Starship construction

Introduction

This is an alternate ship construction system for the Star Frontiers RPG. While all the components are the same as in the standard Knight Hawks rules, this system takes a more realistic approach to the construction of the ships. This ship construction system is volume and mass based. While the KH system is based on picking a hull size and then limiting what the ship could do based on that, in this system you pick the components of the ship based on what you want it to do and the capabilities and performance you want it to have. The hull size is then just a function of the ship's systems.

From the perspective of both the KH board game and general role playing, the resulting ships are nearly identical to those generated with the KH system. The differences are mainly in size and cost.

The main differences are as follows:

- Life support systems have more variety, are more detailed, cost more and are bulkier than in the KH rule. They also scale more realistically as you increase the number of beings supported.
- Hulls have more variety and are more expensive. In addition to the standard hull, we introduce three additional hull grades that have varying cost, mass and hull points. In addition, instead of the cost of the hull scaling linearly with the hull size of the ship, it now scales with the volume of the ship.
- Engines are more appropriately scaled. Each engine type and size now has a thrust rating. This combined with the mass of your ship gives you the acceleration that the ship can achieve. The engine classes are scaled appropriately to provide proper amounts of thrust to move the bigger ships. The costs are also scaled appropriately to the thrust provided by the engines.
- These ships are more expensive. This primarily due to the changes in the cost of hull, engines and life support. All three of these systems are more (and in some cases much more) expensive than the same systems in the KH rules. This was done for a variety of reasons but primarily to make the costs scale realistically with the size and capability of the systems as they grow larger.
- Hull size is computed a little differently. While it still scales exponentially with the volume of the ship, it has now been modified so that the hull size and volume are mathematically related instead of being arbitrarily scaled. This has the result of making the smaller hull sizes larger than the corresponding hull size from KH while the larger HS ships from this system are actually smaller than their corresponding KH HS ships. For example, an average HS 1 ship in the new system is 64 cubic meters in volume which is double the size of a HS 1 ship in KH. And HS 1 in this system goes up to 216 cubic meters which is nearly half the size of a HS 2 ship in KH. On the other end, an average HS 20 ship in the new system has a volume of 512,000 cubic meters which falls between HS 11 and 12 in the KH system.
- One final difference is that the definition of a cargo unit has been standardized to a specific volume. This is more realistic than the KH system of one cargo unit per HS since in that system you could increase the HS by 2 and double the volume but only increase the cargo capacity by 2 not doubling it even though the ship was vastly larger. This eliminates that. It also means that ships will have tens to hundreds to even thousands of cargo units of hauling capacity. A future work will redefine the cargo tables to give prices and volumes to work with this new system.

Unless otherwise described, assume that all systems are identical to the systems described in the KH rules.

Building Ships

There are actually different ways to go about the ship construction process. The first, is fully customizable and results in ships of arbitrary size based solely on the systems and components selected. The second is to pick a standard sized hull and fit what you can into the ship. This latter method is simpler, but requires more compromises in the ship construction system to make everything fit.

We'll describe how to do the fully customized ship construction process first and then cover what needs to be changed for the alternate method. In all cases, fractions should be rounded down to the nearest whole number unless otherwise stated in the construction rules.

The steps to designing and building a new custom spacecraft are:

1. Select purpose of the ship. Doesn't have any direct effect on the ship's statistics, cost, etc but guides the design of the ship through the later stages
2. Decide if ship is to be aerodynamically streamlined for work in atmosphere. If so the volume required by some systems is larger because it has to be housed instead of mounted outside the ship.
3. Select astrogation systems
4. Select communication and sensor systems
5. Select Weapons and Defenses
6. Select Specialized equipment (mining, cargo, etc)
7. Determine cargo bay size
8. Select ship vehicles and bays
9. Determine crew/passenger size
10. Select crew and passenger accommodations
11. Determine life support requirements
12. Determine the Damage Control Systems
13. Determine initial computer requirements
14. Determine hull size
15. Determine hull type
16. Add any additional armor
17. Determine ship's total mass
18. Pick engine type, number and sizes
19. Finalize computer requirements and verify power requirements and size
20. Calculate final cost
21. Determine ADF, DCR, etc

Using the spreadsheet

Accompanying this design document is a spread sheet that will do all the calculations of mass, volume and cost for you as you design your ships. This spreadsheet does the exact calculations described in this document and doesn't used any of the approximations.

To use the spread sheet, just fill in the gray boxes with the appropriate values as you work through the design process. In a couple of places, values computed in one area have to be entered in another. Simply enter the values in the blue and green boxes into the gray boxes with the matching border colors.

In the "Ships Carried in specialized bays or external docks" section, just enter the values for the ships you want to be carried. Put a 1 in the 'bay' or 'dock' column if you want the the specified ships to be in bays or on external docking points. If you have the same type of ship in both locations, use two entries.

Put a 1 in the Aerodynamic box if the ship is to be streamlined for atmosphere and enter a zero or leave it blank otherwise.

The gray areas in the computer section are for entering extra programs from the AD book.

In the backup life support and backup computer sections, enter the number of backup systems you want to have. The spreadsheet assumes complete backups that are identical to the main system. If you want to vary it, you will need to compute the backup information by hand.

Once you're done, the ships final values will be recorded in the area with the red border.

Ship's Purpose

What is the intended purpose of the ship? Is it a military vessel, a freighter, a passenger liner, a private yacht, or something else entirely? While there is no direct cost or impact associated with this choice, knowing what you want the ship to do guides the purchase of the ship's systems and may make decisions on whether or not to include a system easier as you go along.

You might also have a budget for the ship construction process. Keep this in mind as you go along as the costs of some of the various systems can add up fast.

Streamlining

Ships up to 20,000 cubic meters (cu. m hereafter), which is the middle of the HS 7 range, can be streamlined to be able to enter and operate inside planetary atmospheres. You need to decide if you want your ship to be streamlined or not. This has a couple of effects on the design and cost of the ship. If you are going to have a streamlined ship, some systems will take up more volume in the ship. This is due to the fact that in non-streamlined ships, these systems would extend beyond the hull and not have to be completely contained. In addition, streamlined ships cannot have any smaller vessels mounted on external docking points. All smaller craft must be contained inside bays.

Astrogation Systems

Different types of ships need different levels of astrogation equipment. Depending on the type of ship, choose the appropriate astrogation suite from the list below

Shuttles - Only basic astrogation equipment is needed as they are traveling only between ships or from a planet's surface to orbit and back. Cost: 1,000 cr, mass: 0.3 tons, volume: 0.1 cu. m

System Ships - These ships need telescopes and other astrogation devices that will allow them to move around between planets and moons within a system. Cost: 5,000 cr, mass: 1 ton, volume: 2 cu. m.

Starships - In addition to the astrogation requirements of a system ship, these ships need large telescopes and sensitive detectors to measure the positions of faint stars to determine the ships exact position and plot interstellar jumps. Cost: 15,000 cr, mass: 3 tons, volume: 5 cu m.

Deluxe starship package - This is a more sophisticated starship astrogation package that includes more sensitive detectors and a larger telescope. It provides a 20% reduction in the time required to plot an interstellar jump and provides a +10% skill bonus to the astrogators using it. Cost: 50,000 cr, mass: 10 tons, volume: 25 cu. m.

Communication and sensor equipment

There are a variety of communication and sensor equipment that can be employed by the various types of star ships.

Radios

Videocom Radio

Base system: cost: 1,000 cr, mass: 4 tons, volume: 2 cu. m (5 cm if ship is aerodynamically streamlined)

Additional screens: cost: 100 cr, mass: 0.1 ton volume: 0.5 cu m

Subspace Radio

cost: 20,000 cr, mass: 6 tons, volume: 3 cu. m (5 cu. m if ship is aerodynamically streamlined)

Intercom

This is an intraship device that allows communications between various rooms in the ship. The master control panel is typically located on the bridge of the ship with an alternate control panel in the captains quarters. Standard panels are typically found in all major rooms of the ship and all rooms will have at least a speaker panel.

Master Control Panel: cost 50 cr, mass 0.05 tons, volume 1 cu m

Standard Panel: cost: 10 cr, mass 0.01 tons, volume 0.5 cu m

Speaker Panel – This is a simpler panel that contains speakers but no microphones. Typically these panels are placed in locations where announcements need to be heard but two way communication in not necessary. Cost: 5 cr, mass: 0.01 tons, volume: 0.3 cu m

Long Range Detectors

Radar

Radar are combination active/passive systems. In active mode they send out pulses of radio waves and detect the reflected pulses. In passive mode, they scan space for emissions from other ships. The range of the radar system depends on its rating. The higher the rating the more distant an object it can detect due to stronger emitters and more sensitive receivers. It takes a lot of power and large transmitters to get returns from objects in the larger areas covered by the higher rated systems. The listed range is the range for the active system. In passive mode, the ranges are 10 times larger but can only detect targets that are radiating at radio frequencies.

Rating	Range (km)	Multiplier
1	300,000	1
2	600,000	8
3	900,000	27
4	1,200,000	64
5	1,500,000	125

Cost: 10,000 cr x Multiplier, mass: 15 tons x Multiplier, volume: 5 cu m x multiplier (7 cu m if aerodynamically streamlined)

Energy Sensors

These are broad spectrum radiation detectors that look at multiple wavelengths to detect radiation from ship systems. They scan radio, optical, infrared, x-ray, and microwave wavelengths as well as have gamma-ray detectors and look for signatures from ships' engines and power plants. These are completely passive systems and like radar come in different ratings that have increased sensitivity. The ranges listed are for detecting shielded, ship sized energy sources against the cosmic background. If an object is putting out energy emissions that are stronger than typical radiation leaked from ship systems the detection range could be much larger. For example, even a type 1 energy sensor suite will still be able to detect the system's star at ranges of billions of kilometers. Exact details are left up to the referee.

Rating	Range (km)	Multiplier
1	500,000	1
2	1,000,000	8
3	1,500,000	27
4	2,000,000	64
5	2,500,000	125

Cost: 200,000 cr x Multiplier, mass: 50 tons x Multiplier, volume: 20 cu m x multiplier

Local Detectors

Portholes

These are simply sections of the ship' metal hull that have been replaced with a hard, strong, clear plastic panel to allow views outside the ship. As such they don't add mass or volume to the ship, just cost. Each porthole represents a 0.5 m x 0.5 m clear panel. Cost: 50 cr, mass: 0, volume: 0.

Cameras

This is a series of cameras and monitors that are placed around the exterior of the ship. They can be used to monitor the ship's hull or scan space nearby. The standard system includes the cameras necessary to cover the entire ship's hull, data storage system and a set of 6 monitors for use in real time monitoring of the camera system. The exact number of cameras required depends on the ship's size and thus the cost varies as a function of the ship's final volume.

Cost: 25,000 cr + 100c per 1000 cu m volume, mass: 5 tons, volume: 10 cu m

Skin Sensors

Skin sensors are small pressure gauges that can be embedded into the hull of the ship. They allow for notification of the location of anything that comes in contact with the ship's hull. Skin Sensors require a level 1 (1 FP) program to collect and process the data from all the sensors. The cost of the system is dependent on the final volume of the ship.

Cost: 100 cr x sqrt(final volume), mass: 0.01 tons x sqrt (final volume), volume: 1 cu m

Jamming Equipment

White Noise Broadcaster

A white noise broadcasters (WNB) blanket a region of space with radio noise across a wide spectrum that effectively drowns out any other radio communications within that area (either originating or crossing). The strength decreases as a function of the distance from the generator.

The basic WNB blocks all radio communications for ships within 10,000 km of the generator. Beyond that range, the chance of the communication getting through increases by 1% for every 1,000 km of distance from the generator. So a ship that was 45,000 km away, would have a only a 35% chance of getting a message out (45,000 – 10,000 = 35,000/1,000 = 35%)

The deluxe WNB blocks is much larger and requires much more power but can blanket a much larger area. For this WNB, the chance of the communication getting through only increases by 1% per 10,000 km. Under the influence of this WNB, our ship at 45,000 km would only have a 3.5% chance of getting their message out.

Basic System – cost: 80,000 cr, mass: 30 tons, volume: 10 cu m

Deluxe System – cost: 400,000 cr, mass: 1,500 tons, volume: 500 cu m.

Decoys

Decoys are small missiles that once launched, set up an electromagnetic signal that mimics the firing ship on radar. They have no effect on energy sensors. Each decoy is a small rocket, about 4 m long and 1m in diameter. It consists of a small electronics package in the nose (about 0.5 m worth of the body) and the rest of the decoy consists of a fuel tank and small rocket engine. The decoy is capable of up to 5 ADF of acceleration in any one turn and carries enough fuel for a total of 20 ADF. After that fuel is expended, it will continue to operate but must travel in a straight line.

A decoy can either be programmed to follow a predefined course, fly in formation with the launching ship, or be steered after launch. However, choosing the steering option give a 20% chance per turn the decoy is commanded that the signals to the decoy from the launching ship will be detected and the decoy identified and therefore useless.

Since each decoy is housed in it's own launcher, as many decoys can be fired in a single round as the ship's captain would like.

Construction Cost: 20,000 cr, mass: 15 tons , volume: 6 cu m

Reload spent decoy cost: 15,000 cr.

Weapons

The following weapons are available for your ship. For each weapon, the cost, mass and volume are listed as well as the Starship Construction Centers at which the weapon may be available to purchase.

Weapon	Cost (cr)	Mass (tons)	Volume (cu m)	Program Level (FP)	Availability
Laser Canon	15,000	80	40	1 (3)	I, II
Laser Battery	10,000	50	25	1 (4)	I, II
Proton Battery	15,000	60	30	2 (8)	I
Electron Battery	15,000	60	30	2 (6)	I
Disruptor Cannon	30,000	120	60	2 (8)	I
Assault Rocket Launcher	20,000	30	10	1 (4)	I, II
Assault Rocket	10,000	40	10	n/a	I, II
Rocket Battery Array	40,000	120	40	2 (6)	I
Rocket Battery Salvo	5,000	40	10	n/a	I
Torpedo launcher	40,000	225	75	1 (3)	I
Torpedo	20,000	100	20	n/a	I
Mine Spreader	50,000	180	60	1 (1)	I
Mines	25,000	80	20	n/a	I
Seeker Missile Rack	40,000	120	40	n/a	I
Seeker Missile	30,000	160	40	3 (9)	I
Grapples	25,000	180	60	n/a	I
Pod Laser					
Pod Laser Turret					

Defenses

The following defensive system are available. Since the cost of size of many of these systems depend on the final volume and HS of the ship, you should note which you are selecting and then come back to compute the final volume and mass just before you purchase engines.

Defense	Cost (cr)	Mass (tons)	Volume (cu m)	Program Level (FP)	Availability
Reflective Hull	50 x	0.1 ton x	0	n/a	I, II, III

	sqrt(vol)	sqrt (vol)			
Masking Screen Launcher	10,000	30	10	n/a	I, II, III
Masking Screen Charge	10 cr per ton	1 ton x sqrt (vol)	1 cu m x sqrt (vol)	n/a	I, II, III
Electron Screen	200 x sqrt(vol)	30 x HS^2	10 x HS^2	2 (6)	I
Proton Screen	400 x sqrt(vol)	30 x HS^2	10 x HS^2	2 (8)	I
Stasis Screen	300 x sqrt(vol)	30 x HS^2	10 x HS^2	3 (12)	I
ICM Launcher	20,000	30	10	3 (12)	I, II
ICM	2,000	20	5	n/a	I, II

Cargo Hold

Every ship should be able to carry at least a little cargo even if it is just for the ship's personal supplies. Of course the cargo hold will take up the majority of space in a freighter. A typical tramp freighter will have between 5 and 100 cargo units while some of the mega-freighters will have hundreds or even thousands. In addition to the total cargo volume that the ship will carry, the designer needs to decide if it will be one large cargo hold or be divided into a series of smaller holds throughout the ship. This will impact some of the specialized cargo handling equipment that will need to be purchased in the next step.

1 Cargo unit: Cost: N/A (it's just empty space after all and will be accounted for in the cost of the hull), Mass: 0, volume 150 cu m.

Specialized Equipment

These including mining equipment, exploration equipment, cargo handling equipment, etc.

Mining Equipment

Mining Robot – These robots are designed to work semi-independently and work in airless environments as well as on planetary surfaces. They are level 4 heavy-duty robots with an extra pair of limbs containing mining tools. They have a level 2 (4 FP) mining program in addition to the Computer Link and Security Lock programs. Each robot can move up to 4 tons (1 cu m) of material an hour on any body with at least 0.1g.

cost: 18,500 cr, mass: 1 ton, volume: 3 cu m.

Digger shuttle – This is a larger HS 1 shuttle specifically designed to mine low g worlds and transport ore from both low and high g sites. The digger shuttle is a standard 1 cargo unit shuttle, equipped with a single Class A ion engine. It has a 4 being crew capacity and rudimentary life support for two days for a full crew. In addition to the basic cost of the shuttle, it has specialized digging equipment on the nose that costs an additional 8,000 cr and the same level 2 (4 FP) mining program as the mining robots. The shuttle is capable of moving up to 4 tons (1 cu m) of material an hour in its mining role and can transport up to 600 tons (150 cu m) of rock in its cargo hold.

cost: 215,000 cr, mass: 90 tons, volume: 200 cu m.

Orbital Processing Lab – This is a ship based processing facility. It is carried with the ship where ever it goes and processes the raw ore into the refined mineral. Tailings are ejected into space. An OPL is capable of processing up to 10 cubic meters of raw ore per hour. The ship requires a level 4 (12 FP) program to run the OPL.

cost: 100,000 cr, mass: 500 tons, volume: 1000 cu m.

Mineral Refinery – The mineral refinery is a ground based processing facility. It is carried in a large hold of the mining ship and then transported to the surface and assembled. Stored the MR takes up the equivalent of 5 cargo units of storage space and requires five trips by a digger shuttle to ferry it down to the surface. The MR is assembled on the surface and left behind once the mining is done.

The Mineral Refinery requires 240 being-hours of work to assemble. So assuming 10 hours of work per day, it can be assembled by 12 beings (robots or characters) in two days. If fewer workers participate it will take longer and will go faster if there are more workers.

The Mineral Refinery is capable of processing up to 15 cubic meters of raw ore per hour. The cost of the refinery includes a level 4 (16 FP) program needed to manage the ore processing. The hull space used to transport the MR can be used as an additional 5 CU cargo hold when transporting the refined material back from the mining site.

Cost: 216,000 cr, mass: 1500 tons, volume: 750 cu m.

Agriculture Equipment

The base cost of equipping an agriculture spaceship is determined by multiplying the cost of the materials by the number of beings the ship is designed to support. The hull, crew accommodations, engines, crew life support, and other systems must be purchased normally. The following table list the base cost, mass, and volumes of the equipment needed to outfit an agriculture ship. These values are per being supported. For example, if the ship was designed to support 500 beings, all of these values would be multiplied by 500.

Item	**Cost (cr)**	**Mass (tons)**	**Volume (m^3)**
Seeds	3	0.05	0.05
Nutrient Solution	5	0.5	0.5
Solar Collectors	20	0.1	0.05
Growing Area	10	0.2	10

Seeds & Nutrient Solution– This represents the mix of seeds plus the nutrient growing solution needed to provide a balanced diet to one being for one standard month (40 days).

Solar Collectors – This is the equipment needed to properly collect energy from the star for use in growing the plants. Some of it is channeled directly to the plants and some is used to power heaters and full spectrum lamps.

Growing Area – This represents the physical volume used to grow the plants and includes vats and tubs as well as the heaters, lamps and open growing spaces.

Farming Robots – In addition to the plants and related supplies themselves, you need someone or something to tend the planets and care for them as they grow. One farming robot is needed for each 200 beings worth of food being grown (round fractions up). For example, if you were growing food for 500 beings, you would need 500/200 = 2.5 => 3 farming robots. The farming robots are standard bodied, level 3 robots. The cost, mass, and volume specified include the robot as well as storage, docking and minor maintenance facilities.

cost: 3500 cr, mass: 2 tons, volume: 5 cu. m.

These farming robots require supervision. This can be provided by a level 4 robotics expert or by a level 6 robotic brain. The robotic brain costs 17,000 cr. If the ship has a robotic brain, the crops can be grown and harvested completely autonomously on a regular schedule.

Computer Programs

Agriculture – The agriculture program is a level 1 (3 FP) modified life support program that regulates the temperature, water, nutrients, and light in the growing spaces of the Agriculture ship. It is required by any ship to properly use the agriculture equipment.

Robot Management – If the ship has a level 6 robotic brain to supervise the growing and the farming robots, it also requires a level 6 (64 FP) robot management program.

Growing Cycle

The seed and nutrient solution costs represent the materials needed for one standard month (40 days) of growing crops. Crops will be grown and available for harvest and transport every 20 days and the seeds and nutrient solutions must be resupplied after every two harvests. However, if the owner of the ship puts 10% of the crop back into the "fields", a new crop can be grown without purchasing new seeds and nutrient solution. For example, if instead of buying new seed and nutrient solutions every cycle, our ship would us 10% of its crop, or the equivalent of the food for 50 beings to reseed for the next cycle. Thus the ship would actually only feed 450 beings but not need to continually ship in new seed and nutrient solution after every other harvest.

If the owner chooses to reseed the ship from the harvest, there is a chance of crop failure. For every time the ship is reseeded from the harvest, there is a cumulative 1% chance that something will go wrong and the crop will be lost. Thus after a standard year (400 days), the ship will have been reseeded 10 times and there is a 10% chance that the crop will fail. The roll for crop failure should be made every 20 days at the time of the harvest. When the crop fails, roll d100. This is the percentage of the harvest that is salvageable. Regardless of the amount of crops salvaged, a new, fresh supply of seeds and nutrients must be brought in to restock the ship. No new growing cycle can begin until the new supplies arrive.

Transport Equipment

Cargo Arm – This is a robotic arm used to load and unload the shipping containers used to transport cargo. Typically one is needed for every 20 cargo units the ship can carry. At a minimum, one cargo arm is needed per cargo space determined when designing the cargo hold. Each arm can unload up to 3 cargo units of material per hour. The arms are mounted or runners and can move around the cargo hold to pick up cargo and move it to the waiting dock. More arms mean the cargo can be unloaded faster and fewer arms increase the time to get the ship unloaded.

Small ships, such as shuttles and small freighters (less than 10 Cargo Units in size) do not need cargo arms as they are typically small enough that arms on the dock can reach into the holds to unload the cargo. However, any ship over HS 3 should probably have a cargo arm installed. Otherwise, the cargo will have to be unloaded by hand at the rate of 3 CU per day.

cost: 5000 cr, mass: 10 tons, volume 20 cu. m.

Exploration/Research Equipment

Atmoprobe – The cost of the atmoprobe includes the cost of the level 2 (4 FP) computer program that controls the probe. In addition, use of an atmoprobe requires that the ship's computer have a level 3 (9 FP) guidance/analysis program. This program can be used with any number of atmoprobes or landing drones.

Cost: 44,000 cr, mass: 6 tons, volume: 3 cu. m

Landing Drone – The Landing drone is a larger version of the atmoprobe that can be reused if the launching ship goes to the target it was sent to and remounts the drone. The cost includes a level 3 (9 FP) program needed by the landing drone to correctly operate. The landing drone requires the ship's computer to have the same level 3 (9 FP) guidance/analysis program used by the atmoprobe.

Cost: 109,000 cr, mass: 50 tons, volume: 25 cu. m

Laboratory – Laboratories can be purchased for any particular field of science but it must be specified at purchase time what the laboratory's focus is. Each lab requires a level 3 (9 FP) analysis program to assist in data analysis.

Cost: 100,000 cr, mass: 40 tons, volume: 120 cu. m

Remote Probe – These are more general probes than an atmoprobe and are typically sent into regions where the characters cannot go. They provide a +10% bonus on analysis. The cost of the remote probe includes a level 2 (4 FP) program for analysis and data relay. Processing the data returned requires the same analysis program used by the laboratories. If the ship has at least one lab, a separate analysis program is not required. However, if no lab is installed the analysis program must be purchased as well.

Cost: 104,000 cr, mass: 50 tons, volume: 25 cu. m.

Ship vehicles and bays

There are a variety of small ships that a larger ship may be carrying. These include launches, lifeboats, workpods and escape pods. This could also include small shuttles or even fighter craft on military vessels. This ships may be housed internally inside of bays within a ship or just docked externally depending on the ship designer's wishes.

Small Launch - Holds 4 passengers. Cost: 75,000 cr, Mass 50 tons, volume: 20 cu m.

Large Launch - Holds 10 passengers. cost 100,000 cr, mass: 120 tons, volume: 50 cu m.

Small Lifeboat - This lifeboat is designed to hold 10 beings instead of the standard 20. Cost: 75,000 cr. Mass 120 tons, volume: 50 cu m.

Large Lifeboat - This is the standard lifeboat from the KH rules (20 passengers) cost: 100,000 cr, Mass: 200 tons, volume 80 cu m

Escape pod - The mass, cost and volume for an escape pod already include the bay/mount point in which it is held. cost: 30,000 cr, mass: 15 tons, volume: 16 cu m.

Workpod - cost: 75,000cr, mass: 80 tons, volume: 30 cu m.

Other ships – For other small ships (such as fighters and shuttles) that might be carried, design the smaller ships first. Then use the cost, mass, and volume to determine the bay and docking point sizes needed to house the smaller ships

Bays - If the ship's vehicle is to housed inside the parent ship, space must be allocated to house the vehicle and secure it during maneuvers. Depending on the exact shape of the ship's vehicle, the vehicle bay could be up to two to three times the size of the ship itself. Typically, for most ships, it is not that large and we'll use a factor of one and a half. The cost of a bay includes all the machinery needed to dock the craft and secure it during maneuvers.

Cost: 20,000 cr x (HS of vehicle), mass: 25 tons x (HS of vehicle), volume: 1.5 x (volume of vehicle).

For determining bay size, assume that the lifeboats, launches and workpods are HS 1.

External docking point - In this case the smaller ship is just attached to the outside of the mothership with a docking mechanism and connected by some sort of umbilical to allow access from within the main ship. The only space used up within the main ship is a bit of space for the vehicle access room (effectively an airlock) and some support equipment. There is a limit to the number of ships that can be docked in this manner (Need to figure out how to limit it. It needs to relate to the surface area of the ship and the size of the docked vessels.)

Cost: 5000 cr x (HS of vehicle), mass: 15 tons x (HS of docked vehicle), volume: 10 cu m.

For determining dock size, assume that the lifeboats, launches and workpods are HS 1.

Size of crew and number of passengers.

The next step is to determine the number of crew members needed and the number of passengers the ship will accommodate. This will affect both the amount of life support needed as well as have an impact on the final damage control capabilities of the ship (more crew means more things that can be worked on).

Crew

Typically a ship will need at least a pilot, an astrogator, and an engineer. If the ship has more than two engines, you will typically want at least one engineer per pair of engines (round fractions up, i.e. a ship with 3-4 engines would want 2 engineers, a ship with 5-6 engines will want 3 engineers, etc.). Beyond that you will probably want a crew member for each weapon and one for the defenses.

That would represent the bare minimum crew to fly the ship and is typically what is found on small ships and tramp freighters. As ships get larger you may want to budget for additional support crew such as additional engineers, medics, security personnel, etc. Military ships will also typically have two or even three completely crews than can fly and operate the ship in shifts to provide full staffing at all times.

Determine what crew you want the ship to have and record it in the standard crew size box. You will need to provide accommodations and life support for these people in the following sections.

Passengers

Passengers can take the form of paying customers on a passenger liner, a few extra berths rented out on a small freighter, marines or land troops on military ships, or any other beings traveling on the ship that are not part of the ship's crew. Determine the number of passengers you want your ship to support. Accommodations and life support will need to be provided for these beings in addition to that supplied for the crew.

Crew and passenger accommodations

There are a variety of crew and passenger accommodation levels. The cost, mass and volume include the requirements for the cabin itself plus any associated passageways, common areas, cargo storage, etc. Typically, crew cabins are of Journey Class quality. Although on some larger ships, the officers may have cabins that fall under the First Class quality level. Select an appropriate number of cabins of each class for the crew and passengers.

First Class cabin – This level of accommodation requires a Deluxe life support system (see below). cost: 2,000 cr, mass: 2 tons, volume 180 cu m.

Journey class cabin - This level of accommodation requires a Standard life support system (see below). cost: 1,000 cr, mass: 1 ton, volume 75 cu m.

Storage class berth – No life support is needed for this type of accommodation as the passengers as basically shipped as cargo. cost: 2,000 cr, mass: 2 tons, volume: 10 cu m.

Life Support Equipment

Now that you know the number of crew and passengers, you can select the amount of life support equipment the ship needs. It is recommended that you have at least one backup life support system in case there are problems with (or damage to) the primary system. The life support system includes a variety of systems such as air filtering and circulation, food preparation, sanitation facilities, and waste management. Life support on starships are mostly a closed system, almost everything gets recycled. However there are some consumables that do need to be replaced (mainly foodstuffs) every so often.

Your life support system needs to be at least large enough to support the crew and passengers. Typically, ships are designed with a little extra capacity as a safety margin or for emergencies. There are four basic levels of life support available for ships, depending on the ship's needs:

Rudimentary – This is an air supply system only. It doesn't handle food or waste materials and just provides an air supply and air circulation system with filtering. This is the life support system you find on launches, workpods, fighter craft, and other ships that are not designed to be occupied for a long time.

Basic – This level of life support adds basic food storage and preparation, sanitation facilities, and waste management to the air supply system of the rudimentary life support level. Supplies are stored and consumed and waste material has to be removed regularly. There is little to no recycling of materials except for air and water. This level of life support is typical of shuttles and some short distance system ships that typically operate for only short periods of time between calling on bases where their life support can be resupplied and waste material removed. It may also be found on some lifeboats. While you could equip a starship with this type of life support system, making it large enough to support long missions uses up valuable space in the ship and tends to be more expensive in the long run.

Standard – This is the typical system for any starship. It consists of complete air and water recycling, as well as recycling of waste material. It typically includes some sort of hydroponics system for both growing fresh food and recycling carbon dioxide back into oxygen. There are full food preparation facilities as well as complete sanitation facilities. This level of life support is required for Journey class passenger accommodations.

Deluxe – This is a more advanced version of the Standard system. It provides better recycling, larger food preparation facilities, more variety in the fresh foodstuffs, and better (nicer) sanitation and waste management facilities. This level of life support is required for any First Class passenger accommodations.

A ship can have different life support levels for different parts of the ship. This is quite common on passenger liners. For example, if a passenger liner has 20 First Class cabins and 100 Journey class cabins. It is not very likely that the owners will invest in Deluxe life support for the entire ship (although if they did, it would figure prominently in their advertising). Rather they would invest in a Deluxe life support system to cover the First Class cabins and a standard system to cover the Journey Class cabins and the crew.

The volume listed for the life support system includes both the machinery and hardware for processing the air, water, food, and waste material as well as storage space for raw materials and duct work to move material around the ship.

Every life support system has two ratings. The first is the maximum number of beings the system can support. This determines the amount of mass and volume allocated for the life support machinery (pumps, filters, ducts, pipes, etc). The second is the maximum number of days that the system can support those beings without being refilled/recharged. This determines the amount of volume committed to storage of life support supplies.

Base hardware costs and volumes per being supported. All values except base system volume are multiplied by the maximum number of beings the system can support at one time.

Type	**Cost**	**Mass**	**Base system volume**	**Volume**
Rudimentary	500 cr	0.2 tons	1 cu m	0.1 cu m *
Basic	1500 cr	2 tons	6 cu m	5 cu m
Standard	3000 cr	4 tons	15 cu. m	8 cu m
Deluxe	5,000 cr	6 tons	30 cu. m	10 cu m.

* This volume assumes you are equipping a small one or two room craft with this system like a fighter or launch. If you try to put this into a larger ship the volume goes up a factor of 10 for the ducting and pipes needed.

For example, our passenger liner has 20 first class cabins and 100 Journey class cabins for crew and passengers. It would need two life support systems. The Deluxe system would support 20 beings. It would cost 20 x 5000 = 100,000 cr, have a mass of 20 x 6 = 120 tons, and take up 30 (base volume) + 20 x 10 (volume per being) = 230 cubic meters. The Standard system for the Journey class cabins would cost 100 x 3000 = 300,000 cr, have a mass of 100 x 4 = 400 tons and take up 15 + 100 x 8 = 815 cubic meters. Thus the Standard system while being just a little more than 3x the size of the Deluxe system, supports 5x as many beings.

Supply cost per being per day. In addition to the base machinery costs, there is the cost of the food, air and water needed for the beings on board. Multiply each value times the maximum number of beings the system can support and then by the number of days you want to be able to support those beings without a reload/refill of the system.

Type	**Cost**	**Mass**	**Volume**
Rudimentary	10 cr	0.05 tons	.1 cu m
Basic	15 cr	0.15 tons	.4 cu m
Standard	25 cr	0.1 tons	.15 cu m
Deluxe	40 cr	0.15 tons	.25 cu m

So if our passenger liner wanted to support it's full compliment of crew and passengers for 200 days with out a resupply the cost of the supplies and storage areas would be as follows: For the Deluxe system the cost is 40cr x 20 beings x 200 days = 160,000 cr, the mass would be 0.15 tons x 20 x 200 = 600 tons, and the volume would be 0.25 cu m x 20 x 200 = 1000 cubic meters. The standard system supplies would cost 25 cr x 100 beings x 200 days = 500,000 cr, the mass would be 0.1 tons x 100 x 200 = 2000 tons, and the volume would be 0.15 cu m x 100 x200 = 3000 cubic meters.

Damage Control

All ships require a basic damage control system. This requires the Damage Control program to coordinate the automatic and crew efforts to repair the ship. A ship requires a Damage Control program with a level equal to the number of the ship's engines (up to level 6).   You'll determine the level of the program once you select the exact number of engines. However, you can make a pretty good estimate of the number of engines to begin with. Smaller ships typically have 2 engines, mid-sized ships have 4, and the largest ships have 6-8.

Level	1	2	3	4	5	6
Function Points	2	4	8	16	32	64

The basic Damage Control Rating (DCR) of the ship is given by the following:

$$DCR = 3 \times HS + 20$$

Thus a HS 5 ship would have a DCR of 3x5+20 = 35. In addition, the ship gains a bonus of 1 DCR per four crew members (round fractions down). So a ship with a crew of twenty gains a +5 DCR bonus.

Finally, you can augment your ship's DCR by purchasing additional DCR capacity. This represents automated repair systems and robots. The ship will have one maintenance robot for every two additional points of DCR purchased (round fractions up). To use the additional DCR capacity, the ship must have at least a level 4 (16 FP) Robot Management program.

Additional DCR capacity: 1 point – cost: 10000 cr, mass: 2 tons, volume: 5 cu. m.

Ship's Computer

We need to add in a couple of more programs before make our initial calculation of the ship's computer specifications. Unfortunately, all of these programs depend on quantities we don't have yet so at this point we will just make an estimate. For each program record the estimated level and function points.

Alarm

This program monitors the ship's systems and causes lights to flash, alarms to go off, etc. when there is a problem on the ship. A ship requires this program have at least as many levels as the number of engines on the ship (up to level 6). Use the same engine estimate you made for the damage control program. Typically your smaller vessels (up through about HS 6) will have a level 2 program, larger ships will have a level 4 program and only the largest super-sized ships will need a level 5 or 6 program. Based on the expected size of your ship, make an initial guess at the level you will need. It is typically safe to go with a level 4 program. We'll check at the end and adjust if necessary.

Level	1	2	3	4	5	6
Function Points	1	2	4	8	16	32

Computer Lockout

This is a security program that provides protected access to the ships computer. This program needs to have a level at least equal to the computer's level. Most ships, unless they have a lot of weapons, extra programs, or are using Class C atomic engines, end up with a level four computer. The larger ships end up with a level five computer and even a fighter has a level 3 computer. So unless you know you're building a big ship, going with an estimate of level 4 is a safe bet.

Level	1	2	3	4	5	6
Function Points	1	2	4	8	16	32

Drive Program

This is the program that controls the ship's engines. The exact level and function points depend on the type and size of engines you choose. You already estimated the number of engines back when doing the Damage Control program. This time we need the size and type. You probably already know the type of engines you want in your ship so you can estimate the level by how big you expect your ship to be. If it is a small ship that doesn't haul a lot of cargo, you probably want Class A engines. Midsize ships or even small freighters will want Class B and larger ships or medium to large freighters will probably want Class C. The following table lists the level (function points) of the Drive program for the various types and classes of engines

	Class A	Class B	Class C
Atomic	4 (32)	5 (64)	6 (128)
Ion	3 (12)	4 (24)	4 (24)
Chemical	1 (3)	2 (6)	3 (12)

Now that we have all the required programs determined or estimated, add in any additional programs that you might want on the ship from the Alpha Dawn rules such as communications, information storage, installation security, etc.

Once you have all your programs selected, Tally up all the function points of the ship's programs to determine the initial size of the ship's computer. Consult the computer size table in the AD rules to determine the initial estimate of the computer level. (If your guess for the Computer Lockout program was wrong, go ahead and change it now and recalculate your estimate.) The cost of the computer is just the number of function points times 1000.

The mass of the shipboard computer is just the total function points divided by five and the volume is the total function points divided by 10. These values are in tons and cubic meters respectively. These values are much larger than the values given by the AD rules for computers. This is due to the special hardware required for computers to operate in a space environment and also includes any extra shielding, wiring, etc. needed on board the ship.

Also you might consider adding a backup system in case there is damage or problems with the primary system. If you do, determine which programs you want duplicates of and compute the size and cost of the secondary computer system. Or if you just want a complete backup computer, simply double the cost, mass, and volume.

We'll revisit the computer at the very end to make sure everything is correct.

Hull Size

To determine the hull size of the ship, add up the volume of all the components, accommodations and vehicle bays. Don't add in the cargo bays yet. This gives you the total volume of the ship systems in the inhabited or working portions of the ship.

Next we need to add in space for the various control centers of the ship (bridge, engineering, combat centers, etc.) The control stations provide access to the ship's computer for their main function as well as well as providing a versatile acceleration chair so that the operator can function during high g maneuvers.

You typically need one control center for each weapon, one for defenses, one for every two engines, one for astrogation and finally one for the pilot. On smaller vessels such as fighters and shuttles, some of these may be combined into a single station. In addition, you should add in any extra control stations you want the ship to have. This might include a cargo handling station, one for life support monitoring, one for sensors, etc. Finally, add in any backup control stations that you want your ship to have such as backup bridge controls or engineering stations.

Control Station – cost: 500 cr, mass: 1 ton, volume: 4 cu m.

Finally we need to add in all the space for passageways, common areas, and other general spaces throughout the ship. For simplicity we'll assume that these spaces add 25% to the existing volume of the ship's systems. So the total volume of the inhabited/working portion of ship is determined by multiplying the volume of all the components by 1.25.

Finally to get the total ship volume, we add in the volume of the cargo area.

Once we have the total volume of the ship, we can compute the hull size. If you want to calculate it exactly, the hull size is given by the ¼ of the cube root of the total volume, rounded to the nearest integer.

$$HS = 0.25 \times (\text{total volume})^{1/3}$$

Or, if you don't like doing the math, you can look it up on the following table. Simply find the line that corresponds to your total volume and look up the hull size.

Total Volume (cu m)	Hull Size
<215	1
216 - 999	2
1000 - 2743	3
2744 - 5831	4
5832 - 10647	5
10648 - 17575	6
17576 - 26999	7
27000 - 39303	8
39304 - 54871	9
54872 - 74087	10
74088 - 97335	11
97336 - 124999	12
125000 - 157463	13
157464 - 195111	14
195112 - 238327	15
238328 – 287495	16
387496 – 342999	17
343000 - 405223	18
405224 - 474551	19
474552 - 551367	20

If your ship is bigger than HS 20, you'll have to calculate it using the formula. The ship's hull size will determine things like it's Hull points, the number of ships that can be mounted externally and the number of engines it can support. Now that we have the total volume and the hull size, we need to select a hull type to determine the cost of the hull.

Now that you have the total volume and Hull Size of the ship determined, it's time to go back and finalize the size of the any of the defensive screens selected that depend on the ships volume or Hull Size. Update the ship's total volume based on the volume added by the defensive systems. If you want to be exact, you could also update the passageway volume as well but you can also just assume that the extra volume from the defenses is part of that 25% accounted for by the passage ways. Once you have the final volume of the ship, you can proceed to purchase the actual hull.

Hull Type

There are four different hull types. Each type has a mass and cost associated with it depending on the hull type selected. Different hulls provide different amount of hull points for a given ship size.

Hull Type	Cost multiplier	Mass Multiplier	Hull Point Multiplier
Light	35 cr * total volume	0.15 tons * total volume	0.6
Standard	50 cr * total volume	0.25 tons * total volume	1
Armored	100 cr * total volume	0.50 tons * total volume	1.4
Military	200 cr * total volume	0.40 tons * total volume	2

Light Hull – This is a light duty hull. It costs and weighs less than a standard hull but only provides sixty percent of the hull points of a standard hull.

Standard Hull – This is the standard type of ship hull and provides the standard number of hull points. This is the typical hull used on most civilian vessels

Armored Hull – This is the highest grade hull available to civilians. It is twice as massive and twice as expensive as a standard hull and provides a forty percent increase in hull points over a standard hull.

Military Hull – Combining specialized materials and designs, the military grade hull is not available for civilian ships. It is more expensive than even the armored hull although it doesn't contain as much mass and provides double the number of hull points of a standard hull.

Additional Armor

Sometimes even the strongest hull just isn't enough and you want to add more armor to the ship. Once you have your base hull, you can add additional layer of protection to the ship as desired. This will greatly increase the cost and mass of your ship but won't affect the volume.

You can add armor on to the ship to increase it's hull points by up to 25% in 1% increments. The cost of additional armor is 8 cr per cubic meter of volume per percentage increase. Thus to get a 5% HP increase it would cost you 40 cr per cubic meter of the ship, nearly doubling the cost of a standard hull. The armor adds an additional 0.016 tons per cubic meter of volume per percentage increase. Thus that

5% increase above would also add 0.08 tons per cubic meter of the volume of the ship.

The armor modifier for calculating the ships final hull points is just 1+(armor bonus/100). So if my armor bonus is 20% the modifier is 1+(20/100) = 1.2. This will be multiplied by the ships base hull points to determine the actual number of hull points the ship has.

Total Mass

The only thing left is to add in the engines. But first we need to know how much mass the engines will be moving. To do that we tally up the mass of all ship components, the mass of the hull, and any additional armor the ship is carrying. Also add in the mass of all the launches, lifeboats, and workpods but not other ships such as fighters or shuttles. This gives us the "empty" weight of the ship (i.e. carrying no cargo).

To determine the loaded weight, we assume that when the cargo area is loaded, it will be filled with cargo that has an average density of 2 tons per cubic meter. To determine the loaded weight, multiply the number of cargo units that the ship is designed to carry by 300 tons and add it to the ship's empty weight. We also need to add in the mass of all the smaller ships such as fighters and shuttles.

Keep these two numbers handy as they will be used to determine the maximum acceleration the ship can achieve in it's empty and loaded configurations. For military vessels, passenger liners and other ships that aren't designed to haul a lot of cargo, these numbers will not be very different and you can just use the loaded weight in the following steps if you desire. For freight haulers the numbers become quite important and will vary greatly so you should keep track of both of them.

Engines

Now that we know the mass of our ship, it's finally time to determine its propulsion. Each type and size of engine is rated to have a specific thrust and fuel capacity. Your ship's hull size determines the maximum number of engines it can support. You don't have to have to fill all your engine slots if that number of engines are not needed to achieve the performance you desire. And regardless of hull size and engine type, The maximum ADF of any ship is 6.

Hull Size	Max Engines
1	1
2-4	2
5-8	4
9-12	6
12+	8

Engine thrust is given as an arbitrary force rating that has been scaled to work with the mass of the ship as given in tons. To determine the maximum acceleration of your ship, add up the force ratings of all your engines and divide that by the total mass of your ship in tons. The resulting number is the maximum acceleration of your ship in multiples of one standard gravity (10 m/s/s). Round all fractions down.

	Class A		Class B		Class C	
Engine Type	**Thrust**	**Cost**	**Thrust**	**Cost**	**Thrust**	**Cost**
Atomic	6,250	250,000	20,000	1,000,000	80,000	5,000,000
Ion	3,000	100,000	10,000	400,000	40,000	2,000,000
Chemical	6,250	50,000	20,000	200,000	80,000	1,000,000

Record the number, type, and size of engines chosen for your ship.

Next you need to provide fuel for your engines. Each engine uses different types of fuel and have different storage requirements.

Atomic engines

Atomic engines store all their fuel internally. The amount of fuel that can be stored depends on the size of the engine. Each atomic fuel pellet provides enough fuel for 10,000 minutes at 1g of acceleration (1000 ADF) (this isn't exactly correct and I need to rework the math and explanation). That is just enough for one interstellar jump and a little maneuvering around the stations. The cost of a fuel pellet depends on the size of the engine, given in the table below.

In addition, atomic engines require an overhaul every few jumps, again depending on the size of the engines. Consult the table to below to determine the number of fuel pellets held and time between each overhaul for each engine.

Engine Class	Trips between overhauls	Maximum Fuel Pellets loaded	Cost per pellet (cr)
Class A	1	3	10,000
Class B	3	6	32,000
Class C	10	12	130,000

Ion engines

While not as powerful as atomic engines, these engines are reliable and can hold more fuel. While they can technically run off any material, the fuel of choice is hydrogen. Using any other fuel source decreases the thrust provided by the engines by a factor of two. Each engine can hold 10,000 fuel units and each unit provides 1 g of thrust (this isn't exactly correct and I need to rework the math and explanation). A fuel unit costs 10, 35, or 150 cr per unit for Class A, B, or C engines respectively.

Chemical Engines

Each fuel load provides enough thrust to get the ship off or down to the surface of a planet or to provide a total of 8 g of acceleration in space (this isn't exactly correct and I need to rework the math and explanation). Each engine can only hold a single fuel load and must be reloaded after each trip.

Engine Class	Cost of a fuel load
Class A	300 cr

Class B	1000 cr
Class C	4200 cr

Final computer and power requirements

Now that you have the engine size, number and type, you can update the final specs on your computers. Double check the Drive and Alarm programs and make sure that they have enough levels based on the number of engines. Also check the Damage Control program and make sure it's level is high enough as well. Once you have those programs updated, double check the computer level and update the Computer Lockout program as well. This should finalize your computer.

If you want to be exact, you should update the mass and various components that depend on it if you computer size changed. However, this will be a small effect and can easily be absorbed into the scaling we used when generating the passageway area.

Final cost

You've designed your ship, picked all its components and tricked it out exactly how you want it. Now it is time to pay the piper. Tally up the costs of all the components, engines, hull and other items to get the final cost for your new ship.

Final Stats

Now that you are done building, you can tally up the final statistics for your ship. Record the ADF as determined in the engine selection. If you will be using this ship with the standard KH boardgame rules, assume the MR equals the ADF. If you are using a vectored movement system that doesn't use MR, it's not relevant. Record the DCR as determined in that section. Finally, you can compute the HP of your ship based on the components, hull and armor selected.

Hull points

You can compute the hull points in one of two ways. The fast and approximate method is simply to multiply the hull size times five and then multiply by the hull type modifier and the armor modifier. However, not all ships of a given hull size are exactly the same. If you would like to compute the exact number of hull points, use the following formula, rounding the final value down to the nearest whole number.

$$HP = (\text{total volume})^{1/3} \times 1.25 \times (\text{hull type modifier}) \times (\text{armor modifier})$$

For example, if I had an armored hull and a 10% armor bonus, and my ship was a total of 12873 cu. m in volume (HS 6), my Hull Points would be:

Simple method: $6 \times 5 \times 1.4 \times 1.1 = 46.2 = 46$ HP
Exact method: $(12873)^{1/3} \times 1.25 \times 1.4 \times 1.1 = 45.1 = 45$ HP

In this case my ship is a little smaller than the median HS 6 vessel and so the exact method yields one less HP.

Alternate Hull Size First Construction Method