how big a bunker is needed, multiply the cubic feet per hour of coal or wood the vehicle's power plant consumes by the number of hours for which it is to power the vehicle before requiring refuelling. Ground vehicles like steam locomotives are normally designed with less than a day's fuel, 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).

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.

EXAMPLE

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 noise, 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.

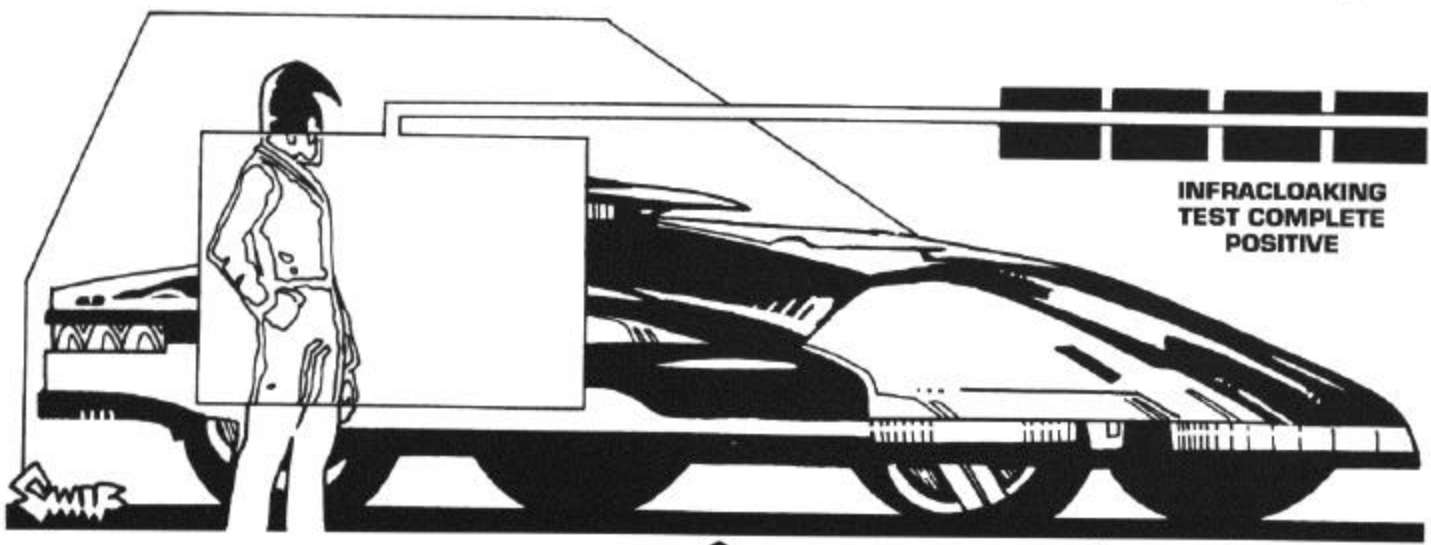
Liquid Crystal Skin (TL8): A simple system that allows the vehicle to assume any paint job or camouflage pattern. The pattern must be manually locked in, and takes five seconds to select.

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.

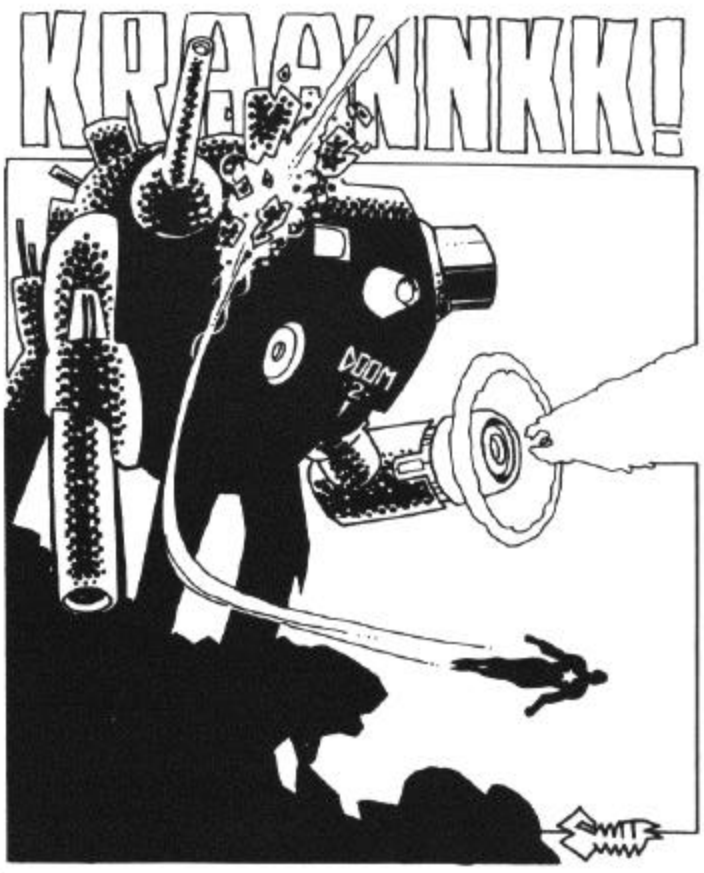
Reactive Armor (late TL7)

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.

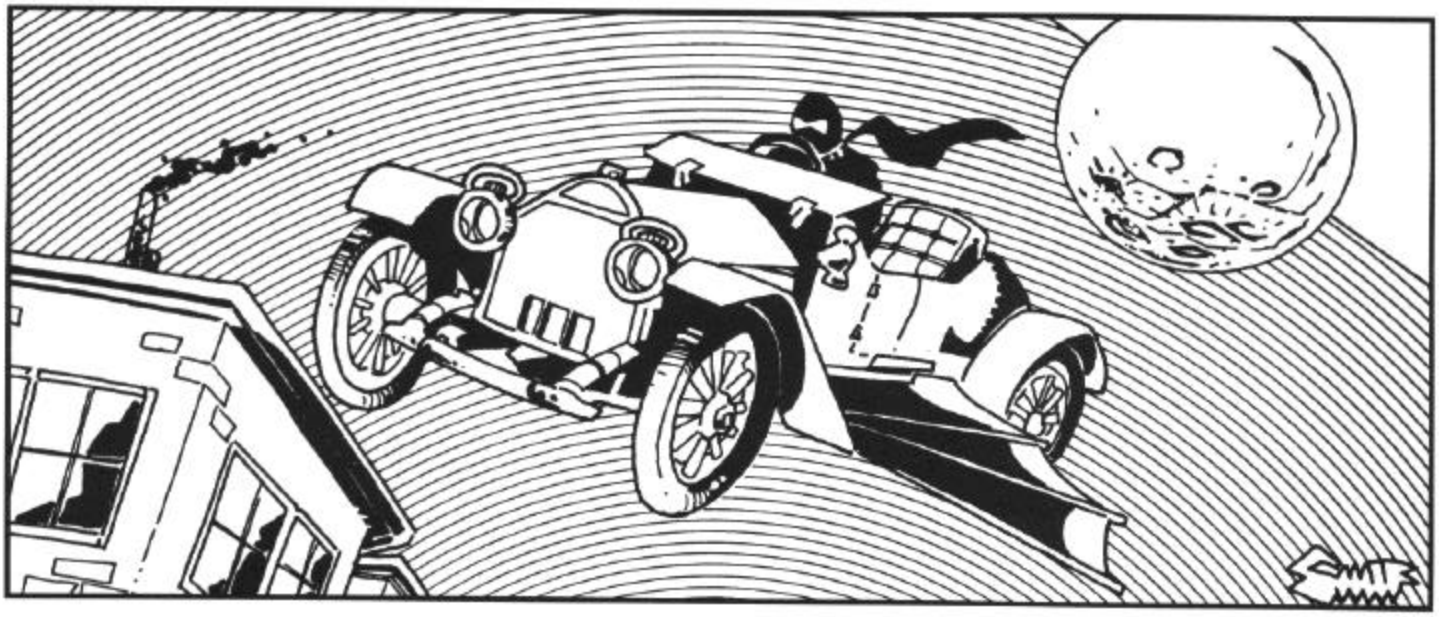
Angled Flight Decks (TL7): This angles the deck so that one landing and one takeoff can be performed at the same time, speeding up operations. Add 50% to cost.

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)

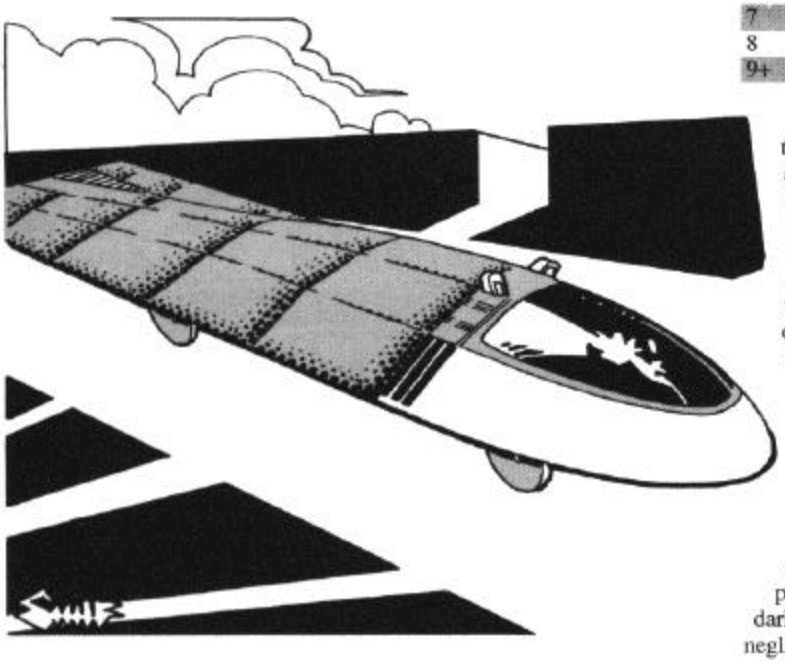
Any vehicle can be covered with photoelectric collectors (solar cells). These convert light (usually sunlight) into electric power. They generally serve as a backup power supply or a means of recharging energy banks, but some vehicles may be entirely solar-powered. Because the power output is generally 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.

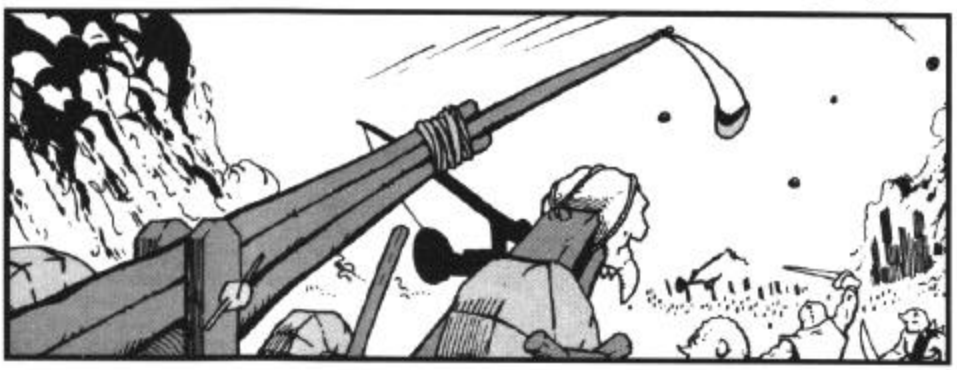
Counterweight weapons use a long sling arm counterbalanced by a heavy weighted box and held back by cords. When these are released, the box falls, the arm snaps up, and the projectile goes flying. They are quite heavy and slow-firing, and are only useful for indirect fire (pp. 179-181). An example of 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.

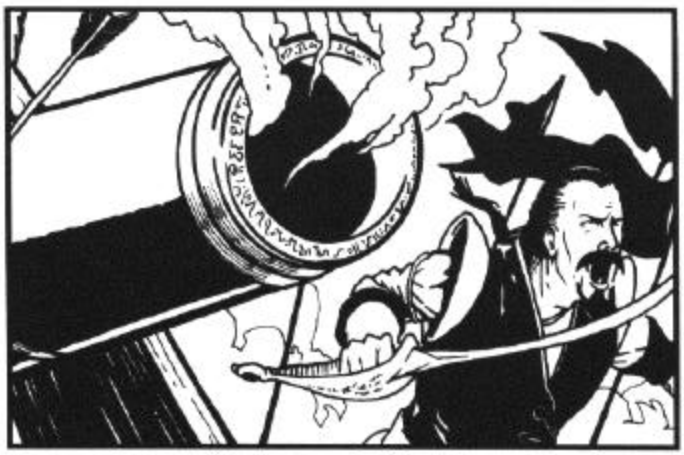
This system is designed to build TL3 to TL16 guns from cannon and machine guns to gravitic railguns. Decide on the tech level of the weapon and then follow the steps below.

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.

We give the gun a bore size of 7.62mm, making it a smallarm.

EXAMPLE

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.

We decide the gun is a conventional rifled weapon.

EXAMPLE

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.

We give the gun no special options.

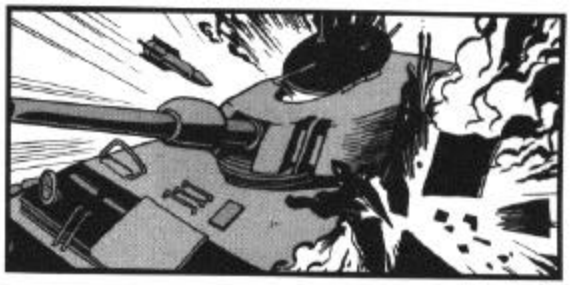
EXAMPLE

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.

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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.)

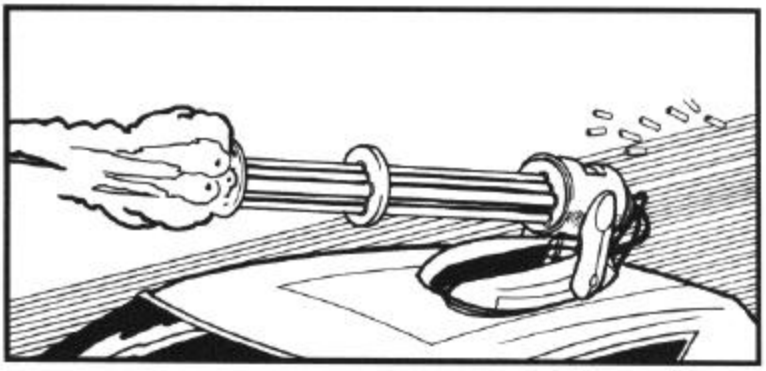
The weapon's malfunction number. If the die roll to hit is equal or greater than this, the weapon malfunctions and ceases to work. Determine Malf. using this table:

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.

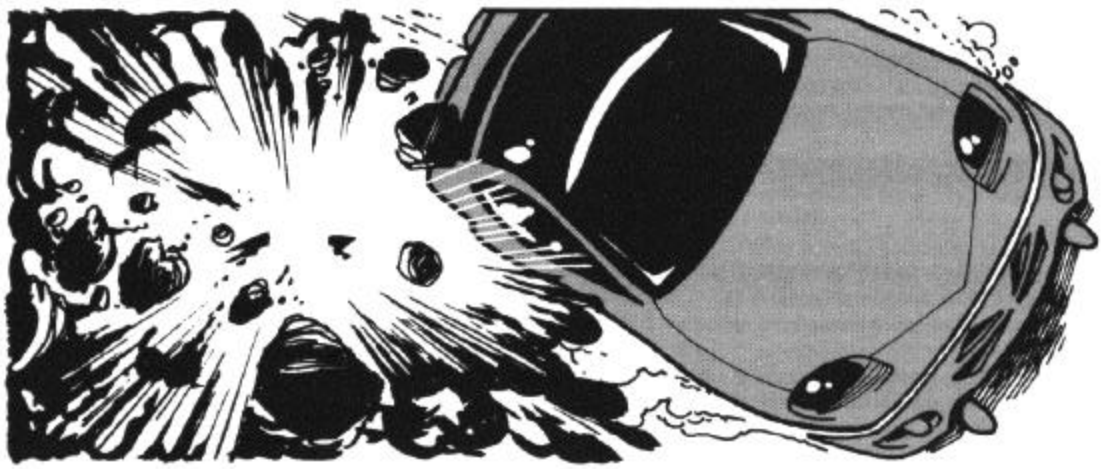
EXAMPLE

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.

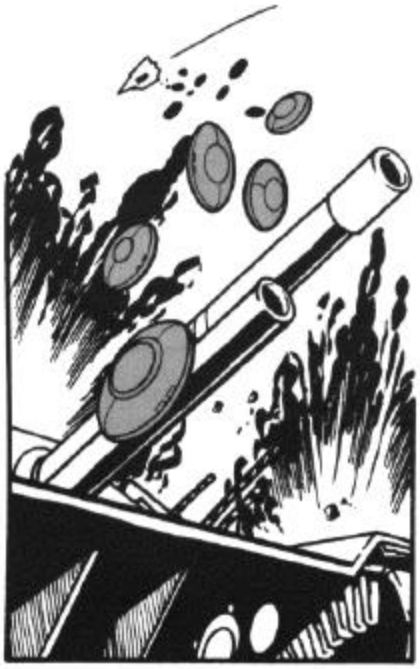
Pesticides and Herbicides (TL6): These are useful for spraying crops, killing insects or defoliating vegetation. Exact effects are up to the GM. Some are harmless; others will have the same effect as tear gas or even nerve gas on anyone in the cloud! Cost is $0.5 per dose.

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.

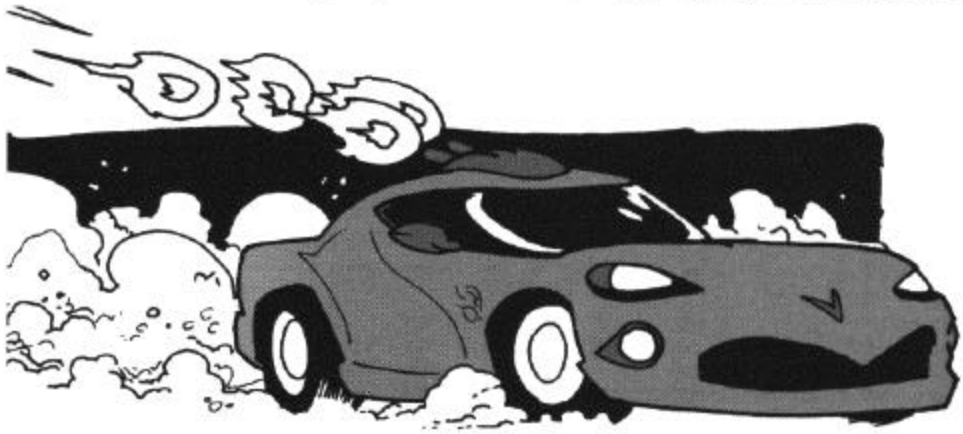
G is 1 if electromag, 1.2 if gravitic.

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.

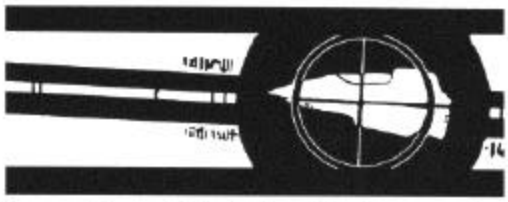
If a weapon has multiple barrels, this will further increase RoF – see below. When calculating RoF statistics, always round fractional RoFs of 1 or more to the nearest whole number; if RoF is less than 1, round loading time to the nearest whole number before finding RoF.

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.

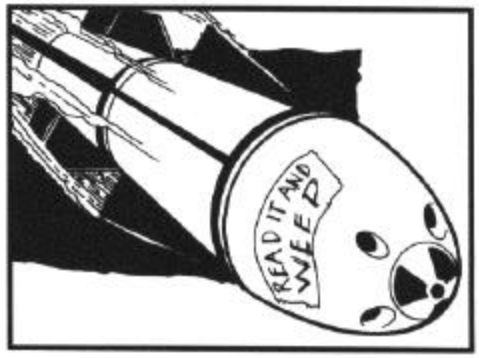
P is 0.2 if extra-low-powered, 0.5 if low-powered, 1 otherwise.

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.

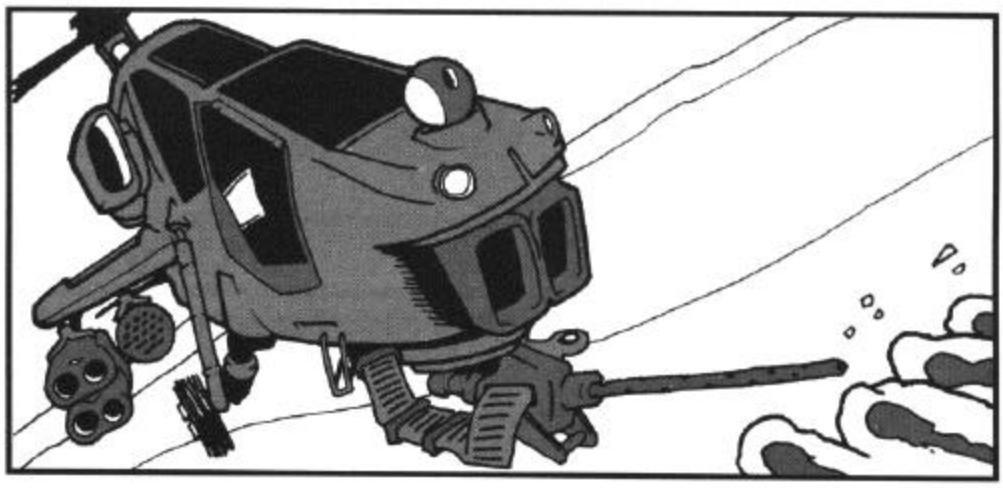
Where:

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).

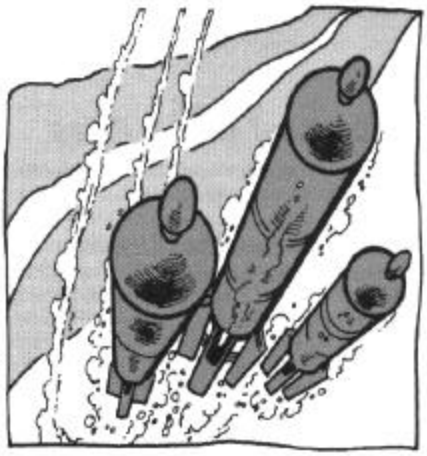
†† Minimum bore size is 120mm at TL7-, 80mm at TL8+.

§ 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).

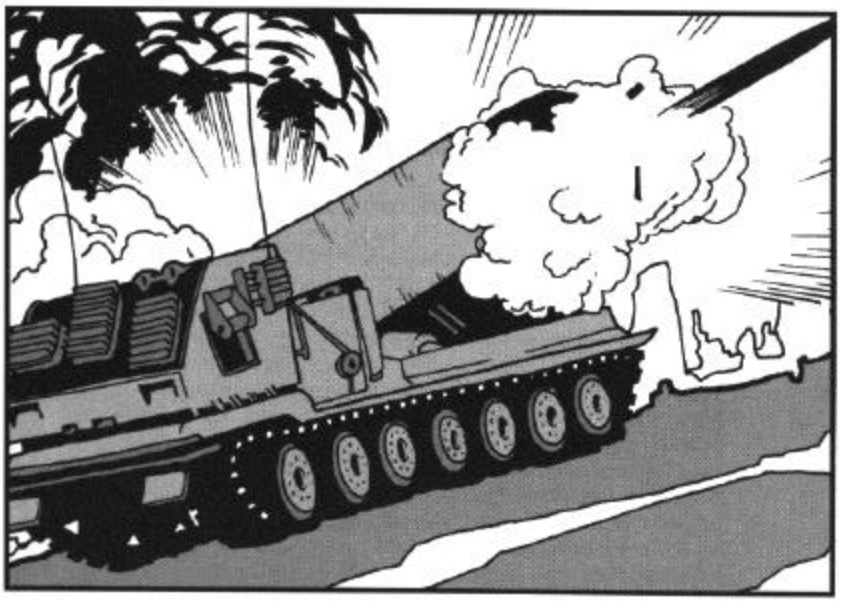
Missiles are self-propelled flying projectiles with their own rocket engine, jet engine or reactionless thruster, such as rockets or guided missiles.

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.

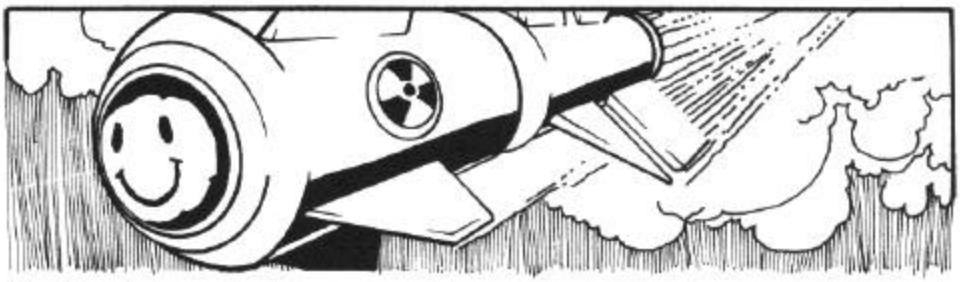
Bombing

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!

Continued on next page . . .



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

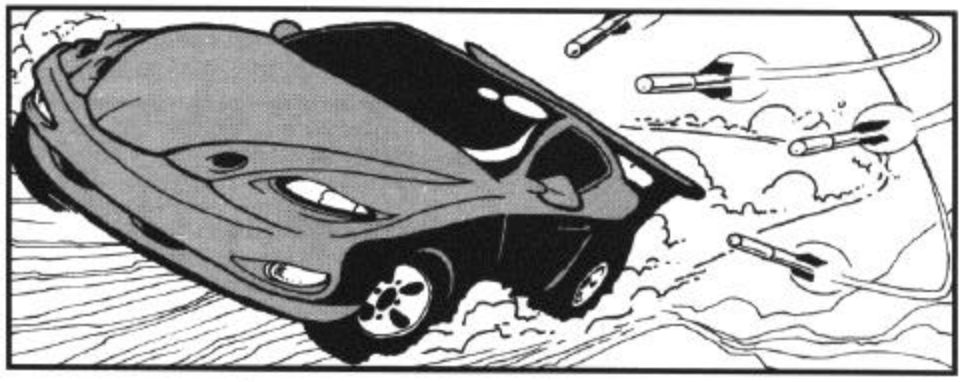
Type	*TL6*	*TL7*	*TL8*	*TL9*	*TL10*	*TL11+*	*Cost*	*Skill*
IG	20	5	2	1	0.25	0.1	$10,000	–
PSH	10	5	2.5	1	1	1	$3,000	TL+8
ASH	20	10	5	2.5	2.5	2.5	$3,000	TL+6
WG	20	10	5	5	5	5	$500	OG
CG	10	2.5	1	0.5	0.25	0.1	$2,000	OG
TVG	no	15	5	2.5	1	0.5	$4,000	OG
IRH	no	2.5	1	0.5	0.25	0.1	$2,000	TL+7
IIRH	no	2.5	1	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	–

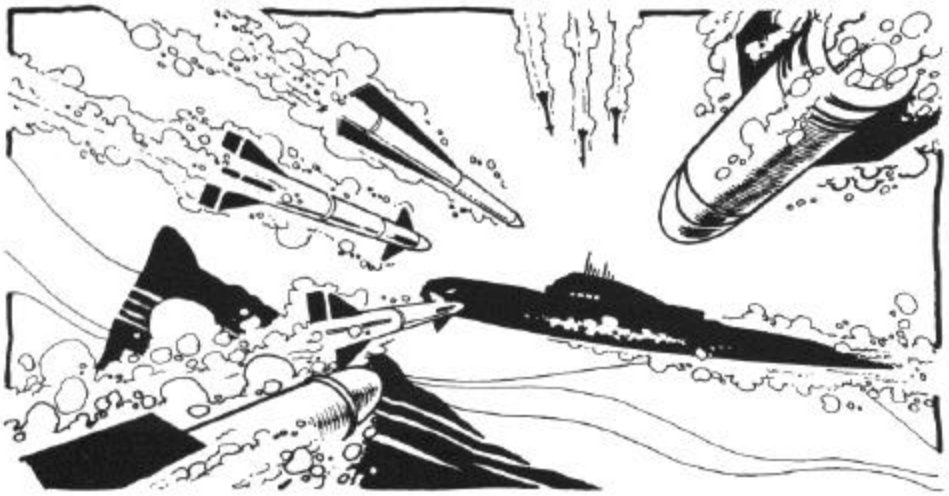
A larger guidance system can be added to improve skill. For each +2 to skill, double weight; e.g., +6 skill would be 8 × weight. Or, a "compact" guidance system with half the normal weight can be taken in return for a -2 penalty to skill. In addition to these options, a "cheap" guidance system can be 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)

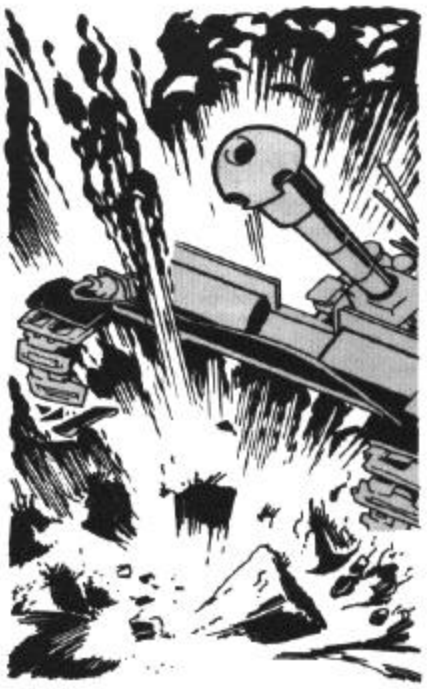
Pressure Trigger (TL6): This is a trigger that sets off the mine when someone or something moves onto it. It is set for a specific weight. (Note that since the trigger sticks out of the ground, the entire weight of a vehicle driving over it is bearing on it, not just the vehicle's ground pressure!) Pressure 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.

Continued on next page . . .



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. Hand-held 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 anti-tank 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.

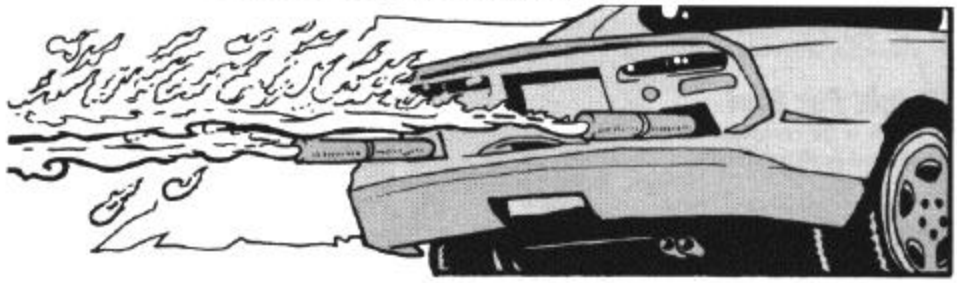
Where:

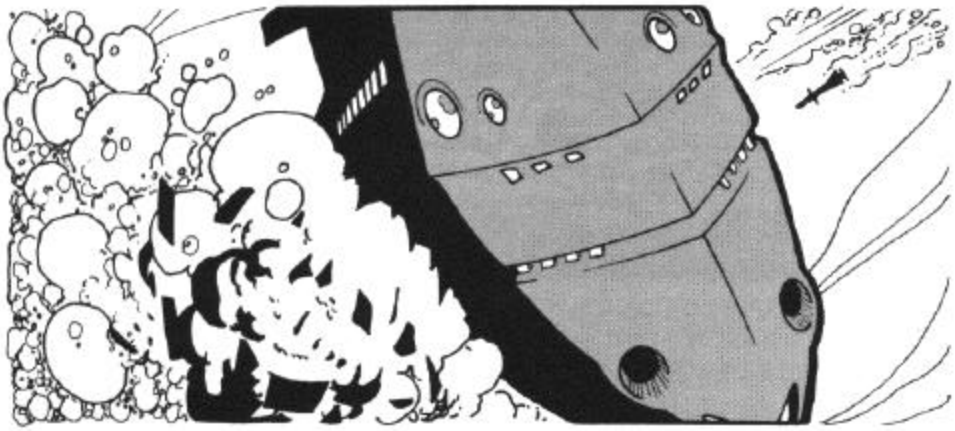
D is the missile's diameter in mm.

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.

Continued on next page . . .





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.

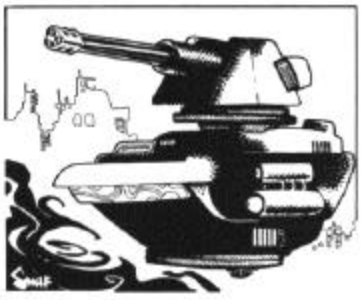
1/2D Range

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.

Continued on next page . . .



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.

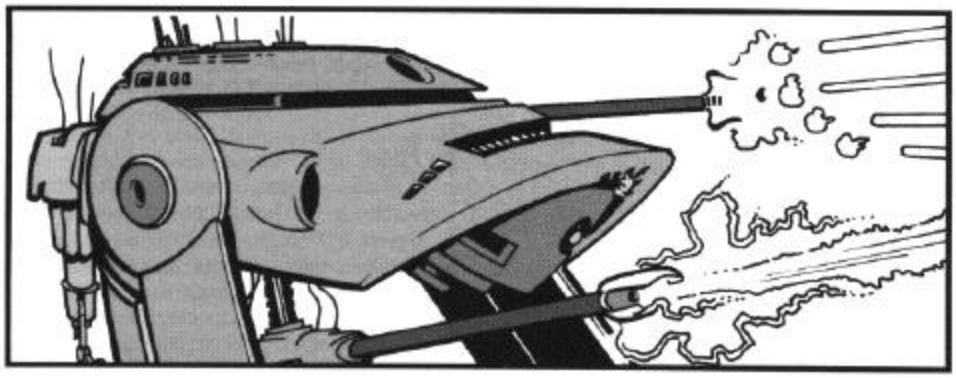
Stunner (TL9): This is a sonic weapon designed to disable without killing. Instead of damage, it has a "HT modifier" that affects the roll to resist it.

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.

Continued on next page . . .

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:

Continued on next page . . .

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.

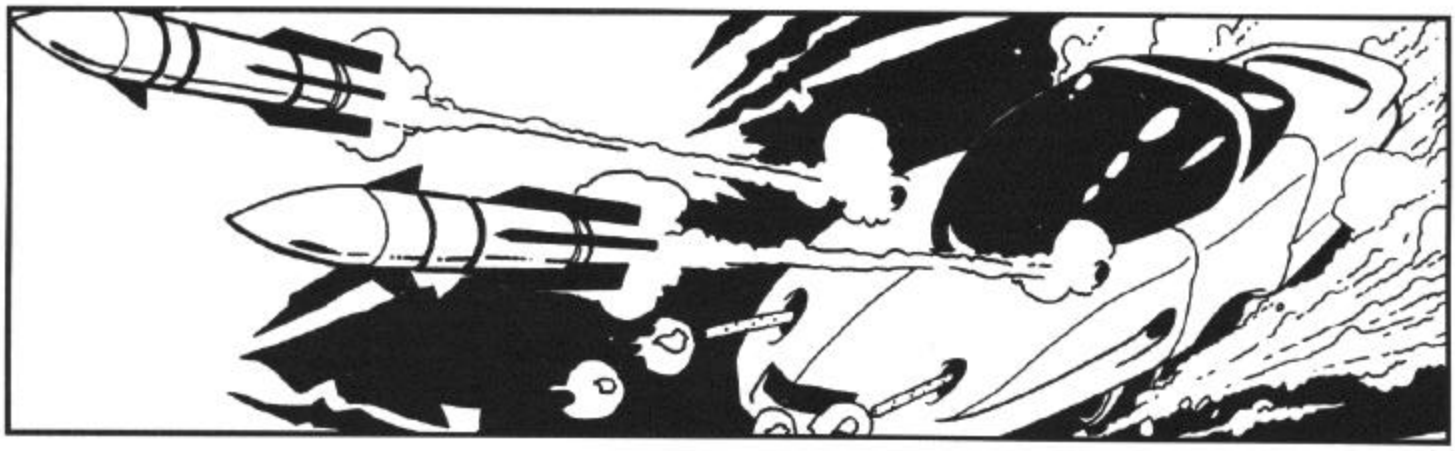
Reputation for Quality: Certain weapons known for their reliability (or lack thereof) may, at the GM's discretion, have their Malf. raised or lowered by one level, to a maximum of Ver. (Crit.).



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 *O* by 0.03 instead of finding its square root.

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.

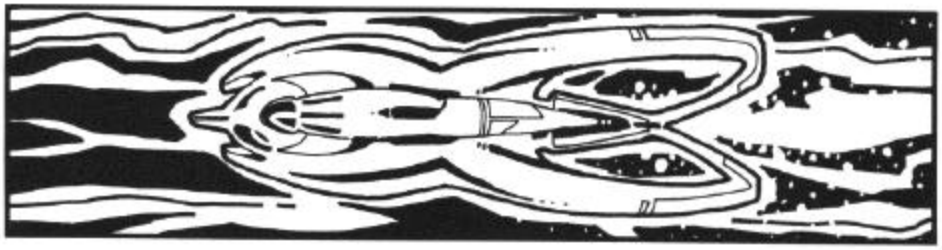
Hand-Held Weapons (Continued)

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.

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.

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).

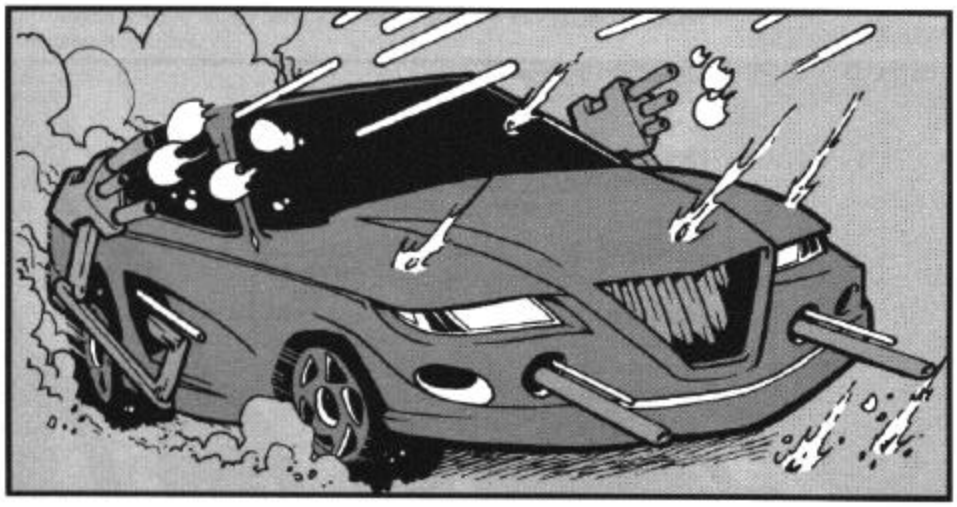
Over 100 lbs.: cost = (weight × $100) + $20,000.

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 0.666if 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	10 mph/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.

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.

EXAMPLE

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.

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.

EXAMPLE

Kitty Hawk's loaded weight is less than its flotation, so it can float.

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 [(Hl × 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:

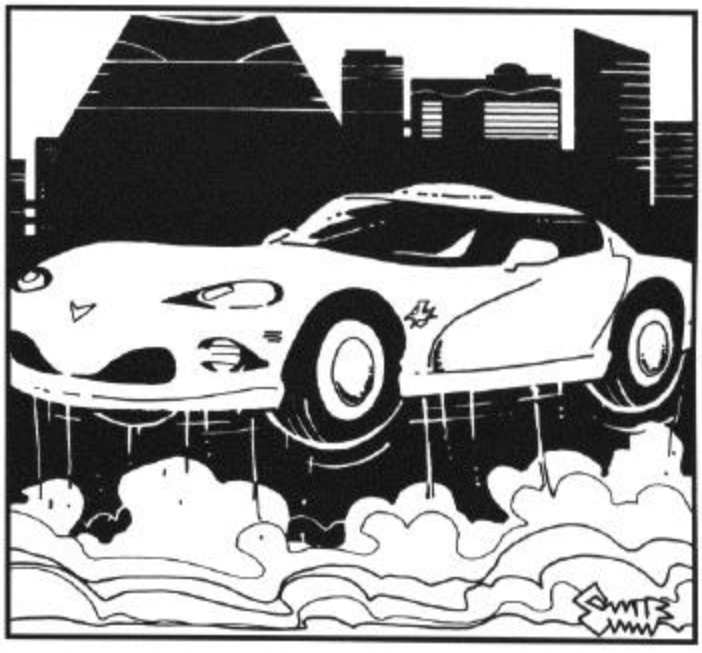
Stall Speed = [(Lwt-Static Lift)/Lift Area] × Sl × Rs.

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)/ SI] + 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).

SI 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 SI 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

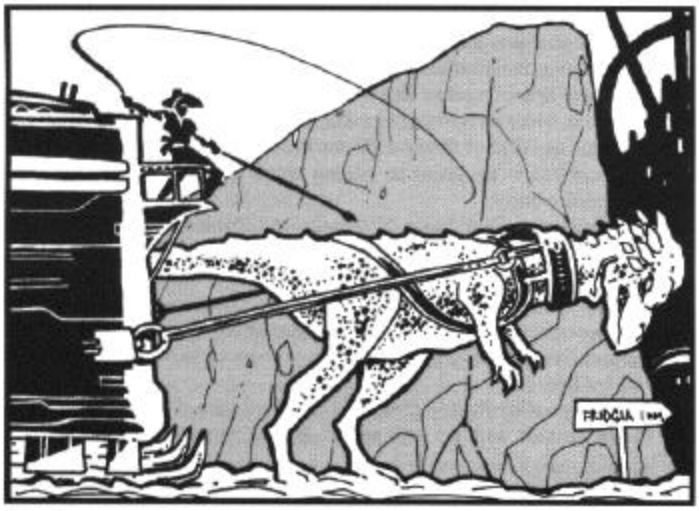
Top Speed: Use the aerodynamic drag and aerial motive thrust to determine the aerial top speed (in mph) using the following formula:

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

* 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.

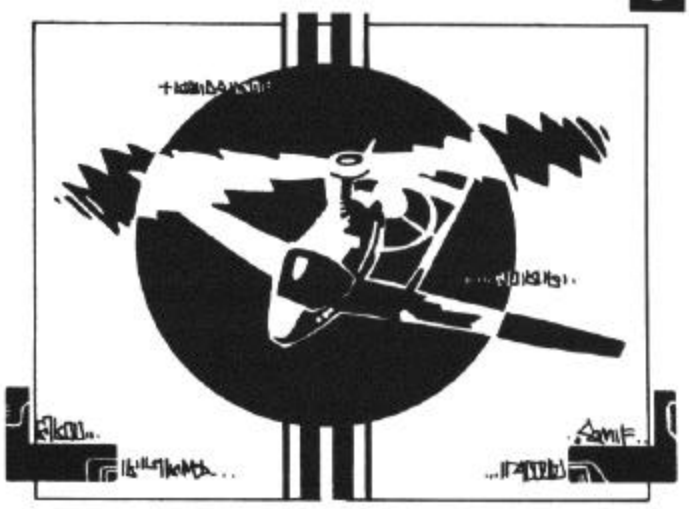
TL is the Tech Level of the wings or rotors. Add one to effective TL for each of these features the vehicle has: responsive structure, high agility wings, variable sweep and computerized controls (this is cumulative). If the vehicle has controlled instability, add *two* to effective TL. If the vehicle 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.

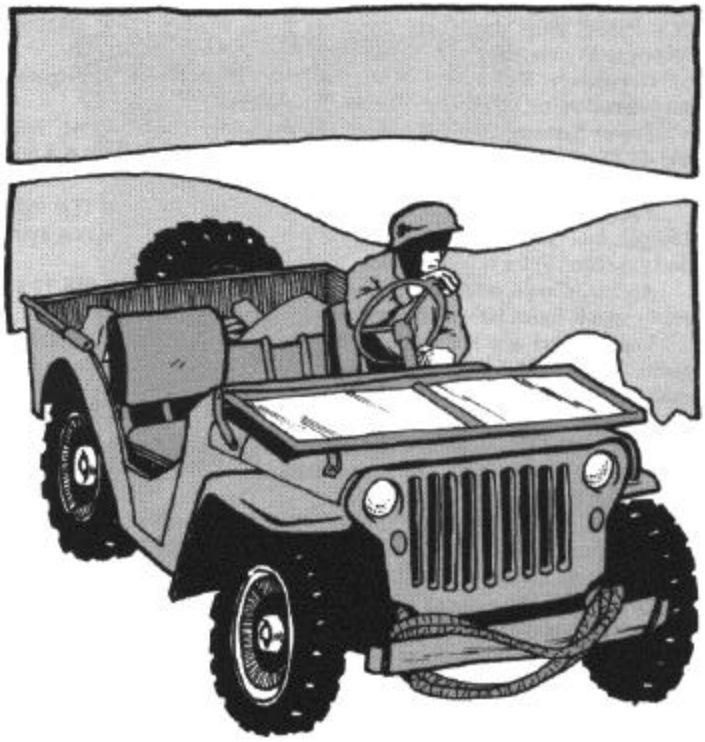
Hit Points: Bo 94, Wh 19 each.

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.

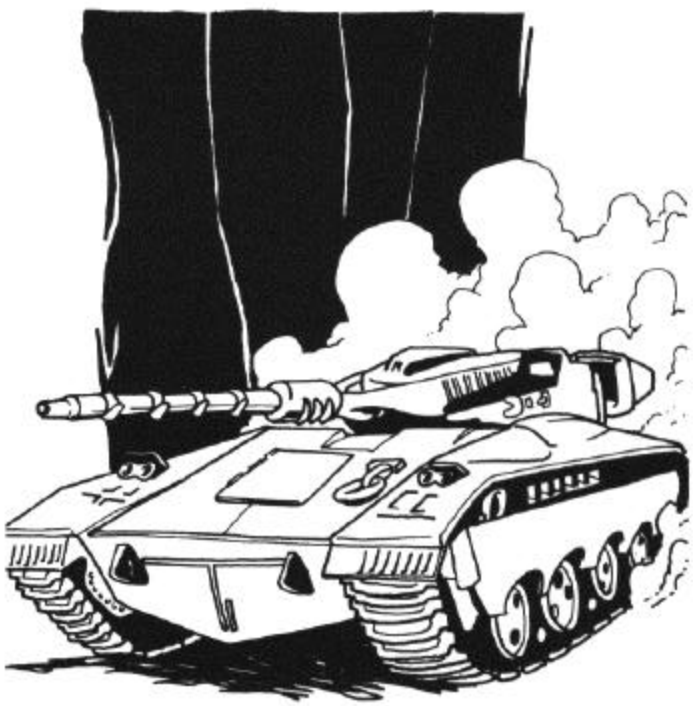
Structural Options: Folding rotors.

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.

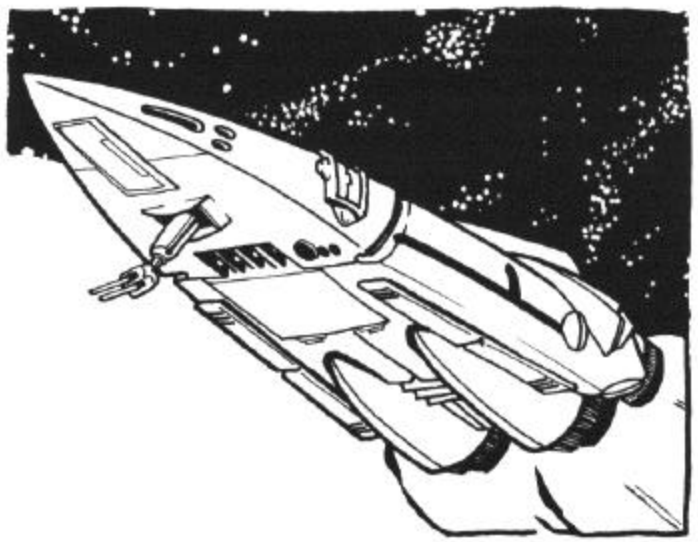
Surface Features: Sealed. Basic stealth.

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.

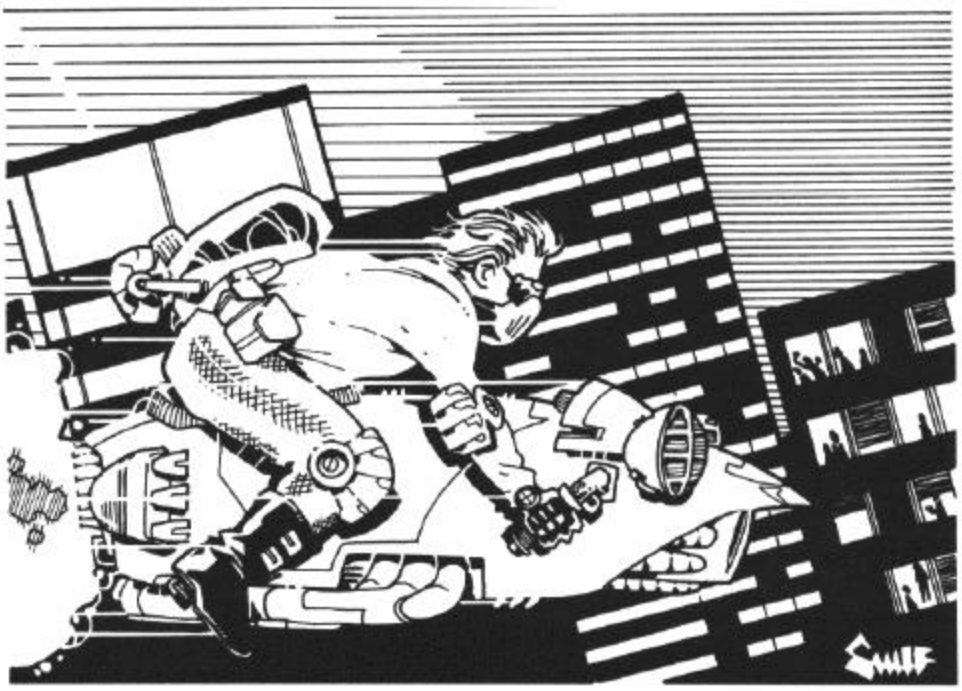
On vehicles that require frequent maintenance, the duties are often split between several people. On vehicles that operate continuously (like ships), this usually means that there is ongoing maintenance performed by the crew. Determine the man-hours of maintenance required per day using the formula 96/maintenance 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.

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.

EXAMPLE

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 (minimum 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 "multi-task" 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. Harnessed animals and anyone strapped into cycle seats also take this amount of damage; anyone in a cycle seat and not strapped in is thrown out of the vehicle.

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.

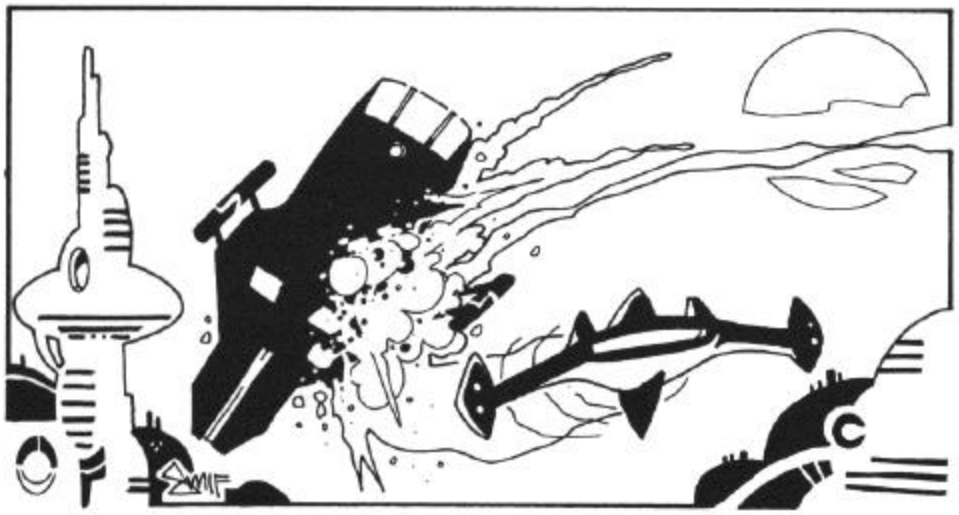
Energy Loss: The vehicle loses 5 yards of altitude. This may cause a crash into the ground if the vehicle is very low. In addition, the vehicle decelerates by 5 mph per 0.25 G of maneuver that was attempted. This may cause a stall (p. 156) if a winged aircraft or autogyro was flying very near its stall 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.

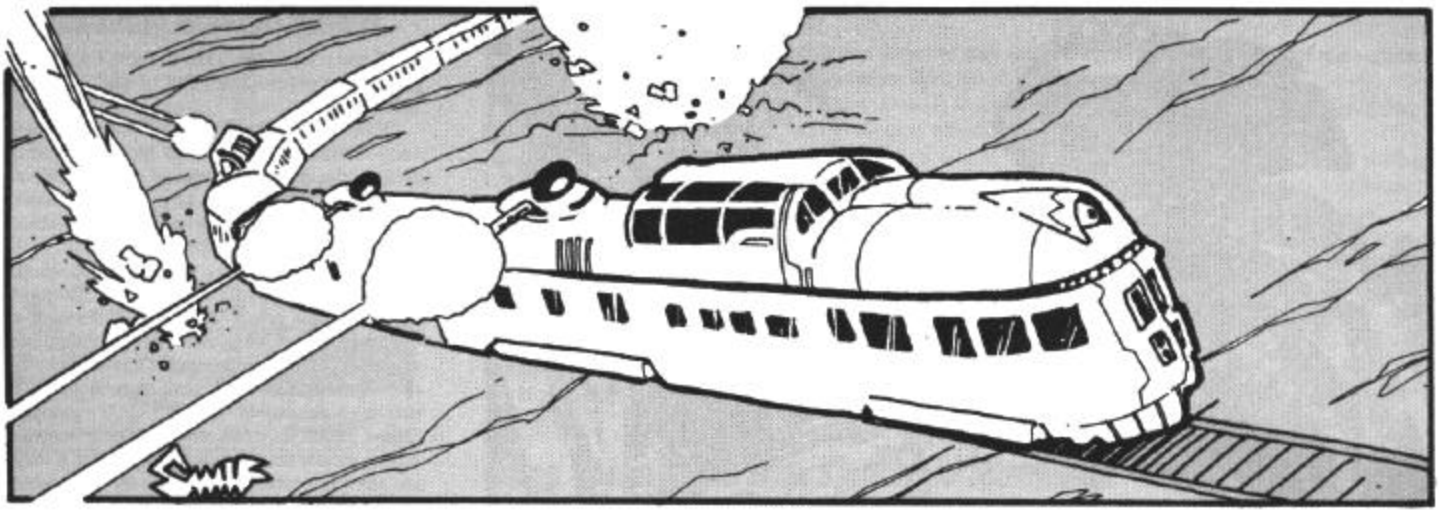
Anyone actually strapped to the vehicle (e.g., chained to a mast) won't fall off.

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).

Continued on next page . . .





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.

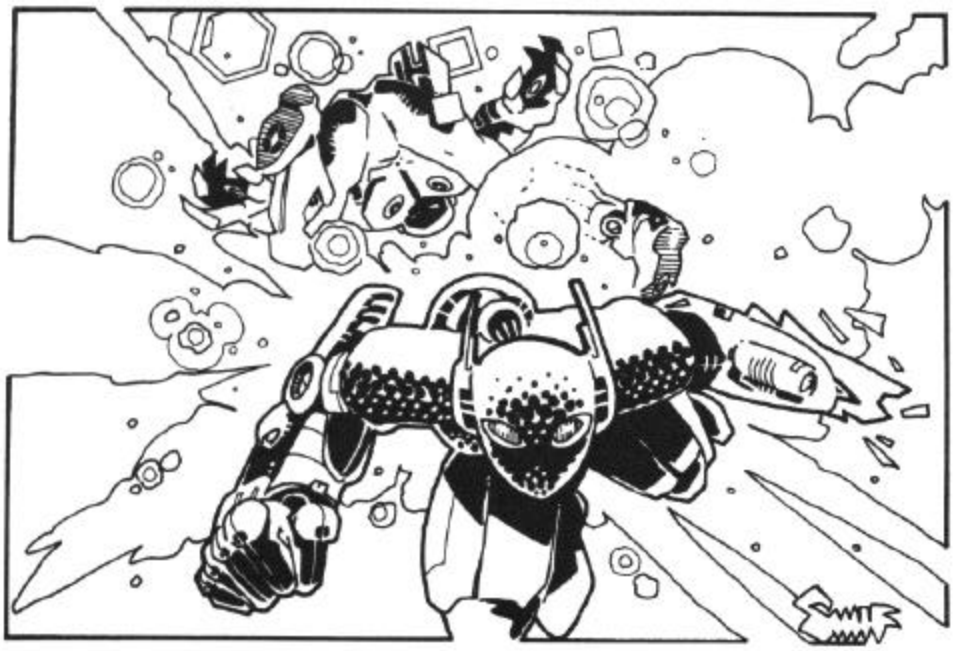
When a vehicle falls to the ground, treat it as if it had a collision (angle as appropriate) with the ground (or whatever else it hits!) at a speed based on its current speed.

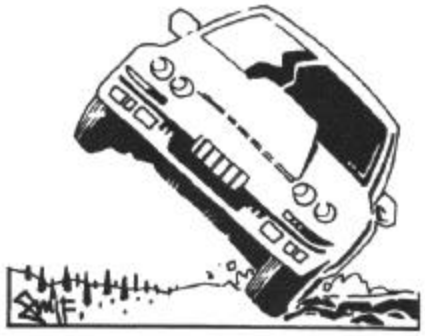
Collisions

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 $10 \times 50 / 200 = 2.5$, 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

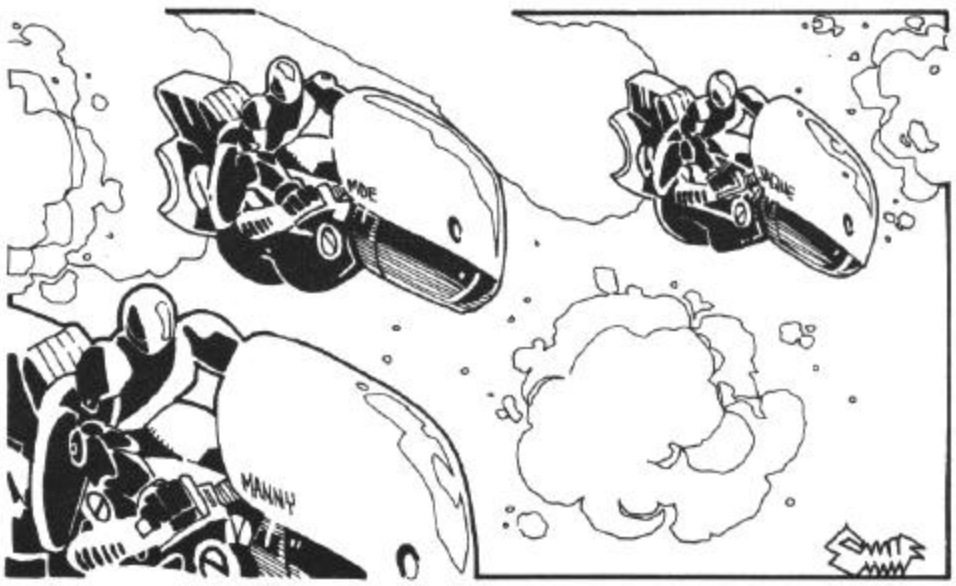
Aircraft speeds are so high that actually mapping out an aerial combat can be very difficult and time consuming. To simplify play, these "dogfight" rules can be used for purely aerial engagements between small numbers of aircraft. Note that while most of the rules in this book are very detailed, this system is intentionally abstract, and the GM should feel free to exercise dramatic license when using it!

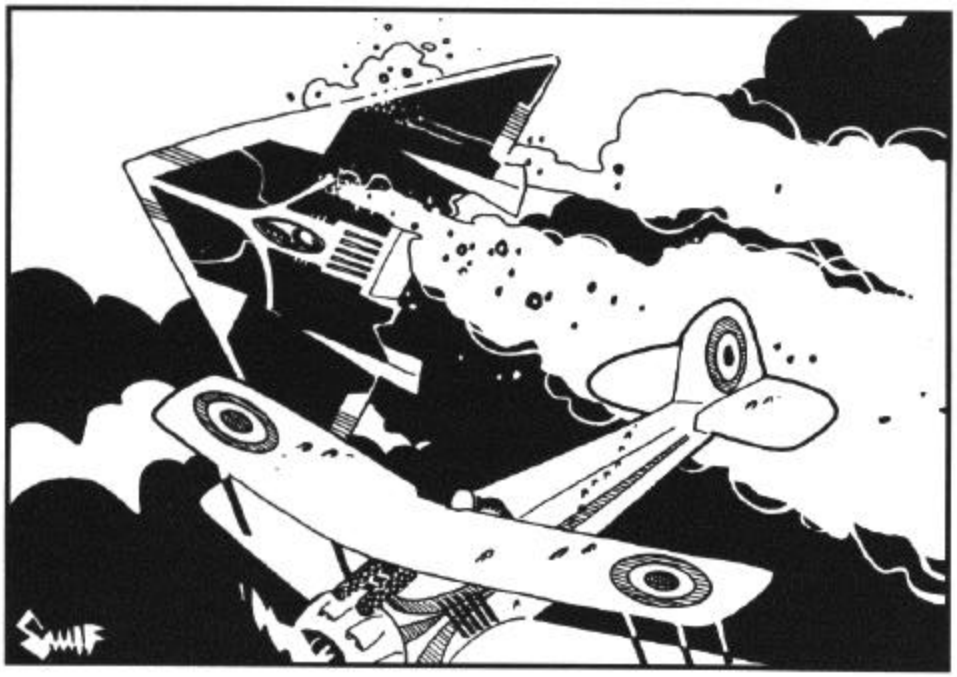
Dogfights consist of two phases: initial contact and the actual dogfight itself. They are divided into *rounds* of 10 seconds each.

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.

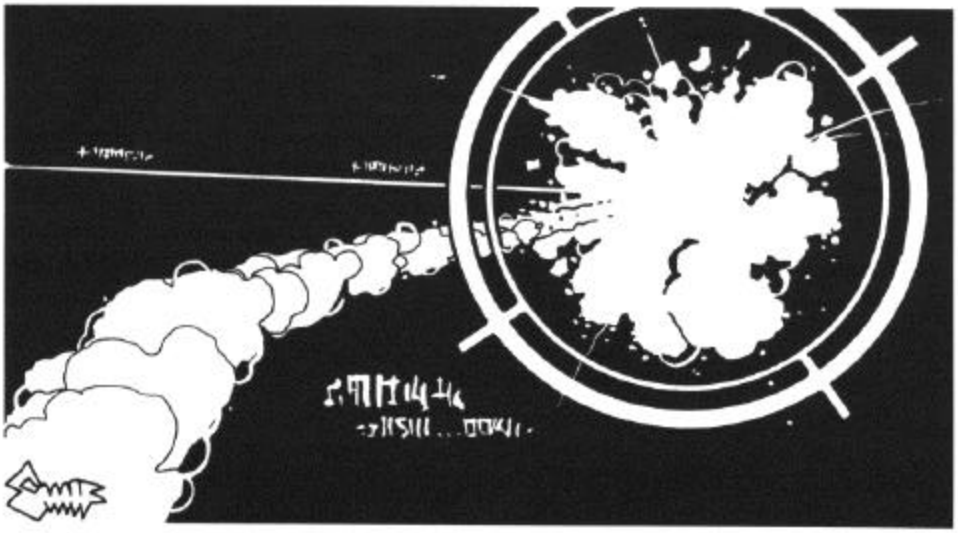
Step 3 – Direct Fire

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.

Continued on next page . . .

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.

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.

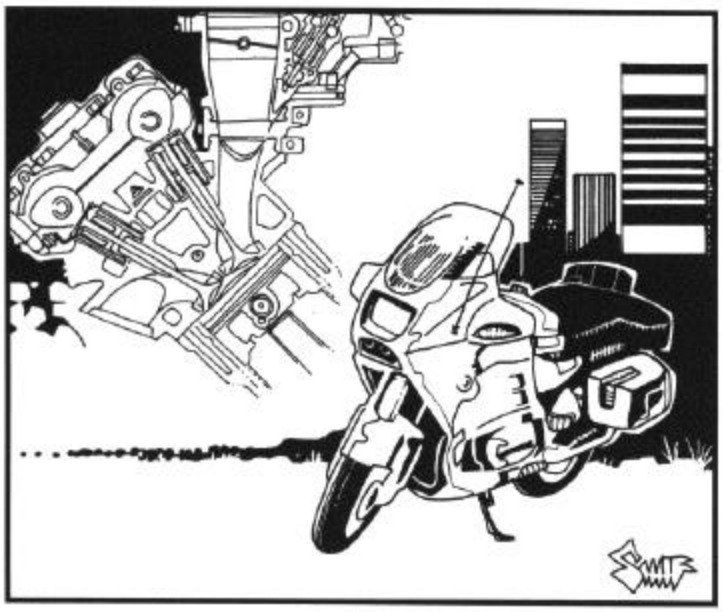
As machine gun fire from the panicked guards rattles off the impenetrable tank armor, Morgan decides to load an HE shell. She fires. Direct hit! Kaboom! Compared to the AP round, it does only 240 points of damage. The armor DR is squared against HE (see p. 190), and stops 36 hits, leaving 204 points 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.

EXAMPLE

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 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.

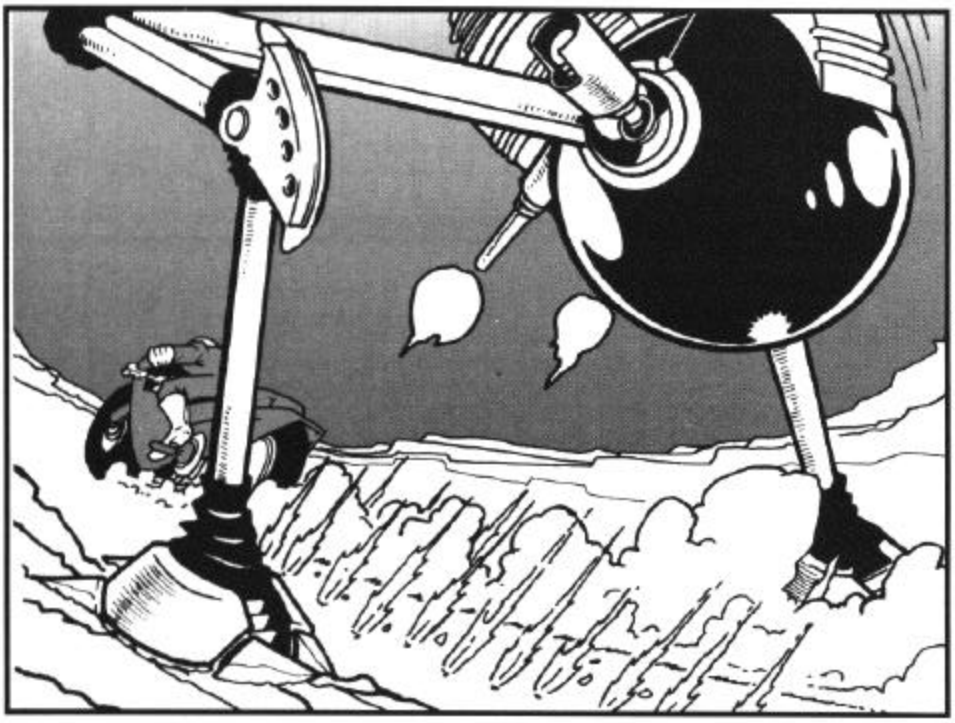
The GM always makes these "sensor rolls" secretly. Add together the sensor's Scan number and the object's Size, Speed/Range, Special, Prior Contact and Distraction modifiers, as well as each sensor's unique Sensor Modifiers (see sidebars of this chapter) to get a *Sensor Skill Modifier*.

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).

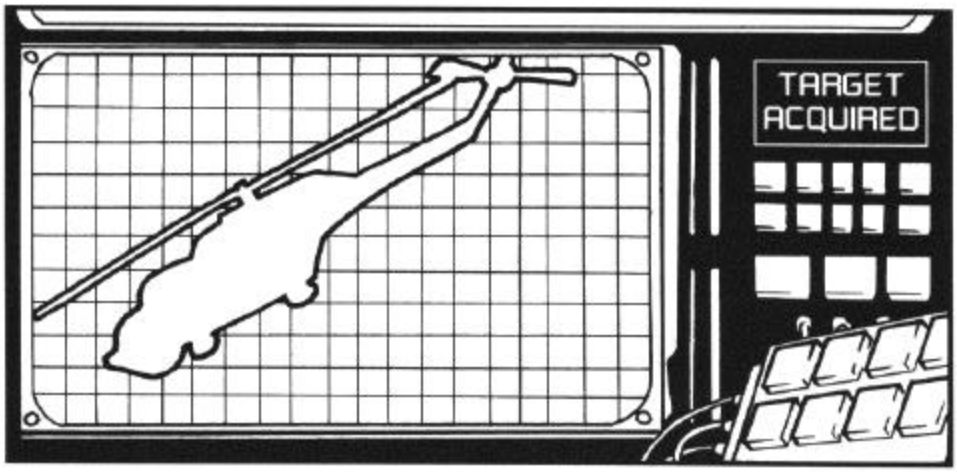
Distraction Modifier: The GM should impose a -4 penalty on any sensor operator who isn't giving his full attention to that particular sensor, e.g., also driving the vehicle, firing weapons or watching other sensors. This is the reason larger vehicles often assign a specialized sensor operator.

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.

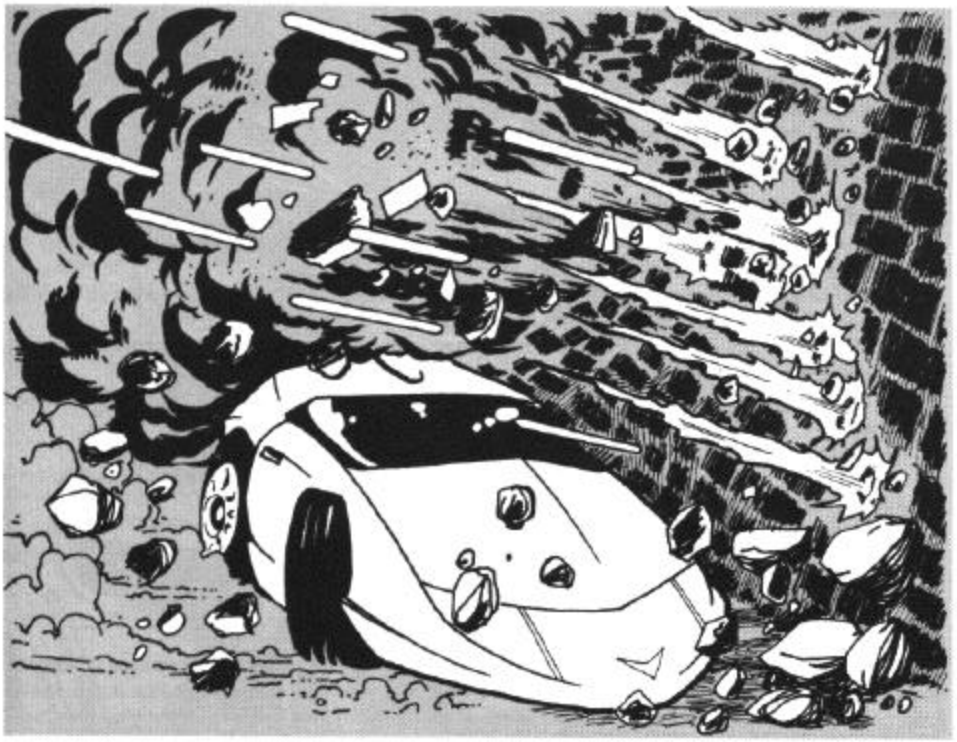


Contact Error: The operator has "detected" an object that isn't there, or has grossly misidentified one that is. This may be a malfunction in the sensor, or it may be the result of operator error. For instance, a building might be misidentified as a vehicle.

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 TL9+, 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 attempt-



ing 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 . . . . .

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.

Continued on next page . . .

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

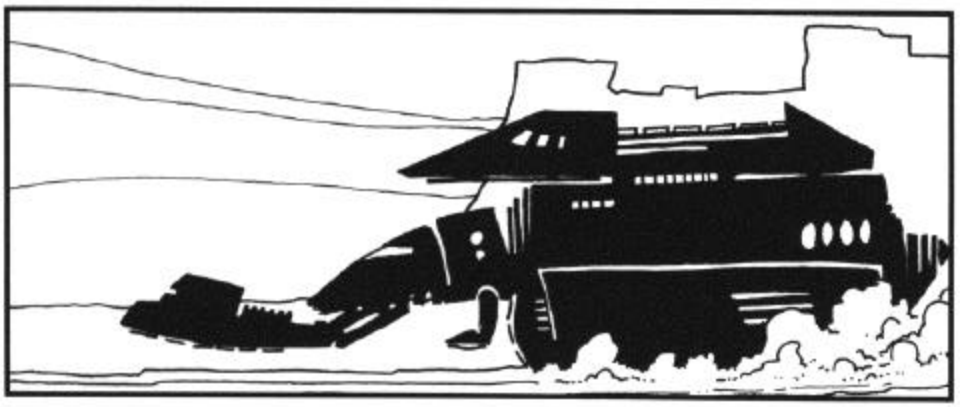
Aside from the horizon and solid objects, LOS can be assumed to be automatically blocked if an object is totally concealed within blackout gas, or 10 yards or more of thick smoke, or 50 yards or more of water, thick fog, snowstorm, cloud bank or dense forest or jungle, or 500 yards or more of mist or 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.

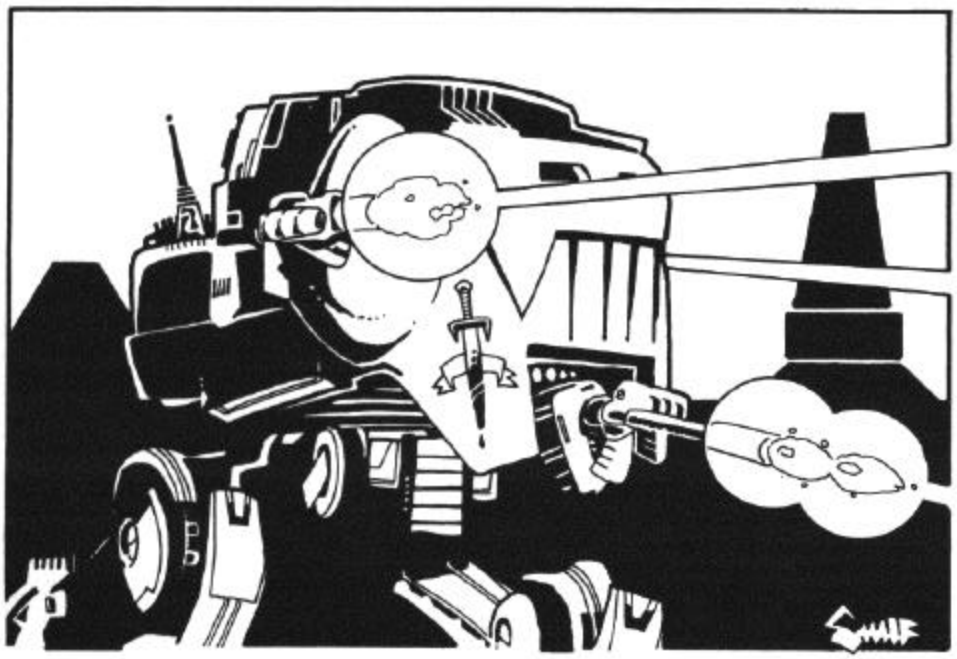
Some vehicles will have computers that can control vehicle weapons. Computers can control one weapon per copy of the Gunner program running.

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.

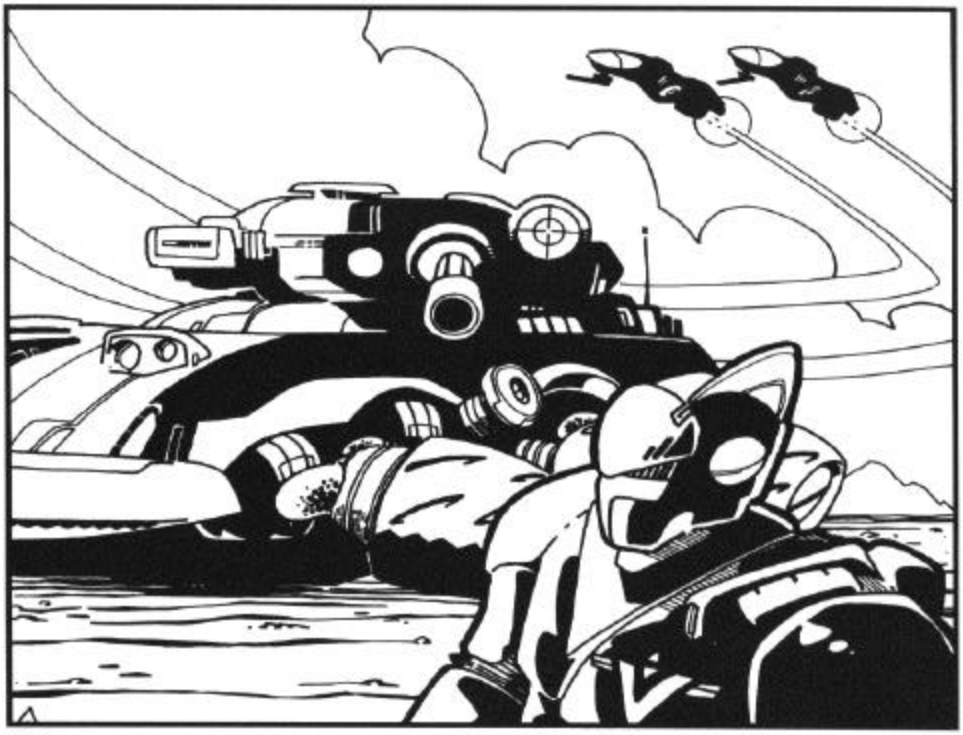
Guided Missiles and Torpedoes: These use special rules, and are described in their own section on p. 192.

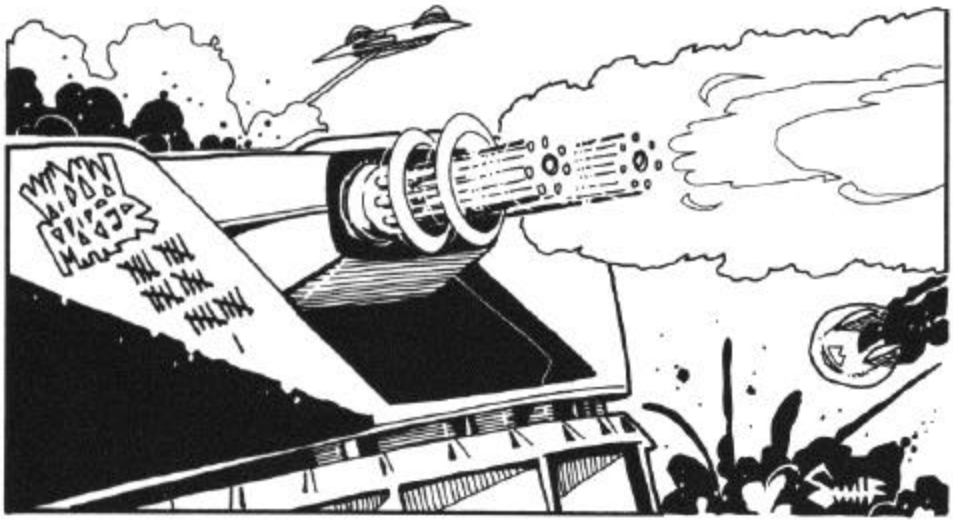
Beehive, Canister, Chainshot, ICM, SATNUC, Shotshell, Shrapnel and SICM: These rounds have special effects or restrictions that apply to their firing and hit probabilities – see the ammunition section on pp. 188-191 of this chapter.

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

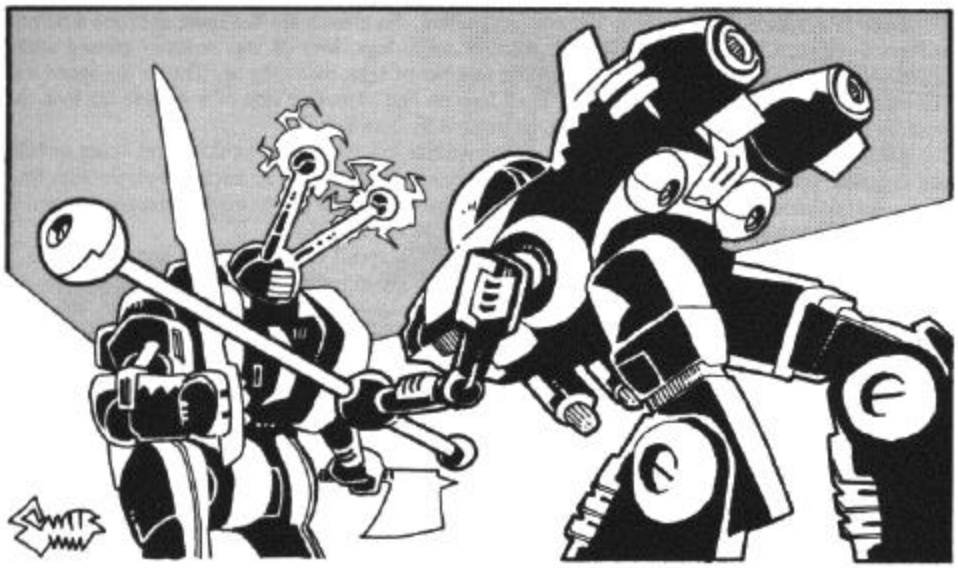
A few years before her Amazonian adventure, Captain Morgan is driving home from the White Sands air field when a terrorist rises from cover . . .

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:

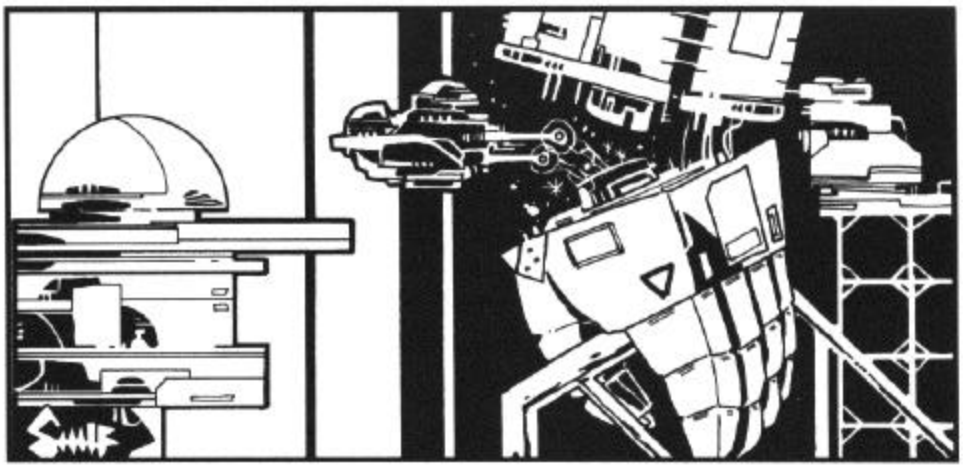
Disabling a propulsion system that is being used eliminates the motive power or motive thrust it produces, which will reduce its top speed and acceleration to zero using that system. If a vehicle has multiple propulsion systems (for instance a multi-engine jet aircraft), only a partial loss occurs – see *Partial Motive Power or Thrust Loss*, below.

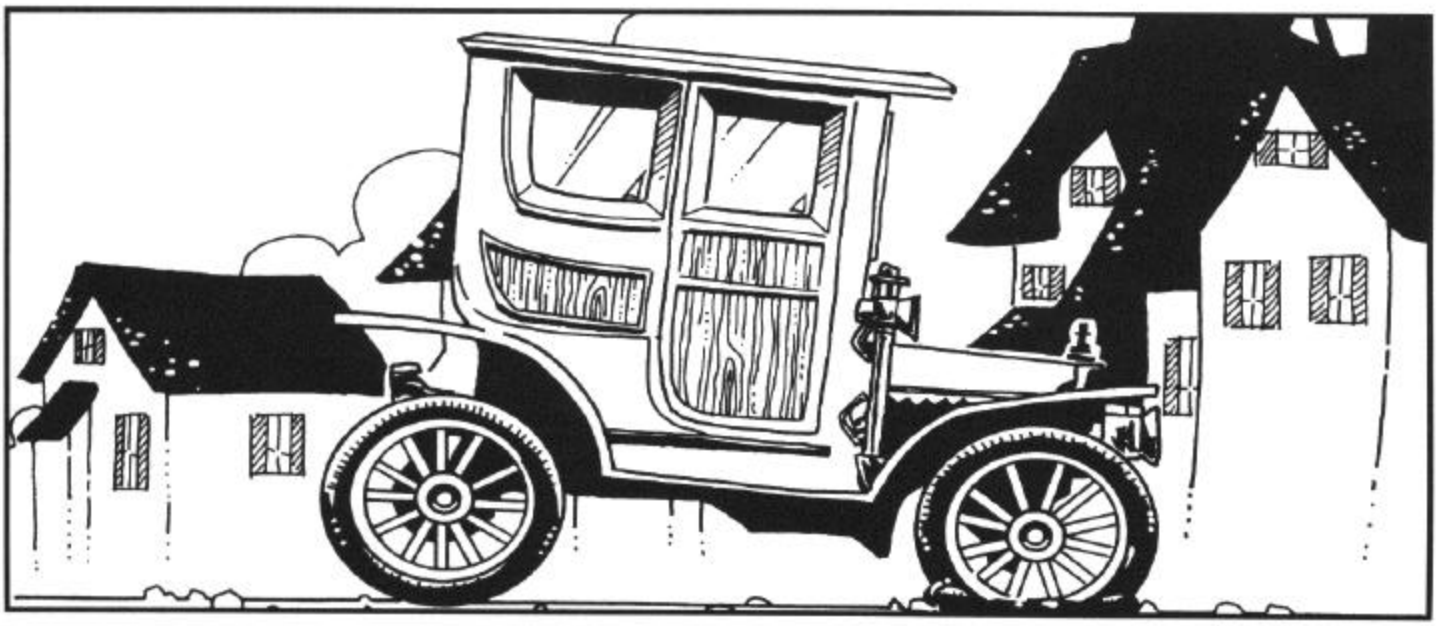
Disabling a location containing lifting gas, contragravity, a helicopter drivetrain, lift engines or fans, or a vectored thrust propulsion system will result in a loss of that system's lift. If the vehicle is flying, this may cause a crash if lift no longer exceeds vehicle weight and the vehicle cannot 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:

Continued on next page . . .

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

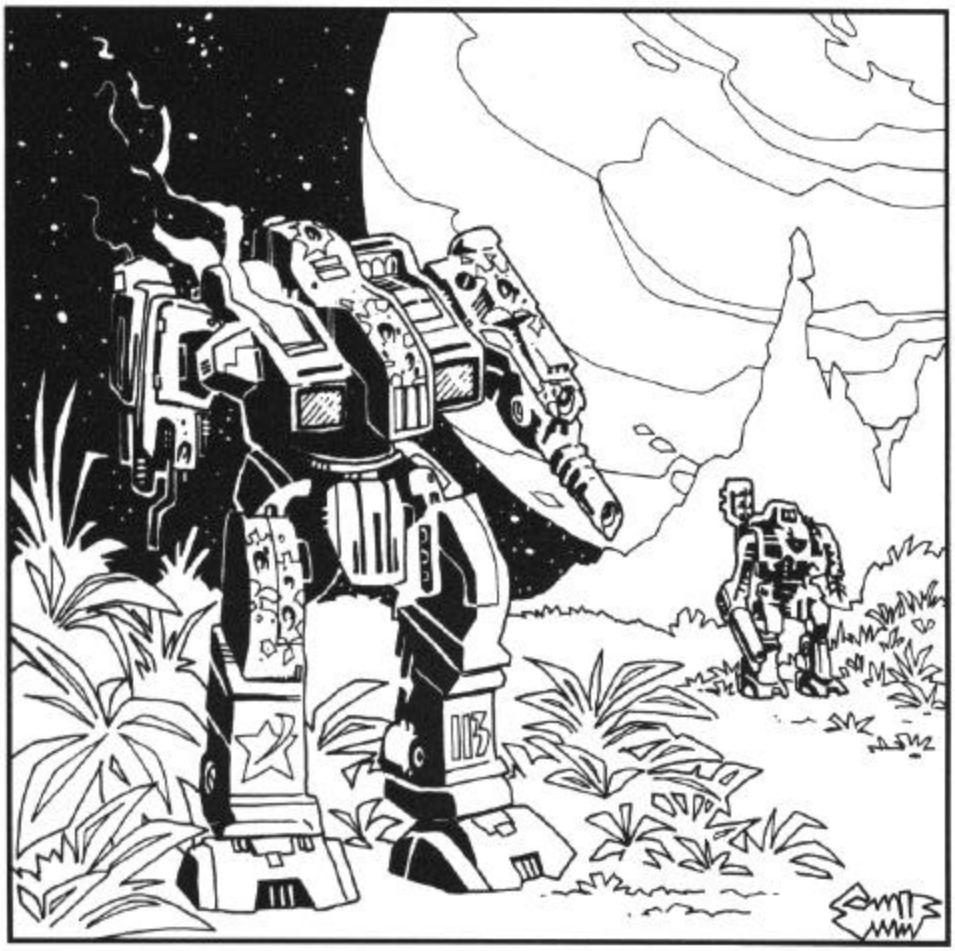
Most components (including cargo) have hit points equal to their surface area in sf, as calculated from their volume – see p. 18 and p. 20. Ruggedized components (p. 27) will have more hit points. Most components are disabled at 0 HP, destroyed at -5 × HP – see p. 180, *Loss of Components*.

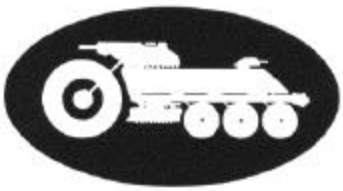
Fuel tanks and lifting gas are exceptions:

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).

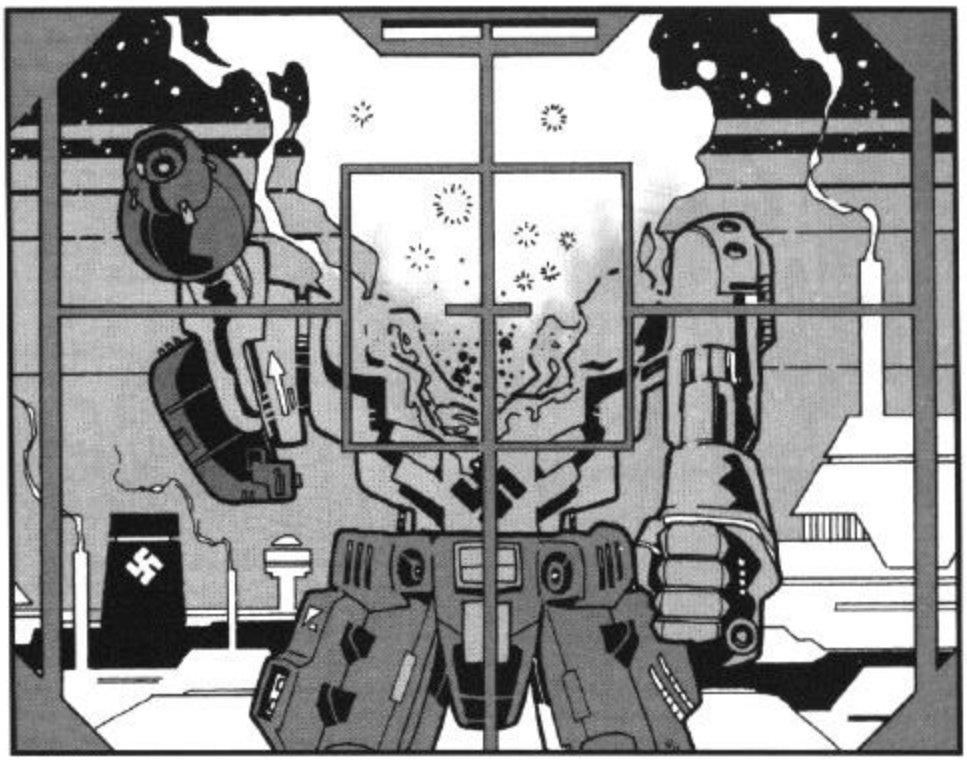
14 – If the vehicle has an energy bank in the location hit, half the maximum kWs of storage capacity (along with half the stored power) are lost. If the vehicle has no energy bank, treat as #6, above.

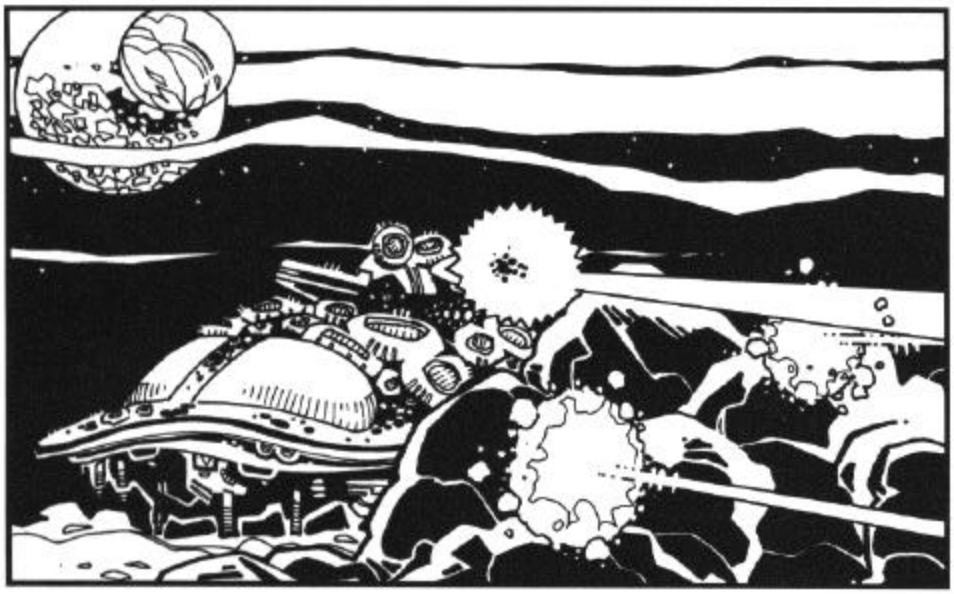
15 – Normal damage; also, if any damage penetrated armor and there is a communication or ECM system in the location hit, one such system is disabled.

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.

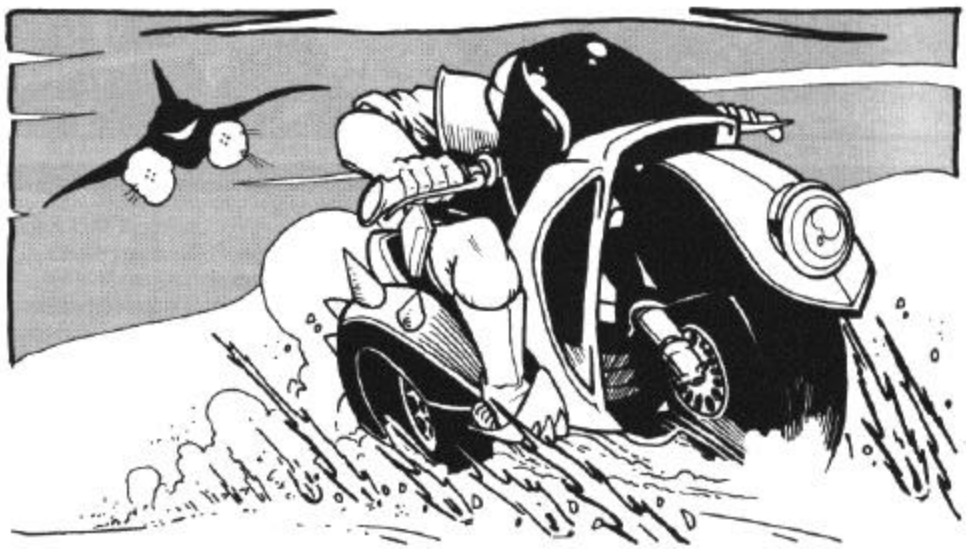
Nuclear power plants incorporate failsafes to keep bad things from happening should they break down. They work . . . most of the time. However, there is a 1 in 6 chance that a fission or fusion plant will undergo an energy release if disabled – this is not a nuclear blast, but a release of (possibly 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.

Continued on next page . . .

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!





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.

EXAMPLE

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.

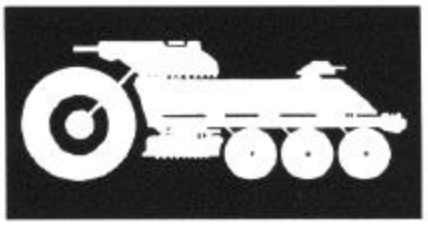
WP: "White Phosphorous" covers the area of effect with a "hot smoke" screen that forms instantly and also blocks infrared and thermograph detection, but only lasts half as long. As well, it scatters burning white phosphorous fragments. Treat as a fragmentation attack (p. B122) with the fragments having 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.

Continued on next page . . .



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.

Continued on next page . . .

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.

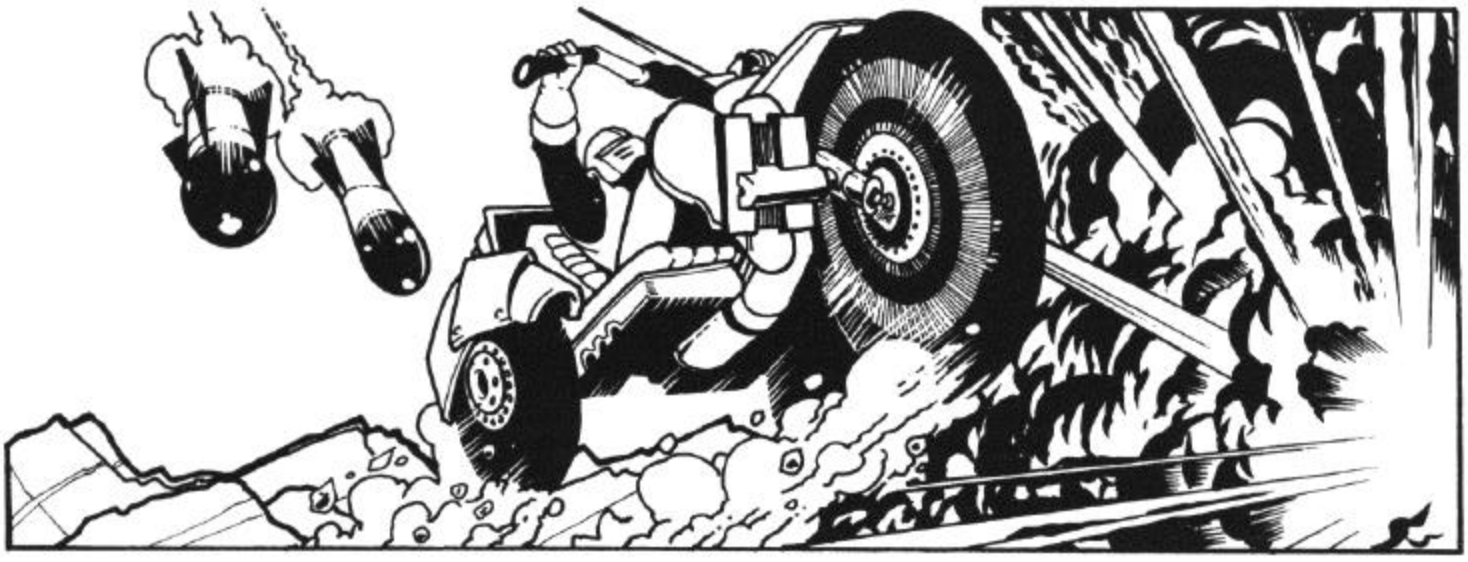
Launching requires an attack maneuver. To launch a missile, the gunner rolls versus his Gunner (Guided Missile) skill at +4. Failure means the missile was incorrectly launched and will automatically crash on its first turn of flight.

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*

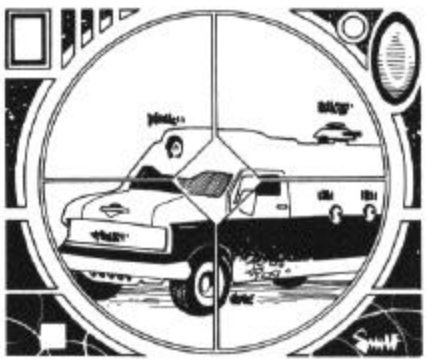
Bursting Class – Submunitions (Continued)

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

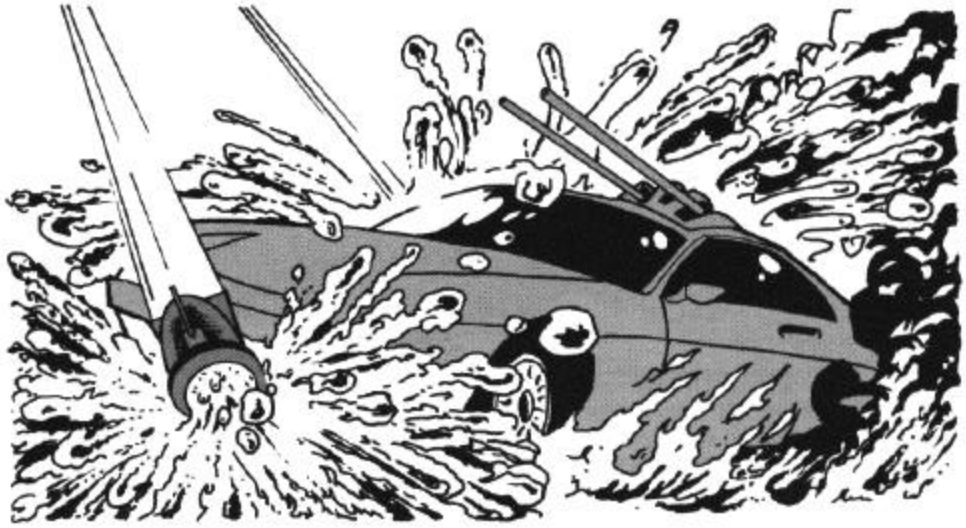
Starshell: Fired into the air, these flares illuminate 100 times the radius shown for a normal CHEM round with light equivalent to daylight. They burn for 5 minutes. Fired at ground targets, they illuminate only ten times the radius shown, but may start fires if in contact with flammable material, or 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 *something* (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

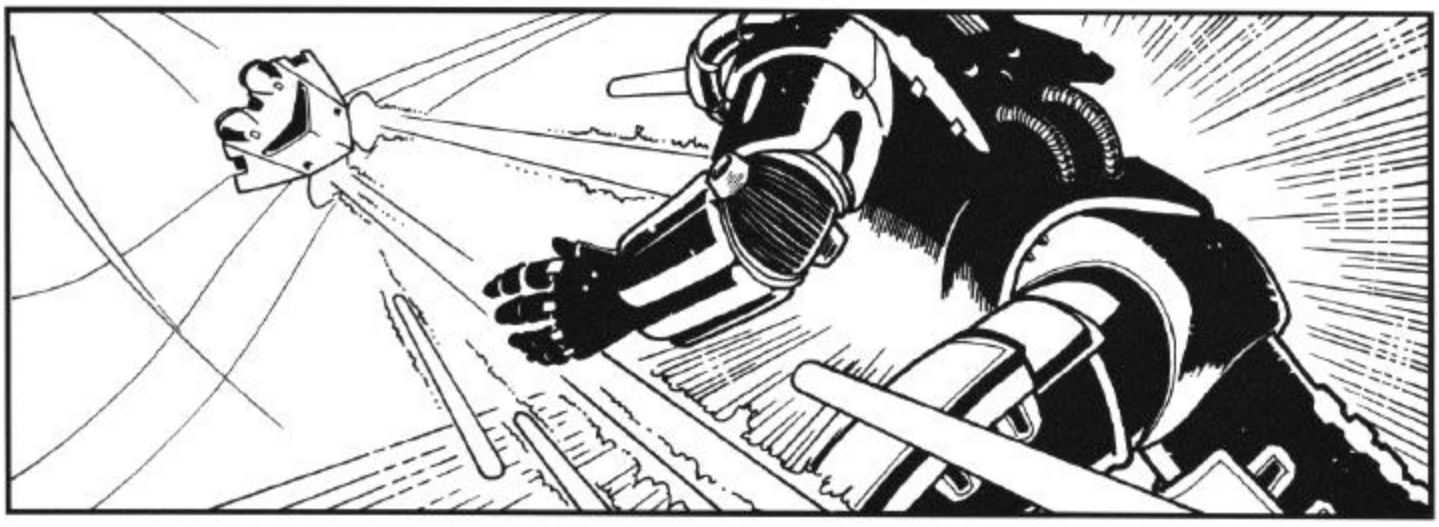
Most types of energy beam have special rules pertaining to how they do damage:

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.

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GURPS Space and Cyberpunk

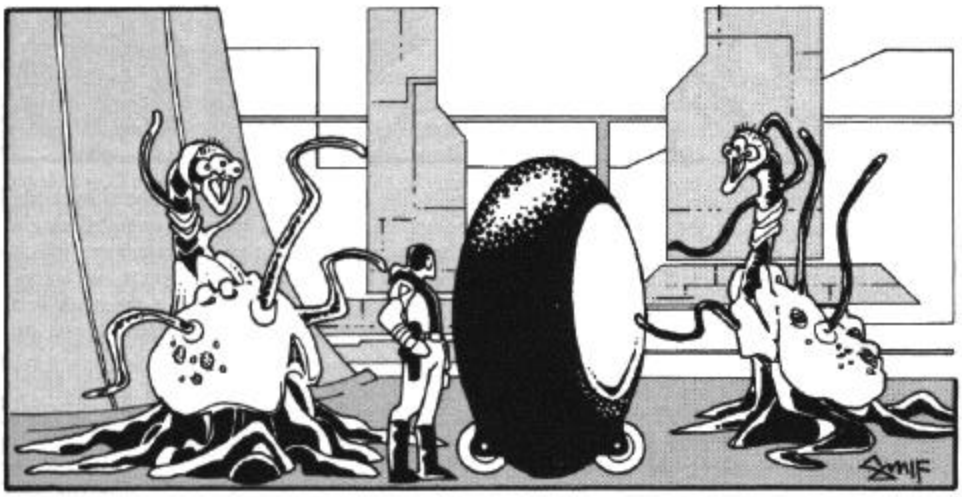
Who knows what vehicles will be built in the future? This book lets you answer that question for your own campaign, creating anything from spaceships to anti-grav cycles.

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.

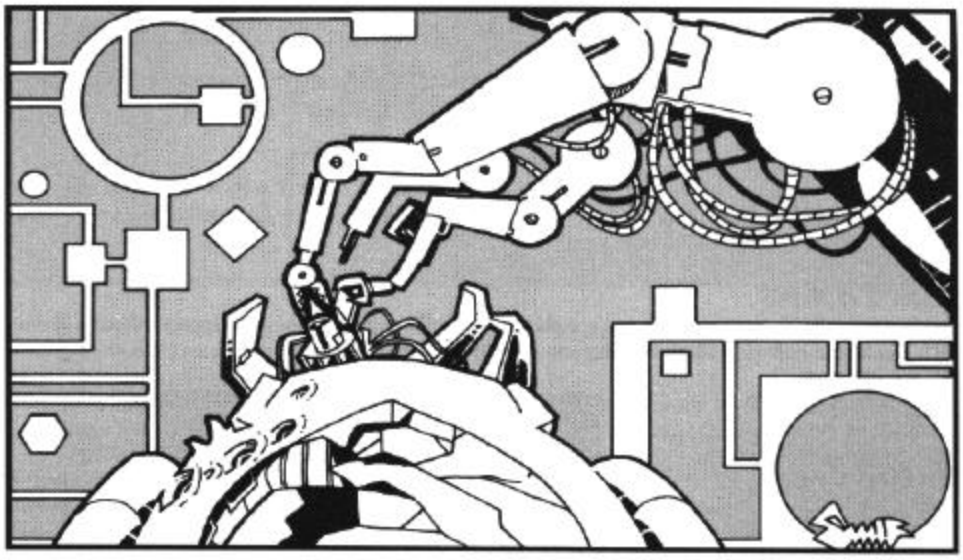
Black-Market Weapons

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!

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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.

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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

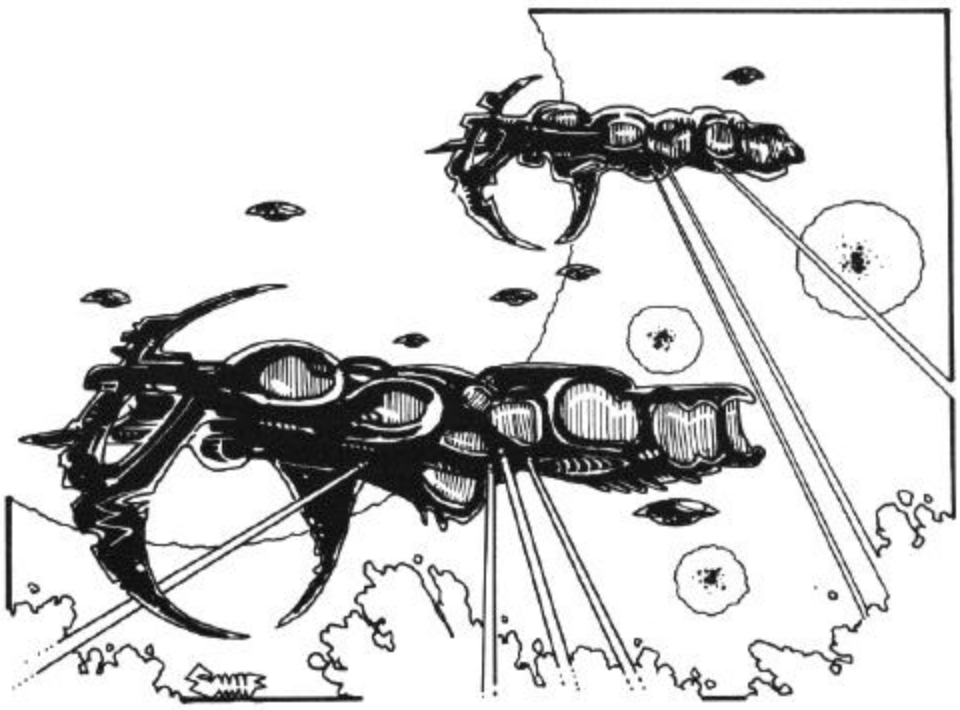
Once a working model is built, no die roll is required to build a copy of it; however, it still takes one week per 6,750 cf (or fraction) of vehicle size to build a copy. For a rush job, doubling the price will halve the time, and tripling the price will cut the time to 1/3. Quadrupling the price will 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.

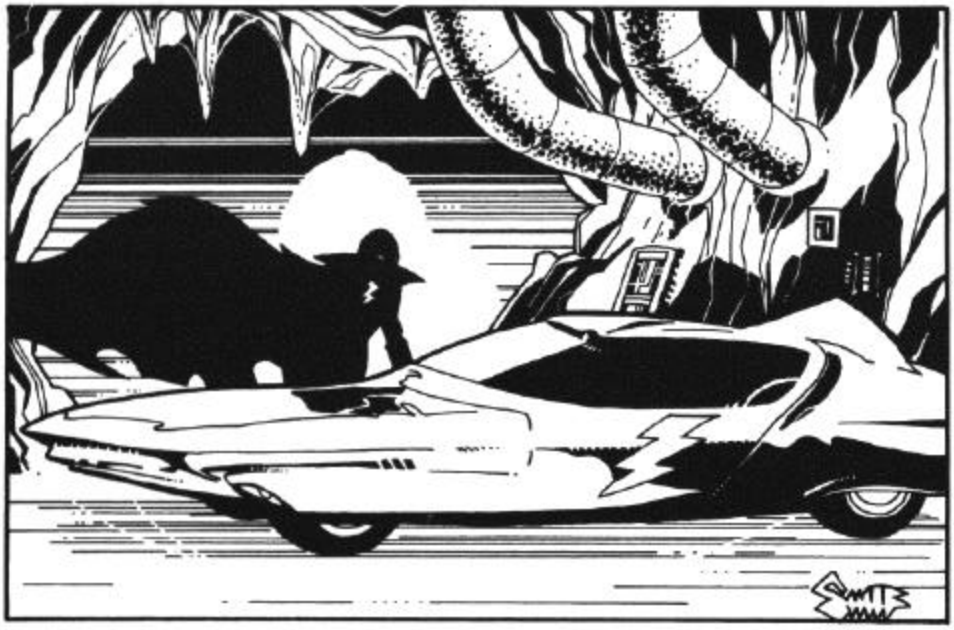
The cost of each production vehicle is 20% of the list price for parts alone, or 100% of the list price including labor.

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.

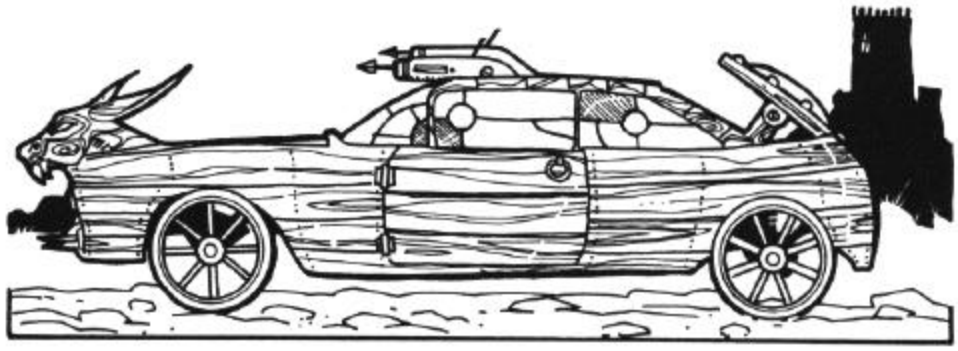


Vehicle Quality – Cheap, Fine and Very Fine Vehicles

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.

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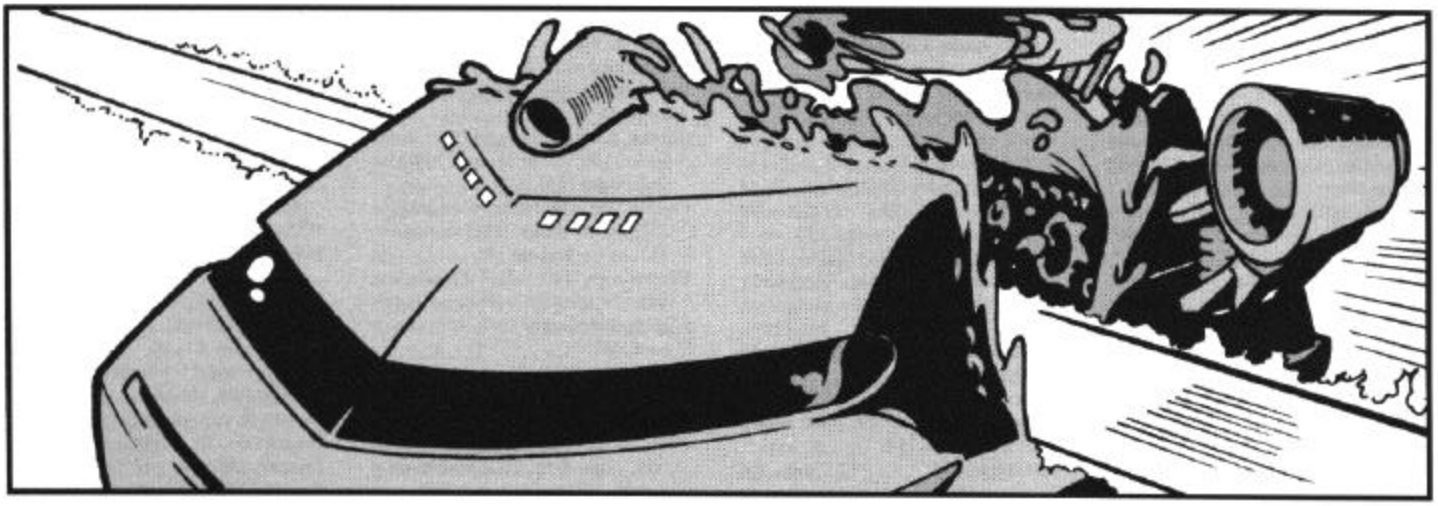
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