Chapter 6- Spaceship Design and Construction

Chapter 6: Ship Design and Construction

General Rules for Construction/ Repair Times and Costs

Ships take approximately 1 day per MCr to build at an orbital or planetary shipyard. This assumes that the ship is being built in a Class A or Class B starport and has a hangar at least twice as large as the ship being built. Use of makeshift facilities to build or repair spacecraft takes twice as long if not being performed at an appropriate starport. Class C starports are capable of building small craft, but it takes them twice as long so it is not nearly as efficient as having a Class A or B starport. Note that a repair craft or spaceport servicing a damaged vessel must be within one tech level or higher of the ship's system in order to service a system aboard the damaged vessel. Jump-5 engines, for example, require a TL 13 (D) or better spaceport and as such it can be hard to find an appropriate repair yard. A TL 9 tramp freighter, on the other hand, can be repaired in almost any facility.

Craft repairing other ships in space must meet a number of characteristics. First, they must have 1 ton of repair drones per 50 tons of ship being repaired. Secondly, they must have at least twice the cargo capacity of any system they are trying to replace. A ship repairing a 100 ton jump drive in space would thus need to have at least 200 tons of cargo space available. Finally, repair craft working on the damaged ship must be able to provide at least 1 grappling arm per 20 tons of equipment being installed. Note that the arms may be provided by more than 1 vessel so small craft may work together to provide sufficient grappling arms.

Ships are limited in size by their abililty to enter jump space. As jump technology improves, larger ships are able to enter jump space. At TL9, ships up to 2000 tons can enter jump space. By TL10 this increases to 3000 tons, and at TL11 the limit becomes 4000 tons. The displacement maxes out by TL13 and 5000 tons. It is not currently possible to maintain a stable jump bubble for ships larger than 5000 tons, although there is a lot of active research going on in this area.

Non-jump spacecraft are not limited by size limits of Jump capable starships. Dispersed hull stations may be constructed in sections and assembled in place, but they are very limited in acceptable thrust. The standard module size of 2000 tons allows them to be efficiently moved between star systems and therefore makes mass production more feasible. Large planetoids have often been hollowed out for bases and these bases may be extremely large. Specialty Maneuver drives may be constructed that are larger than size KK, but these are not mass produced and are therefore substantially more expensive than standard drives. Large ships must be built in the system where they will operate as there is no known way to move large vessels efficiently between systems.

Ships and stations may mount redundant systems such as two engines or power plants. Only 1 system may be functinal at a time, but redundant systems have an effective passover times of 0, meaning no effect in the game. Repairs on the main system can be implemented without shutting down critical ship systems, but ship movement and weapon fire may be limited by the capacity of the backup systems. For example, Meson weapons require a power system output of 5; backup systems cannot always meet this requirement.

Spacegoing craft are divided into several classes of ships. Starships are those that can jump between star systems, while spacecraft is more general and includes all ships able to move themselves through space at 1g or above. Spaceports, orbital stations, bases, etc. are various constructs built in space which have only minimal orbital thrust capability.

Ships are further subdivided by size. All ships under 100 tons (generally in 5-ton increments) are considered small craft and may not have jump drives. General spacecraft are ships between 100 and 1400 tons (generally designed in increments of 100-200 tons). Capital ships displace 1500 tons and above, with a hard upper limit of 5000 tons for jump capable ships. Ships may generally mount any available systems, although small craft have a selection of smaller drive units and power systems designed specifically for them as the larger units may not fit within the smaller hulls. Several other systems such as barbettes or bay weapons have minimum ship sizes and power plant requirements, which make them unsuitable for smaller hulls. Giant ships above 5000 tons are not jump capable but may operate within planetary systems able to construct them.

Hulls, Power Plants, and Drives

All spacecraft require hulls, power plants, and drives of some sort in order to function. Each type of structure provides different capabilities at different price points. The tech level of the system affects everything from the efficiency of the unit to its capabilities. These are some of the most basic requirements of any manufactured system used in space.

Hulls

Hulls provide a general covering over the ship which protects occupants and systems from normal levels of radiation, micrometeorites, vacuum, and many of the other general hazards of space. It also sets a limit on the volume of additional equipment able to be added to the ship. Different size hulls have different capacities and cost very different amounts of money depending upon its intended usage. Every 100 tons of hull provides 2 hull points (round up) and 2 structure points (round down) when engaged in space combat.

Dispersed hull only costs 50% of the normal hull but it is relatively weak. It receives a -4 DM for all operations within an atmosphere, where failures maneuvering in atmospheres causes 2d6 damage to the ship. In addition, armor may not be added to any dispersed hull ship or module. Clamped ships make the joint vessel dispersed.

Standard hull costs the normal amount and provides the usual amount of protection. It receives a -2 DM penalty on atmospheric operations with failure causing 1d6 damage. Armor may be added normally.

Streamlined hulls are 110% of normal cost, but are designed for full atmospheric operations with fuel scoops for bringing on unrefined fuel from gas giants or any other potential hydrogen source. They are designed to enter atmospheres.

Planetoid hulls are approximately spherical, and always considered standard hulls- they may not be streamlined or dispersed. They are the least expensive hull option, and only cost 0.01 MCr per ton to move and drill out. Normal planetoid hulls have 80% useable space and provide 2 free armor points (not included in the max armor). Buffered planetoid hulls have 65% useable space and provide 4 free armor points (not included in the max armor). Planetoids that move at speed <1 may be any size- these are considered asteroids or orbiting bases. The largest jump capable ship is always 5000 tons no matter the source of the hull. Standard engine sizes are limited to a maximum of KK. Larger engines may be built for larger hulls, but they must be specially designed and will cost twice as much due to their non-standard nature.

Armored bulkheads may be used to protect internal systems, giving all internal systems 1 extra damage point. Armored bulkheads use 10% of the ship's total tonnage and adds 10% to the total cost of the ship.

Psionic bulkheads use psionic shielding built into the hull and internal walls of the ship to prevent the use of psionic powers. This shielding costs MCr0.1 per ton and takes up no additional space. The shielding prevents the use of psionics that pass through shielded walls; it does not prevent internal line of sight use of psionics. Thus psionic shielding would prevent teleporting commandos from entering the ship, but would not protect crew in the same compartment once the commandos had entered the ship. Psionic bulkheads are mostly used near worlds where psionics are common, but the high cost of the shielding limits its use.

Modular hulls allow certain systems to be switched in and out to alter the purpose of the ship. Modular hulls may use up to 75% of total tonnage of the ship and increase the price of the hull by the percent that is modular. The bridge, main power plant, drives and armour may not be modular. Modules inside of a ship use the ship's power plant. Externally clamped modules have a max power level of 1 unless it has its own power plant; modules of 100+ tons require their own power plant.

Hull Size	Reinforced Structure per 5%	Reinforced Hull per 10%
10-90	1	3
100-1,000	2	5
1,000-2,000	4	10
2,500+	8	20

Reinforced structure and Reinforced hull gains extra points for those characteristics by spending a percentage of the ship's volume to improve the superstructure. Both types of reinforcemnt cost 0.2 MCr/ton. Reinforced hull and structure is generally restricted to ships that are designed to see combat and have already maxed out their available armor. The table below lists the number of structure and hull points provided by the reinforcements given the overall size of the hull.

Small Craft Hulls

Hull Size (tons)	MCr
10	1.1
20	1.2
30	1.3
40	1.4
50	1.5
60	1.6
70	1.7
80	1.8
90	1.9

Spacecraft Hulls

hull size (tons)	MCr
100	2
200	8
300	12
400	16
500	32
600	48
700	64
800	80
900	90
1000	100
1200	120
1400	140
1600	160
1800	180
2000	200
2500	250
3000	300
3500	350
4000	400
4500	450
5000	500

Giant hulls are only useful within a star system as the largest ship able to enter jump space (currently) is 5000 tons. Standard engines are able to move giant hulls within a system and provide a mobile base which can mount more weaponry than any jump capable ship can match. Because these hulls must be constructed within the system, only systems with class B or better spaceports are able to construct these vessels. Giant hulls also tend to be more expensive and take more time than standard vessels to construct because they cannot fit into regular space docks. While there is no physical upper limit to the size of a giant hull, any vessel that cannot be moved by standard engines (up through size KK) will require unique engines that cost twice normal.

Ship Armor and Shielding

Armor is a special type of modified hull which blocks 1 point of damage from each attack per point of armor. Armor may never be added to dispersed structure ships. Armor is always added in whole point increments so that the ship has a whole number of armor. The entire ship or module must be armored in the same material and to the same level. The base part of a station may have a different amount of armor than station modules. The entire ship must be armored in the same material at the time of construction; armor type may be changed after the ship is built but it must be designed to carry a particular amount of armor in tons. Types of armor available vary according to tech level. Thus a TL10 destroyer could receive a TL12 upgrade increasing its armor protection. Armor applied to a planetoid must encompass the full size of the planetoid (not the available space within the hull) and costs as much for a given hull size as a standard ship hull; ie. it is not cheaper to armor a planetoid than a regular ship despite the difference in hull price.

Armor Type	TL	Protection	Cost	Max Armor
titanium steel	7	2 per 5% hull volume	25% of standard hull per 5%	lesser of TL or 9
crystaliron	10	4 per 5% hull volume	100% of standard hull per 5%	lesser of TL or 13
superdense	12	5 per 5% hull volume	150% of standard hull per 5%	lesser of TL or 13
bonded superdense	14	6 per 5% hull volume	250% of standard hull per 5%	up to TL

Only 1 type of hull shielding may be added to any individual ship. ie. a ship may not be both stealthy and be reflec shielded at the same time. Nuclear dampers, Meson screens and black globes are considered internal ship systems and are not considered shielding applied to the hull of a ship. A ship may therefore have both stealth shielding and nuclear dampers.

heat shielding (TL6) protects ships against burning up during re-entry. It gives a +1 DM piloting roll for entering an atmosphere and costs 0.01 MCr per ton of hull.

reflec shielding (TL9) increases armor against lasers by +3. It costs MCr 0.1 per ton of hull.

rad shielding (TL10) provides radiation and electromagnetic hardening for the entire ship, both the hull and internal structures. It blocks 6 points of damage from any weapon system doing radiation damage which includes particle beams, nuclear weapons, and meson bays. Other radiation sources that cause damage to the crew, including internal sources such as a leaking reactor, are also reduced. Rad shielding costs 0.25 MCr per ton of hull.

stealth shielding (TL11) absorbs radar/lidar beams and disguises heat emissions, giving a -2 DM on sensor checks to lock onto ship. It costs MCr 0.1 per ton of hull.

improved stealth shielding (TL14) is even better at absorbing radar/lidar/densitometry detections and gives a -4 DM on sensor checks to lock onto a ship. It costs MCr 0.3 MCr per ton of hull

Ship Drives and Power Systems

Drives are the devices which propel ships through space. One of the most significant TL 8 accomplishments was the development of the gravitic drive system, or M-drive. These drives are the main maneuvering system of ships at most tech levels. Before the gravitic drive At TL 6-7, reaction drives are the only drive available for space travel. They are the same size as later engines and cost 50% less than M-drives but are very inefficient. Reaction drives consume 1% of total displacement of fuel per hour of 1g thrust (10 combat turns). Ships cannot maneuver after burning all their fuel.

> Some scientists think it may be possible to capture a wormhole and enlarge it many trillions of times to make it big enough for a human or even a spaceship to enter.
>
> *Stephen Hawking*

For small craft, M-drives and power plants intended for spacecraft are too large for the needed performance. To overcome this, smaller M-drives and power plants have been developed that are less efficient overall but come in smaller sizes more appropriate for small craft. The small drives also provide more distinct levels of thrust. Small craft are permitted to use the larger drives, but the possible accelerations are more limited.

Jump drives

Jump drives are the only available way to travel to other star systems. They use refined hydrogen gas to create a bubble in extradimensional space for the ship to exist. Normally ships entering or leaving Jump Space create an easily observed ripple in space-time that can be detected easily (+2DM) even at extreme sensor range. Each jump takes 148+6D6 hours to complete regardless of the distance traveled. Early jump drives are only able to move 1 parsec at a time, while higher tech allows longer jumps to take place in that same 1 week interval. The table below relates the maximum jump distance and maximum ship size available at various tech levels.

Normal Jump drives are offline for 24 hours after re-entering normal space. It is possible to shorten this time, but only at increasing the risk of a misjump. It is impossible within 6 hours of re-entry, -6 DM within 6-12 hours, -4 DM 12-18 hours, and -2DM 19-24 hours after re-entering normal space. Captains generally only jump early when the survival of their ship is at stake as misjumps are often as dangerous as whatever situation is forcing them to leave quickly in the first place.

Navigating through Jump Space is dangerous and requires careful calculations and optimized fuel. Use of unrefined fule gives a -2 DM penalty for accurate jumping. Using drop tanks gives a -2 DM penalty for navigation during a jump. Jumping close to another space body also dangerous, as the gravity well distorts space-time. Navigating a jump takes 10-60 minutes and a successful navigation roll to get to the correct destination (within 1 million kilometers), otherwise the ship misjumps. If a ship misjumps, rolls are repeated until a jump succeeds. The more sequential failures, the farther from the intended destination the ship ends up. In addition, misjumps are hazardous for crewmembers who suffer increasingly more severe effects the worse the misjump.

Fast Cycle Jump Drives are able to jump again 1 hour after arrival. If attempted sooner, there is an increased possibility of a misjump. For 1 minute after jumping, it is a very difficult jump navigation check (-6 DM). For 2 minutes to 29 minutes it is a -4 DM, and 30-59 minutes it is a -2DM roll for a misjump. This assumes that the required amount of fuel is available. Fast cycle jump drives cost 10% more than normal jump drives, take no additional space, and are available 1 tech level above the normal jump drive.

Stealth Jump Drives are available at TL13+ and reduce the chances of observing a ship coming out of jump space. Normally a ship jumping in is automatically detected out to minimal sensor range. A stealth jump drive requires a difficult (-2 DM) sensor check within limited sensor range or a -4 DM very difficult check at minimal range. Stealth jump drives cost 5x normal but take up no additional space. Stealth jump drives may never be fast cycling.

Optional Jump Rule

Higher tech jump drives are more efficient than lower tech systems. If a jump drive can make a Jump-3 or above (available at TL 12), they only need 9 tons of hydrogen per 100 tons of ship per parsec jumped. At Jump-5 and above (available at TL 14 and 15), they only need 8 tons of hydrogen per 100 tons of ship per parsec jumped. Note that a ship must be able to make the longer jumps to take advantage of the reduced fuel requirement. It may choose to make shorter jumps at the reduced fuel level. A jump engine that can only move a ship 1 parsec requires the full amount of fuel even if the rest of the ship is TL15. This change increases the usefulness of high jump multiple engines and makes higher tech jump drives more efficient and more advantageous. The downside is that high tech engines need high tech repairs which are available in fewer systems. The drives themselves are also more expensive and, if the ship is to be able to use their drives to the full potential, a large volume of the ship will be taken up by fuel.

Tech Level	distance (parsecs)	max tonnage	tons fuel per parsec per 100 tons (optional rule amount)
9	1	2000	10
10	1	3000	10
11	2	4000	10
12	3	4000	10 (9)
13	4	5000	10 (9)
14	5	5000	10 (8)
15	6	5000	10 (8)

Space Drives

Chemical rockets known as **reaction drives** are the most primitive type of drive system used to move vessels through space. They are first developed at TL6 but are more common at TL7. They use Newtonian mechanics and accelerate by expelling gas from the engine at high speed to propel a craft forward at a max thrust of 2g. It is very expensive fuel-wise, however, and requires 1% of the vessel displacement in hydrogen per hour of 1g thrust. Oribtal change (takeoff or landing) requires 25% of vessel displacement in fuel per 1.00g of surface gravity; it is easier to achieve orbit on low grav vs high grav worlds. Space stations that generate pseudo-gravity by rotation use 1% of the vessel displacement in gasses expelled to maintain rotation and orbital position per month. They have the same cost and size as gravitic engines but use much more hydrogen.

Maneuver drives use gravitic propulsion which allows safe and easy access to space for the first time starting at TL8. M-drives work by manipulating gravitonic fields that can both thrust a ship through space and create artificial gravity aboard a vessel. Almost all ships have some type of maneuver drive for traveling within a star system as Jump drives do not function consistently within 100 diameters of a large body such as a star, planet, or moon. More powerful M-drives allow more rapid access to orbit from a planetary surface, a shorter length of time to reach the Jump limit around a planet, and an easier time out-maneuvering a ship attempting a boarding operation.

Maneuver drives manipulate gravitic forces using standard energy from fusion power plants and so do not waste precious fuel pushing ships around by passing gas. Because of this, they require a power plant of the same type or larger in order to operate. Space stations require much smaller maneuver drives than ships because they are only required to maintain orbital position and provide internal gravity.

Power Plants

Power plants are essential for providing energy for all systems on ships and stations. The power plant must be able to provide enough energy for the largest drive on the ship, either maneuver or jump drive. The power plant also limits the types of weapons able to be used by a ship or station. TL 8-10 power plants are 25% larger than more modern systems but cost the same amount due to their lower technology. TL15 power plants may be 25% smaller but cost twice as much if high tech fusion plants are used.

Chemical power plants (TL6+) are 50% larger, costs 1.25 MCr/ton, and burn hydrogen fuel at 20x the rate of a fusion power plant.

Fission power plants (TL7+) are the same size and cost as fusion plants but use radioactives to provide power. Each year the plant uses (weekly amount of hydrogen) tons in radioactives. Fuel costs 1 MCr per ton, but is not available in many locations due to the preferred use of fusion powerplants. Radioactives are only available on low tech worlds with primitive space travel or full service Type A starports.

Solar panels must be 1/20 (inner planets), 1/10 (middle planets), or 1/5 (outer planets) the size of a fusion power plant to give everything but energy weapons and engines a power of 1. Solar panels cost 0.1 MCr per ton and take 10-60 minutes to retract or extend on a successful Engineering/Power Plant roll. Ships may not maneuver faster than 0.1g while solar panels are deployed, nor may a ship with panels extended enter a hangar or be clamped to a larger ship without destroying the solar panels. Smaller ships can dock to a vessel that has deployed solar panels normally. Ships depending only on solar panels may not fire energy weapons.

Emergency power systems cost 10% tonnage and cost than the main power plant does. It is only a temporary solution, however, providing 30 minutes of full power (5 combat turns) after the 3rd hit on the power plant. The emergency power plant is destroyed on the next power plant hit.

Spacecraft Drive Performance per Hull Volume

type	100	200	300	400	500	600	700	800	900	1000	1200	1400	1600	1800	2000	2500	3000	3500	4000	4500	5000
A	2	1																			
B	4	2	1	1																	
C	6	3	2	1	1	1															
D	6	4	2	2	1	1	1	1													
E	6	5	3	2	2	1	1	1	1	1											
F	6	6	4	3	2	2	1	1	1	1	1										
G	6	6	4	3	2	2	2	2	1	1	1	1									
H	6	6	5	4	3	2	2	2	2	2	1	1	1								
J	6	6	6	4	3	3	2	2	2	2	2	1	1	1							
K	6	6	6	5	4	3	3	3	2	2	2	2	1	1	1						
L	6	6	6	5	4	3	3	3	3	3	2	2	2	1	1						
M	6	6	6	6	4	4	3	3	3	3	2	2	2	2	1	1					
N	6	6	6	6	5	4	4	4	3	3	3	3	2	2	2	1					
P	6	6	6	6	5	4	4	4	4	4	3	3	3	2	2	1					

Q	6	6	6	6	6	5	4	4	4	4	4	3	3	3	2	2	1				
R	6	6	6	6	6	5	5	5	4	4	4	4	3	3	3	2	1				
S	6	6	6	6	6	5	5	5	5	5	4	4	4	3	3	2	1				
T	6	6	6	6	6	6	5	5	5	5	5	4	4	4	3	3	2	1			
U	6	6	6	6	6	6	6	5	5	5	5	4	4	4	4	3	2	1			
V	6	6	6	6	6	6	6	6	5	5	5	5	4	4	4	3	2	1	1		
W	6	6	6	6	6	6	6	6	6	5	5	5	4	4	4	4	3	2	1	1	
X	6	6	6	6	6	6	6	6	6	6	5	5	5	4	4	4	3	2	1	1	1
Y	6	6	6	6	6	6	6	6	6	6	6	5	5	4	4	4	3	3	2	1	1
Z	6	6	6	6	6	6	6	6	6	6	6	6	5	5	4	4	4	3	2	2	1
AA	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	4	4	3	3	2	2
BB	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	4	4	3	3	2
CC	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	4	4	3	3
DD	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	4	3	3
EE	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	4	4	3
FF	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	4	4
GG	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	4
HH	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5
JJ	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5
KK	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

Spacecraft Drives and Power Plants Prices

		.Jump Drives.			.Maneuver Drives.			.Power Plants.			....Fuel....
Type		tons	MCr		tons	MCr		tons	MCr		tons/wk
A		10	10		2	4		4	8		1
B		15	20		3	8		7	16		2
C		20	30		5	12		10	24		3
D		25	40		7	16		13	32		4
E		30	50		9	20		16	40		5
F		35	60		11	24		19	48		6
G		40	70		13	28		22	56		7
H		45	80		15	32		25	64		8
J		50	90		17	36		28	72		9
K		55	100		19	40		31	80		10
L		60	110		21	44		34	88		11
M		65	120		23	48		37	96		12
N		70	130		25	52		40	104		13
P		75	140		27	56		43	112		14
Q		80	150		29	60		46	120		15

R		85	160		31	64		49	128		16
S		90	170		33	68		52	136		17
T		95	180		35	72		55	144		18
U		100	190		37	76		58	152		19
V		105	200		39	80		61	160		20
W		110	210		41	84		64	168		21
X		115	220		43	88		67	176		22
Y		120	230		45	92		70	184		23
Z		125	240		47	96		73	192		24
AA		135	260		51	104		79	206		26
BB		145	280		55	112		85	222		28
CC		155	300		59	120		91	238		30
DD		165	320		63	128		97	254		32
EE		175	340		67	136		103	280		34
FF		185	360		71	144		109	296		36
GG		200	390		77	156		118	320		39
HH		215	420		83	168		127	344		42
JJ		230	450		89	180		136	368		45
KK		245	480		95	192		145	392		48

Giant Hull Acceleration Table

Ships larger than 5000 tons may only travel in normal space, but are otherwise just like other spacecraft. Using standard engines and powerplants, they may travel at maximum speeds as determined by their size. Ships that have clamped modules may also increase their apparent size for purposes of jump and maneuver drive function. Thus a 2000 ton ship with 4 20 ton clamps may tug 4x 2000 ton modules giving it an apparent size of 10k tons. This ship would be unable to enter jump space while clamped to 4 modules because it exceeds the 5000 ton limit. If attached to a single 2000 ton module, it would only mass 4000 tons and be able to jump.

Engine	7k	10k	13k	16k	19k	22k	26k	30k
Y	1							
Z	1							
AA	1	1						
BB	2	1						
CC	2	2	1					
DD	3	2	1	1				
EE	3	2	1	1				
FF	3	3	2	1	1			
GG	4	3	2	2	1	1		
HH	4	3	3	2	2	1	1	
JJ	5	4	3	3	2	2	1	

KK	5	4	4	3	3	2	2	1

Small Craft

For many craft smaller than 100 tons, the full size spacecraft drives provide more thrust and more power than these vessels require. Because small craft are so useful, engines and powerplants have been standardized to meet the needs of even tiny vessels. Small craft may use larger ship-scale engines, and thrust scales accordingly. A 50 ton small craft with a Type A ship engine would accelerate at 4g; a 25 ton craft would be capable of 8g acceleration, but are limited to 6g's so much of their capability would be wasted. Larger engines and powerplants also typically cost more and take up more space, again wasting precious resources and making the ships less efficient. Smaller engines and powerplants are best suited for lower thrust, general purpose vessels that are common in most civilized systems.

Small Craft Drives

	......Maneuver Drive	....		Power Plant.........		
drive type	size(tons)	price(MCr)		size(tons)	price(MCr)	weekly fuel (tons)
sA	0.5	1		1.2	3	.4
sB	0.7	1.5		1.5	3.5	.5
sC	0.9	2		1.8	4	.6
sD	1.2	2.5		2.1	4.5	0.7
sE	1.5	3		2.4	5	0.8
sF	1.8	3.5		2.7	5.5	0.9
sG	2.1	4		3	6	1.0
sH	2.4	4.5		3.3	6.5	1.1
sJ	2.7	5		3.6	7	1.2
sK	3	5.5		3.9	7.5	1.3
sL	3.3	6		4.5	8	1.5
sM	3.6	7		5.1	9	1.7
sN	3.9	8		5.7	10	1.9
sP	4.2	9		6.3	12	2.1
sQ	4.5	10		6.9	14	2.3
sR	4.8	11		7.5	16	2.5
sS	5.1	12		8.1	18	2.7
sT	5.5	13		8.7	20	2.9
sU	5.7	14		9.3	22	3.1

Small Craft Drive Performance by Hull Volume

drive	10	20	30	40	50	60	70	80	90
sA	2	1							
sB	4	2	1	1					
sC	6	3	2	1	1	1			

sD		4	2	2	1	1	1	1	
sE		5	3	2	2	1	1	1	1
sF		6	4	3	2	2	1	1	1
sG		6	4	3	2	2	2	1	1
sH			5	4	3	2	2	2	1
sJ			6	4	3	3	2	2	2
sK			6	5	4	3	3	2	2
sL				6	4	4	3	3	2
sM					5	4	4	3	3
sN					6	5	4	4	3
sP						6	5	4	4
sQ						6	5	5	4
sR							6	5	4
sS							6	6	5
sT								6	5
sU									6

Fuel Usage and Fuel Tanks

Power plants burn fuel when active, and systems such as life support and gravity require an active power source. While solar panels can power any systems other than the drive or weapons, most of the time power plants will be consuming fuel. Without a power plant, M-drives cannot function and the ship will be under zero-G conditions. The larger the power plant, the more fuel is consumed. Listed in the tables above are fuel consumption rates for small craft and spacecraft power plants.

Ship fuel tanks are contiguous, so fuel may be used for jumping, fueling other ships, or providing power. Ships that do not have enough fuel to make a given jump (either through leaked fuel, inabilty to refine enough fuel, or using it to extend their operations) may not jump until enough fuel is present.

M-drives and P-plants can use nearly any hydrogen. Jump engines, however, require a purer form of hydrogen than the other engines. Refined fuel is available at all Class C or better Starports. Some ships are also equipped with their own fuel processors that will purify acquired hydrogen. Jumping using unrefined hydrogen gives a -2 DM to any Jump made with contaminated fuel.

Drop Tanks (TL9) are disposable, collapseable structures designed to provide fuel for an initial jump without consuming the limited amount of fuel carried by a jump capable ship. Developed at TL9 to expand the range of the jump-1 ships available at the time, ships must be equipped with drop tank clamps in order to use drop tanks. Clamps are generally able to be added on after the initial construction of a ship. When used below TL14, drop tanks are damaged and rendered useless if an 8+ piloting roll is failed (separate from the jump roll). Above TL14, technology has made drop tank use routine. Drop tanks below TL14 give a -2 DM penalty for jump navigation due technical challenges, which decreases to -1 DM at TL14 and above.

If maneuvering with a drop tank attached, adjust the speed of the vessel to account for the drop tank+ ship combination. For anyone crazy enough to take a drop tank into combat, it has 1 hull and 1 structure point per 50 tons. The drop tank size is compared to the ship size, and the tank:ship ratio is the percentage chance of hitting the tank. Every hit will cause hull/structure damage as normal, with every hit causing a fuel hit (with resultant fuel loss) as well. If a destroyed jump tank is not jettisoned immediately it reduces the movement rate by 50% due to drive interference. Drop tank clamps cost 1 MCr and use 2 tons per 50 tons of drop tank to be added and must be a part of the ship. Drop tanks themselves cost 0.1 MCr and weigh 1 ton per 50 tons fuel.

Command/Control Units

Standard Bridges are required for all ships 100 tons displacement or above. These give normal control and tactics checks. The larger the ship the larger the required bridge size. Standard Bridges cost 0.5 MCr per 100 tons of ship.

ship size	bridge size
100-200 tons	10 tons
300-1000 tons	20 tons
1200-2000 tons	40 tons
2500-5000 tons	60 tons

Command Bridges (TL12) are meant to coordinate fleet actions and give +1 DM to naval tactics checks. They cost 50% more than standard bridges and displace 80 tons, and may be used in place of standard bridges.

Compact Bridges (TL8) cram everything into a smaller space. They take up 25% less tonnage and cost the same as a standard bridge, but all actions on the bridge are at -1 DM due to the tight conditions.

Detachable Bridges (TL10) serve as emergency life rafts with re-entry capabilities and 2 weeks of life support.

Hardened Bridges (TL10) protects the bridge occupants and ships computer from 200 rads of radiation and EMP. Hardened bridges cost 25% more than standard and take up the same space. Rad shielding on ships also gives this advantage and is an additive protection.

Holographic Bridges (TL13) use advanced displays and controls which give +2 to ship initiative rolls. These cost 25% more than standard bridges and take up no additional space.

	Type 1	Type 2	Type 3	Type 4
Ship size	200 tons or less	201-1,000 tons	1,001-2,000 tons	More than 2,000 tons
Tonnage	15	30	60	90
Cost per ton of ship	MCr 0.8	MCr 0.8	MCr 0.8	MCr 0.8
Hull	0	0	1	1
Structure	1	1	1	1
Thrust	0.1g	0.1g	0.1g	0.1g

Small Craft Command Requirements

Small Craft require 1 cabin or cockpit if 50 tons or less and small craft larger than 50 tons requires 2 cabins or cockpits. Cockpits take up 1.5 tons/person and are intended for relatively short duration missions. They do not provide sleeping areas or even room to stretch out. Cabins take up 3 tons per person, but can hold 1 extra passenger per 2 people (ie. 6 tons of cabin can carry 3 people) and can serve as a combined command/living area for moderate duration missions. Long and short are relative, but if the pilot will require sleep, assume a cabin is the necessary accomodation. Both cost 0.1 MCr per ton. Cockpits and cabins may be hardened against radiation for 25% of their cost starting at TL12. In addition, unlike larger craft, small craft do not come with an airlock as default. An airlock displaces 1 ton and costs 0.2 MCr.

Robotic, Drone, and Cyborg Ships

Small Craft may be operated as drones using the remote operations skill combined with the appropriate spacecraft skill. A remote operations check is used to control the drone, with a penalty of 2*effect for failed checks. Note that the remote operations check cannot increase the following skill roll. Remote operations work using radio/laser communications up to tech level 12, then use meson communications at higher tech levels. Remote operations using radio are subject to jamming as are other comm checks. Drone controllers are generally very close to the ship itself as radio/laser controls are limited to the speed of light.

All unmanned operations require 2 tons of electronics per standard crew, and ships must be fully crewed or suffer operational penalties. Each ton of control circuits costs 0.5 MCr. Damage to living quarters is transferred to cyborg brains or control circuits which reduce the effective functionality of the ship.

The minimum tech level of a robot is determined by 9+ 2*robot skill level, so a skill 2 robot ship must be at least TL 13. All skills of the robotic ship are assumed to be the same for simplicity. For robotic control, a ship's computer must be equal to the same tech level as the minimum robot skill. For the skill 2 robotic ship above, a TL13 robot requires a Model 5 computer. Redundant computer hardware is highly suggested for all robotic ships as a single lucky hit on the computer would render the entire ship inoperable. Software for controlling the ship costs 0.2MCr/crew for skill 0, 0.6MCr/crew for skill 1, 1.2MCr/crew for skill 2, and 2MCr/crew for skill 3.

Cyborg ships use sophont brains as their control units, and as such the brains have the same skills they acquired during their organic life. Due to specialization, each brain is able to replace 2 crew members as long as it has all of the necessary skills. Each brain requires 1 ton of interface equipment and costs MCr0.1 each. This includes 1 month of nutrients for the cyborg brain. Additional nutrients cost MCr0.1 per brain-year and consumes 1 ton. The neural interface which allows brain to electronic communication is TL12 technology.

Computers and Computer Software

Computer	TL	Rating	MCr
Model 1	7	5	0.03
Model 2	9	10	0.16
Model 3	11	15	2
Model 4	12	20	5
Model 5	13	25	10
Model 6	14	30	20
Model 7	15	35	30

Jump control specialization (bis) increases rating by +5 for jump control only and increases costs by 50%.

Hardened computer systems (fib) are immune to EMP weapons and cost 50% more. Hardening only protects ship electronics and computers including drone or autonomous control electronics, not any passengers or crew. The hardened option may be taken simultaneously with jump specialization.

Ship Programs

program type	TL	Rating	Cost (MCr)	Notes

Maneuvre/0	6	0	included	allows basic control and piloting of ship
Library/0	6	0	included	basic data and stellar information
Intellect	11	10	1	allows verbal and independent control of ship functions
Security/0	8	0	included	protects against hacking and intrusion
Security/n	8+2*n	10*n	n	-2 DM vs hacking and intrusion per level
Jump/n	8+n	5*n	0.1*n	required for jumps up to n parsecs
Autopilot/n	6+2*n	5+5*n	n+1	can make 1 dodge or +1 pilot per level
Fire Control/n	8+n	5*n	2*n	make n attacks or add +n to 1+ attacks
Science/n	8+3n	15*n	3*n	adds +n for laboratory and probe research
Auto Repair/n	8+2*n	10*n	5*n	make n repair attempts or +n to 1+ attempts

Electronics, Sensors and Communications

Standard sensors are the basic sensors every spacecraft will have and are included in the price of other systems. They are not removed when upgraded sensors are installed so they become essentially a backup sensors if the primary system is destroyed. Standard sensors may not have any backups (as they cost nothing and have no weight).

Civilian sensors are upgraded versions of the standard sensors which improve the ability to lock onto targets and collect more detailed information about nearby objects.

Military sensors or better are required for jamming enemy probes, missiles, or communications. They also have more sophisticated tracking and interrogation modes to collect additional information..

At TL11, **advanced sensors** add densitometers to the suite of sensors available making it easier to target particular systems and giving sensors a positive DM for the first time.

System	TL	DM	Tons	MCr	Includes
standard	6	-4	0	0	radar, lidar
civilian	8	-2	1	0.05	radar, lidar
military	10	0	2	1	radar, lidar, jammers
advanced	11	+1	3	2	radar, lidar, jammers, densitometers
very advanced	12	+2	5	4	radar, lidar, jammers, densitometers, NAS
survey	12	+1	10	10	rapid planetary scans using probe drones
countermeasures	13	+1	7	6	advanced sensors +2 for jamming
military countermeasures	15	+1	20	25	advanced sensors +4 for jamming
distributed arrays	11		x3	x3	extends all ranges 1 band, min ship size 2000+ tons
improved processing	11	+1	1	4	improved range bands, easily jammed
enhanced processing	13	+2	2	8	improved range bands, jamming normal

Improved processing upgrades the ability of sensors to interpret confusing or weak signals. This improves the information obtained from any of the sensors by 1 range band, but the analysis is very noise dependent and may be easily jammed, thus making the sensors less useful in combat situations.

Very advanced sensors bring neural activity sensors (NAS) to ships for the first time, improving the type of information regarding crew on nearby ships.

Survey sensors for larger vessels or primarily exploration ships allow a ship to combine the use of probe drones and ship based sensors to more quickly evaluate planetary bodies. While less useful in combat, survey sensors excel at mapping and scanning planetary systems.

Enhanced processing dramatically improves how sensors handle confusing or weak signals. These improvements expand range bands by 1 space and, while still susceptible to jamming, are not easier to jam than normal sensors.

Countermeasures are electronic generators designed to deceive and mislead sensor electronics. They are commonly used to foil missile and torpedo locks as well as disrupt sensor lock-on during combat.

Military countermeasures employ state of the art jamming technology which is extremely effective and masking sensor data and confusing attacking missiles and torpedoes.

Ships without functioning sensors have a -6 DM for all sensor and communication attempts. Stealth technology, particularly stealth coatings, are designed to minimize sensor signals. Ships may not use active countermeasures without negating the effectiveness of their stealth coating.

Crew Requirements

position	salary	minimal	standard	full
officer	7000	none	15	1 per 10 crew
pilot	5000	1	1	3+ backups
navigator	4000	1	1	1+backups
engineer (power engines fuel)	4000	1	1 per 100 tons	1 per 50 tons
sensors/comms	3000	none	1 per system	1 per system + backups
medic	2500	none	1 per sickbay	2 per sickbay
turret gunner	1000	none	1 per turret	1 per turret+ backups
bay gunner	1000	none	2 per bay	3 per bay+ backups
screen operator	1500	none	2 per screen	3 per screen + backups
steward	2000	none	1 per 2 high, 5 passengers	1 per 2 high, 5 passengers
flight crew	1500	none	1 per 30 dock/hangar tons	1 per 20 dock/hangar tons
small craft pilot	3000	none	1 per 30 dock/hangar tons	1 per 20 dock/hangar tons
scientist	2500	none	1 per lab	2 per lab
service crew	1000	none	1 per 15 crew	1 per 10 crew
marine	1000	none	boarding defense	assault troops
general crew	1000	none	1 per 300 hull	1 per 200 hull

agricultural	1000	none	1 per 100	1 per 60
manufacturing	1000	none	1 per 6	1 per 4
storefronts	1000	none	1 per 3	1 per 2
establishments	1000	none	1 per 30	1 per 20

Crew Stations

Officers live one per stateroom and typically can man one or more positions in an emergency. They often have naval or ground assault tactics plus leadership to improve the operations of their unit. Captains receive 50% more salary than the next highest paid person. For smaller vessels, captains will typically assume one of the standard positions aboard ship. For ships with 8 or more crew, a dedicated captain who is an officer is required (although often present with smaller crew). Command vessels have 1 or more additional Flag officers above the captain. The highest ranked flag officer receives 1.5x the pay of the captain and any other flag staff officers receive pay equal to the captain.

Most spacecraft have an absolute minimum crew of 2- one pilot/navigator and one engineer who double as navigator and sensor/comms. This allows no room for error, and any crew casualties are a major problem. In these cases the pilot is usually the captain and earns 1.5x as much as the engineer. Most crewmembers share a stateroom like middle passage passengers.

Many freighter crews work on minimal level of staffing to save money. Military vessels prefer a full crew, plus backups. Assault troops are always in addition to normal ships crews. Many larger official vessels have a frozen watch, crew members who are in low berths who can take over for battle casualties. Crew salaries can make up a large fraction of operational expenses for any vessel, particularly fully staffed ones.

Passengers may be either high or low pasage passengers and have access to the ship's facilities. High passage implies substantial luxuries available, while middle passage is basic access and typical food. Stewards are required to look after both high and middle passage passengers. Low passage passengers occupy low berths and are only revived once the destination is reached. They may carry 20 kg in a locker below the unit.

Small craft often have only a single pilot running the entire ship. This is typical for short-haul piloting such as orbital shuttles or planet-moon transports. Cockpits are only useful for short-haul flights. Control cabins have more ammenities than cockpits and have facilities for longer duration missions such as interplanetary travel or extended patrols in system. Passenger cabins are for used only for shorter (less than a week) trips, while cramped seating is only used for trips less than 24 hours.

> Our three big emergencies are fire, loss of pressurization or contaminated atmosphere. Any of those things in a spaceship are very deadly and time critical. Everybody's trained, but I'm the commander of the ship, and it's up to me to decide.
> *Chris Hadfield*

Barracks are typically only used by military organizations; other purposes such as colonization or prisoner transport are more efficiently carried out using low berths. Sophonts may be crammed into tight quarters during emergencies, but life support systems are not designed to handle higher densities of people and conditions deteriorate quickly. Barracks are only suitable for the lowest ranking individuals- skilled workers generally will not put up with these cramped conditions for very long.

For ships intended to carry more people than staterooms/barracks would normally support, **life support** units can be included to maintain a healthy environment. They are most commonly used on stations, but a lifeboat cutter might be able to squeeze in dozens of people in an emergency.

Low berths are essentially cryofreezers for sophonts. This minimizes life support and space requirements for sophonts travelling between systems and is, by far, the cheapest mode of travel.

Escape pods are designed to provide short term support for one sophont leaving one environment and going to another. They are capable of independent atmospheric reentry but cannot take off under their own power. In the military landing capsules, etc are essentially the same as escape pods that are intended to get troops down to the surface as quickly as possible.

Luxuries are amenities that can provide one level of steward for supporting passengers at an appropriate level. They are usually present on ships intended to carry passengers in style and comfort.

Armories are found on military ships or larger ships which wish to restrict the distribution of weapons. Armories are legally required for weapons that might penetrate the hull, such as fusion weapons or high end missiles, although pirate vessels generally don't care if they fail safety inspections.

Briefing rooms are general use meeting rooms which have displays and screens to help describe a situation or make plans. They provide +1DM tactics or repair operations when planned there.

Detention cells are basically intended for short term restraint of a prisoner or rowdy passenger. Longer term restraint is easier and cheaper in low berths, greatly restricting the need for such facilities.

Laboratories are specialized sections of the ship designed to investigate various phenomena. General labs give allow science investigators to work on any area of research in these labs. Specific labs give a +1 DM for science investigations in their specific area but no benefit in any other. At TL 12, advanced laboratories can provide +1 DM for general labs and +2 DM for specific lab investigations.

Sickbays are intended to treat injured passengers and crew. A sickbay gives a +1 DM to medics working there, or they may have an autodoc which can provide automated care for up to 2 individuals.

Improved Sickbays provide a +2 DM for medics working there.

Libraries are useful for collecting information on trade, people, or cultural information. Searches conducted in a library give +1 DM for cultural or artistic information.

The **ship's locker** is a convenience area for storing general items required aboard a ship. It is meant for things like vacc suits, toolkits, and the like which are assumed to be available but are not specifically stated.

Workshops are areas for constructing or repairing various items found aboard ship. They can give a +1 DM to manufacture or repair small, simple items (with the appropriate skill rolls) and using spare parts that are purchased for exactly these purposes.

Vaults are highly protected areas of the ship which are difficult to access or destroy. It is an internal structure that has 4 hull and 4 structure points independent of the ship itself, meaning the vault can usually be recovered even when the ship itself is destroyed. Vaults typically have a complicated (-6 DM) locking mechanism that may only be opened by certain people or under certain conditions determined when the vault is closed.

Crew Table

Location	TL	tons	MCr	function
stateroom		4	.5	houses 1 officer or 2 crew
low berth	7	.5	.05	one low passenger or frozen watch
escape pod		.5	.1	one sophont or assault soldier
barracks		1.5	0.15	sleeping and living area for 1 soldier
cockpit		1.5	0.15	short-haul piloting region to control a small craft
control cabin		3	0.3	mid- haul small craft control system. 1 extra person per 2 cabins
passenger cabin		1.5	0.15	mid-haul quarters for 1 average size sophont
cramped cabin		.5	.2	short-haul uncomfortable seating for average size sophont
luxuries		1	.1	adds +1 steward to ship
armory		2	.5	provides limited access to weapons/armor for crew
detention cell		2	.25	houses 1 prisoner in secure, cramped quarters
briefing room	8	4	.5	give +1 tactics/repair for operations planned there
laboratory	9	4	1	science general, +1 specific, additional +1 at TL 12, +100% cost
sickbay	9	4	1	+1 medic, or has autodoc for treating 2 sophonts
improved sickbay	12	4	3	+2 medic, or has autodoc for treating 2 sophonts
library	8	4	4	improves searches and arts/humanities research by +1 DM
workshop	8	4	0.3	allows part fabrication and repair bonus
vault	14	12	6	interior emergency unit with 4 hull and 4 structure

Craft and Drone Storage

Mining drones are used to extract ores and minerals from planetary bodies and asteroids. Each set of mining drones are able to process their own displacement of ore per day. Results of the extraction operations are generally checked weekly for each shift using the mining equipment.

Probe drones are 150-200kg drone or robotic sensor systems deployed from a ship to increase the range and amount of information gathered. Different tech levels and types of drones are useful for different purposes and are detailed under drones and robots. Typical tech levels are TL8, TL11, and TL14.

Repair drones are automated units that may be controlled by the ship's computer to repair systems under combat situations or used to fix a disabled ship nearby. A ship requires 1 ton of repair drones per 100 tons of ship to be able to service its own needs or 1 ton of drones per 50 tons of adjacent ship being repaired.

Hangars are full service bays for repairing and storing other craft. They require 130% of the size of craft being stored for the servicing and access. Large hangars may service any amount of ships up to the given total displacement size. They are designed to allow entry, exit, and access while ships are in space.

Docks are minimal storage bays for small craft. They require only the size of the ship being stored and includes no space for servicing craft. They are form fitting and are designed to only handle that size vessel and none other. Larger vessels or stations often include a combination of hangars and docks to maximize the number of craft they can carry but still be able to service them during a voyage. Air rafts and ATV storage docks may be in cargo bays without access to space, in which case they may only be deployed on planets. An empty cargo bay may be used as a work area in these cases.

ship type	dock (tons)	MCr		hangar (tons)	MCr
air raft	4	0		5	1
ATV/ATF	10	0		13	2.6
launch	20	0		26	5.2
boat	30	0		39	7.8
pinnace	40	0		52	10.4
cutter	50	0		65	13
shuttle	95	0		122.5	24.5

Launch tubes are designed for the rapid deployment and recovery of smaller ships. Ships still require hangar space for storage internally. In surprise combat situations launch tubes can allow ships to deploy anti-missile fighters quickly to provide point defense. They may also be used to rapidly recover fighters for an escape.

Grappling arms are essentially cranes used to move larger items and units around during construction, cargo transfer, or recovery operations. They are often found in mining, construction, or repair areas to safely maneuver heavy loads. They provide a +2 to operations switching 30 ton modular cutters and are required when moving modular bays from external clamps to hangars for unloading or reloading.

Docking clamps are devices used to attach ships externally to another vessel. Larger structures require larger docking clamps to hold them. Docking clamps are typically used to shuttle modules or system defense craft from one system to another. 30 ton modules for cutters are able to be stored externally on stations using 1 ton clamps while 2000 ton station modules rely on 20 ton clamps. Modules and craft clamped onto another vessel add their mass to the tug or station for purposes of acceleration and jump travel and may not expand the 5000 ton limit for maximum jump bubble size. Destroying the docking clamp allows 2 ships to drift apart. Ships with modules clamped on are considered dispersed structure ships and lose streamlining.

Clamp Size	Ship Tonnage	MCr
1	10-30	0.5
3	40-90	1.0
10	100-400	2.0
20	500-2,000	4.0
50	15,000	8.0

Drone and Hangar Table

ship system	tons	MCr	description
mining drone	10	2	includes ore handling equipment and drones
probe drones (5)	1	varies	external units deployed to increase rate and type of information
repair drones	1/100	0.2/ton	allows ship auto-repair program to make repair attempts
hangar	varies	0.2/ton	+30% space for access, repair, and diagnostics

dock	varies	0	form fitting spot for a small craft, no room for repairs
launch tube	25X	0.5/ton	25x larger than the largest craft using tube for fast recovery
docking clamp	varies	varies	attaches ships or modules for transport or extended connection
grappling arm (TL8)	2	1	aids in repair, mining, construction, module exchange, etc

Other Ship Components

Cargo spaces are basically storage areas for whatever the ship needs. They usually have access to hangars or outside the ship and carry cargo from one system to another.

Cargo scoops (adapted from the Pirates of Drinax) are typically used by pirates to acquire cargo spaced by terrified freighters. It uses magnets and mesh to capture materials in space and deposit them in a cargo bay. They may be used to capture space junk, EVA sophonts, destroyed ship fragments, etc. Cargo scoops are also used to collect debris near construction or mining areas or after space combat.

Drop tank mounts are primarily used by jump capable starships to fuel their initial jump out of a system. Hydrogen from the drop tanks are used to inflate the mini universe used by jump engines, and then are discarded just prior to jumping. This can increase the effective range of a jump ship and is often used by Jump-1 ships to leave a local group but increases the navigational difficulty. Extra time for plotting jumps involving drop tanks is therefore typical. The external tank itself is jettisoned and may often be reused. When the drop tank is used, an astrogation roll is made; on an 8+ the tank survives, although this roll is not modified by taking extra time. By TL14 drop tank technology is perfected and this roll is no longer necessary. Polities which support drop tank use typically charge a fee for recycling used tanks as the leaving ship is in no position to recycle them. Ships using M-Drives while the drop tank is attached must include that mass for determining their thrust level (ie. a drop tank of 100 tons of fuel would increase the mass of a 400 ton freighter to 500 tons for M-Drive purposes). 2 tons of drop tank mounts are needed per 50 tons of drop tank capacity.

Collapsible drop tanks are used to hold the fuel temporarily before making a jump. They are left behind in system while the fuel is used to inflate the jump bubble. Tanks cost 0.1 MCr per 50 ton capacity and mass 1 ton when carried as cargo.

Fuel scoops are mechanical intakes for collecting hydrogen sources from planetary bodies. They are included in the price of streamlined hulls so they tend not to be purchased separately.

Fuel processors are used to purify hydrogen fuels for use in jump drives. Jumping with impure fuel gives a -2 DM to jump accuracy and eventually will lead to a misjump. 1 ton of fuel processor is able to purify 20 tons of hydrogen per day.

component	TL	tons	MCr
cargo	6	1	0
airlock	6	1	0.05
cargo scoops	8	2	0.5
fuel scoops	6	0	1
fuel processor	6	1	0.05
drop tank mount	9	2/50 ton capacity	1/50 ton
collapsing drop tank	9	50 fuel	0.1

aerofins	7	5% of ship	0.1/ton
breaching tube	10	3	3

Aerofins are used to increase the aerodynamics of small craft or spacecraft in an atmosphere by +2. It works in any atmosphere including gas giant atmospheres when skimming fuel, dodging missiles whie trying to land, or when attempting to set down on an unimproved landing site.

Breaching tubes are used to allow soldiers to transfer from one ship to another without the use of an airlock. Using plasma cutters arranged around an air-tight flexible bridge, breaching tubes may cut through an airlock in 1 minute and cuts through armor at 1 point per minute. They are commonly used by military assault vessels and privateers.

Station Components

Because stations are habitats where people live rather than ships designed for a purpose, there are several components found primarily on stations that are not common in ships. Ships intended to be permanent habitats may have these components just like stations may have any components designed for ships.

Cargo lift airlocks are large, fast cycling airlocks designed for use with grav lifts transferring cargo and people around the station. Intended to function safely even if the transport tubes are pierced, they are an integral part of how modules interact with the base station.

Cargo docks are places for lifts to discharge sophonts and cargo. Modules often have several cargo docks to allow several lifts to be docked at once. This allows a faster flow of material from one place to another and can speed transport out of an area if one dock is reserved for particular use.

Lift tubes are vacuum sealed tubes within base stations that link the various modules together. They are required to take up 25% of the station volume and cost 0.1 MCr per ton. This price includes grav lifts to move around the station and control circuitry to prevent collisions and such. Lifts typically reside in module docks until needed, and autopilot controls work to predict where the heaviest use of lifts will occur to have enough lifts available. The bridge has the ability to comandeer lifts when necessary, and enterprising hackers have been known to tap into this ability.

Life support is used on ships or stations where there are more people than quarters available. When the number of people present exceed the capacity of staterooms, barracks, etc to handle them, additional air and water purifiers, waste systems, etc can be added to keep them alive and healthy. 1 ton of life support is sufficient to support 20 average sized sophonts.

The **command center** of a module is the central area where key module functions are controlled. It must take up 1% of the total tonnage of the module itself, and every module 100 tons or greater must have a command center. Decentralized controls are critical in emergencies for space stations.

Base station Command Centers are responsible not only for controlling key functions of the base station but also for integrating all module command centers and often for controlling base access from space. As they have more requirements, they make up 2% of the tonnage of any base station.

Manufacturing plants are intended primarily for stations where mechanical, chemical and/or technical goods are produced. Often intended for export, it is a way for stations to help support themselves. Often manufacturing plants take raw materials produced by mining nearby planets and convert them into more valuable materials. Manufacturing requires both raw materials as well as storage space for finished products and so often includes cargo space associated with the manufacturing plants. Manufacturing plants require a minimum of 1 worker per 15 units to operate and maintain them.

Agricultural greenhouses are used to provide sophonts with waste recycling and food for extended stays in deep space. At TL8, 30 tons of greenhouse are sufficient to support 1 normal sophont for 1 year. This is reduced to 25 tons of greenhouse space at TL11 and further reduced to 20 tons at TL14. Space reductions are enabled by using genetically engineered crops and better nutrient control. Partial greenhouse support may not be enough to fully support a crew, but the availability of fresh food or luxury items improves morale. Greenhouses require a minimum of 1 worker per 200 tons to operate and maintain them. Large independent bases require extensive greenhouse facilities or regular supply deliveries from planetary bases.

Storefronts are intended to facilitate commerce on board stations. Typical stores are either a mish-mash of items that a particular shopkeeper has collected or it is a specialty shop that caters to a very particular clientele. Shops often cluster together to attract additional shoppers. For many items, stores are the middlemen between producers and consumers and occupy an important position in any economy. They may be fastidious or grungy, reliable or shoddy, legal or semi-legal. Storefronts require a minimum of 1 worker per 3 storefronts to operate and maintain them.

Establishments are places where sophonts congregate for entertainment or other activities. Some are private intimate affairs where only a few are welcome, while a dance club might actively desire the most possible people to enhance their reputation. Modules or stations with many establishments typically have additional life support units associated with them to deal with the dense population, or may have some areas containing specialized environments for taint breathers. Establishments may be high class or crass, discrete or public, honest or crooked. Establishments require a minimum of 1 worker per 30 tons to operate and maintain them.

Station Component Table

component	TL	tons	MCr
cargo lift airlock	8	10	2
cargo dock	8	6	0.5
cargo lift tube	8	25% of hull	0.1/ton
life support	6	1	0.5
command center	6	1% of hull	0.5/ton
base station command	6	2% of hull	0.5/ton
agricultural greenhouse	6	1	0.1/ton
manufacturing plant	6	6	2
storefront	6	10	1
establishment	6	.5/sophont	0.2/ton

Turret Mounts

Turrets are the most common weapon system found on spacecraft of all sizes. Each turret or barbette requires 1 ton of fire control equipment in addition to the turret costs. Ships have 1 hardpoint for every 100 tons of craft, with a minimum of 1 hardpoint for small craft. Small craft are restricted by the size of the turret that they may mount based on the vessel size. Each turret or barbette occupies one hardpoint on the ship. Barbettes are essentially oversized 5 ton turrets designed to support a larger, more powerful weapon system and may not be mounted on ships smaller than 50 tons. Note that some weapon systems also have minimum power requirements in order to operate the weapon systems. The higher tech level needed to operate higher occupancy turrets represents the required miniaturization to fit that many weapon systems into the same displacement tons.

When there is more than one direct fire weapon in a turret, each weapon may be fired at the same target without any penalties. Changing targets for any reason incurs a -1 DM per target change, so if a triple beam laser turret fires at missile #1 and hits, fires at missile #2 and hits (after the -1 DM), a shot at a third missile will be at -2 DM. If the first 2 shots had missed, taking a third shot at the same missile would have no penalty.

When considering upgrades to a weapon system, the upgrade starts at the higher tech level of the turret or the weapon system. Upgrading a triple pulse laser turret, for example, would require TL13 technology (TL11 for the turret, and +2 for the upgrade even though pulse lasers are TL7 technology).

Mount	TL	min size	tons	MCr
single turret	7	20	1	0.2
double turret	9	40	1	0.5
triple turret	11	60	1	1
pop-up turret	+1	+10	2	+1
fixed mounting	6	10	0	0.1

Pop-up turrets are designed as stealth type weapons for pirates or Q-ships who wish to hide their true function. Sensor scans of medium range or longer will not reveal the presence of pop-up turrets, and even minimal range scans require a separate sensors check to identify the pop-up turret. They appear 1 tech level after the visible type of turret is available. Barbettes are not eligible for popup status.

Fixed Mounts are only usually found on small, primitive fighters and only fire in one direction. Barbettes are not eligible for fixed status.

Turret and Barbette Weapon Systems

Pulse lasers are the earliest lasers designed for use in space. They fire a brief, high intensity laser pulse which could cause severe damage when it hits the target. Unfortunately, the short duration of the pulse is difficult to target effectively, giving these weapons a -2 DM for hitting their target. Pulse lasers are common for low-tech anti-ship weapons and can also be used against missiles or torpedoes.

Beam lasers shoot a longer intensity energy pulse that does not suffer the same targeting problems that pulse lasers do. The longer pulse, however, generates a significantly lower beam intensity that only does 1d6 of damage which is relatively easy to block using enough armor. Beam lasers are a common anti-missile or anti-torpedo weapon as they hit more frequently than pulse lasers.

Particle beams are one of the deadliest lower-tech direct fire weapons available. They fire a stream of charged particles that interacts destructively with matter and causes 3d6 damage to the ship and an additional 3d6 radiation damage to the crew of the targeted ship. They do not make good anti-missile or anti-torpedo weapons due to targeting issues. They are relatively expensive, high power weapons and require at least a power level of 2 from the power plant in order to be used in combat. Particle beam barbettes require even more power and need at least a power level of 3 from the power plant.

Particle beams are further restricted as a percentage of turrets that may include particle beams. At a power level of 2 or 3, only 25% of the turrets may have particle beams, rounded down. At power levels 4 or 5, up to 50% of turret weapons may be particle beams. Particle beam barbettes count double in terms of percentages of turret weapons due to their significant power demands. A ship (such as a fighter) that has more than 50% particle beams must have a power level of 6 in order to support such a heavy weapons load.

Missile racks are some of the earliest weapons designed for use in space. Missiles depend upon guidance systems to direct them to their target, but unless the guidance systems are fooled or misdirected they can be exceptionally deadly weapons when fired in salvos. Missile barbettes may fire up to 5 missiles at a time at a single target. Different types of missiles have different effects and can cause different amounts of damage on a successful hit.

Sandcasters are the premier defensive system for lower tech ships. Successfully firing sand reduces the effectiveness of laser weapons from the 'targeted' ship for the combat round by 1d. If a sandcaster fires pebbles at incoming missiles or a ship, a successful hit does 1 point of damage to ships but destroys the incoming missile. Torpedoes, unfortunately, are larger than missiles and are not affected by pebbles or sand. Pebbles may also be directed against attackers trying to board a ship from space, causing 8d6 of personal damage to all individuals in the direction fired.

Railguns are only available in barbette or larger weapon formats and basically accelerate a solid mass at the target ship at very high speeds using kinetic energy to knock out ships. They work best at shorter ranges, but when they hit they do 3d6 damage which can only be reduced by armor.

Torpedoes are the most powerful ship killing weapons available to low tech spacecraft. They are essentially oversized, 1 ton missiles which are impervious to pebbles and can carry a larger warhead than missiles which can penetrate even very tough armor. Torpedoes can miss or be confused, however, or they may be destroyed by a successful laser attack against them. Each torpedo barbette may fire only 1 torpedo at a time.

turret weapon	TL	best range	damage	MCr
pulse laser	6	short	2d6	0.5
beam laser	9	medium	1d6	1
particle beam	8	long	3d6+crew	4
missile rack	6	by missile	by missile	0.75
sandcaster	6	close	special	0.25

barbette type	TL	best range	damage	MCr
particle beam	8	long	4d6+crew	8
missile rack	6	by missile	by missile	2
railgun	9	short	3d6	4
torpedo	7	by torpedo	by torpedo	3

Heavy Weapons

Bay weapons are the heaviest weapons available in space and take up 50 or 100 tons and one hardpoint per emplacement. They also require 1 ton of fire control equipment per bay. Ships over 100 tons may be fitted with 1 bay weapon per 1000 tons of displacement times the power output of a ship, rounded down, with a minimum of one. For example, a 2000 ton cruiser with a power output of 3 could have a maximum of 6 bay weapons. Large bays count as 2 standard bays. Small craft of any size are unable to mount bay weapons.

Ortillery Railguns are designed to bombard immobile targets such as stations and planets. They fire large masses at high velocity that can cause truely massive damage. Like other railguns, they are most effective at short range. They are quite difficult to target, however, and there is a -2 DM penalty for hitting any target that can get out of the way. Ortillery masses are also quite large and may be targeted by lasers to reduce the damage to the target by the amount of damage done to the incoming mass. Large ortillery railguns are known as mass drivers and are illegal on many worlds. When used against planetary targets they are devastating weapons and can throw up dust clouds that may cause long term climate changes akin to large nuclear weapons.

Railgun bays accellerate multiple small masses at the target vessel. The firing vessel rolls 12d6 and then arranges those dice into 4 sets of 3 dice as they wish before determining if the ship was hit or not. This greatly increases the amount of damage done on average per hit. Dice must be arranged before the success of the attack is determined. Large bays go through the same process with 18d6 in 6 groups of 3 instead of only 12d6.

Torpedo bays fire 3 torpedoes instead of 1, increasing the size of the salvo and trying to overwhelm enemy point defense. A large torpedo bay can fire 6 torpedos at once against a single or multiple targets.

Particle beam bays are powerful weapons even at medium tech levels. They require a minimum power level of 3 for small bays or 4 for large bays.

Missile bays fire 12 missiles at a single target. Each missile warhead has a limited damage potential, but a volley of missiles (which may include different types) is very difficult to stop entirely. A large bay fires 24 missiles at once and only capital warships are likely able to completely stop a full volley.

Meson Gun bays are one of the most devastating weapon developments in history. Meson weapons bypass armor and only become destructive once they have penetrated the ship. Combined with the high damage potential of the bay weapons and the radiation damage, a meson armed ship greatly outclasses any lower tech warship in terms of destructive effectiveness. Because of their extreme energy requirements, meson bays require a power level of 5 or better for small bays and 6 for large bays.

Fusion gun bays use fusing hydrogen atoms to target vessels with essentially a directed energy burst. They are quite effective at medium ranges and are not blocked by meson or nuclear shields present on larger warships. Small fusion bays require a power level of 2 or better while large bays require 3 or better to function.

bay weapon	TL	tons	range	damage	MCr
Torpedo Bay	8	50	by torpedo	by torpedo	12
Railgun Bay	10	50	short	3d6 x4	30
Ortillery Bay	9	50	short	8d6	15
Missile Bay	7	50	by missile	by missile	12

Particle Beam Bay	8	50	long	6d6+crew	20
Fusion Gun Bay	12	50	medium	5d6	8
Meson Gun Bay	11	50	long	5d6 +crew	50

Large bay weapons all displace 100 tons and take up 2 hardpoints, and also require 1 ton for fire control circuitry. They count as two bays when determining the number of bays which will fit aboard a ship or module.

large bay	TL	tons	range	damage	MCr
missile flight	8	100	by missile	by missile	24
torpedo flight	9	100	by torpedo	by torpedo	24
Particle Beam Blast	9	100	long	9d6 +crew	40
Fusion Blast	13	100	medium	8d6	16
Meson Blast	12	100	long	8d6 +crew	100
Railgun Blast	11	100	short	3d6 x6	60
Mass Driver	10	100	short	12d6	30

Ammunition

Railgun ammo costs 1000 Cr per ton, with 40 shots per ton. Barbettes fire one shot at a time, small bays use 4, and large railgun bays use 6 shots at once.

Ortillery rounds cost 1000 Cr per ton and give 10 shots per ton. **Mass Driver rounds** cost the same but are twice as large, with only 5 rounds per ton.

Sandcasters are flexible weapons with a variety of possible payloads. All sandcaster ammo consists of a payload in a 50 kg barrel which is broken open when the round is fired. 20 rounds are available per ton of ammunition storage, and any type of accessible round may be loaded, but the load decision must be made before firing. **Sand** is the namesake ammunition load and is good for reducing the effects of laser fire by 1d per successful 'shot'. **Pebbles** are also useful for repelling boarders or destroying incoming missiles (but not torpedoes). One canister of pebbles may target no more than 3 incoming missiles and all missiles must have been fired from the same origin at nearly the same time. **Chaff** rounds are useful for disorienting sensors and communications, but primarily attempting to redirect missile or torpedo guidance systems to target the false reflections instead of the real ship. **Sandcutter** rounds are basically polarizing particles which cause the aggregation of sand and prevent its effective use nearby. It is mostly useful for an attacking ship to prevent the defender from deploying sand and disrupting laser fire, but is only useful at very short range.

Missiles come in any of several varieties, all of which are launched by the same type of launcher and are generally purchased in a 1 ton block of 12 missiles. **Basic missiles** rely upon the sensor lock of the firing vessel and use that to home in on the target vessel. ECM and jamming can distract basic missiles. **Smart missiles** have internal guidance cues which may not be jammed but which are simpler and easier to fool than the more sophisticated sensors on ships. Chaff can be effective against any type of missile by creating an alternative target on an 8 +/- TL difference between ships. **Nuclear missiles** are highly restricted, but can be developed at low tech levels and are extremely effective. They do far more damage to ships compared to normal missiles and also deliver the same amount of radiation damage to unshielded crew. Their use near habitable planets is restricted and may be considered an illegal act of barbarism by other worlds. **Long range missiles** sacrifice warhead yield for longer range. **Shockwave missiles** are designed to counter sandcasters by exploding prior to reaching the target but when successful give a -2 DM penalty to sand, pebbles, and chaff that might be launched to counter an incoming barrage. A turret or bay which launches multiple missiles may fire a mixture of missile types, but the type of missile must be declared at the time of loading.

round	TL	tons	MCr	effect
sand	5	1	.01	reduces laser damage by 1d6
pebbles	5	1	.02	1 damage to ships and missiles
chaff	9	1	.05	-1 DM on sensors and remote operations
sandcutter	9	1	.05	blocks effects of sand

Note that neither missiles nor torpedoes may be made resilient but may have their yield increased as normal. Torpedo and missile launchers may be made resilient.

missile type	TL	speed	duration	damage	MCr (ton)
basic	6	10	10	2d6	.06
smart	8	10	10	2d6	.12
nuclear	6	10	10	4d6 + crew	.18
smart nuclear	8	10	10	4d6 + crew	.30
long range	8	7	20	2d6-1	.18
shockwave	7	10	10	cuts defenses	.18

Torpedoes are more powerful missiles that are not destroyed by pebbles but may be distracted by chaff, ECM, or other things. Each must be loaded before being fired, with the type of torpedo determined at the time of loading. Torpedoes each weigh 1 ton, which is enough that even warships will limit how many they carry. The larger volume does allow a substantially larger warhead, however. Standard torpedoes do 4d6 damage, while nuclear torpedoes do 9d6 damage plus crew radiation hits. Smart torpedoes, like smart missiles, have an internal guidance system which does not require sensor lock-on for targetting. Ortillery torpedoes have a larger warhead specifically for use against immobile targets such as planets and stations. Firing ortillery torpedoes at ships gives a -2 DM to hit. Long range torpedoes sacrifice warhead strength for extended range.

torpedo	TL	tons	speed	duration	damage	MCr
standard	7	1	10	10	4d6	0.3
smart	9	1	10	10	4d6	0.6
nuclear	7	1	10	10	9d6 +crew	0.6
bomb pumped laser	9	1	10	10	6d6 + crew	0.6
smart nuclear	10	1	10	10	9d6 + crew	0.9
smart bomb pumped	10	1	10	10	6d6 + crew	0.9
ortillery	8	1	7	10	7d6	0.6
long range	8	1	10	20	3D6	0.6
long range nuclear	9	1	10	20	7d6 + crew	0.9
decoy	9	1	10	10	misdirection	0.6

Bomb pumped torpedoes are a late modification to standard torpedoes. In order to make torpedo attacks harder to predict and counter, a small nuclear device is used to power an X-ray laser which targets the ship before the torpedo reaches its target. The laser is extremely powerful (6d6) and may be reduced by sand as normal. Because bomb pumped torpedoes explode prior to impact, lasers attempting to destroy them receive a -2 DM for attacks against them.

Decoy torpedoes emit electrical signals and chaff designed to mimic a ship to various sensors. They have a +2 DM compared to chaff due to their sophistication.

Note that torpedoes may not be made resilient, although their launchers can. Torpedoes may have their yield increased as per normal rules. As with sandcasters and missile launchers, torpedo bays may be located with different types of missiles as long as the type of missile is declared when loading the bay.

Radiation Crew Damage

Meson, nuclear, and particle beam weapons do radiation damage on a successful hit. Armor only stops the given amount of particle beam radiation; any damage which penetrates the armor also brings radiation which affects the crew..

Nuclear weapons do 1/2 radiation damage (reduced by armor) when detonated outside the ship using lasers or pebble rounds. Full radiation damage effects that penetrates the armor affects the crew when they actually hit their target.

Missiles and torpedoes distracted by chaff explode far enough away that there is no radiation damage.

Nuclear dampers and Meson screens block both normal damage and radiation damage when successfully deployed. Roll the effectiveness of the screens on each type of damage separately.

Torpedoes and missiles may **not** be made resilient but **may** have their yield increased by tech upgrades.

Torpedoes are NOT affected by pebbles as they are more protected than normal missiles but may still destroyed by laser fire.

Screen Generators

There are 3 different types of screens available to higher tech ships. They are large and expensive, but combined with armor can provide significant resistance against low tech ship killing weapons. A ship must produce 1 power unit for each generator of any type to operate the screens.

Nuclear dampers inhibit the fission reaction required to set off nuclear weapons and block 2d of damage. They reduce both the crew radiation damage as well as direct damage to the ship. Since fusion beams do not cause radiation hits and thus are not blocked by nuclear screens. Note that bomb pumped lasers damage ships with nuclear screens normally (it is laser damage), but the crew radiation hits are blocked by nuclear screens.

Meson screens prevent the decay of mesons inside of the protected area and thus prevent the damaging effects of meson based weaponry. Like nuclear screens, each meson screen block 2d of meson damage including the radiation damage. Because meson and nuclear radiation are fundamentally different forces two different types of screens must be used to protect against the different forms of radiation.

The tech level of the power plant also limits the number of simultaneous screen generators per type at any given time. For larger bases, different screen generators may be used to cover portions of the base- each screen generator can only cover 5000 tons. It is possible that only certain sections of the structure are shielded by meson screens or nuclear dampers; black globe generators are all or nothing and no partial shielding is possible.

TL	Nuclear Damper	Meson Screen	Black Globe
12	1	1	–
13	2	2	–
14	3	3	–
15	4	4	3

Black globe generators are among the rarest and most powerful screens available. Only possible on the most advanced ships, black globes absorb all energy and mass transiting the event horizon. When black globes are on constantly, ships are essentially undetectable other than as an empty spot in space. While this does provide complete protection for as long as the power source on the inside of the sphere lasts, it does have the drawback that nothing from the outside can make it to the inside. All sensors are useless, communications and drives are useless, and no resupply and no refueling is possible.

Energy and mass absorbed by the black globe is converted into energy that is typically stored in capacitors of the jump engines. Each jump engine has capacitors equal to approximately 20% of the tonnage of the engines, and each ton of capacitor is able to absorb 36 points of energy. Additional capacitors may be purchased for 3 MCr/ton. When the capacitors are full, additional energy absorption will cause the entire ship to explode in a massive eruption. Absorbed energy is bled into the rest of the ship systems at 10 percent of the ship's capacity per space combat round allowing the black globe to essentially recharge.

shield generator	TL	tons	MCr
nuclear damper	12	50	50
meson screen	12	50	60
large nuclear damper	13	100	100
large meson screen	13	100	120
black globe generator	15	50	100
black globe capacitors	9	1	3

In order to use black globes in combat, they must be turned off part of the time and on the rest of the time in a varied pattern known as flickering. Flickering black globes will block certain weapons completely, while more extended type weapons will have their damage reduced because it will partially hit the black globes. Beam lasers, particle beams, and fusion guns have extended fire and will block damage equal to the flicker rate. Short duration weapons such as meson bays, pulse lasers, or railguns will be blocked or pass through completely based on the percentage the globe flickers.

Technical limitations make it impossible to predict exactly what instant flickering will take place and so both targeting and firing ships will have a percentage of their weapons fire absorbed by the black globe. Black globes are almost too good at what they do to be an

Active generators	Max Flicker Rate
1	25%
2	50%
3	75%

effective screen. The ship with the black globe generator decides each space combat round what the shield will be doing- on constantly, off constantly, or flickering. Higher flicker rates require more black globe generators to achieve.

Small Craft Weapon Restrictions

Small craft have 1 hardpoint maximum. Smaller ships are limited in the number and type of weapons that may be placed in their hardpoints. Ships less than 20 tons may only carry a single fixed weapon mount. Ships must mass at least 20 tons per weapon in a single turret; ie. in order for a small craft to carry a double turret it must mass at least 40 tons or 60 tons for a triple turret. Barbettes can be fitted to small craft of at least 50 tons but because of hardpoint restrictions they must be the only weapon on board. Particle beam weapons require a ship to be 50% larger than the minimum size for that type of weapon. For example, a fixed mount particle beam weapon may only be mounted on a small craft of 15 tons or greater, while a double particle beam turret would require a small craft of at least 60 tons.

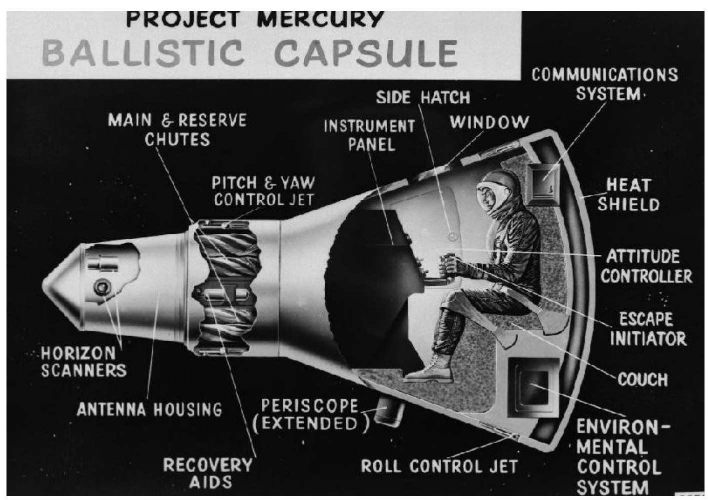
Letter code	Energy Weapons
sA-sF	0
sG-sK	1
sL-sR	2
sS-sZ	3

As small craft are frequently used in atmospheres, they may also mount vehicle scale weapons usable only against vehicles or personnel. These weapons must do less than 8d6 damage (ie. may not affect spacecraft). Small craft may mount 1 small vehicle weapon per 10 tons, and space must be provided for a mount and ammunition (if necessary).

Additionally, small craft power plants are restricted in the number of energy weapons they may support. These restrictions are in addition to the power level restrictions on the weapons themselves. If particle beams are the only weapon on a small craft, it must have a power level of 6. Projectile weapons or launchers are not restricted by the small craft power plant size but will carry a restricted amount of ammunition due to craft size.

Primitive and Advanced Spacecraft

Tech levels are a huge determinant for creating and maintaining a viable spacecraft. Low tech vessels may be repaired almost anywhere, while high tech ships require high tech bases for parts and tools. Repairs are done on a system by system basis, so that if a TL15 vessel has a destroyed fuel processing system a class C, TL9 starport can fix that even if most of the technology is beyond them.



Drive speeds are one of the most significant limitations technology places on spacecraft. Maneuvre drive technology maxes out early, but Jump engines have been advancing steadily. The minimum tech levels required for the given speed using maneuvre or jump drives are:

	1	2	3	4	5	6
Manoeuvre	6	6	8	8	9	9
Jump	9	11	12	13	14	15

Power plants also have different sizes at various TL.

	TL 8-10	TL 11-14	TL 15+
Tonnage	125%	100%	75%
Cost	100%	100%	200%

Weapon/Mount Tech Levels

System	TL		System	TL
Pulse Laser	6		Missile	6
Beam Laser	9		Nuclear Missile	6
Particle Beam	8		Smart Missile	8
Fusion Gun	12		Torpedo	9
Meson Gun	11		Railgun	9
Nuclear Damper	12		Meson Screen	12
single turret	7		double turret	9
triple turret	11		barbette/bay	7

At higher tech levels, it is possible to select upgrades for a higher-technology weapon or screen. One upgrade may be added per two Tech Levels above the minimum TL required for that particular system with a maximum improvement of +3 (ie. +6 tech levels). A +1 upgrade costs 120% of normal, +2 TL upgrade costs 150% of normal, or +3 TL upgrade costs 200% of normal. Some upgrades are double upgrades, consuming two 'slots'. An upgrade may only be taken once. Upgrades may not reduce the size of the weapon or weapon mount. Note that for some upgrades such as triple mount turrets, the turret itself is likely to be the highest tech portion of the weapon and will set the limit of what other upgrades may be applied. Upgrades do not apply to shields.

Accurate (Double Upgrade): Accurate weapons have a +1 DM to all attack rolls.

Easy to Repair: Easy to Repair armaments give a +1 DM to all repair attempts during or after space combat.

High Yield: When rolling damage for a High Yield weapon or screen, any '1's rolled on the dice are counted as '2's. For example, a roll of 1, 1, 2 on a High Yield Particle Beam attack would deal 6 damage, as the two '1's become two '2's. Missiles and torpedoes MAY have a high yield upgrade. Launchers may not.

Long Range: The optimum range for the weapon is increased by one band. For example, a Pulse Laser has an Optimum range of Short. A Long Range Pulse Laser has an Optimum range of Medium instead. Missiles and torpedoes have other options and are not eligible for this upgrade.

Resilient (Double Upgrade): The first hit on a Resilient weapon launcher is ignored. Missiles and torpedoes may not be made resilient, although their launchers may be resilient.

Variable Range (Double Upgrade): A Variable Range weapon increases its Optimum Range by one band in either direction. For example, a Pulse Laser has an Optimum range of Short. A Variable Range Pulse Laser has an Optimum Range of Close-Medium. Missiles and torpedoes do not have a range and cannot use this upgrade.

Very High Yield (Double Upgrade): When rolling damage for a Very High Yield weapon, any '1's or '2's rolled on the dice are counted as '3's. For example, a roll of 1, 1, 2 on a Very High Yield Particle Beam attack would deal 9 damage, as all the dice are below the threshold and become '3's. Missiles and torpedoes MAY have very high yield upgrades. Launchers may not.

Ship Design Descriptor

The following paragraph is a universal ship description format intended to present a consistent layout for describing spacecraft capabilities.

TL: [tl] [ship class]

Using a [dtons] ton [hulltype] hull (hull [hull], structure [structure]), the [ship class] designed by [designer] is intended to [ship description]. The ship has a [jump engine type] jump engine, a [maneuver drive type] maneuver drive and [power plant type] fusion powerplant giving a jump range of [jump range], an acceleration of [acceleration]g and a power level of [power level]. The [streamlining] hull has [armor] points of [armor type] armor [coating]. [aerofins] Fuel tankage of [fuel tonnage] tons supports the powerplant for [endurance] weeks and [jump # and range]. The ship is equipped with [misc equipment]. Adjacent to the [bridge] bridge are [sensors] sensors and a [computer type and programs]. [emergency bridge] The ship has [staterooms] staterooms, [barracks] barracks, [low berths] low berths for a maximum of [occupants] long duration occupants with [low berths] low passengers. The ship has [hard points] hardpoint(s) and [fire control] tons of fire control. Installed on the hardpoints are [weapons list]. [ammunition list] There are [#] screen(s): [screen type]. There are [hangar tonnage] tons of hangar capacity to service [ship ton capacity] tons of ships and [docking tons] tons of docking bays. Cargo capacity is [cargo] tons. Crew features include [crew features]. Other equipment includes [other equipment]. The ship requires a minimum standard crew of [crew # and professions]. The ship costs [ship cost] MCr (not including discounts, ammo, customization or small craft) and takes [build time] weeks to build.

Chapter 6a: Space Stations

> A self-contained world five miles long, located in neutral territory. A place of commerce and diplomacy for a quarter of a million humans and aliens. A shining beacon in space . . . all alone in the night.
>
> *John Sheridan, Babylon 5*

Types of Stations

There are 3 different types of space stations: complete, planetoid, and modular. Complete space stations are built as a single unit with no plans for expansion and no flexibility of components. They are purpose built, and that purpose is difficult to change. They are constructed exactly like regular ships.

Modular stations are composed of a base station with various docking ports intended to attach to any of a number of different modules. Changing out a module allows for flexibility of purpose as well as incremental upgrades in defensive capability, for example. Each module, including the base module, is substantially independent and each has its own power generator, armor, life support, computer, etc. They are also constructed independently, allowing extensive parallel construction. The base station of a modular station is designed to facilitate connections between station modules.

Planetoid stations began as an asteroid or moon and then were hollowed out for various machinery, power plants, etc. Planetoid stations start out with a certain amount of armor due to their method of construction, but have much greater overall mass than a station constructed from scratch. Planetoid stations can include small stations on large satellites. Given the correct infrastructure, modular station elements can be incorporated onto the surface of a planetoid with the 'base' station being built underground. Planetoid stations tend to be the least expensive type for the credit, but are also least efficient in terms of space utilization and mobility.

Station Power, Movement and Construction Requirements

Stations do not generally move under their own power and therefore they may not require engines although they do require power plants. Typically power ratings on ships are determined by how fast the ship will move, and the power plant must be equal to either their jump or maneuver drive ratings. For stations, particularly stations with weapons, having enough power to use their weapons is essential.

A station's base power requirement is 1/3 that of a moving starship; ie. less than a spacecraft but more than a module. This is sufficient for life support, computers, lights, airlocks, orbital maneuvering thrusters, etc. This means that for a 3000 ton station to have a power rating of 1, it would need the same P-plant as a 1000 ton ship to move at thrust 1; ie. a Type-E fusion plant. For that same station to have a power rating of 5 (enough to fire meson gun bays) it would need a Type-S fusion plant. A larger station of 15000 tons (ie. like a 5000 ton ship) would need a Type-X fusion plant for a power rating of 1 or Type-HH for a power rating of 5.

Individual station modules 100 tons or larger must have independent power plants. These may provide more power to certain modules than is available to the station in general. Thus a station defense module may have a power 5 rating for its meson guns even though most of the station does not have that amount of power available. However, because the module is powered independently from the rest of the station, the station does not have the cabling capacity to draw upon the power available to the defense module. Engineers have been known to temporarily connect stations to modules (sometimes even module to module or ships to modules), but such experiments are not to code and prone to frequent (sometimes spectacular) failures.

Alternatively, stations can have multiple smaller power plants. The same 15000 ton station could use 5 Type-X fusion plants to provide the same power as 1 Type-HH power plant. It is space inefficient, but it does supply redundant power so that one sabouteur or lucky weapon hit could not power down the entire base station.

In addition, stations and modules may be equipped with solar panels for indefinite (and nearly free) power. The major limitation of solar power, however, is that it is insufficient to power weapon use or any technology that requires more than a power level of 1. A second redundant power plant can solve that problem, and if the station can afford a short startup time for the reactor, solar power can be a major cost savings in long term space habitats.

Station Movement

Many stations are built where they are going to remain. In some cases, though, it is sometimes necessary to move a station to a new orbit or to change their location due to new construction, other obstacles, etc. Stations may be towed by several starships or system craft working together. Because they are not really meant to be moved, stations may only move at a maximum thrust of 0.1; thus moving a station from one planet to another is going to take a long time. It takes 100x as long as a speed 1 ship to move the same distance. Thus at a speed of 0.1 it takes 63,300 seconds (17.6 hours) to move 1000 km, 200,000 seconds (55.55 hrs) to move 10,000 km, 10,500 minutes (7.3 days) to move 100,000 km, 33,000 minutes (22.9 days) to move 1 million km, 1,760 hours (~2.5 months) to move 10 million km, etc. based on a thrust of 0.1= 1 meter per second squared.

Stations must be moved by ships when in transit. Stations constructed of standard or planetary hulls may have a ship or ships push with any amount of thrust (provided all ships are using the same thrust). For example, a 2000 ton cruiser with a thrust of 3 could move a 60,000 ton station (thrust-3 x 2000 tons x 10). Distributed stations, however, are somewhat fragile; a ship can only push with a maximum of 1 thrust unit. This means in practice that for every 1000 tons of station there must be 100 tons of ship pushing. Thus for a 25,000 ton distributed station, 2,500 tons of spacecraft must be used continuously to move the station. This is not a commonly used technique, however. Modular stations must be disassembled, each separate module moved to their new position, and reassembled onto the base station.

Stations also require minimal thrusters for orbital maneuvering, although stations not orbiting a planet do not require any thrusters (but would be a zero-G station since M-drives provide the gravity for a ship or station). A station requires only enough thrust to achieve a velocity of roughly 0.02 to maintain orbit. Note that this is barely enough to provide gravity and maintain orbit; it is NOT enough to move the station. Thus the 25,000 ton station above only requires a Type C gravitic engine. Only the base module on a station may provide orbital thrusters, so the initial construction of a station limits its maximum size if found in orbit. The base station's engines must support the station and all attached modules.

Station modules are constructed from the same materials and systems used to build spacecraft. Individual station modules are made of standard or dispersed hull material and can survive being transported by jump capable tugs provided the tug has the engine power to move the station and can stay under the 5000 ton limit for jump travel. Larger station modules cannot be moved via jump travel, so these modules must be constructed in system, often in parallel with the base station itself in the same orbit.

Starship and Station Construction

Many starships are built in stations designed for the job. Because they are required to have a fair degree of structural stability (even dispersed starships), spacecraft are always constructed as a single entity. Even modular craft, for example, have their hull value provided by the hosting ship. For construction purposes, starships require a hangar twice as large as the hull size; to build a 5000 ton freighter therefore requires a 10,000 ton hangar. Using a smaller hangar or no hangar doubles construction times making it economically impractical. Note that ship hangars normally need 30% more space just for repair, and construction is a more difficult operation. The construction of a starship or module may only take place at a planet which has the tech level to support that level of construction, so only TL14 and TL15 worlds can build TL 14 class ships. This is one reason lower TL ships are so common around the galaxy.

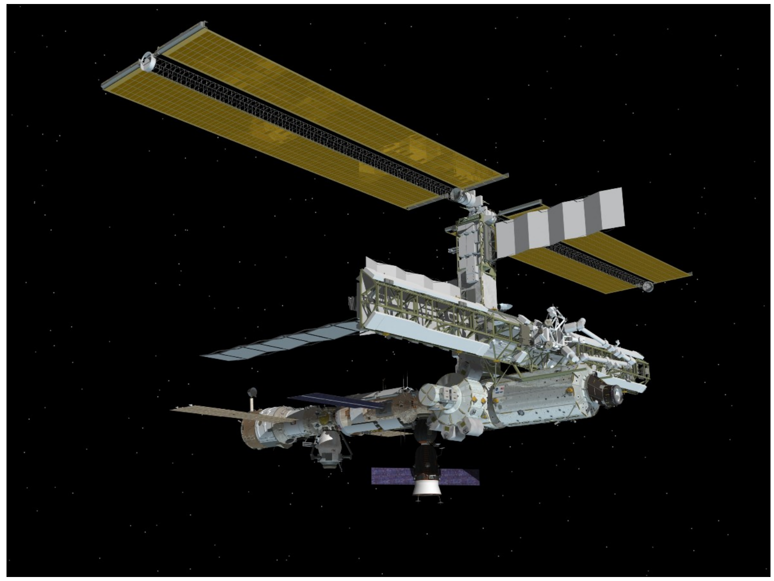
Shipyards are usually a very large dispersed cluster of construction modules that manufacture many different ships at once. Given that large vessels take years to build under the best of circumstances, a large shipyard will have many different hangars where work is under construction. Military shipyards, because they make such a tempting target, always have top notch defenses and usually have their own protecting fleet as well.

Planetoids, because they have the 'shell' of the station already present, are not constructed in a hangar. They must be hollowed out using mining procedures and zero-gravity work which requires a lot of attention and fine detail work. Many of the same techniques used in asteroid mining are used in hollowing out planetoids, allowing a fair amount of switching between these careers. Planetoids take 1 day per 1 MCr construction time; hollowing out a planetoid is faster than constructing in zero-G, but maneuvering the components into place takes more time. Modular structures may be included on planetoids bases, but only on the surface. There, they may be targeted independently, must have their own power, etc, just like other station modules. Planetoids make excellent hangars for constructing large ships or modules as they are relatively inexpensive to hollow out compared to building a hangar from scratch. Planetoids may be pushed around a system using ships the same way that stations may be moved.

Space station modules are usually constructed in hangars similar to starships. Large station modules, however, simply won't fit into most hangars. It is more time consuming to construct a station in zero-G vacuum than in a hangar. For all construction outside of a hangar, time is basically doubled; ie. 2 days per 1 MCr value. Note that ships may be constructed the same way, but the greater efficiency is almost always worth the one-time expenditure to make a hangar capable of building large ships and is assumed in their construction costs and times. Note that the increased time is to construct a station module itself; assembly of already constructed modules generally happens in a 4-24 hour timeframe and is a standard engineering (spacecraft) check.

Modular Station Construction

Some stations, particularly those made from a hollowed out planetoid, can be made as a unit. Other stations, however, have grown and expanded haphazardly over decades or even centuries. Modules within stations have a number of characteristics. First, they must contain independent power supplies and life support for all of their systems. Second, they may be armored individually such that some sections (Meson Weapon Module) can have more protection than Ore Storage. They may also be targeted independently by attacking ships. Station modules are connected by airlocks and must be clamped together using appropriately sized clamps; destroying the clamps will cause station modules to slowly drift apart and prevent movement betwen station modules. Reducing the structure of a module to 0 will cause that module to fragment and break apart similiar to reducing the structure of a ship to 0.



Clamp Tonnage	Attached Module	MCr
1	10-30	0.5
5	40-90	1.0
10	100-300	2.0
20	400-2,000	4.0
50	2,500-15,000	8.0

Life support within a module is generally provided through staterooms or barracks. If a module does not have enough staterooms or barracks, the atmosphere of the module will slowly deteriorate and people will become poisoned as long as they are in overcrowded conditions. Life support for visitors may be provided at 1 ton of life support per 20 average sophonts; this is often used in retail and/or docking areas of stations with large transient populations. 1 ton of life support costs 0.5 MCr. Note that under most circumstances this extra life support is not required; it is only critical when stations are attacked, systems fail, or modules separate from one another.

As with ships, station modules use standard designs that may be replicated across star systems. For example, an Agriculture Module is pretty much the same across worlds because it serves the same function. Because modules must be able to function somewhat independently, they are often constructed at different tech levels. This can cause problems for repair crews tasked with working on all of these different types and tech levels of modules. Stations have a well earned reputation throughout sci-fi literature for being a hodgepodge of styles and a maintenance nightmare. This same modularity, however, allows a station around a TL8 world to have a high tech battle module shipped in from outworld to give an attacking fleet a surprise.

Module Components

Space station modules contain a number of features which allow them to work together efficiently with the base station. Typically large modules are connected to the base station via a central lift system that allows efficient cargo and sophont movement within the station proper. A system of 2 standard airlocks are arranged diagonally across the central cargo lift. Docking clamps (20 tons for a 2000 ton or smaller module, 50 tons for up to 15,000 ton modules) are provided by the base station as attachment points for the various modules. Typically each module provides the space for cargo lifts to reside while being loaded/unloaded and not to block the base station lift tubes. Cargo lift docks, like airlocks, are provided by both the station and the module. Cargo lift airlocks take up 10 tons and cost 2 MCr. Additional cargo lift storage slots for loading and unloading take up 6 tons and cost 0.5 MCr.

Along with docking arrangements, each module greater than 100 tons requires an independent power plant 1/5 the size of an equivalent sized ship with a thrust of 1. Thus a 2000 ton module (a convenient size for construction, freight movement, and clamping) requires a power plant sufficient for a 400 ton vessel to move at thrust 1, or a Type B power plant. If the station is around a middle planet (the typical case), solar panels equal to 1/10 the size of the Type B power plant (0.7 tons) may be used to provide nearly unlimited power for daily needs. Certain modules require higher power, but since modules never have to power gravitic engines they can use smaller power plants than ships. Station modules may never have independent orbital thrusters or M-Drives; the base station is required to provide gravity and orbital maneuvering. When decoupled from the base station, modules lose gravity and zero-G skill becomes critical.

Station modules are armored independently from the base station. All modules have 2 structure and 2 hull points per 100 tons of size, the same as ships. As with ships, armored modules must be constructed with standard hull plating in order to provide sufficient support for the armor. Note that modules are never streamlined. Modules that are not armored may use dispersed structure hull materials that cost 50% of the standard hull material. If a station module loses all structure points, none of the systems present on that module function. Pieces may easily break off and drift away, but in any case the entire module must be replaced. Sophonts unlucky enough to be trapped in a destroyed module may (or may not) be trapped in staterooms which are airtight but can only survive a limited time without power.

Station modules require a certain amount of life support infrastructure to support whatever sophonts are living or working in the module. Normally these are provided by staterooms. In a station, however, people may live in a different module from which they work and they still need to breathe. For such circumstances, life support machinery (CO_2 scrubber, filters, oxygen converters, heaters, etc) may support 20 sophonts per ton of dedicated machinery. Life support for 20 sophonts weighs 1 ton and costs 0.5 MCr to buy and 2000 Cr/month to operate. Certain emergency craft might also carry life support to aid crippled vessels in urgent situations. Note that this support is meant to be temporary; it does not supply room for sleeping, eating, etc- merely the most essential aspects of life in space.

Each station module also requires independent control circuitry to control the functions of the module. Since each module is not responsible for all of the functions of an entire ship, a module's command center weighs 1/100 the total size of the module and costs 0.5 MCr/ ton. Decentralized controls mean that loss of 1 control center does not shut down every module on a station.

Computing power on a space station tends to be distributed to modules that require it. No module may have more than 1 primary computer system active at any time, and control of that module's functions are always operated only by a computer in that module. Backup computer modules that come online in case of damage to the primary system are also allowable. Clever engineers have been known to link computers in one module to another module under emergency situations, but these are jury-rigged and prone to failure.

Screens work differently on space stations due to their modular nature and the nature of the screens. Meson and nuclear screens prevent the damaging effects of those weapons from happening within their protected areas. Thus individual modules may be protected by screeens while others are not. Either the entire module or none of the module may be screened. Screens weigh 50 tons and are sufficient for screening 5000 dtons of space. For modules larger than 5000 tons, additional screens must be used and spread out within that module. Thus a base station module of 20,000 tons would require 4 meson screens in roughly 5000 ton sections to block out 2d of meson damage on a successful screen deployment. This may be accomplished at TL12, as individual screen generators do not have to work together to shield that part of the station. For stronger screens, screen generators can be linked together at higher tech levels (see ship design) as long as power requirements are met. Thus to provide a 20,000 ton base module with 6d of meson screens, each of the 4 'sections' would have 3 screen generators linked together, become available at TL14, and require enough generators to reach power level 3. To be screen for 6d of meson AND 6d of nuclear damage, it would need to have a power level of 6 (3 for meson screening and 3 for nuclear screening) but only TL 14 since the nuclear and meson screens function independently.

Black globe generators, on the other hand, must be large enough to enclose the entire structure in an impenetrable force field. Therefore the base station module must be TL15 (minimum to use a black globe generator) and have a power level of 2 per set of black globe generators installed. For the 20,000 ton base station above, it would require only 4 black globe generators. However, base stations typically have many modules attached to it, increasing the size to cover the entire station (base module + all other modules) to perhaps, 500,000 tons total. Those 4 black globe generators have now multiplied to 100 generators spread throughout the station. Each module using a generator would have to be TL15 and have a minimum power level of 2. Only high end military stations are likely to have black globe generators in any case.

Unlike most ships, space stations are often used as manufacturing hubs for a planet or system. This is an activity related to mining, but takes refined material and creates a finished product out of it. Station manufacturing plants occupy 6 tons of space and cost 1 MCr and typically require 1 crewman (generally a technician, not a full fledged engineer) to operate. For every 60 tons of manufacturing, however, an actual engineer is required to make sure the facilities are properlay maintained and repaired.

Base Stations

Base stations are the key piece which limits the size of the entire station and serve as the structure to which all other modules attach. Independent stations require gravitic engines to work as orbital maneuvering thrusters when orbiting a planet or a star. These thrusters must be able to power 1/50 of the total mass at thrust-1. Note that a base module with an M-Drive must have power plant(s) equal to the size of the M-Drive. This also means that other power plants must also be of the same type. For example, a 1 million ton station requires a Type FF maneuvering engine. The station will then require Type FF power plant(s) or better to support it, and all of the power plants within the base module must be of the same type. Because stations require some orbital maneuvering thrusters and the maximum standard thruster size is KK, this is enough to keep a 1.5 million tons (base station plus all attached modules) in orbit.

If a base module does not have orbital thrusters, it is at the mercy of anything that changes the orbital path of the base. A large ship leaving or arriving, for example, might change the angular momentum of a small station and alter the orbital path. A station without orbital thrusters will require regular adjustment by ships to keep it in a stable orbit. Bodies such as moons or larger asteroids generally will not change their orbital positions unless a great outside force acts upon it.

One of the primary purposes of a base station module is to provide connectivity between different station modules, perhaps a hangar to a cargo bay. The cargo lifts used in the standard module connectors need to have ways of reaching other modules. For anything other than the smallest base modules, this will require 2 paths (ie. moving in opposite directions), or a one-way circular connection to keep traffic jams from occurring. Cargo lift docks move lifts out of the central shaft for loading and unloading and to reduce congestion. The cargo lift tubes and passageways are not expensive, but take up a significant amount of space. For base stations, 25% of the total displacement tons is for lift tubes and associated structures which cost 0.1 MCr/ton.

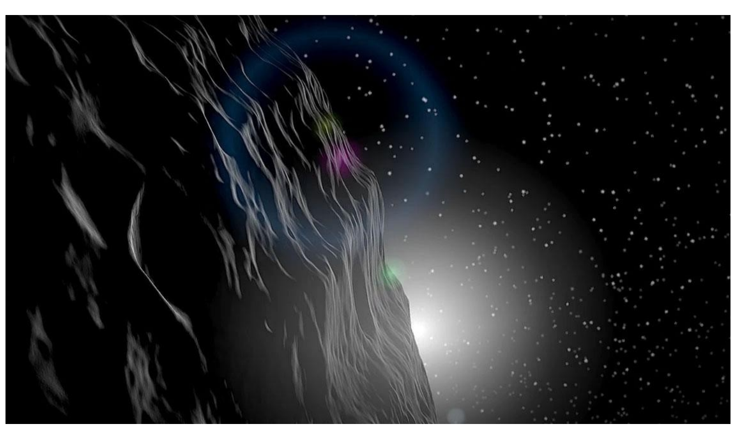
Stations also require more control circuitry than normal modules do. For base stations, the command center displaces 1/50 (2%) of the volume of the base module and costs 0.5 MCr/ton. The minimum computer rating is 5 per quarter million tons of total station. Sensors and sensor arrays are also mounted on the base station, often with redundant arrays to protect against failures. Individual modules may also have their own sensors, particularly for military purposes.

Typically the base command center (along with any defense modules) have the strongest defenses of any part of the station. Armor to reduce damage to the station is almost required for the station to survive. Stations have 2 structure and 2 hull points per 100 tons just as ships and modules. If a normal module is destroyed, that module is lost. If the station loses all structure points then the connecting struts between modules fail and all hell, or at least all modules, break loose as the station breaks apart. Destroying clamps on base stations is another technique to cause modules to be released, but because the module still has its own independent power it may function normally for a time (although transportation to other modules is impossible and communications will probably be disrupted as well).

Cutter Modules as Station Modules

Modular cutters use standardized 30 ton modules that increase the utility and range of functions vessels can carry out. While 30 ton modules would be very small for larger stations, a tiny station could be reconfigured for many different uses by substituting different cutter modules. Unlike larger modules, cutter modules do not require additional power or command center needs as their functions are relatively simple. The base module requires a dedicated airlock (1 ton) and a 1 ton docking clamp to attach each cutter module (which also requires an airlock). For cutter modules attached to a station, they may only require a power level of 1. If a station module includes a certain percentage of 'modular space' for cutter modules, the extra power requirement is not needed as the space is already accounted for using the normal rules for modular ships (just as cutters do not need extra power for modules under normal circumstances).

Planetoid Bases and Outposts



Conceptually, any body in orbit may be made into a base by hollowing out part of the structure for use. A moon such as Luna that has a small underground TL7 structure for 3 people in it is a 'planetoid base'. The difference is in degree. Mining out a planetoid is relatively inexpensive compared to constructing a complete ship of the same size. Planetoids cost 10,000 Cr (0.01 MCr) per ton to hollow out into a base (10 MCr per 1000 tons). The maximum volume which may be hollowed out of any planetoid is 80% of the planetoid's mass, although it is very easy to hollow out smaller percentages (see the TL7 Luna moon base above). Planetoids may not function as modules, but may serve as a base stations for attached modules. They are never streamlined.

Planetoids have a certain amount of inherent armor given their nature. If a planetoid base is less than 65% hollowed out, it receives 4 points of 'free' armor. If a planetoid is less than 20% hollow, more armor to that base may be added according to how large the actual base is; ie. the small Luna base might have 4 additional points of armor added without having to armor the entire moon. These are generally referred to as asteroid bases or moon bases rather than stations. If the planetoid is more than 20% but less than 65% hollow, the entire planetoid must be armored. These are referred to as 'buffered' planetoids and are considered stations. Planetoids 65.1 to 80% hollowed out receive only 2 points of free armor. These stations have more internal room but the external shell is weaker and there is less internal reinforcement. For an old enough society "That's not a moon, it's a space station!" is actually possible.

Planetoid bases that take up less than 20% of the mass of the planetoid do not need additional thrusters to maintain their orbits. The normal changes in mass are generally too small to significantly alter the orbit of the planetoid. (Intentional orbital alterations are another matter entirely.) Buffered and unbuffered planetoids may have their orbits degraded by mass shifts and therefore require regular orbital corrections. As the mass of the station is one structure, the whole mass of the planetoid must be moved either by ships or by gravitic thrusters. As such, the mass of a planetoid station is limited the same way as other stations by the maximum standard engine size of KK (ie. 1.5 million tons) unless a sizable fleet is available to reposition the planetoid. Alternative methods of changing the orbits of planetary bodies (nuclear explosions, etc) are beyond the scope of these stations and should be carefully considered before implementation.

Planetoids can be quite massive, but unless the base is built into or on an actual planet or larger moon the gravity will be minimal at best. In order to provide gravity to the base, a gravitic drive appropriate for the size of the base must be installed. The gravitic drive is not able to move the planetoid, but it is designed to allow sophonts working on the station to be more comfortable and capable in their duties. As with gravity aboard stations, the gravity of the base can be adjusted down to the minimum supplied by the planet or planetoid.

Note that there is nothing to prevent the construction of small planetoid 'stations' that can move quickly. Type KK gravitic M-Drives can move a 5000 ton ship at thrust-6; whether that ship is built of standard hull material or composed of a 5000 ton planetoid is irrelevant. Thus a 30,000 ton planetoid station could move at thrust-1 around the system using a Type KK M-drive. Jump engines, however, have stability issues that limit the maximum size of a jump capable starship to 5000 tons. The pocket universe created by the jump engines are only so stable at TL15. Spacecraft restricted to normal space have no such restrictions. System defense planetoids maxed out on weapons can be remarkably difficult to destroy by incoming jump capable starships.

Planetoid and buffered planetoid stations have the same number of hull and structure points as completely constructed ships; ie. 2 points of hull and 2 points of structure per 100 tons. For small bases on large moons, though, things can be more complicated. A meson gun emplacement buried under 10 km of rock has nearly unlimited structure points, while a base just under the surface might have the same number of structure points as a regular planetoid station. Surface installations have fewer structure points, but a deep base might be relatively easy to completely cut off from the surface. The referee will need to determine precisely what rules apply given the situation on moon bases and base structure.

Feeding the Crew

Living out in 'The Black' is all well and good, but space is a very lonely and empty place. Where do space crews get most of their food? Clearly the bag of chips from the convenience store down the street is out. Some races may enjoy the hunt or prefer sea-based food, but in space habitats such as stations or remote outposts some sacrifices must be made.

Given the variety of sophonts found in the galaxy and their diverse origins, no single type of food is acceptable. Merfolk and avian physiologies aside, a diversified diet is essential for long term health and satisfaction of those living in space. The same is true here on Earth. In short, food must be produced somewhere and that origin has consequences for everyone concerned.

For systems without gravitic drive technology, agriculture is an essential planetary activity which could limit the maximum population on many worlds. In the United States in 2012, roughly 1 acre of arable land was required to feed 1 person for a year. Lower tech societies will generally have lower productivity per acre, and higher tech can reasonably increase efficiency somewhat. If a low tech planet cannot produce enough food, people starve until the balance stabilizes. If a stellar technology system does not have enough arable land for growing their own food, they have 2 choices: 1) import food from other systems, or 2) grow the food in space.

Most polities want control over their own food supplies for self protection, so space (ie. non-habitable regions of a system) might seem preferable. In order to grow food in space, some conversions need to be done. One acre is approximately 4050 square meters of cropland. When taking farming into space, it seems reasonable to use technology such as vertical farming, green walls, hydroponics, multi-level farming, year-round productivity, and more efficient water/fertilizer use. For lettuce in 2015, hydroponics used more water and energy but increased production per 'greenhouse unit' by slightly better than 10-fold. Using this as the average future productivity standard at TL7 suggests that about 350 square meters per person per year is probably doable.

In space, inorganic fertilizers are recyclable and solar or fusion power make light inexpensive. Lighting can be optimized to provide the correct wavelengths for maximum growth. The challenge is growing area or volume. Agricultural modules can be designed to stack atop one another and share common collecting tubes, but plants take up some volume and animals would require even more space to raise for food. Much of that volume will be air, but some will be drone harvesters, transport tubes, lighting, and such. 1 dton has a volume of approximately 14 cubic meters; converting 14 m^3 to a short 1.4m height, this is roughly 10 square meters per dton. If 350 square meters are needed per person per year, then it would take roughly 35 dtons of agricultural volume to feed one person continuously for a year.

Earth is still very much learning how to live in space. By TL8 (particularly with gravitic engines), sophonts are more familiar with the requirements of space life and how to make the most of the available volume. This suggests that about 30 dtons of dedicated agricultural space could support 1 average sophont for 1 year. Naturally smaller or larger beings would need less or more food appropriately. By TL11, genetically engineered plants and even more efficient farming techniques would likely reduce space even further to perhaps 25 dtons per sophont. By TL14, xenoengineering, nanofabrication of recycling equipment and maximization of crop yields can reduce the space required even further to 20 dtons per sophont. This volume of agricultural space would allow a mostly self-sustaining ecosystem for living on a space station or moon base assuming efficient waste and water recycling.

Put another way, a moon base supporting an average population of 10,000 sophonts at TL8 would require 0.3 million tons of agricultural space to feed that many people without food imports. At 0.01 MCr per ton for hollowing out a planetoid base, the 300,000 tons would cost 3,000 MCr just to provide the space to feed that many people, independent of staterooms, power, harvesters, etc. Even at TL14, it would still take 2,000 MCr. For large constructed modules (assuming 1/2 price for dispersed structure), volume costs roughly 0.05 MCr per ton. (It would cost twice as much using standard hull costs.) That means 300,000 tons of module space comes to approximately 15,000 MCr (5x as expensive) to feed those same 10,000 sophonts at TL8. A trillion credit TL14 agricultural 'squadron' could only feed about 1 million people annually. That's a lot of credits!

One workaround fiction authors have used for years is to eat yeast grown in large vats, often with different additives to give various flavors or textures. In reality, yeast digest the same food we do, particularly sucrose, molasses and various other sugars. The do not photosynthesize and therefore they cannot contribute to the actual food supply. In space, the beauty of photosynthesis is that it takes human waste (not just excrement but carbon dioxide as well) and converts it back into consumable food. Since yeast consume sugars and produce their own waste (which may be rather tasty when produced from barley or grapes), they are clearly a poor choice for a primary food source.

Algae cultures might take the place of yeast vats, but the opaque nature of any algae culture (since it must, by definition, absorb light energy to photosynthesize) puts an upper limit on the density of the organisms used. Under ideal high density conditions, algae achieve only about 50% of the biomass that yeasts can. This assumes optimal nutrients, pH, atmosphere, etc. For algal species commonly cultured during the 1990's, typical conditions used produced only 250 mg (yes, milligrams!) of algae per liter according to a UN FAO Fisheries technical report from the United Nations. Besides, eating the same thing day after day, even when prepared differently, would get very boring very quickly. Try eating nothing but broccoli cooked different ways for a week, then imagine doing the same for months on end. Even one week in jump space would cause a quick mutiny!

When viewed under these conditions, habitable planets are the most efficient method to feed sophonts of all types. Inhospitable planets and asteroids could provide the raw materials and resources to protect the environment of the fertile planets and garden worlds. Given that the United States alone had over 900 million acres of farmland as of 2012, habitable planets are clearly the most important source of food in the galaxy. Semi-habitable worlds with non-toxic restrictions may also be quite productive depending upon the crops growing there. Water planets with their massive oceans of productive volume could also be important sources of various foodstuffs. In all cases, planets have significant cost advantages per ton of food production compared to anything in space.

Importing food to stations and asteroid systems is thus likely critical for their survival. When examined closely, a station such as Babylon 5 (250,000 'souls', 5 million 'tons') could not support itself. 5 million tons of just agriculture space at TL11 would feed roughly 200,000 people but allow nothing else, while 250,000 sophonts would need 6.25 million tons devoted just to agriculture. Because many stations are continuously inhabited far from homeworld support, these stations would require regular resupply runs to keep fed.

Calories come primarily from 3 sources: sugars, fats, and proteins. Fats are about twice as efficient (9 cal/g) as sugars (4 cal/g) and proteins (4 cal/g). As these are purified molecules, the tech level of a society cannot really increase these significantly short of a Star Trek replicator reassembling molecules from their component atoms. Organisms take up a fair amount of space, as do all of the molecules humans eat.

Astronauts aboard the International Space Station consume roughly 2 kilograms of food and water per day, and considering the cost of shipping anything from Earth to low orbit NASA minimizes weight everywhere they possibly can. Therefore one ton of imported, processed food will feed (approximately) 500 people well for one day, so perhaps 1000 people would eat a ton of food during an emergency. Thus Babylon 5 would have to get a minimum of 250 tons of food every day from somewhere to feed its 250,000 people. For stations near habitable planets, these shipments might be relatively easy. For an asteroid based system, though, having reliable sources of food shipments would be essential. Disrupting even a few food or water shipments to a base (on Ceres, perhaps?) might quickly create a humanitarian disaster. "Remember the Cant!" for those of you who are fans of ‘The Expanse’.

Just like medieval castles centuries ago, blockades are perhaps the most effective way of neutralizing space bases of all sorts. Stations can have deadly weapon arrays, but meson bays and nuclear torpedoes do not taste very good come dinnertime. Starving people become desperate, and this was historically how 'impregnable' castles would eventually fall. Supply lines in space are just as important as they are during any other time period. This dependence on supplies leads naturally to profitable but dangerous activities such as blockade running, privateering, profiteering, hoarding, price gouging, breaking a blockade, etc.

Another way of taking over a space station might be to contaminate or poison the station's food supply and make it unfit for consumption. In the original Star Trek series "The Trouble with Tribbles", Klingons poisoned the wheat (OK, "quadrotriticale") intended to support a remote outpost in contested space. Given the variety of engineered viruses and plagues available in the far future, a debilitating illness striking at a critical time could give the invaders a quick victory vs a protracted, expensive siege. The Klingon plan may not have been successful, but that does not make it an invalid strategy.

Starships typically do not have to worry as much about the volume of food they consume. Not only do ships have relatively small crews compared to stations, they also typically visit known planets or bases quite regularly. A 2500 ton cruiser with a crew of 100 sophonts, for example, would need less than 1.5 tons of food per week assuming the same nutritional density as planetary food. A small freighter with a crew of 5 could go for more than 3 months on 1 ton of food. Long duration missions into unknown space might be a problem, but normal deployments or trips require minimal space for food storage. A starship uses far more hydrogen fuel than food. Stations and outposts which are continuously manned and located far from home, however, may need rather extensive dedicated agricultural facilities if they are to be self sufficient.