GURPS® Fourth Edition

Spaceships

And More

Written by TEVIET CREIGHTON

Based on *GURPS Spaceships*

by DAVID L. PULVER

additional material by KENNETH PETERS

STEVE JACKSON GAMES

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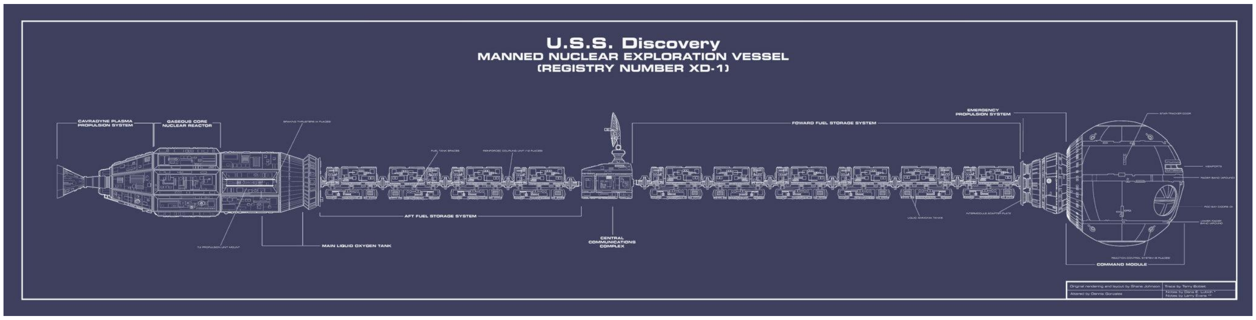

U.S.S. Discovery
MANNED NUCLEAR EXPLORATION VESSEL
(REGISTRY NUMBER XD-1)

Introduction

The ***GURPS Spaceship*** design rules have been expanded (and corrected) through the volumes of that series, as well as various ***Pyramid*** articles and errata. They no longer apply just to spaceships, but can be used to design a variety of mobile vehicles or stationary structures. This book compiles the latest updated rules for design and operations into a single handy reference.

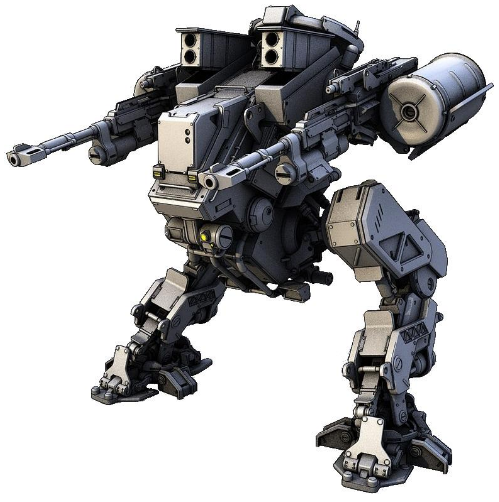
Publication History

The original ***GURPS Spaceships*** series was written by David L. Pulver. This book compiles material from the core book and the supplements ***GURPS Spaceships 3:*** *Warships and Space Pirates*, ***GURPS Spaceships 4:*** *Fighters, Carriers, and Mecha*, ***GURPS Spaceships 5:*** *Exploration and Colony Spacecraft*, ***GURPS Spaceships 6:*** *Mining and Industrial Spacecraft*, ***GURPS Spaceships 7:*** *Divergent and Paranormal Tech* (all written by David Pulver), and the Pyramid articles *Alternate Spaceships* (by David Pulver) in ***Pyramid #3/34:*** *Alternate GURPS* and *Mecha Operations* (by Kenneth Peters) in ***Pyramid #3/40:*** *Vehicles*. Some additional material has been added to this volume by Teviet Creighton.

The original rules for space travel appeared in ***GURPS Space*** (by William Barton and Steve Jackson), and rules for space combat were added by David Pulver to ***GURPS Space, Third Edition***. Rules for some shipboard systems are adapted from the ***GURPS Vehicles Expansion*** volumes, some of which drew on material that originated in ***GURPS Steampunk***, ***GURPS Ultra-Tech***, and ***GURPS Warehouse 23***. Rules for zombie vehicles first appeared in ***GURPS Undead***. Certain game mechanics for hulls and systems came from ***Vorkosigan Saga Sourcebook and Roleplaying Game***.

About the Author

Teviet Creighton is a physics professor and gamer living in South Texas. He has written several ***GURPS*** supplements – none published – including ***GURPS Exotics***, a collection of (barely) hard SF races, and ***GURPS Gya***, a hard fantasy gameworld. All supplements including this one were typeset using the `gurps.cls` class file.



About *GURPS*

Steve Jackson Games is committed to full support of the ***GURPS*** system. Our address is SJ Games, Box 18957, Austin, TX 78760. Please include a self-addressed, stamped envelope (SASE) any time you write us! We can also be reached by e-mail: **info@sjgames.com**. Resources include:

New supplements and adventures. ***GURPS*** continues to grow – see what's new at **www.sjgames.com/gurps**.

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Bibliographies. Many of our books have extensive bibliographies, and we're putting them online -– with links to let you buy the resources that interest you! Go to each book's web page and look for the "Bibliography" link.

Errata. Everyone makes mistakes, including us – but we do our best to fix our errors. Up-to-date errata sheets for all ***GURPS*** releases are available on our website – see above.

Rules and statistics in this book are specifically for the ***GURPS Basic Set,*** *Fourth Edition.* Page references that begin with B refer to that book, not this one.

Chapter One
Design

This chapter provides rules to design and modify vessels, and a catalog of systems to build them with.

Hulls and Systems

These rules can be used to assign statistics to ground, water, air, and spacecraft that range from 10 tons to 3,000,000 tons mass and which are built at TL5 to TL12, with some options for lower TLs. It can also be used to design immobile structures, space stations, etc. Collectively, these are referred to as *vessels*.

Vessels are rated in terms of their mass in short tons (2,000 lbs. per ton), their Size Modifier, and their longest dimension. Decide how large the vessel is by choosing a hull size modifier from SM+4 to SM+15, and whether the hull is *streamlined* or *unstreamlined;* see *Hulls* (p. 6). Certain systems will modify the final Size Modifier or mass of the vessel.

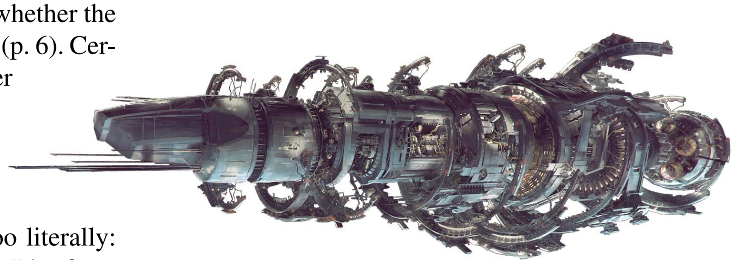
Hulls are divided into three sections: the *front hull*, the *central hull*, and the *rear hull*. Each represents one-third of the vessel's total mass (not volume). This need not be taken too literally: the actual shape may be more complex, e.g., "the front hull section" could include forward-facing parts of the vessel that are actually part of multiple different sub-hulls, pods, or wings.

The front, center, and rear hulls each contain six hull *systems* numbered [1] to [6]. In addition, any *two* of the three hull sections contain a deep-buried system designated [core]. Each system is a major component. The numbers are used for hit location rolls (see p. 104), while the core systems are similar to the vitals location of a human. Each vessel has 20 systems, each 5% of the total mass.

Choose any combination of systems from those listed under *Armor Systems* (p. 9), *Propulsion and Lift Systems* (p. 13), *Power Systems* (p. 28), *Weapon Systems* (p. 34), and *Other Systems* (p. 42). A vessel can have multiple examples of the same system. The choices should fit the setting, which can determine which propulsion systems are available and which superscience technologies exist. Record system statistics, such as the tons of cargo in a hold or engine acceleration, as they are selected.

Vessels can have various optional *design features* (p. 53) and *design switches* (p. 60). These don't count toward the 20 systems.

Refer to *Statistics* (p. 67) to determine how these choices affect the vessels's statistics. Statistics are typically given in *decade scale* (*Scaling Damage*, p. B470), representing 10× the ordinary ***GURPS*** statistic: e.g. dST 15 corresponds to ordinary ST 150, d-damage 6d is ordinary damage 6d×10, etc.



Hulls

A hull is rated for its Size Modifier (SM), which determines the vessel's mass, dST/HP, dimensions, and the base Handling and Stability Rating.

A hull must be streamlined or unstreamlined.

Unstreamlined: This is a spherical, cylindrical, cubical, or humanoid hull, or a complex collection of spheres, saucers, cylinders, booms, and pods. It might be able to fly or swim with enough thrust, but has poor aerodynamics.

Streamlined: A streamlined hull's shape may be a wedge, lifting body, cone, disk, teardrop, bullet, or needle-like shape. It is optimized for high atmospheric or underwater speed (the *Nautical Lines* design switch optimizes it for speed on the water's surface). A streamlined vessel must have at least one Armor system for its front hull or central hull (if a multi-stage design, only the uppermost section need be armored). All of its armor will have lower DR than an unstreamlined hull, due to the greater surface area.

The hull's SM determines its other characteristics:

Hull Size Table

SM	*Loaded Mass*	*Length*	*dST/HP*	*Hnd/SR*
+4	10 tons	10 yards	15	0/4
+5	30 tons	15 yards	20	0/4
+6	100 tons	20 yards	30	0/4
+7	300 tons	30 yards	50	-1/5
+8	1,000 tons	50 yards	70	-1/5
+9	3,000 tons	70 yards	100	-1/5
+10	10,000 tons	100 yards	150	-2/5
+11	30,000 tons	150 yards	200	-2/5
+12	100,000 tons	200 yards	300	-2/5
+13	300,000 tons	300 yards	500	-3/5
+14	1,000,000 tons	500 yards	700	-3/5
+15	3,000,000 tons	700 yards	1,000	-3/5

Larger vessels follow the same progression (SR does not increase beyond 5).

Loaded Mass: The approximate loaded mass of the vessel in tons. To keep this system simple, mass values follow a 1-3-10 progression that conforms with SM.

Length: An average for a typical unstreamlined cylindrical vessel, or for many complex shapes like saucer-boom-and-pod designs. Length is only an approximation; feel free to vary it. Streamlined vessels may be up to twice as long. Stubby cylinders, teardrops, saucers, and other more complex shapes average about 50%-75% of this length. A sphere will be less than half this length.

dST/HP: This is the vessel's decade-scale ST and basic HP value.

Hnd/SR: The base Handling and Stability Rating of a vessel of that size.

A hull has no cost – that depends on the armor or other systems added to it.

Systems

Numerous systems may be built into vessels. The cost, and many other statistics, vary according to the vessel's hull SM, as indicated in the tables in the various *Systems* sections in this chapter.

TL

The suggested TL the system is available at. Most vessels are built using systems from a variety of TLs. All superscience systems (TL^) are optional and their TL is only a suggestion. Some items are referred to as "limited superscience." They don't egregiously violate physical laws, but they do push past the edge of realistic engineering capabilities.

These rules offer a wide variety of superscience technologies, some of which can be overwhelmingly effective if not countered by other superscience! For example, take care to balance weapon damage with DR to avoid vessels that are invulnerable or die instantly.

Location and Other Restrictions

Some systems can only go be placed in certain hull section locations.

[any] means the system can go anywhere.

[core] means it can go in either of the 2 core locations.

[hull] means it can go in any of the 18 hull locations, but cannot be a core system.

[rear] means it can only go in the rear hull and may not be a core system.

[front] means it can only go in the front hull and may not be a core system.

Dollar Cost and Other Statistics

Most systems have a specified cost that increases with Size Modifier, as shown in the system's table. Many systems have other statistics, such as the capacity of a cargo hold or the acceleration of a maneuver drive. Where large numbers are used, the abbreviations K for thousand, M for million, B for billion, and T for trillion are used, e.g., a dollar cost of 30M is $30 million dollars.

When a table has no listing for a given SM, then the system is not available at that SM. You may still be able to install such a system using the rules for *Larger Systems* (p. 8).

Although this design system is intended for vessels with SM+4 or greater, a few tables have entries for SM+3 systems. These are not intended as systems for SM+3 vessels, but for larger vessels using the rules for *Smaller Systems* (p. 8).

High-Energy Systems and Power Points

Certain systems are "high-energy systems" that require a great deal of power. These are indicated with an exclamation point next to their location, e.g., [!]. Each high-energy system operated simultaneously must be assigned one Power Point to power it. If it has two exclamation points (e.g. [!!]), it requires two Power Points, and so on. Power Points are produced by power systems, such as fission power plants. You can design the vessel with enough Power Points to operate every high-energy system that needs to run simultaneously, or install less power, which forces the crew to carefully decide what systems they want powered up at any given time. (Excess power is useful for redundancy in case of damage.)

Vessels without high-energy systems do not require Power Points. It's assumed that built-in auxiliary power supplies or energy banks factored into the systems are sufficient.

Workspaces

Many systems (especially on larger vessel) have a specified number of "workspaces." This determines how many technicians are required to man and maintain that system. Thus, if a system specifies three workspaces, it is normally manned by three crew, who are busy inside that system performing various routine duties, such as monitoring panels or performing maintenance. Workspaces include duty stations for the technicians and workshops that fulfill equipment requirements for these techs to maintain and repair that type of system (or all shipboard systems, for engine rooms). The Automation (p. 54) design feature can reduce or eliminate workspace requirements.

Repair Skill

Systems that can be disabled or destroyed list the skill required to repair them. This is also the skill that crew will need for routine maintenance. Mechanic (Vehicle Type) means the required specialization is the same as the Piloting skill.

Smaller Systems

Designers may squeeze multiple, inferior systems into the same location. Each system can consist of 3 systems worth of hardware rated for a vessel one SM smaller (or 10 systems two SM smaller, or 30 systems three SM smaller, etc.).

A few systems require special treatment:

Armor or Force Screens: These can take up any desired fraction of a system: multiply the dDR or reflected damage dice of the full-size system (and the lift of armor systems that provide contragravity lift) by the corresponding fraction, rounding down. It's very inefficient to spread a smaller vessel's defenses over a larger vessel!

Banned Systems: A smaller exophase field, helicopter rotor, lightspeed drive, ornithopter wings, stasis web, stardrive, or soft-landing system can't be used with a larger ship. At least, not successfully.

Contragravity Lifters: These produce one-third the G (round to one decimal place).

Controls or Sapient Brain: Since this also represents the vessel's attitude thrusters, gyros, etc., a vessel with a smaller system additionally has a -1 penalty to Handling and Stability Rating, and -2 to DX (if applicable).

External Clamp: A smaller external clamp can only be attached to things that are at least three SM smaller than the vessel. (A full-size clamp has no SM limits.)

Factory: Smaller factory systems do not provide a HT bonus.

Fuel Tanks, Sails, Drives, or Engines: Use 1/3 the delta-V reserve of a smaller fuel tank and 1/3 the acceleration of a smaller engine or sail. A scaled-down ramscoop can only provide unlimited fuel to a smaller thruster. When using the *Delta-V Increase Table* (p. 19), smaller tanks count as only one-third of a tank; round fractions down.

Open Space: 1/3 the areas of the full-sized system (round down).

Power: Smaller power plants do not provide sufficient power for normal-size systems, but they can power another scaled-down system.

In addition, some systems can be half-size at half cost:

- Cargo holds (halve capacity).
- Factories (halve output).
- Fuel tanks (halve delta-V reserve, count as a half-tank for delta-V increase).
- Habitats (halve cabin-equivalents).
- Mining and refinery systems (halve output).
- Open spaces (halve areas).
- Passenger seating (halve seats).
- Power plants (fusion and antimatter only – halve Power Points).

Tiny Systems

Most system tables extend only to SM+4 (with a few exceptions), so in most cases a vessel may not install an SM+3 version of a system. However, an SM+3 system can also consist of 300 lbs. of items from ***GURPS High-Tech***, ***GURPS Ultra-Tech***, or other sources. Small vessels may also use half-size SM+4 systems, as above.

Larger Systems

While it's more common to cram in smaller systems, sometimes a *small* ship needs a *big* gun – or a device that isn't normally available at its size. A system that's one SM larger occupies *three times* its usual number of locations, and has the statistics of a system for a larger ship. (Three high-energy systems used to make up a larger system require three Power Points.) A system that's two SM larger occupies *ten times* the number of locations (and requires ten times as many Power Points). A half-size system three SM larger occupies 15 locations. No further increase is possible.

One class of systems requires special treatment:

Defenses: The effectiveness of a larger-scale defensive system is increased because it only has to cover a smaller surface area. Increase the dDR or reflected damage dice of the larger system by 2× if it is one SM larger, or 5× if it is two SM larger. (If it is also a *low-volume* system, p. 9, then it *also* gets the defensive multiplier listed there.)

Other components that *might* have additional effects are better handled by using three normal-size components, since scaling has already been determined.

Empty Systems

If you want to fine-tune the mass of a vessel to a greater precision than the default 1-3-10 progression, you may designate one or more systems as "empty". Each empty system reduces the mass of the vessel by 5%. (The minimum armor requirement for a streamlined vessel is reduced by the same fraction.) Empty systems also reduce the *volume* of the vessel: see *Armor and Volume*, p. 9. If you have 14 or more empty systems, you should consider basing the vessel on a smaller SM hull.

Armor Systems

Armor systems are rated for the decade-scale DR (dDR) that they provide to the hull section they are installed in. Thus, armor on the front hull protects the front of the vessel, armor on the central hull protects the central hull (the sides), and armor on the rear hull protects the back. To fully armor a vessel, add armor systems to the front, central, and rear hull.

The dDR of armor systems also varies depending on whether the vessel is streamlined or not: two values are listed for each armor system, US (unstreamlined) or SL (streamlined). The lower dDR for streamlined vessels represents the same mass of armor spread over a greater surface area.

A streamlined vessel must be given at least one armor system on its front or central hull.

Multiple armor systems ("layers") can protect the same hull section; the dDR of all armor systems on a given hull section are cumulative. Where important (e.g., in the case of semi-ablative or hardened armor), armor layers from outer to innermost protect in the order they are numbered. Civilian vessels often omit armor on some sections to conserve mass. If a hull section is entirely unarmored, it is dDR 0.

(When not using decade-scale damage, e.g., in personal combat, the thin non-structural walls of a dDR 0 unarmored hull section can be assumed to have DR 2 if streamlined or DR 3 if unstreamlined.)

Armor and Volume

GURPS Spaceships is a mass-based system. For the most part, it assumes that mass and volume are roughly equivalent, so a more massive ship is also larger. However, some systems, particularly armor systems, do not contribute significantly to volume. These are collectively referred to as *low-volume* systems. This is normally not enough to actually reduce the SM, but *is* enough to reduce the surface area that the armor is spread over, and hence increase overall DR. A low-volume system can be any of the following:

- An *Empty System* (p. 8).
- Any *Armour System* besides Ice, Wooden, Organic, or Etherwood.

Determine a vessel's *system volume:* the number of systems (starting at 20) *excluding* all low-volume systems. A vessel's dDR will increase if low-volume systems reduce the system volume to 15 or less. Its SM will decrease if the system volume is reduced to 6 or less. Look up the system volume (rounding fractions up) on the *Low-Volume Systems Table*, below.

Low-Volume Systems Table

System Volume	*dDR*	*Target SM*
2 or less	×3.6	-2
3	×3	-1
4	×2.6	-1
5	×2.3	-1
6	×2	-1
7-8	×1.8	0
9	×1.6	0
10	×1.5	0
11-12	×1.4	0
13	×1.3	0
14-15	×1.2	0
16 or more	×1	0

dDR is the multiple to the dDR of *all* armor systems (round fractions down).

Target SM is the adjustment to the vessel's SM, when rolling to detect or attack it. It also affects the *cost* of non-system hull features that depend on SM (e.g. Winged). Since mass is unchanged, the SM change does not otherwise affect capabilities.

Additionally, some vessels contain *high-volume* systems that are *significantly* less dense than average. A high-volume system counts as *multiple* systems when computing the system volume. High-volume systems, and their volume multiples, are as follows:

- *Gasbag* (p. 15): Each counts as 500 systems.
- *Open Space* (p. 51): Each counts as 10 systems.

A vessel's dDR will decrease if high-volume systems increase the system volume by at least 50%. Its SM will increase if the system volume is increased by at least 3×. Look up the system volume, rounded up, on the *High-Volume Systems Table* (below).

High-Volume Systems Table

System Volume	*dDR*	*Target SM*
20-29	×1	0
30-44	×0.8	0
45-59	×0.6	0
60-79	×0.5	+1
80-119	×0.4	+1
120-199	×0.3	+1
×10	×0.2	+2

The progression is open-ended: for each ×10 increase in volume, apply an additional ×0.2 to dDR and +2 to SM. *dDR* and *Target SM* are as above. Use a large system's Target SM when targeting it with *Precision Attacks* (p. 110).

External Systems

Some systems, especially high-volume systems, may be mounted *outside* the armored portion of the hull. They then count as *low*-volume systems for purposes of computing the dDR multiplier, but the systems themselves are not protected by armor, and can be targeted using the rules for *Precision Attacks* (p. 110) and *Targeting Exposed Systems* (p. 110).

Armor, Conventional (TL0) [hull]

This represents both armor plating and structural strengthening of the hull. Numerous varieties are available:

Ice (TL0): This is armor made from frozen water. It may be used to represent spacecraft built from hollowed-out comets or Kuiper Belt objects, although ice is sometimes added atop other armor as cheap shielding for space stations. Ice armor systems provide *semi-ablative* dDR (p. B47) that protects the hull section it is installed in. Ice armor is not available for SM+4 to SM+7 hulls, nor for streamlined hulls. Cost is negligible.

Stone (TL0): This is rock armor for vessels that are hollowed-out asteroids, or covered with a layer of rock or slag. Stone dDR is *semi-ablative* (p. B47). It is unavailable for SM+4 to SM+6 hulls, or for streamlined hulls. Cost is negligible.

Wooden (TL0): Wood is a natural composite material with a high strength-to-weight ratio. This represents ordinary wood (in contrast to the more exotic *organic armor*, below). Wood dDR is treated as semi-ablative vs. burning or corrosion damage. Due to structural limitations, realistic wood cannot be used on vessels larger than SM+9.

Iron (TL5): This is riveted iron plate. It is somewhat less protective than the high-grade steel described below. It may also be available at TL2-4 but is significantly more expensive, costing at least five times as much.

Steel (TL7): This is armor made of high-quality steel plate. It is common due to its low cost.

Light Alloy (TL7): This is armor made of aerospace-grade aluminum or titanium alloys.

Metallic Laminate (TL8): This is titanium, aluminum, beryllium, or ultra-hard steel alloy further reinforced by the addition of carbon fibers, ceramic fibers, or intermetallic laminates.

Advanced Metallic Laminate (TL9): This is armor similar to metallic laminate, but the alloy is reinforced through the addition of super-strong carbon nanotubes, boron nanotubes, or diamond whiskers.

Nanocomposite (TL10): This armor uses ultra-strength carbon or boron nanotube-reinforced polymers. It can also represent biotech hulls far stronger than the organic hull covered below.

Organic (TL10): This is low-cost armor made of advanced biotech materials (space-adapted wood or living tissue, living bioplastic, etc.) Use this for spacecraft with living or high-biotech wood hulls. DR is halved (round down) against burning or corrosion damage. TL11 if engineered or manufactured rather than found (e.g., the body or wood of a space life form).

Diamondoid (TL11): This armor system uses super-hard nano-fabricated materials such as diamondoid, ultra-hard fullerites, or cubic boron nitride. Can also represent exotic superscience "crystal" armors.

Exotic Laminate (TL12): Tougher armor than diamondoid, usually a complex laminate of ultra-hard materials and high-density exotic matter.

Conventional Armor Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Ice												
US dDR	0	0	0	0	1	2	2	3	5	7	10	15
Stone												
US dDR	0	0	0	1	2	2	3	5	7	10	15	20
Wooden												
US dDR	0	1	1	2	2	3	4*	5*	6*	7*	10*	15*
SL dDR	0	0	1	1	1	2	3*	3*	4*	5*	7*	10*
Cost ($)	0	2K	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M
Iron												
US dDR	0	0	1	2	3	5	7	10	15	20	30	50
SL dDR	0	0	1	1	2	3	5	7	10	15	20	30
Cost ($)	0	0	12K	40K	120K	400K	1.2M	4M	12M	40M	120M	400M
Steel												
US dDR	0	1	2	3	5	7	10	15	20	30	50	70
SL dDR	0	0	1	2	3	5	7	10	15	20	30	50
Cost ($)	0	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M
Light Alloy												
US dDR	1	2	3	5	7	10	15	20	30	50	70	100
SL dDR	1	1	2	3	5	7	10	15	20	30	50	70
Cost ($)	5K	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B
Metallic Laminate												
US dDR	2	3	5	7	10	15	20	30	50	70	100	150
SL dDR	1	2	3	5	7	10	15	20	30	50	70	100
Cost ($)	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B
Advanced Metallic Laminate												
US dDR	3	5	7	10	15	20	30	50	70	100	150	200
SL dDR	2	3	5	7	10	15	20	30	50	70	100	150
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B
Nanocomposite												
US dDR	5	7	10	15	20	30	50	70	100	150	200	300
SL dDR	3	5	7	10	15	20	30	50	70	100	150	200
Cost ($)	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B
Organic												
US dDR	1	2	3	5	7	10	15	20	30	50	70	100
SL dDR	0	1	2	3	5	7	10	15	20	30	50	70
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B
Diamondoid												
US dDR	7	10	15	20	30	50	70	100	150	200	300	500
SL dDR	5	7	10	15	20	30	50	70	100	150	200	300
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B
Exotic Laminate												
US dDR	10	15	20	30	50	70	100	150	200	300	500	700
SL dDR	7	10	15	20	30	50	70	100	150	200	300	500
Cost ($)	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B	60B

* Ordinary wooden structures cannot be used on vessels larger than SM+9.

Repair Skill: Armory (Vehicle Armor) for most armor types. For *Ice*, Armory (Vehicle Armor) at -4 for unfamiliarity, unless ice armor is commonly used. For *Stone*, Masonry. For *Wooden*, Carpentry. For *Organic*, either Carpentry for high-biotech wood, Biotechnology (Tissue Engineering) for high-biotech flesh, or even Veterinary for living biostructures.

Armor, Fantastic (TL2^) [hull]

This represents various types of armor or structural material found in fantasy and science-fantasy settings. They often have exotic origins: the sky forests of Jupiter, crystal mined from asteroids or the spheres that separate the heavenly bodies, solidified quintessence, etc.

Etherwood (TL1^): Etherwood is a tough wood that has innate contragravity properties. In addition to serving as armor, every etherwood system provides the vessel with 1/3G of lift. If the lift of etherwood exceeds the planetary gravity, the vessel flies as if it had contragravity lifters (save for the lower lift and lack of power consumption). This makes etherwood systems useful even on vessels too small to get any dDR from them. Etherwood dDR is treated as semi-ablative vs. burning or corrosion damage. Due to the vast size that etherwood trees can grow and the innate antigravity properties, it does not have the structural limitations of ordinary wood: etherwood vessels can have any hull size.

Adamant (TL2^): Many fantasy craft are made of "crystal." Adamant represents this: a material far tougher than ordinary stone, yet easily fabricated (magically or otherwise) into armor material. Earth enchanted by the Essential Earth spell (***GURPS Magic***, p. 53) and turned to stone is treated as adamant. Adamant is semi-ablative: It loses 1 dDR for every 10 points of d-damage it resists (see Semi-Ablative, p. B47).

Skystone (TL2^): This is an arcane crystal that combines the properties of etherwood and adamant. It has as much lifting ability as etherwood (1/3G per system) but is far tougher. Like adamant it is semi-ablative, losing 1 dDR for every 10 points of d-damage resisted. The contragravity lift of skystone and etherwood are cumulative.

Orichalcum (TL2^): A legendary metal with triple the strength of the strongest bronze. It can also represent various other super-strong fantasy metals.

Fantastic Armor Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Etherwood												
US dDR	0	1	1	2	2	3	4	5	6	7	10	15
SL dDR	0	0	1	1	1	2	3	3	4	5	7	10
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B
Adamant												
US dDR	0	1	2	3	5	7	10	15	20	30	50	70
SL dDR	0	0	1	2	3	5	7	10	15	20	30	50
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B
Skystone												
US dDR	0	1	2	3	5	7	10	15	20	30	50	70
SL dDR	0	0	1	2	3	5	7	10	15	20	30	50
Cost ($)	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B
Orichalcum												
US dDR	3	4	6	9	12	18	25	40	60	90	120	180
SL dDR	2	3	4	6	9	12	18	25	40	60	90	120
Cost ($)	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B

Repair Skill: Armory (Vehicle Armor) for most armor types. For *Etherwood*, Carpentry.

Armor, Structural Field (TL11^) [hull!]

This is armor made of unstable exotic matter reinforced by energy fields. Unlike other armor, it has a Power Point requirement. If a structural field armor system ever loses power, the armor itself is destroyed, losing its dDR.

Structural Field Armor Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
US dDR	20	30	50	70	100	150	200	300	500	700	1,000	1,500
SL dDR	15	20	30	50	70	100	150	200	300	500	700	1,000
Cost ($)	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B	100B

Repair Skill: Armory (Vehicle Armor *and* Force Shields).

Force Screen (TL11^) [Any!]

This system generates a protective force field around the entire vessel – it protects all hull sections, not just the one it is installed in. It is rated for the *semi-ablative* (p. B47) dDR that it provides. The table shows the field's dDR and the cost per (high-energy) system. Subtract force screen dDR first, then any armor dDR on the hull section struck.

A force screen regenerates 10% of its lost dDR every second, provided it is powered up. During space combat turns (which represent several seconds to several minutes) the screen is assumed to completely regenerate lost dDR each turn, but it offers reduced protection against repeated attacks during the turn.

A spacecraft may only have one force screen up at any one time. Screens may be light or heavy:

Light Force Screen: A relatively inexpensive design; use the listed dDR.

Heavy Force Screen: A high-power screen; it may function as a light screen, or it can double the dDR by using a second Power Point to reinforce the field.

The screen only provides protection while powered up. For more or less powerful screens and other options, see *Force Screen Variants* (p. 61).

Force Screen Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
TL11^ dDR	15	20	30	50	70	100	150	200	300	500	700	1,000
TL12^ dDR	20	30	50	70	100	150	200	300	500	700	1,000	1,500
Cost ($)												
Light screen	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B	50B
Heavy screen	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B	50B	150B
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300

Repair Skill: Armoury (Force Shields).

Propulsion And Lift Systems

These systems provide propulsion (forward acceleration) or lift (vertical acceleration). In most cases, systems with an acceleration given in Gs can add their accelerations together, while systems that list a Move score cannot. Exceptions are as noted.

Contragravity Lifter (TL^) [Any!]

Many contragravity systems are treated as reactionless drives. This system works differently: it selectively nullifies some or all of the pull of gravity on the spacecraft, but does not actually provide any acceleration. A vessel with contragravity lifters can land on, or take off from, a world regardless of its gravity. The lifter will cancel up to 10G, enough to take off from all normal or gas giant planets.

Contragravity Lifter Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Repair Skill: Mechanic (Contragravity).

Ether Propulsion (TL^) [hull!]

These interact with the ether (see *Etheric Cosmos and Ether Drives*, p. 61), stealing momentum and energy from light. For a minor variation in technobabble, substitute the term "astral" and assume the drive interacts with flow of extraplanar astral energies.

All ether or astral propulsion systems work like reactionless drives, although the boost-drive design switch (p. 60) is a common modification.

Ether Oars (TL^): Each system produces an acceleration of 0.1G. Ether oars do not use Power Points, they require manual operation by the number of crew members indicated below. To propel the ship they must constantly row, moving the oar-like vanes to interact with the surrounding ethereal medium. They cannot be used on craft greater than SM+7. Crew manning the oars must be in passenger seating in the same hull section as the oars.

Ether Screw (or Ether Flukes) (TL^): This electromechanical propeller- or rotor-like device churns the ether, offering 0.2G acceleration per system. Each is a high-energy system that requires one Power Point. Alternately, ether screws can be defined as "ether flukes" representing fin-like devices used to propel a biological space beast.

Ether Sail (TL^): This functions like an ether screw but slower, limited to 0.1G. However, it does not require Power Points, drawing energy entirely from the ether. Unlike space sails they do not cover many square miles, and they resemble normal seagoing masts and rigging in size. They might even be normal equipment made from eldritch substances (cloth spun by the giant moon spiders, etc.). They are exposed systems and are targeted as if they were radiator wings. Vessels that sail in air or space can include an "ether keel" or similar device to let them maneuver freely (unlike realistic space sails).

Powered Ether Sails (TL5+2^): These are ether sails augmented by additional power, allowing them to extend force fields farther into ether space. They require one Power Point and have 0.3G acceleration. Like ether sails, this is an exposed system not protected by armor.

The drive's interactions with the ether can produce exotic visual effects. For example, iridescent wakes and shadowy lees may follow etheric vessels across the sky; the craft's shadow becomes a black, tapering cone surrounded by a rust-colored fringe. (Add +2 to rolls to detect the vessel with passive sensors). In engineering or habitat spaces, interior lights may become red-shifted when the drive is operating (perhaps necessitating ultraviolet lighting aboard the vessel).

Like reactionless engines, ether propulsion can be used in atmosphere unless the GM rules otherwise. If the GM does not want ether propulsion to be useful for atmospheric thrust, he can restrict them to functioning in thin air, at high altitudes, in vacuum, etc.

Ether Propulsion Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Oar crew	1	2	6	20	-	-	-	-	-	-	-	-
Cost ($)	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B

Halve cost for oars; double cost for sails; triple cost for powered ether sails.

Repair Skill: Mechanic (Reactionless Drive).

Flexibody Drivetrain (TL9) [special!]

This system is a set of motors and powered body segments that allow the vehicle to flex its body and slither like a worm or snake, or swim through water.

A flexibody has the same cross-country travel speed as a legged vehicle (as detailed in the ***Basic Set*** vehicle rules), but can squirm through narrow tunnels, burrow through soft soil, or swim in or underwater. It can easily change facing. This effectively doubles the normal arc of fire of any fixed mount weapons.

Three flexibody drivetrain systems *must* be installed, one per hull section. Despite this being a high-energy system, only one Power Point is required *regardless* of the number of systems. Up to three Power Points can be used, with greater power increasing speed and acceleration. The table shows the resultant Move depending on Power Points: This is ground acceleration/top speed and water acceleration/top speed in yards per second.

Power Points	***Move (Ground)***	***Move (Water or Underwater)***
1	1/4	1/2
2	2/8	2/4
3	3/12	3/6

If a flexibody has the nautical lines option (p. 57), double water and underwater speed.

The system is not considered destroyed until all three of its parts are disabled; disabling one part reduces the number of Power Points that can be applied to movement by one.

Cinematic flexibody drivetrains are available for all sizes of vehicle, since it wouldn't be much fun if giant robotic sand worms capable of devouring entire starships were not possible. Realistic designs may be limited to SM+10 or less, however.

Flexibody Drivetrain Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11****	***+12****	***+13****	***+14****	***+15****
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B

* SM+11 flexibody vessels are cinematic (not superscience).

Repair Skill: Mechanic (Flexibody).

Gasbag (TL5*) [hull]

This is a membrane filled with lighter-than-air gas, such as a hydrogen or helium balloon. A gasbag is rated for its tons of lift.

The Lift row of the *Gasbag Table* (below) shows the tons of lift per gasbag. A vessel needs lift greater than its weight to rise (usually four gasbag systems).

Lifting Gas (TL5): The gasbag is filled with hydrogen or helium. The differences are minimal. Large quantities of helium are difficult to acquire at TL5-6; hydrogen is flammable, and hydrogen-filled gasbags are considered volatile systems if damaged when operating in an oxygen atmosphere.

Antigravity Gas (TL^): Weird science gases provide lift beyond that possible for buoyancy alone: 10 times the lift of hydrogen is typical. The origin is up to the GM. Destructive distillation of some natural antigravity material is a logical source, but exposure to radioactivity and the action of acid on "unobtainium" metals are also popular.

Gasbag Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Lift	3	9	30	90	300	900	3,000*	9,000*	30K*	90K*	300K*	900K*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	10K	50K	100K	200K	500K	1M	2M	5M	10M	20M	50M	100M

* Lifting gas on SM+10 or larger vessels requires superscience.

Multiply cost by 5 for antigravity gas.
Repair Skill: Mechanic (Lighter-Than-Air).

Helicopter Rotor (TL7*) [hull!]

This is a set of rotor blades and a transmission for vertical takeoff and landing. This may be a top-and-tail rotor system, multiple main rotors, or coaxial rotors. It is only usable in an environment with at least 0.1 atmospheres of pressure. Vessels can install one or two systems; this represents a more powerful drive, not necessarily two main rotors. Only one Power Point is required to take off, but a second system allows a second Power Point to be allocated, providing increased performance:

Power Points	***Move (Unstreamlined)***	***Move (Streamlined)***
1	5/40	5/100
2	10/50	10/125

Treat *Nautical Lines* (p. 57) as unstreamlined.

This is not cumulative with air performance provided by other systems. However, the blades fold up or lock into rigid air foils during high-speed maneuvers (e.g., when a streamlined ship reenters atmosphere), or when using other propulsion.

Helicopter Rotor Table

SM	***+4***	***+5***	***+6***	***+7****	***+8****	***+9****	***+10****	***+11****	***+12****	***+1****	***+14****	***+15****
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B

* Rotors are TL7 on vessels of up to SM+6. On craft of SM+7 or higher they require superscience, and are TL7^.

Repair Skill: Mechanic (Helicopter).

Jet Engine (TL7) [rear]

This is a reaction engine that uses an atmosphere as reaction mass, instead of or in addition to its own fuel. They function only in an atmosphere with at least 0.1 atmospheres pressure. Turbojets and turbofans require an atmosphere containing oxygen (partial pressure at least 0.02 atmospheres); nuclear air-rams can function in *any* atmosphere.

Use Piloting (Aerospace) skill to control the vessel when flying in atmosphere. The following types are available:

Turbojet (TL7): This includes turbo ramjet or scramjet engines. Each jet engine provides 1G acceleration for calculating atmospheric speed, and consumes one fuel tank worth of jet fuel per half-hour (TL7) or hour (TL8+).

Turbofan (TL7): A turbofan is a jet engine with an added fan that increases the air flow to improve thrust and fuel efficiency. However, it cannot operate at hypersonic speeds. Maximum air speed is 2,000 mph. Each engine provides 0.5G acceleration for calculating atmospheric speed, and consumes one fuel tank worth of jet fuel per hour (TL7) or two hours (TL8+).

Afterburning Turbofan (TL7): As above, but fitted with a reheat system that can augment the thrust by squirting raw fuel into the exhaust, providing a temporary burst of speed at the expense of greatly increased fuel consumption. It has the same normal performance as a turbofan, but the acceleration is multiplied by 1.5 when the afterburner is used (increasing top speed). This quadruples fuel consumption, using one fuel tank every 15 minutes (TL7) or half-hour (TL8).

Fission Air-Ram (TL7): This engine uses a fission reactor to operate a turbofan that sucks in air, heating and expelling it for thrust. It operates two years on an internal nuclear fuel supply. The exhaust is slightly radioactive. Each air-ram produces 0.2G (TL7), 0.4G (TL8), or 0.6G (TL9+) acceleration for calculating atmospheric speed.

Fusion Air-Ram (TL10): This sucks in air, heats it using a fusion reaction, then expels it as reaction mass. It operates five years on an internal fuel supply. The weight includes a high-efficiency fusion reactor that serves only to power the engine. Each air-ram produces 0.2G acceleration for calculating atmospheric speed.

Antimatter Air-Ram (TL10): This sucks in air and injects microscopic amounts of antimatter to heat it to plasma temperatures, then expels it as reaction mass. Its internal antimatter supply can operate it continuously for one month (TL10), one year (TL11), or 10 years (TL12). Each air-ram produces 1G acceleration for calculating atmospheric speed.

Jet Engine Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B

Multiply cost by 1.5 for a turbojet or afterburning turbofan, by 2 for a fission air-ram, or by 5 for a fusion air-ram or antimatter air-ram.

Repair Skill: Mechanic (either Aerospace or Jet Engines).

Jump Gate (TL7*) [hull!]

This is one side of an artificial wormhole portal that connects to another distant jump gate, usually permitting instant FTL transit. This may be a prerequisite for, or alternative to, stardrive engines. The table shows maximum tonnage that can pass through the gate at any one time. Multiple systems installed in the same hull section may combine capacity.

Jump Gate Table

SM	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Max tonnage	100	300	1,000	3,000	10K	30K	100K
Workspaces	0	1	3	10	30	100	300
Cost ($)	150M	500M	1.5B	5B	15B	50B	150B

Repair skill: Electronics Repair (MT).

Lightspeed Drive (TL^) [any!]

This drive permits the spacecraft to accelerate instantly to the speed of light and move through space in a direct path until it intersects a large gravity well (usually in proximity to a star or planet). At that point it drops back to the speed and course it had when it activated the lightspeed drive.

Thus, this is not a faster-than-light stardrive – a journey across 100 light-years takes 100 years of real time. However, no subjective time at all passes aboard the vessel, since it is moving at light speed. Optionally, close passage to celestial bodies can warp its path without deactivating the drive. A successful Navigation (Space) roll (aided by good star charts) ensures the drive deactivates at the correct point; a mistake under- or over-shoots its destination by many light-years. Vessels moving with a lightspeed drive are treated as a beam of weakly interacting particles (analogous to neutrinos) so they pass through other objects, interstellar dust, etc. without ill effect. Speed is equal to the speed of light.

Lightspeed Drive Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Repair Skill: Mechanic (Stardrive).

Magnetic Planetary Drive (TL9^) [special!]

A popular system for flying saucers, this propels the vehicle via interactions with a star or planet's magnetic field – it's essentially a superscience magnetic levitation device. Each system provides 0.5G (TL9), 1G (TL10), or 2G (TL11+) acceleration, but is also a high-energy system requiring one Power Point. The drive must be installed in a core system or the rear hull.

The drive only works if the craft is within the magnetosphere of worlds with strong magnetic fields. In our solar system, the Sun, Earth, Mercury, Jupiter, Saturn, Uranus, and Neptune have strong magnetic fields (that extend up into the orbital space around them); the other planets and most smaller bodies (such as the moon) do not. The drive can cause odd electromagnetic effects beneath it. Headlights blink out, instruments (particularly magnetic compasses) react wildly, etc. The effect is unpredictable; it happens whenever the GM wants it to and does whatever he likes. It is +4 to be detected by any senses that detect magnetic fields.

Magnetic Planetary Drive Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B

Repair Skill: (Reactionless Drive).

Ornithopter Wings (TL5+2) [hull!]*

This is a set of motors and actuators for powered, flapping wings. A vessel given ornithopter wings must be given the winged design feature (p. 59). Each system provides 0.25G acceleration in atmosphere only, and adds +1 to Handling in the air. A ship using ornithopter wings cannot exceed a top air speed of 500 mph.

* Ornithopter wings can only be installed in the central hull.

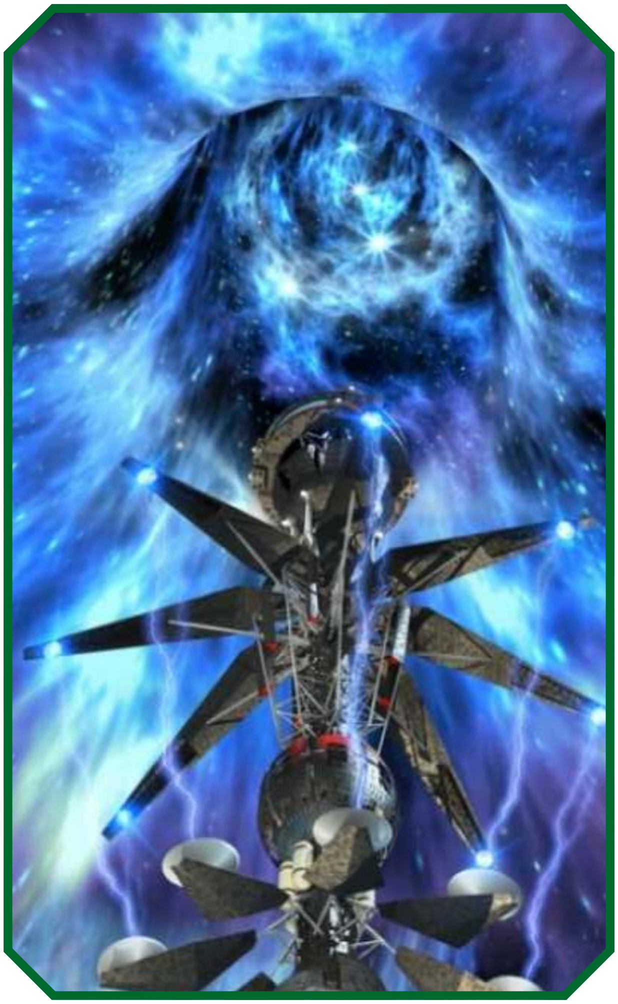
Ornithopter Wing Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B

Repair Skill: Mechanic (Heavy Airplane).

Parachronic Flux And Time-FLux Drive (TL^) [any!!]

These superscience drives allow a spacecraft to travel in time or other dimensions. Each flux drive is a high-energy system requiring two Power Points to operate. For both drives, the GM uses the operating procedures of a probability drive (see *Jump Drive Variations*, p. 80). That is, a Navigation skill roll is required, at a penalty (typically -10) if the destination is unknown; failure sends the vessel somewhere else and disables it until it is repaired.



Time-Flux Drive: This device lets the vehicle travel any distance into the past and/or future, subject to whatever limitations the GM imposes on time travel to manage paradoxes. The user must set specific temporal coordinates, e.g., "200 years, 27 days, three hours, 17 seconds into the past." The device transports the vehicle to that time, though it does not move in space relative to the surface of the Earth (or the nearest other large mass). That is, the drive corrects automatically for planetary rotation, orbit, stellar movement, and so on.

Parachronic Flux Drive: This system is identical in statistics to the time flux drive, but permits travel only to alternate parallel worlds (like a parachronic conveyer).

Flux drives can also have either or both of these options:

Speed-Limited: The vehicle is not instantly transported through time. Instead, it moves the vehicle out of conventional time/space and enters a hyperdimension (similar to hyperspace) where it travels forward or backward through the timestream. If this is a time flux drive, the speed in years per hour is equal to the number of flux systems installed. (Cutting the power drops the vehicle out of the timestream at whatever date it has reached.) If it is a parachronic flux drive, use "para-years": the number of years since the destination reality diverged from the reality the vehicle presently occupies, plus any extra time travel. For example, a trip from our 2006 to the 2006 of a world where things deviated in the year 1916 has a divergence distance of 90 para-years. For a vehicle equipped to travel through time and between parallel worlds, if the journey also involves travel in para-time, e.g., from our 2006 to the year 1950 of a parallel world that diverged in the year 1916, add the temporal distance (56 years) to the "length" of the trip (90 years, for a total of 146 years). It's up to the GM whether this is possible.

Anywhere: This option lets the vehicle travel to any point in time or space. It can go anywhere and anywhen. The standard version can travel anywhere in the universe instantly as per a probability drive with infinite range (p. 80). For the speed-limited version of a time-flux drive, the vehicle can travel as many light-years per hour as it can travel years per hour; thus, add the spatial distance in light-years to the temporal distance in years when calculating travel times.

Parachronic and Time-Flux Drive Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B	60B

Costs are for the parachronic flux drive. A time-flux drive is 10 times cost. Multiply cost by 25 for the anywhere option and by 0.5 for the speed-limited option.

Repair Skill: Electronics Repair (Parachronic or Temporal).

Reaction Engines

These systems propel the vessel according to Newtonian principles, expelling mass to generate thrust. They can only operate if the vessel has fuel tanks (p. 28) with appropriate reaction mass. They are rated for acceleration in gravities (G) per system, with multiple systems representing a multiple engines or a larger engine. However, the vessel's "top speed" in space, or delta-V, does not depend on the number of engines, but rather on the type of engine and number of fuel tanks of reaction mass the vessel has. Each fuel tank of reaction mass adds its rated delta-V to the vessel's delta-V reserve – the maximum total velocity change it can make.

A reaction drive vessel's performance improves if it has a high ratio of fuelled to dry mass, since it gets lighter as tanks are emptied. If *six or more* fuel tanks supply a particular reaction drive, multiply delta-V per tank as shown below:

Delta-V Increase Table

Tanks	*Delta-V*	*Tanks*	*Delta-V*
6-8	×1.2	16	×2
9-12	×1.4	17	×2.2
13-14	×1.6	18	×2.5
15	×1.8	19	×3

Round any fractional fuel tanks down.

If different drive systems share a common fuel type, then you do not usually need to allocate different fuel systems to each drive. Compute the delta-V reserve for the "main" drive system using all the fuel. Each mps of delta-V used by another system drains the delta-V reserve at a multiple or fractional rate, equal to the ratio of the delta-V per tank of the main drive, divided by the delta-V per tank of the currently-operating drive.

Example: A vessel has 10 tanks of hydrogen fuel, a TL9 nuclear thermal rocket (0.45 mps per tank), and a TL9 high-thrust fusion rocket (6 mps per tank). Taking the nuclear thermal rocket as the "main" drive, it has a delta-V reserve of 10×1.4×0.45mps=6.3mps. The fusion rocket uses fuel at relative rate of 0.45mps/6mps=0.075: that is, every mps of delta-V under fusion drive consumes only 0.075mps of the rated reserve.

If the two drives operate simultaneously, add their thrusts and their fuel consumption *rates*. Since consumption rate is proportional to thrust divided by delta-V, this gives the following:

A = A1 + A2
V = A / (A1 / V1 + A2 / V2)

A is the overall acceleration.
V is the overall delta-V.
A1, A2 are the individual engines' acceleration.
V1, V2 are the individual engines' delta-V.

Example: The above rocket has 1 fission rocket system and 4 high-thrust fusion rocket systems, giving, respectively, 0.5G and 0.04G of thrust, and 6.3mps and 84mps of delta-V. Together they provide 0.5G + 0.04G = 0.54G of thrust, and 0.54G / (0.5G / 0.45mps + 0.04G / 6mps) = 6.76mps delta-V.

Reaction Engine, Solid-Fuel Rocket (TL3*) [Rear]

This simple rocket consists of a case of solid fuel attached to a nozzle. It includes everything from ancient Chinese fireworks to the Space Shuttle's booster rockets. Unlike more sophisticated chemical rockets, the fuel and engine are designed as a single unit. Furthermore, a solid-fuel rocket will burn *all* of its fuel once it is lit.

To design a solid-fuel rocket, place the rocket systems *and* fuel systems together in the rear hull section. Larger solid rockets may extend forward into other sections, but the central hull cannot contain *more* fuel systems than the rear hull, and the front hull cannot contain more than the central hull. Each rocket system provides *up to* 3G acceleration. Each tank of solid fuel provides delta-V of 0.01 mps (TL3-4), 0.05 mps (TL5-6), or 0.1 mps (TL7+).

Once the rocket is fired, it will expend *all* of its delta-V. The burn time is equal to 160 seconds times the delta-V (in mps) divided by the acceleration (in G). The rocket can be down-rated to a lower delta-V or acceleration *when it is built* (not when it is used).

Refueling a solid-fuel rocket involves replacing the entire fuel system, including fuel tanks, and requires a shipyard or repair facility.

* Rocket-powered vehicles before TL7 are *cinematic* (not superscience).

Solid-Fuel Rocket Engine Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	10K	50K	100K	200K	500K	1M	2M	5M	10M	20M	50M	100M

Repair Skill: Mechanic (Rockets).

Reaction Engine, Chemical Rocket (TL7) [Rear]

These maneuver drives use chemical fuels to produce high accelerations suitable for lifting off from a planet or close combat, but they burn a great deal of reaction mass and will usually run out of fuel before they can achieve a fast delta-V.

Chemical Rocket (TL7): This is a reaction drive that burns fuel and oxidizer, such as a mix of liquid hydrogen and liquid oxygen, to produce thrust. Each engine provides 3G acceleration. Each fuel tank of rocket fuel provides 0.15 mps delta-V. Spacecraft capable of reaching orbit are often multi-stage designs (see *Integrated Vessel*, p. 49).

HEDM (High Energy Density Materials) Chemical Rocket (TL9): Uses high-energy density materials such as metallic hydrogen or metastable helium, for fuel. Each fuel tank of HEDM fuel provides 0.5 mps delta-V, but may explode if damaged (see *Volatile Systems*, p. 106). Each engine gives 2G acceleration.

Chemical Rocket Engine Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

1.5× cost for HEDM chemical rockets.

Repair Skill: Mechanic (High-Performance Spacecraft or Rockets).

Reaction Engine, Electric (TL8) [Rear!]

These drives require both electrical power and reaction mass.

Ion Drive (TL8): A high-impulse, low-thrust engine that ionizes a reaction mass and accelerates it as a beam of ions to produce thrust. Each ion drive engine provides 0.0005G acceleration, but is a high-energy system that requires one Power Point. Each fuel tank of ionizable reaction mass provides 3 mps delta-V. These statistics also apply to most plasma thruster systems.

Mass Driver (TL9): An electromagnetic accelerator that launches buckets of reaction mass at high velocity to produce thrust. Its performance is unimpressive, but it can use just about anything as reaction mass. Each fuel tank or cargo hold's worth of mass (often powdered rock!) ejected provides 0.3 mps delta-V. Each mass driver engine provides 0.01G acceleration, but is a high-energy system that requires one Power Point.

VASIMR Electric Rocket (TL9): This variable-specific-impulse magneto-plasma rocket heats reaction mass electrically (via radio waves) and expels it as plasma for thrust. It is fuel-efficient, but heavy and power-intensive. As the name suggests, it can vary its performance. Each engine is a high-energy system requiring one Power Point. It operates in a fuel-efficient low-thrust mode producing 0.0002G acceleration or in a high-thrust mode producing 0.002G. Each fuel tank of hydrogen reaction mass gives 10 mps delta-V in low-thrust mode or 0.5 mps in high-thrust mode.

Plasma Torch (TL10^): This is a typical space-opera "plasma rocket" propulsion system. Each engine is a high-energy system that produces 5G acceleration. A fuel tank of hydrogen reaction mass gives 2.5 mps delta-V. It can also operate in a high-efficiency low-thrust mode: It gives 1G acceleration per engine, and each tank of hydrogen has 12.5 mps delta-V.

Options: Ion drives and mass drivers may be designed for high thrust (double acceleration, halve delta-V). VASIMR and plasma torches have a high thrust mode built in.

Electric Reaction Engine Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B

Multiply cost by two for VASIMR engines, or by ten for plasma torch engines.

Repair Skill: Mechanic (Low-Performance Spacecraft), or Mechanic (High-Performance Spacecraft) for plasma torch.

Reaction Engine, Laser Rocket (TL9) [rear]

This provides thrust by evaporating a reaction mass. A ground-based laser installation heats the mass; the ship needs no receiver. It provides 2G acceleration. A fuel tank of ablative plastic offers 0.5 mps delta-V. Like a solid-fuel rocket (p. 19, the fuel tank and rocket are built as a unit, in the rear hull section. If the tanks extend into the central or front hull sections, then the central section cannot contain *more* tanks than the rear section, and the front cannot contain more than the centre. Refueling requires replacing the tanks, not just refilling them.

Each laser rocket engine requires one external laser battery. The required output depends on the size of the spacecraft.

Laser Rocket Engine Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B
Laser	10GJ	30GJ	100GJ	300GJ	1TJ	3TJ	10TJ	30TJ	100TJ	300TJ	1PJ	3PJ

Repair Skill: Mechanic (High-Performance Spacecraft or Rocket).

Reaction Engine, Solar Thermal (TL8) [rear]*

Solar thermal rockets use solar mirrors (p. 33) to directly heat reaction mass. The heated propellant is then expelled via the nozzle to produce thrust. Solar thermal engines offer better thrust than electric rockets without the costs and environmental concerns of nuclear engines.

Each solar thermal engine system requires a functioning solar mirror system to focus sunlight; the combination produces 0.05G acceleration. A fuel tank of hydrogen reaction mass provides 0.3 mps delta-V (TL8) or 0.4 mps delta-V (TL9+).

Acceleration is affected by the vehicle's distance from a star. Divide this by the square of the average distance in AU. For stars with a different luminosity than our own sun, multiply by relative luminosity. However, acceleration can never increase to more than 0.2G per engine.

* Requires one solar mirror system per engine.

Solar Thermal Engine Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B

Repair Skill: Mechanic (Low-Performance Spacecraft).

Reaction Engine, Fission (TL7) [rear]

These drives use nuclear fission to heat reaction mass.

Nuclear Thermal Rocket (NTR) (TL7): This reaction engine heats a fluid as it passes through a built-in solid- or liquid-core nuclear reactor and expels it for thrust. Each NTR engine gives 0.1G acceleration (TL7), 0.2G (TL8), or 0.5G (at TL9+). Each fuel tank of hydrogen gives a delta-V of 0.3 mps (TL7-8) or 0.45 mps (TL9+).

Nuclear Light Bulb (TL9): An enclosed gas-core fission drive; radiation from the reactor (principally light) passes through a transparent containment vessel, to heat the fuel (hence "nuclear light bulb"). Each engine gives 0.01G acceleration (TL9) or 0.05G (TL10+). Each fuel tank of hydrogen gives a delta-V of 0.8 mps.

Nuclear Saltwater Rocket (TL9^): A high-performance "fission torch" rocket fuelled by water containing dissolved salts of enriched uranium in a barely sub-critical state. Released into the reaction chamber, it creates a continuous nuclear reaction directly behind the rocket, using the water as a reaction mass. Each engine gives 2G acceleration. Each fuel tank of uranium-saltwater fuel gives a delta-V of 2.5 mps. The engine and fuel may explode if damaged – see *Volatile Systems* (p. 106).

Options: NTR may use water instead of hydrogen: 3× acceleration, 1/3× delta-V.

Fission Engine Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B

Repair Skill: Mechanic (Fission Engine).

Reaction Engine, Nuclear Pulse (TL7) [rear]

Uses pulse units (shaped nuclear bombs) surrounded by or adjacent to inert reaction mass to generate thrust.

External Pulsed Plasma ("Orion Drive") (TL7): Pulse units are full-size nuclear bombs that are ejected out and exploded behind the vessel. The plasma wave impacts an acceleration pusher plate, producing thrust. The rear hull section must have dDR 50 or better, or dDR 5+ plus a magnetic sail ("Mag-Orion"). Each engine produces 2G acceleration. Each fuel tank of bomb pulse units gives a delta-V of 2 mps (TL7), 3 mps (TL8), 4 mps (TL9), 8 mps (TL10+) delta-V.

Fusion Pulse Drive (TL9): Uses laser beams, particle beams and/or miniscule amounts of antimatter to trigger fusion micro-explosions in tiny nuclear fuel pellets in the reaction chamber. Each engine give 0.02G acceleration (TL9) or 0.05G (TL10+). Each fuel tank of fuel pellets gives a delta-V of 5 mps (TL9), 10 mps (TL10), 40 mps (TL11+).

Advanced Fusion Pulse Drive (TL9): A fusion pulse drive optimized for outer system or interstellar travel. Each engine give 0.005G acceleration. Each fuel tank of fuel pellets gives a delta-V of 20 mps (TL9), 100 mps (TL10), or 350 mps (TL11+).

Super Fusion Pulse Drive (TL11^): Uses extensive superscience (e.g., force field pusher plates and inertial dampers). Each engine give 20G acceleration at TL11 or 100G at TL12. Each tank of fuel pellets gives a delta-V of 350 mps (at all TLs).

Options: Any engine may be *high thrust* (double acceleration but halve delta-V per tank).

Nuclear Pulse Engine Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Multiply cost by two for advanced fusion, or by four for super fusion.

Repair Skill: Mechanic Mechanic (Nuclear Pulse Engine).

Reaction Engine, Fusion (TL9) [rear]

These drives incorporate built-in fusion reactors, producing a hot, high-velocity exhaust.

Fusion Rocket (TL9): Generates a fusion reaction to heat hydrogen into plasma and expel it, adding extra cold mass for extra thrust. Each engine gives 0.005G acceleration. Each fuel tank of hydrogen gives a delta-V of 12 mps (TL9), 60 mps (TL10), 180 mps (TL11), or 450 mps (TL12). Requires minimum SM+9 at TL9; but no limit at TL10+.

Fusion Torch (TL10^): A limited superscience high-performance fusion rocket. Each engine gives 0.5G acceleration. Each fuel tank of hydrogen gives a delta-V of 15 mps (TL10), 45 mps (TL11), or 150 mps (TL12).

Super Fusion Torch (TL11^): A fusion drive derivative of the super fusion reactor (p. 32). Each engine gives 50G acceleration. Each fuel tank of hydrogen gives a delta-V of 450 mps.

Options: Any engine may be *high thrust* (double acceleration but halve delta-V per tank). Any engine can also use *water* instead of hydrogen (triple acceleration, one-third delta-V).

Fusion Engine Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Multiply cost by two for fusion torch, or by four for super fusion torch.

Repair Skill: Mechanic (Fusion Engine).

Reaction Engine, Total Conversion And Antimatter (TL9) [rear]

These offer generally superior performance to nuclear fission or fusion engines, but antimatter fuel is costly! Most engines mix a small amount of antimatter with a greater quantity of matter. Antimatter-catalyzed fuel uses only 10 milligrams of antimatter per ton, antimatter-boosted uses 60 grams, and matter/antimatter uses a (hideously expensive) 1:1 mix. More advanced designs use total conversion of matter, eliminating the expensive fuel.

Antimatter Thermal Rocket (TL9): Annihilation of a tiny amount of antimatter directly heats a reaction mass which is expelled for thrust. Each engine gives 0.1G acceleration (TL9), 0.2G (TL10), or 0.4G (TL11+). Each fuel tank of antimatter-catalyzed hydrogen gives a delta-V of 1.8 mps.

Antimatter Plasma Rocket (TL10): Uses the annihilation of a modest amount of antimatter to heat reaction mass into hot plasma, which is contained in magnetic fields and expelled for thrust. Each engine gives 0.01G acceleration. Each fuel tank of antimatter-boosted hydrogen gives a delta-V of 120 mps (TL10), 360 mps (TL11+).

Antimatter Plasma Torch (TL10^): A high-performance limited superscience version of the antimatter plasma rocket. Each engine provides 1G acceleration. Each fuel tank of antimatter-boosted hydrogen gives a delta-V of 120 mps (TL10), 360 mps (TL11+).

Super Antimatter Plasma Torch (TL11^): Uses superscience technologies such as force field containment to boost performance. Each engine gives 100G acceleration. Each fuel tank of antimatter-boosted hydrogen gives a delta-V of 360 mps. Usually only used if cosmic antimatter reactors exist.

Antimatter Pion (TL11): Matter and antimatter are annihilated at a 1:1 ratio, and magnetic fields focus the resulting charged pions into a near-light speed exhaust. Each engine gives 0.005G acceleration. Each fuel tank of matter/antimatter fuel gives 3,400 mps of delta-V.

Antimatter Pion Torch (TL11^): A superscience version. Each engine gives 0.1G acceleration. Each fuel tank of matter/antimatter fuel gives 3,400 mps of delta-V.

Total Conversion Torch (TL12^): Similar to antimatter pion, but makes use of total conversion of matter, so it can use ordinary fuel and is more efficient. Each engine gives 1G acceleration. Each fuel tank of hydrogen (or anything else) gives a delta-V of 10,000 mps.

Super Conversion Torch (TL12^): An engine derived from the cosmic total conversion reactor. Each engine gives 50G acceleration. Each fuel tank of hydrogen (or anything else) gives a delta-V of 10,000 mps.

Options: Engines can be *high thrust* (2× acceleration, 1/2× delta-V per tank). Antimatter thermal or plasma engines can replace hydrogen with water (3× acceleration, 1/3× delta-V).

Antimatter and Total Conversion Engine Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B

2× cost for antimatter plasma torch or antimatter pion; 4× cost for antimatter pion torch, super antimatter plasma torch, or total conversion torch; 10× for super conversion torch.

Repair Skill: Mechanic (Antimatter or Total Conversion Engine).

Reactionless Engine (TL^) [rear!]

These maneuver drive engines allow the vessel to accelerate without using up reaction mass. Top speed is near-lightspeed ("near-c") (optionally much less, or variable, e.g., $0.01c$ per engine), but each engine is also a high-energy system that requires one Power Point.

Rotary Reactionless (TL7^): For example, a Dean Drive using oscillating rotating masses. Each engine gives 0.1G acceleration. May also go in a Central hull.

Standard Reactionless (TL10^): Each engine gives 0.5G acceleration at TL10 or 1G at TL11-12.

Hot Reactionless (TL10^): Each engine gives 1G acceleration at TL10 or 2G at TL11-12. It has a waste-heat signature equivalent to a conventional drive's exhaust.

Super Reactionless (TL11^): Reactionless drive with 50G acceleration at TL11 or 100G at TL12.

Subwarp (TL^): Each engine gives 500G acceleration. Also use this for most warp drives that can "downshift" to operate as reactionless drives. It will almost always be a pseudovelocity drive (p. 64).

Reactionless Engine Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)												
Rotary	5K	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B
Standard	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B
Hot	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B
Super	60K	200K	600M	2M	6M	20M	60M	200M	600M	2B	6B	20B
Subwarp	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Repair Skill: Mechanic (Reactionless Drive).

Robot Leg (TL9) [hull!]

Vessels designed to walk on the ground require one or more robot leg systems, representing a mechanical leg and associated motors. Two legs are common, but one or more than two legs are possible.

One-legged craft are slower. Those with three or more are less maneuverable but faster and more stable. Robot legs are only practical on SM+4 to SM+7 vessels.

Although a high-energy system, only one Power Point is required regardless of the number of leg systems installed.

Move: Determine both Acceleration in yards/second^2, and Top Speed in yards/second (see p. B463; double this to get mph). Acceleration is 5 for one leg or 10 for two or more legs. Top Speed is 5 times the number of legs, e.g., four legs would give a vehicle Move 10/20.

Robot Leg Table

SM	***+4***	***+5***	***+6***	***+7***
Cost ($)	100K	300K	1M	3M

Repair Skill: Mechanic (Mecha or Robotics).

SAILS, SPACE (TL9 OR TL^) [HULL]

Giant sails that can generate thrust from starlight, nuclear decay, or solar wind. Acceleration is very low, but there is no reaction mass consumption. Space sails are exposed systems unprotected by spacecraft armor. Large space sails may take a long time to unfurl, as listed on the table. A space sail cannot be deployed at the same time as a stasis field or a different type of space sail. Multiple systems represent a larger sail. A space sail can combine its thrust with reaction or reactionless drives only if the *total* acceleration of the other drives is *less* than that of 10 space sail systems (otherwise the shrouds connecting the sail will go slack).

Lightsail (TL9): This solar sail generates thrust from starlight (or a battery of launching lasers). Typical thrust in our inner solar system (at 1 AU from a Sol-type star) is 0.0001G per lightsail system. Thrust is affected by distance from the star: divide it by the square of the average distance. For stars with different luminosity than our own sun, multiply by relative luminosity.

Radioisotope Sail (TL9): Also known as a "fission sail," this sail is coated on one side with a thin layer of radioactive isotope emitting non-penetrating radiation. As the isotope decays, particles escape in one direction, producing thrust. Acceleration is 0.000001G for the first few years of operation. There is no fuel consumption, but as the substance decays, thrust is halved every 14 years. A radioisotope layer can be added to a lightsail, providing thrust when light pressure is unavailable: acceleration and cost add, but the weight of the sail is essentially unchanged.

Magsail (or Plasma Sail) (TL9): A huge superconducting loop mounted in front of the spacecraft that interacts with charged particles from a star's solar wind to generate thrust. It won't provide acceleration far from a star (in interstellar space) but can also be used for deceleration by starships traveling through interstellar space at velocities beyond their top speed. Typical thrust is 0.001G per magsail system, regardless of distance from the star. Top speed cannot exceed 375 mps. A magsail requires one Power Point to activate in the specified time: more or less power will decrease or increase the deployment time. It requires no power to maintain once powered.

Tachyon (TL^): What if a wind of faster-than-light particles blew out from the galactic core? Perhaps there are strange-matter hyperstars there, and these sails can catch the tachyon wind they emit! Tachyon sails are similar to lightsails, but with far greater acceleration. Each system produces 0.1G acceleration. Tachyon intensities vary with distance from the core, but the nearby stars are at essentially the same distance so the effect is negligible.

Tachyon Hypersails (TL^): What if hyperspace were like an ocean and the tachyon winds blew through that, rather than through normal space? A stardrive engine is needed to enter hyperspace, but once there, hypersails are unfurled and used for propulsion! As long as they are in use there is no energy cost to remain in hyperspace. FTL speed is based on sail thrust: Each 0.1G of sail acceleration gives FTL-1 (see *Stardrive Engine*, p. 26. Hyperspacial storms or currents can also exist, further influencing FTL speed.

Space Sail Table

SM*	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13 or more***
Workspaces	0	0	0	0	0	0	1	3	10	-
Deployment	30sec	1min	2min	3min	6min	10min	20min	30min	1hr	-
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	-

* A spacecraft cannot be given a space sail if its SM exceeds its TL.

Multiply deployment time by the number of systems. For magsails, divide by the number of Power Points used.

Multiply cost by 1.5 for a radioisotope sail, 2.5 for a combined radioisotope-lightsail, 4 for a tachyon sail, 8 for a tachyon hypersail.

Repair skill: Mechanic (Lightsail or Magsail).

SCREW PROPELLER (TL6) [REAR!]

These are screw propellers (or ducted propellers) plus associated gearing or electric motors for surface or underwater propulsion. They must be placed in the rear hull. No more than two screw propeller systems may be installed. Despite being a high-energy system, only one Power Point is required regardless of the number of systems, but up to two Power Points per screw propeller system can be allocated. More power increases speed and acceleration.

The vessel's Acceleration is equal to half the number of Power Points.

Top Speed on the surface depends on the Power Points available for propulsion, the vehicle's SM and streamlining, as shown in the table below. The table assumes that the vehicle has the nautical lines feature (p. 57). If it has only ordinary streamlining, mutliply speed by 0.8, and if it is unstreamlined, multiply speed by 0.5 (rounding fractions down).

A vessel with screw propellers can also operate underwater, provided it has either contragravity lifters or submarine ballast tanks (p. 26) and any crew and occupants can still breathe (that is, the vessel does not have *any* of the options listed under *No Life Support*, p. 57). Underwater top speed assumes ordinary streamlining or nautical lines: if unstreamlined, multiply speed by 0.5 (rounding fractions down).

Screw Propeller Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	2K	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M
Top Speed (Surface)												
1 Power	15	15	14	12	12	13	15	16	17	19	21	23
2 Power	20	19	17	15	15	16	17	18	20	21	24	26
3 Power	25	24	20	17	16	17	18	20	22	24	26	28
4 Power	30	26	22	20	20	20	21	22	23	25	26	30
Top Speed (Underwater)												
1 Power	8	9	10	11	13	15	17	19	22	25	28	32
2 Power	10	11	13	15	17	19	22	25	28	32	36	40
3 Power	11	13	15	17	19	22	25	28	32	36	40	45
4 Power	13	15	17	19	22	25	28	32	36	40	45	50

Repair skill: Mechanic (Screw Propeller).

Stardrive Engine (TL^) [Any!]

This is a faster-than-light drive, such as a hyperdrive, jump drive, or warp drive, as well as all necessary fuel supplies or energy banks required to operate it. The exact mechanism is up to the GM. Multiple stardrive engines normally improve performance.

In general, the base speed of a stardrive is multiplied by the number of stardrive engines. For jump drives or other designs that instantly travel an unlimited distance, the time required to prepare a jump drive may be *divided* by number of engines.

Since exact capabilities are up to the GM, stardrives get a simple "FTL rating," e.g., FTL-2 for two drives.

Stardrive Engine: A typical stardrive with FTL-1.

Super Stardrive Engine: In some settings, more powerful stardrives are available that have the same mass. This engine can provide FTL-1 if given one Power Point or boost up to FTL-2 if given two Power Points (!!). At the GM's option, a super stardrive can also represent a drive that provides some extra capability at a higher energy cost.

Spacecraft with stardrives usually require other maneuver drives for sublight travel, especially if the drive ceases to function near a planet or a star's gravity field, only works at particular jump points, or only travels through hyperspace. Some warp drives can simply "downshift" to function at sublight speeds (e.g., upon entering a solar system) – see the Stardrive (Reactionless) (p. 65) design switch.

Stardrive Engine Table

SM*	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

* In *some* settings, stardrives are unavailable for small craft (e.g., SM+4 to SM+6).

Super stardrive engines are 5× cost.

Repair skill: Mechanic (Stardrive).

Submarine Ballast Tank (TL6) [Any]

Vessels intended to operate underwater may install floodable tanks spaced through the vessel along with high-performance pumps to rapidly take in or dump water ballast. This will give it positive buoyancy (to rise to the surface), neutral buoyancy (to swim underwater), or negative buoyancy (to dive). A filled ballast tank may also be used as a filled Fuel Tank of the same SM. Only one Submarine Ballast Tank need be installed on a vessel to let it operate as a submarine, but if the vessel contains enough high-volume systems (p. 9) that it would have a dDR reduction, then those systems will also get flooded.

Submarine Ballast Tank Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Cost ($)	4K	12K	40K	120K	400K	1.2M	4M	12M	40M	120M	400M	1.2B

Repair skill: Mechanic (Vehicle Type).

Tracked Drivetrain (TL6) [hull!]

This system is a set of tank-like caterpillar tracks and running gear along with a suspension and power train, intended for ground mobility. Tracks are excellent for clambering over rough terrain, but are slower than wheels on roads. One or two tracked drivetrain systems can be installed; two systems represent a more powerful drivetrain.

Regardless of whether there are one or two drivetrains, the craft has one pair of tracks, or possibly four tracks if SM+7 or larger.

Only one Power Point is needed, even if there are two drivetrains! However, as many as three Power Points per drivetrain can be used, with greater power increasing tracked speed and acceleration. Ground Move (Acceleration/Top Speed, in yards/second^2 and yards/second) depends on the number of Power Points allocated as shown in the table below.

Power Points	*Move*	*Power Points*	*Move*
1	1/10	4	4/40
2	2/20	5	5/50
3	3/30	6	6/55

Tracked drivetrains are only available for vehicles of SM+10 or smaller. They must go in the central hull.

Tracked Drivetrain Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*
Workspaces	0	0	0	0	0	0	1
Cost ($)	15K	50K	150K	500K	1.5M	5M	15M

Repair skill: Mechanic (Tracked).

Wheeled Drivetrain (TL5) [hull!]

This system is a set of multiple powered wheels along with a suspension and transmission or electric motor. It lets the craft move on the ground. One or two wheeled drivetrain systems can be installed; two systems represent a more powerful drivetrain.

Although a high-energy system, only one Power Point is required *regardless* of the number of wheel systems installed. However, up to three Power Points can be allocated per drivetrain system, with greater power increasing speed and acceleration. Ground Move (Acceleration/Top Speed, in yards/second^2 and yards/second) depends on the number of allocated Power Points and the vehicle's streamlining, as shown below.

Power Points	*Move*	*Power Points*	*Move*
1	2/28	4	8/44
2	4/35	5	10/48
3	6/40	6	12/50

Increase Top Speed by 1.5× if the vehicle has *aerodynamic* streamlining (treat Nautical Lines as unstreamlined).

Wheeled drivetrains are normally road-bound (p. B463); add an * to their speed. To remove this limitation, all wheeled drivetrains on a vehicle may optionally have an off-road design feature, representing a system with bigger tires, heavier suspensions, and all-wheel drive. These reduce top speed by 5 due to increased friction.

Wheeled drivetrains are only available for vehicles of SM+10 or smaller.

Wheeled Drivetrain Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*
Workspaces	0	0	0	0	0	0	1
Cost ($)	3K	10K	30K	100K	300K	1M	3M

Double cost for off-road drivetrains.

Repair skill: Mechanic (Wheeled).

Power Systems

These systems provide energy to other systems, in the form of electricity, mechanical work, sunlight, fuel, or other more exotic forms.

Fuel Tank (TL5) [any]

This is a full tank of fuel for a power plant or reaction mass for a reaction drive, or reactor coolant. See the individual power plant or drive system to determine their fuel requirements. A vessel with one or more reaction drive engines requires at least one fuel tank with appropriate reaction mass to supply those drives. A high technology alternative to fuel tanks for drives that use hydrogen is a *Ramscoop* (p. 33).

The table shows the tons of fuel stored in each fuel tank system, and the cost of each fuel tank system without fuel.

Fuel Tank Table

SM	*+3*	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Fuel tons	0.15	0.5	1.5	5	15	50	150	500	1,500	5,000	15K	50K	150K
Cost ($)	1K	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B

Repair Skill: Mechanic (Vehicle Type).

The list price of a vessel usually neglects the cost of fuel and other consumables; however, for some vehicles, the fuel may be more expensive than the rest of the systems! The following table lists typical costs for various "fuels" (including coolant and reaction mass): use these to determine the fueled vehicle price, or the cost to refuel.

Fuel Cost Table

Fuel	*Cost per Ton*
Water	$20
Nitrogen/oxygen (for coolant or life support)	$150
Ionizable reaction mass (e.g., argon)	$180
Rock dust (for mass drivers)	$2
Solid fuel (TL3-4)	$1K
Solid fuel (TL5-6)	$2K
Solid fuel (TL7+)	$10K
Ablative plastic (for laser rockets)	$80
Rocket fuel (liquid hydrogen/oxygen)	$800
Hydrogen	$2K
Gasoline/diesel	$2K
Jet fuel	$4K
HEDM rocket fuel	$6K
Nebulonic fuel (for ether furnaces)	$4K
Nuclear pellets	$50K
Uranium-saltwater	$100K
Nuclear bomb pulse units	$250K
Antimatter-catalyzed hydrogen or water (TL9)	$200M*
Antimatter-boosted hydrogen or water (TL10)	$120B*
Matter/antimatter (TL11)	$10T*

* Divide cost by 10 per TL after introduction. In superscience settings where total conversion power or cosmic energy technology exists, cost of any type of antimatter reaction mass may be as little as $6,000/ton.

Power Plant, Chemical Energy (TL7) [Any]

This power plant is a high-efficiency chemical energy closed-cycle power plant using hydrogen and liquid oxygen fuel (much like a chemical rocket). There are two variations:

Fuel Cell (TL7): Each system provides one Power Point. It can operate for three hours (TL7), six hours (TL8), 12 hours (TL9), or 24 hours (TL10+) on internal fuel.

MHD Turbine (TL9): An advanced high-performance closed-cycle turbine. Each system provides two Power Points for six hours (TL9), or 12 hours (TL10+) on internal fuel.

Endurance can be extended: each fuel tank of hydrogen-oxygen rocket fuel consumed by the power plant operates it for 4× that duration.

Chemical Energy Power Plant Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	5K	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B

Double cost for MHD turbine.

Repair Skill: Mechanic (Fuel Cell or MHD Turbine).

Power Plant, Combustion (TL6) [Any]

These power plants burn fuel and air to generate power. Unlike a chemical power plant (above), they won't function in space (or in any environment lacking atmospheric oxygen), so they are most useful for creating ground or water vehicles. They only function underwater if the vessel is cruising just beneath the surface and equipped with a snorkel (TL7; +$10 per ton of vessel mass).

Internal Combustion Engine (ICE) (TL6): This is a gasoline or diesel engine. It provides one Power Point per system. Internal fuel provides six hours (TL6), eight hours (TL7), or 10 hours (TL8+) of operation. Additionally, each Fuel Tank of hydrocarbon fuel (gasoline. diesel, or jet fuel) consumed by the engine lets it operate for six times that duration.

Gas Turbine Engine (TL7): A high-performance combustion power plant derived from jet engine technology. It provides two Power Points per system. Internal fuel provides three hours (TL7) or four hours (TL8) of operation. Additionally, each Fuel Tank of hydrocarbon fuel (gasoline, diesel, or jet fuel) consumed lets it operate for six times that duration.

Combustion Engine Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B

Use the listed cost for ICE; double cost for gas turbines.

Repair Skill: Mechanic (Internal Combustion Engine or Gas Turbine).

Power Plant, Ether Furnace (TL5+2^)

This power plant recreates in miniature the bizarre ether flux found in the core of a sun, which permits it to burn many times longer than its chemical nature otherwise allows. Each ether furnace provides one Power Point for three months on internal fuel. Endurance can be extended. Each fuel tank of nebulonic fuel (containing a mixture of liquids and metals similar to the primal solar nebula) operates an ether furnace for an additional year.

Ether Furnace Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

Repair Skill: Mechanic (Ether Furnace).

Power Plant, Magical (TL^) [any]

These power plants are enchanted items. All of them cease to function in regions where magic doesn't work at work at all (no-mana areas). They generate magic power points, which work like normal Power Points except they also power systems with the magic-powered design feature (p. 57).

Mana Engines (TL^): These devices gather ambient magical energy and transform it into mechanical or electrical power. They range from glowing crystals to complex techno-magical machinery. They do not require fuel and produce one magical Power Point.

Soulburner (TL^): A necromantic power plant fuelled by the torment of the souls of sapient beings, who are bound within the device using the Soul Jar spell. Souls burn out (roll vs. Will each year) and need replacement. Assuming Will 10, half the souls are lost every year (on average), or 1/18 of them every month. Any soul with Magery tends to last longer (for up to Magery *squared* years), which may not be to their comfort. Soulburners do not function in no-mana areas. A soulburner generates two Power Points if it has its full complement of souls, or one Power Point if it has at least half as many souls. These are trapped within the machine in a remnant of their body (e.g., as skulls, corpses, etc.). If the machine is destroyed the souls are freed from torment (but still dead).

NEMA Reactor (TL7^): This is an enchanted nuclear fission reactor whose radiation output is partially shifted from hard radiation to magical energy. (NEMA stands for nuclear-enhanced mana area). It generates one ordinary Power Point and an additional Power Point that can only run magic-powered systems. The disadvantage is a critical reactor meltdown can blow a hole in reality or release marauding demons; the effects are up to the GM, but they're usually unpleasant. A NEMA operates 25 years on internal fuel, increased to 50 at TL9 or 75 at TL10+.

Caged Spirit (TL^): These power plants draw magical energy from a trapped demon lord, ancestral spirit, ghost, minor god, or other spirit of great power (relative to the size of the ship). If the power plant or vehicle is destroyed, the entity is released – usually in a bad temper! Caged spirit power plants generate five magical Power Points.

Magical Power Plant Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Souls*	3	10	30	100	300	1K	3K	10K	30K	100K	300K	1M
Cost ($)	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B

* The souls a soulburner requires to generate full Power Points.

Multiply cost by 1.5 for NEMA and 8 for caged spirit.
Repair Skill: Mechanic (Magical Power Plant). NEMA also requires Mechanic (Fission).

Power Siphoning

Optionally, mages or psis can draw power (as FP) directly from any power plant that provides magical or psi Power Points, respectively. This does not require a spell or ability, but the user must remain in contact with a power outlet in a control station within either the power plant or the engine room. Mages can draw up to (HT×0.7×Magery squared) FP per second; those with Magery 0 draw HT/3 FP per second. Round up. Psis use the same formula, replacing Magery with their best psionic Talent. This FP only powers supernatural abilities; it cannot replenish the user's personal points.

On a small ship, or if many users are siphoning power at once, this fully uses one or more Power Points. Divide the ship's weight in tons by four, rounding up. This is the maximum FP per second that each Power Point can provide.

Up to 1/20 of this amount can be siphoned away with negligible effects – some lights dim and flicker. If more is used, the engineer must treat the users as a high-energy "system," allocating one or more Power Points to them specifically for the purpose of siphoning.

Power Plant, Orgone (TL^) [Any]

These use a technology distantly related to the soulburner (p. 30) to convert orgone, a type of life-force, to electricity. Each such engine generates two Power Points indefinitely. However, an orgone engine must remain within (SM-3 × 10,000) miles of a planetary ecosystem to function. (It can operate in orbit around Earthlike worlds.)

It only works in deep space by installing at least one open space system devoted to a functioning ecology of trees, plants, small animals, etc., or, optionally, if the spacecraft is *itself* a living creature. Unlike a soulburner, an orgone engine does not destroy the life-force it feeds upon.

If the engine is disabled or tampered with, roll vs. spacecraft HT. Failure means the engine malfunctions, producing deadly orgone radiation, a toxic anti-life exhaust. The radiation affects everyone in the radiation zone radius shown on the table including all occupants of the spacecraft. Living things slowly sicken, wither, and die. For each hour of exposure, roll vs. Will-3. Failure results in the loss of 1d HT. If his HT is reduced to zero, the victim dies; otherwise, lost HT is recovered at one HT per hour of rest outside the zone.

At the GM's discretion, orgone engines generate psi Power Points instead of regular Power Points, making them only useful for operating psi-powered (p. 58) equipment.

If orgone energy does not exist as such, engine statistics can simply supply another name but have it work the same way, drawing on a living world's life energy (psychic energy, chi, prana, etc.) for power and releasing anti-life energy as exhaust.

Orgone Power Plant Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Rad zone (yards)	15	20	30	50	70	100	150	200	300	500	700	1,000
Cost ($)	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B

Repair Skill: Mechanic (Orgone Power Plant).

Power Plant, Perpetual Motion Machine (TL^) [Any]

These are divergent-technology power sources that operate without requiring fuel, in violation of thermodynamic laws such as conservation of energy. Typical devices are mechanical or electromechanical in nature and involve a complicated array of self-moving wheels, rolling balls, spinning disks, magnetic fields, or pressurized gases and liquid, all somehow managing to generate more power than they consume in operation.

Perpetual motion machines generate one Power Point. They never require fuel.

Perpetual Motion Power Plant Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B

Repair Skill: Mechanic (Perpetual Motion Machine).

Power Plant, Psychotronic (TL9^) [Any]

This power plant draws energy from the minds of psionic individuals connected to it. The plant may be able to tap any psi or it may require people with latent or actual telekinetic or electrokinetic psi ability.

Power Points from a psychotronic power plant can only be used to operate systems designed with the psi-powered design feature (p. 58). They cannot be used for other purposes.

For the psychotronic power plant to work, a minimum number of individuals serving as living psi-batteries must be hooked up to it with psi-amplifying helmets or other devices. This is in addition to the system's workspace requirement.

The GM may allow those with powerful psi abilities to count as two or more individuals. Every 10 character points worth of psi powers count as one person.

If an *Emergency Power Task* (p. 93) for the plant fails, the plant is disabled and the psis powering it are reduced to 1 FP at the start of the next turn. On a critical failure, each psi must immediately roll against HT; success results in unconsciousness for 1d hours while failure causes a heart attack (p. B429).

A psychotronic power plant generates four psi Power Points if installed in an SM+4 to SM+6 ship, and two if installed in an SM+7 or larger ship. The table shows the number of psis needed (modified as detailed above). Plants that need two or more psis but have fewer than the required number can work with half the required psis and generate only one psi Power Point. Those with less than half don't function at all.

Psychotronic Power Plant Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Psis	1	1	1	1	2	4	10	30	100	300	1,000	3,000
Cost ($)	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B

Repair Skill: Electronics Repair (Psychotronics).

Power Plant, Reactor (TL8) [any]

These derive energy from atomic or subatomic interactions, converting a substantial portion of their fuels' mass into energy.

Fission (TL8): This is a high-performance nuclear fission reactor (or on very large vessels, a series of several reactors). Each system provides one Power Point. It will operate for 25 years on internal fuel at TL8, 50 at TL9, or 75 at TL10+.

Fusion (TL9): Uses a thermonuclear fusion reaction; each system provides two Power Points. It has internal fuel for 50 years at TL9, 200 years at TL10, 600 years at TL11, or 1,500 years at TL12. The reactor may be *de-rated* to provide only one Power Point, doubling endurance and halving cost. At TL9 fusion reactors can only be used on SM+10 or larger vessels; there is no limit at TL10+.

Antimatter (TL10): Uses a matter-antimatter reaction. If damaged, it may explode (see *Volatile Systems*, p. 106). Each system provides four Power Points. Internal fuel gives two years endurance (at TL10), 20 years (TL11), or 200 years (TL12). It may be *de-rated:* each -1 Power Point reduces cost by 25% and adds 25% to endurance.

Super Fusion (TL11): An exotic fusion system (muon-catalyzed or black hole catalyzed, for example), or a design that uses force fields, gravity control, etc. to contain the reaction for better performance. Provides four Power Points for 400 years (TL11) or 1,000 years (TL12). It can be *de-rated:* each -1 Power Point reduces cost by 25% and adds 25% to endurance.

Total Conversion (TL12^): Converts matter directly into energy with 100% efficiency. Can also represent other forms of exotic power plant (caged baby universes, etc.). It provides five Power Points with effectively unlimited endurance.

Reactor Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)												
Fission reactor	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B
Fusion reactor	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B
Antimatter	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B	60B
Super Fusion	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B	100B
Total Conversion	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B	60B	200B

Repair skill: Mechanic (Fission, Fusion, Antimatter, or Total Conversion).

Power Plant, Solar Boiler (TL7) [any]

This system draws upon solar radiation as a heat source. It is a steam engine whose heat comes not through fuel consumption but via a solar mirror (p. 33).

The solar boiler is a closed-cycle steam engine that can operate in vacuum. Large mirrors focus sunlight on water pumped through pipes on the sunward side of the vessel; the liquid is vaporized into high-pressure steam. This drives turbines to generate power. The steam is then pumped into pipes under shadow where it rapidly cools and condenses into liquid.

Each solar boiler includes its own water and generates one Power Point indefinitely, but it requires a solar mirror system to do so. There must be solar mirror systems equal to the number of boilers installed.

A solar boiler is only useful when reasonably close to a star. It should be within a distance of two AU from a Sun-like star, if operating in space or on a planet with less than 0.1 atmospheres pressure. On a world with a thicker but still transparent atmosphere, reduce this to 1.5 AU. For brighter or dimmer stars, increase or decrease this distance in proportion to the square root of the star's luminosity. Beyond this distance, or behind any significant cloud cover, it no longer produces significant Power Points.

Solar Boiler Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B

Repair Skill: Mechanic (Steam Engine).

Power Plant, Vacuum Energy (TL9^) [any]

This power plant draws energy from the random electromagnetic fluctuations that exist even at absolute zero. The sum of all the possible frequencies is interpreted as a large (or for some methods of calculation infinite) energy density present even in vacuum. Each system produces three Power Points and operates indefinitely. It can be *de-rated* to produce two Power Points at 2/3 cost or one Power Point at 1/3 cost.

Vacuum Energy Power Plant Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	240K	750K	2.4M	7.5M	24M	75M	240M	750M	2.4B	7.5B	24B	75B

Repair Skill: Mechanic (Vacuum Energy).

Ramscoop (TL10) [front]

An electromagnetic scoop intended to capture interstellar hydrogen molecules for fuel and reaction mass. At 1,800 mps or more, one Ramscoop system provides unlimited reaction mass for *one* drive system: antimatter plasma rocket, antimatter plasma torch, super antimatter plasma torch, fusion rocket, fusion torch, super fusion torch, total conversion torch, or super conversion torch. Each ramscoop requires one Power Point to power up, but no power to maintain.

Exception: Ramscoops used by antimatter engines must be powered continuously by an antimatter reactor.

Ramscoop Table

SM*	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B	100B	300B

Repair skill: Mechanic (Vehicle Type).

Solar Mirror (TL5) [hull]

This is an array of large mirrors primarily designed to focus solar energy on a solar boiler (p. 32) or solar thermal rocket engine (p. 21), but is useful for other functions (e.g., signaling or mining). It is not a power plant as such, but each operating solar boiler or solar thermal rocket requires a solar mirror system to power it.

Solar mirrors are exposed systems. They can be attacked using the *Targeting Exposed Systems* rule (p. 110) as if they were radiators, but unlike other exposed systems they are not diffuse: Mirrors sustain full damage from any attack that hits them.

Solar Mirror Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B

Repair Skill: Mechanic (Solar Power).

Solar Panel Array [hull]

A solar power system. If exposed to sunlight it generates one Power Point. A solar panel array is an exposed system and is not protected by spacecraft armor!

Solar Panel Array Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Cost ($)	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B

Repair Skill: Electrician.

Weapon Systems

These systems primarily allow a vessel to engage in combat; however, they can also prove useful for mining or debris clearance. All are essentially variations on a single generic system.

Weapon, Major Battery (TL2) [hull!*]

This is a single mount for a powerful weapon. It also includes targeting systems for aiming the battery's weapon once the vessel's sensors have detected a target.

First, decide if the weapon will be in a single turret or fixed mount.

Fixed mounts can only fire at targets that are facing the hull section the battery is installed in (e.g., a weapon in the front hull fires forward). However, superior focusing or stabilization systems give fixed mounts better range and fire control (a +2 to hit).

Turrets have a wide firing arc: batteries in the front or rear hull can also fire at targets that are facing the central hull; batteries in the central hull can fire at any targets. Each turret also includes an integral dedicated control station allowing the turret to be manually controlled from within the system.

There are three broad classes of weapon that can be installed in a major battery: beams, launchers, and guns. Each type is divided into several subtypes.

Beams: These are directed-energy weapons. They are rated for output in KJ (kilojoules), MJ (megajoules), GJ (gigajoules), or TJ (terajoules). Refer to *Beam Types* (p. 35) and choose a weapon type; this can modify output.

Guns: These are projectile-firing cannons, or, at lower tech levels, catapults. They're rated for caliber (projectile diameter in centimeters) and number of gun shots carried. Refer to *Gun Types* (p. 36) and choose a weapon type; this may modify caliber and shots.

Launchers: These fire self-propelled missiles. They're rated for the diameter of missile they fire (in cm) and number of missile shots carried. Refer to *Launcher Types* (p. 36) and choose weapon type.

For reference, the table also shows the dice of d-damage of a typical beam weapon (e.g., a pulse laser). Actual damage varies by weapon type – see Chapter 3.

* Depending on the weapon type, this may or may not be a high-energy system. Refer to *Weapon Types* (p. 35).

Major Battery Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*	*+16**
Beam output	3MJ	10MJ	30MJ	100MJ	300MJ	1GJ	3GJ	10GJ	30GJ	100GJ	300GJ	1TJ	3TJ
d-Damage	3d	4d	6d	2d×5	3d×5	4d×5	6d×5	4d×10	6d×10	2d×50	3d×50	4d×50	6d×50
Gun caliber	8cm	10cm	12cm	14cm	16cm	20cm	24cm	28cm	32cm	40cm	48cm	56cm	64cm
Launchers	16cm	20cm	24cm	28cm	32cm	40cm	48cm	56cm	64cm	80cm	96cm	112cm	-
Gun shots	50	70	100	150	200	300	500	700	1,000	1,500	2,000	3,000	5,000
Missile shots	5	7	10	15	20	30	50	70	100	150	200	300	-
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300	1,000
Cost ($)	60K	150K	600K	1.5M	6M	15M	60M	150M	600M	1.5B	6B	15B	60B

* On SM+15 vessels or smaller, this is only available as a Large or Spinal Battery.

Repair Skill: Armoury (Heavy Weapons).

Weapon, Minor Battery (TL2) [hull!*]

These are simply groups of lower-SM weapons grouped together into a single system, using the rules for *Smaller Systems* (p. 8). In the original ***GURPS Spaceships*** rules, these were referred to as *Medium Batteries* (three weapons one SM smaller), *Secondary Batteries* (ten weapons two SM smaller), and *Tertiary Batteries* (thirty weapons three SM smaller). In the new generic rules for smaller systems, this progression can be extended all the way down to SM+4 weapon systems, or even a step further: a 300 lb. SM+3 *Tiny System* (p. 8) can mount up to four standard 70 lb. "semi-portable" weapons from ***GURPS Ultra-Tech***.

The original rules also allowed for some or all of the smaller weapons in a battery to be swapped out for a corresponding amount of cargo space. In the generic small system rules, lower-SM weapons can be freely mixed with other lower-SM systems.

Weapon, Large Battery (TL2) [hull!*]

This is a weapon one SM larger than a Major Battery, built using the rules for *Larger Systems* (p. 8): it takes up three systems, and, if it is a high-energy system, requires three Power Points. The weapon may be in a fixed mount or a (large) turret. All three systems must be hull systems in the same hull section. For an alternative way of arranging large weapon systems, see *Spinal Mount*, below.

Weapon, Spinal Mount (TL2) [hull!*]

This can be a weapon one *or* two SM larger than a Major Battery, built using the rules for *Larger Systems* (p. 8).

A weapon one SM larger takes up three systems, one in *each* of the three hull sections. It is a fixed-mount weapon. At least one of the systems, in the front or the rear section, must be a hull system: this defines the direction of fire. The other systems *may* be core systems, but do not need to be (a spinal mount can run along the side of a vessel). If it is a high-energy weapon system, then it requires *three* Power Points to fire.

A weapon two SM larger takes up ten systems: four in the front or rear hull section (defining the direction that the weapon fires), and three in each of the other sections. It is a fixed-mount weapon. If it is a high-energy weapon system, then it requires *ten* Power Points to fire. A vessel with an extra-large spinal mount is often little more than the weapon itself and supporting power systems.

Weapon Types

Various weapons can be installed in weapons batteries. Their effects are listed in the *Beam Type Table* (p. 37).

Note: If conventional guns or missile launchers are mixed with other weapons in the same battery one Power Point is still required to energize the other weapons, but if that Power Point is not spent, the conventional guns in the battery will still be able to fire.

Beam Types

These are directed-energy weapons. Use Gunner (Beams) skill except for ghost particle beams, which uses Artillery (Beams).

Heat (TL7^): A generic beam of "pure energy" with no special effects at all, for emulating pulp SF beam weapons.

Lightning Cannon (TL5+2^): A low-tech particle beam based around etheric science. It has a visible effect (even in vacuum) similar to a lightning bolt, due to the etheric disturbances it leaves in its wake.

Laser (TL9): A beam laser operating in visible light or near-ultraviolet frequencies.

Particle (TL10): A neutral particle beam optimized for space combat. It has superior armor penetration, but range and accuracy are inferior to lasers.

Plasma (TL10^): These accelerate bolts of ionized plasma with double the damage of other weapons but poor range and accuracy.

UV Laser (TL10): A free electron laser operating in far-ultraviolet frequencies with superior range to lasers.

Electromagnetic Disruptor (TL10^): This is a super-science weapon that affects electronics but not people, such as cinematic versions of "ion cannon," "magnetic pulse," and "maser" technologies.

Mind Disruptor (TL11^): Fires a beam that only affects sentient minds.

Antiparticle (TL11^): Accelerates a beam of antiparticles, causing surface explosions and radiation effects; similar to a particle beam, but with greater damage.

Ghost Particle (TL11^): Fires high-energy mesons or other exotic particles that pass through armor before detonating *inside* the target. Range and accuracy are inferior to a laser. Use Artillery (Beams) to fire it.

Tractor (TL11^): Uses a ranged force field or gravity effect to pull or manipulate objects over a distance, but inflicts no damage at all.

X-Ray Laser (TL11): A free-electron laser operating in the X-ray frequency, with superior range to lasers and excellent penetration.

Graviton (TL11^): Reaches *inside* the target, crushing or shaking it. Range and damage are inferior to lasers, but ignores armor and has superior force field penetration.

Conversion (TL12^): Converts matter into energy or antimatter, not only disintegrating a portion of the target, but also causing an explosion.

Graser (TL12): A gamma-ray laser similar to an X-ray laser, but with greater penetration.

Disintegrator (TL12^): Reduces target to component particles or erases its existence.

Option: Improved (+1TL): A high-efficiency or multi-barrel weapon with the same effectiveness but double the rate of fire. E.g., an "improved UV laser" will be TL11.

Option: Rapid Fire or Very Rapid Fire: All beams except graviton and tractors are also available in *rapid fire* versions with 10× RoF but only 10% of output (e.g., a 3 MJ beam would becomes 300 KJ rapid fire beam), or *very rapid fire* (VRF) with 100× RoF at 1% of output (e.g., 3 MJ would become 30 KJ). This can be combined with "improved."

Gun Types

These are rated for their caliber in centimeters (cm). In space combat, the projectiles fired are often slower than the spacecraft, especially with conventional guns. Range is theoretically unlimited in vacuum but ability to hit is severely limited at a distance. To compensate, high-tech guns fire shell packages with small thrusters and guidance systems for limited course correction. Even so, they're best used in close combat or against non-maneuvering targets (e.g., planets or space stations). Use Gunner (Catapult) or Gunner (Cannon) skill.

Catapult (TL2): These are direct-fire spring- or torsion-powered devices. When used in space combat, they fire iron balls or rocks rather than arrows, since there's no need to stabilize flight in vacuum. They have one-quarter the caliber of a gun. Thus, an SM+7 ship's major battery could have a 3.5 cm catapult. This is *not* a high-energy system.

Conventional Gun (TL7): A large caliber conventional gun similar to a modern tank or heavy naval gun, with a mechanical autoloader. It is *not* a high-energy system.

Electromagnetic Gun (TL9): A coil gun or railgun with much higher muzzle velocity.

Grav Gun (TL11^): A superscience weapon with a very high muzzle velocity.

Option: Rapid Fire or Very Rapid Fire: Any TL6+ gun, or TL5 gun of 6 cm caliber or smaller, is also available in *rapid fire* or *very rapid fire* (VRF) versions. Rapid fire guns have 1/2 the listed caliber (e.g. a 6 cm conventional gun becomes a 3 cm rapid fire gun), but have 10× RoF and five times the shots. A VRF gun is a multi-barrel or fast electromagnetic gun with 1/4 the listed caliber (e.g. 6 cm becomes 1.5 cm), 100× RoF, and 20 times the shots.

Launcher Types

There are three types of launcher, rated for their caliber in cm. Use Gunner (Rocket) or Artillery (Guided Missile) skill.

Rocket Launchers (TL3): These fire unguided rockets. Those at TL3-5 use black-powder propulsion; higher TLs use modern solid fuels. Rocket launchers, unlike other launchers, have the same rapid fire or very rapid fire options as guns. They are not high-energy systems.

Missile Launchers (TL7): These fire self-propelled guided missiles. They are not high-energy systems.

Warp Missile Launchers (TL11^): These fire missiles similar to missile launchers, but accelerate them to relativistic pseudo-velocities (see *Pseudo-Velocity*, p. 64) using an internal warp field accelerator, allowing the missile to reach distant targets nearly instantly. They *are* high-energy systems.

Ammunition Types

These are different types of projectile or warhead that can be loaded into guns and launchers.

Solid Projectile (TL2): A simple "kinetic kill" warhead, causing damage by the sheer velocity of impact.

Timed Fuse (TL3): An explosive shell that sprays high-velocity fragments over its target. This removes any armor divisor, but gives +1 to hit at TL3-5, or +2 at TL6+. The fuse can be disabled to allow a direct kinetic attack, if desired.

Proximity Fuse (TL7): A shell that automatically explodes within a certain distance of its target. Like a timed fuse shell, this removes the armor divisor, but increases the bonus to hit to +4. The fuse can be disabled to allow a direct kinetic attack, if desired.

Nuclear (TL7): A typical fission or multi-stage fission-fusion warhead. Only relatively heavy missiles or bombs may have these warheads.

Antimatter (TL10): A "clean" antimatter-catalyzed fusion warhead that is unaffected by nuclear dampers and may also be smaller in size than a standard nuclear warhead.

X-ray Laser (TL10): This is a set of lasing rods wrapped around a nuclear bomb. The explosion pumps multiple powerful (but short-ranged) x-ray laser beams.

Devourer (TL11): This warhead spreads a swarm of hungry microbots or nanomachines over the target, which eats through the armor and enters the vessel.

Bombs (TL3): These are "missiles" without propulsion systems, though at TL7+ they will have terminal guidance. Each missile can be replaced with up to 3 bombs.

Super Missiles (TL11^) "Super missiles" with 100G+ accelerations may optionally be available (usually if similar accelerations are standard for spacecraft).

Beam Weapon Tables

Beam weapon capabilities depend on the *type* of beam and the *beam output*. First, look up the weapon on the *Beam Type Table*, then consult the appropriate columns of the *Beam Damage and Range Table* for the beam's rated output.

Beam Type Table

TL	*Weapon*	*Damage*	*sAcc*	*Range*	*Rcl*
7^	Heat ray	D1 burn	0	R2	1
5+2^	Lightning Cannon	D1 burn sur (2)	-3	R1	1
9	Laser	D1 burn (2)	0	R2	1
10	Particle	D1 burn rad sur (5)	-3	R1	1
10^	Plasma	D2 burn exp (2)	-6	R0	2
10	UV Laser	D1 burn (2)	0	R3	1
10^	EM Disruptor	D1 special	0	R2	1
11^	Antiparticle	D2 cr exp sur rad (3)	-3	R1	1
11^	Ghost Particle	D1 cr exp (∞)	-3	R1	1
11^	Graviton	D0 cr (∞)	0	R1	1
11^	Tractor	D1 special	0	R1	1
11	X-ray Laser	D1 burn sur (5)	0	R3	1
11^	Mind Disruptor	D1 special	0	R2	1
12^	Conversion	D1 cor (10)	0	R2	1
	follow-up	D1 burn exp rad sur			
12^	Disintegrator	D1 cor (∞)	0	R2	1
12	Graser	D1 burn sur (10)	0	R3	1

Damage: The amount and type of damage inflicted. D0, D1, and D2 refer columns of the *Beam Damage and Range Table*, which gives the decade-scale basic damage. The rest of the entry gives the standard ***GURPS*** damage type from p. B269 (burn is tight-beam burning damage) and armor divisor. For weapons with an (∞) armor divisor or a special damage type, see *Special Beam Weapon Rules* (p. 39)

sAcc: The weapon's Space Accuracy. To find normal Acc, add 18.

Range: The weapon's range. R0, R1, R2, and R3 refer to columns of the *Beam Damage and Range Table*, which gives the 1/2D and Max. ranges in *miles*.

Rcl: The weapon's recoil number.

RoF depends on the battery system, and Shots are unlimited as the weapons draw power.

Beam Damage and Range Table

Output	*D0*	*D1*	*D2*	*R0*	*R1*	*R2*	*R3*
3 KJ	1d-5	1d-3	1d-1	30/100	70/200	150/500	300/1K
10 KJ	1d-4	1d-2	1d	30/100	70/200	150/500	300/1K
30 KJ	1d-3	1d-1	1d+2	30/100	70/200	150/500	300/1K
100 KJ	1d-2	1d	2d	70/200	150/500	300/1K	700/2K
300 KJ	1d-1	1d+2	3d	70/200	150/500	300/1K	700/2K
1 MJ	1d	2d	4d	70/200	150/500	300/1K	700/2K
3 MJ	1d+2	3d	6d	150/500	300/1K	700/2K	1.5K/5K
10 MJ	2d	4d	8d	150/500	300/1K	700/2K	1.5K/5K
30 MJ	3d	6d	6d×2	150/500	300/1K	700/2K	1.5K/5K
100 MJ	4d	8d	4d×5	300/1K	700/2K	1.5K/5K	3K/10K
300 MJ	6d	6d×2	3d×10	300/1K	700/2K	1.5K/5K	3K/10K
1 GJ	8d	4d×5	4d×10	300/1K	700/2K	1.5K/5K	3K/10K
3 GJ	6d×2	3d×10	6d×10	700/2K	1.5K/5K	3K/10K	7K/20K
10 GJ	4d×5	4d×10	8d×10	700/2K	1.5K/5K	3K/10K	7K/20K
30 GJ	3d×10	6d×10	6d×20	700/2K	1.5K/5K	3K/10K	7K/20K
100 GJ	4d×10	8d×10	2d×100	1.5K/5K	3K/10K	7K/20K	15K/50K
300 GJ	6d×10	6d×20	3d×100	1.5K/5K	3K/10K	7K/20K	15K/50K
1 TJ	8d×10	2d×100	4d×100	1.5K/5K	3K/10K	7K/20K	15K/50K
3 TJ	6d×20	3d×100	6d×100	3K/10K	7K/20K	15K/50K	30K/100K
10 TJ	2d×100	4d×100	8d×100	3K/10K	7K/20K	15K/50K	30K/100K
30 TJ	3d×100	6d×100	6d×200	3K/10K	7K/20K	15K/50K	30K/100K
100 TJ	4d×100	8d×100	2d×1,000	7K/20K	15K/50K	30K/100K	70K/200K
300 TJ	6d×100	6d×200	3d×1,000	7K/20K	15K/50K	30K/100K	70K/200K
1 PJ	8d×100	2d×1,000	4d×1,000	7K/20K	15K/50K	30K/100K	70K/200K
3 PJ	6d×200	3d×1,000	6d×1,000	15K/50K	30K/100K	70K/200K	150K/500K

Guns and Launchers Tables

The table below indicates the sAcc, Range, and Recoil of guns and missile launchers.

Guns and Launchers Table

TL	Weapon	sAcc	Move	Rcl
2	Catapult	-17	0.05	3
3-4	Conventional Gun	-16	0.1	3
5-6	Conventional Gun	-12	0.5	3
7+	Conventional Gun	-10	1	3
9	Electromagnetic Gun	-8	2	2
11^	Grav Gun	-5	5	2
3-4	Missile Launcher	-17	4/0.2	1
5-6	Missile Launcher	-16	5/1	1
7-8	Missile Launcher	(TL-8)	6/2	1
9	Missile Launcher	(TL-8)	5/10	1
11^	Super Missile Launcher	(TL-8)	100/100	1
^	Warp Missile Launcher	+17	186K	1

sAcc: The Space Accuracy. Add +3 to sAcc for cosmic-powered electromagnetic guns, grav guns, super missiles, or warp missile launchers. For conventional and EM guns, add +1 for diameter 7cm+ or +2 for diameter 16cm+. For missiles, apply +1 for diameter 32cm+.

Move: For guns, this is the impulse in mps. For missiles and super missiles, it is the acceleration/delta-V in G and mps: double both for diameter 32cm+. For warp missiles, it is pseudovelocity in mps: multiply by ×0.8 (below 32cm) or ×1 (32cm+) to get range in miles.

Rcl: Recoil. For conventional and EM guns, increase by 1 for diameter 7cm+ or 2 for diameter 16cm+.

RoF and Shots depends on the battery system.

Damage depends on the warhead used – conventional, nuclear, or antimatter.

Conventional Warhead Damage Table

Caliber	d-Damage	Caliber	d-Damage
2cm	3d	16cm	6d×4
2.5cm	3d+2	20cm	6d×5
3cm	4d	24cm	6d×6
3.5cm	5d	28cm	6d×7
4cm	6d	32cm	6d×8
5cm	7d	40cm	6d×10
6cm	9d	48cm	6d×12
7cm	11d	56cm	6d×14
8cm	6d×2	64cm	6d×16
10cm	3d×5	80cm	6d×20
12cm	6d×3	96cm	6d×24
14cm	3d×7	112cm	6d×28

Caliber is missile launcher or gun diameter.

d-Damage is the basic damage. It is multiplied by velocity in mps. A proximity detonation has no armor divisor. Otherwise the warhead has a (2) armor divisor.

Nuclear and Antimatter Warhead Damage Table

Warhead Yield	d-Damage
25 kiloton	4d×1,000 burn ex rad sur
linked	3d×1,000 cr ex
100 kiloton	8d×1,000 burn ex rad sur
linked	6d×2,000 cr ex
2.5 megaton	8d×5,000 burn ex rad sur
linked	6d×5,000 cr ex
10 megaton	8d×10,000 burn ex rad sur
linked	6d×20,000 cr ex

Warhead Yield is the equivalent TNT explosion.

d-Damage is the decade-scale direct-hit damage from the warhead. Divide damage by 100 for a proximity detonation, e.g., 2.5 megaton does 8d×50 burn. Linked crushing explosive damage applies only in in an atmosphere: multiply this by air pressure in atmospheres.

Ammunition Weight Table

Caliber	Conventional Gun, Catapult	EM Gun, Grav Gun	Missile	SM
2cm	1/4,000	1/8,000	-	-7
2.5cm	1/2,000	1/5,000	-	-7
3cm	1/1,600	1/3,200	-	-6
3.5cm	1/1,200	1/2,400	-	-6
4cm	1/800	1/1,600	-	-5
5cm	1/400	1/800	-	-5
6cm	1/200	1/400	-	-4
7cm	1/125	1/250	-	-4
8cm	1/80	1/160	-	-3
10cm	1/40	1/80	-	-3
12cm	1/25	1/50	-	-2
14cm	1/16	1/32	-	-2
16cm	1/10	1/20	1/10	-1
20cm	1/5	1/10	1/5	-1
24cm	1/3	1/6	1/3	0
28cm	1/2	1/4	1/2	0
32cm	1	1/2	1	+1
40cm	2	1	2	+1
48cm	3	1.5	3	+2
56cm	4	2	4	+2
64cm	7.5	4	7.5	+3
80cm	-	-	15	+3
96cm	-	-	25	+4
112cm	-	-	40	+4

Ammunition costs $100K per ton for guns, $1M per ton for missiles, $2M per ton for super missiles. Bombs are 1/3 weight. Cost is divided by 10 at TL3-6.

SM is used when the projectile is attacked as part of point defense fire.

Unconventional warheads have a minimum diameter, and an additional cost *per warhead*:

Unconventional Warhead Table

TL	Warhead	Minimum Size	Cost
7	25 kiloton nuclear	16cm	$50K
7	100 kiloton nuclear	20cm	$100K
7	2.5 megaton nuclear	40cm	$500K
7	10 megaton nuclear	56cm	$1M
10	25 kiloton antimatter	10cm	$100K
10	100 kiloton antimatter	16cm	$200K
10	2.5 megaton antimatter	24cm	$1M
10	10 megaton antimatter	40cm	$2M

SPECIAL BEAM WEAPON RULES

The following beam weapons have special effects in combat.

Tractor Beams

These force field projectors are not primarily weapons, but can be used in combat out to their listed range as shown on the *Beam Damage and Range Table* (p. 37). By default they are assumed to be *Tractor-Pressor Beams* that can extert a force in any direction. In some settings, this technology may be capable of *pulling* or *pushing* only; alternatively, dedicated tractor and pressor beams may be available at a discount (half price).

Roll against the Gunner (Beam) skill of the tractor bay operator. Success does not inflict damage. Instead, it exerts a pull on the target measured in gravities (G):

Tractor force = 0.1 ton per MJ of output.

Tractor ST = 100 × square root of (tractor force).

Tractor pull (G) = tractor force / target mass.

Multiple beams working on the same target combine their force.

In the basic space combat system (Chapter 3), a successful tractor lock has no *immediate* effect . . . but on the target's next turn, the gunner may add or subtract the tractor pull to any acceleration that it uses before calculating its acceleration. If target does not accelerate, or if the beam subtracts more acceleration than the ship applies, it's captured; the tractor beam operator may choose the captured spacecraft's next move, using the excess acceleration, and his own skill of Gunner (Beams)-4 instead of the target's Pilot skill.

A dedicated tractor-only beam can add acceleration only if the ship's pilot chose a *closing maneuver* (p. 97), and, if it captures the target, can only force it to take a closing maneuver or a *controlled drift* (p. 97). A pressor-only beam is similar but can add acceleration only to a *retreat* (p. 98), and can only force a captured target to take a *retreat* or *controlled drift* maneuver.

In the tactical space combat system (Chapter 4), compute a Thrust Rating (p. 112) for the tractor beam on its target, based on its tractor pull (above). If the result is 1 or more, then during the beam fire phase, on a successful attack, the gunner may move the target's *vector counter* (p. 113) as desired up to the thrust rating, without changing its facing. A tractor-only beam must move the vector counter to a hex closer to the tractor vessel's own vector counter, while a pressor-only beam must move it to one farther away. If the target's vector counter and position counter are both in, or moved into, the same hex as the tractor vessel's vector and position counters, respectively, then the tractor vessel may maneuver the target as described under *Formations, Rendezvous, Docking, and Recovery* (p. 117), e.g., to pull the target into a hangar bay.

When a tractor beam is used on a vehicle operating a boost drive (p. 60), the GM should first decide whether tractor beams have *any* effect on such vehicles. If they do, use the rules on p. 75 for boost drives in gravity fields: the tractor pull subtracts from the drive's effective thrust, reducing its top speed. If top speed goes below zero, the vessel drops out of boost drive, reverting to its velocity before it activated the drive. Any excess tractor pull can be used to maneuver the vessel as above.

In a gravity well, it may be more useful to use the beam ST score rather than its thrust in Gs, when determining its combat effects. Treat this as lifting and grappling ST, with no striking ST.

Electromagnetic Disruptors (EM Disruptors)

These superscience beam weapons temporarily disrupt electronics or computer systems without affecting the vessel itself or its occupants. They affect characters only if they have the Electrical disadvantage. Vulnerable systems include essentially all TL7+ system, with the exception of armor, cargo hold, engine room, hangar bay, fuel tank, radioisotope sail, soft landing, solar mirror, and any previously disabled systems.

DR protects normally against them, but they do not inflict their damage on the ship's HP, nor is damage cumulative over time. Instead, damage determines only which systems are affected. If the beam's penetrating damage is at least 10% of the ship's dHP, whichever vulnerable system it hits is disabled as vital electronics fail. If the penetrating damage exceeds half the ship's dHP, it affects any vulnerable systems in the hull section hit. If it's equal to or greater than the ship's dHP, it affects every vulnerable system in the entire vessel.

Mind Disruptors

These psionic beam weapons affect occupants without affecting the vessel itself. They have no effect on non-sentient entities or those with the Digital Mind advantage.

Normal DR is ineffective against them but force screens protect at 1% of dDR. No damage is actually inflicted to the vessel's dHP, nor is damage cumulative over time. Instead, damage determines only which occupants are affected. If the beam's penetrating damage is at least 10% of the ship's dHP, any being in the system struck is affected. They must make a Will-6 roll to resist (Will-3 beyond 1/2D range). If the penetrating damage exceeds half the ship's dHP, it affects anyone in the hull section hit. If it is equal to or greater than the ship's dHP, it affects every being in the entire vessel.

Mind shields and psi shielding (p. 58) add to the roll to resist.

Mind disruptor hits produce one of the following effects, chosen before firing.

Hypnagogic Beam: The standard mind disruptor fires a beam of telepathic noise. If the victim fails to resist, he suffers the daze incapacitating condition (p. B428). He is unable to act until struck or shaken, or until a number of minutes pass equal to his margin of failure. If he fails by 5 or more he falls unconscious (p. B429) and is dazed as above after recovery. It also disrupts short-term memory: Victims never remember what happened to them during the second they were shot, or the second before that.

Death Beam: This beam carries a hypnotic compulsion to die. If the resistance roll fails, the victim suffers the choking incapacitating condition (p. B428) for a number of seconds equal to twice his margin of failure. There's nothing lodged in his throat, but he loses 1 FP per second unless he doesn't need to breathe. If he fails by 5 or more, the victim suffers the heart attack mortal condition.

Insanity Beam: This beam unleashes bizarre and terrifying visions from the victim's subconscious mind. He suffers the hallucinating incapacitating condition (p. B429) for one minute times his margin of failure. If he fails by 5 or more, the result is a coma (p. B429) in which he is tormented by horrific dreams. If the victim survives the coma, he gains the Nightmares (12) disadvantage for 1d weeks after.

Psionic Neutralizer: If psychotronic technology exists, psionic neutralizer is another possible setting for neural and mind disruptors. The beam scrambles the areas of the nervous system that control psi powers. Anyone struck loses all his psionic powers for a number of minutes equal to his margin of failure.

Special Ammunition Rules

The following rules apply to ammunition other than standard shells or missiles with conventional or nuclear warhead.

Bombs

A bomb is a missile without propulsion: acceleration and delta-V are both zero. It may only be used by air or space vessels. It has the usual sAcc when dropped on ground targets, but against other airborne or space targets it has sAcc -11. In the basic space combat system (Chapter 3), it has Short (S) range against ground targets but only Point-blank (P) range against space targets.

When dropped on surface targets, bombs rely on targeting data from the launching vessel. However, a forward observer on the ground with line of sight on the target can communicate with the firing vessel or paint the target with a laser designator to guide the bombs. Roll against his Forward Observer skill. Success adds +2 to the roll to hit.

X-Ray Laser Warheads

This warhead has the same cost and caliber restrictions as a 100 kiloton antimatter warhead. It is launched and can maneuver as a missile (in the basic space combat system, it has the missile's range). However, it *attacks* using the rules for *Beam Fire* (p. 100, 118).

The attack has a range of 300/1,000 miles from the point of detonation. It has an RoF equal to 1/2 the diameter in cm, *not* modified by turn length (since it fires all shots at once). Each shot that hits does 10d(5) burn rad sur damage. It detonates far enough from the target that the small nuclear blast does not inflict damage.

Devourer Warheads

This warhead has the same cost and caliber restrictions as a 25 kiloton nuclear warhead. It attacks as a normal non-proximity ballistic attack. It cannot penetrate force screens! Otherwise, a successful hit inflicts corrosion damage depending on the time scale, shown in the following table:

Scale	***d-Damage***
20-second	1d(10) corrosion
1-minute	3d+1(3) corrosion
3-minute	10d corrosion
10-minute	20d(0.5) corrosion

The effect burns out after 10 minutes.

Weapons in Ordinary Combat

All weapon statistics are scaled for space combat. If using these weapons in ordinary combat with one second turns, make these changes:

Damage is d-damage multiplied by 10. For d-damages in the single-die range, use the following conversion:

d-Damage	*Damage*	*d-Damage*	*Damage*
1d-5	1d-2	1d-1	7d
1d-4	1d+2	1d	10d
1d-3	3d	1d+1	13d
1d-2	5d	1d+2	8d×2

For guns, multiply the base damage by the gun's impulse in mps. For missiles, multiply by its delta-V in mps. This is the damage as a kinetic impactor. At TL7+ it has a (2) armor divisor.

Additionally, gun shells and missiles often have an explosive filler. In space this is used to produce kinetic fragments; in an atmosphere, the explosion itself can cause damage. ***GURPS High-Tech*** and ***Ultra-Tech*** have extensive ammunition lists, but for a quick-and-dirty approach, use the following formula:

Dam = 6d × 24 × square root of (Wt × REF).

Dam is crushing explosive damage. Multiply by atmospheric pressure if different from Earth's.

Wt is the shell or missile weight in tons. The formula assumes 7% of that weight is explosive filler.

REF is the relative explosive force of the filler compared with TNT. Typical REFs are given below:

TL	*REF*	*TL*	*REF*
3	0.3	7	1.4
4	0.4	8	1.6
5	0.5	9	1.8
6	1	10+	3

Explosive shells also do fragmentation damage dice equal to one-half the shell diameter in cm: record this in square brackets after the cr ex damage.

Accuracy is sAcc+18. The space range modifiers assumes an Acc 18 weapon fired by a gunner performing All Out (Dedicated) aimed attack with 3+ seconds aim assisted by a +9 vehicular targeting system for a net +30. Using 100 miles for point-blank range gives a -30 range modifier, so the sAcc and Point-Blank modifiers cancel out, providing a net 0 modifier for Acc 18.

Range for beam weapons and warp missile launchers is given in miles. Atmosphere may affect some beam weapons: for UV lasers, or visible or IR lasers firing through fog or mist, the atmosphere provides a cover DR of 1 per 10 yards; for x-ray lasers, grasers, particle and antiparticle beams, this increases to 2 per yard. Multiply cover DR by atmospheric pressure. Warp missiles may or may not work in atmosphere, depending on GM-imposed limits for FTL technologies.

When firing a ballistic weapon in the gravitational field of a planet, maximum range *neglecting atmosphere* is given by:

R = 160 × Imp^2 / G.

R is the range in miles.

Imp is the gun impulse in mps.

G is the planet's gravity in G.

In a Very Thin or denser atmosphere, maximum range may be reduced. For catapults and guns, record the 1/2D and max ranges separated by a slash: if either of them exceed the ballistic range above, use that shorter range instead.

R = 0.5 × D × S / P,   R2 = R / 3.

R and R2 are the max and 1/2D ranges in miles.

D is the gun caliber (diameter) in cm.

S is the streamlining factor: 0.1 at TL3-4, 0.2 at TL5, 1 at TL6+.

P is the atmospheric pressure in atmospheres.

For a normal missile fired in an atmosphere, record its *Air Move* (p. 68) and its max range, separated by a slash:

Move = F × square root of (D / P),

R = 0.1 × Move × dV / A.

Move is the air speed in yards/sec.

R is the range in miles.

F is 10 at TL3-4, 20 at TL5, 100 at TL6+, or 1,000 for TL11^ super missiles.

D is the missile diameter in cm.

P is the atmospheric pressure in atmospheres.

dV is the missile's listed delta-V, in mps.

A is the missile's listed acceleration, in G.

Other Systems

This section collects the remaining components that are not armor, propulsion, power, or weapon systems.

Cargo Hold (TL0) [any]

This is ordinary cargo space. Each system is rated for tons of cargo capacity. The design table shows the capacity of cargo space. Cost is negligible, unless one of the following options is added:

Refrigerated: Refrigerated cargo space adds an extra $0.5K per ton.

Shielded: Concealed and scan-shielded cargo space. Each ton of cargo capacity can instead provide 0.5 tons of shielded cargo capacity for $4K.

Cargo Table

SM	*+3*	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Tons	0.15	0.5	1.5	5	15	50	150	500	1.5K	5K	15K	50K	150K

Repair Skill: Mechanic (Vehicle Type).

Cloaking Device (TL^) [any!]

This is a superscience, energy-intensive stealth system that makes the vessel invisible to vision and to active and passive imaging sensors. The vessel can be detected if it fires weapons or uses a reaction drive. A spacecraft using a cloaking device is -10 to be detected by sensors. During combat, cloaking devices are activated when power is allocated to them.

Cloaking Device Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B	100B

Repair Skill: Electronics Repair (EW).

Computers (TL7) [any]

This represents extra computing systems used for analysis or for hosting AI crewmembers (p. 65).

The table below lists the Complexity of the computer system at a reference TL of 10. By default a computer can run 2 or 6 programs of its rated Complexity as listed (or 10× programs of -1 Complexity, 100× of -2 Complexity, etc.). Extra systems add more capacity. Computers are assumed to be hardened against radiation and EM interference. Other options are given below. Slow, Fast, and Genius are mutually incompatible; others combinations are allowed.

Slow (TL8): -1 Complexity, 1/20 cost.

Fast (TL7): +1 Complexity, 20× cost.

Genius (TL7): +2 Complexity, 500× cost.

High-Capacity (TL7): ×1.5 Programs, 1.5× cost.

Unhardened (TL7): For non-spacefaring civilian vessels. 1/2 cost, counts as a half-sized system (see *Smaller Systems*, p. 8).

Quantum (TL9): The GM may rule that certain programs only run on quantum processors. *Requires* 2 systems; this gives the listed Complexity and Programs. 5× cost *per system*.

FTL (TL11^): A computer with faster-than-light processors. *Requires* 2 systems; this gives +1 Complexity and the listed Programs. 50× cost *per system*.

Computer Table

SM	*+3*	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Complexity	C8	C9	C9	C10	C10	C11	C11	C12	C12	C13	C13	C14	C14
Programs	6	2	6	2	6	2	6	2	6	2	6	2	6
Workspaces	0	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B	60B

Complexity is -6 at TL7, -4 at TL8, -2 at TL9, +1 at TL11, +2 at TL12.

Repair Skill: Electronics Repair (Computers) and Computer Programming.

Controls (TL0) [any]

All vessels capable of maneuvering require controls. Although the system includes the actual control room (and associated computer systems, if any), most of the mass and cost, especially on large vessels, is devoted to systems distributed about the vessel's hull: e.g. basic navigational instruments and communication gear, and the control surfaces, attitude thrusters, or gyros used to alter facing.

The included instruments provide a comm/sensor array level shown on the table below (see *Comm/Sensor Arrays*, p. 84). Many civilian vessels use only this minimal system; for specialized systems, see *Enhanced, Multipurpose, Science, and Tactical Comm/Sensory Arrays* (p. 44).

At TL7+, controls are also rated for the Complexity of the integrated *computer network* (as per p. B472). The network is assumed to be hardened vs. electromagnetic pulse and radiation, if applicable. See the *No Computer* design switch (p. 64) for low-tech or alternate-tech controls that lack computer systems.

Controls are further rated for the number of control stations installed. Each station is a couch or seat appropriate to the vessel's movement and environment, plus a console for controlling shipboard operations such as command, piloting, engineering, navigation, gunnery, sensor operation, or communications.

The more control stations, the less work for any one individual. Without computers, each control station should be assigned a particular task or set of tasks (piloting, navigation, sensors, communicatuon, etc.). Computerized control stations are configurable; there's no need to specify what each one does. For space vessels, assume each control station comes with 24 hours of limited life support for the operator, so a short-range fighter, shuttle, etc. doesn't need a habitat.

You may install fewer control stations: it's possible to have an autonomous vessel with no control stations at all if the vessel is run by sentient AIs instead.

Smaller control systems: A reduced set of controls can be installed using the rules for *Smaller Systems* (p. 8. Since this system includes attitude and maneuver controls, a smaller system gives the vessel -1 to Handling and Stability Rating per -1 rated SM. If operated as a *Robot or Sentient Body* (p. 67), it is at -2 DX per -1 rated SM. The SM+3 entry on the *Controls Table*, below, is intended for this purpose.

Larger control systems: Improved controls come in two types: *Enhanced Comm/Sensor Arrays* (p. 44) for better electronics and instruments, and *Enhanced Controls* (p. 45) for better maneuvering systems. See those system descriptions for details. Vessels can also install extra *Computers* (p. 42), and aircraft can benefit from *Maneuver Enhancement* (p. 50).

Controls Table

SM	***+3***	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Complexity	C5	C6	C6	C7	C7	C8	C8	C9	C9	C10	C10	C11	C11
Comm/sensor	TL-8	TL-7	TL-6	TL-5	TL-4	TL-3	TL-2	TL-1	TL	TL+1	TL+2	TL+3	TL+4
Control Stations	1	1	1	2	3	4	6	10	15	20	30	40	60
Workspaces	0	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

Complexity is 0 at TL6 or less, or -6 at TL7, -4 at TL8, -2 at TL9, +1 at TL11, +2 at TL12 (minimum 0).

Control Stations can be reduced at a savings of $50K per station ($10K for SM+4, no savings at SM+3).

Repair Skill: Electronics Repair (Computers) and Computer Programming (at TL7+), and Electrician (at TL6+); *or* Mechanic (Vehicle Type) at TL5 or less.

Defensive ECM (TL7) [any]

An array of automatic self-defense jamming antenna, decoy systems, etc. that protects the vessel from being hit by enemy fire. Each system gives a -2 to ranged attacks against the vessel. No more than three can be installed. It only applies if the defensive ECM system is of the same or higher TL as the vessel or missile targeting it.

Defensive ECM Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Repair Skill: Electronics Repair (EW).

Digestive System (TL7) [any!]

This is an internal bay equipped with specialized features: crushers, melting furnaces, digestive super-acids, or something similar. When activated, anything held inside (up to its rated capacity) takes the indicated damage; vessels suffer this to each hull section simultaneously.

If a digestive system is placed in a hull location, it can also function as a hangar bay and cargo hold (although its capacity is lower, as shown below). If placed in a core location it can carry cargo, but to access it there must be a hangar bay, cargo bay, or maw system in the same hull section.

Specify the type of damage the bay inflicts: burning, crushing, cutting, or corrosion. For example, a ship inside an SM+10 crushing disposal bay takes 4d+2 damage to the front, central, and rear hulls. High-TL bays also apply an armor divisor. Cutting or burning get a (2) armor divisor at TL9, (3) at TL10, (5) at TL11, and (10) at TL12. Corrosion ignores armor dDR at TL12^. This damage is d-scale; characters who have the misfortune to be caught in such a bay take 10 × damage.

The damage assumes a 20-second turn. Multiply the damage (after subtracting DR) by three for a 1-minute turn, 10 for a 3-minute turn, or 30 for a 10-minute turn.

To use the system, objects must enter, be placed, or be pulled (via robot arms, tractor beam, or by being swallowed via a maw) into the digestive system. After material has been destroyed the system can expel the processed residue or direct it into a refinery, fuel tank, mass driver engine, total conversion power plant, etc.

Digestive System Table

SM	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Capacity (tons)	1	3	10	30	100	300	1,000	3,000	10K	30K
d-Damage	2d+2	3d	3d+2	4d	4d+2	5d	5d+2	6d	6d+2	7d
Workspaces	0	0	0	0	1	3	10	30	100	300
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B

Crushing bays are half cost.

Repair Skill: Mechanic (Vehicle Type).

Engine Room (TL7) [any]

Small spacecraft (SM+5 to SM+9) whose crew wish to perform repairs and maintenance without exiting the vehicle should have an engine room system. An engine room includes room, tools, and parts sufficient to maintain and repair the craft. It isn't required on an SM+5 to SM+9 craft, but lacking one lowers HT and makes repairs harder.

An engine room comes with one workspace (control station).

An engine room should be placed in the same or adjacent hull section as the majority of the drives or power plants. SM+10 or larger spacecraft do not require an engine room system, since all systems that require maintenance include workspaces integral to them (manned by their listed tech crew requirement).

Engine Room Table

SM	*+5*	*+6*	*+7*	*+8*	*+9*	*+10 or more*
Workspaces	1	1	1	1	2	-
Cost ($)	15K	30K	100K	300K	1M	-

Repair Skill: Mechanic (Vehicle Type).

Enhanced Comm/Sensor Arrays (TL7) [hull]

Many vehicles have only a basic comm/sensor array (see *Controls*, p. 43), but some have more sophisticated systems. This is a large multi-function sensor and communications array. It uses an embedded phased array or rotating antenna for communicators and sensors. Installation of more than one array is rare, except for specialized space observatories or intelligence spacecraft. There are four types:

Enhanced Array: A larger and more capable version of the basic array that comes with the controls system.

Science Array: Incorporates highly sensitive instruments for use in astronomical and physics surveys, as well as the same equipment as an enhanced array.

Tactical Array: Has the same capabilities as an enhanced array, but adds the ability to actively jam transmissions and overcome defensive ECM.

Multipurpose Array: Combines science and tactical array functions.

All arrays integrate active sensors, passive sensors, and a comm suite into a single system. The array is rated for its type and comm/sensor array Level, based on SM and TL, e.g., a TL10 SM+8 vessel's Level is 9. The array level is the same for all types; the only differences are their special abilities. The comm/sensor level determines the Telescopic Vision level of the array's passive sensors. For other capabilities, see *Comm/Sensor Arrays* (p. 84) in Chapter 2. See *Design Switches* for various superscience upgrades.

Enhanced, Science, Multipurpose, and Tactical Array Table

SM	***+3***	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Array Level	TL-6	TL-5	TL-4	TL-3	TL-2	TL-1	TL	TL+1	TL+2	TL+3	TL+4	TL+5	TL+6
Workspaces	0	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

Cost is 1× for enhanced, 5× for tactical or science, 10× for multipurpose array.

Repair Skill: Electronics Repair (Communications and Sensors).

Enhanced Controls (TL0) [Any]

This represents improved gyros, servo systems, rudders, maneuvering rockets, etc., to improve a vessel's maneuverability. A system installed at the vessel's rated SM provides +1 to Handling and Stability Rating. If the vehicle has a *Sentient Brain* (p. 52) or is operated as a *Robot or Sentient Body* (p. 67), then it also gets +2 to DX.

A system rated at one SM larger (taking up three system slots) provides +2 Hnd/SR and +4 DX. A system rated at two SM larger (taking up ten system slots) provides +3 Hnd/SR and +6 DX. No further improvement is possible. However, for aircraft, the Handling bonus *is* cumulative with the bonus for *Maneuver Enhancement* (p. 50), to a maximum Handling modifier of +5.

Enhanced Controls Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

Repair Skill: Mechanic (Vehicle Type).

Exophase Field (^) [Any!]

This allows a vessel to go out of phase with reality, perhaps shifting into an adjacent dimension or level of hyperspace. Everything in an exophase field enters an insubstantial state – one that has only limited interactions with ordinary matter and energy. Exophase fields can be explained as moving a ship into a parallel universe, altering its subatomic structure, or turning it into an odd form of "dark matter."

The ship is affected normally by gravity and by graviton or tractor beam weapons. It can also use these devices normally while in exophase. Other physical and energy attacks cannot harm it (nor can it harm others). An exophased ship is also vulnerable to psionic and nonmaterial magical attacks.

It can pass through solid matter, provided it can escape its gravity. It cannot rematerialize inside a solid object; attempting to do so prevents materialization. If the system is depowered while inside a solid object the vessel is destroyed, disintegrating in the other dimension while leaving the solid object unharmed.

The field's outline is visible as a ghost-image across the electromagnetic spectrum – this is a side effect of whatever keeps it anchored in reality. Those within the field will also have a ghostly view of the outside. A ship using an exophase field is invisible to active sensors, but remains visible to passive sensors at a -8 penalty to detection. It uses its own passive sensors at -8 and detects communication signals at the same penalty, but it cannot use active sensors or communications. The ship can interact normally with other ships using exophase fields, however! Whether they can affect (or be affected by) someone who has the Insubstantiality advantage depends on the form of Insubstantiality.

Since it is intangible to matter, a ship in exophase is effectively in vacuum and in free-fall: it cannot use air-breathing engines, wings, ground motive systems, or any other system that requires interacting with the outside world. Reaction drives and reactionless engines still function. Depending on the setting, ether sails, tachyon sails, or hyperdynamic fields may work as well.

An exophased ship is blocked by any force field that stops solid objects or uses the reality-stabilized variant. This also means that the vessel's own *Force Wings* (p. 61), if any, will also be effective. The GM may rule that certain other materials, energy barriers, or magic spells are impenetrable to exophased craft.

Only objects within the exophase field can be carried. Objects released from it materialize (or disintegrate, if they would interpenetrate solid matter).

Exophase Field Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	10M	20M	50M	100M	200M	500M	1B	2B	5B	10B	20B	50B

Repair Skill: Electronics Repair (Parachronic).

External Clamp (TL2) [hull]

This is a system of clamps or grapples that allows the vessel to attach itself to another object that the vessel has rendezvoused with. Attachment takes at least 20 seconds; the subject must be cooperative or not maneuvering. A clamped vessel can be towed or pushed by any drive system with propulsion given in Gs, or an FTL drive. To determine performance, calculate the tons of thrust, equal to its acceleration (or FTL rating) times its mass; then divide by their combined mass to get the new acceleration or rating. The two vessels may also combine their acceleration or FTL ratings: add their thrust or FTL rating together before dividing by combined mass.

If a smaller external clamp is installed (using the rules for *Smaller Systems*, p. 8), then it can only be attached to things that are at least two SM smaller than the *clamp's* rated SM. A full-size clamp has no such limits, and can be used to attach the vessel to a *larger* object if desired.

External Clamp Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Cost ($)	1K	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M

Repair Skill: Mechanic (Vehicle Type).

Extradimensional Interface (TL12^) [core!!]

The vessel is larger inside than on the outside! Hull size of the vessel refers to the extradimensional hull. Thus, an SM+5 vessel has an extradimensional mass of 30 tons but it appears much smaller!

The system reduces the effective SM of the vessel for the purposes of external access (doors, etc.) to it, attacking it, or detecting it; and its effective mass and volume when storing or holding it. The vessel is reduced by -4 SM per system. For example, installing two systems reduces the external SM by -8. A lesser reduction can be specified if desired when the vessel is created.

A vessel with an extradimensional interface cannot have ramscoops, solar panel arrays, reaction engines, hot reactionless thrusters, or any type of sails (e.g., lightsails or ether sails). Its weapon batteries cannot have guns or missile launchers, and any beam weapons must use the energy-phasing surface option. Otherwise, all systems can operate normally.

The destruction of the dimensional interface component can result in the vessel being trapped in the other dimension or destroyed (GM's option).

Extradimensional Interface Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	3M	10M	30M	100M	300M	1B	3B	10B	30B	100B	300B	1T

Repair Skill: Electronics Repair (Parachronic).

Factory (TL5) [any!]

This is an industrial system capable of fabricating goods or spare parts from appropriate components. Use Machinist skill to operate it. The $/hr entry on the table shows the production capacity in dollars per hour worth of goods it can assemble, assuming a TL8 fabricator provided with appropriate blueprints. Factories are unavailable for small (SM+5 or smaller) vessels.

Factory Shop (TL5): This facility must be dedicated toward manufacturing goods of a specific engineering skill and specialization.

Production Line (TL6): This factory must be dedicated to building a single product.

Fabricator (TL8): A high-tech machine shop. Requires component parts equal in mass and costing 40% of the good's value.

Robofac (TL10): As above, but faster and capable of self-operation with its own Machinist-14 skill.

Nanofactory (TL11): A "cornucopia" capable of manufacturing goods from raw materials (carbon, metals, etc.). Requires only an equivalent mass in raw materials.

Replicator (TL12^): A nuclear synthesis machine capable of transforming one element into another, and creating goods from transmutation of bulk matter. The table shows the pounds of goods each system can replicate per hour from an equivalent mass of bulk matter (which can be stored as cargo or fuel).

Any TL8+ factory system (fabricator, production line, etc.) can be designated a bio-tech facility that makes vat-grown products (in accord with its TL). At TL9+ a production line can even represent an artificial womb that, in conjunction with other appropriate design switches, gestates a baby spaceship (see *Maturing Living Ship*, p. 63).

Factory Table

SM	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
$/hr	5K	15K	50K	150K	500K	1.5M	5M	15M	150M	500M
lb/hr*	0.5	1.5	5	15	50	150	500	1,500	5,000	15,000
Workspaces	0	0	0	0	1	3	10	30	100	300
Cost ($)	5M	15M	50M	150M	500M	1.5B	5B	15B	50B	150B

* Replicators use this statistic (instead of $/hr).

Multiply $/hr by 2 for Robofac or 20 for Nanofac; treat as $/week for Factory Shop, or $/day for Production Line.

Multiply cost by 1/10 for Factory Shop, 1/5 for Production Line, 2 for Robofac, 4 for Nanofac, 20 for Replicator.

Repair Skill: Mechanic (Machine Tools) for Factory Shop, Production Line, or Fabricator; Mechanic (Robotics) for Robofac; Mechanic (Nanomachines) for Nanofactory; Electronics Repair (MT) for Replicator.

Habitat (TL1) [any]

Provides living quarters and, at higher tech levels, extended life support for crew during long voyages. At TL7+, a habitat may include a pressurized hull, radiation shielding, and a variety of standard features such as airlocks, hatches, compartmentalization, and elevators. It can contain several different types of facilities, each rated for their space occupied in "cabin-equivalents".

Cabin: Quarters for one person in comfort or shared by two occupants.

Luxury Cabin: A suite with very comfortable quarters for one or two occupants. Counts as two cabins.

Bunkroom: Cramped accommodations with bunk beds for up to four people. Often used for enlisted crew, troops, or colonists. Counts as one cabin.

Cell or Cage: Accommodations equivalent to bunk, but with fewer amenities. Includes a barred door, lock, and surveillance camera (at TL7+). Counts as one cabin.

Specialized Rooms: See below.

Steerage Cargo: Unused tonnage in a habitat is usually assigned to cargo; this is a good way to use up excess capacity. Steerage cargo is climate-controlled, so it can be used for livestock or delicate goods. Each cabin-equivalent can store 5 tons.

Cabins, cells, and bunkrooms are accommodations that permit occupancy for an indefinite period. They have sleeping quarters and sanitary, galley, and dining facilities appropriate to their size and quality. For example, a habitat with 10 luxury cabins will likely have a well-appointed kitchen and sumptuous dining room; one with a single bunkroom may have a microwave oven and a mini-fridge.

At TL7+, habitats include full life support, providing air, climate control, and water for occupants. At TL9+, any accommodations may optionally replace this with *total life support* that grows or manufactures food. Total life support doubles space required (e.g., each cabin counts as 2 cabins). Alternatively, vessels with replicator systems or one or more *Open Space* systems (p. 51) devoted to gardens or farms can be assumed to be able to manufacture all necessary food.

Small vessels, or vessels not requiring long-term accommodations, will not normally have habitats: crew will occupy control stations or workstations, and passengers occupy Passenger Seats (p. 51).

Specialized Rooms for Habitats

Habitats can include various specialized rooms. Multiple facilities can be combined to represent larger examples. The number of cabins that must be exchanged for each specialized room is shown in parenthesis.

Briefing Room (1): A conference room with a table and up to 10 chairs.

Establishment (2): A facility such as a bar, brothel, casino, gym, massage parlor, nursery, salon, classroom, or retail store. Each has standing or seating room for up to 20 patrons, usually manned by one to three staffers.

Hibernation Chamber (TL9) (0.25): A pod housing one person. The "sleeper" inside it is unconscious, but ages at 1/10th speed and does not require sustenance.

Lab (2): A scientific laboratory usable by up to two people simultaneously. Fulfills equipment requirements for a scientific skill, e.g., Chemistry, Biology, Physics, or Science!, with a +1 equipment bonus. Each lab costs an extra $1M ($10M for Physics labs, $30M for Science!). Installing 10+ identical labs qualifies as a "large lab" with +2 bonus; 100+ qualify as a "major lab" with +TL/2 to skill (minimum +3).

Minifac (TL8) (1): A miniaturized version of any Factory system (p. 47) can be installed in a habitat. A minifac is 1/10 the cost and production capacity of an SM+6 factory (e.g., $0.5M and $0.5K/hr. for a fabricator minifac) and, for a robofac, only skill-13.

Office (1): Contains a desk and display terminal for use by one or two administrators, analysts, etc. Useful for skills such as Administration, Computer Operation, Computer Programming, Intelligence Analysis, Market Analysis, or Strategy skill tasks. A habitat with 10 or more offices devoted to the same activity can be classed as an "ops center" with +1 bonus to these tasks, or a "large ops center" with +2 bonus if 100 or more.

Sickbay (1): Medical facilities, e.g., a stabilized diagnostic bed, trauma maintenance, and surgery, for diagnosis and treatment of one patient at a time (First Aid for 1-4 patients). Multiple sickbays extend this, e.g., a "20-bed sickbay" is 100 tons. Fulfills equipment requirements for Diagnosis, First aid, Physician, and Surgery skill with a +2 bonus. Ten-bed or larger sickbays ("clinic") increase this to +3; 100+ beds ("hospital") give +TL/2. At TL9+, any size sickbay can use automeds for extra $100K per bed, allowing AI computer software to treat patients.

Teleport Projector (TL12^) (1): A two-way matter transmitter capable of transmitting 1-2 persons or 0.2 tons cargo. Takes about 10 seconds to send or retrieve and requires an Electronics Operation (MT) skill roll to use properly (-1 per 1,000 miles range), failure meaning a near miss, critical failure disaster; add +4 if beaming between two cooperating systems. It can be controlled from the bay or a control station. See ***GURPS Ultra-Tech*** p. 233 for detailed rules. Costs an extra $20M. Half cost if it can only send or receive.

Workshop (2): Like a lab, but for a non-scientific skill: usually an art, craft, or repair skill such as Photography, Smith, or Armory. One workshop provides space and equipment for three people to work at once, and gives a +2 equipment bonus for the skill; it also counts as basic equipment for related skills. 10 workshops provide a +3 bonus; 100 create a state-of-the-art facility with +TL/2 bonus (minimum +4). Shops for arts and crafts that use fewer or lighter tools (e.g., painting or sewing) take up half the space (one cabin-equivalent).

Repair Skills: If labs, add Electronics Repair (Scientific). If sickbay or hibernation chamber, Electronics Repair (Medical). If office, Electronic Repair (Computers). If teleport projector, Electronics Repair (MT). If minifac, see Factory (p. 47).

Habitat Table

SM	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
No. of Cabins	2	6	20	60	200	600	2,000	6,000	20,000
Workspaces	0	0	0	1	3	10	30	100	300
Cost ($)	300K	1M	3M	10M	30M	100M	300M	1B	3B

Repair Skill: At TL7+, Mechanic (Life Support). If a habitat has total life support, Gardening or (if SM+12 or more) Farming, or at TL10+, possibly Bioengineering (Tissue Engineering) for "faux flesh" food vats. At lower TLs, Housekeeping (this is also the skill used by crew at all TLs assigned to maintenance).

Hangar Bay (TL7) [hull]

A bay capable of storing, launching, and retrieving other vehicles (spacecraft, trucks, etc.). Hangar bays can also be used for cargo, but are less mass-efficient than a cargo hold, due to the other facilities installed in the bay.

On spaceships or submarines, hangar bays include airlock systems so they can be opened without spilling the vessel's air.

The table shows the *capacity* of the bay in tons, which is the maximum mass of craft that can be stowed inside. This can also be used as a cargo hold for "roll-on/roll-off" cargo. *Launch rate* is the maximum tons of craft that can be released or recovered per minute. Craft heavier than this can still be launched or recovered at a slower pace, e.g., an SM+13 bay with a launch rate of 1,000 tons per minute could launch a 3,000 ton ship in 3,000/1,000 = 3 minutes.

Multiple systems placed in the same hull section may be specified as a single larger hangar of greater capacity, e.g., an SM+9 vessel may have "three Hangar Bays [3-5]" with combined 300 tons capacity. Launch rate is unchanged.

Workspace crews are assumed to be maintaining both the bay machinery and the vehicles inside them.

Hangar Bay Table

SM	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Capacity (tons)	1	3	10	30	100	300	1K	3K	10K	30K	100K
Launch rate (tons/min)	1	3	10	20	50	100	200	500	1K	2K	5K
Workspaces	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M

Repair Skill: Mechanic (Vehicle Type).

Holoprojector (TL10^) [hull]

This is a superscience holographic system that projects an image around the vessel to visually disguise it as anything of the same, or one higher, SM. For example, an SM+5 spacecraft could appear as an SM+6 house.

Holoprojector Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

Repair Skill: Electronics Repair (Media).

Integrated Vessel (TL7) [special]

A portion of a vessel may be designated as another smaller vessel joined to the larger vessel, which can be ejected at any time. Taken to the extreme, an *entire vehicle* (usually a giant mecha) may be a combination of smaller vehicles, each capable of independent operation.

More mundanely, this can be used to build a multi-stage rocket, with the front systems comprising the "upper stage" and the rest of the vehicle being the "lower stage". This is done so that the smaller vehicle can add its own rockets' delta-V, without having to pull the weight of the lower stage fuel tanks and booster rockets.

An integrated vessel that is one SM smaller takes up 6 systems in the larger vessel. These can make up the *entire* front or rear hull, or they can be split between two adacent hull sections. An integrated vessel that is two SM smaller takes up 2 systems in the larger vessel: at least one of these must be a hull system if the integrated vessel is to eject without completely breaking open the larger vessel. Smaller integrated vessels may also be designed with the rules for *Smaller Systems* (p. 8), taking up 6/10 of a system for -3 SM, 2/10 for -4 SM, etc.

An integrated vessel placed in the larger vessel's front hull section cannot use weapons, arrays, or engines mounted in its own rear hull section while it is attached; similarly an integrated vessel placed in a rear hull section cannot use weapons, arrays, or engines mounted in its own front hull section. However, if an integrated vessel takes up *all* front hull systems of the larger vessel, and both vessels are streamlined, then the *larger* vessel may waive the streamlining requirement of having at least one armor system in a front or central hull.

The smaller integrated vessel will require a set of *Controls* (p. 43) in order to maneuver separately. The larger vessel need *not* have its own controls, if it is controlled from the integrated vessel: this is typical of lower stages consisting of disposable fuel tanks and rockets. In this case, the larger vessel will have the usual Hnd/SR penalties for relying on a smaller control system, and will lose all maneuvering ability when the controling vehicle detaches.

Ejecting an integrated vehicle takes one space combat turn (20 seconds). Re-integration normally requires a repair yard or similar large facility. and man-hours equal to the vessel's mass in tons (with a typical fee of $1K per man-hour, including labor and use of equipment). However, cinematic, superscience, or TL11+ integrated vessels can re-integrate within a single space combat turn, as the GM allows.

Maneuver Enhancement (TL6) [hull]

Maneuver enhancement represents mass devoted to aerodynamic control systems, and structural strengthening to facilitate high-g maneuvers in a planetary atmosphere. Each system installed adds +1 to air performance Handling.

Maneuver Enhancement Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B

Repair Skill: Mechanic (Aerospace).

Maw (TL8) [front]

This is a powered jaw and mouth, which can deliver a bite attack, swallow food, etc. An ordinary mechanical jaw inflicts thrust-1 crushing damage; when using the combat system in Chapter 3, this converts to d-damage (divide by 10). For +50% cost, a maw inflicts cutting damage instead of crushing.

If a digestive system or hangar bay is in the same section as the maw, a successful attack allows the ship to swallow whole anything small enough to fit in that system. The swallowed object is moved to that location.

Maw Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
d-Damage	1d+2	2d	3d	5d	7d	5d×2	5d×3	5d×4	5d×6	5d×10	5d×14	5d×20
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B

Repair Skill: Mechanic (Robotics or Mecha).

Modular System (TL7) [hull]

Any non-core system or collection of systems can be *modular:* made in such a way that it can easily be removed and replaced by other modular systems. Making a system modular adds 20% to its cost. In addition, the *space* for a modular system is treated as a *Cargo Hold* (p. 42), with an extra flat cost of $1K per ton of module capacity.

Habitat rooms and weapon batteries can be treated as modular at no extra cost, when remodeling or replacing with a new type of that same system.

It takes man-hours equal to the module's mass in tons to swap out a modular system (minimum 1/2 hour). Most shipyards charge a fee of $1K per man-hour to do this. Crews may do so themselves without the heavy equipment found in shipyards, with 10× as much time and a successful Repair skill roll for each system.

Mining and Refinery (TL7) [any!]

These systems require a crew member using Mechanic (Mining) skill to supervise operations (from a control station). Failure reduces output by 10% times margin of failure.

Mining (TL7): A heavy-duty mining and processing system that can extract ore from rock, or convert ice or rock into a powdered residue suitable for use as mass driver reaction mass. It is rated for the tons/hour of ore it can extract or process.

Chemical Refinery (TL7): Different types are possible, but one of the more common types processes ice or water into hydrogen and oxygen for rocket fuel or reaction mass. It is rated for the tons of fuel refined per system per hour.

Mining and Refinery Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B
Tons/hr:												
If Mining	0.05	0.15	0.5	1.5	5	15	50	150	500	1,500	5K	15K
If Refinery	0.15	0.5	1.5	5	15	50	150	500	1,500	5K	15K	50K

Repair Skill: Mechanic (Mining or Refineries).

Open Space (TL7) [any]

This system is an enclosed (and pressurized, if necessary) hall or other large, open space. It contains one or more *open areas* such as an auditorium, farm, garden, pool, theater, or zoo with room for up to 100 people to congregate. Multiple open spaces may be combined to create larger areas.

Twenty open areas are equal to an acre of land (a football-field sized area).

Open spaces used as gardens or farms may provide food requirements for the vessel's occupants. One open space system is sufficient for the entire vessel; excess provide a surplus.

The *Open Space* table shows the number of areas per system. If a large vessel installs a smaller open space system (*Smaller Systems*, p. 8), *do not* use the number on the table for the smaller SM. Instead, use the number for the *vessel's* SM, and divide by 3 for -1 SM, 10 for -2 SM, 30 for -3 SM, etc., rounding down. (This is because a larger vessel has less surface area in proportion to its volume.)

Open Space Table

SM	+8	+9	+10	+11	+12	+13	+14	+15
Areas	1	2	5	10	20	50	100	200
Workspaces	0	0	1	3	10	30	100	300
Cost ($)	100K	200K	500K	1M	2M	5M	10M	20M

Repair Skill: Housekeeping, or if used to grow food, Gardening or Farming.

Passenger Seating (TL1) [any]

This is an alternative to a habitat for a short voyage or small spacecraft. The system contains a number of airliner-style passenger seats, separated by aisles. (Two seats may be replaced by one stabilized stretcher for casualty evacuation.) At TL7+, it includes 24 hours of limited life support per passenger seat or stretcher. The table shows number of seats.

For SM+3 and SM+4 sytems, capacity is increased by eliminating airlocks, aisles, and other access spaces. When used as *Smaller Systems* (p. 8) on a larger-SM vessel, no more than 2 such systems may be used per hull section, and they must be placed in [hull] systems.

Passenger Seating Table

SM	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Seats	1*	1	2	6	20	60	200	600	2K	6K	20K	60K	200K
Cost ($)	1K	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B

* A SM+3 passenger seat system includes no life support.

Repair Skill: Mechanic (Life Support).

Reconfigurable System (TL^ or TL11) [special]

A system can be designed as a multi-function device that can alter its shape and capabilities. Transformation requires 20 seconds. Cost is the combined cost of all systems it can transform into times the number of transformations. Power consumption is that of the current configuration. This is only possible for systems that, in the GM's opinion, would logically share a large number of components or use superscience. Fuel, people, cargo, ammunition, or small craft do not appear when a system transforms. If there is no room for them, they must leave or be removed before a transformation can take place.

Robot Arm (TL8) [hull]

This system is a hand- or gripper-equipped arm, proportionately sized to the spacecraft, that can grab and manipulate spacecraft or other objects using the vessel's decade-scale ST (multiplu by 10 to get a regular ST score).

A robot arm can also function as an external clamp (p. 46).

Robot Arm Table

SM	*+3*	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
dST	10	15	20	30	50	70	100	150	200	300	500	700	1,000
Workspaces	0	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Repair Skill: Mechanic (Robotics or Mecha).

Sentient Brain (TL10*) [any]

The vessel has an integral biological brain with sensory and nervous systems that take up a significant amount of its total mass. A brain allows the vessel to operate just like one with an unmanned computer-controlled system. However, it does not have a Complexity rating, and its Comm/Sensor level is equal to its SM-3.

A brain system communicates via radio. It uses active sensors (radar) and passive sensors but not lasercomms. The GM can vary this. A brain has no control stations.

The GM assigns attributes, skills, and other traits. By default, assume a vessel's brain has DX 12 and IQ 7, but GMs alter these values as desired.

Any damage sustained by a brain system is multiplied by four (after penetrating dDR). If the only brain system is disabled, the vessel is unconscious and cannot control its own systems; if it is destroyed, the vessel is effectively disabled. If a vessel has multiple brains, the workload is divided among them as if they had the Compartmentalized Mind advantage.

An additional variation is available for a sentient brain:

Psionic Sentient Brain (TL^): The brain also produces one psionic Power Point (see *Psi-Powered*, p. 58).

* TL10 for genetically engineered ship brains. No TL for natural creatures.

Sentient Brain Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B

If the brain is psionic, multiply cost by four.

Repair Skill: Surgery.

Soft-Landing System (TL7) [hull]

A reentry shield, airbags, or parachutes designed to allow a vessel that lacks wings, thrust, or contragravity to safely land from low orbit. The system is deploys automatically and is destroyed after landing – it must be replaced each time it's used.

Soft-Landing System Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Cost ($)	20K	50K	100K	200K	500K	1M	2M	5M	10M	20M	50M	100M

Stasis Web (TL12^) [any!]

This system places the spacecraft inside a bubble of time that runs far slower than the rest of the universe. It can be set to last anywhere from six minutes to billions of years as observed by the rest of the universe, while only microseconds pass within the bubble. Anything in stasis is frozen, unable to do anything, but is outside the normal space-time continuum, and cannot be affected by anything within it. The vessel could fall through the heart of a star or survive until the end of the universe. Viewed from the outside, an object encased in a stasis web is a perfectly reflecting mirror, and no sensors of any type can penetrate it. In space combat, stasis webs are turned on during power allocation and last for the duration set by the operator; a spacecraft using a stasis web is effectively indestructible but able to do nothing but perform an uncontrolled drift.

Stasis Web Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	2M	3M	6M	12M	25M	50M	100M	200M	500M	1B	2B	5B

Repair Skill: Armoury or Electronics Repair (Force Shields).

Tail (TL8) [rear]

This is a long flexible tail attached to the rear of a vessel to strike or manipulate things. It can attack anything behind the vessel using d-damage for the vessel's ST.

Impaling: The tail strikes for swing/impaling damage.

Prehensile: The tail functions as a robotic arm with Bad Grip (p. B123). It strikes for thrust/crushing damage.

Striking: The tail strikes for swing/crushing damage.

Weapon: The tail mounts a single weapon system rated at an SM one less than the tail's SM, plus an integral power supply. It has the same arc of fire as a central turret (despite being mounted in the rear). The tail also strikes for thrust/crushing damage.

Tail Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
d-Damage*	1d+2	2d	3d	5d	7d	5d×2	5d×3	5d×4	5d×6	5d×10	5d×14	5d×20
Workspaces	0	0	0	0	0	0	1	3	10	30	100	300
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

* Striking and impaling tails add +1 to d-damage; impaling tails also add the imp damage modifier.

Repair Skill: Electronics Repair (Robotics or Mecha).

Design Features

This is a list of additional options that can be added to systems or vessels. They do not count as systems.

Airbreathing Rockets (TL8)

This feature adds auxiliary air intakes to a rocket, allowing it to operate as a jet engine (p. 16). The combination counts as a single system whose performance depends on the current mode of operation. Allowed combinations are a chemical rocket (p. 20) with a turbojet, turbofan, or turbo-ramjet; a nuclear-thermal rocket (p. 22) with a fission air-ram; any fusion torch (p. 23) with a fusion air-ram; and any antimatter thermal rocket or plasma torch (p. 23) with an antimatter air-ram. Cost is twice the sum of the combined systems. TL is increased by 1: this affects not only when a combination becomes available, but when performance improvements occur.

Area Jammer (TL7)

This feature can be attached to a Defensive ECM system. It gives it an area-jamming mode, protecting nearby vessels as well as itself.

In area-jammer mode, it has half its effect (-1 per system) but protects both itself and other friendly vessels within its jamming radius. Those whose SM exceeds that of the jamming vessel by three or more are not protected, as they are too large to mask.

Area-jammer mode is not cumulative with a vessel's own defensive ECM, nor with the effects of other jammers. Use only the best modifier. Switching modes counts as an Electronics Operation task.

In the basic space combat system (Chapter 3), an area jammer protects all spacecraft in formation with the jamming ship (see *Formations*, p. 109). In the tactical system (Chapter 4), it protects a radius around the jamming vessel, depending on the distance scale as shown in the Area Jam Radius Table (below).

Area Jam Radius Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
10-mile	5	7	10	15	20	30	50	70	100	150	200	300
100-mile	1	1	1	2	2	3	5	7	10	15	20	30
1,000-mile	0	0	0	0	0	0	1	1	1	2	2	3

Armor by Facing

Land and watercraft often have much more complex armor schemes than aircraft or spacecraft. To satisfy this, consider ignoring the rule that Armor systems only protect the subassembly they're placed in. Instead, location of an armor system is irrelevant. Just add the dDR of all systems together, multiply by 2, and divide that dDR as desired among six facings: Front (F), Right (R), Left (L), Back (B), Top (T), and Underside (U). (Assume that underside armor also protects any tracks, legs, or wheels.)

This option is not recommended for spacecraft, as the space combat rules are built around maneuvers and arcs of fire that make use of front, central, and rear hull divisions.

Artificial Gravity and Gravitic Compensators (TL^)

Artificial Gravity: Spacecraft may have superscience artificial gravity generators that create a gravity field that can be varied from 0 to 3G. Artificial gravity may be set for each hull section, and, in habitats or work spaces, for each room (from within the room).

Gravitic Compensators: This field negates up to 99.5% of felt acceleration but does not produce artificial gravity.

Artificial Gravity and Gravitic Compensator Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B

Either capability is distributed through the vessel but will fail locally in systems that are destroyed (e.g., if characters are moving through a wreck, it won't have artificial gravity).

Automation (TL10)

Many systems on large vessels have a "Workspace" entry that represents the facilities that maintain the system and their crew. To reduce technical crew, a spacecraft can have automation. *Total Automation* is available for any system that requires workspaces. It eliminates that requirement. *High Automation* is available for vessels of SM+12 or larger; it reduces number of workspaces (and techs) by a factor of 10. This feature's cost is the number of workspaces the vessel required before reduction multiplied by $5M (total automation) or $1M (high automation). *Example:* If an SM+13 ship required 90 workspaces (and techs), total automation cost would be $450M.

Biomorphics

Any vessel with an appropriate shape can be sculpted to resemble a statue or mannequin of a living thing; for example, a cylinder made to look like a giant whale or a space mecha with arms and legs resembling a humanoid giant. There is no extra cost for this; it's just a matter of how the vessel's appearance is described.

Realistic Biomorphics (TL9): A vessel can be coated with a layer of real or synthetic tissue, complete with details such as hair, scales, fur, or even a face. This may fool some into believing it is a giant creature. A biomorphic vessel's cost depends on its SM.

Biomorphics Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	500K	1M	2M	5M	10M	20M	50M	100M	200M	500M	1B	2B

There is no cost or TL requirement if the spacecraft actually is a living thing.

Buildings

These rules can be used to design buildings and other immobile structures, as well as vehicles. A building can be treated as an unstreamlined hull with no propulsion system. A few special considerations must be made, however.

Vertical Design: A building may be built upright, with its length in the vertical direction: the number of storeys is roughly one-third the length in yards. The "rear hull" section contains the lower third of its storeys, the "central hull" contains the middle third, and the "front hull" contains the upper third. The rear and central sections must contain at least one Armor system, to provide structural support to the upper floors.

Basement: Some or all of the floors of a vertical design building may be designated as basements. A basement costs an extra $1,000 per ton of below-ground systems to cover excavation costs, but are hidden from view and cannot be targeted directly. However, they're automatically buried if the rest of the building is disabled, and destroyed if the rest of the building is destroyed.

Controls: These are not required, but can represent an internal network, external and internal sensors (e.g. a security system), and command center. Since it lacks attitude thrusters or gyros, it can be purchased at half cost (but also halve the savings from omitting control stations).

Engine Room, Workspaces: In a building, these are often referred to as a maintenances rooms or spaces.

Propulsion Systems: A building shouldn't have any system or feature related to mobility or propulsion. It has HP but no ST, and lacks Hnd, SR, or Move statistics.

Enhanced, Multipurpose, and Tactical Comm/Sensor Arrays: Sensor and directional comm ranges will be limited by the horizon. In a vertical-design building, these arrays should be placed on the upper section to ensure a long line of sight.

Weapons: In a vertical design, fixed mounts must be given a facing. This may be either right, left, back, front; upper level mounts may also face top, aiming upward. They can only hit targets within a 60° arc from that facing. Turrets installed in lower or middle sections must be assigned one of these facings (excluding top), but may swivel to hit targets within a 120° arc. Turrets in an upper section are assumed to be roof-mounted and have a 360° arc of fire. Missiles in spinal batteries or in fixed mounts in upper stories may be noted as facing upward (allowing vertical launch). Weapons can't go in basement systems unless either the entire building is underground (in which case top-facing fixed mount or any turret weapons can be installed in upper level section of the basement), or unless they're a third of a spinal battery or a ghost particle beam.

Emergency Ejection (TL7)

Controls on an SM+5 to SM+8 vessel that was not installed in a [core] location may incorporate ejection capability to facilitate rapid escape. Ejection takes only one second (a free action in space combat turns) as long as the control room was not destroyed. Treat an ejected control station as a *life pod* (p. 87) except it holds the crew of the control room (and a backup of the computer). Emergency Ejection adds an extra $500K to cost.

SM+4 controls systems can have an *ejection seat*, not a full lifepod, for $50K. The pilot depends on the life support of his suit. The seat does have a built-in large air tank appropriate to the TL (see ***GURPS Ultra-Tech*** p. 177). Ejection systems are not available for SM+3 controls.

Energy-Phasing Surface (TL12^)

The vessel is surrounded by a superscience array of force lenses, which allows fixed beam weapons mounted anywhere aboard to fire through any point on the surface. They all effectively have universal arcs of fire.

Energy-Phasing Surface Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Cost ($)	500K	1M	2M	5M	10M	20M	50M	100M	200M	500M	1B	2B

Essential Fuel

The Essential Fuel spell (***GURPS Magic***, p. 179) increases spacecraft performance; the engine gets 10 times the delta-V. Since the spell's energy cost is one point per pound of fuel, the efficient casting method is to enchant small quantities (e.g., 10-60 lbs.) repeatedly. As wages vary by TL, the additional cost per ton is shown on the table (depending on the TL of the mage).

Essential Fuel Table

TL	***TL0***	***TL1***	***TL2***	***TL3***	***TL4***	***TL5***	***TL6***	***TL7***	***TL8***	***TL9***	***TL10***	***TL11***	***TL12***
Cost ($/ton)	1,780	1,840	1,920	2K	2.2K	3.2K	4.6K	6K	7.4K	10.2K	16K	22K	30K

Grabber

A robot arm (p. 52) can have reduced dexterity at a significantly lower cost. This cheap, clunky arm is only 10% the normal price, but operates as if it had two levels of Bad Grip (p. B123).

Handheld

A major battery may be designated as a "handheld weapon" for a vessel with a robot arm. A handheld weapon is attached to the hull with a folding bracket or cable that transmits targeting data and electrical power. The cable is equal in length to the vessel's length. When not held, it folds flush against the vessel's side or clamps onto it.

A handheld weapon can only be fired if the spacecraft has one or two arms free. Treat the arm as a turret mount for determining bearing and arc of fire. Using two arms braces the weapon: Add +1 to hit (compared to +2 for a fixed mount).

Besides bracing, handheld weapons have another advantage: They can easily be swapped for other weapons. It takes 20 seconds to remove a handheld device and replace it with another of similar size.

Extra handheld weapons may be carried as cargo: Each masses 1/20th the rated mass of the ship it's designed for. Thus, a weapon for an SM+5 ship masses 1.5 tons.

Handheld weapons are not protected by a vessel's dDR. However, they are rugged and protected with the same dDR as one system of unstreamlined metallic laminate armor: dDR 2 (SM+4), 3 (SM+5), 5 (SM+6), 7 (SM+7), and so on. They can be targeted using the same rules for targeting other specific systems; any damage that penetrates the weapon's integral dDR destroys it.

Hardened Armor and Indestructible Armor

Armor (other than ice, organic, or stone) may be *hardened*. This might represent technologies such as multilayer composites designed to defeat penetration or thin layers of ultra-hard or hyperdense plating. Hardened armor doubles armor cost but reduces the effect of an attack's armor divisor by one step against that armor layer only, as per p. B47. If used, it must be applied to *all* armor systems on a given hull section.

Indestructible Armor (TL^): Buy this as exotic laminate (p. 10) except it has *infinite* dDR, and is 10× the cost. It won't stop attacks that ignore armor. Fictional versions often have certain weaknesses – e.g., it may be transparent (dDR 0 vs. lasers).

Hidden Weapons Batteries

At extra cost, weapons batteries can be hidden. They might be disguised as other systems (such as sensors or cargo doors), be concealed by false facades, use pop-up turrets, etc.

Detection at point-blank or short range (p. 84) does not reveal a hidden weapon battery unless it was fired on its last turn. They can be detected via a successful sensor analysis task.

If using 20 second turns, it takes one turn to ready a hidden turret or to hide a revealed turret, during which time it can't fire. No time is required for fixed batteries. If using longer turns, time requirements are ignored.

A hidden weapons battery is 1.5 times the cost of an ordinary battery.

Hull Length

The hull length guidelines recommend streamlined vessels be twice as long as listed on the *Hull Size Table* (p. 7). Realistically, many unstreamlined vessels will also be that long. Many speculative nuclear or antimatter-powered spacecraft tend to be extremely skinny for their mass (doubling their length), mainly to ensure maximum separation between a radiation-spitting drive and the crew habitat, and also provide room for hull radiators. Doubling length is reasonable for any unstreamlined craft using the Exposed Radiators option (p. 61), especially if thrust is under 0.1G. A good fictional example is the Discovery in *2001: A Space Odyssey*.

Lacks Automation

A spacecraft can have a reduced level of automation provided it has controls with at least one control station. This is the norm for vessels built at TL6 and lower, and common at TL7. Higher TL vessels, especially manned warships, use it on the theory that a larger crew can absorb casualties and perform damage control. A lack of automation gives them intimate familiarity with the ship's workings and prevents them growing bored with nothing but make-work duties.

With this feature, systems require additional workspaces and all multitasking penalties are doubled. Spacecraft no longer require an engine room to perform onboard maintenance and avoid HT penalties.

Lacks automation does not significantly reduce a vessel's cost due to the need for extra maintenance facilities, etc. However, there are fewer things to break down (provided the maintenance crew is on the job) and therefore HT is raised by +1.

If a system type that has a workspaces entry is installed on a vessel that lacks automation, replace its workspaces entry with the one from the *Manual Workspace Table* (below).

Manual Workspace Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Workspaces	1	1	1	1	2	3	10	30	100	300	1,000	3,000

Magical Life Support

In settings where enchantment exists, a habitat can use magic to provide life support. This is practical in an abundant-magic setting where the expense of upgrading items with self-powered Create Air and Create Water spells (using the Power spell) is low enough to factor into the ordinary cost of a habitat system. This provides the benefits of the No Life Support feature (p. 57), while still providing the vessel with a sealed hull and oxygen supply.

Magic-Powered

A high-energy system [!] can be designated as magic-powered. This means it uses "magic Power Points" as generated by a magical power plant (p. 30). It cannot use ordinary Power Points.

A magic-powered system is half-price and may be available at a lower or divergent TL.

Magnetic Tractor Beams

Tractor beams can be defined as superscience magnetic beams. Like heat rays, these are suitable TL7^ weaponry. They only affect vessels with an iron or steel armor system; otherwise they function just like tractor beams.

Methane and Ammonia Reaction Mass

Most reaction engines use hydrogen as the standard reaction mass, and provide an option to use water. Two alternatives are ammonia and methane, both of which are abundant on Earth and many celestial bodies. These increase acceleration at the expense of greater fuel consumption (i.e., reducing the delta-V).

Antimatter thermal rocket, antimatter plasma rocket, antimatter plasma torch, fusion rocket, fusion torch, nuclear thermal rocket, solar thermal rocket, super antimatter plasma torch, and super fusion torch engines can use these alternative reaction masses.

Ammonia: Use of ammonia multiplies acceleration by 2.9 but divides delta-V by 2.9. It costs $250 per ton. Extraterrestrial sources include gas giant atmospheres and comet ice.

Methane: Use of methane multiplies acceleration by 2.8 but divides delta-V by 2.8. Methane costs $500 per ton. Extraterrestrial sources include the atmospheres of Mars and the gas giants, and methane ice from outer system moons, asteroids, and comets.

Nautical Lines

A *streamlined* vessel can have nautical lines. Its hull is boat-shaped like a ship or flying boat, improving its performance should it land in water (or other liquid). However, they are not optimal for air propulsion, and a streamlined craft with nautical lines has only 20% of its normal top air speed.

At TL5 and lower, aerodynamic principles are poorly understood. The GM may require all streamlined vessels to use the nautical lines feature by default.

No Life Support

A craft built to operate in a breathable atmosphere can omit oxygen production equipment. There are three variations on this.

NBC Only (TL7): A nuclear-biological-chemical overpressure system that removes airborne fallout and toxins but won't provide breathable air if none exists. This is typical of filtration systems on tanks or surface warships. The extra space means it has 1.5× as many cabin equivalents in Habitats or 1.5× as many seats in Passenger Seating (round up), but cost also increases by 1.5×. It's still sealed, but lacks vacuum support.

Pressurized (TL5): A pressurized compartment *without* a sophisticated NBC filtration system, typical of high-altitude aircraft. Capacity increases by 1.5×, as above, but cost is unchanged. The system no longer counts as sealed, since it takes in air from outside.

No Life Support: The system is open to the outside atmosphere, like most surface vehicles or low-altitude aircraft. It's no longer sealed or pressurized. The extra room from removing life support allows twice as many cabin equivalents in Habitats or twice as many passenger seats in Passenger Seating to be carried. Cabins still have air conditioning, lights, plumbing, etc.

At TL4 or lower, materials technology is inadequate to provide a sealed hull: *all* vessels must take No Life Support, unless they have magical or exotic alternatives (e.g. *Magical Life Support*, p. 57; *Life Support Field*, p. 62).

Minifacs, teleport projectors, or hibernation systems don't benefit much from the extra space that reducing life support makes available. To represent this, increase the number of cabins these specialized rooms are exchanged for by 1.5× or 2×. Thus, if a vessel has No Life Support (doubling the number of cabins that fit in each Habitat), each minifac installed would be exchanged for two cabins instead of the usual one. Similarly, when replacing cabins with cargo, each unused cabin only provides either three tons (NBC Only or Pressurized) or 2.5 tons cargo (No Life Support) rather than the usual five tons.

An SM+3 Passenger Seating system is already assumed to have no life support: it cannot take these options.

Both of these options are incompatible with Total Life Support. However, either can still be combined with the use of Open Space systems to grow food.

Open-Frame Armor

Armor systems can be designated as open frame. This has four times the normal dDR but only protects against crushing damage from collision with vessels and large objects of SM+4 or more. Open-frame armor gives no protection against weapons fire (including missile impacts, unless the missiles are themselves SM+4 or more).

Optimized Hangar Bay (TL7)

Hangar bays on an SM+8 or larger vessel may be optimized to carry a particular size of craft: That SM must be at least 3 levels smaller than the carrier's. Record this along with its capacity, e.g., "Hangar Bay (300 tons, optimized for SM+6 craft)." Optimized bays have double the listed launch and retrieval rates (see p. 49) for that SM of craft, but the rates are halved for all other ships. There is no extra cost.

Phased Arrays

Advanced laser weapons can incorporate phased-array optics: a two-dimensional emitter composed of numerous cells that projects either a single powerful beam or multiple smaller beams, of variable intensity.

Any major battery equipped with a laser or ultraviolet laser can be designated a phased array. Such batteries appear two TLs later than usual (TL11 for lasers and TL12 for ultraviolet lasers) and cannot be combined with the improved, rapid fire, or very rapid fire options. A phased-array laser or UV laser has the option of firing as a rapid fire weapon at one-tenth output or as a very rapid fire weapon at 1/100 output. In addition, if a phased array does not fire it can perform the active sensor (ladar) or laser communicator functions (only) of an equivalent-SM tactical array.

Psi-Powered (TL^)

A high-energy system [!] can be designated as psi-powered. This means it uses "psi Power Points" as generated by a psychotronic power plant (p. 31). It cannot use ordinary Power Points.

This feature is most suitable for systems that can be explained as psionic in nature. In particular, contragravity lifters, cloaking devices, force screens, standard or rotary reactionless drives, and stardrive engines are appropriate expressions of psi-powered technology. So are weapons batteries that mount graviton or tractor beams (explainable as telekinesis) and heat rays (pyrokinesis).

A psi-powered system is half-price and may be available at a lower or divergent TL.

Psi Shielding (TL^)

This psychotronic grid generates a telepathic mind shield that alerts the crew if a telepath outside the vessel attempts to affect or scan those within it. The system's resistance bonus is its TL-6 (minimum +2). Add the resistance bonus to IQ or Will when the occupants resist a mind-disruptor attack (p. 40) or an advantage with a telepathic power modifier. The shield also resists attempts to locate the occupants' minds using psionic abilities. Such powers must win a Quick Contest against an occupant's Will + the shield's resistance bonus. The GM may allow psi shielding to protect against *Communication and Empathy* or *Mind Control* spells (see ***GURPS Basic Set*** or ***GURPS Magic***). The cost depends on the vessel's SM; see the *Psi Shielding Table* (below).

Psi Shielding Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Cost ($)	500K	1M	2M	5M	10M	20M	50M	100M	200M	500M	1B	2B

Ram

A streamlined vessel with an armored front hull can be reinforced for ramming attacks. Double the dDR of its front-section armor vs. the crushing damage inflicted when it initiates a collision. The ram costs 50% of the price of the front section armor.

Regeneration and Self-Healing

The vessel's hull and structure materials incorporate swarms of self-repair microbots or nanomachines or, if a living thing, their biological equivalent. Damage is rapidly patched. If the vessel is reduced to -5 × HP, it can no longer repair itself: There isn't enough structure left.

Regeneration (TL^): The vessel regenerates 1% of its dHP every minute. This option costs $0.2M per ton of vessel mass, e.g., for an SM+7 (300 ton) spacecraft it costs $60M.

Self-Healing (TL10 or TL^): As above, but the rate is per day. The option costs $0.02M per ton of mass.

Requires Nutrients (TL10 or TL^): The vessel regenerates 10% of its dHP per day, but requires specialized materials equivalent to 10 man-days of food ($20, 0.02 tons) per day times the vessel's dST. If not fed, the vessel will not heal, and will actually *starve*: reduce HT by one per day. The option costs $0.02M per ton of mass.

Spin Gravity (TL7)

Larger *unstreamlined* spacecraft may be designed so part or all of the ship can spin to simulate interior gravity. The maximum gravity (G) possible is shown on the Spin Gravity Table; it can spin slower for lower G. Spin gravity does not provide simulated gravity to core systems. A spacecraft using spin gravity is a -2 on its Handling while spinning.

Spin Gravity Table

SM	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Max G	0.1G	0.15G	0.2G	0.3G	0.5G	0.7G	1G	1.5G
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M

Spin Tethers

A common method of producing higher spin gravity on small vessels is a *spin tether:* Two separate spacecraft with the same Size Modifier are linked by a cable and spun using the vehicles' reaction-control thrusters. Their separation is 100 yards per G, and at least one of the vessels must have an external clamp system.

The cable must be carried in one vessel's cargo or hangar bay and is 1/20,000 of the mass of both vehicles per 100 yards of tether length. It costs $10 per ton of loaded mass. If sufficient cargo space is available, the tether can be retracted. A spacecraft using spin tethers must retract them and cancel its spin before accelerating or changing facing.

Stealth Hull Options (TL8)

Spacecraft may have either or both of these hull options:

Stealth (TL8): The spacecraft hull is harder to detect with sensors. Subtract (TL-6) × 2 from rolls to detect it.

Dynamic Chameleon (TL10): The spacecraft has a digital chameleon surface that can blend the vessel into the background or paint the surface with any desired markings or imagery. It gives a -4 penalty to detect the vehicle with ordinary vision only.

Stealth Options Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Cost ($)												
Chameleon	90K	180K	350K	700K	1.5M	3M	7M	15M	35M	70M	150M	350M
Stealth	125K	250K	500K	1M	2M	5M	10M	20M	50M	100M	200M	500M

Top Deck

A spacecraft can have a flat upper deck (like that of a seagoing ship) on one of its surfaces, where occupants can move about. A vessel with a top deck has a maximum air speed of 500 mph.

Torpedo Tubes and Torpedoes

Any launchers may be designated as torpedo tubes to fire projectiles underwater. Torpedo tubes hold only 80% of normal shots (round up) but can fire both torpedoes and missiles (the latter rise out of water to hit surface, air, or space targets).

Torpedoes have the same warhead, cost, etc. as missiles but operate underwater. Typical TL8+ torpedo are Acc (TL-5), guided or sonar homing, with Move 25 and a range of (1,000 × diameter) yards. TL7 torpedoes are Acc 2 with half that range and Move 25. TL6 torpedoes are unguided, Move 20, Acc 1, with a range of (100 × diameter) yards.

Winged

A streamlined spacecraft of up to SM+12 may be designated as *winged*. It has a wing (and perhaps a tail) and structural strengthening, providing extra lift and better handling when flying in atmosphere. The *Winged Table* shows cost:

Winged Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***
Cost ($)	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	-

Design Switches

These are design choices that apply to an entire setting or class of technology, rather than to a specific vessel: Unlike design features, they ofen apply to *all* vessels using that technology.

Accelerator Tube Limits

In a hard science campaign, GMs may rule certain weapon systems require massive linear accelerator tubes. This means they are only installed in spacecraft with a minimum hull size. This restriction is reasonably applied to particle beams, antiparticle beams, ghost particle beams, gamma-ray lasers, and X-ray lasers. For a *fixed* mount, the minimum rated SM is +10, while for a *turret* mount, the minimum SM is +12.

Thus, for example, a *Spinal Mount* (p. 35) weapon taking up three systems in a SM+9 vessel counts as a SM+10 fixed-mount weapon, and satisfies the limit; whereas a "secondary battery" turret taking up 0.1 systems in a SM+13 vessel counts as a SM+11 turret-mount weapon, and does not satisfy the limit.

Logically, if this switch is used, it means these weapons are unfeasible as personal weapons or on small vehicles.

Boost Drives

Any reactionless drive (including ether or astral drives) can be designated a boost drive. Such designs instantly raise a ship to a substantial velocity without acceleration effects. Boost drives suffer other campaign-specific restrictions at the GM's option, e.g., not functioning, or reduced function, when close to a planet or star's gravity well.

Boost drives have a limited top speed (less than reactionless drives) but can reach that velocity immediately. Instead of constant acceleration, they have a set speed; the GM should establish a figure to suit his campaign. Multiply the acceleration of all boost drives by this base speed. Some suggestions are given below.

One game-balance issue is speeds suitable for local maneuvering and combat are too slow for lengthy interplanetary voyages. The GM can remedy this by giving boost drives a jump in performance under certain conditions, as when they are outside a world's gravity, or outside a solar system in interstellar space. A sample set of numbers for converting reactionless drives into boost drives is:

• Top speed is 10 mps × acceleration within 10 planetary diameters of a world or other large celestial body.

• Top speed is 100 mps × acceleration outside the above radius but within a solar system.

• Top speed is that of light (as a lightspeed drive), or FTL-1 per engine (if a stardrive with the reactionless design switch) once outside a solar system (e.g., about 75 AU from a Sun-like star; see *Warp Drive* (p. 80).

The GM varies these figures as appropriate. For example, in a geocentric universe where solar systems sit within crystal spheres floating in an astral void, the GM may rule top speed (say, light speed or FTL) is only obtained when the crystal spheres are breached.

Boost drives always use the pseudovelocity design switch (p. 64), so there's no need to record this in the ship's description.

Boost drives can use cosmic power (p. 60), drive field (p. 61), negative mass propulsion (p. 63), and stardrive (reactionless) design switches (p. 65). Special rules apply to combat and travel with boost drives; see Chapter 3 for details.

Cosmic Power

In some space opera universes, vessels employ starkly powerful energies far surpassing baseline levels! To handle this, apply the Cosmic Power switch.

Any antimatter or superscience Reactor may be designated as producing Cosmic Power Points instead of Power Points. Typically, their reactor fuel will incorporate some rare hypothetical element or be stored in compact superdense form (at 10× refueling cost or more).

High-energy systems that require Cosmic Power Points are "cosmic powered." The main effect is on beam weapons and force screens:

Cosmic beam weapons get 1,000 times their output: Raise kJ to MJ, raise MJ to GJ, raise GJ to TJ, and raise TJ to PJ (petajoules), e.g., 300GJ becomes 300TJ, which increases damage (see p. 37). Cosmic electromagnetic or grav guns get 10× minimum velocity (see chapter 3) and their sAcc is also increased by +3.

Cosmic force screens get 10 × dDR.

In addition, the following superscience systems can be specified as requiring Cosmic Power Points to work *at all:* cloaking device, contragravity lifter, jump gate, reactionless drive, replicator, stardrive engine, stasis web.

Reactionless drives will usually use either super reactionless or subwarp variants.

If the Cosmic Switch is used, assume spacecraft have enough auxiliary power to power any ordinary systems that use mere high-energy systems without installing power plants! Some ***Ultra-Tech*** gadgets (e.g., disintegrators) assume cosmic power levels!

If using this switch, GMs may optionally make TL^ "cosmic armor" standard as well, at no extra cost for any armor type. Cosmic armor has 10 × dDR (perhaps due to enhancing the nuclear forces binding matter together or a coating of low-cost hyperdense matter) made possible due the vast amount of extra power available to such a society.

Drive Field

Some reactionless drive engines, star drives, or ether drives may generate defensive fields as a side effect of their drive. The GM may rule that any reactionless engine is also a low-powered force screen at no extra power cost. Most often they function as screens with the kinetic and sometimes "partial" design switches (usually either the front or central hull). Ether drives often have only the life support field option.

Exophase Drives: In some settings, the field generated by a warp or pseudovelocity drive is the same as that of an exophase field (p. 45). If this is the case, activating a warp drive automatically puts the spacecraft into exophase; it cannot be used without doing so. There is no added cost if this is a standard setting feature; otherwise, a drive that is also an exophase field costs double the price of *both* of these components. (A warp drive with an exophase drive field is functionally equivalent to a hyperdrive.)

Electro-Mechanical Computers

Computers can be much slower than the baseline. This is typical of some "retrotech" settings, such as golden age space opera. Reduce computer network Complexity by -1 at TL7, -2 at TL8, -3 at TL9, -4 at TL10+.

Etheric Cosmos and Ether Drives

In the 19th century (TL5) light was shown to be a wave, like sound, but what did it travel through, especially in the airless void of space? Physicists speculated the universe was filled with a tenuous form of matter so thin, solid planets passed through it unhindered. They named this substance the luminiferous ("light-carrying") ether.

In addition to *Ether Propulsion* (p. 14), reactionless engines (p. 24) can be defined as "ether engines" that interact with that substance for propulsion. This is a divergent technology (splitting from the mainstream path at TL5). For example, a TL10 standard reactionless engine can become a TL5+5 standard ether reactionless engine.

Exofield Variants

As presented, exophase fields (p. 45) are somewhat cinematic as well as superscience. The following options adjust the way various real and superscience technologies interact.

No EM Interactions: Logically, if an object in exophase has an electromagnetic "ghost image", then it will also interact with lasers, radar, and the charged particles that make up ordinary matter. Conversely, if it is *completely* intangible to matter, it should have *no* electromagnetic signature. With this switch in effect, a vessel in exophase is invisible *and* blind to the outside world, with any sense that relies on electromagnetic waves (radar, ordinary and hyperspectral vision, etc). It must rely on inertial navigation, along with occasional "lookabouts" in normal phase. The vessel can also see with, and be detected by, *passive* gravitic sensors, at the usual -8 penalty in both directions: such sensors are normally TL11^.

No Force Interactions: With this switch, "force" and "gravitic" technologies work on different principles, and only the latter can cross an exophase boundary. Objects in exophase cannot use or be affected by tractor beams, force screens, and the like. Optionally, force screens might affect an exophase vessel *only* if they themselves have certain options, such as *Reality-Stabilized* (p. 62).

Exposed Radiators

If this switch is used, vessels operating in space have large radiator arrays. This is realistic, but often ignored even in hard science fiction!

Exposed radiators are appropriate for any "hard sf" spacecraft with any reactor, or which use any fission, nuclear pulse, fusion, antimatter, or total conversion engine *except* nuclear thermal rocket, external pulsed plasma, or *high-thrust* antimatter thermal rocket engine.

A vessel with exposed radiators has a retractable "main radiator array" extending out like a set of wings or fins. It is not a system – its mass is included with the power plant or drive. But it is vulnerable to damage and special rules apply to using them (or retracting them in combat) – see *Main Radiators in Combat* (p. 109).

Coolant Tanks: A spacecraft with a main radiator array may fill some fuel tanks with coolant to prevent overheating if the radiator is damaged or retracted. Each fuel tank filled with coolant extends operating time when radiators are non-functional by 100%.

Force Screen Variants

Various options are possible for screens. In some settings, specific options may be mandatory. The cost modifier may be applied to the cost of the force screen system, but this is recommended only if multiple variants exist in the same setting. If a mandatory "switch" is applied to all screens, don't worry about it.

Adjustable: Screens can be angled to increase their current dDR across a particular hull section by ×2 at the cost of halving (round down) current dDR across both other hull sections. In combat, this is done when screens are powered up. +100% cost.

Force Wings: A vessel with the adjustable force screen variant can also try to extend and shape that screen to form streamlined, aerodynamic wings providing lift. Readjusting it to serve as force-field wings is an engineering task; it can be done whether the shield is powered up or not. When a screen is used this way its dDR is halved, but the spacecraft gains all the benefits of streamlining and the winged design option. (If it's already streamlined, it gains the benefit of being winged.) This option is incompatible with the energy and nuclear damper force-screen variants.

It adds +50% to force screen cost. The screen must also have the adjustable variant.

Cloaking: Functions as both a screen and cloaking device (p. 42) whenever turned on. +100% cost.

Energy: Only protects against beam weapons (or energy melee weapons like force swords), radiation, and the burning damage of nuclear or antimatter blasts. -50%.

Hardened: The screen is hardened (p. B47) vs. all attacks, e.g., a graviton beam's normal (1/100) divisor vs. screens becomes (1/10). +50% cost.

Kinetic: Only protects against physical attacks, including collisions, conventional gun or missile warheads, and the crushing damage from explosions (including nuclear or antimatter blasts in atmosphere). It won't protect against beams, radiation, or the burning damage from nuclear or antimatter explosions. Useful for GMs who want to downplay missiles without diminishing beams. -50% cost.

Life Support Field: A light force screen can have this option. It is low-powered (DR 0), sufficient only to create a bubble of atmosphere around the vessel. The field's radius is equivalent to the spacecraft's longest dimension (so a 100-yard ship has a field that protrudes 100 yards in either direction extending out from the hull). It provides no protection against attacks, but keeps out rain, snow, or gases (up to five atmospheres of pressure), and there is no risk of depressurization even if holes are blown in the hull. Similarly, in space people can venture onto the ship's surface without suits. A magically powered screen with a life support field is a good option for low-tech spacecraft, which would otherwise have to take the No Life Support feature (p. 57). This is incompatible with other force field options. It is -80% to cost, and it can be integrated at no extra cost with a drive field (p. 61).

Nuclear Damper: Provides no dDR but instead prevents nuclear warheads from detonating. Read "dDR" as "field radius in miles" around the vessel. You can have both a nuclear damper and another force screen.

Opaque: Vision and sensors can't see in through the screen – it just appears a blank bubble (often black or silver) surrounding the vessel. The vessel can be detected and attacked, but sensor analysis tasks against the vessel are impossible and enemy gunners may not target precise locations. People inside can see out normally. +50% cost.

Partial: Screens only affect the hull section they are placed in, but have triple dDR.

Reality-Stabilized: Teleport projectors (and optionally other teleport or Warp effects) will not penetrate it. Gets 1/5 dDR vs. ghost particle beams. +100% cost.

Two-Way: Screened vessel may not fire or launch anything the screen stops. If the screen is opaque, the vessel's crew may not detect other vessels or use sensors. -40% cost.

Velocity: Slow moving objects can pass through the screen. You can walk or throw a baseball through it, but anything over 100 mph (Move 50) is stopped. Does not protect against minimal-speed collisions. -10% cost.

Unless noted, options can be combined at cumulative effect on cost. A screen may not combine energy, EM, and kinetic. Minimum cost of a screen is 10% of listed cost.

FTL Comm/Sensor Arrays (TL^)

The active sensors and/or communicators in a comm/sensor array may optionally work at faster-than-light speeds.

FTL active sensors usually also have extended ranges, but in game terms mainly serve to justify safe navigation using warp drives. The GM may multiply active sensor ranges by 10, or vastly increase them (measured in AU, or even parsecs).

FTL comms allow communication over interstellar distances. GMs can assume FTL signals are instant and comm suite ranges in AU are now measured in parsecs, or give the signal a finite (but faster-than-light) speed. See ***GURPS Space*** for various options.

Gravitic Focus (TL^)

All beams except graviton beams, tractor beams, X-ray lasers and grasers may have gravitic focus (or some similar gimmick) to boost range at the expense of damage. When turned on, treat as if the weapon has 10× its output for range but 1/10th its output for damage. Gunners may opt to turn on or off gravitic focus.

Greater Survivability

Some GMs find that the balance of weapons vs. armor is tilted too heavily in favor of the offense, resulting in ships that seem to be "egg shells armed with hammers." This is in the spirit of 21st century naval and air warfare, but does not emulate space opera combat closer to the feel of 19th and 20th century battleship combat. To improve survivability, GMs may apply one or both of these optional Design Switches.

Advanced Armor: All TL8+ armor types (metallic laminate, advanced metallic laminate, nanocomposite, organic, diamondoid, exotic laminate) are automatically hardened at no extra cost. Vessels that buy hardened armor are in fact *double-hardened* (i.e., they reduce armor divisors by two steps).

Damage Reduction: A high-tech vessel has extensive internal compartmentalization and sophisticated internal damage control systems such as automatic fire suppression, multiply redundant electronics, etc. This may justify giving vessels Damage Reduction 2 (***GURPS Powers***, p. 53). Divide damage suffered by 2 *after* subtracting armor dDR and any other damage modifiers. The GM may rule that a ship that is poorly maintained (HT 8 or less) or is caught completely unprepared for trouble may not qualify for Damage Reduction.

Missile Shield: This option assumes that beam weapons can *easily* hit ballistic weapons that are targeting their vessel, and that this process can be automated. Beam weapons that are assigned to point defense may therefore *automatically* hit a number of incoming ballistic weapons (or ramming spacecraft) up to their maximum rate of fire. Ballistic weapons are killed; ramming spacecraft will suffer damage normally.

Hazardous Drives and Power Plants

Much of the mass of a fission rocket or reactor is radiation shielding. Any fission reactor, air-ram, or reaction engine can be built with minimal shielding. This doubles the acceleration of an engine or air-ram, or doubles the Power Points of a reactor, but makes the device dangerous. It is safe until turned on. However, during operation it gives off a lethal radiation flux (6,000 rads/second). Once used it remains highly radioactive for the next few thousand years. The worst of the waste products decay after a few weeks of disuse, dropping the radiation to 2,000 rads/hour.

Full radiation applies only in the same system (e.g., in a workspace). Exposure is divided by 25 elsewhere in the same hull section and is negligible in other hull sections.

Spacecraft with unshielded engines or power plants are harder to maintain due to the difficulty of working with irradiated systems, and the risk of cumulative damage to other components such as electronics. Apply a -1 to the vessel's HT for each *hull section* that contains any unshielded systems.

Hyperdynamic Field (TL^)

What if hyperspace is filled with a medium significantly denser than vacuum (or the ether)? A vessel with a hyperdynamic field generates a superscience energy field across its body surface that extends into this hyperspace even as the vessel itself occupies normal space. This generates friction; the result is that a spacecraft can then maneuver through space as if it were in an air-filled zero-g environment. Power requirement is negligible. The cost depends on the vessel's SM; see the *Hyperdynamic Field Table* (below).

For more details see Hyperdynamic Cosmos (p. 81) for operating parameters. The maximum speed a vessel can achieve varies, but depends mainly on its drag: Fast hyperdynamic craft are streamlined!

In some universes, a hyperdynamic field is an integral part of all reactionless drives. If so, the GM may assume the hyperdynamic field is part of the drive and need not be purchased separately.

Hyperdynamic Field Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Cost ($)	200K	500K	1M	2M	5M	10M	20M	50M	100M	200M	500M	1B

Maturing Living Ship

Living vessels can become larger over time. To create such a race, the GM determines their longevity and growth cycles. A vessel can be bought as an infant and grown to adulthood. For simplicity, assume ships go through three growth phases and maturation takes (initial Size Modifier) years per phase:

Initial SM: Infant (or egg).

Initial SM + 1: Child (reached after (initial SM) years as an infant).

Initial SM + 2: Adolescent (reached after (initial SM) years as a child).

Initial SM + 3: Maturity (reached after (initial SM) years as an adolescent).

Whether the individual systems of the ship become larger (the usual assumption) or actually change from infancy to adolescence is up to the GM.

Higher-TL vessels benefit from bioengineering by maturing faster. At TL9, divide the time by 2; TL11, by 4; and TL12, by 8.

Multiscanner Array (TL^)

The active sensors in a science or multipurpose array may be optionally be designated as a superscience system that uses para-radar technology. Multiscanner arrays can use their active sensors to scan for life, chemical composition, energy readings, etc.

Negative Mass Propulsion (NMP) Drives (TL^)

Any reactionless drive may be an NMP drive. It uses the juxtaposition of ordinary positive mass and exotic matter that has negative mass (and negative inertia) to provide continuous thrust. It requires neither reaction mass nor energy, and does so without violating the principles of conservation of momentum or energy. It does require the creation of a sizable negative mass, which is expensive. NMP drives are not high-energy or cosmic energy systems but the drives are 10× as expensive.

Low-Tech Vessels

This box serves as a "meta-switch" to highlight those switches and features that apply to non-divergent non-superscience low-tech settings. Some of the switches may be omitted if the setting has a magical or exotic replacement for the missing technology.

- A TL6 setting will normally have No Computers (below).
- A TL5 setting will additionally have Pre-Radio (below).
- A TL4 setting will additionally have No Life Support (p. 57).

No Computer

This is applied to controls systems, particularly in divergent-technology vessels with (TL5+1) or (TL5+2). Computerized systems are completely replaced with manual systems. For targeting and navigational calculations officers rely on their own abilities and charts, slide rules, books of logarithmic tables, etc. Encyclopedias of planetary data, large libraries of expensive photo-slides, complex mechanical steering and stabilization systems, and bulky electromechanical keypunch devices all take the place of computers (and are just as expensive!).

Controls with no computer cannot be unmanned (i.e., built with no control stations).

In addition to being unable to run any computer programs or AI software, the following effects are applied:

Multitasking: All multitasking penalties are *doubled*. Ships with no computers tend to have larger crews!

Gunnery Tasks: Attacks are made at a -5 penalty. Point-defense fire is realistically impossible, but the GM may allow it at a further -5 penalty (total -10).

Sensor and Navigation Tasks: These take 10 minutes each; apply haste penalties from p. B346 to do them faster. Thus, trying to fight in 1-minute turns while performing navigation or sensor analysis requires a very skilled crew.

Communication Tasks: The rules for sensor and navigation tasks apply to signal-enhancement tasks.

Pre-Radio

This option, typical of TL5 and lower designs and their divergent technologies, can apply to a controls system or comm/sensor array. Sensor arrays use only optical telescopes (no active sensors). No comm systems are included at TL3 or lower, and at TL4+, radio and laser communications are replaced with a heliograph for signaling.

Pseudo-Velocity

Reactionless drives and stardrives may produce motion without accumulating momentum or kinetic energy. The drive does not produce acceleration effects on the ship or anything inside it (it's in zero G unless given artificial or spin gravity; crew and vessel don't experience acceleration). If turned off or disabled, a vessel loses all speed gained as a result of acceleration while under pseudo-velocity. In the event of a collision involving the vessel, do not count velocity reached while under pseudo-velocity drive.

Ramscoop Drag

Realistically, ramscoops (p. 33) will create some drag as they collect gas, limiting their top speed. Maximum speed is 300× the delta-V per fuel system specified by the propulsion system. Propulsion *not* fueled by a ramscoop can add its delta-V on top of this. If the final speed is a significant fraction of (or larger than) the speed of light, then it represents a relativistic *rapidity* as given on p. 78.

Realistic Power

In real units, one Power Point equals 1 MW per ton of system mass (50 kW per ton of rated hull mass). To conform with physics, reduce the thrust of ion drives by ×1/5 and mass drivers by ×1/10.

Singularity Drive

Any *stardrive* or *reactionless drive* engine may be a singularity drive, using a miniature black hole or similar object as its power source. It requires no Power Points, but is costly (5× cost) and massive: spacecraft must have SM+(22-TL) or greater.

Slower Industrial Systems

The production capacity for industrial systems can be too high for economic realism or game balance (especially if they are owned by player characters). This design switch reduces the production or refining rate of mining, refinery, fabricator, robofac, nanofac, and replicator systems from "per hour" to "per day." Systems at TL5 drop to "per month" and at TL6, to "per week."

Alternatively, the listed production rate for factories might assume a ready supply of standardized components, circuit boards, hardware, feedstock, etc., with the slower rate applying if the factory must machine, print, or nano-assemble its own components from raw materials and scrap. This *replaces* the slowdown factors for microtech assembly or salvage from ***GURPS Ultra-Tech*** p. 90.

Stardrive Fuel

Rather than assuming they include any necessary fuel, stardrive engines may optionally require separate fuel tanks. Typically, the contents of an entire fuel tank provides enough fuel for one stardrive engine for one jump (if a jump drive) or one week of travel (for hyperdrive or warp drive). Fuel may be hydrogen, or more exotic.

Stardrive (Reactionless)

A stardrive (usually a warp drive or hyperdrive) with this option can function at sublight speeds exactly as if it were a reactionless drive. Sometimes such drives simply boost to light speed as a prerequisite for "going FTL." Specify the type of reactionless drive in parenthesis, e.g., Stardrive (Super Reactionless). No extra cost if this is standard feature of the setting's stardrives, otherwise twice the combined cost of *both* drives.

Zombie Vessels

These are undead vehicles created and reanimated via magic. They appear badly damaged or crippled, showing the violence that disabled them. They do not hold atmosphere, or do so only in a few compartments.

A zombie vessel behaves as if it had the Automaton meta-trait, with an IQ equal to its (modified) computer's (Complexity/2) + 3, regardless of whether originally sentient! If it did not have any computer system, assign IQ 2.

They appear (and show on sensor arrays) as cripples. Their drives and power plants have no IR signature (p. 85); treat as minimal power.

Despite apparent damage, most systems still function. Exceptions are noted below.

Armor: Functions normally.

Controls Reduce computer Complexity by 1.

Comm/Sensor Array: Signals are scarily distorted, as if the person or machine using the communicator had Disturbing Voice (p. B132).

Force Screens: Zombie ships can spontaneously develop other force screen variants such as nuclear damper ("Nukes won't stop it!"), opaque ("Its screen was solid black"), or reality-stabilized ("Why can't we teleport out of here?").

Habitats: These no longer function (or optionally, only function if the spaceship wishes, so it can turn life support on or off, usually at inconvenient moments for any visitors). If they don't function, occupants have to look after their own life support needs. Automeds appear to function ("Looks like sick bay was sealed off") but may be imbued with the vessel's malign spirit. If used, they inflict 1d+1 cutting damage per turn as they flay and dissect the patient. (To escape, roll vs. ST-5 each turn to force the automed's lid open or disable it.) If a corpse is left in the automed for an hour or more, it is reanimated under the ship's control as per the Zombie spell (p. B252).

Power Systems: These provide exactly enough Power Points to operate all high-energy systems, but do not consume fuel, use up endurance, or produce excess power.

Fuel Tanks: These are no longer required, though the GM may rule a vampire ship needs a tank full of blood, which it devours at the usual rate of fuel consumption. Reaction engines no longer require reaction mass, effectively becoming reactionless engines, yet somehow are unable to accelerate faster than their original delta-V.

Weaponry: Ammunition is still required. If the battery runs out, it can't be used unless the vessel has appropriate factory systems to produce it or it captures more.

Except as noted above, a zombie vessel's performance statistics remain as they were in "life." Undead vehicles don't require maintenance, but lost HP are repaired normally. Zombie vessels that had Regeneration or Self-Repair design features by virtue of being living creatures lose their abilities upon becoming undead.

Zombie Vehicle Spell

Creates an undead vehicle. The target must be disabled (i.e., 0 HP or less) but not utterly destroyed (-5 × HP or worse). Robotic vehicles must also have an intact computer.

Duration: Remains animated until destroyed.

Cost: 400 energy points per ton; minimum cost is 8.

Time to Cast: 1 minute.

Prerequisites: Animate Machine and Zombie.

CREW

Suggested crew requirements are given below. On vessels organized on hierarchical lines, 10% of the technicians and most of the bridge crew are usually officers, often provided with better quarters.

AI Crew

Bridge crew, gunners, and administrators may be sapient computer programs, running either on the vessel's basic computer network included with its *Controls* system (p. 43), or on supplementary *Computers* systems (p. 42). Other crew must be live or robots (e.g. Techbots, ***GURPS Ultra-Tech*** p. 85).

GURPS Ultra-Tech, pp. 27-28, provides detailed rules for sentient programs. In brief: a fully-volitional artificial intelligence program (with the AI meta-trait from p. B263) has a Complexity of IQ/2 + 3. Subtract 1 from Complexity for a non-volitional AI (adding the Automaton meta-trait from p. B263); subtract 2 from Complexity for a weak AI (adding Automaton *and* the Cannot Learn disadvantage, p. B125). A software emulation of a living (or formerly-living) person has a Complexity of IQ/2 + 4, based on the *racial* IQ (not the individual's IQ score); subtract 1 from Complexity for species with fixed IQ.

In some settings the GM may rule that sapient programs have special hardware requirements, such as quantum computers (p. 42), but this is not required by default.

An AI pilot can operate a vessel using a DX score in place of an operating skill, as noted under *Other Statistics* (p. 70).

Control Room Crew

One per control station. If there's only one or two control crew, they're usually styled as a pilot and co-pilot. If more, generalize them as "control room crew" or specify various duties or combinations as desired: this can include commanding the spacecraft ("captain" and possibly also "executive officer"), maneuvering the vessel ("pilot"), plotting courses, especially for hyperdrive or jump drive ("navigator"), controlling drives and power plants ("chief engineer"), operating comm/sensor arrays ("communications officer," "sensor operator," "tactical officer," or "science officer" depending on array type), and control of weapon batteries or missile batteries ("gunner").

Turret Gunners

Weapons battery turrets can be controlled from the control room, but also include their own dedicated control station. They are often assigned one gunner per turret.

Technicians for Workspaces

Add up the number of workspaces on the vessel, modifying for automation (p. 54) or lack thereof (p. 56) to find the number of technicians required. Either list that total number of technicians, or for greater detail, specify them by job title based on the Repair skill required (e.g., armorers or life support mechanics) and/or system ("habitat techs"). Warships sometimes carry 2-3× that number of technicians, for extra damage control parties and to replace casualties.

Medics

If a spacecraft habitat has sickbay beds, it should have one medic per 10 (or fraction thereof) non-automed sickbay beds or 20 stretchers.

Passenger Care and Entertainment

Accommodations assigned to paying passengers usually have a passenger attendant for every two luxury-class, five first-class, or 20 economy-class passengers.

Small Craft

Spacecraft may have dedicated crews for any small craft they carry in hangars. Craft used only occasionally (e.g., lifeboats) may not have a dedicated crew; control crew or others will man them as needed. Craft are maintained by hangar workspace techs.

Specialists

Spacecraft whose habitats contain labs, establishments, offices, ops centers, etc. may need appropriate workers (entertainers, administrators, scientists, computer operators, etc.); see the *Specialized Rooms for Habitats* (p. 48) box.

Nonhuman Accommodations and Crew Stations

Statistics assume the occupants are typical humans: 1.5 to 2 yards tall, less than a yard across, around 150 pounds, and of course, human-shaped. The GM may modify the cabin equivalents in a habitat, control stations in a controls system, workspaces in any system, or seats in passenger seating by the difference between the race's SM and the standard SM 0. For example, an SM+5 race treats its habitat as five SM *smaller* when determining the number of cabin equivalents. In general, large nonhumans have a minimum vessel size of (their own SM + 4). So an SM+4 race operates ships of at least SM+8.

Races with the same SM but different body shapes can use each other's stations, seats, or quarters, although not comfortably. Assess a -1 (*or worse*) penalty on skill rolls when using controls designed for a significantly different species.

SUPPLIES

At TL7+, vessels with passenger seating, controls with control stations, or systems with workstations, can have 24 hours limited life support (air and water), included with those systems. Recharging those life systems (including replacement of carbon dioxide scrubbers or NBC filters) costs about $200 per man-day at a maintenance facility. Alternatively, an "open" life system can dispense with scrubbers, but consumes about one ton of nitrogen/oxygen mix per 15 man-days of life support. See *Fuel Cost Table* (p. 28).

Vessels with TL7+ accommodations provide full life support, recycling water and air as needed, but must carry food supplies. Spacecraft with *total* life support, or with replicators or open spaces devoted to farms, may omit food supplies (though they might stock it for variety). Each 500 man-day supply is $1,000 and 1 ton. Gourmet supplies (suitable for first-class passengers) are 10× as expensive.

Before TL5, canning hasn't been invented and fresh food tends to spoil within a month or so. There are plenty of other foods that keep longer, but scurvy (induced by vitamin-C deficiency, caused by a lack of fresh fruit) is a serious threat after several weeks at sea or in space.

If a vessel has no means of acquiring or recycling water, it must carry its water supply. The mass required is one ton of water per 100 man-days ($20 per ton).

Fantasy vessel can avoid these issues with magical spells (Create Air, Create Food, Create Water, etc.); by using crews who need not eat or drink, such as golems or zombies; or even by placing passengers in suspended animation or turning them into stone for the voyage. ***GURPS Magic*** provides many spells that can help with logistical problems.

Statistics

Determine and record the vessel's statistics based on the design decisions. Normally these can be summarized in a vehicle *statistics block* as presented on p. B462.

Skill

For vessels with propulsion systems, the skill required to operate them depends on both the means of propulsion and/or lift, and, in many cases, the *size* of the vessel.

Space: Use Piloting (Lightsail) for vessels with lightsail propulsion, Piloting (Magsail) for magsail propulsion; Piloting (Low-Performance Spacecraft) for other propulsion systems with acceleration under 0.1G; Piloting (High-Performance Spacecraft) if 0.1G+; or Piloting (Starship) for FTL drives that require active maneuvering (including FTL drives with a sublight mode of operation).

Air: Use Piloting (Aerospace) for most vehicles flying with wings or thrust that are also capable of spaceflight. If flying with contragravity, use Piloting (Contragravity). If not capable of reaching orbit, use Piloting (Helicopter) if it uses helicopter rotors; Piloting (Lighter-Than-Air) if it uses gasbags; Piloting (High-Performance Airplane) if winged and top speed exceeds 600 mph; Piloting (Heavy Airplane) if winged and top speed does not exceed 600 mph; or Piloting (Vertol) if it relies on thrust to fly.

Water: For surface movement, use Boating (Large Powerboat) if the vessel is SM+6 or smaller, Shiphandling (Ship) if SM+7 or larger. For underwater movement, use Submarine (Mini-Sub) if SM+6 or smaller, Submarine (Large Sub) if SM+7 or larger.

Ground: Use Driving (Mecha) for legged or flexibody drivetrains; Driving (Tracked) for tracked drivetrains, or Driving (Heavy Wheeled) for wheeled drivetrains.

Robot or Sentient Body: If a vehicle has an artificial intelligence or a *Sentient Brain* (p. 52) piloting it, then the control systems can be integrated directly into the being's kinaesthetic awareness, allowing it to operate the vehicle with a DX attribute rather than a skill. See *Other Statistics* (p. 70). The GM *may* permit this with human operators using a neural interface, or with mind emulations of a living or formerly-living person, so long as the vehicle's shape and range of motion is sufficiently similar to the pilot's proper body.

TL

Record the *maximum* TL of all systems and features. Add ^ if any components use superscience. For divergent TL, determine the earliest point of divergence, then add tech levels to bring it to the maximum: e.g., a vessel with TL5+2 and TL10^ components would be TL5+5^.

dST/HP

Record the value from the *Hull Size Table* (p. 7) that corresponds with the chosen SM. If the vessel has *Empty Systems* (p. 8), round down to the next lower SM.

HT

This starts at HT 13. Reduce HT by 1 for each the following: if the vessel has SM+4 to SM+9 with no engine room; if using high or total automation at TL7-9; for each hull section containing unshielded *Hazardous Drives and Power Plants* (p. 63). Add +1 to HT if it has at least one SM+6 robofac, nanofactory, fabricator, or replicator system aboard. If it has the *Lacks Automation* feature (p. 56), add +1 to HT, and *ignore* the penalty for no engine room (above).

Hnd/SR

If the vessel has no propulsion system, omit. Otherwise, it will have a Hnd/SR score for *each* environment it can operate in. It may also have a different score depending on which drive it is using at any given time. This may be recorded in footnotes or a separate line in the statistics block.

For space, air, and watercraft (both surface and submersible), Hnd/SR is determined primarily by the vessel size. For ground vehicles, it depends on the ground propulsion or drivetrain. Propulsion and other systems may modify Hnd, SR, or both, as listed below.

Hnd/SR Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Space, air, water	0/4	0/4	0/4	-1/5	-1/5	-1/5	-2/5	-2/5	-2/5	-3/5	-3/5	-3/5
Flexibody	0/4	0/4	-1/5	-1/5	-1/5	-2/5	-2/5	-2/5*	-3/5*	-3/5*	-3/5*	-3/5*
One leg	+4/1	+3/1	+2/1	+1/1	-	-	-	-	-	-	-	-
Two legs	+4/3	+3/3	+2/3	+1/3	-	-	-	-	-	-	-	-
Three legs	+3/4	+2/4	+1/4	0/4	-	-	-	-	-	-	-	-
Four or more legs	+3/5	+2/5	+1/5	0/5	-	-	-	-	-	-	-	-
Tracked	-3/5	-3/5	-3/6	-4/6	-4/6	-4/6	-5/6	-	-	-	-	-
Wheeled	-1/4	-1/5	-1/5	-2/6	-2/6	-3/6	-3/6	-	-	-	-	-

* SM+11 and larger flexibody vehicles are cinematic.

General modifiers	
Small controls or sentient brain	-1 Hnd/SR per -1 SM
Enhanced controls	+1, +2, or +3 Hnd/SR
Air modifiers	
Contragravity lifters	+2 Hnd
Winged	+4 Hnd, +1 SR
Maneuver Enhancement	+1 Hnd per system
Ground modifiers	
Legged and streamlined	-1 Hnd
and winged	-1 SR
Tracks/wheels and wings	-1 Hnd

Air and space modifiers	
Acceleration less than 0.01G	-3 Hnd
Acceleration 0.01G+	-2 Hnd
Acceleration 0.1G+	-1 Hnd
Acceleration 1G+	+0 Hnd
Acceleration 10G+	+1 Hnd
Acceleration 100G+	+2 Hnd
Acceleration 1,000G+ or Boost Drive	+3 Hnd
TL4 or less	-2 Hnd/SR
TL5-8	-1 Hnd/SR

Maximum Hnd is +5 regardless of modifiers.

Move

For the most part, this is given in the individual drive system descriptions. For space movement, record acceleration in G and top speed in mps: e.g., "0.001G/375mps". Make a note if the top speed is in fact a Newtonian delta-V reserve. For other environments, acceleration is normally given in yards/second^2 (10× the value in G), and top speed is normally given in yards/second (half the value in mph or 1,800× the value in mps).

A few cases deserve special discussion.

Empty Systems and External Loads

Some vessels have *Empty Systems* (p. 8) that decrease its mass, while others may normally tow external loads that increase its mass. This will change the performance. Acceleration is multiplied by the ratio of the rated mass for the vessel's SM, divided by the total actual mass (reduced by empty systems, increased by external loads). For Newtonian delta-V, multiply the *effective number of fuel systems* by this ratio, which changes the base delta-V *and* the factor from the *Delta-V Increase Table* (p. 19).

Example: A SM+6 spaceship has a chemical rocket (3G, 0.15mps/tank), 12 tanks of fuel, and 4 empty systems. Its rated mass is 100 tons, but the empty systems reduce this to 80 tons. Its final acceleration is 3G × 100 / 80 = 3.75G, and it effectively has 12 × 100 / 80 = 15 systems of fuel, for a delta-V of 0.15mps × 15 × 1.4 = 3.24mps.

Air Move

This describes flying movement in a "very thin" or denser atmosphere (see p. B429), i.e., not trace or vacuum conditions. A ship can fly in atmosphere if it is winged, or has an acceleration greater than local gravity, or is equipped with a lift system such as helicopter rotors, a gasbag, or contragravity lifters with lift exceeding the vessel's weight. Streamlining helps but is not strictly necessary.

For some propulsion systems, such as helicopter rotors or boost drives, speed is set by the drive system. For others, maximum airspeed depends on SM, streamlining, and the acceleration provided by all drive systems that operate in atmosphere. The *Air Speed* table below lists the Base Speed assuming a streamlined aircraft with 1G of thrust. Multiply this by the *square root* of the acceleration in Gs, then by ×0.1 if not streamlined or ×0.2 if it has nautical lines. Speeds are in yards/second; multiply by 2 to get mph. For denser atmospheres, divide by the square root of the atmospheric pressure in standard atmospheres. (Note that air speeds and stall speeds assume fairly high levels of streamlining; many real aircraft will have a lower stall speed and *much* lower top speed).

The table can be extended to larger or smaller vehicles (such as missiles). Each -12 to SM divides speeds by a factor of 10.

Air Speed Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Base Speed	500	600	750	900	1,000	1,250	1,500	2,000	2,500	3,000	3,500	4,000
Stall Speed	100	120	150	180	200	250	300	400	500	600	700	800

SM

Record the rated SM of the hull, plus any modifiers listed under *Armor and Volume* (p. 9).

LWt.

Record the loaded weight corresponding to the rated SM, as listed on the *Hull Size Table* (p. 7). Reduce this by 5% for each *Empty System* (p. 8). If the vehicle design concept normally includes an external load (e.g., a towed craft), add its weight.

Load

This is the sum of the capacities, in tons, of all cargo hold, steerage cargo, and hangar bay systems, plus 0.1 ton per occupant.

Occ.

Occupancy is simply a summary of the vessel's personnel capacity. First, decide if the occupancy statistic will refer to accommodation or short-term occupancy. Usually accommodations are listed if the vessel has them; otherwise record short-term occupancy. If none, record 0.

Long-term accommodations provide full life support for an indefinite period. Occupancy is two per cabin or luxury cabin, four per bunkroom, cell, or cage. Record occupancy followed by the suffixes A (accommodations), S (sealed), and V (vacuum support): e.g., 20ASV. Submersibles or high-altitude aircraft add P (pressurized).

Short-term occupancy provides limited life support for one man-day times occupancy. It is split into crew + passenger occupancy. Crew occupancy is one person per control station, turret, or workspace, and two per lab, establishment, or office. The passenger occupancy is one per seat, stretcher, or sickbay bed, 10 per briefing room, 30 per establishment, 100 per open space. Usually this statistic is only recorded only if the vessel has no long-term occupancy. Record occupancy as "crew + passengers" followed by the suffixes S, P, and V as appropriate (omitting A): e.g., 2+6SV.

A vessel with the *No Life Support* feature (p. 57) will not have the S, P, or V suffixes. If it has the *Pressurized* option, this will give it the P suffix; the *NBC Only* option adds the S suffix as well.

Hibernation chambers are indicated in footnotes.

dDR

For each hull section, add up the total dDR of all armor systems in that section. Record the three sections' dDRs as *Front/Center/Rear*. If all three are the same, record a single dDR.

If using the *Armor by Facing* design feature (p. 54), record separate dDRs for the six facings: Front (F), Right (R), Left (L), Back (B), Top (T), and Underside (U).

Range

For land, sea, and aircraft, it is usually easiest to compute range by working backwards from the vessel's *endurance*. For powered propulsion systems, endurance is that of the power system, along with any fuel that it requires: see the power system's description. Jet engines (p. 16) are their own power system; compute their endurance similarly. Power consumption for these systems normally assume a *cruising* speed around 70% of top speed, so range is given by:

R = 0.7 × V × E.

R is range in miles.
V is top speed in mph.
E is endurance in hours.

Planetbound vessels propelled by reaction engines are treated differently. Endurance depends on the vessel's acceleration and delta-V:

E = 0.046 × dV / A.

dV is Newtonian delta-V in mps.
A is acceleration in G.

Range is then computed as above, but using the *full* top speed (rather than 0.7 × top speed).

If the endurance calculated above is longer than any expected mission, or the vessel's endurance is limited by other factors (such as life support or provisions), record a Range of "-". This is often the case with vessels powered by reactors, solar power, magic, or other exotic systems.

For space vessels, Range is normally given only for FTL drives, or drives with both a limited top speed (such as hyperdynamic or boost drives) *and* a limited power system endurance. In the latter case, compute Range as for an aircraft, above. In the case of an FTL starship, record the vessel's FTL rating: 1× for FTL-1, 2× for FTL-2, etc. This may convert to a range in parsecs according to the setting's FTL assumptions: see *Stardrives* (p. 80). Otherwise, record a Range of "-".

Cost

Total up the cost of all systems, design features, and switches to get the base cost of mass production. Optionally, include the cost of a full load of fuel and other consumables. Limited production (e.g., a NASA spacecraft) is 100-1,000 times cost!

Locations

Many vessels have no specific locations. Add the following locations for specific systems: "A" if it has robot arms (e.g. "2A" for two arms); "H" if it has helicopter rotors; "L" if it has robot legs (e.g. "4L" for four legs); "M" if it has ether or space sails; "Wi" if it is winged.

Each turret-mounted *large* battery is a separate "T" location (e.g. "2T" for two large battery turrets). For smaller turret-mounted batteries, you are free to decide whether multiple batteries in the same hull section are in the same or separate turrets. If this adds up to 3 or more systems in a single turret, it is a "T" location, otherwise it is a "t" location.

Vehicles with tracked drivetrains add the location "2C", or (optionally) "4C" if it is SM+7 or larger. Vehicles with wheeled drivetrains add "4W", "6W", or "8W", as desired.

Vessels with a top deck will have the "O" location. Vessels *lacking* armor systems will typically have a "G" location, representing unarmored windows or other openings. Vessels *with* armor systems will have a "g" location at TL6 or less; at TL7+, armored glass or electronic sensors remove this vulnerability.

Draft

For watercraft operating on the surface, the minimum depth of water that they require is 1/20 of the length listed in the *Hull Size Table* (p. 7). Multiply by 1.5 if streamlined (including nautical lines).

If the weight of the craft is *partially* offset by lift systems (such as contragravity), look up the SM corresponding to the *remaining* (uncancelled) weight. If floating in a liquid other than water, divide the weight by the specific gravity of the liquid relative to water, and look up that SM entry. If the weight lies between entries, use the larger SM.

Crush Depth

This is maximum depth a vessel can dive without being crushed by pressure. It's useful for submarines, but can also be important for spaceships landing in hostile high-pressure environments like Venus or flying in a gas giant atmosphere. The standard formula for the Earth's oceans is:

Crush depth = dDR × 4,500 / Length.

Crush depth is the depth in yards.

dDR is the *minimium* decade-scale damage resistance.

Length is the *actual* length of the vessel in yards.

For alien liquids, *divide* the crush depth by the world's gravity in G, and by the specific gravity of the liquid relative to water. For atmospheric operations (e.g., in a gas giant), divide crush depth (in yards) by 10 to get crush pressure in atmospheres.

Crush depth only applies if a vessel has *pressure-supported* systems, such as passenger and crew seating or habitats. A common design approach is to place these systems, along with extra armor, in an *Integrated Vessel* (p. 49), while other systems occupy the rest of the vessel. The inner pressure vessel is often spherical, giving it a reduced length for its SM.

Stall Speed

Vessels with an Air Move should list their stall speed. This is 0 if the vessel has helicopter rotors, a lift system exceeding its weight, or an air acceleration exceeding local gravity. Otherwise, it can only fly if it has wings. Stall speed depends on SM, and is listed on the *Air Speed Table* (above), in yards/second; multiply by 2 to get mph.

For non-terrestrial environments or high altitudes, multiply stall speed by the square root of local gravity in Gs, and divide by the square root of the atmospheric density (pressure) in standard atmospheres. If the weight of the vessel is *partially* compensated by contragravity or lift systems, reduce the effective "local gravity" accordingly.

This calculation makes the stall speed equal to the top speed for a vessel with an air acceleration of 0.04× local gravity (reduced by lift systems as appropriate). If a vessel does not have at least this much propulsion, then it cannot fly under its own power, though it may still maintain a controlled glide.

Notes

Additional details may be listed under the statics block, or in a separate description. For instance, you may want to note the vessel's performance in other environments; alternatively, these may be listed in separate table rows. A statistics block with multiple entries may have a *Notes* column to link particular entries with specific footnotes.

Other Statistics

A few other statistics may not be captured in a standard vehicle statistics block, especially if the vessel is to be treated as a *character* rather than a vehicle.

If the vessel has a *Sentient Brain* (p. 52) or an AI operator (p. 65), then it has an IQ score as given in those descriptions. Instead of an operating skill, it has a *base* DX score of 12 for a sentient brain or 10 for an AI. Small controls or a small sentient brain reduce DX by -2 per -1 SM, in addition to any effect on IQ. *Enhanced Controls* (p. 45) give +2 or +4 to DX, as listed.

None of the other Hnd/SR bonuses or penalties affect DX, though they do appear as enhancements or limitations to the character's Enhanced Move trait (p. B52), if any. *Increased Stability* is a new special enhancement to Enhanced Move, at +5% per +1 Stability Rating, just like the *Handling Bonus* enhancement.

Chapter Two

Space Travel

Rules for basic vehicle movement on ground, water, and air are given in the ***GURPS Basic Set***, pp. B463-467 (and are intuitive to most players in any case). Travel and operations in interplanetary or interstellar space, not to mention various superscience and mystical cosmologies, requires more extensive discussion.

This chapter collects the rules for space travel and operations from the various ***GURPS Spaceships*** volumes. This includes not just movement, but also common shipboard activities such as sensor scans, rountine maintenance, and refueling.

Space Units

Light Second (LS): The distance light travels in one second: 186,000 miles.

Astronomical Unit (AU): The standard unit for interplanetary distances, equal to the average Earth-Sun separation: 93 million miles.

Light Year (Lyr): The distance light travels in one year: about 63,000 AU, or 6 *trillion* miles.

Parsec (pc): The standard unit for interstellar distance, equal to the distance at which the Earth-Sun separation spans an angle of one arcsecond: 206,000 AU, or 3.26 Lyr.

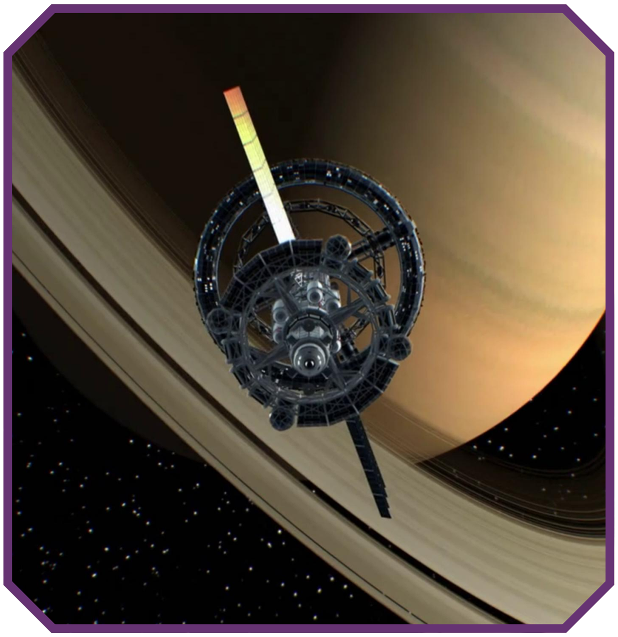
Miles per Second (mps): The standard unit for space velocity, including delta-V: approximately 1,800 yards per second.

Maneuver Drives

Maneuver drives are used to propel a spacecraft through normal space, and if powerful enough, can be used to lift off from a planet or maneuver through an atmosphere.

Interplanetary Voyages

The distance separating two planets in a star system may be as short as the difference between their distances from their star or as long as the sum of those distances, depending on their orbital positions. For an approximation, assume the distance between two worlds is equal to the average orbital radius (distance from its star) of the world *furthest* from that star.



The table on p. 72 shows the orbital radii of planets and other significant bodies in our own solar system. ***GURPS Space*** can be used to determine these statistics for other systems, or the GM can just make up numbers using our solar system as a guideline.

The table shows orbital velocity (how fast the planet is moving in its orbit around the sun) in miles per second and orbital period (the time it takes to orbit the sun) in Earth years. These two statistics are used when calculating *Interplanetary Transfer Orbits* (p. 77). Also shown are gravity (G) and escape velocity, important for determining if a spacecraft can take off or leave orbit.

Solar System Travel Table

Planet	*Orbital Radius*	*Orbital Velocity*	*Orbital Period*	*G*	*Escape Velocity*
Sun	-	-	-	28G	383 mps
Mercury	0.39 AU	29.6 mps	0.24 yr.	0.38G	2.7 mps
Venus	0.72 AU	21.8 mps	0.62 yr.	0.91G	6.4 mps
Earth	1 AU	18.5 mps	1 yr.	1G	6.96 mps
– Luna	0.00257 AU†	0.635 mps†	0.075 yr.†	0.16G	1 mps
Mars	1.5 AU	15.1 mps	1.88 yr.	0.38G	3.1 mps
Ceres*	2.7 AU	11.3 mps	4.6 yr.	0.03G	0.32 mps
Jupiter	5.2 AU	8.1 mps	11.9 yr.	2.36G	37 mps
Saturn	9.5 AU	6.0 mps	29.5 yr.	0.92G	22 mps
Uranus	19 AU	4.2 mps	84 yr.	0.89G	13.2 mps
Neptune	30 AU	3.4 mps	165 yr.	1.19G	14.6 mps
Pluto*	40 AU	2.9 mps	248 yr.	0.067G	0.68 mps
Oort Cloud (comets)*	about 10,000 AU	0.59 mps	1 million yr.	neg.	neg.

* Ceres is the largest main belt asteroid; Pluto is a large Kuiper Belt object. Oort cloud statistics are for a typical long-period comet.

† Orbital parameters for Luna refer to its orbit around the *Earth*, not the Sun.

Other Worlds

For other solar systems, if you know a planet's orbital radius and the mass of the central star, you can compute the planet's orbital velocity and period:

V = 18.5 × square root of (Ms / R)
P = square root of (R^3 / Ms)

V is the orbital velocity in mps.
P is the orbital period in years.
R is the orbital radius in AU.
Ms is the star's mass in solar masses.

For moons orbiting a planet, use the same formulae, but if the planet's mass is given in Earth masses, divide that mass by 333,000 to get it in solar masses.

The surface gravity and escape velocity of a planet (or moon) can be computed from its mass and radius:

G = Me / (Re^2)
Ve = 6.96 × square root of (Me / Re)

G is the surface gravity in Earth gravities.
Ve is the escape velocity in mps.
Me is the world's mass in Earth masses.
Re is the world's radius in Earth radii (3960 miles).

If you don't know a planet's mass, but its composition (density) is similar to Earth. then G and Ve will be approximately Re times the corresponding Earth values.

Newtonian Space Flight and Delta-V

The top speed of a spacecraft that uses a reaction drive is really its "delta-V": the maximum change of velocity it can perform before running out of reaction mass (rocket fuel, etc.). Each acceleration or deceleration "costs" a portion of this delta-V.

The important spacecraft statistics are the acceleration of the reaction drive engines and the delta-V reserve provided by the fuel tanks for those engines. The GM will want to know how far the destination is, in miles or AU, as well as the escape velocity (in mps) and gravity (in G) of the origin or destination worlds.

Example: The *Princess of Helium* is a passenger liner with a fusion torch drive. She's presently in Mars orbit. She has enough reaction mass in her fuel tanks to give the ship a delta-V reserve of 55 mps, and her drive has a 1G acceleration using her fusion torch engines. She's bound for Earth, which at this time we'll assume is about 1.5 AU from Mars.

Getting into Space

To take off from a planet and reach a low orbit around a body, a spacecraft must have an acceleration greater than local gravity (1G for Earth), or it must have wings (in very thin or denser atmosphere) or contragravity lifters. Only the part of the engines' thrust *not* being used to support its weight can be used for acceleration. The vessel must also have enough delta-V to achieve orbital speed, which is 70% of escape speed (4.87 mps for Earth). However, a ship that is already flying at high speed can subtract this from the required velocity.

To break orbit and escape from a planet's gravity well requires delta-V equal to the remaining 30% of escape speed (2.09 mps for Earth). The spacecraft's engines are no longer supporting its weight, so their acceleration and local gravity do not modify this.

The total delta-V requirement to orbit and escape is:

dVo = (0.7×Ve - Air Speed) × A^2 / (A^2 - G^2).
dVe = 0.3×Ve.

dVo and dVe are the delta-V required to achieve orbit and then escape (respectively), in mps.

Ve is the planet's escape speed, in mps.

Air Speed is the top air speed in mps (mph/3,600) for vessels capable of atmospheric flight using non-reaction engines: see Air Move (p. 68). Otherwise treat as 0.

A and G are the spacecraft's acceleration and the local gravity. If the vessel is using contragravity or winged flight, treat G as 0.

Time Spent Maneuvering

Time required to perform a maneuver (reaching orbit, breaking orbit, or any of the maneuvers described in the next section) has the following formula:

T = dV× 0.0456 / A.

T is time in hours.

dV is the total delta-V of the maneuver.

A is the spacecraft's acceleration in G.

Example: The Princess of Helium is orbiting Mars and wants to break orbit. This requires 30% of Mars escape velocity. The escape velocity of Mars is 3.1 mps (see table), so she needs 0.93 mps. She reduces the reaction mass in her tanks from 55 mps to 54.07 mps. She could accelerate at full 1G, but since her passengers are from Mars, she decides to use less than that: a gentle 0.5G, intermediate between Earth and Mars gravity. Accelerating at 0.5G, time required is 0.93 × 0.045 / 0.5 = 0.084 hours, or about 5 minutes. After a brief acceleration, she's free of Mars' gravity!

Reaching the Target

Orbital maneuvers, or interplanetary travel once a spacecraft has escaped orbit, require accelerating to the desired cruising velocity, coasting through space, then decelerating to the velocity required to orbit the destination. Decide how much of the spacecraft's delta-V reserve will be used to accelerate to the cruising velocity. An equal amount is required to decelerate, unless the spacecraft is to fly past or impact the destination.

The spacecraft must also correct for any relative velocity between the origin and destination planets: this can be as little as the difference between their orbital speeds (if they are orbiting in the same direction), or as much as the sum of their speeds (if they are at opposite points in their orbits), and may add to either the acceleration or deceleration maneuvers depending on alignments. For an approximation, assume the typical relative velocity of two worlds is equal to the *larger* of their two orbital speeds, and apply it equally to both the acceleration and deceleration phases. The delta-V requirements are:

dVa = dVd = Vc + 0.5×Vr.

dVa and dVd are the delta-V required for acceleration and deceleration, respectively.

Vr is the relative velocity of the points of departure and arrival.

Vc is the desired cruising speed.

Combined Maneuvers

Breaking orbit (p. 72) and accelerating to cruising speed can be done as a single maneuver. Because of the *Oberth effect* (a kind of gravity assist), the delta-V of the combined maneuver is less than the sum of each. To a reasonable approximation, the combined maneuver's delta-V is the *larger* of dVe and dVa, rather than the sum.

Similarly, orbital insertion at the destination (p. 74) can be combined with deceleration, requiring only the larger of the two delta-V's.

Example: The Princess of Helium has just escaped Mars orbit and is boosting for Earth! She has a reserve of 54.07 mps of delta-V left in her fuel tanks. The navigator decides on a cruising speed of 15 mps: taking Earth's orbital speed of 18.5 mps as the relative orbital velocity, this gives two maneuvers of 15 mps + (18.5/2) mps = 24.25 mps, or 48.5 mps total. Due to the Oberth effect, the 24.25 mps *replaces* the 0.93 mps previously computed for breaking orbit.

Distance Traveled during Maneuvers

An additional consideration that is important for short voyages, high speeds, and/or low accelerations, is the distance that the spacecraft travels during the acceleration and deceleration phases of the journey.

Da = (Vc / 1,000)^2 / Aa.
Dd = (Vc / 1,000)^2 / Ad.

Da and Dd are the distances traveled while accelerating/decelerating, in AU.

Aa and Ad are the acceleration/deceleration in G.

Vc is the cruise speed in mps.

Usually acceleration and deceleration are the same.

Example: With a cruising speed of 15 mps, the Princess of Helium will travel 0.015 × 0.015 /0.5 = 0.00045 AU during each of the acceleration and deceleration phases, or 0.0009 AU total. This is negligible compared to the 1.5 AU voyage, so we'll ignore it.

Travel Time

Time spent accelerating and decelerating is computed as given for *Time Spent Maneuvering*, above. Converting to days gives us:

Ta = dVa × 0.002 / Aa.
Td = dVd × 0.002 / Ad.

Ta and Td are the time spent accelerating and decelerating, in days.

dVa and dVd are the delta-V of the acceleration and deceleration maneuvers, in mps.

Time spent coasting is just the distance traveled (less any amount covered while accelerating/decelerating) divided by cruise speed:

Tc = (D - Da - Dd) × 1,076 / Vc.

D is the distance to the destination, in AU.

Da, Dd are the distances traveled during acceleration/deceleration, in AU.

Tc is the time spent coasting, in days. If the formula gives a negative number, then there is not enough distance to achieve the specified cruising speed: either lower the cruising speed or treat the vessel as undergoing *Continuous Acceleration* (see box on this page).

The total travel time is the sum of the maneuvering time and the coasting time.

Example: With an acceleration of 0.5G and a total delta-V of 48.5 mps, Princess of Helium spends 48.5 × 0.002 / 0.5 = 0.194 days (4.7 hours) combined accelerating and decelerating. In the process, the occupants experience a gentle one-half of Earth gravity. The crusing speed is 15 mps, so the coasting phase lasts 1.5 × 1,076 / 15 = 108 days in zero gravity.

Continuous Acceleration

A reaction drive vessel with enough delta-V, or a reactionless drive, can accelerate to midpoint, turn, then decelerate, thrusting all the way. The delta-V required is:

dV = Vr + 1,505 × square root of (D × A).

dV is the delta-V required in mps.

Vr is the speed of the target relative to the point of departure, in mps.

D is the distance in AU.

A is the acceleration in G.

Total travel time is just the time spent maneuvering, computed as before, which gives the following result:

T = 0.0456 × Vr / A + 69 × square root of (D / A).

T is the travel time in hours.

Vr, A, and D are as before.

Orbital Insertion and Landing

After accelerating, coasting, and decelerating, the spaceship will have matched velocities with its target and be just outside its gravity well. It will most likely want to enter orbit and/or descend to the surface. These are the exact same maneuvers as computed in *Getting into Space* (p. 72), only performed in reverse, and using the target body's parameters. You may perform deceleration and insertion as *Combined Maneuvers* (p. 73), using only the larger delta-V. If the destination has an atmosphere, this can be used to slow the vessel: see *Aerobraking* (p. 76).

Once the descent maneuver is completed, you still have to land! As with liftoff, this requires wings (in very thin or denser atmosphere), contragravity, or thrust exceeding local gravity ("bringing her down on her jets"). Make a Piloting roll, modified by air handling (very thin or denser atmosphere) or space handling (trace atmosphere or vacuum). Failure means the ship must abort and try again. In busy airspace, the pilot may get in trouble for violating regulations. On a critical failure, or any failure by more than its SR, it's a crash landing that inflicts damage as per a collision (p. 104) at 0.1 mps × local gravity in G to one location. Roll: 1-3 front hull, 4-6 center hull.

Apply modifiers for terrain and weather. Spacecraft sensors help with visibility, but storms and obstacles give penalties: -1 (mountains), -2 (skyscrapers, strong winds, thin atmosphere), -3 (electrical storm), -4 (hail, very thin atmosphere), -5 (blizzard), -6 (hurricane). The thin and very thin atmosphere modifiers only apply to winged flight, and weather modifiers will not apply in vacuum.

If the vessel is using reaction engines to land, each attempt takes 15 seconds, and requires spending delta-V reserve equal to 0.1 mps × local gravity (in G) per attempt.

Travel with Reactionless Drives

Spacecraft with reactionless drives don't need to worry about reaction mass. They can continuously accelerate as long as the drives have power, although relativistic effects (p. 78) will keep them below light speed (186,000 mps).

Reactionless drive spaceships use the same calculations as reaction drives for liftoff, travel, and descent, except that they have an effectively infinite delta-V reserve: the delta-V calculations can be used just as an intermediate step to computing travel times. They do not need to limit their "cruising speed", so they will generally use the calculations for *Continuous Acceleration* (above).

Travel with Boost, Hyperdynamic, and Pseudovelocity Drives

Vessels with boost drives (p. 60), hyperdynamic fields (p. 63), or pseudovelocity drives (p. 64), have special rules for space travel. All of these drives have effects that depend on their overall *velocity* as well as acceleration. The GM should decide whether that velocity is relative to some "universal" reference frame, or relative to some

Space Sails and Ramscoops

Treat space sails as reactionless drives with unlimited delta-V. However, accelerations are often so low that the vessels will spend many orbits spiraling from departure to destination. Use the formula for *Continuous Acceleration* (p. 74), but if the transfer time is longer than the orbital period of the smaller orbit, then set Vr and D equal to the *difference* between the planets' orbital velocities and radii (respectively).

Lightsails get more acceleration the closer they are to a star: multiply the base thrust by $(1/R)^2$ where R is the average distance in AU from the star during the voyage. Other sails' accelerations are independent of distance.

Lightsails and *magsails* get their full thrust when accelerating directly away from the Sun. For other maneuvers (including most interplanetary transfers) they must "tack" using the Sun's gravity, limiting their acceleration to at most 0.006 G divided by R^2. For stars other than the Sun, multiply by the star's mass in solar masses. Lightsails will rarely hit this limit, but magsails may, especially in the outer Solar system.

Magsails (but not other sails) are also limited by the speed of the solar wind: typically 375 mps for our Solar system. Above this speed, or in interstellar space, they act as a brake, decelerating the vessel at up to their full rated acceleration.

Ramscoops can provide reaction mass to certain reaction drives, giving them unlimited delta-V (treat as reactionless drives). However, the ship will first need to accelerate normally up to the ramscoop velocity (1,800 mps or more)! Below this speed, the ramscoop operates as a magsail, above.

ether (p. 61) or medium that has its own winds or currents. If this medium is "dragged" along with planets, as some 19th century physicists theorized, then vessels can ignore planetary velocities when using these drives.

Interplanetary Travel

For normal pseudovelocity drives, space travel is identical to a reactionless drive, except when it comes to matching velocities with a target: see below.

Hyperdynamic drives use the same formulae as Newtonian reaction drives, using the hyperdynamic top speed as the cruising speed. For long-range journeys (measured in astronomical units), if the acceleration is high enough, the distance traveled during maneuvers is insignificant, and you need only consider the cruising time.

Boost drives have effectively unlimited acceleration, and can always ignore maneuvering distances.

Getting into Space

Vessels with *pseudovelocity drives* can ascend into space exactly like reactionless drives in vacuum. The pseudovelocity effect negates air friction, but also eliminates winged lift. The vessel cannot achieve *orbit* unless it has ordinary drives to give it orbital velocity.

A *hyperdynamic* vessel can climb into orbit using the usual rules for its propulsion system, except that a *winged* vessel can get lift even on an airless world. Unless the hyperdynamic medium is dragged along with the world, the vessel must overcome any "headwind", or it can loft with a "tailwind", depending on the direction of flow. This can be handled by GM fiat; alternatively, one can determine the "hyperdynamic drag" using the *Air Move* rules (p. 68), and add or subtract that from the vessel's propulsion:

Drag = (Speed / Base Speed / Factor)^2.

Drag is the wind's thrust in G.

Speed is the hyperdynamic "wind speed" in yards per second. Divide speeds in mps by 1,800 to get yards/second. Multiply by 10 if the vessel is unstrealined or if the wind is not from the front; multiply by 5 if it has nautical lines (p. 57).

Base Speed is from the *Air Speed Table* (p. 69).

Factor is the *hyperdynamic factor* described on p. 81.

If the vessel is lifting against a world's gravity, subtract the gravity from the vessel's propulsion; then add (for a tailwind) or subtract (for a headwind) the hyperdynamic drag. This is the final acceleration: if it is positive, then the vessel can lift off. Use this acceleration to compute its ascent speed using the rules for air movement.

A vessel with *boost drives* properly has *infinite* acceleration, and therefore need not be affected by gravity *at all*: it simply moves away from the planet at its boost drive velocity. However, the GM can add some flavor by giving boost drives an *effective thrust rating* that must overcome the planet's gravity. The formula is up to the GM; a simple approach is to use the conversion factor that was used to get the boost speed in the first place:

Tb = Vb / F, Vr = F × (Tb - G).

Tb is the effective thrust of the boost drive in Gs.

Vb is the vessel's boost speed in mps, Vr is the speed reduced by gravity.

G is the gravity in Gs.

F is the conversion factor from p. 60 (or any other factor the GM chooses), e.g: 10 within ten planetary diameters of a world.

Aerobraking

When a spacecraft arrives at a world with an atmosphere, it may use atmospheric drag to shed some or all of its velocity. Even a trace atmosphere can provide substantial drag: most aerobraking maneuvers occur in the thin upper atmosphere.

Aerobraking can provide delta-V that would otherwise come from a reaction drive's fuel reserves. The following maneuvers may be implemented through aerobraking: The deceleration maneuver of interplanetary journeys (p. 73), the arrival maneuver of an interplanetary transfer orbit (p. 77), entering planetary orbit and/or descending to the planet's surface (p. 74), and matching velocities with a planet after disengaging a hyperdynamic or pseudovelocity drive (below) if such matching is not provided by the hyperdynamic or pseudovelocity medium.

However, all of this energy must be dissipated in the form of heat. A streamlined vessel takes the following damage to its front hull:

d-damage = dST × dV (0.1) burn.

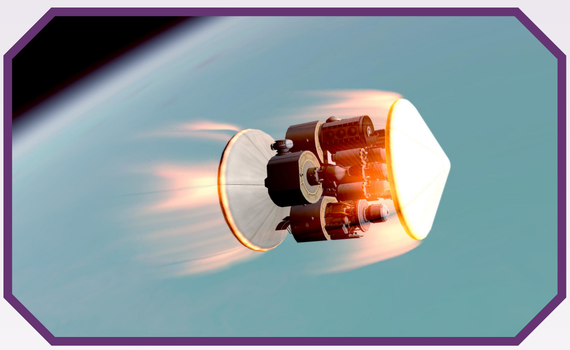
dST is the vessel's own dST/HP statistic.

dV is the delta-V being shed, in mps. You may choose to provide only part of a maneuver's delta-V with aerobraking, using drive systems for the rest.

As indicated, the damage is burning with a (0.1) armor divisor; i.e. armor provides 10× its usual protection. Aerobraking vessels whose heat shielding is penetrated are almost always destroyed.

Controlled aerobraking requires a streamlined vessel and a Piloting roll. Modifiers: -2 for thin atmosphere, -4 for very thin atmosphere, -6 for trace atmosphere. Success performs the maneuver as intended. Ordinary failure changes the delta-V by 0.1 mps times the margin of failure, in a random direction. This may increase damage beyond the vessel's tolerances, or cause an unintended re-entry; alternatively it might fail to shed enough delta-V to capture the vessel into orbit. Failure by more than the vessel's SR, or critical failure, causes it to tumble out of control: damage is increased by 10× and is applied to *all* hull sections. This is *always* the result if an unstreamlined vessel attempts aerobraking.

A *Soft-Landing System* (p. 52) uses disposable heatshields, parachutes, ballutes, etc. to allow even an unstreamlined vessel to aerobrake safely. Up to 10 mps of aerobraking can be provided with no control roll required and no damage to the rest of the vessel. However, the soft landing system itself is sacrificed in the process.



Matching Velocities

A vessel with hyperdynamic drives can only match velocities if the target's speed *with respect to the hyperdynamic medium* is less than the vessel's top hyperdynamic speed. This may not be an issue if the target (e.g. a planet) drags the medium along with it: the vessel can simply turn off its propulsion, and the hyperdynamic field will slow it to a "stop" next to the planet.

A pseudovelocity drive or boost drive *cannot* perform any velocity matching: when the drive is disengaged, the vessel has the same velocity as it had when it started. If pseudovelocity is relative to a local planetary mass, then simply turning off the drive upon arrival will leave you drifting with whatever residual velocity you started with relative to your planet of departure.

If pseudovelocity is relative to an absolute frame, then upon turning off the drive you will have a relative velocity equal to the relative velocity of the two planets at departure and arrival. This will depend on where they were in their respective orbits at those times, but *at best* (closest approach of planets orbiting in the same direction), it is equal to the *difference* in their orbital speeds around their star. For orbital velocities for planets in our solar system, see the *Solar System Travel Table* (p. 72).

Any residual speed after deactivating the pseudovelocity drive or hyperdynamic field must be canceled by ordinary (non-pseudovelocity) acceleration or delta-V. Thus, a ship with a pseudovelocity drive may end up with very similar delta-V requirements as one without, though the *duration* of the journey will be much shorter. If the destination world has an atmosphere, then *aerobraking* (above) may also be an option.

Example: The spaceship Dawn's Arrow has a boost drive with a top speed of 60 mps. Traveling from Earth to Uranus (average 19 AU) takes 19 × 1,076 / 60 = 341 days. Earth orbits the Sun at 18.5 mps, Uranus at 4.2 mps; the relative velocity can range from 14.3 mps to 22.7 mps. If pseudovelocity is relative to the nearest planet, this is ignored; if pseudovelocity is relative to an absolute frame, then Dawn's Arrow will need reaction drives (or aerobraking) with at least 14.3 mps of delta-V to match speeds.

Limitations

The GM may opt to limit hyperdynamic, pseudovelocity, and boost drives in much the same way as stardrives (p. 80). For example, they may not work in close proximity to a planet's gravity well, thus requiring some other propulsion system to reach orbit or fly in atmosphere.

Interplanetary Transfer Orbits

Planets and other celestial bodies don't stand still. It's possible to carefully time an interplanetary trip so that the two planets' own orbits provide most of the necessary delta-V. Exact travel times will vary depending on the time of year. However, you can estimate the statistics of typical low-energy transfer orbit between two planets or other bodies using their orbital velocities and orbital periods. The *Solar System Travel Table* (p. 72) shows values for planets in our own system.

A transfer orbit involves two maneuvers, one at the inner planet 1 and another at the outer planet 2. Numbers refer to the order of the planets, not the maneuvers – a spacecraft traveling from an outer planet to an inner one will perform maneuver 2 first. The delta-V requirements of the two maneuvers are:

dV1 = (V1 - V2)/2,
dV2 = (V1 - V2)/2 *or* **V2** (whichever is less).

dV1, dV2 are the delta-V's of the two maneuvers.

V1, V2 are the orbital speeds of the two planets, with V1 > V2.

This is an *approximation* to the minimum-energy "Hohmann" transfer. Note that dV1 and dV2 can each be performed as *Combined Maneuvers* (p. 73) with breaking or inserting into orbit.

The time spent maneuvering is the usual **0.0456 × dV / A** (in hours). But most of the trip is usually spent drifting in the transfer orbit:

T = (T1 + T2) / 4.

T is the travel time, and T1 and T2 are the orbital periods of the two planets (usually listed in Earth years; multiply by 365 for days). If this is longer than the time spent maneuvering, then you can assume that maneuvering time is subsumed into the transit time.

However, optimal transfer orbits require planetary alignments that recur only at specific times. The time between launch "windows" is the *synodic period:*

Ts = 1 / (1 / T1 - 1 / T2).

If you don't plan on keeping track of planetary positions, you can randomly determine the time to the *next* window by multiplying Ts by 1d/6.

In some cases, with very low-thrust drives, time spent maneuvering may be *longer* than the free-fall transit time. In this case, use the maneuvering time instead of the transit time as the duration of the voyage, and ignore alignment windows. The vessel is under *continuous* thrust, in a trajectory that slowly spirals outward or inward towards the destination orbit.

Example: The *Firestar 1* is going to Mars! Fully-fueled in low Earth orbit, its TL9 nuclear-thermal rockets give it 0.5G of acceleration and 7.56 mps of delta-V. Earth has an orbital speed of 18.5 mps and Mars is 15.1 mps, so dV1 = 18.5 - 15.1 = 3.4 mps and dV2 is the same. Breaking low Earth orbit would require 0.3 × 6.96 = 2.09 mps and inserting into low Mars orbit 0.3 × 3.1 = 0.93 mps: since these are less than dV1 and dV2 respectively, they are ignored.

Total delta-V is 6.8 mps each way, 13.6 mps round trip; but the *Firestar 1* is designed to use *aerobraking* (p. 76) to perform orbital insertion maneuvers at Mars (outbound) and Earth (returning). It has dST/HP 50; per the rules on p. 76 it will take 50 × 3.4 = 170 points of burning d-damage, with a (0.1) armor divisor: its dDR 21 front armour will protect it completely. Final reaction drive delta-V requirement is just the remaining two 3.4 mps maneuvers, 6.8 mps overall.

Time under thrust is 0.0456 × 3.4 / 0.5 = 0.31 hours (i.e. 19 minutes) on each leg, and the transit time is (1 + 1.88) / 4 = 0.72 years (263 days). Launch windows occur every 1 / (1/1 - 1/1.88) = 2.1 years.

Relativistic Travel

As a spaceship approaches the speed of light, time as measured by people aboard runs more slowly when compared to the "normal" time of the rest of the universe. This is known as *time dilation*.

Time dilation has several effects. One is that a continually-accelerating vessel will gradually approach, but not exceed, the speed of light: the "proper" acceleration felt by the crew gets stretched out over longer and longer intervals of external time. Another effect is that very long sublight voyages can be accomplished in a comparatively short amount of shipboard time.

A useful quantity is the vessel's *rapidity:* the speed it would have if relativity did not apply. Rapidity is given in units of the speed of light c. For a reaction drive vessel that has undergone a specified Newtonian delta-V, it is:

Rapidity = dV / 186,000

dV is the delta-V in mps.

For a continuously-accelerating vessel, 1G applied over 1 year produces a rapidity of very nearly c (actually $1.032c$), giving the following formula:

Rapidity = A × T

A is the acceleration in G.

T is the time spent accelerating in years.

Rapidity can exceed $1c$, but the ship's *actual* speed is always less: the *Speed* column of the *Relativistic Speed and Time Table* (below) gives the actual speed in units of c, for different rapidities.

Relativistic Speed and Time Table

Rapidity	*Speed*	*Time*	*Distance*	*Rapidity*	*Speed*	*Time*	*Distance*	*Rapidity*	*Speed*	*Time*	*Distance*
0.1	0.10	0.10	0.005	1.1	0.80	1.3	0.67	2.1	0.97	4.0	3.1
0.2	0.20	0.20	0.02	1.2	0.83	1.5	0.81	2.2	0.98	4.5	3.6
0.3	0.29	0.30	0.05	1.3	0.86	1.7	0.97	2.3	0.98	4.9	4.0
0.4	0.38	0.41	0.08	1.4	0.89	1.9	1.2	2.4	0.98	5.5	4.6
0.5	0.46	0.52	0.13	1.5	0.91	2.1	1.4	2.5	0.99	6.1	5.1
0.6	0.54	0.64	0.19	1.6	0.92	2.4	1.6	2.6	0.99	6.7	5.8
0.7	0.60	0.76	0.26	1.7	0.94	2.7	1.8	2.7	0.99	7.4	6.5
0.8	0.66	0.89	0.34	1.8	0.95	2.9	2.1	2.8	0.99	8.2	7.3
0.9	0.72	1.0	0.43	1.9	0.96	3.3	2.4	2.9	0.99	9.1	8.1
1.0	0.76	1.2	0.54	2.0	0.96	3.6	2.8	3.0	≈1.00	10.0	9.0

Continuous Acceleration

If a vessel is accelerating at a constant rate, then the *Time* and *Distance* columns give the (external) time in years and distance in light-years that the ship would spend accelerating to, or decelerating from, the listed rapidity, for 1G acceleration. *Divide* both the time and the distance by the ship's actual acceleration in G:

Da = Distance / Aa　　**Ta = Time / Aa**

Dd = Distance / Ad　　**Td = Time / Ad**

Aa and Ad are the acceleration and deceleration in G.

Da and Dd are the distances traveled while accelerating and decelerating, in light-years: divide by 3.26 to get parsecs.

Ta and Tb are the external time spent accelerating and decelerating, in years.

This can be reversed to compute the time (both shipboard and external) that a vessel requires to travel a given distance. Assuming acceleration and deceleration are equal, divide the journey into two equal parts: the first half will be spent accelerating, the second half decelerating. Find the appropriate *Distance* entry on the table for the midpoint of the journey:

Distance = 0.5 × D × A

D is the *total* distance in light-years; multiply a distance in parsecs by 3.26 to get light-years.

A is the acceleration in G.

Look this distance up on the table to find the corresponding *Rapidity* and *Time*, and *divide* those by acceleration in G to get the shipboard and external times (in years). This is the time for *each* of the acceleration and deceleration phases; double to get the entire journey:

Ts = 2 × Rapidity / A

Te = 2 × Time / A

Ts and Te are the shipboard and external times, in years, for the entire journey.

Example: The *Tau-Zero* is a ramscoop-powered fusion torch ship capable of 0.5G of continuous acceleration. It is traveling to Sirius, 2.6 parsecs (8.6 light-years) away. It will accelerate over a distance of 4.3 light-years and decelerate for the same distance. Multiplying 4.3 light-years by 0.5G gives 2.15, close to the *Distance* entry for a rapidity of 1.8. This is the rapidity that the vessel has at turnover. Shipboard travel time is $2 \times 1.8 / 0.5 = 7.2$ years, and external (Galactic standard) time is $2 \times 2.9 / 0.5 = 9.6$ years, to travel 8.6 light-years.

Cruising Speed

A ship's speed may be limited by its drive, reaction mass, or external factors such as the interstellar medium. In this case the journey will have three phases: acceleration, cruise, and deceleration.

Look up the top speed (in units of *c*) in the *Speed* column of the *Relativistic Speed and Time Table*, and find the maximum (cruising) *Rapidity*. Compute the (external) times Ta, Td spent accelerating/decelerating as specified above for continuous acceleration. *Shipboard* time is given by:

Tsa = Rapidity / Aa

Tsd = Rapidity / Ad

Tsa and Tsd are shipboard acceleration and deceleration times in years.

Next, from the cruising Rapidity, compute the distances Da, Dd traveled during the acceleration and deceleration phases (in light-years). Subtract these from the total distance to find the cruising distance, and hence the time spent cruising:

Tsc = (D - Da - Dd) / Time

Tc = (D - Da - Dd) / Speed

Speed is the cruise speed in units of *c*.

Time is the corresponding *Time* entry in the table.

D is the total distance in light-years. Multiply a distance in parsecs by 3.26 to get light-years.

Tsc and Tc are the shipboard and external cruise times in years. If the formulae give a negative number, then the ship does not have enough distance to reach the specified cruising speed: either lower the desired cruising speed, or treat the vessel as continuously accelerating, as above.

Total trip times, to ship-borne travelers and outside observers, are:

Ts = Tsa + Tsc + Tsd

Te = Ta + Tc + Td

Example: The *Tau-Zero* decides to limit its top speed to 0.8*c*: a Rapidity of 1.1. It takes 1.1 / 0.5 = 2.2 years of shipboard time and 1.3 / 0.5 = 2.6 years of external time, as well as 0.67 / 0.5 = 1.3 light-years of distance, for *each* of the acceleration and deceleration phases. It cruises for the remaining 8.6 - 1.3 - 1.3 = 6 light-years between Sol and Sirius, taking 6 / 1.3 = 4.6 years of shipboard time and 6 / 0.8 = 7.5 years of external time. The total journey lasts only 4.6 + 2.2 + 2.2 = 9 years shipboard time, but 7.5 + 2.6 + 2.6 = 12.7 years of Galactic standard time.

Formal Terminology

The quantity 1 + Distance from the *Relativistic Speed and Time Table* is also known as the *Lorentz factor* or *gamma* of an object. The Time entry on the table is sometimes referred to as the *proper velocity* or *celerity*.

Extending the Table

For *very* high-speed ultra-relativistic travel, the *Relativistic Speed and Time Table* can be extended beyond a Rapidity of 3, as follows:

- Each +2.3 *added* to Rapidity *multiplies* Time by ×10.
- Distance is approximately equal to Time - 1.
- Speed can be treated as 1 (i.e. the speed of light) for most purposes.

Example: The *Tau-Zero* sets off on a journey to the Galactic centre, 8,000 parsecs (26,000 light-years) away. The turnover point corresponds to a Distance entry of 0.5 × 26,000 × 0.5 = 6,500, well beyond the last entry on the table. The corresponding Time is 6,500 + 1, so the journey will take 2 × 6,501 / 0.5 = 26,004 years: just 4 years longer than a pulse of light. However, 6,500 is close to 6,700 = 6.7 × 10 × 10 × 10, corresponding to a Rapidity at turnover of 2.6 + 2.3 + 2.3 + 2.3 = 9.5. The *shipboard* duration will be only 2 × 9.5 / 0.5 = 38 years: well within the lifespan of the crew and passengers!

If you want to avoid the table altogether, and you have a scientific calculator with *hyperbolic* trigonometric functions, you can use the following formulas involving the hyperbolic tangent (tanh), sine (sinh) and cosine (cosh) functions, and their inverses:

Speed = tanh(Rapidity)

Time = sinh(Rapidity)

Distance = cosh(Rapidity) - 1

Rapidity = inverse tanh(Speed)

Rapidity = inverse sinh(Time)

Rapidity = inverse cosh(Distance + 1)

The rest of the formulae can be used as given; only the table lookups are replaced.

Collisions

Relativity affects the *energy* and *momentum* of a vessel, as well as the time experienced by those aboard. For any collision between a relativistic vessel and a non-relativistic vessel or object (e.g., a planet), wherever a formula calls for the relative speed in mps, use 186,000 mps × the *Time* entry on the *Relativistic Speed and Time Table*, based on its current rapidity.

If *two* relativistically-moving objects collide, treat the collision as either head-on, rear-end, or right-angled. For a head-on collision, *add* the rapidities of the two objects, and look up the corresponding *Time* entry: relative speed is again 186,000 mps × Time. For a rear-end collision, do the same but *subtract* the two rapidities. For a right-angled collision, use the *larger* rapidity.

Stardrives

Stardrives can work in just about any way the GM wishes. Thus, their performance depends on the intended scope of the campaign more than anything else. The GM should work out the mechanics of stardrive operation to suit the campaign. ***GURPS Space*** has detailed guidelines on the many different options and possibilities for GMs who wish to design their stardrives to suit a campaign. For GMs without ***GURPS Space***, this section presents some ready-to-use examples.

Hyperdrive

This drive assumes the existence of hyperspace, a parallel dimension in which differing laws of physics permit faster-than-light travel. A vessel with a hyperdrive may enter hyperspace, taking a "short cut" through that dimension for a few days or weeks while traveling at faster than light speeds, then emerge back into the normal universe.

Typically, a starship must set a course to a specific destination, the navigator must plot a course, and then power up the drive to enter hyperspace. Some variants of hyperdrive also require first accelerating to a minimum velocity (which may be as high as near-light speeds) while heading in the general direction of the target. Once in hyperspace, a starship does not interact with the normal universe and may not maneuver or deviate from its plotted course. This may work differently in some universes!

The hyperspace voyage, or "skip," lasts for **distance in parsecs / FTL speed** days. Then the spaceship emerges into normal space. Any restrictions that apply to entering hyperspace usually apply to leaving it, e.g., if the drive won't work near a planet or star's gravity the starship must emerge a considerable distance away from any celestial bodies.

Skip accuracy typically is up to the GM, but often a successful Navigation (Hyperspace) roll is required. Plotting normally takes about 30 minutes and usually can only be done from the general area of space where the skip is being performed. Success gets the spacecraft as close as it can safely come to the destination (depending on drive technology). Failure may be a miss by 10% of that safe distance × the margin of failure. Critical failure may be off by parsecs, an arrival someplace unpleasant, or an *arrival* closer than the safe distance with the drive disabled (destroyed on a failed HT roll).

Jump Drive

This drive assumes the existence of natural or artificial jump points. These are "wormholes" or "jump lines" that connect two distant points in space, usually over interstellar distances, and may require a special drive to open.

Solar systems on main travel routes will have two or more jump points leading to different destinations, creating a network of jump point routes that connect one system to the next. There may also be cul-de-sacs systems – dead ends with only one jump point. Jump point connections may or may not relate to real space: a jump point may connect to the nearest star, halfway across the galaxy, or even to alternate dimensions or times. Their size is also up to the GM – they could be thousands of miles across, or small enough that they limit the size of ships that can traverse them.

To use a jump point, a ship travels to it, powers up the jump drive, and is transported through to the other end of the jump point. Often the engines must be powered up for a total of 60/FTL minutes, where FTL equals the FTL rating. A jump is normally instantaneous (although the GM may rule it requires a finite time). Jump points are often located thousands or millions of miles from planets, stars, and other jump points, so lengthy voyages through normal space may also be required. Therefore, a jump drive is usually accompanied by another type of space drive.

Jump points that automatically connect directly to a single other jump point generally don't require Navigation rolls, although a Navigation or Piloting roll may be required if entering a jump point requires a very precise course.

Jump Drive Variations

Hyper Jump Drive: The starship must be at a jump point to use the drive, but the destination may be any other jump point within range and the drive otherwise functions like a hyperdrive.

Probability Drive: When activated, probability is altered so the spacecraft vanishes from its own location and appears somewhere else, without crossing intervening space. Range is up to the GM; it could even be infinite. Using a probability drive requires Navigation or Electronics Operation (Matter Transmission) rolls, with a hefty minus (e.g., -10) if the destination is uncharted. Failure results in the starship becoming lost – it could turn up just about anywhere – and disables the drive until repaired. A critical failure may warp probability in strange ways, producing bizarre events or stranding the vessel in an entirely different dimension.

Warp Drive

This allows the ship to travel and maneuver at faster-than-light speeds while still interacting with the normal universe. The drive may surround the ship it is mounted on in an energy field, such as a bubble of hyperspace, or may be a "blink warp" drive that moves the ship forward via a series of rapid micro-jumps.

A typical warp drive ship has a speed in parsecs per day equal to its FTL rating. (A speed of one parsec per day is equivalent to 220,000,000 miles per second.)

Standard warp drives only function in deep space. Some are automatically slowed to sublight speed when in close proximity to a star (e.g., within about 75 AU of a sun-sized body) but still work, e.g., at a speed of light-seconds per minute rather than parsecs/day.

Fantastic Cosmology

In some fantasy and science-fiction settings, space itself behaves differently.

The Crystal Spheres

In early models of geocentric cosmology, the sun and planets rotated around Earth, attached to invisible crystal spheres powered by divine movers, with the "fixed stars" on the outermost non-rotating shell. The universe's boundaries may be somewhat circumscribed: For example, in Ptolemy's cosmos (a standard model in the Middle Ages) the moon was the correct distance from Earth, but other planets were much nearer, and the fixed stars a mere 80,000,000 miles (0.86 AU) away. Complicated submotions, called epicycles, were invented to ensure they matched the observed motions of the sun and planets, but a fantasy world could avoid this with heavenly bodies in circular orbits.

If the crystal spheres are themselves ethereal in nature (as was often believed), it's possible a vessel simply passes through them to visit other solar systems (if these exist). Outer spheres might form a barrier to travel, in which case a stardrive engine is required to "break through" them. What lies beyond may be some form of astral space or hyperspace – perhaps best treated as if it were hyperspace, with the normal rules for travel in place.

The Edge of the World

A flat or gently curving world can have a literal edge! If so, there may be no such thing as a planetary orbit. Perhaps air and gravity terminate as soon as this limit is crossed and a vessel pushed or sailed off finds itself drifting in space.

Hyperdynamic Cosmos

In this universe, hyperspace has *friction*, and spaceships extend special *hyperdynamic fields* (p. 63) into it to maneuver much like flying in the air. This is a justification for having spaceships maneuver in cinematic fashion.

The GM must set the hyper-factor of hyperspace, which determines how much faster vessels move than in air. (Hyperdynamic friction is 1 / hyperdynamic factor^2 times that of air.) A factor of 100 (constant at all TLs) is the default, but it can be less or more. It's possible various "levels" of hyperspace exist, with other factors accessible to higher-TL fields, or the value can go up with increasing distance from a stellar or planetary mass. The hyper-factor could vary by region of space. Hyperspace might even have currents, winds, or calms that locally modify the hyper-factor or the vessel's speed.

A spacecraft in a hyperdynamic field maneuvers exactly like an aircraft, flying in a pseudo-atmosphere in zero gravity. Thus, it has no stall speed but is still affected normally by the gravity of planets and stars.

With this option, spacecraft benefit from streamlined hulls even if they never enter atmosphere.

Handling: Use the Air Performance Hnd/SR modifiers.

Hyperdynamic Top Speed: Use the top air speed except the acceleration performance is based on those engines that function in vacuum (that is, jet engines and rotors don't count). Then multiply the top speed by the hyper-factor, representing the reduced drag of hyperspace compared to normal air.

Air-Filled Cosmos

What if the universe was full of air and the motions of the planets and stars were driven by aetherial winds? In game terms this works just like a hyperdynamic cosmos, except there's no need for a doubletalk hyperdynamic field generator and top speed is not multiplied by a hyper-factor. If the medium is breathable the vessel doesn't require air, and habitats get by with the *No Life Support* feature (p. 57). These qualities might realistically exist in or near planetary- and solar system-scale megastructures.

Interstellar voyages are possible in an air-filled cosmos. The GM may determine the stars are a lot closer or allow vessels to sail into natural wormholes ("aether vortices"), or the eye of a celestial storm could emerge in another star system!

SPACE OPERATIONS

These are common activities such as entering or leaving the vessel, sensor scans, maintenance, and refueling.

ACCESS

The most common way to board a spacecraft is via a the vessel's airlock, but there are other methods!

Airlock

An airlock allows people to enter or leave a ship in space without decompressing the vessel. The airlock is chamber with a heavy, pressure-tight door, valve, or hatch at either end. Some superscience airlocks may use rigid, airtight force fields instead of doors, although these are risky if the power fails!

The outer door connects the chamber to the outside. The inner door leads from the chamber to the spacecraft's corridors in whatever hull location the airlock is in.

A control panel is outside the spacecraft next to the outer door. A second panel is in the airlock chamber. A third panel is in the spacecraft corridor beside the inner door. Each panel includes airlock controls, an intercom, and a camera. The airlock can be operated via input from a panel, a control station, or the spacecraft's computer.

Individual control panels may be left "unlocked" so anyone can access them. Otherwise, a visitor must insert an access key, type an access code, submit to a biometric scan, or call someone for permission to enter (procedures will vary for each spacecraft).

Pressure sensors and a pump are installed in the airlock.

Airlock Capacity

The capacity of an airlock is the maximum number of human-sized individuals that can occupy it. The table below shows airlock capacity and area (in hexes) by spacecraft SM:

SM	+5-7	+8	+9	+10	+11	+12	+13	+14	+15
Capacity	1	2	3	4	5	6	7	8	9
Hexes	1	1	1	1	2	2	2	2	4

Airlock Doors: These have half of the armor of the hull section they are installed in. Multiply the hull section's dDR by 5 to determine an airlock's DR. They are HP 75.

Entering a Spacecraft via Airlock

1. Access the outer airlock's control panel, or call inside. 2+ seconds.

2. Option: Use airlock controls to alter the pressure in the airlock chamber to the same pressure as the outside environment. It takes 1 minute × pressure differential in atmospheres, e.g., 1 minute to go from standard atmosphere (1 atm) to vacuum.

3. Unlock and open the outer door. 2 seconds. The atmosphere in the airlock chamber (if any) and outside environment will mix.

4. Enter airlock chamber. 1 second.

5. Use airlock controls to close and lock outer door. 1 second.

6. Option: If sensors indicate a foreign atmosphere in the airlock chamber, use controls to pump out existing air and replace it with the spacecraft's own atmosphere. 1 minute + (1 minute × pressure differential).

7. Option: If the airlock chamber is equipped with decontamination systems, initiate these procedures. This takes a further (13-TL) minutes.

8. Use controls to unlock and open outer door. 1 second.

9. Enter spacecraft. 1 second.

Chambers can typically vary their pressure from 0 to $5n$ atmospheres, where n is the hull dDR.

Exiting an Airlock

1. From inside the spacecraft, unlock and open the inner door. 2 seconds.

2. Enter airlock chamber. 1 second.

3. Close and lock inner door. 2 seconds.

4. Option: If the airlocks are equipped with decontamination systems, use controls to initiate decontamination. These procedures take (13-TL) minutes.

5. Option: If the external pressure is less than that of the spacecraft, e.g., a vacuum, depressurize the airlock chamber. This will prevent the occupants being blown out into space when the door is opened! This takes two seconds to initiate. A depressurization warning sounds. The pressure starts to drop slowly to the desired level, which takes 1 minute × pressure differential in Earth atmospheres. The cycle can be halted or reversed.

6. Unlock and open outer door. 1 second. The airlock chamber is exposed to the outside environment. If the outside environment is at a lower pressure than the chamber, any air rushes out, possibly also sucking out any occupants of the airlock chamber.

7. Leave airlock (unless blown out already!). 1 second.

Docking

Standard airlock doors are designed so that a spaceship can mate airlocks directly with a station, or so that a small craft can mate directly with a larger spacecraft. Airlocks designed by different spacefaring cultures are normally incompatible, but regular trade might result in agreements that standardize these fixtures, even between aliens!

Docking takes about one minute and requires a Piloting roll by the pilot of any craft that is actively maneuvering. The larger craft will usually hold its course as the smaller one docks (only the pilot of the smaller craft rolls), but if both vessels are maneuvering, both pilots must roll. Failure means that another minute is needed. Critical failure results in an emergency situation. Roll again: any success means trouble is averted, but a second failure or critical failure results in a 0.1 mps collision (p. 104).

Passage Tubes

A passage tube is a flexible tube that connects the airlocks of two spacecraft in space that have compatible atmospheres. It holds pressure, allowing the occupants to travel between ships without the need to cycle airlocks. It may be extended out to 30 yards, is about two yards in diameter, and hooks to standard fittings around exterior airlocks. Rigging it takes about an hour in free fall (30 minutes with multiple workers), and requires a Mechanic (Vehicle Type) roll.

Emergency Pressure Doors

Spacecraft may have pressure-tight doors to seal off compartments.

SM +4-6 spacecraft have no pressure doors. If the spacecraft hull is breached or a cargo bay door is opened, the entire spacecraft is affected.

SM +7-9 spacecraft have pressure doors that separate each hull section: one for the front hull, one for the center hull, and one for the rear hull. A breach or open cargo bay door will affect the hull section it occurs in.

SM +10 and up spacecraft have pressure doors that separate each *system*, excluding armor systems. A breach or open bay door only affects that particular system.

Doors are armored with half the dDR of their hull section's armor, or DR 5 if the hull section has no armor. A door seals shut automatically if emergency sensors detect pressure loss, fire, or smoke in the compartments on either side of the door. Doors will seal in two seconds and will do (ship SM) dice crushing damage each turn to anyone caught in them. A character next to a door can roll vs. DX to try and jam the door or dive through it. Failure means the character was caught by the door and takes damage. Roll hit location – if the door fails to kill the character (torso or head) or destroy a limb (or whatever was jammed into it), then it is stuck open. Doors can be manually overridden via the vessel's computer or control stations; authority to do this is usually restricted to engineering damage control teams or the spacecraft's command crew.

Cargo Bay Doors

If a spacecraft hull section has cargo holds, it will have cargo bay doors. A given hull section has *one* set of cargo bay doors, which provide access to all cargo holds in that part of the hull. Doors have the same dDR as the spacecraft hull. They are not airlocks – air spilled is lost. It takes two seconds to open or close cargo bay door, using controls next to the bay doors on the outside and inside. Computer AIs and control stations can also open or lock them.

The maximum SM object that easily fits through cargo hold doors is the hull SM-5 if the hull section has 1-2 cargo holds, or hull SM-4 if it has 3-6. A successful Freight Handling roll lets an object of one SM greater to be maneuvered through the door. Failure means the item is stuck, requiring minor repairs (dismantling the door or the object) to clear access. The actual width and length a cargo bay door (in yards) is shown below, depending on the number of cargo holds in that hull section:

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
1-2 holds	1	1.5	2	3	5	7	10	15	20	30	50	70
3+ holds	1.5	2	3	5	7	10	15	20	30	50	70	100

Hangar Bay Doors

Hangar bays are equipped with much larger doors than cargo bays. Moreover, the entire bay is designed to function as a giant airlock! It can be evacuated (storing the air in holding tanks) before the doors are opened. It takes 1.5 minutes × pressure differential (in atmospheres) to change the pressure in a hangar bay. Thus, it usually takes 1.5 minutes to go from 1 atmosphere to vacuum, or vice versa. The normal procedure is to evacuate the hangar bay and keep it evacuated during all launch or recovery operations.

If a spacecraft hull section (front, central, or rear) has hangar bays, it has hangar bay doors. They take two seconds to open or close. A given hull section has one set of hangar bay doors, which accesses all hangar bays in it. The diameter (in yards) is shown below:

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
1-2 bays	1.5	2	3	5	7	10	15	20	30	50	70	100
3+ bays	2	3	5	7	10	15	20	30	50	70	100	150

The maximum SM object that can be maneuvered through the doors is hull SM-4 if 1-2 bays or hull SM-3 if 3-6 bays. Squeezing larger objects through is not possible, as the airlocks are more complex than cargo bay doors.

Hull Breaches

Another way to get into or out of a spacecraft is through a big hole. The hull is *breached* if any non-core system is disabled or destroyed. Typical breach diameter (in yards) is shown on the table below. For disabled systems, roll for diameter. For destroyed systems, the breach is automatically the maximum possible size that can be rolled.

See the section on *Emergency Pressure Doors* for how much of the hull will be evacuated or exposed to foreign atmosphere during a breach. Most spacecraft systems are designed to survive decompression, but plants in open spaces and delicate furnishings or supplies in habitats (e.g., bottles of wine in bar establishments, etc.) will be lost if exposed.

SM	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***	
Disabled	1d-4	1d-3	1d-2	1d	1d+2	2d	2d+3	4d+1	6d-1	8d+2	12d-2	16d+4
Destroyed	2	3	4	6	8	12	15	25	35	50	70	100

Teleport Projectors

Why bother with doors? See *Teleport Projector* (p. 48).

Cargo Handling

Loading or unloading time for cargo is about one man-hour per 100 tons at a port facility with heavy machinery or if the vessel is docked in a larger spacecraft's hangar bay, or at a rate of 1 man-hour per 10 tons otherwise (including moving ammunition from a cargo bay to a gun or launcher, or a vessel in a hangar bay). Roll against Freight Handling (and Hazardous Materials, if necessary) skill to properly load cargo. Success means everything is stowed properly. Failure means it was stowed haphazardly: any attempts to unload the cargo take twice as long. Critical failure results in unsafe stowage: triple unload time, and the cargo may break, leak, or escape!

Computers and Software

Spacecraft with computer networks use the rules on p. B473. Control stations and offices or ops centers have terminals that can access it; computers carried by occupants and desktop models installed in cabins or bunkrooms may be able to interface with the network if it's designed to allow it.

These rules ignore most software. Ship navigation, targeting, etc., is a simple computing problem; even the lowest-complexity spacecraft systems can simultaneously run all necessary software. Weapon sAcc values already include targeting programs.

The major advantage of better computers is to run high complexity programs like cryptographic analysis, language translation, or even Artificial Intelligences that can function as crew members! See ***GURPS Ultra-Tech*** for AIs and other software.

Comm/Sensor Arrays

Any vessel with controls has a basic comm/sensor array. Some vessels have enhanced, multipurpose, science, or tactical comm/sensor arrays. All are integrated communication and sensor suites whose capabilities are simplified into a single comm/sensor array *level*.

Unless given the FTL option, detection and communications occur at the speed of light, and over long distances. Time lag is one second per 186,000 miles, or 500 seconds per AU, each way.

Arrays have the following navigational, sensor, and communications capabilities:

Passive Sensors

Comm/sensor arrays include telescopes (visual, infrared, ultraviolet, radio) for navigation, detection, and targeting. They usually operate in infrared mode for long range detection, but also produce telescopic imagery ("on screen") or perform multispectral sensing.

Passive sensors are operated from a control station (or by a sapient program). The operator uses Electronics Operation (Sensors) skill, using the *Sensors* rules (p. B471). The sensors are vehicular imaging sensors (p. B471) that provide Hyperspectral Vision (p. B60) with Extended Low Band (and Extended High Band, for science and multipurpose arrays), Telescopic Vision (p. B92) and 360° Vision (p. B34). The Telescopic Vision Level is equal to the comm/sensor array level.

Passive sensors can also detect and locate any operating active sensor or broadcast signal within twice its own range (see Signal Detection, below).

Spacecraft will usually be using passive sensors to detect other spacecraft. The relevant modifiers are summarized below. Roll vs. Electronics Operations (Sensor) skill adding the modifiers shown below; if the modifiers total +10 or more, the GM may assume automatic identification. Passive sensors only detect objects in line of sight – something behind a world, larger station, underwater, etc. won't be detected. Modifiers:

SM: Add the object or spacecraft's Size Modifier.

Time Spent: Assume a complete scan around the vessel takes 20 seconds. Time spent modifiers apply (e.g., +3 for a full 3-minute space combat turn, or +5 for half an hour).

Range: Apply the Range modifiers from p. B550. In space combat, -10 at zero (100 yards), -30 at point-blank (100 miles), -34 at close (500 miles), -38 at short (2,500 miles), -42 at long (10,000 miles), -46 at extreme (50,000 miles). For astronomical ranges: -50 at 200,000 miles

(1 LS), -54 at 1 million miles (5 LS), -60 at 10 million miles (100 LS), -66 at 100 million miles (1 AU), -72 at 1 billion miles (10 AU), -75 at 7 billion miles (75 AU; scan entire solar system).

Telescopic Vision: Reduce the above range penalty by the level of Telescopic Vision. You may "zoom in" and use twice the Level if the target's approximate location is already known. This includes attempts to get a better look at a detected target, rolls to spot targets whose orbits are already charted (e.g., charted satellites, celestial bodies, etc.) or whose radio, radar, or transponder emissions have been detected.

Damage: If an enhanced, tactical, multipurpose, or science array is disabled or destroyed, a vessel can use its basic array. A basic array is only destroyed if the controls or spacecraft is destroyed. All arrays are at -1 if the spacecraft is reduced to 0 HP or less.

Observation: +10 if object is in plain sight (in space, air, or a world's surface) rather than concealed, camouflaged, hidden among debris, or using a Cloaking Device.

In Space: +2 if the object is silhouetted against a larger celestial body, +24 if silhouetted against deep space. Note that this is cumulative with the plain sight modifier.

IR Signature: Spacecraft often put out a lot of heat and light! If trying to detect a spacecraft or similar object, apply the single highest applicable modifier:

Minimal power: 0*.

Auxiliary power: +3.

Fuel cell, solar panels, or jet engine: +4

MHD turbine, chemical or HEDM rocket engine, or flying in atmosphere at 3,600+ mph: +5

Fission reactor, nuclear thermal rocket, nuclear light bulb, or performing a high-speed atmospheric reentry: +6.

Antimatter thermal rocket engine, antimatter reactor, fusion reactor, super fusion reactor, total conversion reactor, magsail, lightsail: +7.

Fusion pulse drive or fusion rocket engine: +8.

Advanced fusion pulse, antimatter plasma, nuclear saltwater rocket, or external pulsed plasma engine: +9.

Antimatter plasma torch, antimatter pion, or fusion torch engine: +10.

Antimatter pion torch, super antimatter plasma torch, or total conversion torch engine: +11.

Super conversion torch engine, or any "cosmic" power plant: +12.

Reaction engine modifiers assume the rear hull (with drive) is facing toward the sensor array; if it's the central hull, reduce by one; if it's the front hull, reduce by two.

Countermeasures: The following modifiers apply:

-10 if target is using a cloaking device.

-2 × (TL-6) if using a stealth hull unless the target has signature modifiers of +5 or more.

* Auxiliary power permits operation of all non-high-energy or cosmic energy systems. Minimal power does not permit the use of any life support (except hibernation chambers), active sensors, or ECM.

Failure means no contact (a critical failure may mean a misidentified contact or other error); the operator may repeat the task on later turns if there is reason to believe something is out there.

Success means detection of the object's presence, range, course, temperature class, and SM, but no other details. Once an object is detected the sensors will automatically keep track of it (along with anything it launches). It remains detected as long as it remains in line of sight and does not activate a cloaking device. If it cloaks, a new detection roll is required. If it leaves line of sight and reappears later, a new roll is also needed.

Signal Detection

The passive sensors in comm/sensor arrays also incorporate radio, laser, and radar detectors. If a vessel is using radar or broadcasting radio signals, or using a transponder, these sensors automatically detect the signal out to twice the active or broadcast range (1.5× range if the signal was low-probability intercept (LPI) – see p. B82). Ladar and tight beam laser comm signals are detected only if the spacecraft was their target, or happened to be in their path. FTL radio and para-radar multiscanner emissions can only be detected if the vessel also uses such a system; if so, treat them as radio and radar, respectively. The sensor operator will detect the type of signal, the content of any (non-encrypted) broadcast and an approximate bearing (passive sensors can use twice their Telescopic Vision level from range modifier). A successful Electronics Operation (EW) roll can also reveal useful details ("that was a Type 23 radar used by the Federal Navy").

Detection

This information is automatically available about a detected spacecraft:

Size, mass, power plant, and power points.

Acceleration and type of maneuver drive, if the spacecraft accelerated.

At point-blank or short range, these systems will be visible if they are in a hull section on a detected object facing the targeting vessel:

Comm/sensor array (any type), habitat, hangar bay, reaction drives, weapon battery, robot arms or legs, any destroyed systems (but not what they were), open space.

Operating force screens (at GM's option).

The main radiator array and winged features.

Additional information may be available via Sensor Analysis tasks (p. 94).

Active Sensors

Active sensors in a comm/ sensor array consist of radar and ladar used for navigation, detection, and targeting. Their range is measured in light seconds (one light second is 186,000 miles). They can be operated from one of the vessel's control stations or its computer. All sensors can generate multiple sensor beams that can track any number of targets simultaneously.

Active sensors are less important for spacecraft than passive sensors; usually the passive sensors detect targets at much longer distances. Active sensors are mainly used as part of targeting systems, for radar mapping of worlds (especially if cloud covered) and, with superscience multiscanners, for "sensor scans" to analyze a target.

Active sensor use in space combat is integrated into the combat rules in Chapter 3. Otherwise, use the vehicular active sensor rules (p. B471-472).

All types of array can be used as a radar (p. B81) with the Extended Arc (360 degrees), LPI, and Multimode enhancements. Enhanced, tactical, and science arrays also include a ladar (p. B81) with Extended Arc (360 degrees) and LPI enhancements; see Scanning Sense, pp. B81-82. If the spacecraft has the multiscanner design switch all arrays have a para-radar (p. B81) with the Extended Arc (360 degrees) enhancements.

The active sensor's range in light seconds is determined by the array level: see *Active Sensor and Comm Range Table* below. You can multiply by 200,000 to get range in miles. On a world, it can see out to the horizon.

Active Sensor and Comm Range Table

Level	*Range*	*Level*	*Range*
1	0.1	10	3
2	0.15	11	5
3	0.2	12	7
4	0.3	13	10
5	0.5	14	15
6	0.7	15	20
7	1	16	30
8	1.5	17	50
9	2	18	70

Heliographs

Heliographs are a means of signaling with the pre-radio design switch. A stabilized heliograph is standard equipment in a control room or comm/sensor array built at TL4 and higher.

A heliograph consists of a mirror and a sighting device. A pulse code is sent by moving a reflected beam from the mirror on and off the target. Messages cannot be sent while the vessel is maneuvering or using spin gravity.

The transmission rate is the same as telegraphy (see Electronics Operation (Communications) skill, p. B189). Use the *Active Sensor and Comm Range Table* (above) to determine range, reading the range on the table as "tens of miles."

For interplanetary communications, a solar mirror or lightsail can be pressed into service as a giant heliograph. Look up the operating ship's SM on the *Active Sensor and Comm Range Table*, reading that as the "level" of the array. The result is the range in AU. A solar mirror sends signals at the same speed as a heliograph. A lightsail is slow to manipulate and can send, at best, a few characters per hour.

Communications ("Comm Suites")

Comm/sensor arrays have very long range laser communication and radio (p. B91), communicators. Range depends on the array level – see the *Active Sensor and Comm Range Table*, reading the range in astronomical units (AU). E.g., a Level 8 array has a 1.5 LS range active sensor and 1.5 AU range comm suite. Use the communications rules on p. B471 and p. B91.

Spacecraft also have internal intercoms in all systems except armor and fuel tanks, as well as outside next to airlock, hangar, and cargo doors.

Transponders

Comm suites may be set to automatically broadcast identification codes for traffic control purposes. Regulations may require civilian spacecraft to broadcast their identity using transponders whenever they are operating in civilized shipping lanes. Crews that find this onerous may reprogram them to emit false identity signals. Reprogramming a transponder may be a trivial exercise, or it may require difficult Electronics Operation (EW) or Computer Programming rolls (GM's discretion). The usual deterrent to using a false signal or no signal is fines or worse if caught by authorities.

Overloading Life Support

A spacecraft's ability to carry people is normally limited by its rated occupancy, but it can be increased *in extremis* by cramming more people into it. Roll 3d against

HT+4 each day of overloading, at -1 per full 10% by which the number of people aboard exceeds system capacity. On a failure, the system begins to break down, losing 10% of its current capacity for each point by which the roll was missed. A Mechanic (Life Support) roll can be attempted once per day; if it succeeds, it will restore 10% of full capacity. Once the life-support system begins to fail, the effect snowballs; if the ship remains overloaded, life support will eventually reach 0% and fail. At that point, all oxygen in the air will be used up within a few hours. Then everyone who needs to breathe will start to suffocate.

Repair and Maintenance

Spacers often spend much of their time maintaining onboard systems; the listed workspace requirements in Chapter 1 cover the crew (humans or robot) needed.

See the Damage Control rules in Chapter 3 for the rolls needed to repair disabled systems and dHP. A destroyed system must be replaced at full cost (usually at a shipyard with sufficient hangar space for the vessel) plus a 10% fee. It will normally require one day per spaceship dHP for a full dockyard to replace a destroyed system. Multiply this time by 10 if the space yard doesn't have sufficient hangar space to put the spacecraft in an internal dock. If the spacecraft has fabricators, robofacs, nanofacs, or replicators, it can manufacture replacements onboard.

Refueling

Reaction drives consume reaction mass from fuel tanks as spacecraft use up their delta-V. Some power plants require periodic refueling.

Refueling Fuel Tanks

Fuel tanks are rated for their tons of fuel and the delta-V reserve they provide. The cost to completely refill a tank depends on the tons and type of reaction mass stored in it, as listed on p. 28.

Fuel Transfers

If two spacecraft with different sizes or different reaction drives transfers tons of reaction mass between each other, adjust each of their reserves of delta-V.

For a spacecraft with fewer than 6 fuel tank systems, its current delta-V reserve is given by its fully-fueled delta-V multiplied by the fraction of fuel remaining.

If a ship has 6 or more fuel tank systems, convert tons of fuel into the number of fuel systems (p. 28), and recompute its delta-V as described for *Reaction Engines* (p. 19), including the modifiers from the *Delta-V Increase Table*.

A spacecraft can transfer up to 10% of its total fuel or reaction mass every three minutes (1% every 20-second turn).

Power Plant Refueling

Power plants whose endurance is measured in years combine refueling with major reactor overhauls (since their cores are often radioactive). The fuel for the normal listed endurance is included with the spacecraft's cost. Refueling requires a shipyard of the power plant's TL or greater. The cost, with maintenance, is a fraction of the cost of the power plant: 10% for fission, fusion, or super fusion power plants, 50% for antimatter power plants.

Chemical energy and combustion power plants are refueled the same way as fuel tanks. Refueling a chemical energy power plant's internal fuel supply costs 1/4 of the cost replacing a tank of rocket fuel for the same SM vessel. Refueling a combustion power plant's internal fuel costs 1/6 of the cost of a tank of gasoline, diesel, or jet fuel for the same SM vessel.

Drop Capsules

These tiny spacecraft are designed to let their occupants enter atmosphere safely. They are normally carried in hangar bays, though they may also replace 32 cm or larger missiles and be carried in missile launchers. They are smaller than standard craft and have only attitude thrusters, but can reenter atmosphere as per Soft Landing System. De-orbiting takes two or three rotations around a planet with an Earthlike atmosphere (more for a planet with a thinner atmosphere, such as Mars). During this time, radio, radar, and all passive sensors will be blinded due to plasma effects.

See ***GURPS Ultra-Tech*** (p. 232) for detailed descriptions of their capabilities.

Life Pod (TL9): Four-person escape capsule with 90 man-days life support.

Drop Capsule (TL10): A basic landing capsule; not reusable; it breaks open a mile up to allow occupants (or packages) to descend via parachute, parawing, grav belt, etc.

Stealth Capsule (TL10): As above, but packed with countermeasures with a stealth hull. Either treat as if it had three Defensive ECM systems, or use the more detailed rules in ***GURPS Ultra-Tech***.

Drop Capsules Table

TL	*Vehicle*	*dST/HP*	*Hnd/SR*	*HT*	*Move*	*LWt*	*Load*	*SM*	*Occ.*	*dDR*	*Cost*
9	Life Pod	5	-5/1	13	0.1G/0.3mps	1	0.5	+2	4SV	2/10/2	$100K
10	Drop Capsule	5	-	13	-	1	0.5	+2	2SV	2/10/2	$10K
10	Stealth Capsule	5	-	13	-	1	0.3	+2	1SV	2/10/2	$50K

Chapter Three

Basic Space Combat

Combat in space occurs on scales vastly different than those of standard ***GURPS*** vehicle combat rules (pp. B467-470). This chapter presents basic, somewhat abstract combat rules on a scale suitable for space engagements. More explicit map-based combat rules are presented in Chapter 4.

The Engagement

Before combat can occur, opposing vessels must have maneuvered into the same area of space, typically within a few hundred to several thousand miles of each other. Use the space travel and detection rules in Chapter 2, and the combatant's relative courses and planned dispositions to determine if an encounter is likely. The GM may assume that neither side has detected the other, or may start the battle assuming detection has already occurred. The GM must also decide on encounter distance and turn length.

Ambush and Surprise

In some situations, one side may be able to ambush the other. Situations that might let a spacecraft get close enough to avoid detection include:

• All of one side's spacecraft are using cloaking devices.

• A seemingly-friendly spacecraft suddenly attacks.

• A spaceship appears unexpectedly from inside a space station, asteroid base, etc.

• A spacecraft was masked by a planet, moon, asteroid, or large space station.

The GM may rule that an ambush does or does not take place on the basis of a roleplayed situation, a clever plan, or a Quick Contest of Tactics skill.

Vessels on an ambushed side will have surprised crews (see below), and the GM may also rule that the encounter will take place at a shorter distance than usual.

Encounter Distance

Select the encounter scale that suits the type of vessels involved.

Close Combat Scale: Typical engagement range is 20 to 2,000 miles. This is suggested if most important vessels involved have delta-V reserves below 5 mps or if no weapons have ranges greater than Short. It shouldn't be used if vessels have 50G or more acceleration, as they'll race through the engagement area.

Standard Combat Scale: Typical engagement range is 200 to 20,000 miles. This scale works best for vessels with 0.5G to 500G acceleration, or if no weapons have ranges greater than Long.

Distant Combat Scale: Typical engagement range is 2,000 to 200,000 miles. This scale is suggested if at least some of the spacecraft involved use weapons with Extreme range or if very fast drives (50G and up) are used.

Turn Length

Space battles are fought in space combat turns whose length depends on the encounter scale and spacecraft performance. The GM determines turn length by selecting a reference spacecraft acceleration from the *Acceleration Scale Table* below, and cross-indexing it with the encounter distance. Ideally, all spaceships will fall into the same acceleration category. If not, the GM decides on the reference vessel – usually either the best-performing craft, one that's most typical of the encounter, or the most important craft (e.g., the PCs' ship).

Acceleration Scale Table

Acceleration	*Close Scale*	*Standard Scale*	*Distant Scale*
Under 0.05G	10-minute	10-minute*	10-minute*
0.05G+	3-minute	10-minute	10-minute*
0.5G+	1-minute	3-minute	10-minute
10G+	20-second	1-minute	3-minute
50G+	20-second†	20-second	1-minute
500G+	20-second†	20-second†	20-second

* Spacecraft with the reference acceleration or less can't significantly alter course during the fight – tactics will be dominated by gunnery and damage control, not maneuver.

† Spacecraft with the reference acceleration are properly moving too fast for this encounter scale to be optimum, although you may use this scale if you wish!

Example: The smuggler *Rose of Rigel* (with 2G acceleration) is boosting away from the planet Moonjam. In orbit is the hostile patrol ship *Shambleu* (4G acceleration). The GM decides it will be a standard scale encounter. Their drives both fall into the 0.5G+ category, so the GM cross indexes that with standard Scale and determines the space combat turn will be three minutes long.

In some cases the reference vessel's maximum *speed* is more important than acceleration when determining turn length: if its speed is limited, then space combat will be slow no matter how quickly it can accelerate. This is particularly relevant if the reference vessel has a *Boost Drive* (p. 60, or is operating in a *Hyperdynamic* or *Air-Filled Cosmos* (p. 81), or simply has a Newtonian reaction drive with a limited delta-V. In that case, look up the reference vessel's top speed in the *Speed Scale Table* to determine the reference turn length. Use the *larger* of the turn lengths obtained from the vessel's acceleration and speed. A "no" means none of the turn lengths are suitable: try a different encounter distance or use another vessel as the reference spacecraft. (The spacecraft that gave the "no" result may be making a *Fast Pass* through the encounter area; see below).

Speed Scale Table

Speed	*Close Scale*	*Standard Scale*	*Distant Scale*
Under 0.1 mps+	10-minute	10-minute*	10-minute*
0.1 mps+	3-minute	10-minute*	10-minute*
0.3 mps+	1-minute	10-minute	10-minute*
1 mps+	20-second	3-minute	10-minute*
3 mps+	20-second†	1-minute	10-minute
10 mps+	no	20-second	3-minute
30 mps+	no	20-second†	1-minute
100 mps+	no	no	20-second

* Spacecraft with the reference speed or less can't significantly alter position during the fight – tactics will be dominated by gunnery and damage control, not maneuver.

† Spacecraft with the reference speed are properly moving too fast for this encounter scale to be optimum, although you may use this scale if you wish!

Example: The starship Dawn's Arrow has two boost engines, each rated for a top speed of 30 mps. If we chose a standard scale (based on its weapon ranges), a suitable time scale would be a 20-second turn. Since a boost drive has effectively *infinite* acceleration, the speed-based time scale is automatically longer than any acceleration-based time scale.

Encounter Velocity and Fast Passes

Based on decisions made before the battle begins, the GM should have an idea how fast vessels are moving. Using the table below, determine whether any spacecraft are making a fast pass – moving so quickly they'll flash right through the encounter area in a turn or two. Examine the table below, comparing turn length and encounter distance to find a threshold velocity.

Fast Pass Threshold Table

Scale	*Close*	*Standard*	*Distant*
20-second turn	50 mps+	500 mps+	5,000 mps+
1-minute turn	15 mps+	150 mps+	1,500 mps+
3-minute turn	5 mps+	50 mps+	500 mps+
10-minute turn	1.5 mps+	15 mps+	150 mps+

Any spacecraft the GM decides has a velocity exceeding this threshold is making a "fast pass." Others are moving slowly enough to stay in the battle area. This is a fuzzy line: If a craft is within +/-50%, the GM can opt to treat it as fast or not, as desired.

Example: Continuing from the previous example, the GM decides the *Rose of Rigel* has just exceeded 7 mps, Moonjam's escape velocity, and that *Shambleu* is probably at orbital velocity, around 5 mps. Both of these falls under the 50 mps threshold for a standard scale encounter with 3-minute turns, so neither spacecraft is making a fast pass.

Pre-Battle Preparation

Current Delta-V: If a spacecraft has already used a reaction drive before the combat began, note how much of its delta-V reserve remains available.

Formations: Spacecraft may be declared either to be in formation or docked, before an engagement begins. See *Formations* (p. 109).

Crew and Passenger Locations: The GM should know where each PC and important NPC is in the spacecraft, and have a general idea where everyone else is as well. Some tasks can only be properly performed from certain systems (see *Character Actions*, p. 91). On SM+5-6 spacecraft, characters may only occupy cargo, control, hangar, habitat, or passenger seat systems. On larger spacecraft, characters may be in any system save armor or (non-empty) fuel tanks. For simplicity, you can assume everyone is at their duty station and passengers are in habitats.

Surprised Crews: If a vessel's crew are surprised (see below) some crew may be in the wrong place, e.g., not at their action stations. They may have to take one or more space combat turns to reach their actions stations – see *Internal Movement* (p. 107).

Space Combat Turns

Space combat is fought in a series of *space combat turns* that range from 20 seconds to 10 minutes long depending on the chosen time scale. Each spacecraft takes its turn in sequence, until all vessels have had their turn, then they start over. This is like personal combat, except that the turns are organized by spacecraft rather than by character.

The sequence in which spacecraft act is up to the GM. The default starting sequence is the Speed of each pilot who was controlling each vessel at the start of the battle. If pilots have the same Speed, the lowest SM spacecraft goes first; break further ties with a die roll. Alternatively, the GM can have the first actions go to all spacecraft on the side that won a Quick Contest of Tactics or which was able to perform an ambush.

Either way, the sequence is retained each turn, even if the pilot or situation changes (omitting vessels that were destroyed). If a new vessel enters the battle, add it to the end of sequence. If one is launched from a hangar bay, insert it into the sequence after the launching craft. Objects other than spacecraft, such as individuals or installations, can also take turns. E.g., a cluster of spaceport buildings

When Not To Use These Rules

These rules are intended to handle battles at great distances, often involving large crews. Don't use them where standard one-second combat turns and range calculations in yards are more appropriate! E.g., if a spaceship is strafing a party of adventurers on the ground, fighting an airplane, or boarded, feel free to switch to the standard ***GURPS Basic Set*** vehicle rules. Refer to the vessel's short-form statistic block (multiplying dDR by 10 and dST/HP by 10 to get the unscaled values) and use *Weapons in Ordinary Combat* (p. 41).

on a planet or moon, with its own sensors, hangars, and weapon batteries, could be treated like a spacecraft.

On each spacecraft's turn, the important characters aboard it each take their own individual turns, performing tasks described below. After they have acted, the spacecraft's turn is over; proceed to the next vessel in the sequence. Once every spacecraft has had its turn, begin again, repeating the same sequence with surviving spacecraft acting in the exact same order as before.

Action During a Turn

On a spacecraft's turn, all player characters aboard, and any NPCs performing important roles, take their own turns, organized as shown below.

During the spacecraft's turn, PCs and other key characters decide what duties they'll perform, if they differ from last turn. If characters are moving about the vessel or staying put, this is also resolved now (including boarding of small craft).

Characters aboard a single spacecraft take their own individual turns in the order shown below. Following this ensures that the commander's skill rolls for handling the ship can affect the crew, that the engineer provides power to drives and weapons so the pilot and gunners can use them, and so on. However, this isn't a war game – the GM should feel free to vary the sequence as dramatically appropriate!

Characters may perform a single task without penalty, or, since each turn represents a lengthy period, may combine multiple tasks at a penalty; see *Multitasking* (p. 92). There's no need to try and do every task, e.g., the single crew member on a space fighter might decide to perform only a piloting and a gunnery task, ignoring everything else. Similarly, a space station or vessel that's out of fuel may omit piloting tasks.

Functional Systems and Control Stations

Some tasks refer to systems or control stations being "functional" as a prerequisite. A functional system has not been disabled or destroyed. If the system is a high-energy system, it must also have a Power Point assigned to it (or multiple Power Points, if it requires them). Subsystems such as control stations or weapons are functional if the system they are installed in is functional.

1. Command Tasks: One character acting as commanding officer (and optionally one acting as executive officer) may perform *Command Tasks* (p. 92).

2. Engineering Tasks: One character acting as chief engineer may allocate power (if necessary) and optionally perform an extra action from the *Engineering Tasks* (p. 93).

3. Navigation Tasks: One character serving as navigator may perform *Navigation Tasks* (p. 93).

4. Piloting Tasks: One character serving as pilot may perform *Piloting Tasks* (p. 94). At the start of this phase, any attack vector or collision course results achieved by another spacecraft against the pilot's vessel are removed (but engagement or rendezvous results will remain) – see *Range* (p. 98). If no one is performing a pilot task, the spacecraft performs an Uncontrolled Drift (p. 98). If a collision course result is achieved, the pilot may opt to attempt a collision attack, but need not do so.

5. Electronics Operation Tasks: All characters acting as sensor or comm operators can perform *Communications Tasks* (p. 95) or *Sensor Tasks* (p. 94) for the systems they control.

6. Gunnery Tasks: All characters controlling functional weapons may perform *Gunnery Tasks* (p. 94), or may alternatively delay performing tasks until Step 7, after the piloting tasks have been performed and the range has (possibly) changed.

7. Crew Tasks: Other crew members may perform tasks or other actions. The only activities given special rules here are *Damage Control Tasks* (p. 96), but there are plenty of opportunities for other activity. Medics can treat the injured in their system, stewards can try to calm passengers, boarding parties can rally at airlocks or fight aboard ship, passengers can hide in cabins, don space suits, or try to hijack the ship, etc.

Character Actions

Since each turn is longer than one second, characters don't take maneuvers. Instead, they perform *tasks* that represent multiple maneuvers over a period of time.

Character actions are divided into several task categories, such as Command or Gunnery, which determine when tasks are performed. These are often assigned to specific people (e.g., the pilot performs Piloting tasks) but a title isn't necessary, e.g., the ship's cook could run to a control station and take over the ship's helm.

Sapient computer programs (see ***GURPS Ultra-Tech***) that are running on the spacecraft's computer network may perform certain tasks, if so noted. Aside from existing in the computer network, they use the same rules as other characters.

Multitasking

Characters can try to perform more than one *different* task in a turn, with certain restrictions. A character can only perform those tasks possible from the system he spent the entire turn in. The same task can't be performed multiple times in a turn.

There is a skill penalty for multitasking, which is applied to *all* tasks:

• -2 per added task after the first, if it's part of the same category, e.g., two different Command tasks.

• -4 per added task after the first of a different category, e.g., both a Command and a Piloting task.

If a character will multitask, indicate it when they perform the *first* task, so that the penalty can be applied to *all* tasks they perform during the turn.

Command Tasks

"Chief engineer, I need those engines on line now! Get me more power!"

No more than two crew (usually a captain and either an executive or tactical officer) may perform command tasks aboard a spacecraft in a given turn. Their authority must be recognized by the crew under them. Command tasks may be performed from a functional control station or by a sapient program capable of interacting with the crew.

A commanding officer may tell the other key crew members what to do! Since each turn represents several seconds to 10 minutes, this is a free action. You can also spend time talking via communicator with someone outside the vessel, such as another spacecraft commander, using social skills such as Diplomacy or Intimidation. This will rarely count as a task unless it takes the entire turn.

In addition to talking and giving orders, you may perform any of the following tasks during the turn. Unless noted, all effects last until your next turn.

Tasks other than motivate crewman can only be attempted once *per spacecraft* per turn. Motivate crewman can only be performed once per enemy spacecraft per turn.

Leadership Task

The spacecraft's commander or executive officer (but not both) may spend the turn inspiring all of his subordinates. This is a use of Leadership skill to improve morale and self-control, as described on p. B204. In addition to the bonuses on p. B204, a roll that succeeds by five or more, or is a critical success, will add +1 to the average Spacer skill of subordinates (but not the character performing the task).

Motivate Crewman Task

Motivate a single subordinate who you believe is performing an important task, such the pilot or engineer. Roll against your Shiphandling skill. Success gives them a +1 on any tasks they perform through the turn. Failure means you're distracting them, giving them a -1 penalty. Double this on critical success or failure! Modifier: -2 if you are in different systems (unless either of you are computer programs).

Shiphandling Task

Enable a subordinate to perform Piloting tasks with Spacer instead of Piloting skill by directing him. Use the lower of their Spacer or your Shiphandling skill in lieu of Piloting skill. You'll tell them what to do – it's up to the GM which of you makes the skill roll. Unless either of you are computer programs, you must both be in the same system. The main advantage of this task is that it's a command task rather than a piloting task: you can "steer the ship" while doing another command task with a -2 rather than -4 penalty.

Space Tactics Task

Pick a single enemy spacecraft or formation, predict what it will do, and relay that plan to any subordinates.

Pre-Battle Turns

Each spacecraft's first turn is a pre-battle turn, which represents what it was doing just before the combat started. There are certain restrictions on tasks during a pre-battle turn:

• Pilots cannot perform Closing or Retreat maneuvers.

• Gunners may not perform Aim and Attack or Launch tasks.

• A spacecraft may not activate a stardrive (save for warp drives used for maneuver).

If combat is expected, pilots should usually choose Hold Course or Evasive Action as their pre-battle maneuver, and gunners take Wait (Point Defense) tasks to avoid nasty surprises.

Surprised Crews: If the GM judges that surprise has occurred (see *Ambush and Surprise*, p. 88), the GM may rule that some or all crew members are elsewhere aboard the vessel. They may have to use their prebattle turn for internal movement (p. 107). Space warships normally make sure at least some of their crew on duty at all times, but other vessels may not be as vigilant.

You may choose "offensive tactics" (reduces your target's Dodge by 1) or "defensive tactics" (increases your pilot's Dodge by 1 against that target). To do so, roll against your the lower of your Navigation (Space) or Tactics skill (or their defaults). Add +1 in a 1 minute turn, +2 in 3 minute turn, +3 in a 10 minute turn. *Exception:* If the target vessel (or formation's leader) had someone performing the Space Tactics task last turn, whether focused on your vessel or not, success requires a Quick Contest of skill against him (if so, don't bother modifying for time). A critical failure means a bad plan that gives your foe the benefit; a critical success doubles the bonus.

Engineering Tasks

"Allocate power to main disintegrator weapon, force field, and two engines!"

These tasks involve allocating Power Points and upgrading the efficiency of engines or power plants. Only one character aboard a spacecraft may perform an Engineering task in a given turn – he's operating the vessel's main engineering console. (On large vessels a dedicated chief engineer will do so). He must be at a functional control station or be a sapient computer program. (References to Power Points apply to Cosmic Power Points if the spacecraft is using them instead.) The following tasks can be performed. Each tasks can only be attempted once per turn.

Allocate Power Task

If a spacecraft has fewer Power Points than it does high-energy systems, you can reallocate these Power Points, deciding which systems to "power up." This also includes the control of any systems "on" (when powered) or "off" (when not): force screens, jump gates, nuclear dampers, some stardrives, and stasis webs. It also includes angling of adjustable force screens. No skill roll is required. Power allocation counts as a task for multitasking only if allocation (and/or force screen angle) changed from last turn, or if the spacecraft gained or lost Power Points (e.g., due to power plant damage).

Increase Power Task

If a spacecraft has one or more Power Points available, you may try to increase their efficiency. Make an Electrician skill roll. Success means that careful switching and husbanding of power gives one extra Power Point to use this turn. Failure means it doesn't; critical failure overloads the system, halving (round down) Power Points available this turn. If you attempt this task, roll before allocating power.

Emergency Power Task

You may dangerously overstress one or more identical reactor or chemical power plant systems. Roll against the repair skill listed for that power system. Success *doubles* the Power Points it can provide this turn, but unless you get a critical success, also stresses it: any attempt to use it to increase power any time in the next hour is at -4. Failure doubles the Power Points but disables the power plant at the start of your next turn. Critical failure disables it immediately without gain. If you attempt this task, roll before allocating power.

Emergency Thrust Task

You may overload the engines of one or more engine systems (except for chemical rocket, HEDM rocket, lightsail, or magsail). Use the same procedure as emergency power, except instead of doubling power, the acceleration doubles. A high-energy system whose thrust is doubled requires doubles the Power Points; a reaction drive will require delta-V commensurate with its increased acceleration. It's up to the GM whether a stardrive can benefit from this – usually a warp drive can, but not other types.

Navigation Tasks

"Just give me another six minutes to plot the course, captain!"

Navigation and sensor operation are closely related aboard a spacecraft, so the same character can perform both activities with only a -2 multitasking penalty.

To perform these tasks, a character must be occupying a functional control station or be a running sapient computer program.

Navigation can always be attempted until the vessel is actually destroyed (even if it requires looking out viewports), but is at -2 or worse (GM's option) if the vessel is reduced to 0 or fewer dHP. Enhanced, science, tactical, or multipurpose arrays can only use their bonus if functional. A spacecraft is also limited to performing no more than one of these tasks per turn per Array (i.e., one task if it has a basic array, or two if it has a basic and another array, etc.) regardless of the number of navigators or sensor operators. Each task can only be performed once per turn.

Tactical Navigation

This involves assisting the spacecraft's pilot in plotting the best course around obstacles or threats. Roll against the *lower* of the navigator's Electronics Operation (Sensor) or Navigation (Space) skill. Success gives +1 to the pilot's Piloting skill (or Shiphandling or Spacer, if that's used instead) this turn. Failure by only 1-3 has no effect; failure by 4 or more results in a -1 penalty. Double effects on critical success or failure.

FTL Navigation

Activating a stardrive involves allocating power to the drive. However, some stardrives (especially hyperdrives and some jump drives) require the navigator first plot an interstellar course, which may take several turns and require a skill roll. If performed in combat, this a navigation task; see *Hyperdrive*, p. 80 for an example.

Sensor Tasks

"Fusion drive flare at six o'clock!"

Navigation and sensor operation are closely related aboard a spacecraft, so the same character can perform both activities with only a -2 multitasking penalty.

To perform these tasks, a character must be occupying a functional control station or be a running sapient computer program. Enhanced, science, tactical or multipurpose arrays can only use their comm/sensor level if functional; the basic array is always functional.

A character can perform multiple sensor analysis tasks on *different* targets by multitasking, but the vessel is limited to a maximum of one sensor detection task per array that it has per turn.

Sensor Detection Task

A character performing this task is using the spacecraft's comm/sensor array to actively look for objects of interest that have yet to be detected. Detection in space usually uses passive sensors. A single task allows the character to roll to detect each significant object that has *not yet been detected*, using the *Passive Sensors* rules on p. 84. Once an object has been detected it is automatically tracked by the spacecraft's navigation system; a task is no longer needed to look for it.

Alternatively, you can use active sensors (p. 86) although this is rarely as useful.

Sensor Analysis Task

Attempt to analyze sensor data of a detected object to determine details. For either of the following tasks, roll at -6 in a 20-second turn, +1 in a 3-minute turn, or +3 in a 10-minute turn. Repeated attempts in successive turns are possible. A critical success may reveal additional details, a critical failure provide misinformation.

Engineering Analysis: Roll against your Engineer (Spaceships or Starships) skill. Add +3 if your sensors incorporated a multiscanner. Success reveals the basic system type (e.g., "habitat" or "chemical rocket engine") of all six hull systems [1-6] on the hull section facing your vessel, and whether they are functional, disabled, or destroyed. Only the first, outer armor layer's composition is revealed. Details that vary from system to system are not revealed: you would not know what type of weapon was in a spinal weapon system, or the exact types of cabins in a habitat. Core systems are hidden. Success by 5+ is required to detect any weak points in the hull that can be targeted.

Bio Analysis: If using a multiscanner, you can roll against Biology skill to analyze sensor data and determine number and species (if known) of life forms aboard the vessel. This will also reveal the presence of any living systems (gardens, organic hulls, etc.).

Exception: Neither task may be performed if the target is using a powered-up cloaking device, opaque force screen, or stasis web, even if sensors did detect the target.

Piloting Tasks

"Evasive action at 3G!"

These tasks involve maneuvering the spacecraft. Only *one* character – the spacecraft's pilot – performs Piloting tasks during a spacecraft's turn (aside from dodging, which doesn't count as a task) and he can only perform one such task. On vessels without maneuver drives, this can involve using attitude controls or gyros used to change facing.

Usually the spacecraft's Piloting skill is used. A DX-based Spacer roll can be substituted if the crewman performing the piloting task is supervised by a supervisor using the Shiphandling command task; the crewman's skill cannot exceed the commander's Shiphandling skill.

A pilot must be in a functional control station or be a running computer program.

Move Maneuvers

You're controlling the vessel. In the basic combat system, pick a "piloting maneuver" (p. 96) such as Closing or Evasive Action for your spaceship, assigning the spacecraft's acceleration and facing as per the maneuver.

Spacecraft whose Closing maneuver achieved a collision course may elect to ram: if so, resolve this immediately using the *Collisions and Conventional Warheads* (p. 104) rules. The attempt may be interrupted by Point Defense Fire if the target's gunners took a Wait (Point Defense) task last turn.

Other Actions

If the spacecraft has robotic arms, robotic legs, or external clamps, and is in position to use them, you can control them to move, clamp, or manipulate things (using Ready maneuvers, etc.) based on whatever work could be done over the length of the turn.

Gunnery Tasks

*"Forward laser battery will target the frigate **Prospero**."*

"Load launchers one and two with nuclear missiles with 100-kiloton nuclear warheads. Load launchers three and four with conventional missiles . . . launch!"

A gunnery task allows a character to control one of the following: a single turret weapon; a single spinal weapon; all *identical* fixed mount weapons in a major or minor battery. The character must be in a functional control station, or alternatively, a computer program running on the spacecraft's network. Alternatively, the character may occupy and control a turret using its dedicated controls. The character may perform one of the following tasks with the weapon or weapons controlled.

A single character may never perform more than one gunnery task per turn (with the exception of spreading fire). Multiple gunners can't control the same weapons.

Aim and Attack

You aim and fire at a specified target or targets. You are assumed to be making All-Out (Deliberate) Attacks after three or more seconds of aim; this is factored into the combat tables. Resolve the attacks immediately, using the *Weapons Fire* rules (p. 100). High-energy systems may only fire if their system was powered. (Exception: If a weapons battery contains conventional guns or missile launchers, these do not require power.) The rate of fire of weapons is scaled with turn length. An attack represents sustained firing over the turn.

Wait (Aim and Attack)

You delay your attack. You may attack a single target during its own turn, firing in the target's own gunnery phase. If the target also fires, your attack is considered to be *simultaneous* with the target spacecraft for purpose of damage (you can resolve it in any order). The advantage is this lets you attack after an enemy has moved closer to your vessel; the disadvantage is that it gets to shoot back (or move away). You must specify the target you are waiting for. (You may decide to change targets and instead attack another target, but you will suffer a -2 penalty.)

Wait (Point Defense)

You may reserve the weapon or weapons you are controlling for defensive fire against incoming ballistic attacks. If, during the period until your next turn, any incoming missiles or vessels successfully attack your spacecraft (or one you are in formation with), you may immediately interrupt fire at them using the Point Defense rules (p. 102). You can opt to use only some of your RoF; if so, you may attack again with unused shots against further incoming ballistic attacks before the start of your next turn.

Communication Tasks

"Comm officer: I'm enhancing the alien signal. Putting it on audio . . ."

Anyone with access to a spacecraft's control station (or a sapient computer program) can engage in routine chatter on communications channels and keep a channel open for incoming messages. See Chapter 2 for the vessel's communication systems. Comms have no difficulty communicating with targets at battle ranges. Skill rolls for using comm systems are only made for emergency or abnormal uses of the skill (see p. B189).

To perform such communications tasks, you must be in a functional control station. This is *not* a singular position – a spacecraft may have enough channels to allow multiple crew to perform comm tasks, although this is typical only of command ships, orbital ports, or fighter carriers. The following special tasks can be performed:

Supervise Damage Control Task

Advise and coordinate a damage control party by using damage report data from the control station. Roll against the lower of your Electronics Operation (Comms) or Spacer skill. Success adds a +1 bonus to that team's damage control rolls this turn (+2 on a critical success). Failure has no effect; critical failure means you distract them: a -1 penalty. Can only be performed once per party.

Signal Enhancement Task

If a message is too weak, garbled, or static-filled, make an Electronics Operation (Comms) roll to interpret it. This may require a Quick Contest with another comm operator's Electronics Operation (EW) if he's jamming you. Each spacecraft may add their comm/sensor array level. You can also use this for Signal Detection (p. 85).

Signal Jamming Task

If the spacecraft has a tactical or multipurpose array, you may use it to jam broadcast radio signals (and FTL radio, if you have that technology) within up to 1% of communication range. Your jamming is automatically successful, but another comm operator who is performing signal enhancement task can get through if they win a

Keeping it Simple: NPC Crew Actions

The full Character Action rules are intended for situations where PCs and important NPC characters are involved. Otherwise, streamline procedures.

Give an NPC-run spacecraft crew an average skill level – typically 10 for rookie, 11 for average, 12 for experienced, 13 for veteran, or 14 for elite crews. Simplify crew tasks as follows:

Command: Don't worry about this! Assume the enemy commander is busy giving orders.

Engineering: Allocate power if necessary; ignore the other options.

Piloting: Use the full rules.

Gunnery: Use the full rules.

Damage Control: Use the normal rules, assuming a spacecraft has access to one damage control party for every engine room system it has.

Other Tasks: Ignore them unless the GM thinks they're important to the situation, e.g., Sensor Detection if opposing vessels haven't yet been spotted.

Quick Contest (as described above). This can only be performed once per array per turn.

Damage Control Tasks

You're trying to fix something or rescue someone, by yourself or leading a team. Damage control doesn't take place in a fixed location: you can move from system to system, but can only perform damage control if in the system that is disabled or (in the case of rescue activities) destroyed. There are four damage control tasks:

Emergency Repairs: Perform emergency repairs to a specific disabled system the team is occupying. A destroyed system can't be repaired.

Halt Catastrophe: Attempt to shut down a disabled or destroyed volatile system (such as an antimatter reactor) before it explodes.

Rescue: Attempt to rescue occupants trapped in a destroyed compartment. See *Rescue*, p. 108.

Structural Repairs: Perform lasting repairs to fix general dHP loss. This is usually only attempted during 10 minute turns. Destroyed system can't be repaired.

These procedures are covered in detail under *Damage Control* (p. 107).

Space Movement

If the pilot performed a Move maneuver as his piloting task, he must further specify which single *pilot maneuver* detailed below will be used. Each option represents in abstract fashion how his spacecraft is moving relative to the other combatants. The maneuvers are Closing, Controlled Drift, Evasive Action, Hold Course, and Retreat.

If no one was piloting the vessel (or it's unable to change course) the spacecraft's movement defaults to Uncontrolled Drift. See Pre-Battle Turns for other restrictions.

Fast Pass Status

If a spacecraft begins its turn with Fast Pass status, it will race out of combat range and leave the battle at the *start* of its *second* turn. This means it gets the pre-battle and first turn, and opponents get their own turn to maneuver and attack it.

After the spacecraft leaves the battle area, the GM may use the rules in Chapter 2 to determine how long it takes to decelerate and return to the battle, based on its velocity. In many instances it may take hours or even days to reverse course, depending on how quickly the vessel was going and the combat's turn length. It's usually easiest to assume the vessel is out of the fight! If there are no other foes, the battle ends (for the moment).

Acceleration Bonus

All maneuvers except Drifts provide the option to accelerate to gain an *acceleration bonus*. This is enough acceleration for a long enough period to achieve a significant position change during the turn. It depends on turn length and encounter scale.

Acceleration: To achieve an acceleration bonus, the spacecraft must be able to accelerate. This requires at least one functional maneuver drive (engine or sail) or a warp drive. Drives are rated for maximum acceleration; high-energy system [!] drives may only be used if they were allocated power.

Burning Fuel: Reaction drives have a limited delta-V reserve. To sustain acceleration through the space combat turn, a reaction drive spaceship must also spend some of its delta-V reserve, using up the reaction mass in its fuel tanks.

Boost Drives: A vessel with the boost drive design switch (p. 60) has unlimited acceleration but limited speed. Treat it as a reaction drive expending delta-V equal to the top speed, and ignore its acceleration.

The table below shows the acceleration required to get a +2 acceleration bonus, and in parenthesis, the delta-V cost per +2 bonus that reaction engines pay from their fuel tank's delta-V reserve. A spacecraft using a reaction drive must meet both requirements.

Acceleration Bonus Table

Close-Scale Encounter	***Requirements***
20-second turn	10G (and 1 mps) per +2
1-minute turn	1G (and 0.3 mps) per +2
3-minute turn	0.1G (and 0.1 mps) per +2
10-minute turn	0.01G (and 0.03 mps) per +2
Standard-Scale Encounter	***Requirements***
20-second turn	100G (and 10 mps) per +2
1-minute turn	10G (and 3 mps) per +2
3-minute turn	1G (and 1 mps) per +2
10-minute turn	0.1G (and 0.3 mps) per +2
Distant-Scale Encounter	***Requirements***
20-second turn	1,000G (and 100 mps) per +2
1-minute turn	100G (and 30 mps) per +2
3-minute turn	10G (and 10 mps) per +2
10-minute turn	1G (and 3 mps) per +2

(Each +1 bonus is half the required acceleration and delta-V).

Pilot Maneuvers

A pilot who takes a Move maneuver must specify which of these pilot maneuvers he is performing: Closing, Controlled Drift, Evasive Action, Hold Course, or Retreat. Some maneuvers have specific prerequisites. If a spacecraft isn't piloted, it defaults to Uncontrolled Drift. A spacecraft pilot can only perform one maneuver in a turn.

On the first turn of a battle, you may not choose a Closing maneuver unless you have fast pass status.

Maneuver Modifiers

Some maneuvers involve Quick Contests of skill. In addition to the specific modifiers listed, the following modifiers may apply to each pilot in the contest:

Acceleration bonus (p. 96) if their spacecraft accelerated.

Handling of the spacecraft.

Multitasking penalties (p. 92).

-6 if engaged in a Quick Contest of Skill with a target that you have not detected.

Any relevant modifiers to skill due to appropriate tasks performed to assist the pilot (tactical navigation, etc.).

The modifiers of the maneuvering spacecraft are based on this turn's situation, while those of the target spacecraft are based on its situation in its own last turn. The GM will need to keep track of the maneuver (and acceleration) a spacecraft used on its last turn.

Facing

Facing is which of your hull sections – front, central, or rear – face your opponents. A pilot chooses facing within the limits specified for the maneuver he picked. It remains until his next turn. The major effects are:

• Facing determines which weapons on the spacecraft can fire – see *Bearing* (p. 100).

• Only the hull section that faces your opponents can be targeted by enemy fire aimed at the spacecraft's hull, though certain other exposed systems can also be attacked.

Closing Maneuver

You are attempting to maneuver your vessel close to a particular target. Select a vessel (or other object, such as an asteroid or spaceport) as the target of your maneuver.

Example One: During a standard-scale encounter fought in 3-minute turns, the privateer *Revenge*, equipped with fusion torch drives, is using a Closing move to chase the retreating merchant *Innsmouth*. The *Revenge* knows *Innsmouth* accelerated at 1G last turn for +2 acceleration bonus. The Revenge wants to be faster. It has three high-thrust fusion torch engines with 3G total acceleration, and only 12 mps of delta-V left in its tanks; as this is a reaction drive, it must pay the delta-V cost and minimum acceleration. It goes for a +6 bonus, which requires 3G and 3 mps. This leaves only 9 mps in its tanks!

Example Two: During a distant-scale encounter fought in 10-minute turns, the mining ship *49er* would like to Retreat. However, she has only 0.01G acceleration from her mass driver engine, and that's below the 0.5G for significant maneuver in this scale. *49er* won't be able to perform any maneuvers that require an acceleration bonus.

You must accelerate fast enough to receive an acceleration bonus (p. 96) or be making a fast pass (p. 89). If your target's last maneuver was Controlled Drift or Uncontrolled Drift, roll against your Piloting skill (adding Maneuver Modifiers, p. 97) to succeed. Otherwise, success requires winning a Quick Contest of Piloting Skill with the target's Pilot; you both add Maneuver Modifiers. If the target's last maneuver was Evasive Action, he receives double his acceleration bonus.

If you succeed and were not already engaged with that target, your vessel can either achieve an "attack vector" (p. 98) against that target – a quick, close approach – or choose to be "advantaged" (p. 99) against the target, outmaneuvering it. If you succeeded by 10+, you may combine advantaged and an attack vector, or instead of doing so, choose either to be "engaged" (closing and matching velocity) or make a "collision course" (p. 98) – a very close approach – to the target.

If you were already engaged against that target at the start of your turn, success lets you choose to be advantaged against it or perform a collision course; success by 10+ lets you combine both, or opt instead to "rendezvous" (p. 98) with the target (for docking).

Facing: If you accelerated, your front hull faces all opponents. Otherwise, decide whether your front, central, or rear hull faces all opponents. Exception: If you *lost* the Quick Contest against a foe who was advantaged against you on his last turn, then his vessel is still advantaged against you and he may choose your facing toward him.

Closing Strategies

You may modify a closing maneuver by choosing one of these options:

Dedicated: You are at +3 on your Piloting skill when performing a Closing maneuver, but your spacecraft cannot Dodge until your next turn.

Ambush: You may use this option against a target that performed Hold Course or a Closing maneuver on its last turn, but only if your vessel was not yet Detected, or if the GM rules that sufficient cover exists (e.g., in crowded orbital space, a cinematic asteroid belt, the upper atmosphere of a gas giant, etc.) to make this possible. You need not accelerate – instead, you ambush the opponent as it passes you by. You both may opt to substitute Tactics for Piloting, and the effects of both your own and your target's acceleration bonus are halved (rounding down); otherwise, use the normal Closing rules.

Controlled Drift

You don't accelerate, but can use your spacecraft's attitude controls (gyros or reaction thrusters) to change your vessel's facing. If you were engaged or rendezvoused with any spacecraft or other objects at the start of your turn, you remain so.

Facing: You can decide whether your front, central, or rear hull faces all opponents; if you don't specify, assume it's your central hull. Optionally, you may be tumbling: if so, *all* hull sections face all opponents. Beam or gun attacks you make while tumbling are at -4. Any opponent may choose which section to target (taking the -4 penalty) or roll randomly (1-2 front, 3-4 central, 5-6 rear) when he scores a hit.

Evasive Action

You are maneuvering to make it more difficult for opponents to close with or attack your vessel, or to set up a future Retreat maneuver. You must accelerate fast enough to get an acceleration bonus (p. 96).

You automatically break away from any vessels or other objects engaged or rendezvoused with you. You (and they) lose this position.

You don't make any skill rolls now, but until your next turn will add *twice* your acceleration bonus to any Quick Contest made to avoid an opponent closing on you (see *Closing Maneuver*, p. 97). You'll also get +1 to Dodge.

Facing: Your central or rear hull face all opponents not advantaged against you – decide which.

Hold Course

You are maneuvering on a steady course without getting near any particular vessel. You must accelerate, but may not exceed a +3 acceleration bonus.

If you began your turn engaged with any vessels or other objects, you're still engaged to them, but rendezvous status is lost (unless a vessel is clamped to you – see *External Clamp*, p. 46).

Any opponent Closing with you before your next turn will need to win a Quick Contest of Piloting skill with you (and you'll add your acceleration bonus) – see *Closing Maneuver* (p. 97).

Facing: Your front or central hull must face all opponents not advantaged against you (your choice).

Retreat

You're trying to escape! Your last turn's maneuver must have been Evasive Action or Retreat. If your last maneuver was Evasive Action, your spacecraft must also accelerate fast enough to receive an acceleration bonus (p. 96).

Any opponent Closing with you before your next turn will need to win a Quick Contest of success to close the range; you'll add your acceleration bonus (see *Closing Maneuver*, p. 97).

You automatically break away from any vessels or other objects engaged or rendezvoused with you. You (and they) lose this position.

You can still be attacked by enemy vessels, until the start of your next turn. At that point your vessel escapes the encounter area! Vessels that were Closing may follow you (see *Closing Maneuver*, p. 97). All others will be left behind. Should multiple spacecraft choose to retreat and escape, they may choose to escape in the same direction. If so, they and any successful pursuers form the same new engagement (GM's option).

Facing: Your vessel's rear hull faces all opponents not advantaged against you if you accelerated; if you did not, choose whether your front hull, central hull, or rear hull does.

Uncontrolled Drift ("Drift")

This is the *absence* of deliberate maneuver. An uncontrolled drift occurs if a spacecraft begins its piloting turn with no one piloting it. You can't dodge.

The GM should also assign Uncontrolled Drift to any locations or objects such as asteroid bases, lost spacers, drifting life pods, etc., that are important to the situation. They may take a turn in the sequence (during which people on them can act).

Uncontrolled Drift is treated exactly as a Controlled Drift maneuver except for facing.

Facing: Whatever facing you had on your last turn continues to face all opponents not advantaged against your vessel.

Range

Range measures how far apart two spacecraft (or formations) are. In the basic combat system, range is simplified into *range categories*: Zero (Z), Point-blank (P), Close (C), Short (S), Long (L), and Extreme (X). The range category is determined by the combat scale and the *situation* between the attacking or scanning vessel and its target, as determined by the results of the last maneuver of the vessel whose turn it is. Refer to the *Range Table* below.

The possible situations resulting from a pilot manever (p. 96) are as follows:

Rendezvous: Use this whenever spacecraft are docked with or grappled to one another, or achieve a Rendezvous result.

Collision Course: If your spacecraft achieved a collision course result against the target use this column to find the range toward the target and any vessel it was in formation or rendezvoused with.

Attack vector: If your spacecraft achieved an attack vector against a target this turn, use this column to calculate your range toward it. The range also applies to any vessel it was in formation, rendezvoused, or engaged with. This status remains until the piloting step of each target's turn.

Engaged: If your spacecraft engaged a target this turn, use this column to calculate your range toward it and any vessel it was in formation, rendezvoused, or engaged with. Each vessel remains engaged unless their own next maneuver indicates engagement is broken.

Neutral: This is the default column. Use this column to calculate range if your vessel failed to succeed with a Closing maneuver this turn, or if its own last maneuver was Evasive Action, Controlled Drift, Hold Course, Retreat, or Uncontrolled Drift.

In Formation or Incoming: All vessels in formation with one another are at point-blank range to each other, as are incoming ballistic attacks.

Attack run and collision course positions last until the piloting task phase of the subject's turn. This status remains until the piloting turn of each target.

Engagement or rendezvous positions may continue from turn to turn unless broken by the target's own maneuver.

Range Table

Situation	***Close scale***	***Standard scale***	***Distant scale***
Rendezvous	Zero	Zero	Zero
In Formation or Incoming	Point-blank	Point-blank	Point-Blank
Collision Course	Point-blank	Close	Short
Attack vector or Engaged	Close	Short	Long
Neutral	Short	Long	Extreme

Example: The battleship *Ares* performs a Closing maneuver and succeeds in achieving a engaged result against the assault ship *Logic of Empire*. The battle is being fought in the standard combat scale, so in *Ares*' turn the range to *Logic of Empire* is Short. The *Logic of Empire* was in formation with the destroyer *Terrible Beauty* so the range toward *Terrible Beauty* is also Short. A third enemy cruiser, the *Talon*, is also in the battle; since it wasn't in formation with either, it's neutral and so is at Long range to *Ares*.

On its turn, the *Logic of Empire* performs an Evasive Action maneuver. This breaks engaged status; it's now neutral to *Ares*, and is at Long range toward it. However, *Terrible Beauty* on its turn chooses a Controlled Drift – which means that without any need for a skill roll, it automatically remains engaged to *Ares* and is at Short range to it.

Although the basic space combat system handles spacecraft positions abstractly, it is sometimes necessary to convert between range categories and actual distances in miles. See the *Range Conversion Table*, below.

Range Conversion Table

Range	***Distance***
Z	0 mi.
P	100 mi.
C	500 mi.
S	2,000 mi.
L	10,000 mi.
X	>10,000 mi.

If a distance lies between two entries, then it falls within the *longer* range category.

Advantaged Status

If you achieved this result against an opponent, it means you outmaneuvered it. Your advantaged vessel may opt to approach its target from a *different* facing adjacent to the one that normally faces him: he may choose front or rear instead of the central hull, or choose the central hull instead of front or rear. If the target's last maneuver was Uncontrolled Drift, advantage allows him to approach any face (e.g., he may approach from the rear even if the target's front was facing all opponents, or vice versa.) Advantaged status confers no benefit against a tumbling target.

The advantaged status you gained only lasts until your opponent's next turn – it goes away as soon as he chooses a maneuver. (Exception: if he chose Uncontrolled Drift, or failed badly on a Closing maneuver it persists until the start of your own next turn.)

Pseudo-Atmospheric Movement

Vessels maneuvering with boost drives (p. 60) or hyperdynamic fields (p. 63), or moving in an air-filled cosmos (p. 81), use the same combat movement rules, with the following exceptions:

1. You cannot choose a controlled drift maneuver – you have to pick a maneuver that requires acceleration, or use an uncontrolled drift.

2. You cannot choose a closing maneuver against an enemy spacecraft if the target was, on its last turn, advantaged against you, *and* the target's pilot decided that your vessel's rear hull faced toward his craft.

3. Fast passes are not allowed.

Weapons Fire

Weapons may fire using an Aim and Attack task. They may also fire as point defense at an incoming missile, shell, or ramming vessel if the gunner chose a Wait (Point Defense) task.

Bearing

The facing of the firing vessel toward the target determines what weapons can fire.

Spinal battery weapons can only fire at a target their spacecraft's front hull is facing (unless the weapon faces the rear; then the rear hull must face the target).

Fixed mount weapons can only fire at a target if the weapon is in installed in a hull section facing the enemy.

Turret weapons in the front hull can fire at targets that the attacking vessel's front or central hull is facing.

Turret weapons in the rear hull can fire at targets that the attacking vessel's rear or central hull is facing.

Turret weapons in the central hull can fire at any target.

Rate of Fire

Each weapon's RoF includes time aiming or programming weapons and time for beams to cool and guns or missiles to reload between shots. The table shows RoF per weapon. All identical fixed mount weapons in the same battery may be fired simultaneously – multiply RoF by number of fixed mounts:

RoF Table

Class of Weapon	*20-sec.*	*1-min.*	*3-min.*	*10-min.*
Catapult	1†	1	3	10
TL3+ Rockets§	1‡	1‡	1‡	1
TL3 Gun, to 20cm	1†	1	3	10
TL3 Gun, over 20cm	1‡	1‡	1‡	1
TL4-5 Gun, to 14cm	1	3	10	30
TL4-5 Gun, over 14cm	1†	1	3	10
TL7+ Missiles	1	3	10	30
TL7+ Beam or Gun*§	1	3	10	30

* Beams are available in *improved* (2× RoF) versions.

§ Available in *rapid fire* (10× RoF) and *very rapid fire* (100× RoF) versions.

† Takes two 20-second turns to reload after firing.

‡ Takes 30 turns (20-second scale), 10 turns (1-minute scale), or three turns (3-minute scale) to reload after firing.

Example: A medium battery with three fixed mounts each with rapid fire improved lasers firing in a 3-minute turn has RoF 10×10×2×3 = RoF 600.

If a weapon has RoF 2+, the gunner must specify how many shots will be fired, up to the maximum of the weapon's RoF. Guns and launchers are limited by the total number of shots remaining (especially at 3-minute and 10-minute scales!).

Targets

A gunner must indicate the target before attacking. The target must be within range and within the weapon's bearing. It can be:

• A spacecraft or other object in space.

• An object on a world (or within atmosphere) – see *Ground Fire* (p. 109).

• In point defense, a salvo of one or more incoming missiles or shells, or a spacecraft attempting to ram, that is targeting either the attacker's own vessel or another vessel that he is in formation or rendezvoused with.

Hull Section

An attack on a spacecraft is ordinarily assumed to be targeted against the target's hull section that faces the attacker.

If the target's front or rear hull is facing the attacker, this must be targeted.

If the target's central hull is facing the attacker, the attacker may target the central (the default target), front, or rear hull.

An attacker may specify a more precise location in the hull using the Precision Attacks (p. 110) rules. Certain large exposed systems or features, such as lightsails, can also be targeted instead of the hull: see *Targeting Exposed Systems* (p. 110) or Spreading Fire (below).

Spreading Fire

A gunner may choose to divide his shots among *different targets*, either attacking multiple targets, or firing at different parts of a single vessel. All targets must be specified before rolling to hit. It imposes an extra -2 penalty per different target engaged (applied to all attack rolls) when firing beams or guns, or a -1 penalty per target if firing missiles. One attack roll is made for each target.

Note that a salvo of multiple incoming missiles or gun shells launched as a single attack do *not* count as a different targets – all shots in the attack are a single target.

Beam Fire

Beams can attack targets out to their specified maximum ranges: Point-blank (P), Short (S), Long (L), or Extreme (X). These can be computed from the *Beam Damage and Range Table* (p. 37) and the *Range Conversion Table* (p. 99), giving the following result:

Basic Combat Beam Range Table

Output	*R0*	*R1*	*R2*	*R3*
3KJ-30KJ	P	P/C	C	C/S
100KJ-1MJ	P/C	C	C/S	S
3MJ-30MJ	C	C/S	S	S/L
100MJ-1GJ	C/S	S	S/L	L
3GJ-30GJ	S	S/L	L	L/X
100GJ-1TJ	S/L	L	L/X	X
3TJ-30TJ	L	L/X	X	X
100TJ-1PJ	L/X	X	X	X
3PJ+	X	X	X	X

If two ranges are separated by a slash, the beam does full damage at the shorter range, and half damage out to the longer range. Only detected targets can be attacked.

Beam Attack Rolls

Roll 3d against effective skill to hit. Use Gunner (Beams) for most beam weapons or Artillery (Beams) for ghost particle beams, or for any beam fire being directed from space against unseen surface targets by a forward observer. Figure the effective skill by taking that base skill and applying the modifiers shown below. Note that these modifiers combine aiming, targeting systems, and range penalties to get manageable numbers; see *Space Weapons in Ordinary Combat* (p. 41) for specifics.

Target Size: Add the target's SM.

sAcc: Add the Space Accuracy of the weapon (this is 0 for most beam weapons). Add +1 for 1GJ or larger weapons.

Space Range: +20 at zero, 0 at Point-blank, -4 at Close, -8 at Short, -12 at Long, -16 at Extreme.

Visibility: -10 if the target is using a Cloaking Device (-4 if your sensors have detected him but he's still cloaked).

Spinal or Fixed Mount: +2 if firing any fixed mount.

Damage: -2 if the attacker has 0 HP or less (from damage to its distributed sensor and computer network).

Target: -1 if attacking streamlined target's front or rear hull. -5 if aiming for a specific spacecraft hit location (see *Precision Attacks*, p. 110); -10 if aiming for a weak point in armor. -2 per defensive ECM system (-1 if attacker has a functional tactical or multipurpose array).

Surface Targets: If attacking surface targets during space combat, apply any relevant Target or Visibility modifiers from p. B548, e.g., for cover.

Multitasking: Apply any multitasking penalties (p. 92). This includes a -2 per target penalty for dividing rapid fire among multiple targets.

Point-Defense: If firing in point-defense against any ballistic attack with a relative velocity of 300 mps or more, apply the following modifier: -3 if 300 mps, -6 if 1,000 mps, -9 if 3,000 mps, -12 if 10,000 mps, -15 if 30,000 mps, -18 if 100,000 mps+.

Rapid Fire: If firing multiple shots at the same target apply a "shots fired" modifier from the table below.

Rapid Fire Table

Shots	*Bonus*	*Shots*	*Bonus*
2-4	0	50-99	+6
5-8	+1	100-199	+7
9-12	+2	200-399	+8
13-16	+3	400-799	+9
17-24	+4	800-1,599	+10
25-49	+5	etc.	etc.

(This expands the rapid fire modifier on p. B548.)

Successful Attacks

A roll of the effective skill number or less means the target was hit. If firing multiple shots at a particular target, score one extra hit per full multiple of Recoil by which you made your attack roll, to a maximum of the number of shots that were actually fired. Recoil is 2 for plasma beams, 1 otherwise.

GMs may optionally add +1 to Recoil in 3-minute or 10-minute turns (as in ***GURPS Interstellar Wars***) to represent the fact that weapons are taking pauses to aim and assess the situation; this will reduce hits, which can improve playability!

As usual, critical success means the target cannot dodge and critical failure means no hits occur. Assume the firing system malfunctions on a critical failure (treat as a disabled system but with no crew casualties).

Beam attacks may be avoided – see *Dodge* (p. 103).

Ballistic Attacks

Guns, missile launchers, and ramming spacecraft all use these rules. Since the attacker is usually steering or homing on the target, range modifiers are irrelevant – what matters is the relative velocity. If firing a missile launcher or gun, be sure to specify the type of warhead used if different types are carried.

Effective Range

While projectiles fired in space will fly forever, they have a limited *effective* range for hitting a target in combat. This depends on their speed and maneuverability during flight (not so much on their terminal guidance), as given by the Move score on the *Guns and Launchers Table* (p. 38).

For guns and unguided rockets, base effective range is C if the impulse or delta-V is 1 mps or less (conventional guns and unguided rockets), S if greater than 1 mps (electromagnetic and grav guns).

For guided missiles, base effective range is L if the delta-V is 2 mps or less (TL7 missiles below 32cm), and X if delta-V is greater than 2 mps (all other TL7+ missiles).

Basic Combat Ballistic Range Table

Weapon	*Range*
Conventional Gun or Catapult	C
Electromagnetic or Grav Gun	S
TL3-6 Rocket	C
TL7 Missile (under 32cm)	L
Other Missiles	X

For *all* guns and missiles, increase maximum effective range by one step (to a maximum of X) if firing on a stationary target, or one whose last maneuver was Controlled Drift or Uncontrolled Drift.

For bombs or space mines, effective range is P, or S if dropped on a surface target.

Timed and Proximity Detonations

The gunner making a missile or gun attack may opt to fuse the missiles or shells used for *timed detonation* (at TL3+) or *proximity detonation* (at TL7+). This will significantly increase the chance of a hit, but reduces damage (if a nuclear or antimatter warhead) or armor divisor (if a conventional warhead). All shells or missiles in the attack must have the same fusing.

Relative Velocity

In the basic combat system, this is simplified to an "average" value that is based on the scale chosen and the weapon used. Compare the time and distance scales to find the typical base velocity. If the vessel has a rendezvous or engaged position toward the target, use that value instead. If a spacecraft is making a fast pass, use its actual velocity.

Base Relative Velocity Table (mps)

Scale	*Close*	*Standard*	*Distant*
20-second turn	1	10	100
1-minute turn	1/3	3	30
3-minute turn	1/10	1	10
10-minute turn	0	1/3	3
If rendezvous	0	0	0
If engaged	1/6	1/2	1/2

If the attack is a gun shell or missile, and this is less than the gun's impulse or the missile's delta-V, as listed on the *Guns and Launchers Table* (p. 38), raise the relative velocity up to that level. Exception: At Point-blank or Short range, or if the attacking spacecraft's last turn's maneuver was to Retreat, use only *half* of a missile's delta-V (a gun's impulse is unchanged).

A warp missile's impulse is a *pseudo-velocity* (p. 64): use that as its velocity if anyone tries to shoot the missile, but for computing damage (below), treat it as an ordinary TL9+ missile with a delta-V of 10 mps. Optionally, this may apply to super-missiles as well (if their reactionless engines are pseudovelocity drives).

Point Defense Attacks

A defender who took a Wait (Point Defense) maneuver may interrupt to fire against any incoming missiles, gun shells or any spacecraft that is about to ram.

Point Defense attacks are announced and resolved immediately after a successful ballistic attack roll is made but before the target performs its Dodge roll.

After an attack roll is made, any gunners on the target vessel who chose perform Wait (Point Defense) maneuvers may opt to fire as detailed in the Wait (Point Defense) task (p. 95). Targets of point defense fire may not themselves Dodge (or use Point Defense).

Example: It's a 3-minute turn in close combat scale, so the typical velocity is normally 1/10 mps. However, the attacker is using a TL9 missile, so the velocity is raised to 10 mps.

Point Defense Fire and Relative Velocity: When firing missile launchers or guns in point defense against an incoming ballistic attack, the relative velocity is simply the relative velocity of the ballistic attack.

Ballistic Attack Roll

Base skill with a ramming attack is your Piloting skill. The base skill otherwise is Artillery (Guided Missile) for missiles or Artillery (Cannon) for guns. Exception: for fire at point-blank range with guns, use Gunner (Cannon) instead.

Figure effective skill by taking the base skill and applying the modifiers shown below. Note that these modifiers combine aiming, targeting systems, and range penalties.

Target Size: Add the target's SM. If ramming, use the greater of your own or the target's SM – it's easier to squash small vessels if you're gigantic!

Handling or sAcc: Add the attacking gun or missile's sAcc (see *Guns and Launcher Table*, p. 38) or, if ramming, the attacking spacecraft's Handling.

Space Range: +20 at zero. *Unguided* catapults, guns, and rockets (anything before TL7) have a range penalty of 0 at Point-blank, -4 at Close, -8 at Short, -12 at Long, -16 at Extreme. *Guided* rounds have no range penalties.

Visibility: -10 if target using Cloaking Device (-4 if your sensors have detected him but he's still cloaked).

Target: -1 if attacking streamlined target's front or rear hull. -5 if aiming for a specific spacecraft hit location (see

Precision Attacks, p. 110), or -10 if aiming for a weak point in armor. -2 per defensive ECM system (-1 if attacker has a functional tactical or multipurpose array).

Timed or Proximity Detonation: If using a warhead fused for timed detonation, add +1 to hit at TL3-5, or +2 at TL6+. If fused for proximity detonation (available at TL7+), add +4 to hit.

Surface Targets: If attacking surface targets apply any relevant Target or Visibility modifiers from p. B548, e.g., for cover.

Relative Velocity: Based on the relative velocity of the collision: +6 if 0, +3 if 0.3 mps, 0 if 1 mps, -3 if 3 mps, -6 if 10 mps, -9 if 30 mps, -12 if 100 mps, -15 if 300 mps, -18 if 1,000 mps, -21 if 3,000 mps, -24 if 10,000 mps, -27 if 30,000 mps, -30 if 100,000 mps+.

Rapid Fire or Multiple Incoming: If firing multiple gun shots or missiles apply a "rapid fire" modifier from the *Rapid Fire Table* (p. 101).

Successful Attacks

A roll of the effective skill number or less means the target was hit. If firing multiple shots at a particular target, or if a timed or proximity fused conventional warhead explodes, score one extra hit per full multiple of Recoil by which you make your attack roll, to a maximum of the number of shots that were actually fired (or 10× that if using a explosive conventional warhead).

Recoil is 1 for missiles; for guns, see the *Guns and Launchers Table* (p. 38). Add +1 to effective Rcl. if any nuclear or antimatter warheads were used in the attack due to fratricide – the warheads destroying one another if shots are spaced too closely together.

GMs may optionally add +1 to Recoil in 3-minute or 10-minute turns.

Critical success means the target cannot dodge and critical failure means no hits occur.

Dodge

A spacecraft may attempt to dodge a beam or ballistic attack, provided its most recent movement was one other than Controlled or Uncontrolled Drift. (A pilot also may not dodge if his spacecraft's last maneuver was Closing with the Deliberate option.)

Roll to dodge once per attack. If multiple hits were scored by the attack, the margin of success on the dodge roll determines the number of additional hits that were dodged.

Dodge = (Piloting skill/2) + Handling + modifiers.

Piloting skill/2 is half the skill (round up) of the pilot. If no one is piloting the spacecraft or the spacecraft did not achieve at least a +0 acceleration bonus, it can't dodge. Combat Reflexes or Enhanced Time Sense add +1 to Dodge.

Dodge modifiers are:

Defensive Tactics, Offensive Tactics, Tactical Navigation: These command or navigation tasks may modify your dodge or that of your opponent's.

Turn Length: +1 during 1-minute turns, +2 in 3-minute turns, +3 in 10-minute turns.

Defensive ECM: +1 defense bonus per system installed, to a maximum of +3; the ECM must be of a TL equal or higher than the attacker's.

Evasive Action Maneuver: +1 to Dodge.

A ballistic attack (ramming spacecraft, incoming shell or missile) can't dodge point defense fire.

Damage

All damage inflicted using these rules is decade-scale (i.e., in multiples of 10 points of damage). Roll the basic damage for every hit scored against a target.

Exception: If firing in point defense against incoming missiles or shells, don't bother rolling damage – each weapon hit (including tractor beams) kills one missile or shell.

If the target has a functional and operating stasis web, it is immune to damage as long as the field is up – don't bother rolling damage vs. a target with an operating stasis web.

Beam Damage

The *Beam Damage and Range Table* (p. 37) gives the basic damage of most beam weapons, based on their output. If beam weapons fire at a target that is at or beyond their half-damage range, halve basic damage (rounding down). The *Beam Type Table* (p. 37) indicates the type of damage inflicted by different weapon types.

Certain beam types affect their targets other than through damage: these are described in *Special Beam Weapon Rules* (p. 39).

Ballistic Attack Damage

Use these rules for missiles, gun or catapult projectiles, and collisions.

Nuclear and Antimatter Warheads

Damage depends on the warhead's yield, as shown on the *Nuclear and Antimatter Warhead Damage Table* (p. 38). This is applied to the target *and* any object rendezvoused with it.

Collisions and Conventional Warheads

Guns and missiles with conventional warheads, and spacecraft that ram or accidentally collide with objects, inflict decade-scale damage based on the relative velocity of the collision.

In a collision, *both* parties involved take the same dice of damage. If a gun shot or missile hits something, the shell or missile is destroyed, but it inflicts damage on the target.

Gun or Missile: A hit from a gun or missile with a conventional warhead inflicts d-damage using the formula below.

Ramming or Colliding Spacecraft: A collision inflicts crushing d-damage using the Collision formula shown below.

Gun or Missile = Weapon d-Damage × V.

Collision = 6d × 3 × lesser dST × V.

Round to the nearest die.

Lesser dST is that of the object with the least dST (or basic dHP), or either, if identical. For example, if a 30-ton fighter with dST 20 collides with a 10,000-ton freighter with dST 150 they each inflict damage to the other based on dST 20; if a spaceship crashes into a world or other immovable object, use the ship's dST.

Weapon d-Damage is found on the *Conventional Warhead Damage Table* (p. 38).

V depends on relative velocity in miles per second (mps) as calculated under *Ballistic Attacks* (p. 102). Adjust this to a "real" velocity if using pseudo-velocity (p. 64) rules.

HULL DAMAGE AND HIT LOCATION

Attacks may strike various locations on a vessel:

Hull Section

An attack normally strikes a particular hull section (front, central, or rear hull). If so, determine the specific location struck. Systems in each hull section are numbered **[1]** to **[6]**. Roll 1d to determine which system in the attacked hull section was hit. Destroyed locations can be hit (the damage will pass through and affect another system as detailed below).

Exception: If *every* system in a hull section was destroyed, the attack instead hits the same numbered system in the *adjacent* hull section: front or rear hull are adjacent to central; otherwise roll 1d: 1-3 front, 4-6 rear. The attack ignores all armor dDR!

If making a precision attack (p. 110), the attacker can specify which of the six hull locations is hit.

Exposed Systems

If attacking an exposed system, see the rules for *Targeting Exposed Systems* (p. 110).

Damage Resistance

Spacecraft damage resistance is decade-scale, abbreviated dDR. Many spacecraft weapons have armor divisors, e.g., (2) as indicated for beams in the *Beam Type Table* (p. 37 and in the rules for ballistic attacks. Divide dDR by the armor divisor, rounding down. Hardened armor or screens may negate armor divisors (see p. B47). Spacecraft may have several types of defense that provide DR, which protect in the following order.

1. Force Screens

If the target is protected by a functional force screen, subtract the screen's dDR. Force screens normally protect the entire vessel, but are semi-ablative: every 10 points of basic d-damage rolled reduces the screen's dDR by 1 against other attacks *occuring in that same turn*. Design switches may change this!

2. Armor

If a location on a hull section was hit, subtract the cumulative dDR of its armor systems from the damage. (This combined dDR will be noted in the spacecraft's DR statistic.) Exception: If the initial system hit location roll happens to be a *destroyed* armor system, ignore that system's dDR. Disabled armor systems protect normally.

Armor does not protect exposed systems.

3. Penetrating Damage

If any basic damage remains after subtracting screen and armor dDR, this is the penetrating d-damage. If no basic damage remains, the hit failed to penetrate.

If a location on a hull section was hit, see *Damage to Hull Sections* (below).

For exposed systems, see *Targeting Exposed Systems* (p. 110).

DAMAGE TO HULL SECTIONS

Penetrating damage reduces the spacecraft's dHP. If the damage was great enough, it may also disable one or more spacecraft systems.

If the penetrating damage was at least 10% but less than 50% of dHP, the system hit is *disabled*. A system that was already damaged is *destroyed*. If it was already destroyed, the next undestroyed numbered system in that hull section is damaged, counting upward. E.g., if system [4] is rolled but both it and system [5] had already been destroyed, system [6] is disabled (or destroyed, if already disabled) instead. After system [6] go on to any undestroyed [core] system if one exists in that section; if not, start again with system [1].

If the penetrating damage was at least 50% of dHP, the system hit is destroyed, whether or not it was originally damaged. If it was already destroyed, the next-numbered undestroyed system will be destroyed, as described above. In addition, one other random system in that location suffers a damage result: roll hit location, skipping upward for systems already destroyed as described above.

If the penetrating damage was enough to reduce the reduce the vehicle's dHP to -1 × dHP or worse, check to see if the vessel was destroyed; if it was, don't bother applying individual system damage. If it wasn't destroyed, apply the results detailed above.

Negative HP and Destruction

Vessels that are reduced to 0 or lower dHP are badly damaged, but may still function. Due to the detailed damage location system, do not make HT rolls to see if the vessel is still working – that's simply determined by the specific systems that remain intact.

However, when a spacecraft reaches -1 × basic dHP, it has suffered such damage to its structural integrity that it must make a HT roll to avoid destruction. On a failure, it is destroyed. If it survives, further HT rolls are required each time the spacecraft is reduced to another multiple of -1 × basic dHP. At -5 × basic dHP the vessel is automatically destroyed.

A destroyed vessel is just wreckage, but some types of systems might still be functional. Armor, cargo, habitats, hangars, missile batteries, open space, passenger seating, and integrated vessels are still functional if they haven't yet suffered damage. All other systems stop functioning as data, power, and fuel lines are cut. If further damage reduces a destroyed vessel to -10 × basic dHP, it is vaporized.

Effects of 0 dHP

A vessel at 0 dHP or less suffers these penalties as a result of damage to distributed systems:

All comm/sensor array levels are -1.

Its Handling is reduced by 2.

Its gunners have a -2 to hit when making beam attack rolls.

Integrated Vessel

If a spacecraft with an attached integrated vessel system takes damage to that system, apply it to the integrated vessel, rather than to the rest of the spacecraft. If the integrated vessel separates, the systems in the containing vessel are treated as "destroyed" for damage purposes. They have no armor dDR and system damage cascades to the next system or hull section.

Empty Systems

A hull location designated as an *Empty System* (p. 8) is treated as "destroyed" for damage purposes: damage moves on to the next system.

Disabled Systems

If a system is disabled it is normally no longer functional. The various capabilities that are described in Chapter 1 for the systems won't work. The system can't be used for any task that is described as requiring a "functional" system. If there are occupants in a disabled system, check for injury: see *Casualties* (p. 106). There are some special cases:

Disabled Armor

If an attack targets weak points in the armor (*Precision Attacks*, p. 110), attacks to that hull section (not just that location) completely ignore the armor system's dDR. (Armor dDR from *other* armor systems is still just halved against such attacks.)

Disabled Cargo

If a cargo hold is disabled, half of the cargo in the hold is destroyed. Certain types of hazardous cargo (e.g., ammunition, antimatter, etc.) may be considered volatile systems (p. 106) at the GM's option.

Disabled Controls

When controls are disabled, only half (round *up*) of the control stations cease to function and the vessel's computer network's Complexity is reduced by 1. The remaining control stations are only lost when the system is destroyed.

Disabled Habitat or Passenger Seats

If disabled (or destroyed), in addition to rendering facilities in it non-functional, life support will be affected as various cabins, seats, etc., are lost. See *Overloading Life Support* (p. 86) in Chapter 2. Usually there's no immediate effect (a few hours of residual air, etc.), so don't worry about it until later. There's a 2-in-6 chance any cells or cages will open, allowing survivors to escape.

Disabled Fuel Tank

If a fuel tank that provides delta-V reserve is disabled (or destroyed) the spaceship loses **N/F** of its *remaining* delta-V reserve, where *N* is the number of fuel tanks that were just disabled or destroyed, and *F* is the number of functional fuel tank systems (with that type of reaction mass) that it had left before the damage.

Example: A spaceship with four fuel tanks of hydrogen has a delta-V reserve of 63 mps. One of its four fuel tanks is hit and disabled, so it loses 1/4 (rounded up) of its total remaining delta-V reserve, or 16 mps. It is now down to a delta-V reserve of 47 mps. Suppose it used up 17 mps while accelerating, leaving 30 mps, and then is hit again, this time losing two fuel tanks. It now loses two of three tanks, so it loses 2/3 of its 30 mps of delta-V reserve, or 20 mps; this leaves it with only 10 mps left in a single remaining tank.

Emergency repairs to a fuel tank won't restore delta-V reserve, but will let the tank be refueled.

Disabled Hangar Bays

All vehicles are unable to launch.

Disabled Minor Batteries

Disabling it renders half (round up) of the turrets or fixed mounts in the system non-functional. The others still function.

Destroyed Systems

A system that is disabled again is destroyed. The system stops working, and cannot be fixed. Some special cases:

Destroyed Armor

A destroyed armor system still provides dDR to the hull section – the holes aren't that big. Exception: any *initial* hit location roll against that location ignores its dDR.

Destroyed Volatile Systems

See *Volatile Systems* (p. 106).

Destroyed Hangar

All vehicles and cargo in the hangar are also destroyed, unless there is a reason to believe that won't happen (e.g., a small craft with an activated stasis web).

Volatile Systems

Certain systems are highly *volatile:* any system holding missiles, or missiles or gun shells with antimatter warheads; any fuel tanks with antimatter-boosted hydrogen, matter-antimatter, fissionable saltwater, or HEDM fuel; an antimatter power plant; a cargo hold whose contents the GM determines are volatile (e.g., full of explosives).

If a volatile system is disabled, roll against the spacecraft's HT. A failed roll means the spacecraft will explode (reduced to -10×HP) at the end of its next turn. A critical failure means it explodes immediately (unless PC-occupied). If a volatile system is destroyed, roll at -5!

If a spacecraft explodes, it inflicts (6d×basic dHP) crushing explosion damage to any spacecraft docked with it; multiply by 10, change this to burning damage, and add surge and radiation modifiers if antimatter warheads, power plants, or fuel are exploding!

Casualties

If people are inside a system when it is disabled or destroyed, they may be injured. If the entire vessel is destroyed by a single attack, "destroyed" applies to everyone aboard.

Most NPCs: Assume half (round up) of NPCs in a disabled system are incapacitated (reduced to 0 HP or less) or dead. All NPCs in a destroyed system are seriously injured or dead. The rest have light or no injuries. Animals, plants, etc. suffer comparable casualties.

PCs and Major NPCs: Roll 1d on the *Casualty Table* for each character in a disabled or destroyed system:

Casualty Table

Roll	*Effect*
2-	No effect
3	2d-1 lethal electrical damage
4	3d-2 cutting damage
5	3d-2(10) burning damage
6	6d×6 crushing damage
7	Blown outside the spacecraft; also roll again with no modifiers
8+	3d×5(10) burning damage

Add +1 if the system (or entire vessel) was destroyed rather than disabled or +5 if the system or vessel was vaporized (-10×HP). Subtract 1 if in a core system. DR from advantages or armor protects normally.

If a system is destroyed, survivors will be trapped in the wreckage (unless accidentally blown outside) until rescued.

A character who is blown out also rolls 1d again on the table (with no modifiers) to determine if he also took any damage as he was blown out. He (or his corpse) will be floating 1d×10 yards outside the vessel and can be assumed to be drifting away from the spacecraft at a velocity of (1d) yards/second. He is otherwise traveling in the same direction and speed as the spacecraft, but will be left behind if it accelerates before he can get aboard. If the spacecraft accelerates, he has time equal to the length of the space combat turn to be rescued or get back himself (usually only possible if he has a thruster pack, line gun, etc.) – if not, he'll be left behind!

Anyone who is blown out of a spacecraft or in a system that is *destroyed* is exposed to vacuum, and, if the ship was not already depressurized, explosive decompression. See p. B437. All crew and passengers usually suit-up in dangerous situations.

Ignore these special effects if the spacecraft isn't in vacuum.

If a spacecraft is vaporized (-10×HP) all survivors are also floating in space.

Damage Modifiers

Certain damage modifiers cause special effects. The GM may skip these rules to speed up combat.

Surge (sur) Damage Modifier

Weapons with this damage modifier can fry electrical systems. If a surge attack does any penetrating damage, the ship must roll vs. HT. On a failure, make one extra system damage roll in that hull section: Ignore the result if the system rolled is armor, cargo hold, engine room, hangar bay, fuel tank, soft landing system, or a previously disabled system. On a critical failure, all systems in that section *except* those mentioned above are disabled! Surge damage can be fully repaired by emergency repairs and disabled systems can still be damaged normally (physically disabled on the first roll, destroyed on the second). Personnel occupying a system taking surge damage do not roll for injuries.

Radiation (rad) Damage Modifier

If a system damage roll resulting from an attack with a radiation (rad) damage modifier indicates an occupied system is damaged, occupants also suffer 3d×10 rads. The vessel's radiation PF does not apply – this is scatter from the penetrating beam itself.

Explosive (ex) Damage Modifiers

Except as noted for nuclear and antimatter warheads and ghost particle beams, ignore explosion modifier – the blasts are too small to catch anyone else at space combat scale. Explosive and incendiary modifiers are listed for use during attacks on ground targets, etc.

Action Aboard

This section covers activities that involve moving about or leaving the spacecraft.

Internal Movement

The length of a space combat turn determines whether or not movement in the spacecraft counts as a character's task for the turn.

Internal Movement Table

Hull/Turn:	*20-sec.*	*1-min.*	*3-min.*	*10-min.*
SM+5 to +7	1	0	0	0
SM+8 to +9	2	1	0	0
SM+10 to +12	5	2	1	0
SM+13 & up	10	3	1	0

Cross-index spacecraft SM with the turn length.

Time (if 1 or more) is doubled if moving to a different hull section.

0: The character can move without taking a space combat turn, but must specify which spacecraft system he occupies at the start of each turn.

1+: The number of space combat turns the character must spend moving between parts of the spacecraft. He cannot perform other actions. Double the time required if moving from to a different hull section. If space combat is likely to use 20-second turns, you don't want to be caught in your cabin's bathroom!

If a spacecraft is in microgravity a Freefall skill roll is required to navigate through the vessel. A failed roll means the character doesn't reach his destination in time.

If a spacecraft was accelerating at 3× or more a crewman's home gravity, the crewman won't be able to move unless provided with assistance (e.g., exoskeletons) or the spacecraft has gravitic compensators (or the equivalent).

Movement is dangerous if the spacecraft is dodging! If the craft performs a Dodge any time the character was in transit, roll against the moving character's Spacer skill. Success means the character is able to secure himself; otherwise he suffers the equivalent of a 10-yard fall (20 on a critical failure) per G of acceleration the spacecraft was using (modified for gravitic compensators, p. 54).

Characters can use airlocks or cargo hatches to enter or leave the spacecraft (possibly boarding a docked spacecraft). This takes an entire turn. If a character is outside the vessel, specify which system he is outside. If that system is the first location to be hit by an attack, the character suffers the *full* damage of the attack.

Damage Control

A damage control party may perform four different tasks: emergency repairs, rescue, structural repairs, or halt catastrophe. No more than one party can work on the same system, perform structural repairs, or try to avert the same catastrophe in a given turn.

In small spacecraft the damage control "party" may be a single character. On large spacecraft, a damage control party of several characters is usually used. If a party is involved, skill rolls will be made by the team leader, against the lower of his skill (usually the required Repair skill) or the average skill of the team. When calculating their average skill, team members use either Spacer-2 or their Repair skill, whichever is best.

The size of the party, relative to the size of the system, modifies the damage control roll, as listed below. Cross-index the number of people in the party with the SM of the spacecraft to find the modifier. "No" means the party is too large to fit into a system. Only one party can attempt to fix a given system in a single turn.

Damage Control Party Size Modifier

Party/SM	*+5-9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
One crew	0	-3	-5	-7	-9	-10*	-10*
2-5 crew	+1	0	-3	-5	-7	-9	-10*
6-19 crew	+1	+1	0	-3	-5	-7	-9
20-59 crew	no	+1	+1	0	-3	-5	-7
60-199 crew	no	no	+1	+1	0	-3	-5
200-599 crew	no	no	no	+1	+1	0	-3
600+ crew	no	no	no	no	+1	+1	0

* Can be only attempted by PCs or PC-led parties in cinematic games.

Each damage control roll represents one combat turn's worth of work: this may give either "extra time" or "haste" modifiers (p. B346), depending on the task being attempted, as given below.

Damage Control Time Modifier

Turn Length	Jury-Rig	Structural Repairs	Rescue	Halt Catastrophe
20 seconds	-10*	No	-9	0
1 minute	-9	-10*	-3	0
3 minutes	-3	-9	0	0
10 minutes	0	-3	+1	0
30 minutes†	+1	0	+3	n/a

* Can be only attempted by PCs or PC-led parties in cinematic games.

† For repairs performed out of combat.

Emergency Repairs

It is possible to quickly repair disabled systems by swapping in parts, switching to backup systems, and replacing blown electronics. The required repair skill is shown in the system descriptions in Chapter 1.

Apply the Damage Control Party Size Modifier, and the Damage Control Time Modifier using the Jury-Rig column. Other functional spacecraft systems can help by providing parts: Add +1 per fabricator or robofac system the spacecraft has; +2 per nanofac or replicator.

If emergency repairs succeed, the system is jury-rigged and no longer disabled – it will be functional again at the start of the spacecraft's *next* turn. Critical success means it's fixed immediately. Failure means it's not fixed yet, but you can try again on later turns. Critical failure means the system can't be fixed without major repairs – there's no chance of doing so until after the combat is over.

A jury-rigged system is fixed, but counts as two systems for the purpose of maintenance until fully repaired. Repairs will hold for at least a few hours, but at the start of any *future* combat or other stressful situation in which a jury-rigged system is used, roll against the spacecraft's HT: failure means the system is disabled. (Roll only when the system is first used, and only once for the entire combat.) Assume it's fully fixed only after all lost dHP suffered by the vessel are repaired.

Structural Repairs

Usually performed after combat is over, this represents generalized repair to the vessel's structural integrity, and is normally performed by teams working throughout the vessel. Use Mechanic (Vehicle type) skill. Apply the Damage Control Party Size Modifier, and the Damage Control Time Modifier using the Structural Repairs column, with an additional -2 penalty if the spacecraft is at 0 dHP or less. Success restores dHP × margin of success.

Rescue

Survivors of a *destroyed* system that remain in the spacecraft will be trapped in the wreckage and may need medical attention. A damage control team may attempt to get them out. The leader rolls against the team's average Spacer skill with the party size and time modifiers (using the Rescue column). Critical success rescues everyone. Success rescues half (round up) of the victims. On a failure, no victims are rescued; on a critical failure, a disaster injures or kills half (round up) of the survivors; for PCs and important NPCs roll again on the Casualty Table.

Halt Catastrophe

It's possible to try and prevent the ship from blowing up due to a destroyed volatile system. The damage control party must be in the volatile system or the same hull section. Roll vs. the repair skill required for that system (for volatile cargo, it's the GM's decision) with the party size modifier, and a -4 if in the same section but a different system; the time modifier is always 0. Success means the disaster is averted. Failure means it isn't . . .

Boarding

A drifting spacecraft can be boarded if another spaceship's pilot has achieved a Rendezvous position with it. This means the spacecraft have matched velocities at zero or near-zero range and may be any distance from in contact to several miles of each other (default 100 yards).

On future turns, boarding is possible: see *Access* (p. 82) for various methods to get in. Boarding actions should use the normal combat rules. If boarding action takes place, pause the space combat until the action is resolved or the time represented by the turn length has passed.

Deliberate attacks, sabotage, stray shots, etc. may damage, disable, or destroy systems from inside. Use the normal rules for damage to objects. Remember to convert between decade-scale and normal scale. Assume spacecraft have only DR 2 vs. internal attacks, but since spacecraft HP are decade-scale, divide damage by 10 before applying it to dHP. If enough damage is done internally to force a system damage roll, instead of rolling apply the damage to the system where the fighting or sabotage is occurring.

Launching Small Craft

"The reactor's going to blow! Everyone to the lifeboats!"

Occupants may board spacecraft or inside a hangar bay in the same time it takes to move to a new system. That means that in a long-enough turn, it's possible to board a vessel or and launch in only one turn.

Spacecraft can maneuver out of an open hangar bay during the pilot task phase of their vessel's turn. When a new spacecraft is launched, it is added to the turn sequence. Instead of acting in accordance with pilot Speed, it takes its turn immediately after the launching spacecraft and begins in formation with that spacecraft.

Hangar bays have a launch rate that limits the maximum number of vessels that can launch or recover in a minute (represented by surface area considerations). To get the rate per turn, divide rate per minute by three in 20-second turns, multiply by three in 3-minute or 10 in 10-minute turns. Minimum time required is one turn.

A pilot in formation with a larger spacecraft with an open hangar bay may use his turn to maneuver into the bay, provided it has sufficient capacity to accept his vessel. Again, the time required depends on the launch rate of the hangar bay.

A Piloting skill roll is required for recovery operations. Out of combat, spacecraft usually use the Extra Time rules (p. B346) – a commercial ship often spends 30× time (for +5 to skill) while docking! Failure results in an "abort" – no recovery takes place. Critical failure results in a 0.5 mps collision. The GM may ignore critical failures if the character would succeed on a roll of 16 or less, treating them as aborts instead.

Special Rules

These rules cover a variety of special situations.

Formations

A spacecraft may maneuver in formation with another friendly spacecraft ("the leader"). To enter formation, its pilot must declare it is doing so, and must choose the *exact* same movement option and acceleration on its own turn as the formation leader did. If the formation leader was Closing, the pilot must also do so, selecting the same target (or its wreckage, if the target was destroyed!). He must also achieve the same result against that the target that the formation leader did. If a spaceship fails to follow any of these requirements, it is not in formation.

These rules apply to all spacecraft as long as they are in formation:

• Attack Run, Rendezvous, and Engaged results on one member are assumed to have applied to every member of the formation.

• They are treated as point-blank range to other vessels in their formation, which means they may be able to fire defensively against incoming missiles or ram attempts.

Ground Fire

If the battle is taking place in the vicinity of a planet, moon, or asteroid, vessels in orbit may direct fire down onto it, or vice versa.

The distance from low orbit to the surface is Short Range. Higher orbits may be at Long Range.

If the body has more than a trace atmosphere, certain beam weapons firing in either direction may have trouble penetrating the atmosphere, which provides cover DR against UV lasers, x-ray lasers, grasers, antiparticle beams, and particle beams. See *Weapons in Ordinary Combat* (p. 41. A Terrestrial world's atmosphere is typically around 10,000 yards thick, so a cover DR of 1 per 10 yards (typical of UV lasers) converts to a total decade-scale dDR of 10, while a cover DR or 2 per yard (vs. x-ray lasers, grasers, and particle and antiparticle beams) gives dDR 2,000. Multiply these numbers by the atmospheric pressure in atmospheres, if different from Earth-normal; the armor divisor for the beam type also applies.

GMs may decide that clouds block fire on a particular target. This depends on climate and weather, but may occur occasionally on planets with standard atmospheres, often for dense atmospheres, and perpetually for very dense or superdense atmospheres. Radar can see through clouds, but passive and ladar sensors cannot, making precise identification of targets problematic without someone on the ground; this requires them to use Forward Observer skill and the gunner to use Artillery (Beams) instead of Gunner (Beams).

Clouds additionally provide a dDR vs. visible-light and infrared laser fire of 20× the planet's atmospheric pressure measured in atmospheres; e.g., dDR 20 on Earth.

Main Radiators in Combat (Optional)

If spacecraft have main radiators (see *Exposed Radiators* design switch, p. 61), they can retract them to reduce their vulnerability in combat. Retracting the radiators does not require a task, but the radiators are not considered retracted until the start of the spacecraft's *next* turn.

If a spacecraft's main radiator was disabled, destroyed, or has been retracted, those of its systems requiring exposed radiators have 30 minutes before they overheat, and must shut down after 100 turns at 20-second scale, 30 turns at 1-minute scale, 10 turns at 3-minute scale, or 2 turns at 10-minute scale. This can be extended: each Fuel Tank that is filled with coolant (usually liquid nitrogen or oxygen, p. 28) instead of fuel adds 100% to the operating time of a single system (your choice) after which the coolant is used up.

Each turn functional main radiators are extended reduces accumulated time to overheat by one turn. If they overheat, the spacecraft must shut down these systems until radiators are repaired or redeployed.

Precision Attacks

Any attack (ramming, gunnery, or missile) may be targeted at a specific hull system [1-6] location in the facing hull section (e.g., "location 3 in front hull") at a -5 to hit. The gunner may not know what system is in that location unless he's at zero, close, or point-blank range, performed an engineering analysis task, or has blueprints of the target.

A gunner performing a precision attack may also target weak points in a spacecraft's armor (such as hatches, ducts, etc.) at -10 to hit. This can only be performed at zero, close, or point-blank range or if a successful engineering analysis task was performed against that target. The GM may allow precision attacks without these prerequisites against a vessel whose blueprints are on file ("we have the plans of the enemy monitor – aim for the exhaust duct!"). Use half the armor dDR (round down), then apply any armor divisors. Exception: if the target has disabled or destroyed armor systems in the attacked hull section, their dDR is completely ignored when targeting weak points.

Ghost Particle Beams: A ghost particle beam gunner may opt to fire at *any* of the target's hull sections – not just the section facing his spacecraft. A ghost particle beam gunner can also opt to target precise locations in any hull section with the usual -5 penalty for precision attacks, but may additionally choose to target core rather than hull sections by taking a further -3 penalty (total -8).

Near Miss and Hit Location: If an attack that took a penalty for a precision attack misses by only 1, a single shot still hits a random location on the hull section facing the attacking spacecraft.

Targeting Exposed Systems

Deployed main radiator arrays (p. 109), as well as magsails, lightsails, solar panel systems, and any system designated as an *external system* (p. 10), are *exposed systems*.

They can be targeted separately by beam or gun fire. Use the spacecraft's SM+3 for lightsails, solar panels, or magsails. For main radiator arrays, use SM if the central hull is facing the attacker, or SM-5 otherwise.

If hit, armor dDR does not protect, but due to the large size and diffuse construction of these features, any damage that is less than 10% of spacecraft dHP is ignored. Damage equal to or greater than the spacecraft's dHP will disable the system or main radiator, or destroy it if already disabled. No other damage is done to the spacecraft.

A successful attack with a nuclear or antimatter warhead will *automatically* destroy any deployed exposed systems in addition to its other effects.

ECCM and ECM Tasks

GMs who want to involve characters in electronic warfare may use these two complementary tasks. They are performed in the Electronics Operation Task phase. Vessels often assign these tasks to sensor operators; large or specialized craft may also have dedicated electronic warfare operators.

Electronic Counter-Countermeasures (ECCM) Task

A character can perform this task if his spacecraft has a tactical or multipurpose array. He uses it to analyze and degrade a specific enemy vessel's electronic countermeasures. This is effective against any vessel that has a defensive ECM or cloaking device system.

The task requires a Quick Contest of Electronics Operation (EW) skill with the target. The attacker adds his array level; the target adds +2 per defensive ECM system installed. If the target vessel does not have a sensor operator who was performing an EW task, use a default skill 8.

Failure means the target uses his full defensive ECM. Success reduces his defensive ECM bonus by the margin of success (to a minimum of zero). It also reduces the modifiers for any cloaking device! These effects last until the ECCM operator's next electronic operation task phase.

This task can be performed against multiple vessels in succession, using the normal penalties for multitasking.

Electronic Countermeasures (ECM) Task

This involves managing defensive ECM and cloaking device systems. Normally, no skill roll is required . . . unless the enemy attempts an ECCM task against your vessel. If so, using this task defends against his ECCM attempt, rather than the default skill 8.

When performing this task, the sensor operator may additionally opt to use defensive ECM in escort mode. This *halves* its modifiers but protects all allied craft in formation with the vessel as long as their SM is no more than two greater than the defending vessel's. Multiple sources of defensive ECM are not cumulative; use the best single value. If an enemy attempts to use ECCM against any protected vessel in formation, the contest is against the defending vessel.

Special Weapons Rules

The combat and non-combat uses of certain superscience beam weapons are discussed on p. 39. Exotic nonconventional non-nuclear gun and missile warheads are discussed on p. 40.

Chapter Four
Tactical Space Combat

This chapter is a map-based expansion to the basic space combat system in Chapter 3. The GM should be familiar with the basic rules before using them. Like the tactical combat system in the ***GURPS Basic Set***, it covers the exceptions and special cases that arise when fighting using a hex grid battle map.

The tactical rules present an approximation of realistic Newtonian movement in space, simplified by utilizing only two dimensions and assuming thrust occurs all at once, rather than being spread out over a turn. However, they give a sense for how spacecraft may maneuver and make it easier to play out running battles and dynamic tactical situations. Nonetheless, a GM should only use these hex-based rules when all players enjoy tactically detailed space combat, as these rules require extra time to set up and play. GMs who prefer a faster and more cinematic approach should continue to use the basic combat system.

The Tactical Engagement

The GM will need to make certain additional preparations before using the tactical combat rules: dealing with scaling factors, and preparing any necessary components and statistics.

Scale

The most important decision is the time and distance scale. As with the basic combat system, these rules can be used with various time and distance scales.

Distance scale may be 10 miles/hex, 100 miles/hex, 1,000 miles/hex, or 10,000 miles/hex.

Time scale may be 20 seconds, 1 minute, 3 minutes, or 10 minutes.

It's not fun if ship acceleration or starting velocities lets them flash across multiple map sheets in a single turn, or if they take several turns to make a minor course change. Similarly, weapon ranges should neither dominate the entire map nor have trouble getting into combat range. Before battle begins, the GM should use the *Velocity and Acceleration Table* (p. 112), considering both the spaceships *and* the projectiles they will be firing, as well as the *Beam Damage and Range Table* (p. 37), to determine which time and distance scales suit the PCs' ship and its opposition.

Tactical space combat plays most smoothly when the chosen time and distance scales result in the combatants having statistics within these ranges:

Starting velocities (below) of 0-12 hexes/turn (and ideally 0-3).

Thrust ratings of 1/2 to 12 (and ideally 1-6).

Burn points, for spaceships using reaction engines, equal or greater than the thrust ratings.

Burn points, for any missiles and guns, in the 0-10 range (and ideally in the 1-10 range if a primary weapons).

Beam weapon max ranges (p. 37) in the 3-30 hex range.

A mismatch can be inevitable, especially when a more advanced vessel fights a lower-TL design. If so, scale the fight around the most important vessel's performance (often that of the PCs' ship). It is still possible to play when some or all combatants have parameters outside these ranges, but it can be awkward to run. In situations where no combination of scale appears to give playable numbers, just use the basic combat system.

Starting Velocity, Thrust Rating, and Burn Points

The GM should determine vessels speeds in miles per second (relative to the nearest world) from travel decisions made before the battle begins. See Chapter 2 for examples. If using reaction drive ships, the GM should also know what their delta-V reserve (in mps) is at the start of the battle. With this information and each vessels' statistics, determine the following statistics for each combatant vessel.

Starting Velocity: The vessel's current velocity in hexes/turn. Convert the vessel's travel velocity into hexes per turn using the formula in the *Velocity* column of the *Velocity and Acceleration Table* (below).

Thrust Rating (TR): The vessel's acceleration in hexes/turn each turn. Convert the vessel's propulsion in G to a *thrust rating* using the formula in the *Acceleration* column of the *Velocity and Acceleration Table* (below). If this result is less than 1, convert it to a fraction, e.g., Thrust Rating 0.02 would be a fractional thrust of 1/50. Spacecraft with fractional thrust use special rules.

Burn Points (BP): The delta-V in hexes/turn; the maximum acceleration usable before running out of fuel. Convert the vessel's current delta-V reserve to burn points using the formula in the *Velocity* column of the *Velocity and Acceleration Table* (below). Round down to a whole number: if this brings it to zero, then the vessel cannot maneuver significantly on the combat scale. (It may still play a combat role as a stationary or drifting "artillery piece").

Velocity and Acceleration Table

Turn Length	***Velocity***	***Acceleration***
10-mile hexes		
20-second turn	mps × 2	G / 5
1-minute turn	mps × 6	G × 2
3-minute turn	mps × 20	G × 20
10-minute turn	mps × 60	G × 200
100-mile hexes		
20-second turn	mps / 5	G / 50
1-minute turn	mps × 2/3	G / 5
3-minute turn	mps × 2	G × 2
10-minute turn	mps × 6	G × 20
1,000-mile hexes		
20-second turn	mps / 50	G / 500
1-minute turn	mps / 15	G / 50
3-minute turn	mps / 5	G / 5
10-minute turn	mps × 2/3	G × 2
10,000-mile hexes		
20-second turn	mps / 500	G / 5,000
1-minute turn	mps / 150	G / 500
3-minute turn	mps / 50	G / 50
10-minute turn	mps / 15	G / 5

Example: A spacecraft begins with a velocity of two miles per second and a delta-V reserve of 24 mps. It has an acceleration of 1.5G. The GM decides to use 100-mile scale and 3-minute turns. Therefore, its starting velocity is 4 hexes/turn, its thrust rating is 3, and it will have 48 burn points.

Thrust Rating and Burn Points of Projectiles

For ships with ballistic weapons (catapults, guns, unguided rockets, and guided missiles), you should also compute the thrust rating and burn points for each type of ordinance it plans to use in combat.

Rockets and Missiles: The Move column of the *Guns and Launchers Table* (p. 38) lists the acceleration in G and delta-V in mps. Convert these to thrust rating and burn points for the chosen scale, as above, and write them down.

Catapults and Guns: The Move column lists an *impulse* in mps: convert this to burn points as above. There is no thrust rating; the burn points are spent all at once, when the projectile is fired.

As with ships, round burn points down to a whole number. If this rounds to zero, then the projectile is not really "fired" on this combat scale, but may be "dropped" on a trajectory that will intercept a target.

Beam and Warp Missile Ranges

These attacks travel at or close to the speed of light, typically reaching their targets in under a second. On the scale of these combat rules, they are assigned a *maximum range* rather than a velocity or burn points.

Beam Weapons: Record the weapon's 1/D and Max ranges in hexes. These are computed by taking the ranges in miles from p. 37, and *dividing* by the distance scale (10, 100, 1,000, or 10,000 miles per hex).

Warp Missiles: These missiles have a pseudo-velocity drive (p. 64) that burns out in 0.75 seconds or 1 second, depending on missile diameter. Range in hexes is 150,000 (below 32 cm) or 186,000 (32 cm+), *divided* by the distance scale (10, 100, 1,000, or 10,000 miles per hex). 1/2D and Max ranges are identical.

Hex Map

The GM will need to prepare a map if space combat is a possibility. Hexes should be big enough to stack a couple of counters or miniatures in it.

It's a good idea to have a map with dimensions (in hexes) at least five times the *fastest* vessel's starting velocity and/or thrust rating (or number of burn points, if that's *less* than the thrust rating).

Even so, a map is limited in size but space is effectively infinite, so fast-moving spacecraft can eventually run off the edge. The GM may want to have some extra map sheets handy to lay down in whatever direction the fight carries the combatants.

If that's not practical, another way to get extra space is to periodically displace all spacecraft counters (and all celestial bodies and other objects shown on the map) by the same number of hexes in an appropriate direction.

If a situation arises where most or all participants are moving in a similar direction (e.g. a pursuit), you can also "zero out" their average velocity by keeping the ships' position counters in place but moving their *vector* counters by the same amount, so that they are closer to their position counters. See *Counters* (below). Effectively, you are giving your *frame of reference* (the map) a velocity that carries it along with the ships. If you need to know the ships' *final* velocity in the original frame of reference, keep track of the shift(s) you applied to the vector counters and reverse them at the end of combat. (Exception: Do not use this option if any of the ships have pseudovelocity drives, hyperdynamic fields, or other motive systems that work with an absolute frame of reference: see p. 123).

Placement of Celestial Bodies

If action occurs near planets or other celestial bodies, the GM should either draw them on the map, or mark their position with counters or templates (which will make it easier to displace them). For bodies *much* larger than the chosen scale, indicate an edge of the map that represents their boundaries. Depending on the scale, it may also be necessary to calculate and mark their gravity fields. See *Celestial Bodies* (p. 121).

Counters

Each spacecraft requires a *position counter* to indicate the vessel's actual present location. This can be a miniature figure, actual counter, or other marker. It must be distinguishable from other counters, with an identifiable front to indicate facing.

Spacecraft also require a *vector counter* to show their future position. This counter must also be marked to show facing and the position counter it belongs to. Its facing is *always* identical to the facing of the position counter. If the position counter changes facing, change the vector counter to show the same facing. The facing of the vector counter is used when determining the hexes into which the vessel can accelerate.

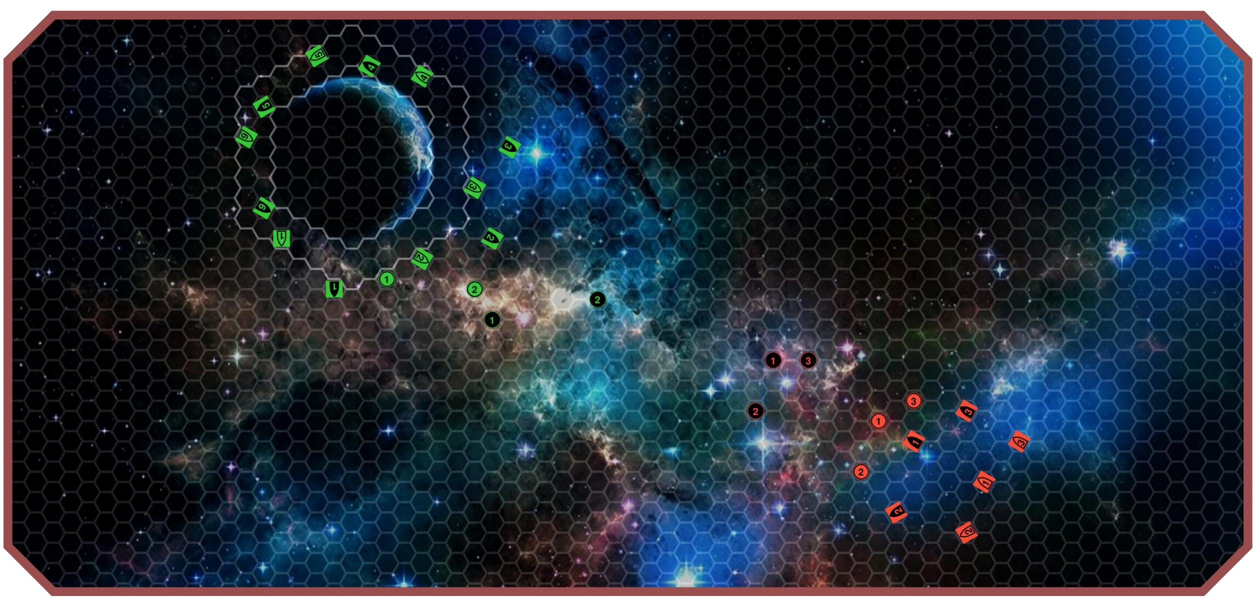
Spacecraft with guns or missile launchers will need additional position and vector counters to represent fired salvos. Each pair of counters should be assigned a number so players can record their status. Ideally there should be a couple of salvo counters for each ship's ballistic weapon battery, but if most batteries on the ship fire identical weapons and tend to launch at the same targets, far fewer may be needed.

Placement of Spacecraft Counters

The GM places friendly, neutral, and hostile spacecraft on the map, with the exception of any that have yet to be launched or are otherwise hidden.

In situations where neither side has spotted the other, use the guidelines for detection (p. 85) and for ambush and surprise (p. 88).

The distance separating opposing spacecraft will depend on the situation that led to the engagement. For example, if the PCs' pirate ship is fleeing a space station, pursued by the patrol, they will already have detected each other, and be only a few hexes apart when the fight begins. In the case of meeting engagements or interceptions, a suitable distance is the lesser of the detection range or the longest weapon range (the GM may modify this if it seems excessively short or long). For example, if one side's longest-range weapon has a 10-hex range and the other's has a 3-hex range, use 10 hexes.



If the engagement is the climax of a pursuit, place the quarry in the center of the map and the pursuers on one edge. Bear in mind that the pursuer will be unable to catch up unless his craft can reach a higher velocity, or can launch smaller craft that can do so.

The GM should ask players for all necessary information regarding their own spacecraft's position and actions before the battle. Based on this information, the GM places all spacecraft on the map. All counters must be positioned so that they are fully inside a hex, and must face one of the six hex sides.

If stations or spacecraft with low accelerations are to be important in the engagement, the GM should place them carefully to ensure they'll be involved in the action rather than left behind!

Placement of Vector Counters

The GM places each vessel's vector counter to indicate its current course and velocity. The location of a vector counter is where the spacecraft will be at the end of its turn – its projected course, if it does not maneuver.

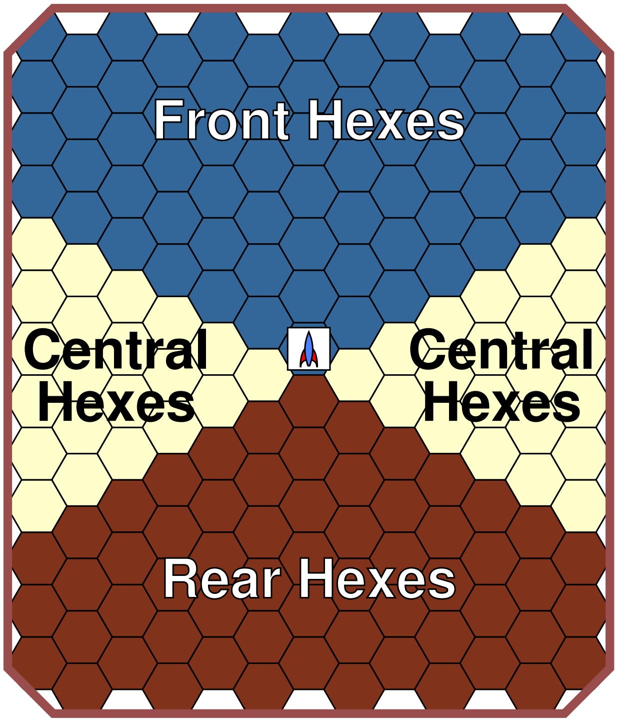
The distance from the position counter to the vector counter determines the spacecraft's speed. Each hex of distance is a speed of one hex/turn; see *Starting Velocity* (p. 112). Thus, a stationary spacecraft has its vector counter in the same hex as its position counter, while one moving at a velocity of one hex per turn has its vector counter in an adjacent hex.

Stacking

Any number of spacecraft and vector counters can occupy the same hex, unless they are large enough to fill it. However, this would require a truly enormous craft, one of SM+21 for a 10-mile hex (increased by +6 for each 10-fold increase in hex scale).

Counters and Facing

A position counter's facing is indicated by the hex side its counter front is pointing. A vector counter *must* have the same facing as its spacecraft counter.



The position counter's facing determines which hull section – front, central, or rear – faces an opponent. The front hull faces anything in its own hex or its front hexes; the central hull faces anything in its central hexes; the rear hull faces anything in its rear hexes. Counters must always face hex sides (rather than hex points).

The vector counter's facing (identical to its spacecraft's) is used in the acceleration rules.

Action During a Turn

These rules detail changes to the basic combat *Action During a Turn* rules (p. 91). Unless noted otherwise, the rules in that section continue to be used.

Pre-Battle Turns

In the tactical system, skip the pre-battle turn – if the spacecraft should have ready time before they move into range, start them at a significant distance from one another! The GM must decide whether or not force fields, stasis fields, cloaking devices, or other equipment that must be powered up are activated at the start of the battle.

Sequence of Action

The sequence of action differs slightly from that of the Basic Combat System: It is simultaneous rather than sequential.

Each turn is still divided into sequential phases for different crew positions. However, within each phase, resolve actions for *all* crew on *all* spacecraft before the next phase begins. Thus, in 1. Command Tasks, the command crew of every spacecraft in the battle performs command tasks. In Phase 2: Engineering, the engineering officers of every spacecraft allocate power and perform other engineering tasks . . . and so on. The sequence of action is:

1. Command Tasks.
2. Engineering Tasks.
3. Navigation Tasks.
4. Piloting Tasks.
5. Electronics Operation Tasks.
6. Gunnery Tasks.
 A. Missile Launch and Maneuver.
 B. Gun Fire.
 C. Beam Fire.
 D. Ballistic Attack.
7. Crew Tasks.
8. Movement.

This sequence is the same as that of the basic combat system (p. 91) except for the subdivision of the Gunnery tasks and addition of Movement.

Note: Crews of vessels in hangar bays (or similar) that have not yet launched may still perform activities, e.g., engineering tasks to power up systems prior to launch.

Order of Action

The order of action within the above phases is assumed to be simultaneous, but it's easier to manage if all crew members performing tasks do so one ship at a time.

In the Piloting Task phase, that order is determined by a Piloting skill roll. In other phases, the order is less critical, as all fire is assumed to be simultaneous. For phases other than Piloting Tasks the GM may roll randomly to see which ship acts first, or decide what his NPCs will do and then have the PCs declare their actions. In a multi-ship battle, the GM can roll randomly to see which *side* goes first, then have each side's commander alternate choosing a ship to perform the tasks until every crew has acted. The GM can retain this order in other phases, or determine the order anew each phase.

1-3. Command, Engineering, Navigation Tasks

Use the rules from (pp. 92-93), except tasks for all vessels on both sides are resolved one spacecraft at a time within each phase before proceeding to the next phase.

4. Piloting Tasks

In this phase, piloting tasks are resolved one spacecraft's pilot at a time. All the basic combat system's "Pilot Maneuvers" (p. 96) are replaced by a single "Maneuvering Task."

First, determine the tactical initiative for this phase. Make a Piloting skill roll for each spacecraft that is capable of maneuvering.

Each pilot rolls against Piloting skill + Handling. This is not a task in itself, but the rolls will be modified by penalties for multitasking.

Pilots may then act in the *reverse order* of their margin of success (or least margin of failure). That is, the most successful pilot gets to act last.

Example: There are four spacecraft capable of maneuvering, so each of their pilots get to roll. Kim fails by 1, Luke fails by 3, Trask succeeds by 1, and James succeeds by 7. Therefore Luke must go first, followed by Kim, Trask, and James.

Once the order of initiative is determined each spacecraft may maneuver, as detailed under *Tactical Maneuvering* (p. 116).

5. Electronics Operation Tasks

Characters acting as sensor or comm operators can perform communication and sensor tasks, one spacecraft at a time. Use the basic space combat rules for Communications Tasks (p. 95) and Sensor Tasks (p. 94). However, the range modifiers for detection (p. 84) are replaced with the *Space Range Modifier Table* (p. 118).

6. Gunnery Tasks

The Gunnery tasks are broken into *four* phases: Missile Launch and Maneuver; Gun Fire; Beam Fire; Ballistic Attack. Resolve all actions for all vessels and salvos in one phase before proceeding to the next.

Gunners only perform Aim and Attack or Wait (Point Defense) tasks (p. 95). The Wait (Aim and Attack) is not used in tactical combat.

6A. Missile Launch and Maneuver

Any gunner controlling missile launchers may launch missiles in this phase using an Aim and Attack maneuver; see *Gun and Missile Salvos* (p. 117). Existing missiles may accelerate, and any gravity (p. 121) effects are applied to missile salvos. No attack rolls are made in this phase.

Exception: Warp missiles are fired and maneuvered in the Gun Fire phase below.

6B. Gun Fire

A gunner controlling guns (or launchers with warp missiles) can fire them in this phase using an Aim and Attack task; see *Gun and Missile Salvos* (p. 117). Gun salvos already fired can no longer maneuver, but gravity can affect them.

6C. Beam Fire

Gunners declare tasks and resolve fire one gunner and one spacecraft at a time. Gunners may choose to fire immediately using an Aim and Attack maneuver or to hold their fire for defensive purposes using Wait (Point Defense) maneuver.

Aim and Attack actions are considered simultaneous; a gunner ignores any damage he or his vessel sustained during this phase when he fires back.

See *Beam Fire* (p. 118) for the rules changes from the basic combat system.

6D. Ballistic Attack

A spacecraft or a salvo ("the attacker") can attempt a ballistic attack vs. another vessel ("the target") if on a collision course with it. See *Maneuvering Missile Salvos* (p. 117).

If a spacecraft or salvo encounters an object large enough to fill a hex (such as a planet), a collision may be unavoidable. See *Celestial Bodies* (p. 121).

7. Crew Tasks

Resolve crew tasks such as damage control (p. 107) one spacecraft at a time in any order the GM wishes.

8. Movement

A vessel or salvo moves if its position counter and vector counter occupy different hexes. Resolve movement one vessel at a time, but the order doesn't matter. See *Vector Movement* (p. 120).

Tactical Maneuvering

During the Piloting Tasks phase, a spacecraft's pilot may have his vessel *change facing*, *accelerate*, or both. Spacecraft may also launch, enter formation, rendezvous, and recover under certain circumstances. All are part of the same piloting task. However, facing changes occur *before* acceleration.

To be able to dodge, a spacecraft must have accelerated by 1 hex in Phase 4. To qualify for an evasive maneuver bonus, a spacecraft must have changed facing *and* accelerated. If many spacecraft maneuvered, make a note of which ones qualify!

Change Facing ("Turn")

This involves using the spacecraft or missile's thrusters to change facing. This alters the facing of the position (and vector) counter by one or more hex sides.

Spacecraft require a functional Control system to change facing.

The maximum facing change a vessel can perform during the turn, measured in hex sides, is shown on the *Facing Change Table* (below). Cross index the vessel's SM with the time scale to find the maximum facing change.

Facing Change Table

SM	***20-sec.***	***1-min.***	***3-min.***	***10-min.***
+6 or less*	any	any	any	any
+7-9	2 sides	any	any	any
+10-12	1 side	2 sides	any	any
+13 and up	1 side	1 side	2 sides	any

* Including missiles.

A craft with a fractional thrust rating may not change facing while in the process of performing an extended burn (see *Fractional Thrust and Extended Burns*, below).

Accelerate

Acceleration involves moving the accelerating craft's *vector* counter and thus altering its course and speed, since the vector counter is where the vessel will end its turn.

The vector counter can be moved up to as many hexes as the maneuvering craft's current thrust rating. If using a reaction drive, each hex moved requires expending one burn point.

A vector counter can only move into one of its own front hexes, and cannot change its own facing while moving. However, as a vessel has three front hexes, and the counter can move into any of them each time it moves one hex forward, this permits considerable freedom of maneuver.

Exception: A spacecraft accelerating with a rotary reactionless drive or space sail can move its vector counter in any direction, independent of facing.

Fractional Thrust and Extended Burns

A spacecraft with a fractional Thrust Rating must accelerate constantly in one direction for multiple turns to produce one hex of acceleration. This is called an *extended burn*. For example, a spacecraft with Thrust Rating 1/50 thrust requires a 50-turn extended burn to produce one hex/turn change in velocity. A vessel with a fractional thrust rating may not change facing while performing an extended burn.

Launch

Craft in hangars, in docking clamps, or on the ground may be launched in this phase, subject to the rules detailed on p. 108. Since tactical turns are simultaneous, they enter play immediately.

Place ships on the map with their position and vector counters in the same hexes as those of the launching spacecraft. The facing of the small craft's counters depends on the hull location of the launch system, typically a hangar bay, external clamp, or robot arm:

• If the launch system was in the front hull, the launched object's counter must face one of the launching spacecraft's front hexes.

• If the launch system was in the central hull, the launched object's counter must face one of the launching spacecraft's central hexes.

• If the launch system was in the rear hull, the launched object's counter must face one of the launching spacecraft's rear hexes.

Within these limits, the specific facing is up to the small craft's pilot. A craft that has just launched may also accelerate or maneuver. Determine the order they will maneuver relative to other craft in the usual fashion.

Missiles are not considered small craft; they launch in the Gunnery Tasks phase.

Formations, Rendezvous, Docking, and Recovery

A spacecraft is considered to be "in formation" with another spacecraft if its position counter is in the same hex as the other vessel's position counter, and its vector counter is in the same hex as the other vessel's vector counter. This replaces the requirements listed on p. 109.

Vessels in formation can attempt to enter hangar bays, etc., as detailed on p. 108, provided they are already in formation or move into formation after accelerating. If a spacecraft successfully enters a hangar bay, remove it from the map.

Vessels in formation may choose to use point defense fire to protect the vessels they are in formation with.

A vessel may attempt to rendezvous with one other vessel they are in formation with, provided they are capable of maneuver and the other is cooperative or cannot maneuver. A vessel that has rendezvoused with another is within a few dozen yards of it and can attempt docking procedures (see p. 82). Personnel may also attempt boarding in the Crew Tasks phase by leaping across, or using grappling hooks, thruster packs, etc. If either vessel has an external clamp or robot arm, the crew may use it to grab and connect the two vessels; see p. 46.

WEAPONS FIRE IN TACTICAL COMBAT

These rules detail the changes in the basic combat system.

GUN AND MISSILE SALVOS

Missiles are launched in Phase 6A. Gun salvos are launched in Phase 6B. Both use similar rules. Shots of the same type, launched simultaneously, form a salvo.

A salvo can be one or many shots. It is represented by position and vector counters, like a spacecraft. When a gunner fires different types of missiles make a record of pertinent information: the identity of the salvo, the type and number of shots in it, and – for missiles – their thrust rating and burn points.

Example: Jan controls a tertiary battery with 28cm missile launchers that has RoF 30. He fires 30 identical nuclear missiles as a salvo. His player should record: "Salvo #3 (Jan): 30 × 28cm nuclear missiles, Thrust 10, Burn Points 20."

Place the salvo's position counter in the same hex as the launching spacecraft's position counter. Place the salvo's vector counter in the same hex as the launching spacecraft's own vector counter.

Missile counter facing is not important. Gun salvo vector counter's facing is important and depends on the battery that fired it.

Fixed battery in front hull or spinal mount: It must face one of the launching spacecraft vector counter's front hex sides.

Turret battery in front hull: It must face one of the launching spacecraft vector counter's front or central hex sides

Fixed battery in central hull: It must face one of the launching spacecraft vector counter's central hex sides.

Turret battery in central hull: It may face any hex side.

Fixed battery in rear hull (or rear-facing spinal mount): It must face one of the launching spacecraft vector counter's rear hex sides.

Turret battery in rear hull: It must face one of the launching spacecraft vector counter's rear or central hex sides

Maneuvering Missile Salvos

A missile salvo (including one that has just been launched) will maneuver in Phase 6A. Missile Launch and Maneuver.

Its gunner decides whether it will *drift* or *accelerate*. Missile salvos can accelerate in any direction. A drifting missile does nothing. Acceleration moves the salvo's *vector counter* a maximum distance in hexes equal to its missiles' thrust rating. However, each hex of thrust requires expending one burn point. If out of burn points, a missile can only drift. Salvos should maneuver to achieve a collision course with a desired target; see *Ballistic Attack* (p. 119) for requirements.

Exception: Warp missiles are exceptions. They maneuver in the gun phase.

Ballistic Impulse of Gun Salvos

Immediately after firing a salvo of gun shots, the gunner may accelerate the salvo's vector counter, moving it up to the maximum number of hexes given by its burn points. A gun shot's vector counter may only be moved into its own *front* hexes. This represents the initial velocity imparted by the gun's propellant or accelerator.

Gunners should generally strive to move their salvo's vector counter so that it ends in a hex containing a target's vector counter (or stationary target).

Gun salvos and warp missiles can only accelerate on the turn they are launched: any unused burn points are discarded. On later turns they drift. GMs may wish to remove them at the end of the turn that they were launched, if it's not likely they are going to hit anything significant in their path.

Warp Missiles: These operate in the Gun Fire phase but use special rules. Move the warp missile salvo's vector counter to any target point that is within its range (see *Beam and Warp Missile Ranges*, p. 112) and the vector counter's front hexes.

Beam Fire

Gunners controlling beam weapons use Aim and Attack tasks or Wait (Point Defense) tasks (p. 94). The former are resolved in the Beam Fire phase; the latter in the Ballistic Attack phase. All fire in a phase is considered simultaneous.

Bearing

The facing of a firing vessel determines what beam weapons can fire. This depends on the location of the weapon battery, and the type of weapon or mount:

Spinal mount weapons can only fire on targets in the spacecraft position counter's front hexes and its own hex. (If the spinal mount was defined as rear-facing, it instead fires into the spacecraft position counter's rear hexes.)

Fixed mounts in the front hull can fire into the spacecraft position counter's front hexes and own hex.

Fixed mounts in the central hull can fire into the spacecraft position counter's central hexes.

Fixed mounts in the rear hull can fire into the spacecraft position counter's rear hexes.

Turrets in the front hull can fire into the spacecraft position counter's front or central hexes, and its own hex.

Turrets in the central hull can fire at any target.

Turrets in the rear hull can fire into the spacecraft position counter's rear or central hexes.

Rate of Fire, Range, and Targets

The rate of fire rules (p. 100) and target rules (p. 100) are unchanged. Range rules (p. 98) are replaced by the calculations in *Beam and Warp Missile Ranges* (p. 112) to find range in hexes.

Beam Fire Attack Rolls

Use the basic space combat system's Beam Attack Rolls rules and modifiers (p. 101) with the exception of Space Range. Replace the space range modifiers with the following based on the chosen scale and range in hexes.

Space Range: Use the modifiers on the *Space Range Modifier Table* (below) based on hex scale and range in hexes.

Space Range Modifier Table

Hexes	***10-mile***	***100-mile***	***1,000-mile***	***10,000-mile***
Rendezvous	+20	+20	+20	+20
Point Defense	0	0	0	0
0	+12	+6	0	-6
1	+6	0	-6	-12
2	+4	-2	-8	-14
3-4	+3	-3	-9	-15
5-6	+2	-4	-10	-16
7-9	+1	-5	-11	-17
10-14	0	-6	-12	-18
15-19	-1	-7	-13	-19
20-29	-2	-8	-14	-20
30-49	-3	-9	-15	-21
50-69	-4	-10	-16	-22
70-99	-5	-11	-17	-23
100-149	-6	-12	-18	-24
150-199	-7	-13	-19	-25
200-299	-8	-14	-20	-26
per ×10	-6	-6	-6	-6

Rendezvous is for fire against vessels that have rendezvoused with the firing craft's vessel (i.e., firing at craft that are at boarding/docking ranges).

Point Defense is for point defense fire against incoming ballistic attacks (attacking the point-defending vessel or another in formation with it).

0 is for firing against targets in the same hex.

Dodge in Tactical Combat

A spacecraft may dodge beam fire or ballistic attack as described under Dodge (p. 103). However, the prerequisites for dodge differ from the basic space combat system. A spacecraft may now dodge provided it accelerated by at least one hex/turn during this turn's Piloting Task phase. It gets the +1 Evasive Action Maneuver bonus if it accelerated *and* changed facing. A vessel held in a docking clamp or robot arm can't dodge. Salvos do not dodge.

Ballistic Attack

Ballistic attack occurs if the attacker's vector (the line from its position counter hex to its vector counter hex) passes *into or through* a hex with the target's vector counter. In the case of motionless targets (i.e., no vector counter), a ballistic attack occurs if that line passes into or through their hex. The decision to make a ballistic attack is voluntary unless the attacker or target fills the hex (see *Stacking*, p. 114, and *Celestial Bodies*, p. 121).

The pilot (for an intercepting vessel) or gunner (for a salvo) resolves the attack: Declare the attempt, calculate the relative velocity, and roll to hit.

If the target fills the hex, a hit is automatic, but you may still want to make an attack roll if trying to hit a smaller part of the target, or a city, building, parked spacecraft, etc., that is located on the surface of a celestial body.

If multiple ballistic attacks are declared in a turn, resolve them in the order of highest to lowest interceptor velocity, breaking ties by die roll or GM fiat.

Ballistic attacks are resolved using the rules below. They may be interrupted by attempts at point defense (p. 102) if a gunner (on the target or on a vessel in formation with it) chose a Wait (Point Defense) task.

Resolving a Ballistic Attack

Ballistic attack rolls are made during the Ballistic Attack phase of the turn. Resolve them one at a time in any order. To resolve each ballistic attack:

1. Calculate the relative velocity of the interceptor and target.
2. Make a ballistic attack roll.
3. Resolve any Point Defense by the target or an ally in formation with it.
4. If the target was hit, make dodge rolls.
5. If the target fails to dodge, determine damage.

Calculating Relative Velocity

The basic space combat rules for calculating relative velocity (p. 102) and the *Base Relative Velocity Table* are replaced with the following rule.

If the attacker and target's position counters are in different hexes: Note the target's vector. This is the distance and direction from its present position to its vector counter. For instance, it might be two hexes "north" and three "north-west." (If the target is motionless, it is zero.) Next, note the attacker's position counter, and without moving it, determine the hex it would move to if the target's vector were applied to it. For example, in the above case, if moving it two hexes north and three north-west. Count the hexes from that point to the *attacker's* vector counter: this is the relative velocity in hexes/turn.

If the attacker and target's position counters are in the same hex: Relative velocity is the range from the interceptor's vector counter to the target's vector counter. (For a motionless target, use the target's position counter as its vector counter.)

Make a note of the relative velocity: It will be needed both for an attack roll modifier and collision damage.

Ballistic Attack Roll

All missiles or shots in a salvo make one attack per target. When attacking a formation, they can be divided at will among the vessels in formation (making one attack each).

Rules for ballistic attacks are resolved as described under basic combat's *Ballistic Attack Roll* (p. 102), but the Relative Velocity Modifier is replaced by the one shown in the table above, and a Turn Length modifier is applied. For gun or missile salvos, be sure to indicate if using proximity detonation (p. 102) before the attack roll.

Relative Velocity Modifier: Use relative velocity in hexes/turn (*Calculating Relative Velocity*, above) to derive a modifier via the *Relative Velocity Ballistic Modifier Table* (below), using the column for the hex scale. For example, a relative velocity of eight hexes/turn in 100-mile scale is a -3 to hit.

Turn Length Modifier: -6 for a 20-second turn, -3 for a 1-minute turn, 0 for a 3-minute turn, +3 for a 10-minute turn.

Relative Velocity Modifier Table

Hexes/Turn	*10-mile*	*100-mile*	*1,000-mile*	*10,000-mile*
0	+10	+4	-2	-8
1	+8	+2	-4	-10
2	+6	0	-6	-12
3-4	+5	-1	-7	-13
5-6	+4	-2	-8	-14
7-9	+3	-3	-9	-15
10-15	+2	-4	-10	-16
15-19	+1	-5	-11	-17
20-29	0	-6	-12	-18
30-49	-1	-7	-13	-19
50-69	-2	-8	-14	-20
70-99	-3	-9	-15	-21
100-149	-4	-10	-16	-22
per ×10	-6	-6	-6	-6

Removing Salvos

Ships or salvos that miss their targets (or were dodged) remain on the map (and can conceivably attack or maneuver again in latter turns). If some shots in a salvo missed, reduce the recorded number of missiles or shells left in the salvo by the number of hits. *Exception:* proximity-fused shots are lost whether they hit or miss!

Damage in Tactical Combat

Damage rules are unchanged from basic space combat except as noted below.

Ballistic Attack Damage

Nuclear and antimatter warheads may potentially affect everything in a hex. Collisions and conventional warhead damage depends on relative velocity in hexes/turn.

Nuclear and Antimatter Warheads in Tactical Combat

Use the damage listed on the *Nuclear and Antimatter Warhead Damage Table* (p. 38), with two additional considerations.

Rendezvous: Any object that the target rendezvoused with is also caught in the blast and takes the same damage.

Collateral Damage in 10-Mile Hexes: A 10-mile hex scale is small enough that every other vessel or object in the same hex may also be affected! Roll proximity damage, and then divide the rolled damage by another factor of 100.

Collision and Conventional Warheads in Tactical Combat

The *Collisions and Conventional Warheads* rules (p. 104) are unchanged, except damage is calculated using a hex-based formula:

Gun or Missile = d-Damage × V × scale factor.

Collision = 6d × 3 × lesser dST × V × scale factor.

V is the relative velocity in hexes per turn as determined on p. 119.

Scale Factor is shown on the table below.

Lesser dST is the smaller of the victim or colliding vessel's dST.

d-Damage is the dice of damage based on warhead caliber (p. 38).

Scale Factor Table

Scales	*10-mile*	*100-mile*	*1,000-mile*	*10,000-mile*
20-second	0.5	5	50	500
1-minute	0.15	1.5	15	150
3-minute	0.05	0.5	5	50
10-minute	0.015	0.15	1.5	15

Warp missiles and subwarp drives use pseudo-velocity. For collision *damage* purposes, treat the velocity as 10 mps or actual velocity, whichever is less. The GM may also rule that any reactionless drives and super missiles use the pseudo-velocity rules.

Hull Damage and Hit Location

These rules are unchanged from the basic combat system. However, the GM may want to make up position and vector counters for characters blown out of a spacecraft (p. 106), treating them just like a small craft that had been (inadvertently) launched. Even if they can't maneuver, this will make it possible to determine whether a rescue mission can reach them!

Vector Movement

In Phase 8, for each spacecraft or other moving object, the GM or a player should do the following:

1. Put a placeholder (such as a small coin or die) in the hex containing the spacecraft's counter.
2. Move the spacecraft's counter into the same hex as its vector counter.
3. Imagine a line from the center of the placeholder's hex through the center of the spacecraft counter's hex and onward in the same direction. Move the vector counter along that line for a distance equal to the distance between the placeholder and the spacecraft counter.

That is, a spacecraft moves into the same place as its vector counter, and the vector counter is moved to a new location along the same projected course. In this way, a spacecraft that doesn't accelerate will continue to move each turn in the same direction, at the same speed, following its vector.

If a spacecraft or other object passes close to a world, gravity effects come into play, if using those rules. See *Gravity* (p. 121). If gravity effects do *not* come into play, or after they have been resolved, remove the placeholder and proceed with the next vessel or object's movement. The turn ends after all moving objects have been moved.

FTL Movement: If an FTL drive was powered up in the Engineering Task phase, any faster-than-light movement takes place at the start of this phase.

Salvos: GMs may remove salvos from the map at the end of this phase if it appears they can't hit anything and nothing is likely to blunder into them. This is the case for gun salvos and for missile salvos that ran out of burn points.

Special Rules

Most special combat rules from pp. 109-110 are unchanged from the basic space combat system

Rules for *Formations* are altered as detailed in *Formations, Rendezvous, Docking, and Recovery* (p. 117).

Rules for gravity from planets and other celestial bodies (below) are specific to the tactical system.

Celestial Bodies

Space actions may occur near planets, moons, asteroids, stars, and other celestial bodies. The rules for using these bodies depend on their size and the map scale.

Scaling and Celestial Bodies

To place a celestial body the GM will need to know its approximate diameter and its surface gravity. For example, Earth has a diameter of 7,926 miles, a radius of 3,963 miles, and a gravity of 1G. ***GURPS Space*** can be used to calculate any of these values for other celestial bodies.

Typical Gravity and Diameter

Gravity	*Description and Diameter*
0.01G-0.03G	Medium asteroids (50-300 miles diameter)
0.03G-0.1G	Small moons, large asteroids (200-1,000 miles)
0.1G-0.3G	Large moons, small planets (600-3,000 miles)
0.3G-1G	Medium planets (3,000-10,000 miles)
1G-3G	Large planets, small gas giants (10,000-30,000 miles)
3G-10G	Large gas giants (20,000-100,000 miles)
10G-30G	Brown dwarfs, small stars
30G-100G	Most stars
100G-300G	Neutron stars, black holes

A celestial body's diameter in hexes is simply its diameter divided by the hex scale. It can be depicted on the map by making a cut-out template or drawing on the map sheet. If its size is less than one hex, it can still be depicted as a point on the map; its gravity (see below) may be larger than its own diameter, and spacecraft may hide behind it.

A celestial body should *not* be used if its size and influence utterly dominates the map at the chosen scale. A reasonable limit is 10 hexes in diameter. Larger bodies should be left off the map (assume the battle is occurring at a distance from them) or serve as a *backdrop* (p. 122). Alternatively, the scale should be adjusted to accommodate them.

The typical maximum size of a celestial body is shown below:

10-mile scale: Small or medium asteroids; small moons (up to 100 miles diameter).

100-mile scale: Large asteroids; medium-size moons (up to 1,000 miles diameter).

1,000-mile scale: Moons; medium-sized planets (up to 10,000 miles diameter).

10,000-mile scale: All planets, including gas giants (up to 100,000 miles diameter).

Gravity

The influence of a celestial body's gravity is represented by a *G-thrust rating* representing how much it pulls nearby objects toward it. Use the *G-Thrust Table* (below) to calculate the thrust rating for the celestial body. To find the G-thrust rating, multiply the celestial body's surface gravity by the appropriate factor on the *G-Thrust Table*. Treat this like a spacecraft thrust rating, but round to a whole number.

The gravity thrust should be between 1 and 12. If less than one, gravity has no noticeable effect at this scale (which simplifies things!). The body is on the map, but its gravity pull is negligible in this scale. If it's 13+, gravity will pull all the combatants off the map straight away! Consider switching to a different scale if that celestial body is to be part of the encounter.

G-Thrust Table

Hexes/Turn	*10-mile*	*100-mile*	*1,000-mile*	*10,000-mile*
20-second	0.2	0.02	0.002	0.0002
1-minute	2	0.2	0.02	0.002
3-minute	20	2	0.2	0.02
10-minute	200	20	2	0.2

Gravity Bands

A celestial body's gravity pull gets weaker with distance. This is depicted by a series of gravity bands, which can be shown by drawing circles on the map of progressively greater radius, each with a lower G-thrust. To find the radius and strength (in G-thrust) of these gravity bands, consult the *Gravity Band Table* (p. 122).

The vertical G-thrust column is the surface gravity G-thrust, as calculated above. The horizontal columns numbered -1 to -12 are range bands, where the gravity thrust drops by 1, 2, and so on. The numbers on the table are distance multipliers. Multiply the radius of the object in hexes times this number to get the radius where G-thrust drops by one.

Round the result to the nearest integer. It is entirely possible that the numbers will round to the same value, meaning the gravity drops off quickly across the single hex.

Gravity Band Table

G-Thrust	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12
1	1.4											
2	1.2	1.7										
3	1.2	1.4	2.0									
4	1.1	1.3	1.6	2.2								
5	1.1	1.2	1.4	1.7	2.5							
6	1.1	1.2	1.3	1.5	1.9	2.6						
7	1.1	1.2	1.3	1.4	1.6	2.0	2.8					
8	1.1	1.1	1.2	1.3	1.5	1.7	2.1	3.0				
9	1.1	1.1	1.2	1.3	1.4	1.6	1.8	2.2	3.1			
10	1.0	1.1	1.2	1.3	1.4	1.5	1.7	1.9	2.3	3.3		
11	1.0	1.1	1.2	1.2	1.3	1.4	1.6	1.7	2.0	2.5	3.5	
12	1.0	1.1	1.1	1.2	1.3	1.4	1.5	1.6	1.8	2.0	2.6	3.6

Example: A world with a four-hex radius has G-thrust 2. At the surface the thrust is 2; at $1.2 \times 4 = 4.8$, rounded to 5 hexes, thrust is 1; at $1.7 \times 4 = 6.8$, rounded to 7 hexes or more, G-thrust is zero. The range bands are thus: 0-4 hexes: 2; 5-6 hexes: 1; 7+ hexes: 0.

Effects of Celestial Bodies

A celestial body large enough to fill one or more hexes will block movement and fire.

A spacecraft or salvo on a collision course with it will automatically hit and collide with it (unless shot down). Even if the body can move, it's too large to dodge.

Beam fire (except ghost particle beams) cannot shoot through the body, though targets on or above its surface may be attacked as per *Ground Fire* rules (p. 109). Instead of treating beam fire as Short or Long Range, count the actual range.

Small Bodies: If a celestial body is not large enough to fill a hex, it's simply treated as a (motionless) drifting spacecraft. Vessels may deliberately attempt to collide with or rendezvous with it, using the rules for spacecraft collisions.

Landing: A vessel able to rendezvous with a body may opt to land, or, if the body has an atmosphere, to enter atmosphere (see *Orbital Insertion and Landing*, p. 74). Attempting to land on a star, gas giant, or stellar remnant is generally fatal. A vessel with an active stasis field may survive, but will usually be trapped within the body's gravity.

Gravity Effects

Any celestial body with gravity bands extending past its surface can accelerate a spacecraft or salvo.

Spacecraft: During the Piloting Task phase, examine the current position of the spacecraft counter. If it is within a gravity band, move its vector counter by an amount equal to the Gravity Thrust rating in a direction toward the center of the gravity source.

Salvos: For salvos, do the same during Phase 6A for missiles or Phase 6B for guns. Note that this is the only way that gun salvos can change course after their first turn.

Backdrops

A *very* large body, at or beyond one edge of the map, may simply apply an arbitrary gravity thrust rating to the entire map. For example, a planet off the south end of the map can be represented an appropriate vector that pulls everything "south."

Pseudovelocity Drives

A vessel with a pseudovelocity drive (p. 64) has both a "true" real-space velocity vector *and* a pseudo-velocity vector than governs its movement. The pseudovelocity vector is where the vessel will move in Phase 8 of the tactical combat sequence, and is used to determine relative velocity for purposes of targeting the vessel. The true velocity is used to determine relative velocity for purposes of inflicting damage in a collision (p. 120).

When a pseudovelocity drive is activated, the pseudovelocity and the true velocity are initially the same. Thrust with pseudovelocity drives alters only the pseudovelocity vector, while other forms of thrust apply to *both* the pseudovelocity and the real velocity vectors. When the pseudovelocity drive is deactivated (or destroyed), the pseudovelocity vector vanishes, and the vessel reverts to its true velocity.

If the ship has *only* pseudovelocity drives, and there is nothing in the engagement that is likely to affect its true velocity (for instance, gravity or tractor beams), then you can simply note the true velocity on a scratch pad or record sheet, and use only a pseudovelocity vector counter (while the drive is active). Otherwise, you will need *two* vector counters to keep track of both velocities.

Hyperdynamic and Boost Drives

Hyperdynamic fields (p. 63) and boost drives (p. 60) give a vessel a fixed *top speed*, and allow it to change the direction it moves by changing its facing. Vessels with these systems use the rules for *High-Speed Movement* from ***GURPS Basic Set*** (p. B394), rather than the vector movement rules in this chapter.

An *Air-Filled Cosmos* (p. 81) can also be treated like a hyperdynamic field that gives *every* vessel a hyper-factor of 1.

Calculate a vessel's top speed in hexes/turn from mps using the *Velocity* column of the *Velocity and Acceleration Table* (p. 112). If the vessel has propulsion systems that can be powered up individually, calculate the top speed for each combination. Also compute its scaled *Thrust Rating* (TR) from its propulsion in G using the *Acceleration* column, as usual. Finally, determine its *Maneuver Rating* (MR) in the same way as its TR, but using a minimum of 1G if the propulsion was less than 1G.

Boost drives have effectively infinite TR and MR.

Movement

Vector counters are not used for these movement rules. Spacecraft move during their pilot's maneuver step rather than the space movement phase. Keep track of the vessel's current speed (in hexes/turn). At the start of the pilot's turn, he can increase this speed by up to TR hexes/turn (to a maximum of the vessel's top speed), or he can decelerate by up to MR hexes/turn (to a minimum of zero). If TR is a fraction, then the pilot must wait several turns between successive 1 hex/turn accelerations, as described for *Fractional Thrust and Externded Burns* (p. 116); however, the vessel *may* change facing during the extended burn as described below.

A vessel can move forward into any of its three front hexes *without* changing facing. It can only change facing after it has moved forward a number of hexes equal to its *turning radius*:

R = V / MR (cinematic)
R = (V^2) / MR (realistic)

R is the turning radius in hexes.
V is the *current* speed in hexes/turn.
MR is the maneuver rating.

Hyperdynamic vessels will normally use the cinematic formula. Vessels in an air-filled cosmos might use the realistic formula in a hard-science scenario (e.g. an air-filled microgravity megastructure). Boost drive vessels have a turning radius of zero. Round fractional results down.

Use the rules for *Pushing the Envelope* (p. B395) to decelerate faster or make tighter turns.

Large vessels may also be limited in in how quickly they can change facing, *regardless* of their velocity. Refer to the *Facing Change Table* (p. 116) to find the maximum facing change per combat turn. A vessel that is limited to 2 sides of facing change should travel at least half of its movement between facing changes in the same turn. If a vessel has a turning radius of zero *and* a maximum facing change of "any", then it can adjust its facing as desired after each hex of movement.

External Forces

If a hyperdynamic or boost-drive vessel is subject to an *external* force, such as gravity or tractor beams, then this should be added to or subtracted from the vessel's own thrust, depending on the direction of the force. This affects both TR *and* top speed. For simplicity, compute these effects *once* at the start of the Piloting Tasks phase.

The GM may rule that boost drives may not be affected by external forces *at all*. If they are, see *Travel with Boost, Hyperdynamic, and Pseudovelocity Drives* (p. 74), especially the section on *Getting Into Space*, for suggestions on converting between boost speed and effective thrust.

Frame-Dragging

Top speed is always calculated with respect to some frame of reference: either an absolute universal frame, or some hyperdynamic or ethereal medium. These movement rules assume that the combat map is "at rest" with respect to this frame. If the hyperdynamic medium is *flowing* through the map (or, conversely, the map is moving the other way through the medium), then convert the flow speed into hexes/turn using the *Velocity* column of the *Velocity and Acceleration Table* (p. 112), and assign it an appropriate direction on the map.

At the end of its movement, any vessel with operating hyperdynamic fields or boost drives has its final position adjusted by the given number of hexes in the given direction. For greater precision, if the flow is more than 1 hex/turn, then the player should apply the adjustment as a set of single-hex shifts over the course of the movement phase: e.g. a flow of 3 hexes/turn would be applied as three separate 1-hex adjustments after the vessel has traveled 1/3, 2/3, and all of its total movement.

An ether or hyperdynamic medium may also have its own internal currents, be pulled along with nearby bodies, etc., causing the flow vector to be different on different parts of the map. If these currents are known, they should be marked on the map; otherwise the GM may keep them as a surprise for unwary pilots! A vessel that spends only a part of its movement phase under the influence of a particular current will only experience a corresponding fraction of the overall drag.

Chapter Five

Cinematic Space Action

These rules are intended to give the feel of space opera. They are modular, allowing GMs to decide which are used in the campaign. They may be used for any spacecraft.

Although intended for cinematic play, many of these rules can be used in realistic games if the GM believes they are a good fit. In particular *Cockpit Multitasking*, *Relative Target Size*, *Improvised Weapons*, and *Crash Landings in Hangar Bays* are suitable for any situations.

A few are noted as usable only in the basic space-combat system in Chapter 3. Otherwise, rules that require modification for hex-based tactical combat (Chapter 4) have extra *Tactical Combat* notes.

Cinematic Piloting

These feats let pilots pull off stunts. If the GM wishes to give players an advantage, restrict them to the PCs and perhaps a few major NPCs.

Closing Strategy: Reversal

This is an alternative closing strategy (p. 97) that lets you turn a foe's advantage against him, e.g., by looping up, around, and behind him, or suddenly decelerating so he overshoots in front of you.

You can only use this strategy against a target you're not engaged with, and which, on its last turn, was Closing on your vessel, *and* achieved an attack vector or collision course against you. You can't attempt a Reversal against a foe who successfully used the defensive tactics Space Tactics task against your vessel this turn.

Resolve this as a normal Closing maneuver, except you use your opponent's Acceleration Bonus or your own, whichever is *better*. (Choosing a high Acceleration Bonus isn't useful for this maneuver but is helpful should foes attempt maneuvers against you on their upcoming turns.) You take a -2 penalty when performing a Reversal (it's a tricky maneuver); you suffer a further -2 if you already used it vs. this target (or a foe in formation with it) during this battle.

If you succeed you *must* opt to be advantaged, and if you succeed by 10+, you *must* combine advantaged with an attack vector.

Tactical Combat: Not usable.

Hugging the Enemy

Small vessels gain an advantage over larger foes by maneuvering in close with them. A spaceship at zero range (p. 98) with a target whose SM exceeds its own by at least three may declare it is "hugging" the larger vessel. This means it is using it as terrain it can hide behind.

The smaller craft is so close to the larger vessel, the normal bearing rules do not apply. Instead, only *turrets* in batteries on the hull section facing the smaller vessel can attack. Moreover, weapons in major batteries are at -6, minor batteries 1 SM smaller are at -4, and batteries 2 SM smaller are at -2.

Fire against the smaller vessel by another craft is at -3, and a shot that misses or is dodged has a chance (the larger vessel's Size Modifier minus 3 on 3d) of hitting the larger vessel it was hugging.

These effects persist only until the smaller vessel's next turn. To continue hugging its target, it must maneuver to retain zero range.

Tactical Combat: Hugging the enemy may be used in tactical combat when in the same hex as the larger vessel. Declare it when the smaller vessel maneuvers.

Landing on a Spacecraft

A small spacecraft may actually land on a larger vessel, even if that vehicle lacks external clamps or hangar bays, and/or is uncooperative! This can only be performed on a spacecraft whose SM exceeds your own by eight or more. Thus, an SM+4 fighter can land on a craft with SM+12 or more. (The GM is free to rule that a ship's unique geometry precludes available landing space, however.) It requires a Rendezvous, followed by a Piloting roll for the actual landing. Use the same rules as for entering a hangar, but with an extra -4 penalty. All landings (and subsequent takeoffs) are assumed to use low-powered attitude thrusters (as incorporated into the spacecraft's control system) and do not damage either vessel.

Tactical Combat: This rule can be used if the spacecraft have matched velocities (with their vector counter and position counter in the same location).

Sacrificial Dodge

Your spacecraft can defend another by flying into the path of an attack against it! To do so, your ship must be flying in formation or rendezvoused with the ally you are protecting. Announce a sacrificial dodge *after* the enemy makes his attack roll but *before* your friend attempts his defense roll. Use the ordinary rules for a dodge. If you succeed, *you* are hit by the attack. If you fail, you didn't move in time, but your ally still gets his normal defense roll. In either case, since you moved, you cannot retreat if *you* are attacked before your next turn. This is a cinematic rule if dodging beam weapons, but reasonably realistic for dodging ballistic attacks.

Tactical Combat: This defense can be used if the allied spacecraft are in the same hex. Ignore the references to retreating, but otherwise the procedure is identical.

Space Piloting Techniques

GMs may allow space pilots to learn particular techniques – for example, a smuggler might practice evasive maneuvering. Individuals often give them flashy names such as "Reverse Cobra" or "Freda's Feint."

Tactical Combat: These techniques are usable only with the basic space combat system.

Aggressive Maneuvering

Average

Default: prerequisite skill.

Prerequisite: Piloting (High-Performance Spacecraft); cannot exceed prerequisite skill+2.

You are skilled at offensive space-combat maneuvers. If you know this technique above default, you may use it instead of the underlying Piloting skill when you take the Closing maneuver option, except for Closing maneuvers that use the Ambush or Reversal strategies.

Ambush Maneuver

Average

Default: prerequisite skill.

Prerequisite: Piloting (any type); cannot exceed prerequisite skill+3.

You are skilled at carefully timed ambushes. If you know this technique above default, you may use it instead of the underlying Piloting skill when you take a Closing maneuver using the Ambush strategy.

Escape Maneuver

Average

Default: prerequisite skill.

Prerequisite: Piloting (High-Performance Spacecraft); cannot exceed prerequisite skill+4.

You are familiar with space-combat maneuvers designed to break off from combat. If you know this technique above default, you may use it instead of the underlying Piloting skill if your last movement option was Retreat and a foe is Closing against you.

Evasive Maneuvering

Average

Default: prerequisite skill.

Prerequisite: Piloting (High-Performance Spacecraft); cannot exceed prerequisite skill+4.

You are skilled at performing evasive space-combat maneuvers. If you know this technique above default, you may use it instead of the underlying Piloting skill if your last movement option was Evasive Action and a foe is Closing against you.

Reversal Maneuver

Average

Default: prerequisite skill.

Prerequisite: Piloting (High-Performance Spacecraft); cannot exceed prerequisite skill+3.

You are skilled at sudden direction changes. If you know this technique above default, you may use it instead of the underlying Piloting skill when you take a Closing maneuver using the Reversal strategy.

Large Space Battles

An epic battle may involve hundreds or thousands of ships sprawling over a vast area of space. In such a situation, the GM need only resolve that part of the fight closest to the player characters' own craft.

The GM may opt to treat their actions as a microcosm of the greater conflict. Have the odds against them reflect those facing the rest of the force. For example, if 200 Federation star fighters (including the PCs' ship) engage 430 Imperial fighters and supporting vessels, the odds are about two to one. So if there are three fighters piloted by the heroes plus two NPC allies, have them face off against 10 enemy vessels.

Should both fleets vary widely in tonnage and composition, determine odds based on the total tonnage of ships involved. Thus, if seven billion tons of enemy ships engage five billion tons of allied vessels, odds are about seven to five. If the party has a 300-ton patrol ship and two 30-ton fighters, send about 360 × 7 / 5 = 500 tons of enemy vessels against them.

GMs may wish to pepper the micro-level ship-to-ship action with descriptions of how the larger battle is faring, including inspiring or panicked orders from any superiors. Other events add spice, such as a badly damaged allied vessel suddenly appearing, pursued by an enemy ship, or drifting survivors calling for rescue.

It's up to the GM how to resolve the larger conflict. He can handle this by fiat, with the PCs' actions immaterial against the course of events. They can "win the skirmish but lose the battle" if that suits the overall plot of the campaign. However, he may choose to have the ebb and flow of the fight reflect the fate of the team's spacecraft. Thus, if the heroes' ship destroys half their foes; takes only minor damage; and forces the rest to retreat, the GM might assume their side wins with only a few losses, and half the enemy fleet is wiped out. A critical battle can be divided into phases, each fought against different opponents. If the team commands an important vessel, they may have a chance to strike a decisive blow, such as attacking an enemy flagship (or defending their own); destroying a key target; or landing a commando force to seize a critical port or defense headquarters.

Cinematic Clichés

Some are silly, some not . . . but they can all add to the cinematic feel of a space battle.

2D Thinking

The GM may provide a +2 bonus to Tactics rolls in space combat for commanders who have the 3D Spatial Sense advantage. Everyone else "thinks two-dimensionally" and thus is astounded when a more astute captain demonstrates otherwise.

Accidental Collisions While Dodging

If a spacecraft is part of a formation, the GM may rule that a *critical failure* on any dodge roll means that it suffers an immediate low-speed collision (typically at about 0.1 mps velocity) with another craft in that formation. The other ship's pilot may dodge to avoid this. If a spacecraft is hugging the enemy, a critical failure on a dodge roll results in an immediate low-speed collision with the vessel it is hugging.

Cockpit Multitasking

Multitasking (p. 92) is much easier on very small (SM+4-6) spacecraft where all the controls are within easy reach of a single operator. The skill penalty is only -1 per added task of the same or different category.

Exploding Spacecraft and Fireballs

If a volatile system on a spacecraft (excluding one with PCs aboard) is destroyed, roll against the vessel's HT. Any failure means it explodes *immediately!*

Any spacecraft at zero range to the enemy, or point-blank range and on an attack vector or collision course, may also be caught in the fireball. Its pilot may dodge to veer away from or outrun the explosion. He rolls at +3 if he was at point-blank range but gets no bonus at zero range. Failure means he is caught in the fireball. His spacecraft suffers damage to its front hull section based on the SM of the exploding foe and the range; see the *Fireball Damage Table* (below).

Fireball Damage Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Point-blank	1d-3	1d-2	1d-1	1d	1d+1	1d+2	2d	2d+1	2d+2	3d	3d+1	3d+2
Zero	1d+2	2d	3d	4d	5d	7d	5d×2	5d×3	2d×10	3d×10	5d×10	7d×10

Tactical Combat: This only applies if the victim rendezvoused with the exploding foe (use zero-range damage) or was in the same hex in 10-mile scale (use Point-Blank damage).

Exploding Instrumentation

In cinematic space opera, fuses haven't been invented! If the dDR of the control room's hull section is penetrated by any attack with the Surge damage modifier, roll 1d. On a 6 an electromagnetic surge explodes one control station console (GM's choice or roll randomly), doing 3d-2 burning damage to the operator.

Flag Command Tasks

A group of spacecraft may have one designated squadron commander, who can perform Flag Command tasks in the turn's Command phase. To perform these tasks, the squadron commander must be in either a spacecraft's control room or an ops center devoted to Strategy or Tactics skill. The following flag command tasks are possible:

Squadron Leadership

Motivate individual spacecraft commanders who recognize his authority by communicating with and supervising them. Both vessels must have a functioning comm/sensor array. Roll against Leadership skill. Success inspires them. This gives the benefit of a successful Leadership roll (adding to morale and self-control) as per p. B204, plus adds +1 to their own Tactics skill. Failure distracts them: -1 to their skill.

Heroic Speech

May be delivered only once during a battle, across open channels to everyone in the force. Roll against the lower of Leadership and Performance skill, at a -4 penalty. Success adds +1 to the Spacer skill of the entire squadron for the duration of the engagement. Failure has no effect. Critical failure gives a -1 penalty.

In devout cultures, Religious Ritual can be substituted for Leadership skill, if performed by a recognized religious authority.

Space Strategy

Use Strategy (Space) skill to deduce enemy plans; see p. B222.

Force Screen Options

These design switches for force screens can convey a cinematic feel.

Kinetic Transfer: This is intended for battles fought during 20-second turns. The screens convert some of the energy from all attacks – even beams – into kinetic energy. A single attack on a powered-up screen that exceeds half the screen's dDR makes the protected ship shake! Crewmembers may fall down or out of their chairs (if not wearing seatbelts) and all tasks (other than by sapient computer programs) take a -1 penalty until the end of the ship's next turn.

Prismatic Screens: In some classic space operas, force screens change color as they absorb energy, glowing red to orange to yellow and so on up the spectrum, eventually flaring violet and overloading. Replace the rules for screen ablation with the following: A screen that takes more damage than half its dDR in one hit gains one energy level and shifts one color up the spectrum. Screens go from transparent through red, orange, yellow, green, blue, indigo, violet, and finally ultraviolet. If a screen passes ultraviolet, it overloads and its generator is automatically disabled (as if knocked out by enemy fire). Using this variation, screens recover energy levels at a steady rate set by the GM. One level every combat round (whatever the usual turn scale is) is a convenient number.

Improvised Weapons

Even an unarmed spacecraft can be a powerful weapon. These offenses are sometimes realistic, but usually opponents in non-cinematic settings are clever enough not to fall for these tricks.

Crash Landings in Hangar Bays

Piloting skill rolls are required to recover spacecraft in hangar bays (p. 108); normally a failed roll means an "abort" as detailed in those rules. However, if a pilot does not wish to abort he may instead crash-land into the hangar bay, treating it as a 0.1 mps collision with the vessel; the carrier's armor doesn't protect it. If a vehicle is badly damaged (dHP 0 or less) it can't abort and must crash-land on a failed recovery roll!

A crew chief supervising a hangar deck can rig emergency landing procedures (capture nets, firefighting gear, etc.) to recover a single damaged vessel. If no other landings are going on that turn, he may roll against Spacer skill. Preparation takes one minute but extra time modifiers can be applied. Success halves any collision damage from a failed roll; it does not modify damage from a critical failure (which usually means he missed the hangar bay entirely).

Reaction Drives as Weapons

Reaction drives produce a lot of power and radiation but they are not focused, so unless a target is directly behind them they aren't much use as weapons. Someone in line with an ion drive's exhaust or anyone within a few thousand yards of the rear of a spaceship using external pulsed plasma gets hurt, but the drive can't be directed as a beam over any distance.

However, some drives *are* both hot and coherent enough to be usable as weapons, or can be focused to work as such with little effort. Treat each of these sails or engines as having the same effect as a fixed mount weapon in a rear-facing minor battery rated at one less than the ship's SM. All engine-weapons must be aimed at the same target.

The pilot must use a Move maneuver and an Aim and Attack task; in basic combat, he must also select the Evasive Action or Retreat option. All fire is at a -4 penalty and uses the lower of the firing pilot's Piloting or appropriate Gunner skill.

Engine	***Weapon Equivalent***
Antimatter Pion or Pion Torch	Particle beam but (2) armor divisor
Fusion Torch, Antimatter Plasma Torch	Plasma beam but (0.5) armor divisor
Fusion Rocket, Antimatter Plasma Rocket	Plasma beam but (0.2) armor divisor
Super Fusion or Super Antimatter Plasma Torch	Plasma beam, no armor divisor
Total Conversion Torch	Graser
Mass Driver	Electromagnetic Gun*

* If firing cargo rather than simple dust.

Tactical Combat: As above, except the pilot does not select an Evasive Maneuver or Retreat option. Instead, he must have used the drive to accelerate by at least enough to produce one hex/turn of thrust away from the target.

Lightsails as Weapons

A lightsail may focus light into a wide but hot beam if it is *not* being used for propulsion that turn. Each sail functions as a single heat-beam turret with the output of a minor battery rated at one less than the sail system's SM. The lightsail beam has a (0.1) armor divisor, but otherwise uses the normal rules for heat beams.

Tactical Combat: Use the same rules.

Stardrive Engines as Weapons

Stardrive technologies may be hazardous depending on their exact capabilities and limitations. For example, in some science-fiction settings activating a hyperspace drive in close proximity to another spacecraft is disastrous, leaving both vessels lost in space or destroyed. Such an action requires powering and activating a stardrive while at zero range to another vehicle.

Tactical Combat: This is only effective when vessels have rendezvoused with each other, or when both are positioned in the same hex using a 10-mile scale.

Sensor Arrays as Weapons

A comm/sensor array's active ladar and laser communicators may be tightly focused as laser weapons if not being used for sensor or communication tasks that turn.

Only tactical or multipurpose arrays on SM +7 or larger vessels are powerful enough. Treat each comm/sensor array used in this fashion as a *single* laser with the output of a minor battery rated at *three* less than the ship's SM, *and* the option to use either rapid fire (at 10% output) or very rapid fire (at 1% output).

The weapon type depends on the TL: At TL8, treat it as a heat ray. At TL9, as a laser. At TL10, a UV laser. At TL11-12, an improved UV laser. For example, a TL11 spacecraft with SM+8 using a tactical array as a weapon fires as a single 10 MJ improved UV laser turret (1 MJ if rapid fire, or 100 KJ if used for very rapid fire). Otherwise, all normal rules for beam weapons apply to them.

Improvised Missiles

It may be possible to dump material into the path of an enemy spacecraft; if the foe moves too fast, it may collide with the obstacles. Potential improvised missiles include cargo, fuel that freezes (such as water), and solids (like rock dust).

This tactic can be used by spacecraft at zero or point-blank range to their opponents. Either or both vessels must be performing a fast pass. (If not, they can easily avoid the improvised missile.) A Quick Contest of Tactics between the captains determines if the timing is right. The dropping ship gets a +3 bonus if the scale is Close but a -3 if it is Distant. Victory means the loads are on target; any other result means they were dropped too early or too late.

Since improvised missiles are unpowered and unguided, hitting with one is strictly a matter of luck. Roll 3d against the SM-3 of the target vessel. Add +1 for a ton of dispersed debris or reaction mass; each tenfold increase in tonnage adds an extra +1. The margin of success is the number of impacts.

The target gets a Dodge roll to avoid each impact. Treat each collision as a 2 cm conventional warhead, adjusting damage for relative velocity.

Tactical Combat: This tactic may be used if both spacecraft are positioned in the same hex but their vector counters are in different hexes.

Relative Target Size

Weapons and targeting systems on vessels are optimized for attacking craft of similar or larger size. The heavier weapons and batteries on large warships may have trouble zeroing in on lesser craft. ("Those gnats are too small to track! Launch our fighters and destroy them ship to ship!")

A spacecraft with this design switch that fires a spinal weapon or main battery at a smaller, maneuvering target suffers a -1 penalty per SM difference between the SM of the ship and the target. For a minor battery (of any rated SM), the penalty is *half* the difference in SM between the attacking *ship* and the target, rounded up. A maneuvering target is one that can dodge; thus this penalty does not apply when firing against incoming missiles, since they do not dodge.

Environmental Effects

The following rules add extra "terrain effects" to the basic space combat system.

Fighting in Low Orbit

If a fight takes place in low orbit around a planet or other celestial body, vessels move at several miles per second. The assumption is they all orbit the same direction and so their speed is ignored – the craft are effectively at the same speed relative to one another unless they maneuver. However, any vessels orbiting in different directions can be treated as if making fast passes (p. 96) at up to twice the world's orbital velocity. The GM may similarly rule that ground stations involved in the battle can only participate for one turn (as per the Fast Pass status rule) before they vanish over the horizon.

A vessel that meets the requirements for landing (see Chapter 2) may do so in combat. Functionally, reentry or landing is equivalent to a taking a Hold Course maneuver (or series of maneuvers) for the time required to land. A landing spacecraft cannot change facing.

Cinematic Cliché: Spacecraft crippled while in orbit do not remain there, but fall into a decaying orbit and burn up within 2d turns!

Tactical Combat: Use the rules for celestial bodies on p, 121.

Nebulas, Ion Storms, and Gas Clouds

A real nebula is highly diffuse and has no effect on a realistic battle (except forcing ramscoops to operate at reduced speeds). In contrast, cinematic nebulas are depicted as thick enough to impede vision or sensors! If they're the wave fronts of recent supernovas, they're filled with dramatic electrical and plasma discharges or "ion storms" that further degrade a vessel's capabilities. These conditions could also describe the upper reaches of a gas giant's atmosphere.

In such circumstances, the following guidelines apply.

All spacecraft are treated as if they have a powered-up cloaking device. (The energies disrupt actual cloaking devices, so vessels that already have them get no extra benefit!)

Beam weapon ranges degrade as they pass through clouds of gas. Assume that all lasers, X-ray lasers, and grasers, and optionally any type of superscience beam (such as disintegrators), are reduced from range class R2 or R3 to range class R1 (i.e., the same range as a particle beam). Thick storms limit *all* beam weapons to range class R0 (i.e., the same range as plasma beams).

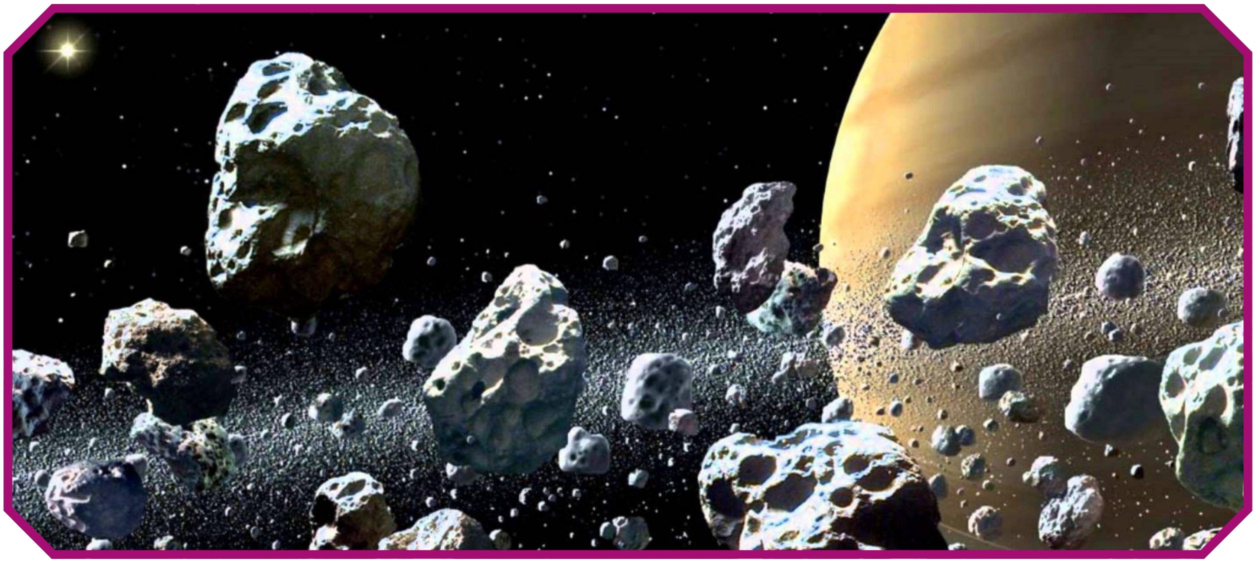
Cinematic teleport projectors stop working. Optionally, the same effect prevents stardrive from operating, or reduces the acceleration of subwarp drives from their normal 500G to a "mere" 50G per engine.

Unpredictable Debris Fields

A debris field is any dense cluster of asteroids, ice chunks, giant boulders, or other space junk: multiple large objects, all moving unpredictably. These include cinematically dense asteroid fields, comet tails, a gas giant's rings, a tight cluster of space stations and satellites, and the not-yet-dispersed wreckage of a recent battle. A vessel that proceeds slowly and cautiously through a field should have no problems, but high-speed combat maneuvers within one can be perilous!

In the basic combat system, the GM may rule that the entire fight takes place in a debris field. A spacecraft exits a field by performing a Retreat maneuver (or successfully pursuing another retreating vessel) and leaves the engagement. Alternatively, one may be close to the engagement area but the combatants might not begin within it. If so, spacecraft can choose to enter it using a retreat maneuver. They and any pursuers may then use the rules for evasive action and fast passes through a debris field as long as they remain.

Tactical Combat: The GM should decide on the extent of the field and mark those hexes that are part of it. Debris-



field hexes can form a continuous belt or scatter here and there across the map.

Cover in a Debris Field

A debris field is dense enough to give a spacecraft a cover bonus! Ships in a field are at -2 to be hit if the fragments are larger than they, or -1 if they are of equal size (GM's call). This does not apply to ghost particle beam fire, but the same modifiers do apply to all detection rolls.

Tactical Combat: This only applies if the line of fire passes into or through a debris-field hex or, in the case of missiles or guns, if the target is inside a debris hex.

Risking Collision

In the basic combat system, *any* spacecraft that used a Closing Maneuver, Evasive Action, or Retreat with an acceleration bonus of +3 or more, or that performed a fast pass, risks crashing into something. Roll 3d at the end of the vehicle's Piloting tasks step. On a roll less than or equal to the vessel's (SM+3)/2 (rounded up) the spacecraft is on a collision course with a chunk of debris. Roll 3d-3 to determine the Size Modifier of the object and see *Resolving Debris Collisions* (below).

Tactical Combat: Debris-field hexes should be marked on the map and spacecraft should attempt to maneuver around them. If a ship's course from its placeholder to its position intersects these hexes traveling two or more hexes per turn, it is fast enough to be at risk. Roll at the end of the vessel's vector movement step (with the same chance as described above) to determine if a collision occurs.

Resolving Debris Collisions

If a collision is indicated, find the SM of the object as detailed above. Then consult the *Object Table* (below) to determine its dHP and dDR.

Object Table

SM	dHP	dDR	SM	dHP	dDR
0	6	0	+8	140	7
+1	10	0	+9	200	10
+2	14	1	+10	300	15
+3	20	1	+11	400	20
+4	30	2	+12	600	30
+5	40	2	+13	1,000	50
+6	60	3	+14	1,400	70
+7	100	5	+15	2,000	100

Facing: If a spacecraft made a fast pass or closed, the object collides with its front hull. If it took evasive action, roll 1d: 1-3 = front hull, 4-5 = central hull, 6 = rear hull.

Base Relative Velocity: Use the *Base Relative Velocity Table* (p. 102), treating the object as if it were closing. If the ship performed a fast pass, use the moving vessel's actual velocity instead.

Point Defense: The colliding spacecraft may attempt Point Defense attacks if it meets the criteria to do so (see p. 102). However, it's harder to stop a big inert object than a small missile! It requires reducing the object to -5 × dHP or less; bringing it to 0 dHP won't stop it in time, but it results in smaller, more diffuse chunks of rubble. Treat the fragment's SM as two less when it strikes. (An object reduced to SM-1 has dHP 4; at SM-2 it has dHP 3).

Dodging: If the spacecraft is eligible, it may attempt to dodge the object (or fragments); otherwise it is struck.

Impact: Determine damage using the *Collisions and Conventional Warheads* rule (p. 104), treating the object as a ramming spacecraft with the SM and dHP shown on the *Object Table* (above).

Chapter Six
Space Hazards

Spacecraft may face danger aplenty before they even make planetfall! This chapter details natural hazards encountered while voyaging through space.

Meteoroids and Space Junk

A solar system contains countless *meteoroids*. These are drifting chunks of rocky debris ranging from sand grain to boulder size. Most are fragments formed from billions of years of accidental collisions between larger asteroids. Some faster-moving meteoroids are the residue from comets' tails.

Meteoroids in our solar system travel at 10-12 miles per second (the orbital velocity of the asteroid belt); "meteoroid storms" produced by passing comets reach 40-50 mps. Spacecraft are regularly struck by small meteoroids but the vast majority of these are sand-grain sized, too small to do more than pockmark a vessel's hull. A greater risk is manmade debris. Most space junk, like paint flecks, is too tiny to worry about, but some pieces are large enough to cause damage and all travel at dangerously high orbital velocities. This is 5-6 mps in low Earth orbit, which means a possible closing velocity of 10 mps if the ship orbits in the other direction.

The odds of impacting an object large enough to do catastrophic damage are *very* low in deep space, but are increased in a debris-cluttered planetary orbit (such as modern-day Earth); while traveling the path of a comet; or when moving through the aftermath of a large space battle. Other conditions that put spacecraft in constant danger of hitting asteroids or meteoroids are cinematic; see p. 129 for these types of debris fields.

There's no serious risk of collision in interstellar space unless the GM wants one for plot reasons. In interplanetary space, roll every year for a stray meteoroid hit. In debris-cluttered orbits, roll every six months. In hazardous environments, such as orbital space after a battle or in the vicinity of a comet's tail, check at least once, then again each month, and more often if a cascade catastrophe (below) has occurred. Roll 3d; if it's equal or less than the vessel's SM/2 (rounded up) the spacecraft has a close encounter at some point when the crew least expects it.

Time Scale: A meteoroid or debris chunk small enough to escape early notice, but fast enough to cause damage, is detected only at the last moment. Resolve the possible impact using 20-second turns when calculating rate of fire.

Facing: Debris normally impacts the front hull. In complex situations (maneuvering in the wake of a comet, escaping from a debris-choked orbit), roll 1d: 1-3 = front hull, 4-5 = central hull, 6 = rear hull.

Base Relative Velocity: Use 10 mps or the vessel's actual velocity, whichever is

Cascade Catastrophes

Earth orbit currently contains thousands of fragments of launch vehicles, paint chips, inactive satellites, debris from space weapons tests, and other junk. The same is true of space around other inhabited planets if care was not taken to avoid such problems, or in the aftermath of a major accident or battle. Orbital decay, the sheer vastness of space available even in "crowded" orbits, the tiny size of most debris, and "graveyard orbits" for satellite disposal mitigate any risk this trash poses under normal conditions. However, it is possible a war, terrorist act, or simple accident could result in an ablation cascade event, where space junk crashes into other satellites and space junk, producing a chain of additional collisions and debris and rendering orbital space hazardous to navigation. The aftermath of a catastrophe might require daily or hourly collision checks, and make leaving the atmosphere suicidal for unarmored space vehicles.

greater. Multiply velocity by five in the case of "meteoroid storms" produced by high-velocity comets.

Point Defense: The colliding spacecraft may attempt a Point Defense attack (see p. 102). Most debris is SM-10 and any hit destroys it.

Dodging: The spacecraft may attempt to dodge the debris (if eligible to dodge).

Impact: The incoming junk causes 1d damage per 10 mps of velocity.

Interstellar Impact Hazards

Interstellar space (beyond a solar system's halo of comets) is largely free of meteoroids, but contains stray atoms of hydrogen and helium as well as occasional dust grains. These are very tiny (some 100-200 nanometers across) and thinly spread (maybe 1,000 grains per cubic kilometer). Even so, that's enough to be a hazard to a spacecraft moving at the velocities needed to cross interstellar space in a reasonable timeframe.

Due to the sustained nature of this sort of damage, it's not realistic to roll for hits and damage. Instead, a craft must have enough frontal armor (representing impact shielding) and/or force screen protection to provide necessary continuous protection.

The table shows the ablation effects at various fractions of the speed of light (every 0.1*c* is 18,628 mps) in terms of lost frontal armor dDR. After frontal armor is utterly ablated, each point instead causes 3d of decade-scale damage to the front hull.

Interstellar dust grains likely contain iron. If a ramscoop-equipped spacecraft moves at velocities high enough for the ramscoop to operate, the GM may rule it ignores these speed limits as the magnetic field deflects the iron. However, a ramscoop-equipped ship won't be able to use the field during the time it is accelerating from lower velocities since doing so would actually brake the spacecraft, so it still needs tough frontal armor to reach these velocities.

Ablation Table

Velocity	***Ablation***
0.1*c*	1 per 50 years
0.2*c*	1 per six years
0.3*c*	1 per two years
0.4*c*	1 per eight months (1.5/year)
0.5*c*	1 per four months (3/year)
0.6*c*	1 per two months (6/year)
0.7*c*	1 per month
0.8*c*	2 per month
0.9*c*	3 per month

Radiation Hazards

Radiation (see pp. B435-436) is especially deadly in space because ships and stations are beyond the natural shield of a planet's magnetic field and thick atmosphere. Spacecraft electronics (such as computers) are hardened against high levels of radiation. However, the fragile biological occupants are vulnerable to numerous hazards. These include solar flares, cosmic background radiation, and the radiation belts of worlds with magnetic fields.

The risk of cosmic rays within a solar system is affected by the fluctuation of a star's magnetic field, which provides some shielding within the system. When the sun is especially active (e.g., for a few weeks after a flare – see below) exposure is less (halve the rads/week). At a great distance from the star (75+ AU away from a sun-sized star) and in interstellar space, exposure is greater (double the rads/week).

Cosmic Rays

Galactic cosmic rays are charged particles (atomic nuclei, electrons, positrons, etc.) that originate beyond the solar system, traveling through space at near-light speeds. Their high energy is difficult to shield against; they smash through matter, leaving a train of ionized atoms that kill living cells.

Unshielded individuals may notice these impacts as sporadic bright flashes in their eyes, even in total darkness. Cosmic rays are a hazard anywhere outside a world's magnetic field. They inflict 1 rad per week, and since they are highly penetrating all radiation PF is divided by 100. However, the exposure is halved if the vessel is in the shadow of a planet, moon, or other large body.

Solar Flares

Solar flares are storms of high-energy protons emitted by stars. Different stars are more or less energetic; the notes below apply to our sun, a G2 main-sequence star.

Our sun follows a rough 11-year cycle of flare activity, and during peak periods (the solar max) multiple flares may occur within the space of a few weeks. A typical flare lasts several hours. Since its particles travel below light speed, the light of the flare is seen before they hit; this provides about 10 minutes of warning per AU of distance from the active star.

On average, small flares occur 1d times each year and deliver 50-150 rads; midsize flares every 2-5 years delivering 200-1,200 rads; and major ones a few times every decade (at the solar max) delivering 2,000-6,000 rads. These dosage levels apply in space at a distance of 1 AU from the sun; divide by the square of the actual distance. Thus, occupants 0.5 AU from the sun during a small 100-rad flare might take 100 / 0.25 = 400 rads.

Solar flares are relatively non-penetrating: multiply radiation PF by 20.

Planetary Radiation Belts

Earth (and other worlds with metallic cores, including gas giants like Jupiter) is surrounded by a pair of donut-shaped magnetic fields. Those charged particles produced by the solar wind, and cosmic rays that are not deflected, are stored and trapped there.

Earth's radiation belts are known as the Van Allen belts and are described below.

The highest energies are found in the *inner radiation belt*. It extends 400 to 4,000 miles above the Earth at the equator. However, the belt is actually aligned with the magnetic axis of the Earth, which is tilted away from the axis of Earth's rotation. As a result, while the belt starts 800-900 miles above the surface on one side of Earth, off the coast of Brazil is the "South Atlantic Anomaly" where radiation is especially intense at an altitude of only 150-200 miles. Spacecraft and stations are best positioned in orbits that minimize exposure to the inner radiation belt. Lengthy unprotected exposure can cause radiation sickness and damage electronic systems.

The *outer radiation belt* is more tenuous and found at higher altitudes. It stretches from about 15,000 to 23,000 miles above the equator, although it curves downward toward each pole. Its radiation is primarily lower-energy ions and electrons produced by the solar wind, and so it is less hazardous than the inner belt.

On average, the exposure in the inner radiation belt is about 4 rads/day; the outer belt can be ignored, as even a spaceship's "default" dDR 0 hull is protection enough against it.

Radiation Protection

The risk of radiation exposure is one reason to favor unmanned or robot-crewed vessels for long voyages, but various strategies can mitigate danger to living travelers.

Radiation protection is measured by a Protection Factor (PF). Different radiation hazards are more or less penetrating. Radiation from cosmic rays divides PF by 100, while solar flares and planetary radiation belts multiply the PF by 20: for more details, see *Radiation Protection*, p. B436.

Manned spacecraft are assumed to be configured so the mass of the vessel serves as radiation shielding. That is, living quarters, control rooms, habitats, engine rooms, passenger seating, any system in a [core] location, and similar inhabited systems are all placed so they're surrounded by unoccupied systems, providing natural "mass-shielding."

To determine the PF shielding one of these systems, total the number of non-core systems in that hull section, excluding any Cargo, Habitat, Hangar Bay, or Open Space systems. Cross-index that number with the SM of the spacecraft on the *Radiation Protection Table* (below) to find PF.

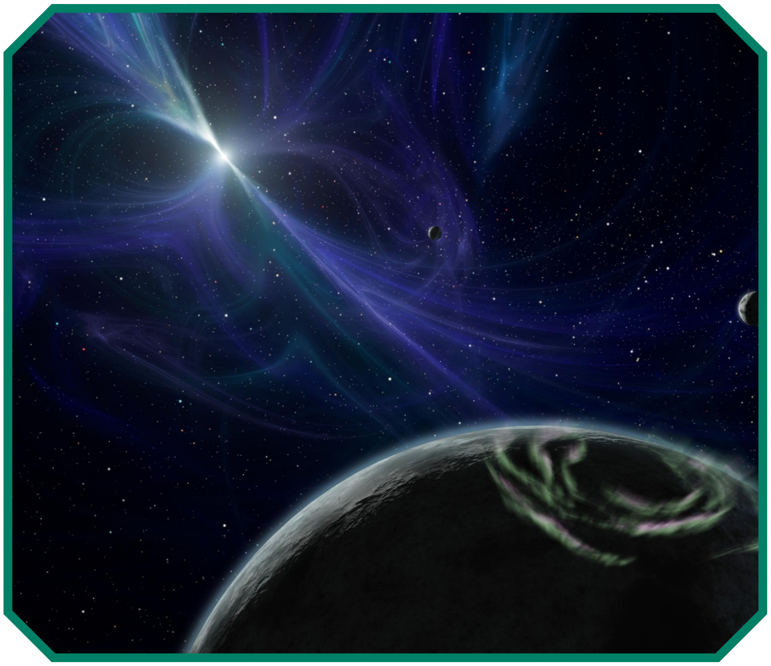
Characters may find themselves in non-mass-shielded systems. To calculate radiation PF for occupants of such systems use the same procedure, but only count armor systems.

Any occupants of a core system receive double the effective PF.

Example: An SM+9 starship's central hull has one armor, one habitat, one cargo hold, and three fuel tank systems, plus a control room in its core. There are therefore four non-core systems (the armor and fuel tanks) that count for radiation protection, so the habitat's occupants receive PF 300 and the control room PF 600 (since it's in the core). If an occupant was not in the mass-shielded control room or habitat (e.g., visiting the cargo hold) only the one armor system would count, and so anyone exposed in the cargo hold would get only PF 70.

Radiation Protection Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
0 systems	5	7	10	15	25	40	50	75	100	150	200	300
1 system	10	15	20	30	50	70	100	150	200	300	400	600
2 systems	20	30	40	60	100	150	200	300	400	600	800	1,200
3 systems	30	45	60	90	150	200	300	450	600	900	1,200	1,800
4 systems	40	60	80	120	200	300	400	600	800	1,200	1,600	2,400
5 systems	50	75	100	150	250	350	500	750	1,000	1,500	2,000	3,000
6 systems	60	90	120	250	300	450	600	900	1,200	1,800	4,000	3,600



Mitigating Radiation Effects

Even in a well-shielded ship some radiation gets through, especially cosmic rays (which divide PF by 100), and exposure builds up over time. This is a serious limitation on long manned space missions, but the threat is mitigated at higher TLs.

Anti-radiation drugs provide some protection against exposure, and at TL10+, cell-repair nanotechnology is sufficiently advanced that spacefarers can just take a pill to protect against routine exposure (see p. B436).

Genetic engineering may also create spacefaring parahuman or alien sub-races with advantages such as Radiation Tolerance (p. B79) or Regeneration (Heals Radiation) (p. B80). ***GURPS Bio-Tech*** provides several examples of all three approaches.

Lost in Space

Vessels traveling through normal space have no problem navigating, but the peculiarities of stardrive technology may result in starships experiencing navigation errors: drive malfunctions that result in a faster-than-light voyage ending up many parsecs from where it's supposed to be. Similar difficulties occur when exploring a new jump point or wormhole. The starship may have the power to get home again . . . but only if the navigator can find out where the ship is in the first place!

The best way for a lost craft to find itself is by using pulsars. These spinning neutron stars emit powerful and directional beams of radio waves that sweep through space with the regularity of an atomic clock. Moreover, each pulsar emits radiation with a unique pulse period and shape. The galaxy's pulsar characteristics and locations are well known, and are the equivalent of lighthouse beacons for lost interstellar travelers. By tracking the exact time of arrival of pulses from a sample of pulsars, a vessel's navigator can determine the position of the starship.

Locating pulsars requires using a spacecraft's comm/sensor array as a radio telescope. Roll against the lower of Astronomy and Navigation skill every eight hours, adding the ship's array level; apply a penalty of -8 if using a basic or tactical array and -4 for a science or multipurpose array. Three successes means the vessel's location is known. Using documented pulsars for interstellar navigation is workable if one is still in the same galaxy or an adjacent satellite galaxy (e.g., one of the Magellanic Clouds).

Space Monsters

Active, aggressive space-traveling vacuum-dwelling creatures capable of threatening a starship are not very plausible, but then again neither is faster-than-light travel . . . and they add interest to a space-opera setting.

The most likely habitat for vacuum-dwellers is a system's Kuiper Belt or Oort cloud (where water – as ice – and complex hydrocarbons are found among comets). Another possible space environment is the (relatively) dense molecular clouds in nebulae, though the being could be a complex magnetic field or energy pattern within a stellar atmosphere. Even more exotic environments are possible: Creatures could be natives of hyperspace.

Space monsters may have a complex reproductive cycle in which some stages live on small bodies, planets, or stars while others migrate through space.

Cryptobiology of Space: Myths and legends of a particular space monster may convince a patron to fund a bio-survey expedition into a distant deep-space location to prove its existence. There may not be a real monster but the expedition itself still faces plenty of other challenges, especially if the creature's rumored haunts are politically sensitive areas (located between warring powers), infested by pirates, etc.

Here Be Dragons: Aggressive space monsters happen to infest a particular region of space – or perhaps live in hyperspace or near wormholes – and don't like spaceships! (Maybe they think they're rival beasts intruding on their territory, or they try to mate with them with catastrophic results.) Such periodic attacks might be a rare menace, or they could be a common "wandering encounter" that justifies arming civilian spaceships.

Moby Dick: Space monsters may produce exotic and valuable substances in their bodies. Maybe they're living super-fusion reactors with magnetic monopoles, or they have organs that are the key to faster-than-light travel, or their bodies contain advanced organic superconductors. Hunting them is lucrative, but also potentially dangerous – the creatures themselves are a threat, rival hunters (or game wardens) are present, or other great entities also prey upon them.

Wild Horses: If you capture a space monster, maybe you can tame it and harness it to propel a spacecraft, ride on or in it, or enter symbiosis with it.

The Creature That Ate Space Station Alpha: A space monster (or swarm of monsters) attacks a station or colony! The colonists have inadvertently upset the monster – perhaps they mined an asteroid or comet that was really one of its eggs or nests, or a megaproject (building a Dyson sphere) encroached on its territory. Maybe they just had the bad luck to settle a system in the path of a million-year migration cycle for a swarm of battleship-sized fusion-powered space locusts! Solving the problem involves a combination of exobiology (to find out more about the aliens' strengths and weaknesses) and space warfare (to stop them).

If space monsters don't exist naturally, it may be possible to build them. ***GURPS Bio-Tech*** (p. 98) contains character creation guidelines and examples of living bio-spaceships. These rules can be easily adapted to create natural space monsters.

Chapter Seven
Space Exploration

A frequent goal of space travel is to explore strange new worlds, to seek out new life and new civilizations, and to boldly go where no character has gone before. This chapter explores the motives of space exploration missions. Additionally, it provides game mechanics for specialized tasks performed by survey ships and crews, including remote survey procedures, on-site planetary exploration, and first contact with new species.

Expeditions

Space exploration may be scientific, military, commercial, or private in nature . . . and sometimes all of these at once. For example, a mission to determine the source of a strange signal from a far-off star system could involve the scientific community (who want to solve the mystery and make contact with any aliens), the military (who want to assess and neutralize any alien threats), and large corporations (eager to establish trade relations or gain access to alien technology). This leads to conflicts as each partner pursues its own agenda. The interests and motives behind the mission determine the expedition's character, resources, and goals.

Scientific Expeditions

The desire to make discoveries and prove theories is a powerful motivation for space exploration, especially if there is reason to believe life can be found on other worlds. Remote astronomical observations only reveal the gross physical details of the universe. Studying extraterrestrial planetology, biology, or ecology, and understanding alien societies requires explorers, whether machines or living beings.

A scientific mission may be tightly focused on one goal ("to investigate the red spots moving on the south polar ocean of Crompton IV") or more general ("a five-year mission to explore Frontier Sector"). The expedition can be a relatively low-key affair like many of today's unmanned probes, or a major commitment such as the Apollo moon-landing program. If spaceflight is relatively inexpensive, universities and research institutes may fund interplanetary or interstellar expeditions on their own. Major efforts – like those that require building new designs of spacecraft – require significant government or corporate funding, and thus need to justify their commercial or strategic interests.

Where spaceflight is expensive, scientific missions may be the responsibility of a government space agency. This creates tension between missions intended to serve the government's interests and those that are purely scientific in character.

Strategic and Political Expeditions

Governments sponsor exploration and colonization to gain prestige, subsidize jobs in their aerospace industry, determine the existence of threats such as hostile aliens, or extend their sphere of influence by visiting and claiming new worlds.

Strategic exploration is also driven by a need to map out faster-than-light wormhole or jump points vital to trade and naval operations. If two or more spacefaring powers border the same unexplored area of space, rival armed expeditions may come into conflict as each side races to "plant its flag" on new worlds or star systems, or to establish "facts on the grounds" by creating colonies. These objectives combine with scientific goals, although the science element takes second place to political aims.

This may be handled by a space navy's warships (with some civilian specialists aboard), or by a civilian or paramilitary space agency or survey service operating its own dedicated exploration and research vessels.

Commercial Expeditions

Commercial expeditions are motivated by profit, seeking out resources to exploit or real estate to claim and sell to future colonists. Explorers work directly for interested governments or corporations, or are freelancers hoping to sell what they find. Governments also co-sponsor commercial expeditions to provide assistance to business or because they control the economy.

The missions are only viable if the return justifies the cost. The greatest expense is the spacecraft and fuel to reach the destination. Business-driven expeditions use commercially available equipment to reduce mission costs, though innovative ship designs or components are developed when critical to success (or seen as good investments in themselves).

The viability of commercial exploration also depends on the legal framework in place. Can explorers claim an entire world (including settlement rights and geological and biological resources) for themselves? What are the criteria for a claim: telescopic detection, first robot landing, first people on the ground, or actual homesteading and economic development? Is exploration a lawless free-for-all, or does a central body recognize, distribute, and sell claims, such as a government, a scientific agency, or a religion?

When spaceflight is relatively inexpensive and business interests can claim the worlds they investigate, it leads to a flurry of economic-based exploration. Even when a government claims all new worlds found in their sphere of influence, there's a niche for corporate and independent explorers who receive sizable bounties or royalties (or a monopoly on trading rights) for the planets they explore. They might compete with illegal "pirate" explorers who operate outside the law, keeping their finds secret to allow unregulated exploitation by criminals or ruthless corporations. Depending on the nature of the government, these rogues are portrayed as heroes or villains.

Establishing contact with alien species (or long-lost colonies) is another objective of business interests, and perhaps the ultimate prize of such an expedition. Corporations want to establish monopolistic trade deals and gain privileged access to new technologies. Ruthless explorers have other things in mind, seeking out civilizations or ecologies that can be looted and species to enslave. With the advantage of superior technology, even a small ultra-tech corporation might take complete control of a lower tech-level world!

Commercial missions have goals beyond claiming and exploiting new worlds and civilizations. A media company may commission an exploration as part of a documentary on an exotic astronomical feature, or tourists may pay to go where few have gone before. When alien life is known to exist, someone may want a biological survey expedition. It can take multiple missions over decades or centuries before a complex alien ecosystem is fully understood. Truly foreign plants, animals, and microorganisms are valuable to biotech companies interested in marketing new drugs, foodstuffs, and other products. There may even be a lucrative market for exotic alien pets.

Missionary Expeditions

If extraterrestrial civilizations exist, religions and quasi-religious ideologies may send out missionary expeditions to contact and convert aliens. These may be sponsored by churches or the government, depending on the role of religion in the society.

Colonization Missions

Explorers may seek land to colonize. But why should they want to cross the depths of space instead of making their homeworld's deserts bloom or mining the sea floor? Some possible motivations for extraterrestrial colonization are suggested below.

Freedom

Minority groups whose way of life is threatened by a majority may desire to found a settlement far from their culture's power and influence. The only way to do this on a crowded high-tech planet might be a voyage to another world. The group must be powerful enough to afford the venture, but not so powerful they could just remain behind to change the system. It's a strong motivation, whether to escape persecution or to create a bold new political or social experiment. A majority group may even fund such an effort in order to peacefully exile a troublesome minority.

Running Colonization Campaigns

Most outposts and colonies take years to establish and grow. Their operations have little to do with spacecraft and everything to do with logistical and sociological factors, and the nature and characteristics of the world being colonized. These are beyond the scope of this book: GMs running such games should refer to ***GURPS Space*** (p. 13) for colonial and refugee-based campaigns and ***GURPS Space*** (pp. 90-93) for game mechanics (e.g., necessary population, a planet's carrying capacity, and growth rates).

Population Pressure

A popular justification for colonizing other worlds is to relieve population pressure. In practice, this is difficult. Unless space travel is incredibly fast and cheap, it won't make much difference. However, the socioeconomic stresses brought about by overpopulation (war, famine, overcrowding, reduced resources, lack of jobs,

Suspended Animation and Nanostasis

At TL10+ spacecraft with hibernation chambers may use more effective suspended-animation capsules or nanostasis tanks to reduce metabolic activity to zero or near-zero levels, resulting in no aging even on long journeys. No maintenance is needed. See ***GURPS Bio-Tech*** (p. 146-147) for detailed rules.

etc.) themselves encourage people to seek a better life, even on another world.

Involuntary Exile

If transport expenses are modest, a government may opt to move criminal or political dissidents to distant colonies, seeing exile as a "humane" alternative to imprisonment, reeducation, or execution (or just a cheaper or more politically expedient alternative, period).

Religious Imperatives

Many religions embrace missionary activities, or encourage followers to procreate. Millions of people have spent lives and treasure on dangerous pilgrimages and multigenerational projects (pyramids, cathedrals, etc.) under the impetus of faith. Future religions may spread these motivations among the cosmos.

Political Rivalry

Opposing superpowers can compete through an aggressive program of space colonization. However, colonies founded for propaganda purposes may face a desperate struggle to survive if the political situation changes due to the collapse or distraction of the founding power bloc.

Incremental Colonization

Sometimes colonization is an accidental side effect of other activities. Off-world outposts may be established for scientific, economic, or military purposes, using temporary personnel. But as they grow and offer more comforts to their inhabitants, it may become easier to extend personnel tours than to rotate them back. Facilities develop to make the outpost self-supporting; people stationed there for long periods have children who see it as their home . . . and eventually, without any prior intent, it grows into a de facto colony.

New Lands, New Resources

If space travel is affordable, colonization may be for the most basic of reasons: to acquire territory to settle and resources to ship home. Another, perhaps more likely, option is the existence of "triangle trade." A colony provides goods to nearby resource-extraction operations – for example, greenhouses and other manufacturing facilities on Mars supply an asteroid-belt mining operation, which then supplies Earth with raw materials, which in turn ships expensive manufactured goods to Mars. Such a program might work if it's cheaper to make certain necessities on Mars for sale in the asteroid belt than it is to lift them off high-gravity Earth.

A Better Life

Historically, wages in new colonies are higher since there's an initial labor shortage. This is especially compelling if there is some way of sending a portion of the earnings "back home" to support one's relatives and/or secure their migration to the new lands.

Industrial Parks

A habitable planet like Earth is a complex ecosystem with a limited "carrying capacity." Even the "empty" deserts and oceans are part of an interconnected biosphere. Changes, additions, and subtractions are unwise. In contrast, lifeless moons, asteroids, and empty space itself may be a great place to build megaprojects and locate dangerous or polluting mines and industry.

To Preserve the Species

Off-world colonies may be established for the same reason people care about secure radioactive waste storage or reversing the greenhouse effect. Conservation movements all involve present sacrifice to benefit future generations. People spend resources on what amounts to a secure off-site backup for the species, so all a civilization's eggs aren't kept in the same planetary basket in the event of unforeseen disaster on a planetwrecking (or worse) scale. This can justify interplanetary, interstellar, or even extragalactic colonies.

Growth Tanks

Growth Tanks (TL9): These artificial wombs can be installed in habitats to grow complex organisms (including humans) from frozen genetic material stored in cargo. 20 growth tanks for human-sized specimens replace a single cabin; raising an organism to the point where it can survive outside the tank requires the normal gestation period (e.g., about nine months for a human baby). Growth takes the normal time. See ***GURPS Bio-Tech*** (p. 20-21) for detailed rules.

Refugees from Disaster

If an existential disaster *does* occur, there may be time for inhabitants to escape the home planet (or solar system, or galaxy . . .), to avoid destruction or enslavement and seek new homes elsewhere in the cosmos. If there is plenty of warning (and sufficient technology and space industry) it's possible to save everyone who wants to leave. Otherwise, only a fraction of the population may escape, though this could range from a few people to billions. Where time and resources permit, smaller survey expeditions should be sent in advance to find suitable new homes. Otherwise the colony ships carrying the refugees have to do the exploring themselves. They could be in desperate straits, with vessels that are overcrowded, lack fuel and supplies, and hold unskilled passengers who never planned to be colonists. Refugees may also have the psychological scars from whatever disaster drove them into space, especially if only a minority escaped. If they were fleeing war rather than natural disaster, they may have enemies on their tail . . .

Remote Survey Procedures

This section describes the tasks an exploration ship crew performs when approaching an unexplored star system. The majority of these procedures are intended for interstellar exploration, but some are applicable to interplanetary missions. They require a vessel's comm/sensor array, and specialists using it must have access to a control station.

Acquisition and analysis of survey data requires a significant investment of time, so procedures use long task (p. B346) rules. The time can be increased or decreased using the *Time Spent* rules; in cinematic games, attempting them almost instantly (at a -10 penalty) is common. The GM may make task rolls for the players to keep them in the dark about whether they are succeeding.

Out-System Survey Tasks

These procedures involve remote evaluation and mapping of the worlds in a target star system. They can be performed over interstellar ranges.

Survey operations begin long before a spacecraft enters the system. A slower-than-light expedition is almost certainly directed toward a target that has already been thoroughly studied. The destination may have been observed for years, even centuries, before any star probes were built. Large telescope arrays perform solar-system detection activities at a range of dozens of parsecs or more at TL8, and hundreds or even thousands at higher TLs. However, such endeavors can take months for each scan, and the galaxy has billions of stars! Also, surveys across thousands of light years are thousands of years out of date unless the sensors operate at faster-than-light speeds. Detected stars or planets are (usually!) still there, but all signs of intelligence such as radio signals are a year old for every light year (3.26 years old per parsec). Civilizations could have risen, fallen, or radically changed by the time their signals arrive. As such, even if long-range survey data is available, it's common for exploration spacecraft to perform their own checks as they approach to gain more recent information that they can trust.

Starships that don't travel through normal space but use jump drives or hyperdrives can appear in a system they haven't studied at all. If so, it's still possible to use any of these out-system procedures from within the star system itself.

System Mapping

This involves studying the space around a star to locate planets and other bodies. Observers find any gas giants, determine the plane of the ecliptic (where most planets orbit), and then hunt for smaller worlds and other masses. (Again, if an expedition is planned to a well-studied but never-visited system, this data may already be available.)

System mapping is a long task using Electronics Operation (Sensor) skill that takes eight hours per attempt. Explorers slowly approaching from many parsecs away can take full advantage of extra time and spend as long as 240 hours per attempt (at +5 to skill).

Modifiers: Add the spacecraft's comm/sensor array level; add a further +3 if it has a science or multipurpose array. No range modifiers apply within 200 AU of the solar system. Otherwise, use the *Size and Speed/Range Table*, but read each yard as "100 AU." A parsec is about 200,000 AU and so is roughly equivalent to a "mile" on the table. Also, apply a modifier based on the approximate size of the largest world in a normal orbit around the star: -12 if it's tiny (like Mercury), -8 if it's small (Mars) or dispersed like an asteroid belt, -6 if standard (Earth), and -4 if large (a few times larger than Earth but smaller than a gas giant). There's no penalty if the largest world is a gas giant. (See ***GURPS Space***, p. 75, for more detailed definitions of various world sizes.)

Completion of system mapping means all planets within the plane of the ecliptic are located, and the solar system's general outlines are mapped. The existence of asteroid belts (and any Kuiper Belt or Oort cloud) is discovered, as is the presence of larger moons (such as Luna or Titan). However, tracking down the location of every small planetoid or tiny moon and detecting celestial bodies (such as comets and Kuiper-Belt objects) with eccentric orbits may take months or years of additional work. The presence of any stellar-scale megastructures – such as ring worlds and Dyson spheres (***GURPS Space***, p. 133) – is also known.

System mapping may be a necessary prerequisite for plotting routes to neighboring stars, locating jump points or wormholes, etc.

Basic Planetary Analysis

Once system mapping is done, an additional study can be made of individual planets. This involves spectroscopic and other data to estimate characteristics such as temperature and atmospheric composition.

Successful study also reveals the presence of seas and oceans (through detection of water vapor) and key biosignatures such as abundant atmospheric oxygen and methane (the likeliest indicator of carbon-based life on the surface). Other clues can come from light reflected from a planet: Photosynthetic life-forms (and some artificial constructs) polarize reflected light in a uniform fashion, giving it a handedness not found in random reflections of sunlight from atmosphere or rocks.

Each planetary analysis is a long task requiring eight man-hours of Astronomy work. Completion provides enough data on the planet's approximate size, mass, temperature, and atmosphere to tentatively assign to it one of the world-type categories listed in ***GURPS Space*** (p. 77), such as Standard (Garden) or Small (Hadean). However, at interstellar ranges a classification is never certain. For example, a recent comet strike could elevate methane or water vapor levels on a world, giving a "false positive" biosignature.

Interstellar Signal Detection

Another task that can be undertaken at interstellar range is seeking out radio or other signals produced by a technological civilization. As a general rule, a people at TL7 or higher produce emissions detectable at this distance, although the GM may decide for whatever reason that a civilization isn't emitting anything. (Maybe they don't have mass media, or communicate with something other than electromagnetic radiation, or live underwater and the signals can't penetrate through to the surface . . .) TL6 civilizations may broadcast signals, but these are too faint to distinguish from noise at interstellar ranges. On the other hand, it's also possible powerful signals might be emitted by exotic alien animals or races (e.g., space-dwelling plasma entities) that naturally use radio for communication.

Signal detection is a long task that requires eight hours per attempt. Roll against Electronics Operation (Sensors) or Electronics Operation (Communications).

Modifiers: Add the comm/sensor array's level. If using a basic, enhanced, or tactical array, apply *Tech-Level Modifiers* (p. B168); these systems are optimized for detecting the signatures common to their own TL, not for outside-the-box solutions. Apply range modifiers from the *Size and Speed/Range Table*, but read "yards" as "parsecs," e.g., no penalty up to two parsecs, -1 at three parsecs, etc. Apply a population modifier. There's no modifier if the world's population is one billion; each order of magnitude increase adds +3; each order of magnitude decrease is -3. Add twice the spaceport class (see ***GURPS Space***, p. 97); a system with a busy spaceport has more messages transmitted into deep space. (If the target deliberately beams messages across interstellar distances in the direction of the observers, add +10 or more.)

There is no modifier for TL: Ultra-tech civilizations produce more (and more powerful) emissions, but their signals are more efficient and thus harder to detect.

If the task is successful the observer detects any population that engages in extensive radio and/or radar emissions. This is most TL7+ civilizations with populations over a million in which broadcast radio or TV are in active use. It also includes less-populous groups with extensive industrialization (robot factories, etc.), deliberate space broadcasting (sending messages between off-world ships, satellites, or colonies), or a preference for radio communication. Remember radio or other electromagnetic signals travel at light speed, so observers pick up signals emitted years ago (3.26 years/parsec) rather than what is currently beamed out.

The exact signals detected are the strongest radio or other electromagnetic signals emitted by the star system that would have reached the observer at his current position during the time spent listening. Much of it may be garbled noise, but if there's mass media (or the equivalent), success should glean a number of hours of language samples equal to 10-60% of the time spent listening (see *Linguistic Assessment*, p. 143). Analysis of the content *requires* linguistic assessment.

In-System Survey Tasks

These tasks should be performed after a survey spacecraft arrives in a star system.

Scientific Instrument Survey

Sensor arrays provide a variety of readings such as spectroscopic data, energy emissions, etc. Scientists analyze the data they provide using Chemistry, Geography (Physical), Geology, Physics, and Meteorology skills. Passive sensors are supplemented by active sensors if a ship is within range (p. 86), although vessels forgo active sensors if they are trying to avoid detection.

Each analysis made using a particular skill is a task unto itself taking four hours. Roll vs. the appropriate skill or Electronics Operation (Scientific), whichever is less. For

Geology, Geography, and Meteorology, use planet-type specialization (p. B180).

Analysis can be performed in real time as data comes in, or later. Apply time modifiers based on both the duration of the observation and the length of time spent during the analysis. Coming closer to the target as the scan is ongoing changes the range, so modifiers for range are based on the average distance throughout the observation.

Modifiers: Long-Distance Modifiers (p. B241), e.g., -6 at 100 miles, -7 at 300 miles, -8 at 1,000 miles, -9 at 3,000 miles, -10 at 10,000 miles, -11 at 30,000 miles, -12 at 100,000 miles, etc. Add comm/sensor array level; add +4 with a science or multipurpose array. Add +2 if using active sensors, or +4 if this is a superscience multiscanner array.

The information provided by each task depends on the skill:

Chemistry: The atmospheric pressure and composition (***GURPS Space***, pp. 80-81), with the exception of any organic toxins.

Geography (Physical): The diameter, mass, density, surface gravity, hydrographic coverage, and climate (see ***GURPS Space***, p. 77). This confirms any earlier discovery of world type. It also provides details of *environment types* (pp. B223-224 and ***GURPS Space***, p. 142) within the limits of the resolution of any map that was made.

Geology: The levels of tectonic activity and volcanism, and a rough guide to the age of the world. This is a necessary prerequisite for any planetary geological surveys (see below).

Meteorology: The types of weather found on the planet. Success is also a necessary condition for any attempt by a non-native at weather forecasting on the world.

Physics: Details of the planetary magnetic field and radiation belts (if any). At TL9+, study of neutrino and gamma-ray emissions reveals sources of high energy such as power reactors using nuclear fusion (via strong neutrino emissions) or antimatter (via distinctly polarized gamma-rays and large numbers of anti-neutrinos).

Completion of all these tasks calculates a preliminary *habitability* score (see ***GURPS Space***, p. 88). Any failure means the analysis has not been completed. Further attempts are possible with extra time; a critical failure means incorrect conclusions are drawn.

Direct Planetary Imaging

In addition to the scientific data detailed above, a spacecraft's sensors can provide multispectral images of the planet. Processing and manipulation at a variety of wavelengths and exposure times can improve resolution and create planetary maps.

Rather than rolling to detect any of countless features at different ranges, it's easiest to just determine the smallest object to be resolved at a given range. Find the Range modifier to the world, and take its absolute value (e.g., 66 for a -66 range modifier). Subtract (27 + array level). This is the smallest SM feature that shows up in images.

Example: A spaceship with array level 9 is observing planet Rukia at a range of one million miles (a -54 range modifier). Features on Rukia no smaller than 54 - (27 + 9) = SM+18, or 1 mile can be resolved. This reveals the alien cities dotted on the world's surface (and the surprising lack of roads connecting them), but not the flying dragon-like aliens flitting about their towers. It may, however, show the mile-long jet contrails through the atmosphere produced by the planet's extensive aerospace traffic.

As resolution improves, further analysis is possible. The base time required for preliminary analysis is one planetary day (or eight hours, whichever is more); to make a complete, detailed map, ships orbit and map the planet over several days; this provides extra time bonuses. Add +3 if the spacecraft used active sensors (see p. 86 for active sensor ranges). Generally, a minimum spatial resolution of SM+5 (15 yards) or smaller is required for useful data.

A successful Cartography skill roll produces an accurate map at the above resolution. Failure means it has enough errors to cause problems for its users (apply a penalty to Navigation rolls equal to margin of failure). Critical failure means the adventure is impacted (e.g., a landing spot noted as flat terrain is actually a treacherous swamp). The GM may wish to roll secretly.

Use Biology skill (with world-type specializations) to make informed speculation on life-forms (such as areas of vegetation) large enough to be visible. It won't reveal anything directly about things too small to spot, but a scientist could draw broad conclusions about the number and type of smaller organisms required to support those larger creatures or areas of vegetation that are visible to the sensors.

Use Geography (Political) skill to estimate the existence and extent of any civilization based on visible features. For example, if a civilization has cultivated fields, long straight roads, sprawling cities, etc., these are noticed at a resolution of a couple of miles (SM+18). On the other hand, a small cluster of tents for a group of hunter-gatherers requires a resolution of SM+2. A resolution of SM+5 or less (capable of distinguishing individual buildings, campfires, herds, etc.) allows a roll to identify population and TL to within an order of magnitude (this is the Population Rating, or PR; see ***GURPS Space***, p. 91).

Planetary Exploration

Every new planet is the product of billions of years of isolated evolution, full of traits unique to itself. Real understanding of any world requires explorers (or their robots) to go down to the surface and get their hands dirty.

Geological Survey

A detailed terrain map from active sensors gives some information about subsurface geological formations and tentative knowledge of the world's geologic activity (see ***GURPS Space***, pp. 119-121), but a complete picture requires on-site inspection. At a minimum, a number of geological surveys equal to the diameter of the planet in thousands of miles at different types of terrain are required.

Each such survey requires 40 man-hours each of Geology and Electronics Operation (Scientific) work and the use of specialized equipment to obtain rock or ice-core samples, seismic readings, and measuring key geologic features. Portable laboratories (see ***GURPS Ultra-Tech***, pp. 66-67) are carried as cargo for this purpose.

Modifiers: -2 if no active sensors were used in mapping; equipment modifiers.

The collected samples are returned to the survey vessel. At the GM's discretion, these may be treated as "on-site" resources for Prospecting; provide evidence of exotic transuranic elements; have fossils or embedded organisms (requiring use of Paleontology skill to analyze them); or possess other properties of interest.

Analysis

A Geology skill task (taking 40 hours of work) provides a preliminary assessment of planetary resources.

Modifiers: Apply modifiers from the spacecraft's geology lab facilities.

This gives a precise estimate of the age of the planet, and identifies any special features about its overall composition. On planets without life-forms, this should be sufficient to determine the Resource Value Modifier (see ***GURPS Space***, p. 87). Determining the exact mineral wealth of the planet (and what constitutes "valuable" varies by TL and setting) and locations for commercial extraction takes months or years of additional work, but the analysis provides enough data within an order of magnitude for decision makers to judge whether to proceed with prospecting and exploitation. Chemistry might be necessary to identify trace elements or the structure of unusual compounds.

Biological Survey

A vessel's integral equipment supports one simultaneous survey per biology or Science! lab aboard. On a garden world with abundant native plant and animal life, it is impossible to do more than the most rudimentary research into the planet's ecology (for that, see below).

During the biological survey, the explorer collects soil, air, and water samples, deploys unattended sensors, recovers seeds and insect equivalents, and traps animal life for later analysis. Small animals can be easily captured for intensive study; large creatures are usually better anaesthetized or killed, then autopsied, to enable gross anatomic studies. Tissue samples, ova, and sperm are collected for gene sequencing and possible creation of research specimens using growth tanks (p. 138).

If available, robots disguised with biomorphic coverings that were grown on-site, or captured animals implanted with neural interfaces, deploy surveillance devices and direct researchers to nests and food sources. Capturing or monitoring animal specimens can play out

Surveys on Non-Garden Worlds

The survey rules detailed above mostly apply to garden worlds where there is a wide variety of obvious life. On other worlds, it may be uncertain whether life even exists at all! Life-forms may be limited to microorganisms, be found only in a limited number of environments, or simply be too alien for easy identification. If so, the primary goal of a biological survey is to determine whether there is any life. The GM may impose penalties or extend the time required based on how hard the life-forms are to find or analyze. If it is confined to certain environments or regions of the planet, the expedition must search the right spot. For instance, the only life on a world might be located in thermal vents at the bottom of a subsurface ocean beneath 50 miles of ice. A survey performed at the surface would reveal no life; the explorers would only succeed if they breached the ice and sampled the deep ocean environment.

as a series of mini-adventures so long as the players and GM are comfortable with the details.

A preliminary biological survey requires at least as many study sites as there are distinct environments on the world, although settling for a few representative locations is common. The survey requires at least 60 man-hours of Biology work per environment studied. Specialties may be required (Botany to study plant samples, Zoology for captured animals, Biochemistry or Microbiology for bacteria and soil samples, and so on). On worlds with extensive seas or oceans, GMs may split biological survey work into separate land and ocean surveys, treating each distinctly. Ocean surveys require that the team has equipment for underwater operations, e.g., submarines (manned or robotic), diving gear, etc.

Modifiers: Equipment quality.

Completion of the survey recovers a representative collection of biological organisms and environmental samples (such as soil samples).

Analysis

Analysis is a long task that requires 20 hours of Biology work for *each* survey to catalogue and assay the samples collected. Use the appropriate planet-type specialty (p. B180).

Modifiers: Apply modifiers from the spacecraft's biology lab facilities.

Once analysis is complete, the biological survey yields enough information to get a broad picture of a world's natural history. Major plant and animal orders are understood and the prevalent large species are identified. The researchers discover, at least in outline, the biochemical basis of life on the planet (see ***GURPS Space***, p. 140) and, at late TL9+, have sequenced the genome of several animals and plant species. (At a lower TL, analysis of a genome may take months or years.) Successful study can also answer basic questions for colonists and castaways, such as:

• Is the environment inherently hazardous (will it eat or poison us)?
• Is the environment benign (can we eat them)?
• Is the environment sustainable (do we have to take vitamins, or can we just live off the land)?

Bioengineering skill is invaluable in interpreting the genetic data. If live samples were collected, Animal Handling and Biology (Entomology) may be required to wrangle the critters in the lab.

Ecological Survey

To gain a real understanding of how local ecosystems work, a full ecological survey is necessary. This is a series of long tasks that takes *at least* 3d years to complete. The surveyors must painstakingly identify local species down to the smallest animal and plant forms. Further, the team must observe how they interact over several local years to make sure any seasonal changes are noticed and understood. The survey involves many rolls against various Biology specialties.

Ideally this should be done in advance of any colonization effort, but greed or politics may result in it being delayed until after an outpost or even a full-scale colony is established, sometimes with dangerous or tragic consequences.

First Contact

If explorers have determined intelligent life is present, the question of contact arises. Many starfaring cultures establish contact protocols, sometimes with the force of law behind them. Unofficial expeditions develop their own adhoc procedures.

Careful explorers avoid going in to contact a new society "cold"; if possible they secretly observe the natives for weeks, perhaps even months or years, from hiding. Of course, a covert exploration may only be possible if the natives have inferior technology; many space drives have obvious signatures. And sometimes contact is made via radio or other means well before any exploration ship arrives.

In space opera genres, "careful" and "first contact" rarely go together. Boring processes like initial linguistic and sociological assessments are omitted or left for later, or handled by ultra-tech instantaneous translators, and the crew jumps right into either a covert or overt contact situation. (This may explain why there are so many hostile aliens and interstellar wars in such settings!)

Linguistic Assessment

The most important pre-contact task is a study of the major local language. If the native society is at a low level of development (TL0-5), samples of the language must be gathered via direct monitoring of conversations. This means placing audio bugs (or just hiding "open mike" communicators) and/or infiltrating stealthy reconnaissance robots (or microbots) into inhabited areas.

Deploying surveillance systems can be an adventure in itself, with a risk of sudden and inadvertent "overt contact" if the team fails to preserve secrecy. The mission may be trivial if the characters have very advanced technology, such as swarms of tiny microbots or chameleon invisibility suits (see ***GURPS Ultra-Tech***). Alternatively, the activities may require Electronics Operations (Surveillance), Stealth, and Camouflage rolls. Robot spies and hidden bugs are normally almost impossible for a low-tech society to detect. How many hours of useful samples are gathered is up to the GM. Depending on the technology used and the area spied on (assuming they found a settlement to monitor), each bug may get as many as 1d-2 hours of samples (minimum 0) every eight hours of monitoring.

If the natives have electromagnetic communications, remote linguistic assessment should be possible from anywhere in the star system, and perhaps from interstellar distances (see *Interstellar Signal Detection*, p. 140). Where societies use modulated electromagnetic signals, radio and/or television communications can be monitored. Some species may use communications that require special effort to tap into, e.g., an aquatic race using sonar signals, which would require deploying underwater listening devices. The GM has to resolve such exceptions. Sometimes the first challenge is to figure out how a race communicates: Chemical pheromones, telepathy, etc., may impose major challenges!

Radio monitoring can be done from space without risk of detection. Use Electronics Operation (Communications) to tap into local radio nets using the vessel's communication systems; see the rules on p. 86 for typical comm ranges. But at high tech levels signals may become difficult to interpret. As analog gives way to digital (normally at late TL7), the eavesdropper must first break the local protocols that encode voice, video, or text data. This is a long task requiring eight hours per attempt and several hours worth of samples. Use Cryptography skill; apply a -10 penalty; add the Complexity of the spacecraft's computers; and add -2 for every native TL above 8. Ship communicators gather one hour of useful samples for every two hours spent monitoring.

The GM determines how many hours are needed before a working model of the language is derived. If the local language is descended from a known language (as for a lost colony of some kind) then completion of a long task using Linguistics skill, taking eight hours per attempt, may be enough to "break" the new dialect. If the tongue is completely unknown, at least (2d+8) × 10 hours of samples are needed, more if the language has bizarre syntax or is communicated in an unusual manner – which is likely the case if it belongs to a hitherto unknown alien species. In any case, Linguistics rolls are needed to analyze the samples properly and to create a database for the new language, which is a long task taking *at least* 200 hours. At this point, the database is still incomplete and does not permit anyone to learn the language at better than a Broken comprehension level. At TL11+, highly advanced translation programs may allow "real-time" cracking of languages, greatly speeding this process – see ***GURPS Ultra-Tech*** (p. 48).

Sociological Assessment

Once a local language is decoded, explorers may use its concepts and their earlier planetary observations to estimate local cultural, social, and political parameters. Again, this is based on information gathered remotely through covert observation, robotic reconnaissance, and/or radio monitoring. However, even if a language is understood, it takes considerably more work to gain insight into the local culture.

They Know We're Coming

The orderly step-by-step processes of "linguistic assessment – sociological assessment – covert contact – overt contact" work when an exploration ship is observing a pre-spacefaring culture, or has access to low-signature superscience drives or cloaking device technologies.

However, many realistic space drives such as fusion and antimatter drives are sufficiently "bright" that most populated high-tech worlds can spot the drive flare of a decelerating sublight starship weeks, or even months or years, in advance.

In such circumstances, the decision making in any "first contact" situation is bilateral. Both sides make choices starting with "linguistic assessment" (the locals work to crack whatever messages the starfarers beamed toward them, and vice versa), then proceed straight into an "overt contact" situation.

The natives may have days or even months (depending on the incoming ship's sensor and drive performance) to come up with a response (or several responses, if they lack a single government). They can select ambassadors, prepare (quarantined) quarters for visitors, and, if divided into factions, quarrel or fight over who represents them. If they have the capability, they may choose to meet their visitors in space, for self-defense or to impress them. And if they have anything they feel the urge to hide (war fleets, the presence of dissenting factions or recent conflict, etc.) they may also have time to prepare deceptions!

The rules below assume at least 200 hours of language samples have been gathered and are backed up by actual observation of the world. If less is available when the explorers try to make a sociological assessment, apply at a -1 penalty to each skill roll for every 10 full hours of deficit. Extra samples give a +1 bonus for every 100 hours of surplus. Video samples count double if they show natives interacting socially. Rolls are per day of observation for gauging TL or population, or per week of observation for political structure or institutions. These rolls shouldn't be considered a structured set of tasks; rather, they represent a gradual accumulation of insights.

Technology Level: The easiest parameter to assess from a distance is the level of technological development. The overall TL of a society should be obvious by the time the initial language database is complete, without need for skill rolls.

Population: The native population is also fairly easy to estimate by this time. Roll against Geography (Political) to get a better estimate of the world's native population than earlier imagery-based studies (within 25%), and again to estimate the population of any specific area.

Political Structure: A contact team can uncover the world's dominant government types. Intercepted communications give some idea who makes decisions and how political power is implemented. Roll against Sociology to make this determination.

Specific Political Institutions: The details of local politics and customs are rarely as obvious as the overall structure. Roll against Anthropology to make a rough remote assessment of local political bodies and laws (including approximate average CR). Unless the world is culturally homogenous, this only gives insight into one or two majority cultures.

Economics: Roll against Economics to assign a *Trade Classification* (above).

Instead of resolving the sociological assessment purely with skill rolls, the GM may play out the process of observation and deduction in greater detail. In this case the GM should provide clues to social parameters by describing the exploration team's observations, perhaps even before the language database is built.

For example, rather than calling for an Anthropology skill roll and telling successful players "this lost Earth colony's dominant society is a highly regimented socialist dictatorship," the GM can describe scenes of cities filled with large, monumental arenas and gray housing blocks; the scarcity of personal vehicles; the long queues outside many buildings; and everyone's drab clothes or uniforms. Of course, some of the explorers' observations can be misleading . . .

Trade Classifications

These economically meaningful world characteristics influence the cost of and demand for goods. Assign them to planets when creating a universe! It's possible that multiple classificauons – or *none* – apply to any given world.

Agricultural (Ag): The economy is dominated by the production of foodstuffs, timber, and similar biological products. This is characteristic of garden worlds (or those terraformed to that standard) with TL1+ and populations of at least 1,000 but no more than 100 million.

Extreme (Ex): The world is inhospitable, at least to the dominant trading species in the region. The population lives in artificial habitats, and extensive protective gear (such as environment suits or sealed vehicles) is required to venture outside.

Industrial (In): The economy is highly industrialized and produces plentiful manufactured goods for export. This is characteristic of worlds with a 100 million+ population, a Wealth level of Average or better, and a TL that's equal to, greater than, or no more than one below the average campaign TL.

Militarized (M): Applies if there are significant rebel, terrorist, or naval installations present, or the world is embroiled in a war, cold war, or arms race with its neighbors.

Non-Agricultural (Na): The world lacks the capability to produce sufficient food to feed itself, due to environmental or economic conditions. Many Extreme environments also qualify as Non-Agricultural (though some produce sufficient food in domes, by using hydroponics, food replicators, etc).

Non-Industrial (Ni): The world has little or no heavy industry, and imports all major equipment. This may represent a shortage of factories or resources. This is characteristic of worlds with populations under 10 million, or with higher populations at TL4 or less.

Poor (Po): The world suffers from a poor standard of living, with little buying power. This is typical of worlds with an average Wealth level of Poor or Dead Broke. The GM may class all TL0-2 worlds as Poor.

Rich (Ri): The population enjoys a high standard of living. This is typical of worlds where the average Wealth level is Comfortable or better.

This treatment gives the players more latitude to direct the investigation, perhaps using other skills to ferret out bits of evidence. Once they've drawn and stated their characters' conclusions the GM can make skill rolls, granting bonuses if the players were perceptive or penalties if they were not, and provide PCs with further data based on their success or failure. If the investigators aren't experts themselves but command a large expedition, the GM may have various NPC scientists present their interpretations, including recommendations on whether it's safe to make further contact. The GM can roll against the advisors' skills, modified by the observations of those NPCs directing them. This gets interesting if the GM decides different experts have their own agendas, interpretations, and requests ("Let's move the ship closer" or "We really have to get bugs into that temple complex"); the survey team has to decide if a culture is ready for contact, or is potentially hostile. It's then up to the PCs in command to decide whose advice to take . . . do they order further covert or remote studies, choose to proceed with overt contact, or even terminate the mission?

Covert Contact

Once the linguistic and sociological assessments are finished, the leaders of an exploration team may authorize a covert contact mission. This is not intended to open communications, but rather to gather more information without revealing themselves to the natives.

Some first-contact protocols prohibit covert contact, either on ethical grounds ("We have nothing to hide") or because the risk an accidental discovery of the undercover team may lead to an *uncontrolled* "overt contact" situation. Not only might this result in the loss of the team (e.g., they're mistaken for local spies, foreign intruders, monsters, evil spirits, etc.), but it could trigger larger-scale hostilities. In fact, if the native society is of equal or greater TL to the contact team, a covert operation is sufficiently risky that the practical choice is open contact or no contact at all. An exception is covert contact with a far-flung cosmopolitan interstellar society that encompasses numerous alien or bio-engineered races – if so, covert contact is fairly easy, since visitors from distant parts of the polity are common. If you can meet 40 alien races in a spaceport cantina, a 41st race showing up might not make much of an impression!

The whole concept of covert contact implies the capability of explorers to *be* secretive when they move among the natives. If they're different, physically or mentally, covert contact may only be possible with extreme measures. Possibilities include surgery or nanotechnology to physically transform the team into duplicates of the inhabitants; the creation of robotic or biological android bodies that match native physiology; the replacement of locals with such duplicates; the capture of natives and

implantation of "puppet" implants to possess native bodies; and the use of psionics to infiltrate the society.

Biohazard and biocompatibility issues must also be considered and dealt with. Based on earlier biological surveys, a cautious team ensures they neither contract diseases from the natives nor spread pathogens among them. Realistically native microbes are unlikely to infect a truly alien species; toxic or allergic reactions from native life-forms are possible, as are attacks by any alien equivalent of mold that considers humans (or their equipment) just another source of edible hydrocarbons. A contact team may trust advanced symbiotic nanomachines or pan-immunity drugs to police their bodies. Even so, the best way to be safe is simply avoid direct contact and clean exposed surfaces with conventional toxic cleansers (iodine, hydrogen peroxide, alcohol, etc.). It's difficult to be stealthy if wearing a full-body environment suit, but there may be ultra-tech alternatives like advanced skin-tight suits and transparent masks, sterile robots, and so on. Of course, if a suit or vehicle suffers penetrating damage due to accident or combat, exposure may be unavoidable.

Any covert team planning to remain on a world for long-term observation also needs some way to sustain itself (and power equipment). For example, can they consume food and water, or must they bring in supplies? This may require packing sufficient provisions, vitamin supplements, and power cells for the duration of the mission, and/or insuring proper protection against local microbiological hazards in food and water.

If, despite these risks, covert contact is attempted, the team must be as familiar as possible with the native language and customs. If they successfully performed the Linguistic and Sociological Assessment steps, they may have enough data to speak a native language at a Broken level, but their understanding of local culture is too incomplete to permit any level of Cultural Familiarity. The team should also make (or steal) clothing and personal equipment designed to fit with local styles. Money is a problem, especially if the local technology produces elaborate currency that is hard to counterfeit without close examination. Instead a team may opt to carry compact valuables such as precious metals or gemstones, or, if their protocols permit, a carefully chosen selection of trade items. Explorers may be able to get away with carrying gear or weapons more advanced than the local TL, but the items should be disguised, implanted, or easily concealed (Holdout skill is useful).

They should arrive in an inhabited area in a frontier or rural region that allows for an unobserved landing. Stealth spacecraft (or drop capsules or teleport projectors) may be used; the expedition might even be equipped with landing craft designed for that purpose. If slipping past local sensor nets, see the *Comm/Sensor Arrays* rules on p. 84. Once the team lands, it should make its way into contact with the local population. The team may pretend to be native foreigners visiting from a different region, although this can add its own complications if the inhabitants tend to distrust foreigners! Otherwise the characters may simply avoid attracting attention and set up a secure base in a location that lets them observe the locals and gather samples of artifacts.

Any covert contact mission should be played out as an adventure. Its goal is to gather detailed information about local languages, culture, political structures, society, biology, laws, and customs. Some covert teams have additional agendas, e.g., acquisition of military intelligence to make a threat assessment or to prepare for future conquest, or gathering economic information in advance of opening trade. They may also attempt to obtain samples for local identity documents, currency, personal equipment, clothing, vehicles, animals, and so on to support further operations. They may be assigned to gather recordings of local gatherings, political meetings, stories, or dramatic presentations, as well as collecting scrolls, books, newspapers, downloads from computer networks – anything that improves the expedition's grasp of language and culture. Naturally this means interacting with the local population or resorting to stealth and theft of artifacts (which in some circumstances may be the only practical option!); finding open-minded locals with whom to make overt contact; or even kidnapping "specimens." When the team interacts with residents, GMs should remember to apply all usual penalties to social skills for lack of language or Cultural Familiarity.

Depending on the team's goals it may take one or several missions of varying duration before they decide to conclude the covert stage of a contact operation. In some cases, this phase may proceed for many years, especially if authorities decide overt meetings are dangerous to either party. Successful covert contact missions enable the exploration team to improve their language database (or simply get more practice) so members can buy up to an Accented language comprehension level. Cultural Familiarity may also be purchased.

> *Yet across the gulf of space . . . intellects vast and cool and unsympathetic, regarded this earth with envious eyes, and slowly and surely drew their plans against us.*
>
> *– H. G. Wells,*
> ***The War of the Worlds***

Overt Contact

Once covert contact is finished, or if the step was skipped entirely, the exploration team moves to open, overt contact. Some societies have "non-interference" doctrines or laws prohibiting space explorers from legally making open contact with low-technology societies not "ready" for contact, and others are nervous about providing potential rivals with knowledge of their existence.

Overt contact may follow various procedures, but all of these approaches boil down to using Influence skills in the hope of obtaining a favorable reaction; again, be sure to apply modifiers for language comprehension and lack of Cultural Familiarity.

For peaceful contact with TL7+ societies, the simplest form of overt contact is to transmit radio or other communications in the local language(s), with the content of the message based on any study of the local culture and its institutions. Such a message may be open ("This is the Galactic Federation starship *Unity*, transmitting on all frequencies: Greetings, Hives of Xaxnor, we come in peace and seek permission to cross-pollinate with your worldminds").

However, if investigation has determined an open message may destabilize native institutions, the starfarers might instead covertly deliver their message to local authorities or other selected groups, leaving them to decide whether to best break the news of first contact to their people . . . or to keep it secret. The latter amounts to a de facto alliance between the visitors and one or more native factions, often involving the exchange of advanced off-world technology for the right to study and/or exploit the populace or resources and potentially leading to various covert operations.

If the visitors intend a peaceful takeover or assimilation, they might instead dramatically overawe the natives with advanced technology – the "flying saucers on the White House lawn" scenario. There are risks, though: Depending on the society, an entire civilization might overreact, resulting in widespread panic and possible social collapse! Also, since surprised locals may attack, this approach works best if the visitor's vessel is confident in its defenses! With primitive locals, another approach is to pretend to be gods or other supernatural entities, which can be most effective if study allows the newcomers to employ motifs based on local beliefs. Not all contact teams care about local stability or perpetuating existing power structures. If conquest is planned, "overt contact" may be a surprise attack on any space forces, followed (in some cases) by orbital bombardment, troop landings, or both. In such cases, causing a panic is an objective rather than something to be avoided.

Once local authorities or populations have dealt with the initial shock of contact (or have been defeated by an invasion), the overt contact team makes agreements to secure whatever they're after. Some may be open about their goals; others may find it expedient to limit the information presented immediately to the natives, for sociological, security, or economic reasons. For example, high-technology items may be *demonstrated* as a means of proving the team's claims or extraterrestrial origin, but *how* devices work is left to later technology-exchange agreements.

First contact teams may avoid entangling themselves in existing social and political power struggles, at least until they have a good handle on what's going on. But backing one faction or organization (and perhaps even helping it take over the planet) is a useful strategy to secure influence, and may be a necessity if the team is the "front end" of an attempt to colonize, conquer, or assimilate the native society.

Negotiations with newly contacted worlds require a delicate touch. A first contact team may simply secure an agreement for future talks at a governmental level, having no authority to make anything resembling a treaty. In that case, follow-up missions are left to specialized organizations (a diplomatic corps, state department, etc.). Or they may attempt to gain agreements that give access to the local population (enough for in-depth linguistic or sociological surveys), an exchange of ambassadors, a semi-permanent outpost, or permission to settle part of the system.

Chapter Eight

Examples

The ***GURPS Spaceships*** series is predominantly a catalogue of vehicles, interspersed with rules. The primary aim of this supplement is to collect the rules in one place, but it is also useful to provide some examples to illustrate the rules and the standard format for recording spaceships.

Baikonur Launch Vehicle (TL7)

This system is designed to transport a 100-ton payload from an Earth-gravity world's surface to low orbit. It is a three-stage system consisting of two booster stages and the 100-ton spacecraft (the Space Transport Vehicle, or "STV"). Vessels are named after planetary spaceports.

First Stage (Two Boosters and STV) (TL7)

This stack consists of a chemical rocket and 650 tons of rocket fuel, onto which are bolted the second and third stages. The entire spacecraft is a streamlined SM+8 hull. It masses 1,000 tons. This stage adds 2.52 mps to delta-V.

Front Hull	***System***
[1-6]	Integrated Vessel (second stage; below).
Central Hull	***System***
[1-6,core]	Fuel Tanks (50 tons rocket fuel providing 0.21 mps delta-V each).
Rear Hull	***System***
[1-2]	Chemical Rocket Engines (3G acceleration each).
[3-6,core]	Fuel Tanks (50 tons rocket fuel providing 0.21 mps delta-V each).

Second Stage (Booster and STV) (TL7)

This stack consists of a chemical rocket engine and 195 tons of rocket fuel, onto which is bolted the final stage. The entire spacecraft is a streamlined SM+7 hull. It masses 300 tons. This stage adds 3.12 mps to delta-V (total 5.66 mps), enough to reach low orbit.

Front Hull	***System***
[1-6]	Integrated Vessel (third stage; below).
Central Hull	***System***
[1-6,core]	Fuel Tanks (15 tons rocket fuel providing 0.24 mps delta-V each).
Rear Hull	***System***
[1]	Chemical Rocket Engines (3G acceleration).
[2-6,core]	Fuel Tanks (15 tons rocket fuel providing 0.24 mps delta-V each).

Third Stage (Space Transport Vehicle) (TL8)

Any 100-ton streamlined spacecraft can be used for the third stage! The STV system shown below is a typical, automated cargo spacecraft. Most of the payload is in 10 hangars joined to form a single bay with a 30-ton capacity. This can deploy any 30-ton payload (e.g., a ship, barge, or satellite).

The STV has a streamlined hull and masses 100 tons (SM+6). It boosts its own 0.45-mps delta-V with the 5.66 mps from the first and second stages, for a total of 6.09 mps.

Front Hull	***System***
[1]	Light Alloy Armor (dDR 2).
[2-6]	Hangar Bays (3 tons capacity each).
[core]	Controls (C1 computer, array Level 2, no control stations).
Central Hull	***System***
[1]	Light Alloy Armor (dDR 2).
[2-6]	Hangar Bays (3 tons capacity each).
[core]	Cargo Hold (5 tons capacity).
Rear Hull	***System***
[1]	Light Alloy Armor (dDR 2).
[2]	Chemical Rocket Engines (3G acceleration).
[3-6]	Fuel Tanks (5 tons rocket fuel providing 0.15 mps delta-V each).

TL	*Vehicle*	*dST/HP*	*Hnd/SR*	*HT*	*Move*	*Lwt.*	*Load*	*SM*	*Occ.*	*dDR*	*Range*	*Cost*
PILOTING/TL7 (HIGH-PERFORMANCE SPACECRAFT)												
7	*Baikonur* 1st Stage	70	-1/5	13	6G/2.52 mps	1,000	300	+8	-	0/0/0	0	$7.6M
7	*Baikonur* 2nd Stage	50	-1/5	13	3G/+3.12 mps	300	100	+7	-	2/0/0	0	+$2.2M
8	*Baikonur* 3rd Stage STV	30	0/4	13	3G/+0.45 mps	100	35	+6	-	2/2/2	0	+$0.9M

Top air speed is 6,100 mph.

Flora-Class Prospector Robot (TL9)

This 30-foot tall (SM+4) tripodal robot is designed for surveying habitable planets. It is covered in a biomorphic cladding that mimics a tree or similar-sized variety of local plant life, allowing it to operate discreetly even on inhabited worlds.

At the top of the unit is a head turret containing a blue-green point defense laser (***GURPS Ultra-Tech*** p. 115) for defense or collecting samples. At its base is a maw that can grind rocks, or swallow living specimens whole and disgorge them unharmed. The maw leads to a multipurpose controlled-environment storage system large enough to accommodate up to three human-sized specimens in reasonable comfort (or three times as many in cramped "cattle-car" conditions) – treat as a hangar bay with 1 ton capacity. This bay can also feed crushed material to an ore processor and chemical refinery.

The robot also has a 1-ton cargo hold that usually carries a combination of techbots (***Ultra-Tech*** p. 85), mobile laboratories (***Ultra-Tech*** p. 67), explorer swarm hives (***Ultra-Tech*** p. 67), samples, and refined ore. Its Complexity 7 computer normally runs an IQ 10 non-volitional general AI, which is adequate for basic reconaissance and prospecting. Note that its power plant can only operate one high-power system at a time: it can't walk while shooting (for instance).

Units are named after the type of plant they mimic.

Front Hull	***System***
[1]	Advanced Metallic Laminate Armour (dDR 3).
[2!]	Turret with 300KJ rapid-fire laser.
[3]	Science Array (Level 4).
[4]	Fission reactor (provides 1 Power Point).
[5-6]	Cargo Hold (1 ton total).
[core]	Computer (C7).
Central Hull	***System***
[1]	Advanced Metallic Laminate Armour (dDR 3).
[2-3]	Robot Arms (dST 15).
[4-5]	Robot Legs (2 of 3, ground Move 10/15).
[6!]	Small (1/2 scale) Mining (0.025 tons/hr), Refinery (0.075 tons/hr).
[core]	Controls (C4 computer; array Level 3; no control stations).
Rear Hull	***System***
[1]	Advanced Metallic Laminate Armour (dDR 3).
[2!]	Robot Leg (1 of 3, ground Move 10/15).
[3-5]	Large (SM+5) Hangar Bay (1 ton capacity).
[6]	Maw (d-damage 1d+2 cut).

It has realistic biomorphics, and no crew.

TL	*Vehicle*	*dST/HP*	*Hnd/SR*	*HT*	*Move*	*Lwt.*	*Load*	*SM*	*Occ.*	*dDR*	*Range*	*Cost*
DRIVING/TL9 (MECHA)												
9	*Flora*-class	15	+3/4	12	10/15	10	2.3	+4	0	3	-	$1,496K

Pluto-Class Ice Ship (TL10)

The ice ship consists of a 2.7 million ton icy asteroid or comet with an attached fusion engine and control system (3 million tons total, SM+15). A fraction of the asteroid is converted to water-reaction mass for the fusion engine; the remaining 2.5 million tons is delivered to the customer.

A ship of this sort takes 10 years from the Kuiper Belt (some 31 AU out from the sun) to rendezvous with a destination in need of volatiles. Engineering vessels then dismantle the expensive fusion rocket and control systems while a swarm of mining craft take apart the asteroid. Alternatively, the vessel could be directed on a collision course with a planet in need of volatiles for terraforming.

Front Hull	***System***
[1-6]	Ice Armor (total dDR 90).
[core]	Controls (C11 computer, array Level 14, no control stations).
Central Hull	***System***
[1-6]	Ice Armor (total dDR 90).
[core]	Fuel Tank (150,000 tons water with 20 mps delta-V).
Rear Hull	***System***
[1-5]	Ice Armor (total dDR 75).
[6]	Fusion Rocket (with water, 0.015G acceleration).

It has total automation.

TL	*Vehicle*	*dST/HP*	*Hnd/SR*	*HT*	*Move*	*Lwt.*	*Load*	*SM*	*Occ.*	*dDR*	*Range*	*Cost*
PILOTING/TL10 (LOW-PERFORMANCE SPACECRAFT)												
10	*Pluto*-class	1,000	-5/5	13	0.015G/20 mps	3,000,000	0	+15	0	90/90/75	-	$39.997B

EOS STARPROBE (TL10)

This is an interstellar von Neumann machine: a minimal robofac seed probe capable of establishing an industrial base on a comet or asteroid. It is built on a 100 ton (SM+6) hull. It has enough fuel to boost (gradually) up to its ramscoop activation speed of 1,800 mps, after which it can continue to accelerate to a substantial fraction of the speed of light. As it approaches a target system, it uses its ramscoop for magnetic braking, maneuvering to a small icy body for refueling. A typical 10-lightyear hop takes a little over a century, with the spacecraft achieving speeds of nearly 20% of *c* at turnaround. (If using the *Ramscoop Drag* switch on p. 64, then the ship's maximum speed is 0.1*c*, and such a journey will take 130 years.)

If *Eos* finds asteroids with suitable raw materials, it will stop to build a manufacturing base, using its robofac and "crew" of techbots (***GURPS Ultra-Tech*** p. 85). Assuming the more pessimistic rules for *Slower Industrial Systems* (p. 64), it will take about 66 years to replicate a new *Eos* probe from raw resources.

The base can also assemble prospecting vessels to survey the rest of the system. If the system proves to be inhabited or otherwise "interesting", *Eos* will fabricate more specialized exploration and infiltration units, from its copious store of blueprints. *Eos*'s Complexity 10 computer system normally runs an IQ 14 strong volitional AI – enough to manage the industrial base and its non-volitional servants – but its memory banks also contain hundreds of specialist AIs that can be brought out of storage as additional computational resources are built.

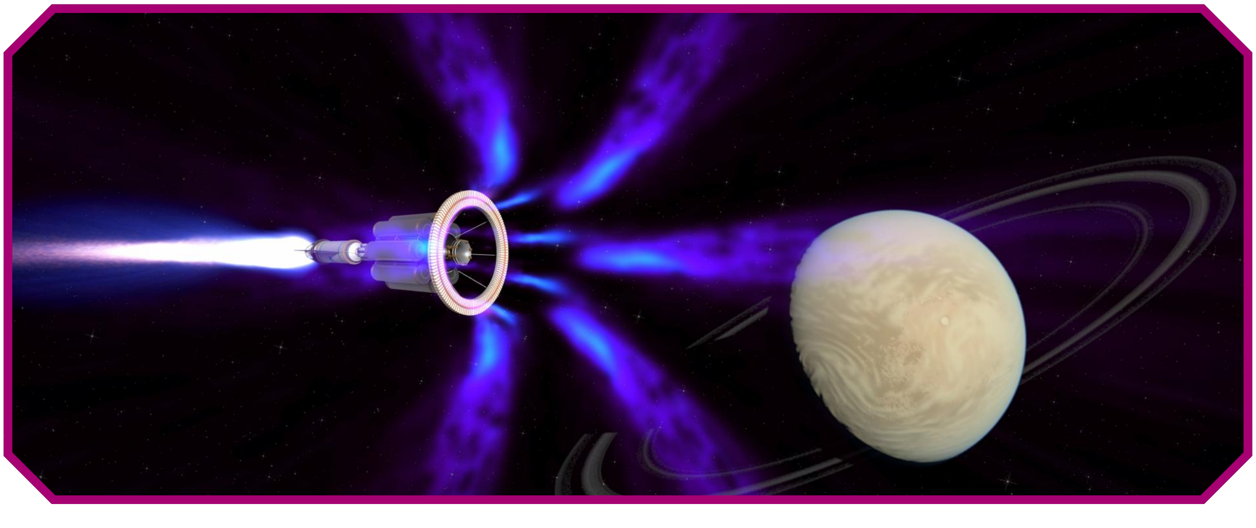
At TL10, this vessel is the smallest possible self-replicating industrial system capable of interstellar flight, and it has very little in the way of redundancy or threat protection: about 1 in 6 starprobes are lost in transit or fail to replicate. This is a calculated design choice – it is cheaper to simply build more starprobes than to make them more robust.

Front Hull	***System***
[1]	2 small (SM+5) Ramscoops, 3 small (SM+4) systems: 2 Robot Arms (dST 15), Major Battery (3MJ improved laser turret).
[2-6,core]	Fuel Tanks (50 tons hydrogen with 120 mps delta-V each).
Central Hull	***System***
[1-5]	Fuel Tanks (50 tons hydrogen with 120 mps delta-V each).
[6]	Factory (robofac, $10K/hr).
[core]	Small (1/2 scale) Fusion Reactor (provides 1 Power Point), 5 small (SM+4) systems: Controls (C6 computer, array Level 3, no control stations), Computer (fast, C10), Multipurpose Array (Level 5), Mining (0.05 tons/hr), Refinery (0.15 tons/hr hydrogen).
Rear Hull	***System***
[1]	2 small (SM+5) Fusion Rockets (0.0017G acceleration each), small (SM+5) Cargo Hold (1.5 tons: 60 Techbots).
[2-6]	Fuel Tanks (50 tons hydrogen with 120 mps delta-V each).

The spacecraft has no crew. It has techbots and repair swarms for routine maintenance, giving it the Self-Healing feature.

TL	*Vehicle*	*dST/HP*	*Hnd/SR*	*HT*	*Move*	*Lwt.*	*Load*	*SM*	*Occ.*	*dDR*	*Range*	*Cost*
PILOTING/TL10 (LOW-PERFORMANCE SPACECRAFT)												
10	*Eos*	30	-5/2	13	0.0033G/1,920 mps*	100	1.5	+6	0	0	-	$24.08M

* Near-*c* with ramscoop.



KIEV-CLASS FARHAULER (TL10^)

This tramp freighter is constructed using a streamlined hull that masses 3,000 tons (SM+9) and is about 200 feet long. Built with limited-superscience technology, it is intended for interstellar cargo hauling and transport in frontier sectors. Because it visits backwater planets that lack orbital facilities, the Kiev is designed with enough thrust and delta-V to land on or take off from an Earthlike world. It's a typical space-opera design, with a defensive armament to give it some chance when fighting off pirates and other hostiles.

Ships are named after port cities from either the space age or the nautical age.

Front Hull	***System***
[1]	Light Alloy Armor (dDR 7).
[2]	Habitat (18 cabins, two-bed automed sickbay).
[3-6]	Cargo Holds (150 tons capacity each).
[core]	Controls (C8 computers, array Level 8, 6 control stations).

Central Hull	***System***
[1]	Light Alloy Armor (dDR 7).
[2-3]	Cargo Holds (150 tons capacity each).
[4!]	2 small (SM+6) turrets, with 30 MJ UV lasers; 140 tons cargo.
[5-6]	Fuel Tanks (150 tons water providing 5 mps delta-V each).

Rear Hull	***System***
[1]	Light Alloy Armor (dDR 7).
[2-3]	Fuel Tanks (150 tons water providing 5 mps delta-V each).
[4]	Engine Room (2 workspaces).
[5]	Fusion Torch Engine (with water, 1.5G acceleration).
[6!]	Stardrive Engine (FTL-1).
[core]	Fusion Reactor (2 Power Points).

The typical crew consists of six bridge officers (captain, pilot, sensor officer, navigator/gunner, engineering officer, and comm officer/gunner), two engine-room technicians, and a cargo master.

TL	***Vehicle***	***dST/HP***	***Hnd/SR***	***HT***	***Move***	***Lwt.***	***Load***	***SM***	***Occ.***	***dDR***	***Range***	***Cost***
PILOTING/TL10 (HIGH-PERFORMANCE SPACECRAFT)												
10^	*Kiev*-Class	100	-1/5	13	1.5G/20 mps	3,000	1,043.6	+9	36ASV	7/7/7	1×	$139.7M

Top air speed is 2,450 mph.

AZRAEL-CLASS WORLD KILLER (TL11)

This is an example of an unmanned relativistic doomsday machine designed to destroy planets across interstellar ranges.

Built with an unstreamlined 10,000-ton (SM+10) hull, it uses a fusion rocket engine with plentiful fuel tanks to accelerate to 1,800 mps (about 1% of light speed), then activates its ramscoop to accelerate to speeds in excess of 0.5*c*. The Azrael's primary kill mechanism is its own mass. At 0.5*c* (with 45% of its mass used up) it can impact with over 42,000,000 megatons of kinetic energy, which is in the "dinosaur killer" range – enough to devastate a planet. Missiles from its tertiary battery can also have a significant impact (about 700 megatons each at 0.5*c*) but it releases them ahead of itself to destroy secondary targets in the system – space stations, defense systems, kinetic barriers, and so on.

Front Hull	***System***
[1-2]	Diamondoid Armor (total dDR 140).
[3!]	Ramscoop.
[4!]	Major Battery (fixed mount very rapid fire 30 MJ improved UV laser).
[5]	30 small (SM+7) fixed mount 28cm missile launchers.
[6]	Fuel Tank (500 tons hydrogen with 252 mps delta-V).
[core]	Controls (C10 computer, array Level 10, no control stations).

Central Hull	***System***
[1]	Diamondoid Armor (dDR 70).
[2-6]	Fuel Tank (500 tons hydrogen with 252 mps delta-V each).

Rear Hull	***System***
[1]	Diamondoid Armor (dDR 70).
[2-3]	Fusion Rocket (0.005G acceleration each).
[4-6]	Fuel Tanks (500 tons hydrogen with 252 mps delta-V each).
[core]	Fusion Reactor (2 Power Points).

It has total automation.

TL	***Vehicle***	***dST/HP***	***Hnd/SR***	***HT***	***Move***	***Lwt.***	***Load***	***SM***	***Occ.***	***dDR***	***Range***	***Cost***
11	*Azrael*-class	150	-4/5	13	0.01G/2,268 mps*	10,000	0	+10	0	140/70/70	-	$1,901.5B

* Near-*c* with ramscoop.

Einstein-Class Pioneer Ramship (TL11)

This sublight starship is also called a ram-augmented rocket. Built on a 10,000 ton unstreamlined hull (SM+10), it relies on internal fuel tanks to accelerate to 1,800 mps (0.01c). It then uses its ramscoop to gather reaction mass from the tenuous interstellar hydrogen clouds that exist between the stars and accelerates to 0.5c or more, protected against dust collisions by its ramscoop and tough hull. Its laser eliminates larger chunks of debris in its way.

This vessel is intended for multiyear voyages, in ship time . . . thanks to relativistic time-dilation, this might mean centuries or millennia pass in the outside universe while it cruises at high fractions of light speed! Such a craft may even become a time capsule to the future, whose crew are the only ones in the universe who remember their own society – or even their own species.

Front Hull	*System*
[1]	Nanocomposite Armor (dDR 50).
[2!]	Ramscoop.†
[3]	Controls (C10 computer, array Level 10, 10 control stations).†
[4]	Hangar Bay (300 tons capacity).†
[5!]	1 small (SM+9) fixed mount very rapid fire 100MJ improved UV laser; 300 tons cargo.†
[6]	Science Array (Level 12).†
[core]	Habitat (20 cabins with total life support, bar, gym, school room, 4 labs, office, and 5-bed sickbay).†

Central Hull	*System*
[1]	Nanocomposite Armor (dDR 50).
[2-6]	Fuel Tanks (500 tons hydrogen with 252 mps delta-V each).

Rear Hull	*System*
[1]	Nanocomposite Armor (dDR 50).
[2]	Fusion Rocket (0.005G acceleration).†
[3-6]	Fuel Tanks (500 tons hydrogen with 252 mps delta-V each).
[core]	Fusion Reactor (2 Power Points and 1,500 years endurance).†

† One workspace each.

The spacecraft has exposed radiators. The typical complement consists of 10 control crew, a medic, eight scientists, a teacher, and eight technicians.

TL	*Vehicle*	*dST/HP*	*Hnd/SR*	*HT*	*Move*	*Lwt.*	*Load*	*SM*	*Occ.*	*dDR*	*Range*	*Cost*
PILOTING/TL11 (LOW-PERFORMANCE SPACECRAFT)												
11	*Einstein*-class	150	-5/5	13	0.005G/2,268 mps*	10,000	604	+10	40ASV	50	-	$1,532M

* Near-c with ramscoop.

Starhawk Star Fighter (TL11^)

This small space-superiority interstellar fighter is a fast, agile design intended for dogfights and strafing. It is thin-skinned but heavily protected by a defensive force screen. However, its reliance on screens and energy weapons strain its power-generation capability; it can't operate every system at once! Unusual for fighters, it has an engine room (often manned by a robot) for repairs. The Starhawk's 45' streamlined hull masses 30 tons (SM+5).

Front Hull	*System*
[1]	Hardened Nanocomposite Armor (dDR 5).
[2]	Major Battery (fixed mount 20cm missile launcher).
[3-6!]	Major Batteries (fixed mount 10 MJ X-ray laser each).

Central Hull	*System*
[1]	Hardened Nanocomposite Armor (dDR 5).
[2]	Tactical Array (Level 7).
[3]	Fuel Tank (1.5 tons hydrogen with 450 mps delta-V).
[4]	Engine Room (1 workspace).
[5!]	Light Force Screen (dDR 20).
[6]	Defensive ECM.
[core]	Controls (C7 computer, array Level 5, 1 control station).

Rear Hull	*System*
[1]	Hardened Nanocomposite Armor (dDR 5).
[2-5]	Super Fusion Torch Engines (50G acceleration each).
[6!]	Stardrive Engine (FTL-1).
[core]	Super Fusion Reactor (4 Power Points).

It has wings and gravitic compensators. Typical crew is a single pilot.

TL	*Vehicle*	*dST/HP*	*Hnd/SR*	*HT*	*Move*	*Lwt.*	*Load*	*SM*	*Occ.*	*dDR*	*Range*	*Cost*
PILOTING/TL11 (HIGH-PERFORMANCE SPACECRAFT)												
11^	*Starhawk*	20	+2/4	13	200G/450 mps	30	0.1	+5	1SV	5*	1×	$9.115M

* Hardened; add dDR 20 if force screen is powered up.

In atmosphere, Hnd/SR is +5/5 and top air speed is 35,000 mph.

Astrid-Class Time Travel Capsule (TL12^)

This "vehicle" is a small pocket universe, connected to normal space through a dimensional interface: it can "travel" through time and space by withdrawing and reinserting its dimensional interface at any point in the space-time continuum. From the outside, the interface presents itself as a conveniently-sized portal, such as a telephone booth (SM+1). Inside, however, is a 100-foot wide spherical vessel (SM+9), housing machinery and a spacious reconfigurable habitat. Cloaking force fields and holoprojectors protect and conceal the interface from external threats, while a conversion reactor and replicator system make it internally self-sufficient.

Astrid is both an acronym and the lead ship name; other vessels in this class are named (and styled) after historical queens: *Victoria*, *Livia*, *Fu Hao*, *Nefertiti*, etc.

Front Hull	***System***
[1]	Exotic Laminate Armor (dDR 70).
[2!!]	Heavy Force Screen (Cloaking, dDR 200).
[3]	Engine Room (2 workspaces).
[4]	Controls (C10 computer, array Level 10, 6 control stations).
[5]	Science Array (Level 12).
[6]	Holoprojector
Central Hull	***System***
[1]	Exotic Laminate Armor (dDR 70).
[2-6]	Reconfigurable Systems: Habitat (100 cabin-equivalents) or Open Space (10 areas) or combination.
[core!!]	Extradimensional Interface.
Rear Hull	***System***
[1]	Exotic Laminate Armor (dDR 70).
[2-3]	Total Conversion Reactor (provides 10 Power Points).
[4!!]	Time-Flux Drive (Anywhere).
[5!]	Factory (Replicator, 15 lb/hr).
[6]	Cargo Hold (150 tons).
[core!!]	Extradimensional Interface.

It has artificial gravity and regeneration. Typical crew is 6 bridge crew and 2 technicians.

TL	*Vehicle*	*dST/HP*	*Hnd/SR*	*HT*	*Move*	*Lwt.*	*Load*	*SM*	*Occ.*	*dDR*	*Range*	*Cost*
ELECTRONICS OPERATION/TL12 (TEMPORAL)												
12^	*Astrid*-class	100	-	14	-	3,000	650	+9	200ASPV	270	∞	$8,058M

Space Amoeba

A giant blob of protoplasmic matter, this starfaring horror masses 3,000,000 tons. Its semi-solid nucleus is equivalent to an unstreamlined SM+15 hull 700 yards in diameter. Its undulations warp space-time around it, allowing it to move as if using ether sails. It may or may not be sapient, but it is hungry! Its normal prey is other star beasts but it has no compunction about absorbing and devouring ships and space stations. This size amoeba cannot survive in a gravity field, however, so it stays away from planets.

Although its core is a few hundred yards, its highly diffuse bulk covers several hundred miles. Spacecraft maneuver inside the amoeba without doing it (or themselves) any damage; the creature's ability to grasp, slow, and eat objects within that area with its cilia is represented by batteries of tractor beams, which capture food and propel it toward its nucleus. The space amoeba was built as if it were a TL12^ vessel.

Front Hull	***System***
[1-3]	Organic Armor (total dDR 300).
[4!]	Powered Ether Sails (0.3G acceleration).
[5!]	30 small (-3 SM) turrets with 30 GJ tractor beams).
[6!]	Digestive System (corrosive).
Central Hull	***System***
[1-3]	Organic Armor (total dDR 300).
[4!]	Powered Ether Sails (0.3G acceleration).
[5!]	30 small (-3 SM) turrets with 30 GJ tractor beams).
[6!]	Digestive System (corrosive).
[core]	Sapient Brain (array Level 12).
Rear Hull	***System***
[1-3]	Organic Armor (total dDR 300).
[4!]	Powered Ether Sails (0.3G acceleration).
[6!]	30 small (-3 SM) turrets with 30 GJ tractor beams).
[5!]	Digestive System (corrosive).
[core]	Total Conversion Power Plant (5 Power Points).

It has regeneration and total automation. It has no crew.

TL	*Vehicle*	*dST/HP*	*Hnd/SR*	*HT*	*Move*	*Lwt.*	*Load*	*SM*	*Occ.*	*dDR*	*Range*	*Cost*
PILOTING/TL^ (HIGH-PERFORMANCE SPACECRAFT)												
^	Space Amoeba	1,000	-4/5	13	0.9G/*c*	3,000,000	0	+15	0	300	-	N/A

Tables

A summary of tables from Chapter 1 (only), provided as a quick reference when designing vessels.

Armor Systems

Conventional Armor Table

SM	***+4***	***+5***	***+6***	***+7***	***+8***	***+9***	***+10***	***+11***	***+12***	***+13***	***+14***	***+15***
Ice												
US dDR	0	0	0	0	1	2	2	3	5	7	10	15
Stone												
US dDR	0	0	0	1	2	2	3	5	7	10	15	20
Wooden												
US dDR	0	1	1	2	2	3	4*	5*	6*	7*	10*	15*
SL dDR	0	0	1	1	1	2	3*	3*	4*	5*	7*	10*
Cost ($)	0	2K	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M
Iron												
US dDR	0	0	1	2	3	5	7	10	15	20	30	50
SL dDR	0	0	1	1	2	3	5	7	10	15	20	30
Cost ($)	0	0	12K	40K	120K	400K	1.2M	4M	12M	40M	120M	400M
Steel												
US dDR	0	1	2	3	5	7	10	15	20	30	50	70
SL dDR	0	0	1	2	3	5	7	10	15	20	30	50
Cost ($)	0	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M
Light Alloy												
US dDR	1	2	3	5	7	10	15	20	30	50	70	100
SL dDR	1	1	2	3	5	7	10	15	20	30	50	70
Cost ($)	5K	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B
Metallic Laminate												
US dDR	2	3	5	7	10	15	20	30	50	70	100	150
SL dDR	1	2	3	5	7	10	15	20	30	50	70	100
Cost ($)	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B
Advanced Metallic Laminate												
US dDR	3	5	7	10	15	20	30	50	70	100	150	200
SL dDR	2	3	5	7	10	15	20	30	50	70	100	150
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B
Nanocomposite												
US dDR	5	7	10	15	20	30	50	70	100	150	200	300
SL dDR	3	5	7	10	15	20	30	50	70	100	150	200
Cost ($)	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B
Organic												
US dDR	1	2	3	5	7	10	15	20	30	50	70	100
SL dDR	0	1	2	3	5	7	10	15	20	30	50	70
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B
Diamondoid												
US dDR	7	10	15	20	30	50	70	100	150	200	300	500
SL dDR	5	7	10	15	20	30	50	70	100	150	200	300
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B
Exotic Laminate												
US dDR	10	15	20	30	50	70	100	150	200	300	500	700
SL dDR	7	10	15	20	30	50	70	100	150	200	300	500
Cost ($)	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B	60B

Fantastic Armor Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Etherwood												
US dDR	0	1	1	2	2	3	4	5	6	7	10	15
SL dDR	0	0	1	1	1	2	3	3	4	5	7	10
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B
Adamant												
US dDR	0	1	2	3	5	7	10	15	20	30	50	70
SL dDR	0	0	1	2	3	5	7	10	15	20	30	50
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B
Skystone												
US dDR	0	1	2	3	5	7	10	15	20	30	50	70
SL dDR	0	0	1	2	3	5	7	10	15	20	30	50
Cost ($)	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B
Orichalcum												
US dDR	3	4	6	9	12	18	25	40	60	90	120	180
SL dDR	2	3	4	6	9	12	18	25	40	60	90	120
Cost ($)	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B

Structural Field Armor Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
US dDR	20	30	50	70	100	150	200	300	500	700	1,000	1,500
SL dDR	15	20	30	50	70	100	150	200	300	500	700	1,000
Cost ($)	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B	100B

Force Screen Table †

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
TL11^ dDR	15	20	30	50	70	100	150	200	300	500	700	1,000
TL12^ dDR	20	30	50	70	100	150	200	300	500	700	1,000	1,500
Cost ($)												
Light screen	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B	50B
Heavy screen	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B	50B	150B

Propulsion and Lift Systems

Contragravity Lifter Table †

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Ether Propulsion Table †

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Oar crew	1	2	6	20	-	-	-	-	-	-	-	-
Cost ($)	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B

Flexibody Drivetrain Table †

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11**	*+12**	*+13**	*+14**	*+15**
Cost ($)	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B

Gasbag Table †

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Lift	3	9	30	90	300	900	3,000*	9,000*	30K*	90K*	300K*	900K*
Cost ($)	10K	50K	100K	200K	500K	1M	2M	5M	10M	20M	50M	100M

Helicopter Rotor Table †

SM	+4	+5	+6	+7*	+8*	+9*	+10*	+11*	+12*	+1*	+14*	+15*
Cost ($)	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B

Jet Engine Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B

Jump Gate Table †

SM	+9	+10	+11	+12	+13	+14	+15
Max tonnage	100	300	1,000	3,000	10K	30K	100K
Cost ($)	150M	500M	1.5B	5B	15B	50B	150B

Lightspeed Drive Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Magnetic Planetary Drive Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B

Ornithopter Wing Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B

Parachronic and Time-Flux Drive Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B	60B

Solid-Fuel Rocket Engine Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	10K	50K	100K	200K	500K	1M	2M	5M	10M	20M	50M	100M

Chemical Rocket Engine Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

Electric Reaction Engine Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B

Laser Rocket Engine Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B
Laser	10GJ	30GJ	100GJ	300GJ	1TJ	3TJ	10TJ	30TJ	100TJ	300TJ	1PJ	3PJ

Solar Thermal Engine Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B

Fission Engine Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B

Nuclear Pulse Engine Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Fusion Engine Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Antimatter and Total Conversion Engine Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B

Reactionless Engine Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)												
Rotary	5K	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B
Standard	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B
Hot	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B
Super	60K	200K	600M	2M	6M	20M	60M	200M	600M	2B	6B	20B
Subwarp	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Robot Leg Table

SM	+4	+5	+6	+7
Cost ($)	100K	300K	1M	3M

Space Sail Table †

SM*	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13 or more
Deployment	30sec	1min	2min	3min	6min	10min	20min	30min	1hr	-
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	-

Screw Propeller Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	2K	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M
Top Speed (Surface)												
1 Power	15	15	14	12	12	13	15	16	17	19	21	23
2 Power	20	19	17	15	15	16	17	18	20	21	24	26
3 Power	25	24	20	17	16	17	18	20	22	24	26	28
4 Power	30	26	22	20	20	20	21	22	23	25	26	30
Top Speed (Underwater)												
1 Power	8	9	10	11	13	15	17	19	22	25	28	32
2 Power	10	11	13	15	17	19	22	25	28	32	36	40
3 Power	11	13	15	17	19	22	25	28	32	36	40	45
4 Power	13	15	17	19	22	25	28	32	36	40	45	50

Stardrive Engine Table †

SM*	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Submarine Ballast Tank Table

SM*	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	4K	12K	40K	120K	400K	1.2M	4M	12M	40M	120M	400M	1.2B

Tracked Drivetrain Table †

SM	+4	+5	+6	+7	+8	+9	+10
Cost ($)	15K	50K	150K	500K	1.5M	5M	15M

Wheeled Drivetrain Table †

SM	+4	+5	+6	+7	+8	+9	+10
Cost ($)	3K	10K	30K	100K	300K	1M	3M

Power Systems

Fuel Tank Table

SM	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Fuel tons	0.15	0.5	1.5	5	15	50	150	500	1,500	5,000	15K	50K	150K
Cost ($)	1K	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B

Chemical Energy Power Plant Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	5K	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B

Combustion Engine Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B

Ether Furnace Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

Magical Power Plant Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Souls*	3	10	30	100	300	1K	3K	10K	30K	100K	300K	1M
Cost ($)	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B

Orgone Power Plant Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Rad zone (yards)	15	20	30	50	70	100	150	200	300	500	700	1,000
Cost ($)	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B

Perpetual Motion Power Plant Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B

Psychotronic Power Plant Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Psis	1	1	1	1	2	4	10	30	100	300	1,000	3,000
Cost ($)	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B

Reactor Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)												
Fission reactor	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B
Fusion reactor	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B
Antimatter	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B	60B
Super Fusion	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B	100B
Total Conversion	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B	60B	200B

Solar Boiler Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B

Vacuum Energy Power Plant Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	240K	750K	2.4M	7.5M	24M	75M	240M	750M	2.4B	7.5B	24B	75B

Ramscoop Table †

SM*	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B	100B	300B

Solar Mirror Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B

Solar Panel Array Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B	15B

WEAPON SYSTEMS

Major Battery Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15	+16*
Beam output	3MJ	10MJ	30MJ	100MJ	300MJ	1GJ	3GJ	10GJ	30GJ	100GJ	300GJ	1TJ	3TJ
d-Damage	3d	4d	6d	2d×5	3d×5	4d×5	6d×5	4d×10	6d×10	2d×50	3d×50	4d×50	6d×50
Gun caliber	8cm	10cm	12cm	14cm	16cm	20cm	24cm	28cm	32cm	40cm	48cm	56cm	64cm
Launchers	16cm	20cm	24cm	28cm	32cm	40cm	48cm	56cm	64cm	80cm	96cm	112cm	-
Gun shots	50	70	100	150	200	300	500	700	1,000	1,500	2,000	3,000	5,000
Missile shots	5	7	10	15	20	30	50	70	100	150	200	300	-
Cost ($)	60K	150K	600K	1.5M	6M	15M	60M	150M	600M	1.5B	6B	15B	60B

OTHER SYSTEMS

Cargo Table

SM	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Tons	0.15	0.5	1.5	5	15	50	150	500	1.5K	5K	15K	50K	150K

Cloaking Device Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B	100B

Computer Table †

SM	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Complexity	C8	C9	C9	C10	C10	C11	C11	C12	C12	C13	C13	C14	C14
Programs	6	2	6	2	6	2	6	2	6	2	6	2	6
Cost ($)	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B	20B	60B

Controls Table †

SM	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Complexity	C5	C6	C6	C7	C7	C8	C8	C9	C9	C10	C10	C11	C11
Comm/sensor	TL-8	TL-7	TL-6	TL-5	TL-4	TL-3	TL-2	TL-1	TL	TL+1	TL+2	TL+3	TL+4
Control Stations	1	1	1	2	3	4	6	10	15	20	30	40	60
Cost ($)	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

Defensive ECM Table †

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Digestive System Table †

SM	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Capacity (tons)	1	3	10	30	100	300	1,000	3,000	10K	30K
d-Damage	2d+2	3d	3d+2	4d	4d+2	5d	5d+2	6d	6d+2	7d
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B

Engine Room Table

SM	*+5*	*+6*	*+7*	*+8*	*+9*	*+10 or more*
Workspaces	1	1	1	1	2	-
Cost ($)	15K	30K	100K	300K	1M	-

Enhanced, Science, Multipurpose, and Tactical Array Table †

SM	*+3*	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Array Level	TL-6	TL-5	TL-4	TL-3	TL-2	TL-1	TL	TL+1	TL+2	TL+3	TL+4	TL+5	TL+6
Cost ($)	6K	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

Enhanced Controls Table †

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

Exophase Field Table †

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Cost ($)	10M	20M	50M	100M	200M	500M	1B	2B	5B	10B	20B	50B

External Clamp Table

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Cost ($)	1K	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M

Extradimensional Interface Table †

SM	*+4*	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Cost ($)	3M	10M	30M	100M	300M	1B	3B	10B	30B	100B	300B	1T

Factory Table †

SM	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
$/hr	5K	15K	50K	150K	500K	1.5M	5M	15M	150M	500M
lb/hr*	0.5	1.5	5	15	50	150	500	1,500	5,000	15,000
Cost ($)	5M	15M	50M	150M	500M	1.5B	5B	15B	50B	150B

Habitat Table †

SM	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
No. of Cabins	2	6	20	60	200	600	2,000	6,000	20,000
Cost ($)	300K	1M	3M	10M	30M	100M	300M	1B	3B

Hangar Bay Table †

SM	*+5*	*+6*	*+7*	*+8*	*+9*	*+10*	*+11*	*+12*	*+13*	*+14*	*+15*
Capacity (tons)	1	3	10	30	100	300	1K	3K	10K	30K	100K
Launch rate (tons/min)	1	3	10	20	50	100	200	500	1K	2K	5K
Cost ($)	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M

Holoprojector Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

Maneuver Enhancement Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B

Maw Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
d-Damage	1d+2	2d	3d	5d	7d	5d×2	5d×3	5d×4	5d×6	5d×10	5d×14	5d×20
Cost ($)	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B

Mining and Refinery Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B
Tons/hr:												
If Mining	0.05	0.15	0.5	1.5	5	15	50	150	500	1,500	5K	15K
If Refinery	0.15	0.5	1.5	5	15	50	150	500	1,500	5K	15K	50K

Open Space Table †

SM	+8	+9	+10	+11	+12	+13	+14	+15
Areas	1	2	5	10	20	50	100	200
Cost ($)	100K	200K	500K	1M	2M	5M	10M	20M

Passenger Seating Table

SM	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Seats	1*	1	2	6	20	60	200	600	2K	6K	20K	60K	200K
Cost ($)	1K	3K	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B

Robot Arm Table †

SM	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
dST	10	15	20	30	50	70	100	150	200	300	500	700	1,000
Cost ($)	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B	10B	30B

Sentient Brain Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	15K	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	1.5B	5B

Soft-Landing System Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	20K	50K	100K	200K	500K	1M	2M	5M	10M	20M	50M	100M

Stasis Web Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	2M	3M	6M	12M	25M	50M	100M	200M	500M	1B	2B	5B

Tail Table †

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
d-Damage*	1d+2	2d	3d	5d	7d	5d×2	5d×3	5d×4	5d×6	5d×10	5d×14	5d×20
Cost ($)	20K	60K	200K	600K	2M	6M	20M	60M	200M	600M	2B	6B

Design Features and Switches

Area Jam Radius Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
10-mile	5	7	10	15	20	30	50	70	100	150	200	300
100-mile	1	1	1	2	2	3	5	7	10	15	20	30
1,000-mile	0	0	0	0	0	0	1	1	1	2	2	3

Artificial Gravity and Gravitic Compensator Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	10K	30K	100K	300K	1M	3M	10M	30M	100M	300M	1B	3B

Biomorphics Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	500K	1M	2M	5M	10M	20M	50M	100M	200M	500M	1B	2B

Energy-Phasing Surface Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	500K	1M	2M	5M	10M	20M	50M	100M	200M	500M	1B	2B

Hyperdynamic Field Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	200K	500K	1M	2M	5M	10M	20M	50M	100M	200M	500M	1B

Psi Shielding Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)	500K	1M	2M	5M	10M	20M	50M	100M	200M	500M	1B	2B

Spin Gravity Table

SM	+8	+9	+10	+11	+12	+13	+14	+15
Max G	0.1G	0.15G	0.2G	0.3G	0.5G	0.7G	1G	1.5G
Cost ($)	100K	300K	1M	3M	10M	30M	100M	300M

Stealth Options Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Cost ($)												
Chameleon	90K	180K	350K	700K	1.5M	3M	7M	15M	35M	70M	150M	350M
Stealth	125K	250K	500K	1M	2M	5M	10M	20M	50M	100M	200M	500M

Winged Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13
Cost ($)	50K	150K	500K	1.5M	5M	15M	50M	150M	500M	-

Workspace Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
High Automation	0	0	0	0	0	0	0	0	1	3	10	30
Normal Automation	0	0	0	0	0	0	1	3	10	30	100	300
Lacks Automation	1	1	1	1	2	3	10	30	100	300	1,000	3,000

† These systems require workspaces (unless fully-automated); see *Workspace Table* (above) for crew requirements.
* Special rules apply; see the full system descriptions for details.

Other Design Tables

Hull Size Table

SM	Loaded Mass	Length	dST/HP	Hnd/SR
+4	10 tons	10 yards	15	0/4
+5	30 tons	15 yards	20	0/4
+6	100 tons	20 yards	30	0/4
+7	300 tons	30 yards	50	-1/5
+8	1,000 tons	50 yards	70	-1/5
+9	3,000 tons	70 yards	100	-1/5
+10	10,000 tons	100 yards	150	-2/5
+11	30,000 tons	150 yards	200	-2/5
+12	100,000 tons	200 yards	300	-2/5
+13	300,000 tons	300 yards	500	-3/5
+14	1,000,000 tons	500 yards	700	-3/5
+15	3,000,000 tons	700 yards	1,000	-3/5

Low-Volume Systems Table

System Volume	dDR	Target SM
2 or less	×3.6	-2
3	×3	-1
4	×2.6	-1
5	×2.3	-1
6	×2	-1
7-8	×1.8	0
9	×1.6	0
10	×1.5	0
11-12	×1.4	0
13	×1.3	0
14-15	×1.2	0
16 or more	×1	0

Delta-V Increase Table

Tanks	Delta-V	Tanks	Delta-V
6-8	×1.2	16	×2
9-12	×1.4	17	×2.2
13-14	×1.6	18	×2.5
15	×1.8	19	×3

High-Volume Systems Table

System Volume	dDR	Target SM
20-29	×1	0
30-44	×0.8	0
45-59	×0.6	0
60-79	×0.5	+1
80-119	×0.4	+1
120-199	×0.3	+1
×10	×0.2	+2

Hnd/SR Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Space, air, water	0/4	0/4	0/4	-1/5	-1/5	-1/5	-2/5	-2/5	-2/5	-3/5	-3/5	-3/5
Flexibody	0/4	0/4	-1/5	-1/5	-1/5	-2/5	-2/5	-2/5*	-3/5*	-3/5*	-3/5*	-3/5*
One leg	+4/1	+3/1	+2/1	+1/1	-	-	-	-	-	-	-	-
Two legs	+4/3	+3/3	+2/3	+1/3	-	-	-	-	-	-	-	-
Three legs	+3/4	+2/4	+1/4	0/4	-	-	-	-	-	-	-	-
Four or more legs	+3/5	+2/5	+1/5	0/5	-	-	-	-	-	-	-	-
Tracked	-3/5	-3/5	-3/6	-4/6	-4/6	-4/6	-5/6	-	-	-	-	-
Wheeled	-1/4	-1/5	-1/5	-2/6	-2/6	-3/6	-3/6	-	-	-	-	-

Air Speed Table

SM	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14	+15
Base Speed	500	600	750	900	1,000	1,250	1,500	2,000	2,500	3,000	3,500	4,000
Stall Speed	100	120	150	180	200	250	300	400	500	600	700	800

Drivetrain Speed Table

Power Points	1	2	3	4	5	6
Flexibody (ground)	1/4	2/8	3/12	-	-	-
Flexibody (water)	1/2	2/4	3/6	-	-	-
Helicopter (unstreamlined)	5/40	10/50	-	-	-	-
Helicopter (streamlined)	5/100	10/125	-	-	-	-
Tracked	1/10	2/20	3/30	4/40	5/50	6/55
Wheeled	2/28	4/35	6/40	8/44	10/48	12/50

Essential Fuel Table

TL	TL0	TL1	TL2	TL3	TL4	TL5	TL6	TL7	TL8	TL9	TL10	TL11	TL12
Cost ($/ton)	1,780	1,840	1,920	2K	2.2K	3.2K	4.6K	6K	7.4K	10.2K	16K	22K	30K

Fuel Cost Table

Fuel	Cost per Ton
Water	$20
Nitrogen/oxygen (for coolant or life support)	$150
Ionizable reaction mass (e.g., argon)	$180
Rock dust (for mass drivers)	$2
Solid fuel (TL3-4)	$1K
Solid fuel (TL5-6)	$2K
Solid fuel (TL7+)	$10K
Ablative plastic (for laser rockets)	$80
Rocket fuel (liquid hydrogen/oxygen)	$800
Hydrogen	$2K
Gasoline/diesel	$2K
Jet fuel	$4K
HEDM rocket fuel	$6K
Nebulonic fuel (for ether furnaces)	$4K
Nuclear pellets	$50K
Uranium-saltwater	$100K
Nuclear bomb pulse units	$250K
Antimatter-catalyzed hydrogen or water	$20K*
Antimatter-boosted hydrogen or water	$12M*
Matter/antimatter	$10T*

Ammunition Weight Table

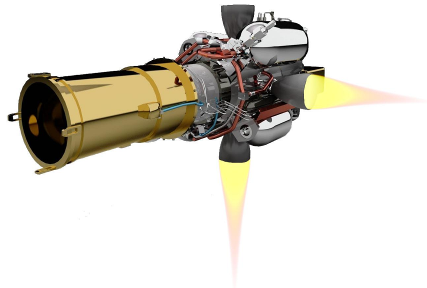
Caliber	Conventional Gun, Catapult	EM Gun, Grav Gun	Missile	SM
2cm	1/4,000	1/8,000	-	-7
2.5cm	1/2,000	1/5,000	-	-7
3cm	1/1,600	1/3,200	-	-6
3.5cm	1/1,200	1/2,400	-	-6
4cm	1/800	1/1,600	-	-5
5cm	1/400	1/800	-	-5
6cm	1/200	1/400	-	-4
7cm	1/125	1/250	-	-4
8cm	1/80	1/160	-	-3
10cm	1/40	1/80	-	-3
12cm	1/25	1/50	-	-2
14cm	1/16	1/32	-	-2
16cm	1/10	1/20	1/10	-1
20cm	1/5	1/10	1/5	-1
24cm	1/3	1/6	1/3	0
28cm	1/2	1/4	1/2	0
32cm	1	1/2	1	+1
40cm	2	1	2	+1
48cm	3	1.5	3	+2
56cm	4	2	4	+2
64cm	7.5	4	7.5	+3
80cm	-	-	15	+3
96cm	-	-	25	+4
112cm	-	-	40	+4

Beam Type Table

TL	Weapon	Damage	sAcc	Range	Rcl
7^	Heat ray	D1 burn	0	R2	1
5+2^	Lightning Cannon	D1 burn sur(2)	-3	R1	1
9	Laser	D1 burn (2)	0	R2	1
10	Particle	D1 burn rad sur (5)	-3	R1	1
10^	Plasma	D2 burn exp (2)	-6	R0	2
10	UV Laser	D1 burn (2)	0	R3	1
10^	EM Disruptor	D1 special	0	R2	1
11^	Antiparticle	D2 cr exp sur rad (3)	-3	R1	1
11^	Ghost Particle	D1 cr exp (∞)	-3	R1	1
11^	Graviton	D0 cr (∞)	0	R1	1
11^	Tractor	D1 special	0	R1	1
11	X-ray Laser	D1 burn sur (5)	0	R3	1
11^	Mind Disruptor	D1 special	0	R2	1
12^	Conversion	D1 cor (10)	0	R2	1
	follow-up	D1 burn exp rad sur			
12^	Disintegrator	D1 cor (∞)	0	R2	1
12	Graser	D1 burn sur (10)	0	R3	1

Guns and Launchers Table

TL	Weapon	sAcc	Move	Rcl
2	Catapult	-17	0.05	3
3-4	Conventional Gun	-16	0.1	3
5-6	Conventional Gun	-12	0.5	3
7+	Conventional Gun	-10	1	3
9	Electromagnetic Gun	-8	2	2
11^	Grav Gun	-5	5	2
3-4	Missile Launcher	-17	4/0.2	1
5-6	Missile Launcher	-16	5/1	1
7-8	Missile Launcher	(TL-8)	6/2	1
9	Missile Launcher	(TL-8)	5/10	1
11^	Super Missile Launcher	(TL-8)	100/100	1
^	Warp Missile Launcher	+17	186K	1



Beam Damage and Range Table

Output	D0	D1	D2	R0	R1	R2	R3
3 KJ	1d-5	1d-3	1d-1	30/100	70/200	150/500	300/1K
10 KJ	1d-4	1d-2	1d	30/100	70/200	150/500	300/1K
30 KJ	1d-3	1d-1	1d+2	30/100	70/200	150/500	300/1K
100 KJ	1d-2	1d	2d	70/200	150/500	300/1K	700/2K
300 KJ	1d-1	1d+2	3d	70/200	150/500	300/1K	700/2K
1 MJ	1d	2d	4d	70/200	150/500	300/1K	700/2K
3 MJ	1d+2	3d	6d	150/500	300/1K	700/2K	1.5K/5K
10 MJ	2d	4d	8d	150/500	300/1K	700/2K	1.5K/5K
30 MJ	3d	6d	6d×2	150/500	300/1K	700/2K	1.5K/5K
100 MJ	4d	8d	4d×5	300/1K	700/2K	1.5K/5K	3K/10K
300 MJ	6d	6d×2	3d×10	300/1K	700/2K	1.5K/5K	3K/10K
1 GJ	8d	4d×5	4d×10	300/1K	700/2K	1.5K/5K	3K/10K
3 GJ	6d×2	3d×10	6d×10	700/2K	1.5K/5K	3K/10K	7K/20K
10 GJ	4d×5	4d×10	8d×10	700/2K	1.5K/5K	3K/10K	7K/20K
30 GJ	3d×10	6d×10	6d×20	700/2K	1.5K/5K	3K/10K	7K/20K
100 GJ	4d×10	8d×10	2d×100	1.5K/5K	3K/10K	7K/20K	15K/50K
300 GJ	6d×10	6d×20	3d×100	1.5K/5K	3K/10K	7K/20K	15K/50K
1 TJ	8d×10	2d×100	4d×100	1.5K/5K	3K/10K	7K/20K	15K/50K
3 TJ	6d×20	3d×100	6d×100	3K/10K	7K/20K	15K/50K	30K/100K
10 TJ	2d×100	4d×100	8d×100	3K/10K	7K/20K	15K/50K	30K/100K
30 TJ	3d×100	6d×100	6d×200	3K/10K	7K/20K	15K/50K	30K/100K
100 TJ	4d×100	8d×100	2d×1,000	7K/20K	15K/50K	30K/100K	70K/200K
300 TJ	6d×100	6d×200	3d×1,000	7K/20K	15K/50K	30K/100K	70K/200K
1 PJ	8d×100	2d×1,000	4d×1,000	7K/20K	15K/50K	30K/100K	70K/200K
3 PJ	6d×200	3d×1,000	6d×1,000	15K/50K	30K/100K	70K/200K	150K/500K

Conventional Warhead Damage Table

Caliber	d-Damage	Caliber	d-Damage
2cm	3d	16cm	6d×4
2.5cm	3d+2	20cm	6d×5
3cm	4d	24cm	6d×6
3.5cm	5d	28cm	6d×7
4cm	6d	32cm	6d×8
5cm	7d	40cm	6d×10
6cm	9d	48cm	6d×12
7cm	11d	56cm	6d×14
8cm	6d×2	64cm	6d×16
10cm	3d×5	80cm	6d×20
12cm	6d×3	96cm	6d×24
14cm	3d×7	112cm	6d×28

Nuclear and Antimatter Warhead Damage Table

Warhead Yield	d-Damage
25 kiloton	4d×1,000 burn ex rad sur
linked	3d×1,000 cr ex
100 kiloton	8d×1,000 burn ex rad sur
linked	6d×2,000 cr ex
2.5 megaton	8d×5,000 burn ex rad sur
linked	6d×5,000 cr ex
10 megaton	8d×10,000 burn ex rad sur
linked	6d×20,000 cr ex

Unconventional Warhead Table

TL	Warhead	Minimum Size	Cost
7	25 kiloton nuclear	16cm	$50K
7	100 kiloton nuclear	20cm	$100K
7	2.5 megaton nuclear	40cm	$500K
7	10 megaton nuclear	56cm	$1M
10	25 kiloton antimatter	10cm	$100K
10	100 kiloton antimatter	16cm	$200K
10	2.5 megaton antimatter	24cm	$1M
10	10 megaton antimatter	40cm	$2M