# The Authorised Evochron Mercenaries' Technical Manual V3.2

*(or "How your equipment works")*

Extended & Revised Third Edition

*created by DaveK (aka Incoming)*

Users who would like a deeper explanation of the underlying physics outlined here can use on-line sources in the **omninet** knowledge bases:

**Grammatically Organised Online General Language Expert** AI system

**Wisdom Intelligence & Knowledge Information** AI system (that became self aware in 2394)

Start in the 20th/21st Century Physics and Cosmology Sections and work from there.

This manual has been written because information explaining how the technology that we depend on for survival has not been clearly explained elsewhere - or at least not in readily accessible places.

A great deal, in fact the vast majority, of the technology we take for granted today was developed from theories and discoveries in twentieth and twenty-first century fundamental physics. Subsequent centuries lead to the slow development of technology that could turn the theoretical constructs of relativity and quantum theory (primarily) into the reliable and practical equipment we often take for granted today.

## *Notes about the Third Edition*

*There has been a substantial rearrangement of the material into a more logical sequence and several new sections of material have been added;*

- *all basic equipment is now covered (e.g. antimissile systems, cargo containers, fusion cells)*
- *the weapons section has been split into offensive and defensive sub-sections*
- *the section on armour has been much expanded to include new military developments*
- *shield technology has moved from space-time manipulation to weapons: defence*
- *long distance jump drive travel calculations have been updated with latest research findings*
- *portable power sources have their own section*
- *Appendices giving basic data relevant to main content have been added*

## *Revisions to the third edition (January 2012)*

- *the contents list has been improved*
- *a section of sub-light engine performance data has been added*

*(our grateful thanks to Marvin for the technical data in the Appendices on ship frames, engines, wings and weapons)*

# Contents

Key to abbreviations

BH - Black Hole
CDM - Cold Dark Matter
DE - Dark Energy
FaF - Fire and forget missiles allows pilots to concentrate on staying alive in combat after launching missiles
FT - Fulcrum Torpedo
FtL - faster than light (applied to travel through space)
IFF - Identify Friend or Foe; a transmitter receiver that identifies you to other spacecraft and stations as friendly or hostile
SIF - structural integrity field
SoL - speed of light (c in the Einstein mass energy equivalence equation - $E=mc^2$)
QVee - Quantum Vacuum Energy Extraction (technology or unit) - also able to extract antimatter and normal matter from the vacuum of space
WH - Wormhole

# Introduction

In early 20th century on Earth, Albert Einstein developed his theories of special and then general relativity. Amongst many other consequences this put a speed limit on the universe - the speed of light (SoL), or more properly the speed of all electromagnetic radiation.

This belief held until the early 21st Century when neutrino's ability to travel faster than SoL was demonstrated and explained; Tachyons don't travel slower than SoL - the latter were theoretical until discovered! Actually Einstein's theory didn't say FtL travel is impossible, just that you can't accelerate an object up to the speed of light. Photons are born, live and die at the speed of light. Tachyons never slow down to the speed of light. In a nuclear pile at the centre of a nuclear power station, electrons are born travelling faster than the SoL and immediately have to slow down. As they do so they emit their excess kinetic energy as light - this is the origin of Cerenkov radiation - the blue glow seen in the pile of an old fashioned nuclear power station, still used on some frontier worlds!



If you lived on one side of an enormous mountain range you might well think that there was no way that you could cross it, but you wouldn't think that there was no-one living on the other side.

Relativity explained gravity in terms of four dimensional space time. Mass "bends" space-time like a bowling ball on a rubber sheet - the bigger the mass the greater the bending. Objects move across the sheet and like a marble passing near the bowling ball, curve around due to the dent in the sheet. Gravity is just the curve in space time causing planets to orbit their star or objects to fall downwards.
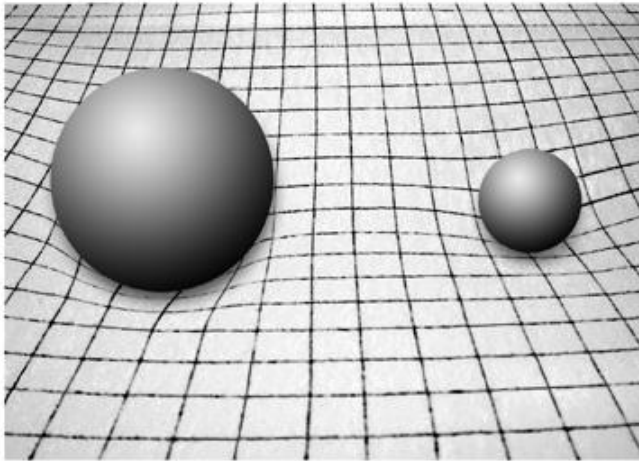


A second important consequence is that if the mass of an object is large enough gravity causing it to contract can overcome all the forces of repulsion in matter and the object shrinks to zero size - a singularity. There is a distance outside the singularity within which no object travelling at less than the speed of light can escape. This is the "event horizon".

A blackhole has a massive distortion effect on space-time and if large enough is able to create a wormhole event horizon in it centre.



A decade after Einstein published his work quantum theory was developed. Until the middle of the 21st century it only explained the behaviour of particles at the atomic and sub-atomic level. Our technology developed out of our deeper and deeper understanding of relativity and quantum theory and how they were finally melded into a **Grand Unified Theory (GUT) or Theory of Everything (ToE).**

# Background Theory I - rewriting how the universe works

In the late 20th and early 21st century several major developments in cosmology, and quantum theory fatally challenged the standard physics descriptions about the universe

Galaxies were found to have insufficient mass / matter in them to hold together at the rate they were spinning. The Universe was shown, not only to be expanding but that the rate of expansion was accelerating. Neutrino's were found to be able to travel faster than the speed of light. Black holes were shown to "evaporate" by emitting Hawking radiation, as a result of Quantum Uncertainty (in extension of Heisenberg's famous principle)

The result of these discoveries was a traumatic and radical rewrite of fundamental physics comparable with the impact of relativity and quantum theory on "classical physics" at the start of the twentieth century

The visible matter in the universe could only account for 30% of the mass required to explain the movement of galaxies and clusters of galaxies. 70% of the mass of the universe (called Cold Dark Matter or CDM) permeates space and couldn't be seen, felt or measured.

The cause of the acceleration of the rate of expansion of the universe (effectively the increased rate of stretching of the fabric of space and time) was due to an unknown and unmeasured new force which appeared to have negative gravity. This was called Dark Energy (DE)

Treasured theories were modified or replaced. The result was jump gates, jump drives, shield technology, particle weapons and the ability of small ships to travel across the universe without having to carry all their own fuel. Even stations could be created and projected across vast distances to develop new star systems. Ships could carry small generators that "projected" a solid and real unit that could process space time and create fuel or repair ships or extract energy rapidly from the vacuum energy permeating all of space.

Humankind left it's nest, the Solar System and moved to the stars; Evochron was born

All of our space travel and combat technology depends on the interaction between these new discoveries

# Background Theory II - where the energy and matter come from

Quantum foam, also referred to as space-time foam arises as an outcome of Heisenberg's Uncertainty Principle when applied to an absolute vacuum. It is basically subatomic space-time turbulence at extremely small distances and is the building blocks of the foundations of the fabric of the universe.

At such small scales of time and space the Uncertainty Principle allows particles and energy to briefly come into existence, and then annihilate each other without violating energy conservation laws . As the scale of time and space being discussed shrinks, the energy of the Virtual particles increases. According to Einstein's Theory of General Relativity, energy curves space-time. So at sufficiently small scales the energy of the fluctuations is large enough disrupts the smooth space-time seen at larger scales - giving space-time a "foamy" character. The energy tied up in the transient particles averages out at $10^{107}$ Mega Joules per cubic meter of the vacuum. That is a 1 followed by 107 zeroes!

Our energy harvesting technology based on this property is pathetically inefficient, but given the sheer quantity of energy available Quantum Vacuum Energy Extraction technology (QVee's) can still supply sufficient energy to power a capital ship or create and then jump a trade station 20K sectors across space. They can also be made small enough to power the typical frame sizes used by Mercenaries in Evochron.

Quantum Vacuum fluctuations are always created as particle/antiparticle pairs. Professor Stephen Hawking (late 20th century/early 21st Century) realised that the creation of these virtual particles near the "event horizon" of a Black Hole (or later a laboratory created singularity) would have some very significant consequences. It is how "Hawking radiation" is created. The net energy of the Universe remains zero so long as the particle pairs annihilate each other within "Planck Time" (10-43 second). If one of the pair is pulled through the event horizon into the black hole before this, then the other particle becomes "real" and energy/mass is essentially radiated into space from the black hole. This loss is cumulative and results in the black hole's disappearance over time. The time required is dependent on the mass of the black hole. This explains why natural WH's of Type I and Type II can be found both be found - the former inside a black hole and the latter free in space

Later, when it became possible to create small captive "singularities" in the lab it was realised that the energy radiated was even easier to manage than fusion generators (that mimic the centre of a star!)

Quantum fluctuations occur in a vacuum formed by joining the singularity confinement chamber of the QVee with the vacuum space outside the ship. The virtual particles produced are manipulated so that either matter or antimatter are collected. (both leaking out would lead to a mutual annihilation and the ship would explode spectacularly! - See Fulcrum Torpedo below)

Anti matter can be collected for use in FT,s, is possibly the explosive mechanism in Excalibur warheads, whilst matter particles can be converted into (storable) fuel or pure energy (described by Einstein's famous equation E=mc2).

The amount of energy available from empty space is almost beyond human comprehension.

**Using Einstein's equation E=mc$^2$ we can calculate that if one gram of matter is converted to energy it releases 10$^{11}$ MJ (100 billion MJ).** This corresponds to the release by half a gram of antimatter and half a gram of matter mixed together or to put it another way, if we extract 1g of "particle pairs" from the quantum vacuum foam we could use them to create this amount of energy. Using the traditional historical equivalence to the explosive TNT **- a 1g matter/antimatter explosion = 43 000 tonnes of TNT.** The nuclear bomb dropped on Hiroshima = 15 000 tonnes TNT**. The energy contained in 1 gram of matter/antimatter is enough power the average household module for 4500 years**

The efficiency of the particle extraction depends on the mass of the black hole and it's corresponding event horizon. Our technology only needs to use a tiny singularity to extract sufficient energy to power stations and ships.

Shield generation employs a two component system. One involves gravitons. Gravitons are part of the great success of quantum field theory (in particular, the standard model) at modelling the behaviour of all other known forces of nature as being mediated by elementary particles: electromagnetism is moderated by photons (this means that photons carry the electromagnetic force from object to object). Gluons mediate the strong nuclear forces, W&Z bosons the weak nuclear force.

The gravitational interaction is likewise mediated by an elementary particle, dubbed the graviton. In the classical limit, the theory would reduce to General Relativity and conform to Newton's law of gravitation.

The importance of the graviton (as well as being a major component of our defensive shield field matrix and tractor beams) is its role in linking quantum gravity (Quantum Theory) with relativistic gravity (Relativity) and out everyday experiences (classical gravity) into the **Grand Unified Theory**, aka the **Theory of Everything**. This was the Holy Grail of physicists in the 20th and 21st Centuries.

A wormhole is, fundamentally, a "shortcut" through space-time. For a simple visual explanation of a wormhole, consider space-time as a two-dimensional (2D) surface. If this surface is folded along a third dimension, it allows one to picture a wormhole "bridge" between the two sides of the fold.
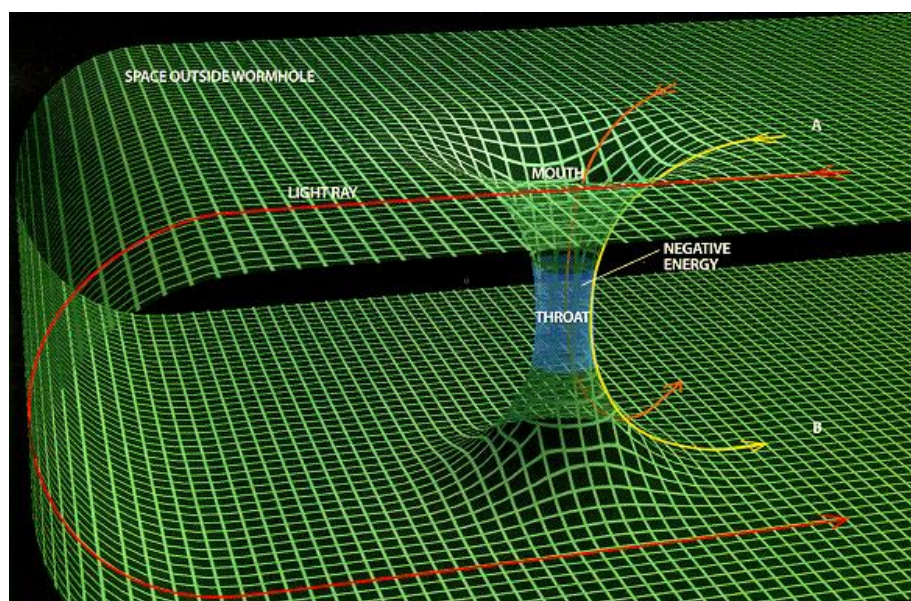
This is merely an image to convey an essentially unimaginable structure existing in 4 or more dimensions. The parts of the wormhole are higher-dimensional analogues for the parts of the curved 2D surface; for example, instead of mouths which are circular holes in a 2D plane, a real wormhole's mouths spheres in 3D space.  A wormhole is  much like a tunnel with two ends each in separate points in space-time.



Lorentzian traversable wormholes (to give them their full name!) allow travel from one part of the universe to another part of that same universe very quickly or would allow travel from one universe to another. The possibility of traversable wormholes in general relativity was first demonstrated by Kip Thorne in a 1988 paper. The type of traversable wormhole proposed, has a mouth held open by a spherical shell of "Exotic Matter" (material that has negative mass/energy).

It is ironic that despite the universal furore generated when neutrino's were shown to exceed the speed of light in 2011, none of our technology actually uses faster than light travel. The impossibility of accelerating a ship to light speed only applies locally. Wormholes allow faster-than-light travel by ensuring that the speed of light is not exceeded locally at any time. While travelling through a wormhole, slower-than-light speeds are used. If two points are connected by a wormhole, the time taken to traverse it would be less than the time it would take a light beam to make the journey if it took a path through space outside the wormhole. However, a light beam travelling through the wormhole would always beat the traveller. As an analogy, running around to the opposite side of a mountain at maximum speed may take longer than walking through a tunnel crossing it

## The Technology

The following explanations are inevitably simplified. The details of some aspects are Top Secret. If you begin to struggle then remember Arthur C Clarke's 3rd Law of Technology.

*"Any sufficiently advanced technology is indistinguishable from magic"*

Professor Gehm's Corollary to Clarke's Third Law says that

*"Any technology distinguishable from magic is insufficiently advanced"*

I think that this manual bears out Clarke's proposition!

# Drive Technology including Worm Holes

## Sub-lightspeed drives

Processed fuel is converted into plasma which is accelerated and ejected at near light speed from the main engine exhausts or from the manoeuvring thrusters.

Engine classes (C1 - C10), all have same acceleration capability but different plasma velocities. As a result all civilian ships accelerate at the same rate but have different maximum velocities based on the ejection speed of the plasma.

Military ships have modifications from reverse engineered Vonari technology and have drives with increased efficiency of the plasma accelerators to increase the max speed of the plasma and therefore mil ships accelerate faster.

Comparative data - based on a C1 civilian drive with maximum velocity = 1

C1 breaks CMD into particles of mass 10 and accelerates them to a velocity V=1;  hence max velocity = 1

C10 breaks CMD into particles of mass 1 and accelerates them to a velocity V=10; hence max velocity = 10

Acceleration (related to particle mass x particle velocity) is constant because : 10x1 = 1x10

Following the Newton's laws of equal and opposite action and reaction, the top speed of a ship obviously depends on its mass - the more mass the lower the top speed. Pilots trade off more armour, weapons and equipment slots in return for increased mass and hence a slower ship with poorer agility.

The use of an "afterburner" or "military burner" supercharges the drive unit and allows the acceleration and the maximum speeds to be exceeded but at a vastly increased cost in the rate of fuel use. In combat this is an acceptable trade off. An optional add-on booster to the fitted afterburner system is also available.

A major step forward came when military research released build details of the  "IDS multiplier" which increases plasma acceleration efficiency by streamlining energy input rate without a meltdown of the injectors and hence increases plasma velocity by a factor of between 2x and 5x

thus C1 with IDS multiplier @ x4 breaks CMD into particles of mass 10 and velocity V=4; hence max velocity = 4

**The afterburner drive** (also sometimes referred to as the afterburner overdrive) uses energy from the ship's main power system for additional thrust. It is an optional add-on to the afterburner (aka military burn) system fitted as standard to ship frames.

It can improve afterburner performance about 35-70%, depending on frame and engine configuration, but can only operate for short bursts due to the dependency on the ship's energy reserves. This is another piece of equipment that competes for main energy system output.

The standard manufacturer fitted afterburner facility has a powerful pump and cooling system so it can burn fuel at an accelerated rate whilst preventing damage to the plasma creation chambers and plasma acceleration module. The afterburner drive booster add-on unit increases the energy to the plasma creation and acceleration system but quite quickly overloads the cooling system - hence it is meant for very short duration emergency situations.

## Just how fast can I go? - Experiments in Engine Performance

### How do normal ship engines perform in extreme circumstances?

I received this report from DeepSpaceTwo, now safely back at **DSRS Copernicus**. Since he can no longer explore deep space he has turned his attention to technology performance!

"It is common knowledge that the class of an engine does not determine a ship's acceleration, only its top speed. Afterburners increase both acceleration and top speed - hence their usefulness in combat. Military engines have a higher acceleration than civilian engines.

As a scientist I was intrigued with an assumption by an experienced pilot that if you set your ship into Inertial Flight Mode and use your afterburner you will accelerate to 9999 or until you run out of fuel. It got me thinking. I was fairly sure from experience that the rate of acceleration decreased as speed increased. I had assumed therefore that there would be a maximum speed that a ship could achieve and that it would not necessarily be the 9999 limit on a ships velocity indicator. Obviously you might run out of fuel before you hit top speed.

I decided to find out what was happening.

I chose measure the performance of several different classes of civilian and military ship, choosing a top and bottom class frame from each;

• A fully stripped out Talon with a 2800 capacity fuel tank
• A lightly equipped Ferret with its maximum 400 capacity fuel tank
• A Leviathan with a 2000 capacity fuel tank
• A Chimera with a 2000 capacity fuel tank

I'll give detailed data for the Leviathan - the other three ships behaved in the same way.

The Graph 1 shows how speed increases with burn time. The steepness of the curve is a measure of the rate of acceleration - the steeper the curve the faster you are acceleration. From a standing start, using afterburner in Inertial Flight Mode, the initial acceleration up to 5000 is very good, but acceleration starts to fall off after that; the conclusion is that there is little point trying to accelerate beyond 5000 using the afterburner. The change in speed is not straight line - it is a curve that gets flatter and flatter - a power law. It also gets close and closer to a final value - the maximum speed you can go. A graph that levels off slowly, approaching a final value is known as an asymptotic graph!

speed vs time in seconds
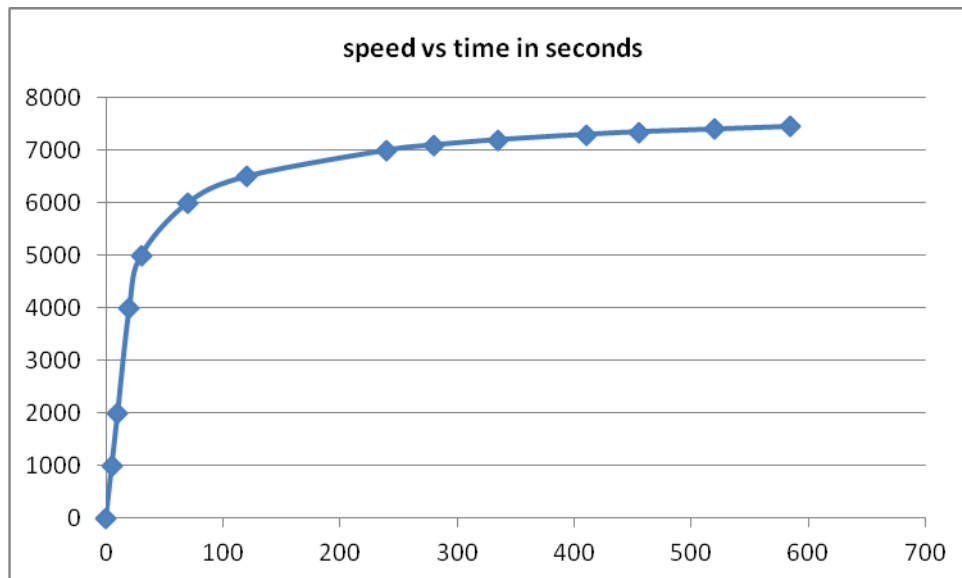
Although the fuel ran out before the top speed was reached I used the trend in change of acceleration to calculate (extrapolate) that the maximum speed achievable would be just under 7900.

All four ships have a maximum attainable speed of between 7800 and 7900

The second graph shows the time it takes to increase your speed by 10 at different starting speeds. It shows that the time taken increases at an increasing rate; This is another way of showing that the changes are not straight line but are a power law. For example it takes 19 seconds to go from 7500 to 7510, but 91 seconds to go from 7800 to 7810 and a whopping 165 seconds to go from 7875 to 7885. Since fuel is burned at a constant rate this also means that every increase of 10 in speed takes more fuel as you go faster.
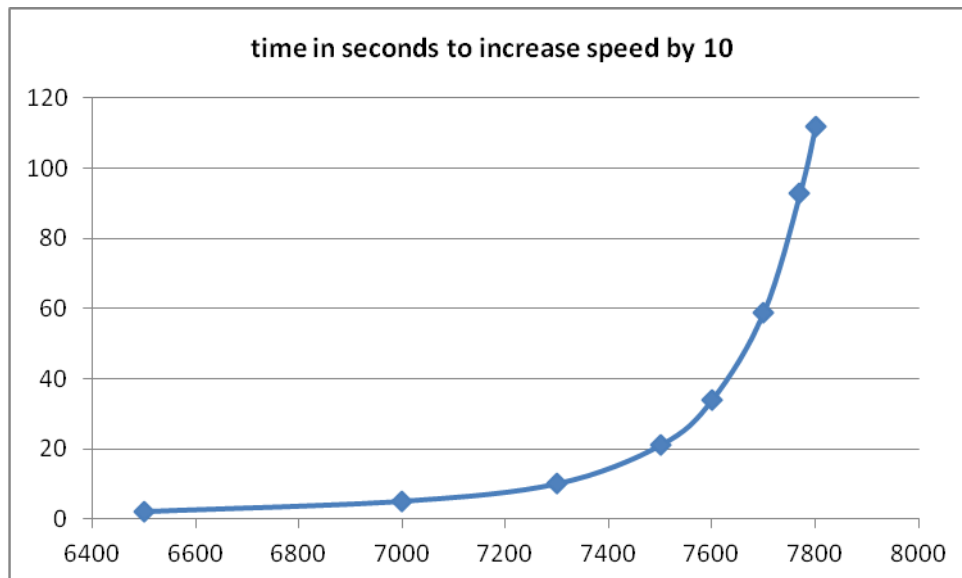


The third graph shows how speed is related to the amount of fuel used.
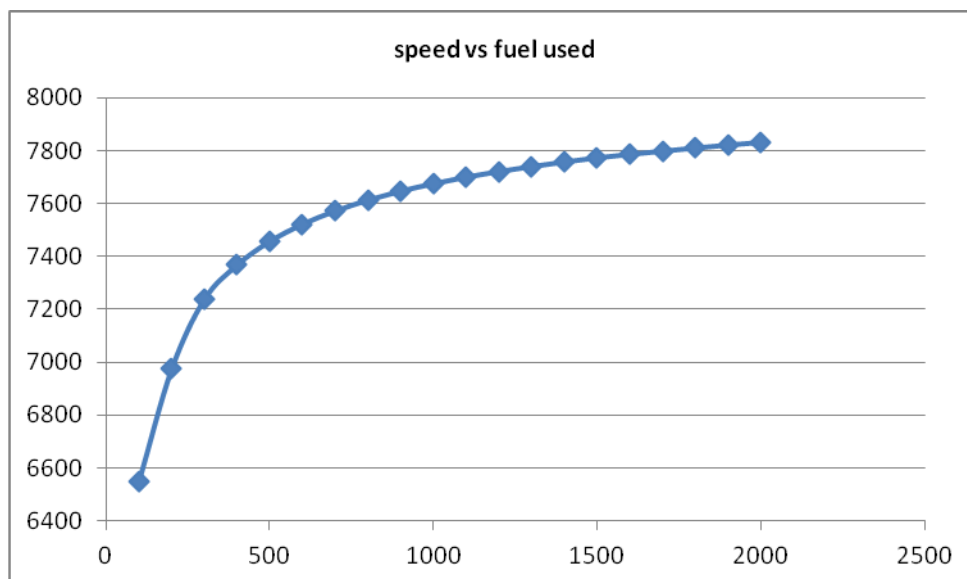


To accelerate from standing start to 6000 takes 50 units of fuel - equivalent to an average of speed increase of 120 per unit of fuel. 50 units of fuel will also accelerate you from
• 6000 to 6700 (an average increase of 16 in speed per unit of fuel)
• 6700 to 6940 (an average increase of 5 in speed per unit of fuel)
• 7312 to 7377 (an average increase of 1 in speed per unit of fuel)

The trend continues until we can see that 100 units of fuel will accelerate you from 7874 to 7882 - equivalent to an 12.5 units of fuel for an increase in speed of 1!

## What happens when I slow down?

Deceleration also uses sub-light engines.

Graph 4 show a full acceleration / deceleration cycle in a Chimera:
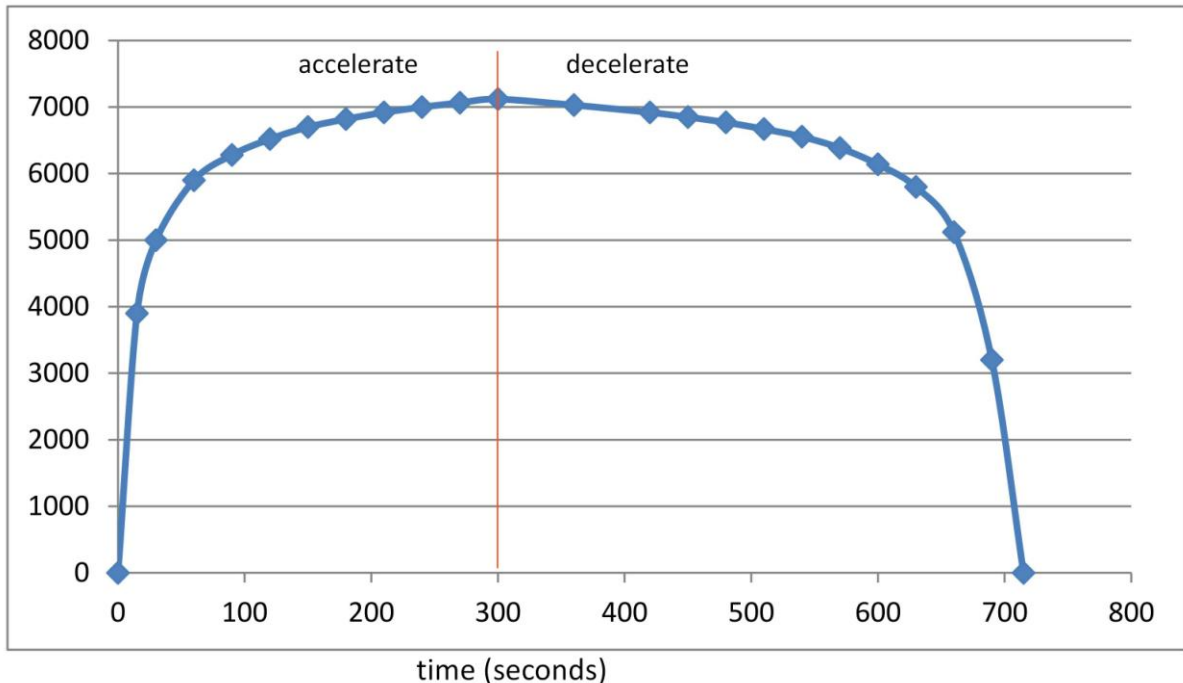


It took 300 seconds to accelerate to 7120 and 415 seconds to slow down again since the afterburner wasn't used in the slowing phase. The curves are symmetrical - the faster you are travelling the slower velocity changes occur under a constant thrust.

To slow down quickly and hence conserve fuel, just do a jump! (Thanks TJJ). If you are short of fuel this could be into a station if you can see it on the NavMap or know the coordinates or it could be just near to where you are.

**Bingo fuel** is equal to **(class of Fulcrum Drive +10)** - the extra 10 units of fuel allows for slowing down after the jump plus a bit to manoeuvre into the station you build or deploy!!

## The Explanation

One would expect that under a constant force (the engine burn) acceleration would remain constant and hence velocity would continue to increase. However there is friction in space - even interstellar space contains hydrogen and helium atoms, plus odd bits of material spat out in super novae. Certainly not enough to slow you down from 5000 or so, though

Ignoring Relativity and assuming we maintain the rapid initial acceleration (30 seconds to reach 5000m/s) then to reach SoL (300 000 000m/s) would take 10 million seconds = 117 days (continuous afterburner). The acceleration works out at around 170 m/s/s - so we are actually accelerating at 17g. Obviously there is a limit to how long a pilot, even encased in an acceleration suit can withstand this punishment

According to Einstein mass increases with velocity, so the effect of your engines actually starts to have a real impact at around 90% of the SoL. The acceleration rate in a frame would require a long time to reach even a small fraction of the speed of light and hence a lot of fuel.

Quick calculations using the relativistic mass - speed equation form General Relativity show that the equations describing how increasing speed affects relativistic mass are exponential. Starting with the ship's mass = 1.0, then as speed approaches the SoL, the ship's mass increases like this:

| Fraction of SoL | Relative mass of ship |
|---|---|
| 0.10 | 1.05 |
| 0.50 | 1.15 |
| 0.67 | 1.35 |
| 0.80 | 1.8 |
| 0.90 | 2.5 |
| 0.99 | 5.5 |
| 0.995 | 12.5 |
| 0.999 | 25 |
| 0.9999 | 75 |
| 0.99999 | 390 |
| 0.999999 | 575 |
| 0.9999999 | 1750 |
| 0.99999999 | 3900 |
| 0.999999999 | 12250 |
| 0.999999999999 | 387500 |

The ship has doubled in mass by 90% SoL, increased to 25x its mass by 99.9 SoL and the numbers from there show how quickly the increase in mass increases.

Increased mass needs increased force to accelerate it (F=ma) and when the SoL is reached the mass becomes infinite - hence in normal space SoL is the speed limit.

Relativity shows that as speed increases time of the outside world slows for the pilot of the ship. So even if you could get across the galaxy in a reasonable time (as opposed a third of a year) by getting close to the speed of light, for the outside (of your ship) world hundreds or thousands of years would have passed.

All of which shows why the Fulcrum Drive had to be invented (in 2178)

NASA's studies have shown that the fuel requirement, using water as the reaction mass from a plasma engine would require a small moon sized water asteroid (from the oort belt) to provide enough fuel to get to 0.2 SoL, given the ship itself would need to be big to carry the requiremEmts for a very long journey. With jump drives and jump gates the only reason to try for SoL is to go deep space .

### *So why are we limited to less than 8000mps using sub-light engines?*
There is spacial distortion caused by the use of graviton particles by the shield system. The shields act as weapon protection and also as deflector shields for the "muck" in space. Since there is a limited amount of energy available to the ship and as it travels faster the shields have a greater

amount of dust, molecules and ionised particles to deflect and hence have to use a higher proportion of the energy. The relativistic effect of the shield matrix on the matter it has to deflect is large; The mass increase of the particles at the point they interact with the shield hence leads to an exponentially increasing energy requirement.

The engines use a plasma ejection system.

If travel is required above 6000 mps the ships' designers decided that jump engines would the preferred method of moving from place to place. As a consequence they calibrated the ships central control AI to shunt energy to the shields at cost to the engines to ensure the safety of the ship. The ship's acceleration is controlled by the momentum of the ejected plasma and basically there isn't enough energy (nor ability of the plasma focussing system) to handle higher plasma through put or increased ejection speed - hence the speed limit is reached asymptotically.

Obviously a more streamlined shape is more efficient (but more expensive to make and maintain) - hence military ships (based on darts!) can accelerate faster than civilian ships - this is coupled with the higher specification plasma production and ejection systems in military ships. but military designers like civilian designers still realise that combat pilots using normal engines would and should work within a limit of 5000 - 6000mps. They are expected to use the Fulcrum Jump Drive to micro-jump into and out of the fur-ball. Hence the military designers have limited the top speed of military ships via the energy distribution control AI core, just as the civilian designers did.

# Fulcrum Jump Drive

From SW3DG SpaceSims Wiki

The term 'Fulcrum' in physics refers to a pivot point of a lever. This central location of contact accurately reflects the principle behind the jump drive technology found in SW3DG space-sims. A Fulcrum Jump Drive operates by creating a pivot point in space between two locations. One of the locations is the ship's current position while the other is a destination the pilot selects and enters into the navigation computer to tell the jump drive where to go. When activated, the jump drive concentrates a massive amount of energy to form an artificial event horizon (fulcrum point) in front of the ship. As power to the event horizon increases, the gravity it generates also increases and forces the ship to be drawn closer to the fulcrum point. The gravity field is extremely precise, focused directly back toward the ship it is attracting. The jump drive maintains the event horizon at a set distance ahead of the ship, so as the ship continues to move forward at an increasing velocity, the fulcrum point also moves at the same increasing rate, staying ahead of the ship at a consistent distance.



Spacecraft

Event Horizon
(Fulcrum Point)

Gravity Field
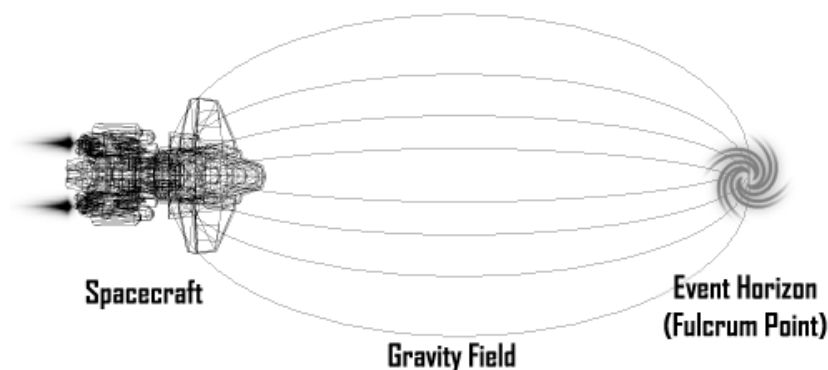
Eventually, the increasing force of the event horizon and its gravity brings the ship to an extremely high velocity, fast enough for the ship to safely pass through the fulcrum point. When the ship reaches the event horizon at the required speed, it triggers the folding of space between the two points, the ship passes through the event horizon and arrives at the destination location. Because Fulcrum Point folds space between two points, the ship does not have to be facing the destination before activating the drive. For the same reason the direction that the ship will be travelling after the jump is the same as before the jump. The scope of the event is so precise and narrow, that only the ship itself is able to pass through. However, even to create an event horizon this small requires an extremely high amount of energy to generate. Ships are generally left drained of their power reserves and the release of energy creates a bright flash of light visible to any nearby viewers.

Effectively the jump drive creates and temporarily stabilises a small wormhole and accelerates the ship so that it can safely pass through without damage which occurs when near a WH event horizon.

Fuel is used at the rate of 1 unit per sector of jump, plus extra fuel (around 1.5 units) to decelerate the ship regardless of jump distance - a 2400 volume fuel tank can traverse about 2000 sectors with a fuel reserve of 100 units using a Mantis Drive. However, if you fly inertial the extra fuel *isn't* used. But when you get to your destination, the Autopilot will shuttle back and forth until you run out of fuel and are doomed unless you are there to switch it off - is it worth the risk?

The higher the class of jump drive the more sectors can be traversed per jump. Since the deceleration fuel use is constant, higher class drives are also more efficient. For a class 1 drive the "extra" fuel is 60% of the total "jump" fuel used whilst for a class 10 (Mantis) drive the "extra" fuel is only 13% of the total.

## System to system jumping (black holes, wormholes & gates)

This depends on wormholes. The basic theory is the same as the small event horizons generated by the Fulcrum jump drive, but utilises "permanent" WHs. All appear as blue spheres with a rippled fluid surface. There are three types:

**Type I worm holes** are found at the centres of some BH's. Not all BH's have the conditions needed to create and stabilise a WH
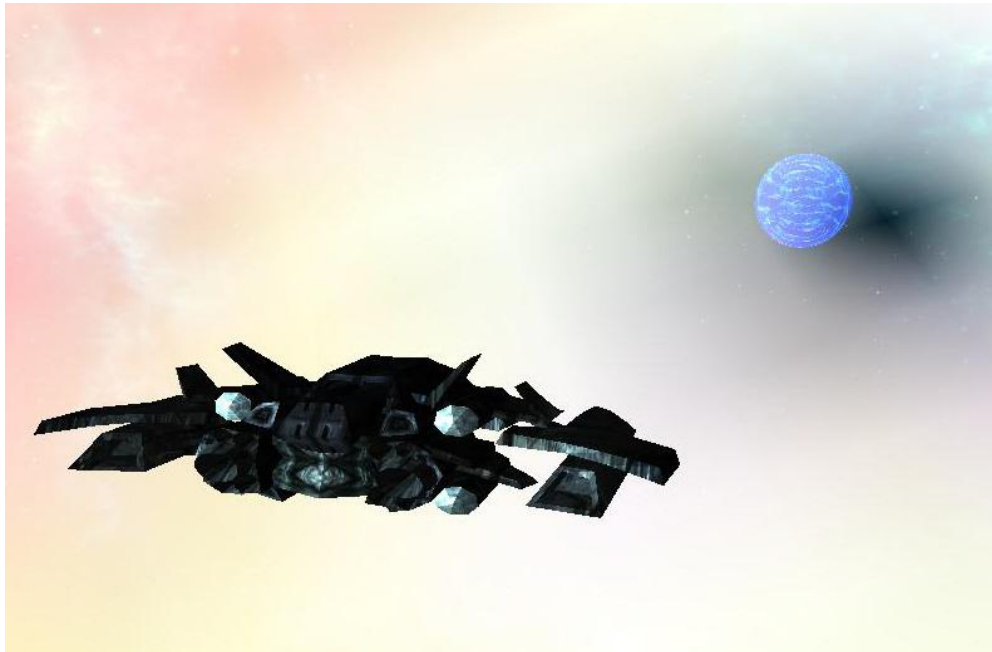


**Type II worm holes** are stable enough to survive the eventual evaporation of the BH by its emission of Hawking radiation (see later). The negative mass/energy "exotic material" created in the intense BH gravity field interacting with CDM became incorporated into the WH "entrance" and stopped it from collapsing after the BH has evaporated away.
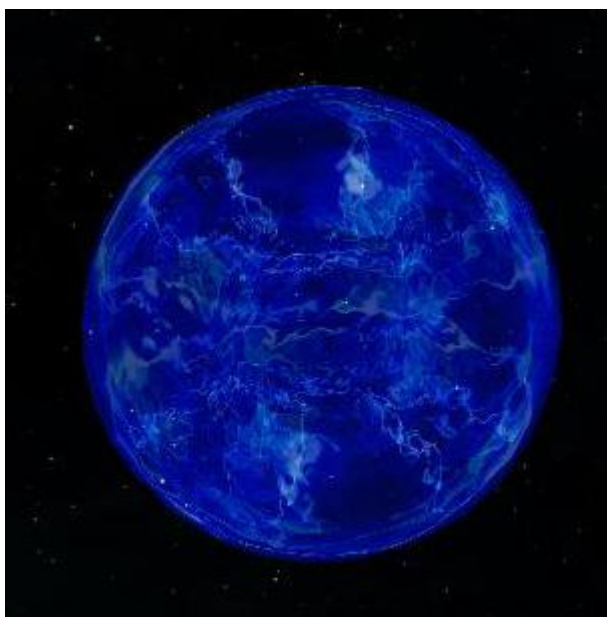
*Type I* & *II* can be considered to be wild (as in wild animal) WH's

## Type III worm holes - the Jump Gate is one of humankind's most important inventions. The gate mechanism first produces the WH event horizon in the centre of the ring. "Exotic (negative mass/energy) matter" is created in the gate surround, mimicking what happens in a BH, and is injected into the event horizon causing the WH to increase in size - it also stops the created WH from collapsing. The balance is very sensitive and so the WH is only stable as long as the gate generators are operating.
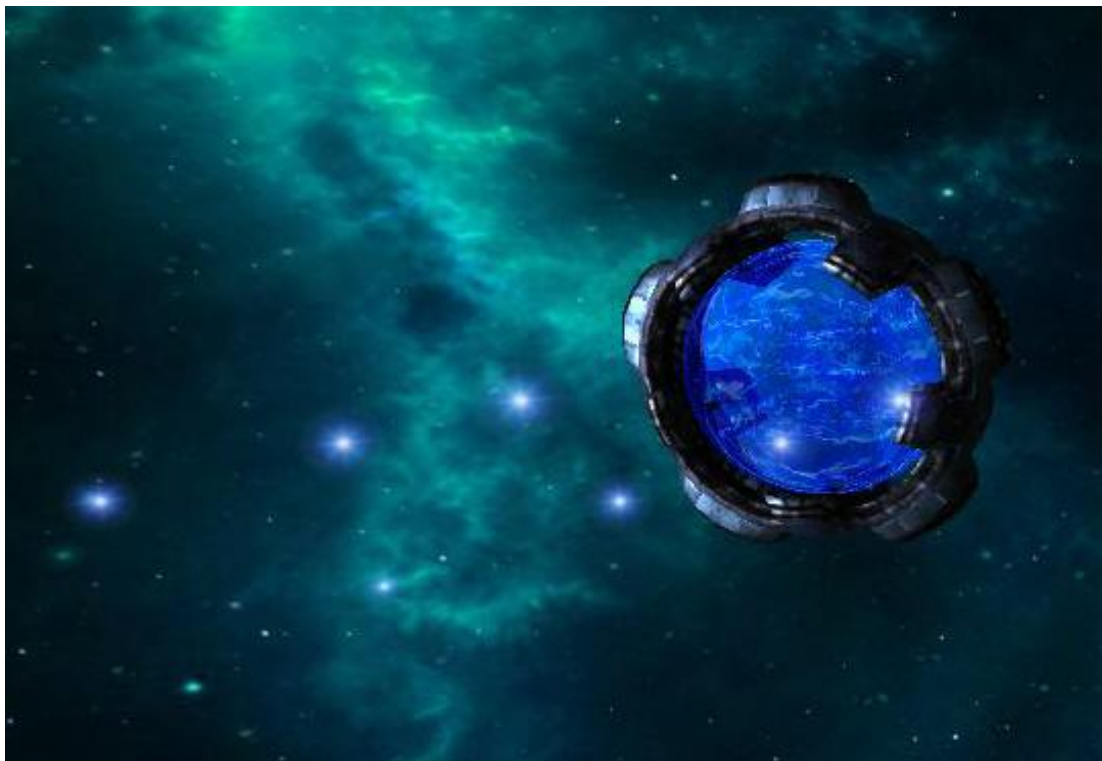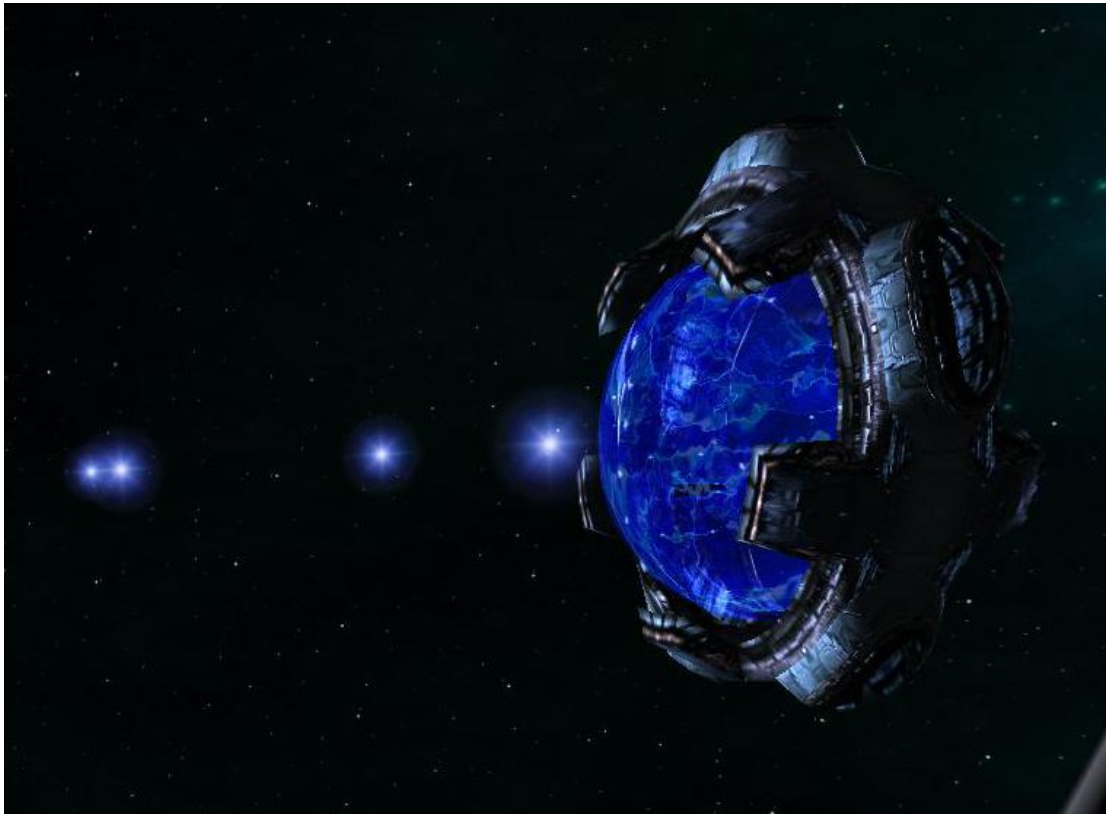
## Speeds of the four technologies compared to the speed of Light

Calculating a speed for each technology is difficult - it depends on a number of factors. For example a gate jump takes the same time regardless of distance, and therefore will be faster over longer distances - the RiftSpace and Andromeda results below show this. The following speeds are calculated for typical journeys for each of the methods of travel

| method of travel | | light speed |
|---|---|---|
| sub-light drive | @ velocity = 1000 -  5000<br><br>short range movement within a sector | 0.0016 - 0.00033 |
| jump drive  technology | 2000  jumps using a Mantis Drive | 0.05 |
| | One sector jump | 0.07 |
| gate technology | typical jump between systems | 130 |
| wormhole jump | e.g. to Rift Space - 10 secs transit time | 410 |
| blackhole jump | e.g. to Andromeda - 2 x 10 secs transit time including jump into BH | 730 |

SoL = 300 000 kilometres / second

The reason a one sector jump is (perhaps surprisingly) "faster" than a 2000 sector journey is the effect of the recharge time between jumps on the multiple jump journey.

The BH jump to Andromeda is faster than the WH jump to RiftSpace simply because the distance is much greater

So basically, rounding the speeds (in terms of the speed of light) we get

| sub-light drive | jump drive | gates jump | BH/WH jump |
|---|---|---|---|
| 0.01 | 0.1 | 100 | 500 |

This means that jump drives are 10x faster than "normal" flying ; gates are 1000x faster than the jump drives and BH/WH jumps over long distances are 5x faster than gates.

If jump drives appear to be slow, it's because the SoL is so fast. A jump drive moves you at between 15 000 and 21 000 kilometres per second!

A realistic working speed  achieved by a mix of jumps and gates can be found by flying across Evochron between Emerald and Onyx. The journey used a Mantis (10 jump drive) and the location of the gates was known. The average time taken is 130 seconds and the distance (taking into account the diagonal nature of the journey) is 6888 sectors. The speed achieved 18 times the speed of light.

The ship took 2 minutes 10 seconds; a pulse of light would have taken 39 minutes to make the same journey! So would radio waves - think about a conversation with a 39 minutes delay between speaking and the other person hearing you! (see FtL Communication below)

# Weapons Systems

## Particle Cannon

CDM is "harvested and converted to "normal matter. Packets of matter are heated to 6000 K and so converted into plasma. The charged plasma is then accelerated electrostatically and ejected through focussing "electromagnetic lenses" at very high speed. The damage is caused by the combination of very high energy (temperature), momentum (mass x velocity) and kinetic energy (mass x velocity $^2$)

C1 - C10 particle beams produce plasma "packets" with different energies; the lower class weapons with low yields use energy at a lower rate and hence have a faster recycle rate. The shields are damaged by the disruptive effect of the high energy charged plasma particles disrupting space-time when they intersect the shield field matrix, draining energy from the shield. Shields are taken down by draining energy faster than a target ship's energy generators can recharge the shield capacitors.

The hull is damaged by the extremely high temperature of the plasma packets - the hull is melted and then vaporised! Military research into ablative armour (which acts in the same way as the ceramic tiles on planetary shuttles) were unsuccessful on the whole because the extreme energy levels of the plasma "ate through" the hull material at a fast enough rate to still destroy it. Attempts to conduct the heat away failed for similar reasons - the plasma delivers energy faster than it can be dealt with. However both developments do allow the hull armour to survive a little longer.

Plasma consists of high energy charged particles and so plasma packets tend to fly apart due to the mutual repulsion of the particles. The emr lens systems focus them as effectively as possible, but cannon ranges are limited to a max of around 700 metres. (Beam weapons can have a much higher range, but for practical combat reasons they are linked to the cannon so that the pilot can use the two in tandem). A beam cannon at long range is both hard to control against a small fast moving target and also doesn't inflict damage quickly enough to disable a ship or destroy it without particle beams being used as well.

Cannon with specific effects have been developed by tweaking the plasma mix and mass of the plasma packets.

The **Eclipse** and the **Banshee** trade space in the ultra high temperature plasma packet chain for an denser packets with increased mass. CDM is converted in the form of very small particles. These are partially ionised, accelerated to the same speed as the plasma packets and are slotted into the stream of plasma packets. The ship is hit by one type after the other. The outcome is that the kinetic energy "slaps" the ship around, though it is not as effective at damaging the hull, but the plasma packets deplete the shields and do hull damage. Once the shields are down and the hull breeched both plasma and solids wreak havoc inside the ship

The **SunRail** and the **Trebuchet** were an experiment that, whilst not being a failure, weren't as effective as theoretical calculations had suggested. They are not a popular choice. Tight plasma packets are not maximally efficient in depleting shield energy, but are very effective at causing hull damage when the shields are breeched. With these two cannon, the plasma mix is spread out more and so more of its energy is utilised in the disruption of the shield field matrix, resulting in a faster shield depletion and hence a bigger drain on the ships energy generators and store. The **Trebuchet** sacrifices some shield damage capacity so that when a shield segment fails (either intermittently or totally) it can still cause some hull and energy subsystem damage.

It was a great idea in theory but most pilots found their own combinations of beam/particle weapons to be more effective for their combat style. Some argue however that as part of an attack group against capital ships they can take the shielding down significantly quicker - the jury is still out!

A simple view of which cannon are most effective would be to multiply the firing rate per minute by the yield (damage done) per hit. This gives the maximum damage inflicted per minute. In theory the higher the better. However higher class cannon have a lower rate of fire and deplete ship's energy reserves more quickly. They cannot be fired in long bursts without depleting the energy store, requiring a pilot to be without cannon in the combat zone until the store recharges.

Secondly, this simple analysis assumes that every shot hits. In a combat melee, using MTDS it is rare that all shots hits. Mercenaries experiment until they find a combination of yield and fire rate that suits their combat style. The author uses a C5 beam combined with C2 IceSpear cannon (yield 3000 / min) and finds it far more effective in combat than any others including the C8 Maxim-R (yield 12000 / min) and C14 Phantom (yield 19800 / min)

## Beam Cannon

All beam weapons use the transformation of matter to energy as described in Einstein's equation. The energy is released as electromagnetic radiation. A small proportion is within the visible range of the spectrum so that pilots can "see" the beam - somewhat like tracer rounds of a few centuries ago.

The difference between the classes (C1 - C5) is in the intensity and the wavelength of the emr emitted. C1 emit in the infra red (heat) through visible and into ultra violet regions (causes sunburn!!). The energy of emr is related to the wavelength which gets shorter at higher energies. The beam classes go up through X-rays, gamma rays and cosmic rays in order of increasing energy content

The main damage is done to the shields in a similar manner to the plasma packets of particle weapons; the emr disrupts the shield field matrix, which requires more energy to reform it. The "damage" eventually drains the ships shield generation capacity. Whilst beam weapons can do some hull damage a combat pilot requires particle weapons to create sufficient damage quickly enough to destroy the hostile.



**The Cannon Relay System** doubles the energy capacity of the primary weapon system and adds two additional gun barrels to an installed particle cannon. It works by storing extra power in a network of capacitors, supplying sufficient energy for two firing cycles of the primary weapons thus doubling the rate of fire.

Overheating of either beam or particle cannon can cause severe damage the system components, so weapons systems automatically shuts down before the damage occurs.

**The Cannon Heatsink** helps keep primary particle cannons cooler during their firing cycles, allowing them to fire at significantly faster rates.

In particle weapons overheating distorts the plasma acceleration chambers and plasma electromagnetic focussing "lenses". In beam weapons overheating distorts alignment of the lasing mirror chambers, preventing the energy cascade required for producing the coherent emr "beam".

Cooling via a cannon heatsink is obviously beneficial to a pilot's combat life expectancy!

## Missiles:

These are equipped with basic propulsion units and "chase" electronics to lock onto target heat signature giving the missiles a FaF capability (Fire and Forget). Various amounts of "explosives" cause the damage. Missiles are equipped with close proximity fuses so that a direct hit is not needed.

When you buy a missile it's electronic IFF (Identify Friend Foe) subsystem is programmed with your ship's identity beacon code. The missile will not lock onto you if it loses its primary target. However, it is unable to identify any other ship in the vicinity as non-hostile and so may lock onto "friendlies" if it's primary target is lost or destroyed. The eight-pack Excalibur has something of a reputation for biting the goodies as well as the baddies! Research into auto identification of "friendlies" has proved unsuccessful - systems that could identify "friendlies" were too easily spoofed by hostiles broadcasting "friendly" codes.

There are several specialist missiles that are fitted with detectors that targets appropriate subsystem

**Leech**: explosive payload is replaced with an EMR pulse generator which scrambles the electronics of the ship including the AI system control module. This system could in theory be used in the CM facility fitted as standard to ship frames. However the individual pulse generators are too bulky and too costly for the rate they would be deployed in a typical combat situation. There is also risk taking out the electronic systems of ships in the vicinity (including the ship that fired them!)

**Cyclone**: the explosive is swapped for a slug of very high density material; travelling at a high velocity when it reaches the target a shaped explosive charge in the warhead accelerates the solid plug to in excess of 5000. This is sufficient to locally overload a small part of the shield field and punch through. The head spreads on contact with the hull and transfers is KE energy to the frame. With stronger shield systems the impact on the shield is sufficient to shake the frame as well as drain energy from the shield

**Lynx** & **Rage**: sophisticated electronic detectors and a modified version of the em pulse generator are fine-tuned to the engine and weapons sub-system control electronics. Being a narrow bandwidth

pulse it is stronger and hence able to do more damage than the broader spectrum Leech - the specifically targeted systems therefore remain off line for a longer period.

**The Fulcrum Torpedo** (FT) utilises an antimatter/matter warhead with containment field! After a preset travel time the antimatter containment field is collapsed and the ensuing matter/antimatter annihilation creates a super heated high energy burst. Few things can withstand a FT explosion. Fractions of a gram of antimatter are all that is required (see energy calculations above)
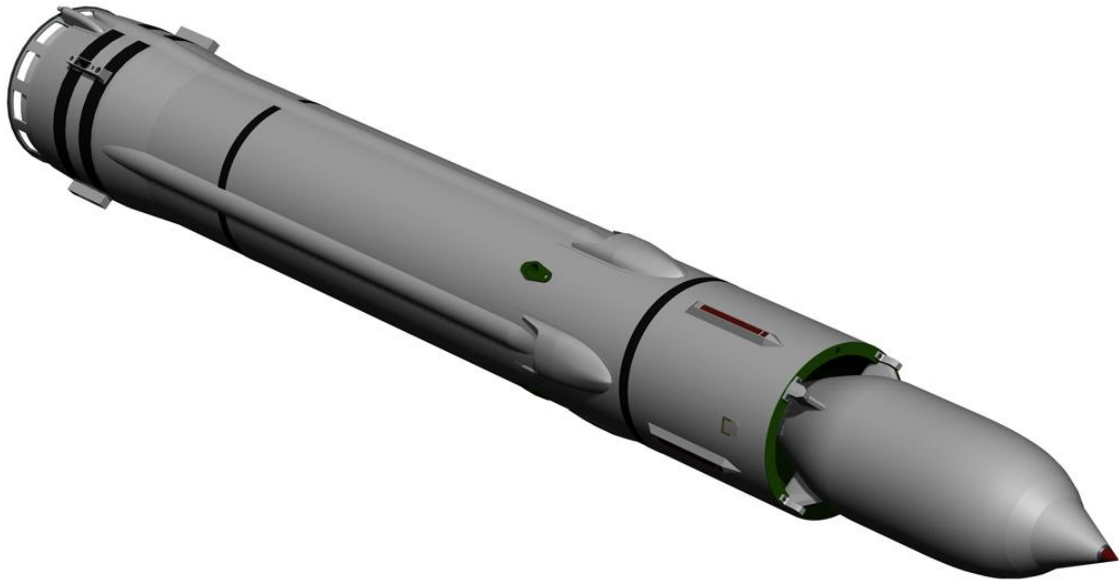


Anti matter can only be held in a shaped magnetic "bottle" containment shield. The strength of the required magnetic (in such a small volume) field requires superconducting magnets and a very complex AI controlled shaping system. There have to be several backup safety mechanisms incorporated so that the missile can withstand the stresses of normal handling, loading and firing.

Because of the complexity of holding antimatter in a matter based missile the construction is significantly more complex than "normal" missiles and hence it is significantly more expensive than any other missile (with the exception of the Regenerative Excalibur Missile System).

There were some experiments with low energy superconductor materials that are significantly less expensive than the ambient temperature materials being used. The cooling system utilised the low temperature of surrounding space to keep the containment field generator at 120 degrees below zero via a heat radiating "fin" on the ships outer hull. This was designed to be a passive system utilising the temperature differential between the near zero of space and the "hot" containment generator inside the ship. Initial tests were promising but in real life tests several problems arose;

The fin had to be made much larger and an active heat pumping system used since heat loss was less efficient inside the shield matrix, and if the fin was outside the matrix it was too easily damaged.

A secondary cooling system had to be fitted for situations where the ship was in a "hot" environment, for example near a star or jumping through WH (gates, fulcrum drive or "wild").

This need for dual cooling required a dedicated AI temperature control sub-system since the FT mechanism is obviously "fail to lethal". Attempts to create a "fail to safe" containment bottle

ejection systems became so complex that they were expensive and too bulky to be fitted into a standard frame. Passive cooling was abandoned and high temperature materials retained.

**Excalibur Pack**: How the Excalibur self-regeneration missile packs work is top secret. A few pilots have tried to "reverse engineer" the sealed units (the silver case in the diagram below) but a series of spectacular accidents and pilots who simply "dropped off the radar" has taught a strong lesson.



3 metres

To maximise the effectiveness of a multiple missile launch system, the missiles have to launched in a very short time. Launching all eight missiles at once or in bursts of four increased the complexity, size, mass and cost of the missile modules beyond the budget of the target market

The Excalibur system therefore launches its missiles sequentially, rather than in multiple missile bursts. The launch system has to handle eight missiles in less than two seconds. A single launch tube/load mechanism couldn't handle such a rate of fire.

The research team developed a mechanism that was based on the historical **Vulcan AutoCannon** which used rotating multiple barrels. This in turn was based on the 18th Century Gatling machine gun. The external part of the system consists of a four rapidly rotating launch tubes. Missiles are launched when the tube moves into the top centre ("fire") position. The first missile is launched and the barrel rotates one place. The second missile is launched and the first tube begins its reload sequence; the barrel rotates again and this sequence continues until all eight missiles are fired.

A barrel has three quarter rotations during which it is reloaded with its second missile. A complete Excalibur Pack launch requires two complete rotations with the tubes with each tube launching two missiles.

Tentative theories (aka scuttlebutt!) have suggested that CDM harvested from the space around the ship could be the source of the matter needed to create the body of the missile and the control AI cores; a miniaturised quantum vacuum fuel generator could provide the fuel (equivalent to a miniaturised fuel processor station) and the small amount of antimatter (3 mins isn't long to reload eight missiles!) to create the explosive warhead but this is all speculation. As one pilot said in frustration when his unit malfunctioned a long way from a repair facility " . . . Vice only knows how the @#*$ works!"

Military research personnel, when asked how the Excal pack works replied (with straight faces) " . . . very well indeed!"

## Other weapons technology

**The proximity mine** is a relatively low yield FT system minus the drive unit. It is detonated by emr signal from your ship.

**The one shot stealth device and the sensor probe** work in a similar way to their big brothers.

**The station detonator** mechanism is top secret and the technology is highly protected (see Excalibur Missile Pack above).

It targets the fabric of a constructed station as well as disrupting the structural integrity field. Rather than using explosive technology, the SD folds the fabric of space-time within the station, disrupting the structural integrity field, disassembling the matter and shifting it into the space through which a WH would normally thread. The result is that the station disappears (though there is some residual energy production visible as a flame ball).



Ships in the vicinity are not damaged, though it is advisable to have a fully charged shield active if you remain in the vicinity!

The quoted yield is actually the equivalent explosive yield it would require to physically blow up the massive station. ("massive" is used in the sense of containing megatonnes of matter). It is obvious why the mechanism is both secret and extremely will protected.

# Defence

## Shield Matrix Fields

Shields are designed to stop emr beam and mass effect weapons as well as missile explosions. A strong electromagnetic field is used to deflect particle weapons. As well as defence against weapon fire this part of the shield prevents damage of high speed travel through space (dust - micrometeorites etc) The second part of the shield field matrix employs a modification of the space-time field in a 3D arc centred on the shield projector. This employs graviton particles. The two effects are calibrated so that they are contiguous (both in exactly the same place)

Impacts on the shield field matrix causes Cerenkov radiation (see above) to be released, often perceived as a flash of blue which "lights up" the shield, rendering it briefly visible.



To an observer it appears that the intruding object, plasma packet or mass slug bounces off the shields - in fact the gravitational spatial distortion becomes so great that the path of the object is radically altered.

Shields operate by creating a layer, or layers, of energetic distortion containing a high concentration of graviton particles around the object to be protected. A graviton is the quantum exchange particle of gravity, much as a photon is a particle of light and is the exchange particle for electromagnetic force.

On capital ships, the shield is created in six sections; fore & aft and starboard & port. and dorsal & ventral. Smaller ships like the ones used by Mercenaries have four shield generators which wrap around the ship; fore & aft and starboard & port. In Mercenary ships the shield energies are emitted from localised projectors. Capital ships, being so large, employ a network of "grid" emitters laid out on the ship's surface.  Shields are obviously essential equipment on all ships.
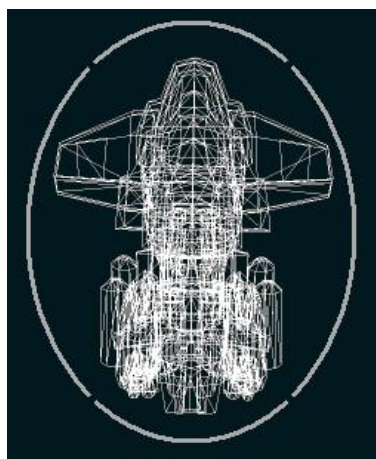
Neither matter nor highly-concentrated energy can normally penetrate a shield. When shields are energized at a high level, most matter or energy that comes into contact with the shields will be harmlessly deflected away. This is important in combat, as shields are essential for hull protection. If the shields don't fail, hull damage is negligible.

Continuous or extremely powerful energy discharges can progressively dissipate the integrity of a shield to the point of failure. Shield capacities varied according to many variables, mainly the power available from the capacitor storage system and the shield energy generation modules. Universal calculations of how much damage a shield can take are difficult to estimate.

Therefore, during combat pilots need to continually monitor on shield strength, usually as a percentage of total effectiveness, with 100% meaning that the shields are at full capacity, and lower percentage scores indicating weaker shield conditions. Mercenary ships are fitted with a bar chart of the four shield modules. Most pilots also fit a HUD display that shows amber/yellow when some shield damage is done and red immediately prior to shield failure. The info is displayed around the tactical HUD display.

In combat some sections of the shield grid are subject to more damage than other sections, and hence can be reinforced by shunting additional power reserves from fully charged shield sections. Shields are said to be "holding" if damage is not sufficient enough to allow a compromise and hull damage; if the shields are "buckling" or "failing," then a total loss of shield protection is imminent.



**Shield Boosters** are the power storage part of the shield system. They are a series of capacitors that store energy for each shield array. A single cell provides basic storage capacity for the shield system. It is possible to fit up to five of these booster cells



**The Shield Array Recharger** works as an energy transfer system and provides additional energy to shield arrays that become critically depleted. This is done by routing power from the main energy system to the shield system. For additional defensive capabilities, particularly for heavy transport ships with fewer offensive options, this can be a very effective device. Since it is competing for main system energy there is obviously a limit to the amount and duration of energy transfer possible.

**The Anti-Missile System** is a semi-effective beam weapon that targets an inbound missile as it approaches your ship. It fires an invisible beam of X-ray frequency laser (coherent) energy at the missile to heat it up and cause it to explode before it reaches its target. Since the system is automated it doesn't emit any visible light that could act as a tracer and an aid to manual sighting.

If you turn away from the incoming missile, you give the system more time to be effective and hit the missile with more energy before it hits your ship. Also, since this system operates independently of the countermeasure system, you can also bombard the missile with CM energy for additional effectiveness, which is particularly effective against multiple inbound missiles.



**The Automatic CM Launcher** does exactly what the name implies. It will begin launching CM's as soon as a missile approaches effective countermeasure range. It can be wasteful with CM's, so pilots should train to use this system most effectively to minimize CM loss. A relatively unsophisticated (and hence affordable) AI core modules tracks incoming missiles and makes pessimistic decisions about the timing and number of CM units to release. The design criteria are based on the premise that a pilot would rather have to replace CM units more often than die!

The CM units used are quite simple. Chaff can't be used because it doesn't disperse rapidly enough in a vacuum and at space combat speeds ships leave chaff shadow very quickly anyway. Electronic jamming or emr pulse generation systems (as used in the Leech missile) were considered. However the individual pulse generators are too bulky and too costly for the rate they would be deployed in a typical combat situation. There is also risk taking out the electronic systems of the ships in the vicinity (including the ship that fired them!)

Each CM unit is "fire and forget" (FaF), non-tracking and passive. It releases a spherical wave of microwave frequency energy that heats the missiles and eventually causes their detonation. Several CM's are usually required, though competent combat pilots tend to develop an excellent sense of timing and can take a missile out with one CM (if they haven't already shot it out of the sky with cannon fire!)

**Armour** is a somewhat valuable commodity constructed from metal ore. It can be built at constructor stations from mined metal for higher trade values.  Nickel/Iron asteroids often contain traces of rare metals such as vanadium, chromium and titanium along with platinum. Mixtures of these metals creates very strong, dense metal alloys. When processed at a molecular level to optimise their performance the resultant armour is very resistant to damage.

It is well known that military frames have some better technology than civilian frames. In military frames the metals are processed with zero defects making the metal alloy armour as strong as it can possibly be. However the military have experimented with alternative armour types.

*Reflective Armour*  The Evoch-C is the next generation of Alliance military fighter technology. Its reflective armour offers slightly better protection against particle cannons compared to the Wraith. Reflective armour is more properly known as *electric reactive armour* (also known as *electromagnetic reactive armour*, or colloquially as *electric armour*). This armour is made up of multiple cells of two or more conductive plates separated by some space or by an insulating material, creating a high-power capacitor.

In operation, a high-voltage power source charges the appropriate armour cell. The armour utilises the fact that plasma packets can have their trajectories deflected by a magnetic or electric field. The armour, being a ferro- metallic alloy capacitor can have an intense local magnetic field induced in it.

The cell is also charged so as to repel incoming packets of charged plasma. Due to the speed and energy of the plasma packets full deflection cannot be achieved but there is benefit in a direct line hit being deflected in to a more "glancing" hit.

*Composite Armour*  The Chimera is the result of numerous experiments and design concepts to produce the ultimate heavy attack spacecraft. The ply-carbon plate armour is an advanced example of The ply-carbon plate armour is an advanced example of composite armour. Most composite armour are lighter than their all-metal equivalent, but instead occupy a larger volume for the same resistance to penetration. As the military have shown in the Chimera it is possible to design composite armour stronger, lighter and less voluminous than traditional armour, but the cost is prohibitively high for normal deployment.

*Chimera's Armour:* The Chimera's armour is based on the idea of creating a layered structure in from graphene nanotube monomolecular sheets. Each sheet has all the tubes aligned and has great impact resistance along the direction that the tubes are aligned. The armour is create monolayer at e time and has the direction of the nanotubes' orientation rotated by 15 degrees between each sheet. The resulting sandwich of millions of such layers results in armour that can dissipate the energy of hits outwards from the impact point. along the direction of the tubes

The inert graphene liner is sandwiched between two metal alloy armour plates. When struck by a plasma packet's  , some of the impact energy is dissipated into the inert inner layer, and the resulting high pressure causes a localized bending or bulging of the plates in the area of the impact. As the plates bulge, the point of plasma impact shifts with the plate bulging, increasing the effective thickness of the armour.

The cost of producing the "***Non-explosive and non-energetic reactive armour***" (***NERA/NxRA***) is exorbitant - it has been estimated that the hull makes up more than 70% of the total cost of a Chimera. However it is the elite ship of any Evochron Naval Taskforce

## Stations:

These come in three fundamental types; Built stations, found in charted (gated) systems only. Constructed stations have the same shell as built stations but require the inside volume for AI modules, structural integrity field generators and auto-fabricators. They have no living occupants. Deployed stations are much smaller, not permanent and have limited, specialised functionality

## Built Stations

Found in all the developed "charted" systems with access to jump gates. Occupied by real people (and several alien species in some systems). They contain a large permanent population who work there and a large transient population of Mercenaries, traders, naval personnel etc. For many of the "permanent" population, it is "home" - they were born and grew up on the station and will live there unless they choose a life as a Mercenary. They have very strong defensive shielding and are able to withstand FTs' and station detonators.

## Constructed Stations

**Trade Stations** A build constructor unit actually doesn't build the station. The shipboard installed constructor unit sends coordinates to a central construction facility in Sapphire. The plan for the particular construct required is used to create a shell plus the fabrication equipment for the items stocked by the station. The AI core modules are also created along with energy generators etc. These sections are "jumped" to the  coordinates and self assemble within the station shell using energy extracted from the quantum vacuum foam surrounding your ship using a QVee module in the constructor.

If you watch a trade station being "built" you will see nothing a for a period of time then suddenly the shell appears (returns to normal space from jump space). There is a propagation of the structural integrity field that holds the station together (an expanding blue glow) as the AI units and fabrication equipment appear within the shell and integrate with it. Finally after all the parts are in place the AI is activated. Look carefully and you will see a little "shiver/ripple" across the docking station atmospheric shield as the AI does a complete system check. The station is now ready for use!

This also explains why as a pilot you only get a license for the station - effectively you haven't built it, only requested that it is built at your location. Note that the cost of a station "build" is significantly less than the cost of a license!

The requirements for the equipment inside means that there is no room for "staff" - everything is automated. There is also no room for strong defensive shields - a constructed station is vulnerable to Station Detonators that disrupt the AI and the structural integrity field that hold the basic shell structure together. (See Station Detonators above). The result is that the station self destructs so as not to be a navigational danger or an attraction to undesirable and criminal elements who might use the raw materials and technology to create their own fortresses. "Sapphire Construction" is looking at the possibility of the AI modules and construction equipment being  jumped back to Sapphire for refurbishment and re-use

There is a distance limit to the jump technology for transferring the stations. Beyond around 20K sectors from Sapphire you cannot "build" a station. Despite years of research the 20K jump system cannot be miniaturised sufficiently to fit into even a large capital ship, never mind a typical Mercenary vessel - the research continues!

**Research stations** utilise AI cores and quantum computers to provide a rapid and sophisticated data analysis capacity within the system. This is a streamlined version of the distributed computing networks first seen in the late twentieth century.

**Energy stations** are a combined QVee system and construction facility, specialising in providing energy products for use in other stations and equipment. The speed of development of a system is directly related to availability of energy and the facilities needed to harness it and use it

**Ore processors and Constructor stations** perform basically the same functions. Constructor stations are more specialised and limited but they are accessible to pilots. Ore processors are automated and meet the needs and demand from trade and other stations and cities that require "parts" for their construction industries

## Deployed Stations

These are small and have a very limited functionality. On the upside, being smaller and simpler the deploy constructor can use cold dark matter as a raw material and quantum foam as an energy source. The structural integrity and functioning depends on information transmitted by the deploy constructor unit. If you move the constructor beyond the range of the transmitter (one sector) the deployed station self destructs (scuttles as the Mercenaries say!)

**Fuel processors** contain a small singularity QVee unit which sifts matter particles out of the matter/antimatter virtual particle pairs of the quantum foam. The antimatter particles are converted into fuel. Ironically controlling the process is energy intensive and so the ships core generators are used to power the control system, Hence the continual charge/discharge cycles as fuel is "made" in 5 units "chunks"

**Energy stations** works in a similar way but doesn't process the extracted energy into storable fuel - it feeds it into all of your ships systems simultaneously for an instant boost

**Repair systems** are a masterpiece of design. An AI core analyses the damage to your ship and uses fabricators to create the necessary items. It uses converted CDM as its raw material and a small QVee energy extraction system to power everything that needs to be done.

**Shield arrays** are a bigger and much more powerful version of the unit in your ship (or a scaled down version of the unit in a real trade station!). It uses IFF technology to allow friendlies in and to keep hostiles out. To ensure that if hostiles do manage to bypass the IFF identification protocols, the field also suppresses all weapons systems on all ships inside the shield sphere. If hostiles do manage to get in they cannot do much damage. However , pilots need to be aware of the tactic of physically bumping you out of the shield sphere so that you are no longer protected! It is possible to piggy back a shield array onto a fuel processor so that you can sit in safety for the time it takes to refuel.

**Sensor arrays** auto ping a sector using passive and active sensor technology and record the position of every ship they find. The information is transmitted to all parts of the sector and displayed on your nav map - and also on the nav maps of every other ship in the sector! Be warned - you can "see", but can also be "seen"

# Quantum & Space-Time Field Manipulation Technology

## Shields Technology - see above

## Stealth Generator

The stealth system (be it the one shot, short life unit or the much more expensive permanent unit) work by creating a field that warps space-time so that all emr bends round it completely. Looking at a cloaked object from any angle lets you see an undistorted view of what is behind it.

The generator also masks the heat signature of the ship. Heat is infra red emr, but the stealth field has to deal with it being created inside the field. This is hard to do with 100% efficiency. Use of the afterburner both overloads the energy drain of the ship's energy core and creates too much heat for the stealth system to handle. The designers considered disabling the afterburner system, but decided that a pilot would only use an afterburner when stealthed in emergencies. As a result, activating your afterburner switches off the stealth system, allowing shield recharge to begin immediately - hostiles would spot you anyway from the heat signal that leaked through the field. The ship has to use passive "radar" whilst stealthed or its presence would be detected.

The big disadvantage of the stealth system is that it is incompatible with the shield system. When the stealth generator switches on the shield collapses. The manufacturers have used this conflict to make the generators smaller and cheaper - they tap into the energy sources normally used for the shield.

When the stealth generator is switched off again it takes a significant amount of time to recharge the shields to a level where they can protect the ship. It is also means that until the shield system fully recharges the generator can't be used again!

If there is any shield damage at all the stealth generator will not start, so pilots need to activate it prior to being hit in the combat zone. They also need to leave the combat zone before switching off the generator to avoid being shieldless "sitting ducks"

The other big downside of using a stealth system is that weapons systems are taken off line when the stealth field is active. A pilot dreaming of sneaking up on someone's six, uncloaking, firing and recloaking is in for a very big disappointment!!

However, used carefully they are very useful for scanning contracts in hostile space. You can ambush someone using stealth but you need to be able to guarantee delivering a killing blow before your target can respond and also be able to vacate the area before his wingman can retaliate!

## Structural integrity Fields

The main function is to increase the structural integrity of large, relatively weak structures such as trade stations.

This field is a modification of the combat shield and is projected through the structure of a station essentially turning the material into a cross between matter and force field. This increases the strength and rigidity by orders of magnitude, allowing the materials to withstand the stresses associated with their mass (megatonnes) size and operations.

## Mining Beams

This a dual purpose system used to extract and collect metals, water, oxygen etc from asteroids and the atmosphere and seas of planets as well as "tractor" mined material into containers in a cargo bay. It is capable of tractoring containers and rescue pods as well. The tractor field part of the mining beam is generated by graviton manipulation to literally lift the processed bits of the asteroid crust into the cargo bay. Similarly it can manipulate rescue pods and cargo containers

When mining asteroids the beam control system recognises that it is aimed at raw materials and uses the weapon system's plasma generators to create a lower energy plasma beam. This beams ablates the asteroid and mass spectrograph analysers identify the metal being released by analysing the light emitted in the vaporisation of the asteroid surface. The material is concentrated and then transferred into cargo containers.

In nebulae & star coronae (for fuel gathering), planetary atmospheres and oceans etc, the system automatically recognises that the plasma beam is redundant. Similarly the simple AI unit in the beam generator can identify rescue pods and jettisoned containers and moves into retrieval mode automatically.

Recent developments in the AI core have lead to the availability of specialist mining beams that recognise a specific material (diamond - platinum - gold - metal ore) and ignore the rest. The beams can still be used for pod/container retrieval.

## Asteroids exist mainly as one of three types:

Water ice asteroids exist in the outer most part of start systems as "leftovers" of the systems formation. Periodically an asteroid's orbit is gravitationally perturbed and it begins a long fall "in system towards the star. Some are evaporated before they reach the inner parts of the system, some don't survive their swing around the star and some pick up gravitational energy from the star and are flung out into space. Asteroids like this are called comets. They form a major source of water for many remote arid systems.

Carbonaceous asteroids contain many complex organic molecules and form raw materials for much of Evochron's chemical industry, creating medicines, plastics and resins and fibres and elastomers, solvents, detergents, dyes and pigments, paints and varnishes and other coatings, adhesives, lubricants and coolants, gels *etc*. Carbonaceous asteroids also contain diamonds.

Nickel/Iron asteroids these often contain traces of rare metals such as vanadium, chromium and titanium along with platinum. Mixtures of these metals creates very strong, dense metal alloys. When processed at a molecular level to optimise their performance the resultant armour is very resistant to damage.

In asteroid fields collisions between these large chunks of brittle materials leads to their fragmentation, mixing and reformation, resulting in asteroids that contain metals and diamonds.

# FtL Communications

## Chatting across the Universe

When humankind first travelled to another planet, as opposed to the Moon, they chose Mars. Electromagnetic radiation (EMR) includes light and radio waves. It takes between 3 minutes and 22 minutes to travel  between the two planets. Imagine the early morning exchange (using an average 10 minute delay) between Mars Control on Earth and the Mars habitat in the *Timoshenko crater* near *Tempe Fossae* in *Tempe Terra* lowlands of Mars

All times given as Earth UCT

| Time | Earth | Mars |
|------|-------|------|
| 8:00 | "Good Morning Mars" | |
| 8:10 | | hears Mission Control greeting |
| 8:11 | | "Hi MC - everything is good here" |
| 8:21 | hears Mars' hello | |
| 8:22 | "Good - here's the latest on your request . . ." | |
| 8:32 | | hears response to their request. |

It made conversations impossible. Pluto was even worse with an average of a four hour delay. A method of sending signals FtL was urgent! Three basic ideas researched based on Quantum Theory and Relativity.

**The first method  involves the creation small (atomic or  nano-sized) paired wormholes dedicated to communication** by means of a laser whose pulses traverse the wormhole at the speed of light thus achieving FtL transmission speeds. This is basically a microscopic version of a jump gate. Present theories of wormhole formation suggest they would *not* become "time-holes", allowing FtL communication without the additional complication of allowing communication with the past or the future! Some sections of the science community and the military are sorely disappointed. The *Evochron Lottery* organisers are greatly relieved.

Since jump technology was already being developed, and because of problems with the technology involved with Quantum entanglement and the fragility of the entanglement of the photons, WH communication  is the technology used in human controlled space in Evochron.

Initially the transmitter created a wormhole between itself and the receiver.  Only these two communication units could communicate via the WH created. This has the advantage of very secure communications (and is still used by the military for passing ultra secret information). The disadvantage is that multi-person communications and general universe wide broadcasts can't be made.

These issue of these broadcast problems was solved by creating a network of satellite relay stations throughout Evochron. The communicator in a ship creates a WH to the nearest relay station. The relay stations are linked to each other in the network via permanent micro-WH's. The message has encoded in it the recipient's *receiver identification code* and sends the message to the nearest relay station in the network to the receiver. This relay then creates a WH to the intended recipient's communicator.

If multiple person communication or general broadcasts are required then the relay stations create WHs to either each of the appropriate persons' receivers or all the communicators within their range.

However, there is still a short delay in the transmission of the message, though it is very much faster than gate jumping because the messages don't need to be accelerated first like ships do. There is also an issue with bandwidth - verbal communication requires a *much* higher bandwidth than typed speech. Consequently ship to ship messages are typed into a "chat" window. The general experience is acceptable but it can be amusing to see two conversations going on between two people at the same time! In general multiple person broadcasts, there are often several conversations mixed together!

**The second method employs (faster than light!) tachyons**. It is rumoured that Vonari use tachyon based communications for real-time communication over long distances. Some affluent mercenaries have also managed to acquire adapted Vonari technology which allows them to use speech communication. There are some issues about signal breakup (garbling their messages) and a very high AI decoding requirement which can at times interfere with the AI management systems of the ships fitted with the technology; data screen updates can become a little (or a lot!) "laggy"!
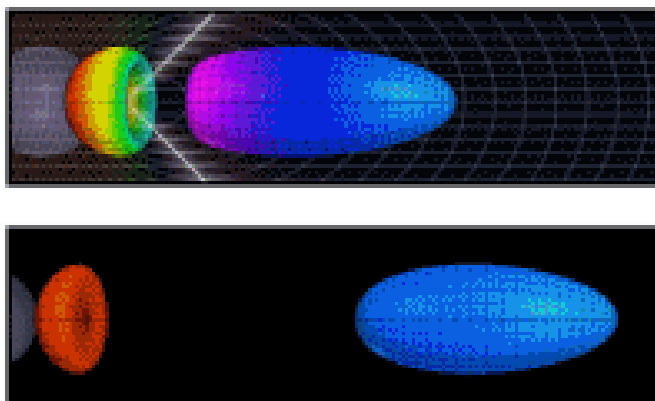


Since a tachyon moves faster than the SoL we cannot see it approaching. After a tachyon has passed nearby, we would be able to see two images of it, appearing and departing in opposite directions. The black line is the shock wave of Cherenkov radiation (see above), shown only in the diagram at one moment of time. There is a good animation at  http://en.wikipedia.org/wiki/File:Tachyon04s.gif
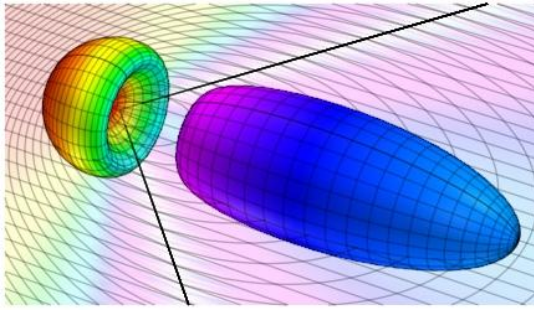
Due to quantum particle/wave duality whereby particles have wavelike properties and vice versa, the tachyon stream can have its wave train frequency modulated to behave like a FtL equivalent of a FM radio wave used for short range communications.

## The third method utilises the properties of quantum entangled particles, a technology that is used in the quantum computers utilised in the highest power AI modules.

The method is based on the  creation of pairs (or pairs of pairs or pairs of pairs of pairs etc) of quantum entangled photons using a quantum cloning system. One of the entangled particles is transported to each end of the communication "line". Collapsing the quantum state of one of the entangled particles instantly causes the collapse of the all the others regardless of how far away they are. Each particle can be used to transmit only one bit of data and so a typical message requires around 10K entangled photons..

The problem is the that the particles can only separated after they are made in entangled pairs or groups and have to travel to their destination using methods that are less than the SoL. One way around this limit is to create a network of prepared particle pairs that must be set up in advance and be kept "topped up". This is coupled to distribution via a network of relay stations similar to that built for WH communication. This is a technically and practically difficult solution, since the entanglement is fragile.

However, research continues because it would allow near instant communications across the universe.

# Portable Energy Resources

**Anti-matter cells** are a high end energy source that are extremely expensive to produce and provide a very long lifespan. As a result, a premium is paid for these devices to anyone who can deliver them. Antimatter cells us a micro QVee unit to extract antimatter from the quantum vacuum. This is used in nano-gram scales in a matter/antimatter reaction cell, releasing very high quantities of energy. The antimatter extractor isn't very efficient but given the amount of matter released by even a gram of antimatter in contact with matter, it is more than adequate for its purpose. It is also much safer since the energy can be produced at a controlled rate and there is little chance of a significant amount of antimatter leaking out at any given time

**Fusion cells** are also a high end energy source, but are much easier to produce. They feature a very long lifespan and usually provide a high price for shipping. These employ "cold fusion" cells and hence don't need the complex magnetic containment "bottles" required for hot fusion (that recreates conditions in the centre of a star (temperatures of 15 000 000 K or more!)

Cold fusion was first reported in 1989 by Stanley Pons and Martin Fleischmann. It was the most heavily hyped science story of the decade, but the awed excitement quickly evaporated amid accusations of fraud and incompetence. When it was over, Pons and Fleischmann were humiliated by the scientific establishment; their reputations ruined,; "Cold fusion" and "hoax" became synonymous in most people's minds. However many reputable scientists continued to play with cold fusion and in 2025 Pons and Fleischmann were completely vindicated, when they shared the Nobel Prize for Physics for their discovery.

Cold fusion systems are still based on the basic same system reported by P&F in 1989. Their system had produced excess heat in quantities that could only be explained in terms of nuclear processes. They further reported measuring small amounts of nuclear reaction by products, including neutrons and tritium. Their small tabletop experiment involved the electrolysis of "heavy water" using palladium electrodes. Heavy water is water in which the two hydrogen atoms are replaces by the isotope of hydrogen called deuterium. Hydrogen atoms, the simplest atoms, contain one proton and one electron; deuterium atoms are have one proton and one neutron in their nuclei plus an electron in orbit. Palladium is a member of the platinum group of metal elements in the periodic table along with platinum (!), rhodium, ruthenium, iridium and osmium group. They are all excellent catalysts.

Modern "Low Energy Nuclear Reaction" (LENR) cold fusion units utilise the Mossbauer effect, a process isomeric nuclear transitions in a chemically bound crystal structure solid. The regular array of the crystal both increases the fusion efficiency greatly but also allows a finer degree of control.
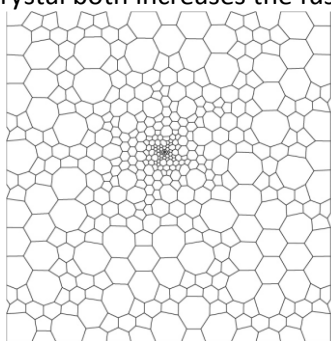


Deuterium-Tritium mixtures are used as the "fuel" with dendritic palladium hydride electrodes. The fractal dendritic structure increases the surface area to volume ratio of the palladium electrodes by a factor of 10 000.

Diagram of a dendritic fractal structure

# Miscellaneous Technologies



**Fuel Converters** are a remarkable piece of equipment that can transform high energy photons from solar corona or nebula clouds into fuel. It connects to the tractor beam system and fuel tank to directly deposit the converted fuel into the tank.
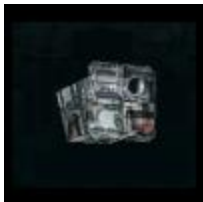


**Cargo containers** have a programmable radio frequency identification (RFID) tag built into their structure. RFID tags are intelligent "bar codes" that can talk to a networked cargo handling system to track every product that is put into a cargo container.

These passive RFID tags can store up to 2 kilobytes of data and are composed of a microchip, antenna and, in the case of active and semi-passive tags, a power source. The tag's components are enclosed within tough tamper proof plastic envelope within a cavity within the container wall.

At a basic level, each tag works in the same way:

- Data stored within an RFID tag's microchip waits to be read.
- The tag's antenna receives electromagnetic energy from an RFID reader's antenna.
- Using power from its internal battery or power harvested from the reader's electromagnetic field, the tag sends radio waves back to the reader.
- The reader picks up the tag's radio waves and interprets the frequencies as meaningful data.

An RFID will broadcast the contents when interrogated by an appropriate electronic transmitter. RFID technology became common in the late twentieth century. This facility is primarily designed for automated cargo handling between different stations, ships and trade stations and between ships in space. Cargo scanners are a modification of this technology that allows the detection of the identity of cargo (either in open space or in a ship's cargo bay) at a much longer range of between 500 and 2500, depending upon the scanner's class.

**Repair Devices** automatically repair subsystem and hull damage in-flight. Installing one of these means you don't have to dock and pay for repairs. Subsystem damage can be repaired fairly quickly, but hull damage takes a long time to repair. Class 1, 2 and 3 devices are available. Military ships are rumoured to be fitted with even higher classes.

An AI core module analyses the damage to the hull and internal systems. A QVee module creates the solid materials required and provides the energy for fabrication of various replacement components. Given the size limitations of a shipboard repair system the process is quite slow. Many pilots use the facility if they have some free time or no access to a station - otherwise deploying a repair station or using the facilities in a trade station can get a pilot back into the action far more quickly!

The matter extracted from by the QVee from the quantum vacuum is used to repair hull damage - it doesn't repair the "paint job". You can fly and fight again but everyone knows you got burned!

# Appendices

## Ship Frames (Civilian)

| | |
|---|---|
| **Talon** | The Talon is a scout class frame that provides a basic platform for new mercenaries. It is inexpensive to build and operate. While the weapon options and defensive capabilities are limited, the Talon frame is the fastest platform and most manoeuvrable. While its design possibilities are limited, it can be optimized effectively for particular advantages. |
| **Pulsar** | The Pulsar frame expands on the original and provides more assembly resources with a minimal reduction in performance and manoeuvrability. It also includes substantially more armour and is a more flexible platform from a design options standpoint. |
| **Saber** | The Saber is a fighter class frame, although it is also used as a scout by many mercenaries. Its reinforced armour and efficient power system provide a high level of protection for such a small frame. Like the Raven, the Saber frame is considered to be the best choice for light and medium combat duties by most mercenaries and is very affordable. |
| **Raven** | The Raven frame expands on the Saber design. With a larger size, it offers more assembly resources and armour at a similar level of performance. Named after the Alliance combat spacecraft that fought in the first Alliance-Federation war, the new Raven provides a solid platform for mercenaries looking for a capable combat frame with amazing performance and manoeuvrability. |
| **Striker** | The Striker frame is a unique compact design that uses blended metallic composites for very effective armour protection and advanced technology to keep its overall size small compared to other frames. Its rounded shape and powerful energy system allow it to have a high level of assembly resources and support for energy hungry shield systems. An excellent multi-role frame. |
| **Phoenix** | The Phoenix class frame is a revised version of the Striker, offering a much larger structure with more assembly resources and armour. These improvements are available with a minimal reduction in agility. Most mercenaries who prefer the advantages of the Striker frame choose the Phoenix as the best version. |
| **Hunter** | Designed to survive intense large scale battles and protect valuable cargo from even the most powerful adversaries, the Hunter class frame boasts triple layer metallic composite armour and plenty of assembly resources for high end components. It's main drawback is limited agility and speed, but it is ideal for mercenaries who require high end offensive and defensive capabilities. |
| **Renegade** | The Renegade class frame was built as a combat oriented upgrade to the Hunter frame. It sacrifices some agility for a larger size with 25 more assembly resource points and another layer of armour. It also features a compression capacitor in its engine management module, which helps to minimize the loss of speed, resulting in a reduction of only 50 MPS base speed compared to the Hunter frame. |

| | |
|---|---|
| **Centurion** | Considered the battleship among mercenaries, the Centurion frame commands attention and respect. Only wealthy mercenaries can afford to buy and operate this ship, but the reward is a commanding lead over other frames in most combat situations. It can be designed to also be an effective transport, offering a level of cargo safety far above what other ships are capable of. |
| **Leviathan** | Several private mercenary groups pooled their resources together to develop the Leviathan class frame as an answer to the Centurion which had dominated much of Evochron for a long time. The Leviathan offers an unequalled level of assembly resources and armour. It usually takes a skilled group of pilots to defeat one of these ships. |
| **Arrow** | One of the first Federation frames made available to mercenaries operating in Alliance space, the Arrow frame offers remarkable agility. While not quite as fast as the Alliance built Talon, its powerful thruster system gives it a manoeuvrability level that's over 20% higher. |
| **Scorpion** | The Scorpion offers a robust platform for a light frame. With a higher design capacity than most other light frames coupled with agility that matches the Arrow, it is a very capable platform for light transport and combat duties. This frame is also popular for racing. |
| **Panther** | The Panther is a sleek design offering high speed and moderate assembly capacity. It's not quite as agile as the lighter Federation frames, but can hold its own against the Alliance Talon and Saber frames. With its higher design capacity and high speed for its size, this frame is a popular choice for mercenaries who trade in moderate to hostile space. |
| **Mirage** | The Mirage frame is a very capable medium combat platform. Complementing its thick armour is a high power shield core similar to the design used on the military's Aries fighter. It's not quite as fast as the comparable Alliance Raven frame, but it has an edge in agility and design capacity. This frame is a popular choice among skilled combat pilots. |
| **Venture** | The Venture was designed for moderate transport duties. It has a relatively high assembly capacity for its size along with a multi-coil shield core. While its additional bulk does limit its velocity and acceleration, powerful manoeuvring thrusters help it match the agility of the lighter Mirage frame, even with its heavier hull armour. |
| **Sentinel** | Named after the defensive combat role it was built for, the Sentinel is often used in escort and support duties. It has earned a reputation of being able to take a hit. With its moderate assembly and design capacities, it can also be made into a formidable offensive combat spacecraft. Mercenaries often devote its available resources to weapons and shields. |

| | |
|---|---|
| **Guardian** | The Guardian is based on the Sentinel's design, but adds significantly more armour, assembly and design capacity, and shielding. Its ability to carry a much higher payload comes at a price, its speed and agility are significantly less than the lighter Sentinel. However, many pilots consider its additional protection well worth the price. |
| **Legacy** | The Legacy frame is designed to provide a high cargo and weapon capacity in one of the fastest and most agile heavy designs. It features much better agility compared to a similarly configured Renegade frame along with a slight speed and acceleration advantage. Because of its agility, this frame is often used in heavy combat roles. |
| **Mammoth** | Designed to be a heavy transport, the Mammoth offers enough design capacity to carry many of the most advanced equipment upgrades at the same time. While it's slightly slower than a comparable Centurion, it is significantly more manoeuvrable. This ship is often the preferred choice for surviving in hostile space. |
| **Starmaster** | Little is known about this frame. The Starmaster is rumoured to be built in only a few secret locations and is generally only owned by the wealthiest of mercenaries. |

## Ship Frames (Military)

| | |
|---|---|
| **Ferret** | The Ferret is a lightweight scout spacecraft designed for high speed reconnaissance. It carries a basic internal missile rail of 4 hardpoints. The Ferret has minimal armour, but its high agility and speed makes it very effective at evading missiles and gunfire. |
| **Aries** | The Aries is categorized as a scout but provides sufficient armour and speed for it to be effective in light fighter roles as well. This spacecraft is often used for training combat fighter pilots. It is also often used for patrols and scout duties that require more range than the Ferret can provide. |
| **Shadow** | The Shadow is the Alliance's primary light attack fighter. For its size and agility, this spacecraft carries a remarkably high payload limit. It also features a shield core with nearly the same output capacity as the Wraith. Its wing design also gives it an advantage in atmosphere manoeuvrability while its composite armour offers good resistance against direct hull impacts. |
| **Wraith** | Considered to be the front line fighter in the Alliance Navy, the Wraith is a multi-purpose medium range strike fighter with extreme speed and agility. With 8 hardpoints and moderate armour, it's a well rounded fighter package capable of filling a variety of combat roles. |
| **Evoch-C** | The Evoch-C is the next generation of Alliance military fighter technology. It includes a manoeuvring system based on reverse engineered Vonari spacecraft and unique ion-pulse engines that together provide the most agile and fast spacecraft known to exist. Its reflective armour offers slightly better protection against particle cannons compared to the Wraith. |
| **Evoch-E** | The Evoch-E is a heavily redesigned version of the C model. This platform essentially takes the original Evoch design and improves it in virtually every area. It is faster, more manoeuvrable, and better armoured than the original. The only drawbacks to this design over the C model are higher fuel use and cost. This new fighter is considered the latest in technology. |
| **Lamprey** | The Lamprey is based on the Evoch-E platform, but is modified to perform a more strike oriented role. What it lacks in speed and agility, it makes up for in armour and shielding. It's unique forward swept wing is combined with a powerful thruster set which provides excellent agility in planet atmospheres and open space. |
| **Firestar** | Considered by many to be the best overall strike spacecraft, the Firestar is an all-new design built to replace the aging Avenger. It offers a significant speed advantage over the Avenger while being barely slower than the Lamprey. It's also much more agile than the Avenger with a minimal reduction in armour. As a result, this design is also capable in a dogfight. |

| | |
|---|---|
| **Avenger** | The Avenger is designed to be a heavy interceptor and strike spacecraft. Its thick armour coupled with high speed and agility for its size give it a distinct advantage in many heavy combat roles and strike missions against powerful capital ships. The Avenger is the primary strike and intercept spacecraft of the Alliance Navy. |
| **Shrike** | The Shrike is a major redesign of the Avenger platform. It is a heavy attack spacecraft optimized for capital ship engagements. Its reactive armour and powerful shield core provide an effective defence against flak cannons and particle gun impacts. The Shrike also has the highest speed of its class, allowing it to reach its target quickly. |
| **Predator** | The Predator is generally regarded as the Alliance Navy's most powerful heavy attack spacecraft. It has the heaviest armour of any military spacecraft and provides agility that exceeds even the lighter civilian Centurion and Leviathan frames. It is used sparingly due to its high construction and repair costs, but is the spacecraft of choice when the objective involves high numbers of powerful enemy forces. |
| **Chimera** | The Chimera is the result of numerous experiments and design concepts to produce the ultimate heavy attack spacecraft. Its high fuel burn rate and extreme cost limit its practicality and accessibility. But with its decent agility and speed, immense shield core, and ply-carbon plate armour, it is a force virtually no one wants to go up against on the battlefield. |

## Engine data:

**Engine Class 1**  Illumine Mark I Engine While merely an entry level engine, the Illumine is ideal for Scouts that are designed more for shipping, mining, cleaning,  trade, and other non-combat objectives.  The engine is known  for its low cost of operation, being the most fuel efficient type of engine available to mercenaries.

**Engine Class 2**  Illumine Mark II Engine This upgraded version of the Illumine engine provides adequate performance for light combat duties, but is generally considered to be best for non-combat objectives.  It's small design, low fuel consumption, and modest output provides a good first  upgrade for rookie mercenaries flying light spacecraft.

**Engine Class 3**  Voyage Mark I Engine Designed to provide a high level of power with minimal assembly use, the Voyage class engine is the ideal choice for small spacecraft that need assembly resources for other  critical components.  It also includes twin vertical stabilizers to improve atmospheric control.

**Engine Class 4**  Voyage Mark II Engine The Mark II offers remarkable power output for its size and assembly resources.  It's considered by most mercenaries to be the best choice for light and medium class spacecraft.  It also offers close to the power output of a Richton engine with a  substantially lower assembly resource requirement.

**Engine Class 5**  Richton Ion Engine The military research division in the Richton system developed this engine for use in interceptor class combat spacecraft and was soon made available to mercenaries  looking for a propulsion system that balances fuel  consumption with power output.  The Ricthon is a good overall choice for a variety of combat and non-combat roles.

**Engine Class 6**  Clan Richton Ion Engine The CR Ion Engine Improves the power capacity of the original Richton version with a very small increase in fuel consumption.  Not generally recommended for smaller spacecraft, the Clan Richton engine is a good fit for  medium sized spacecraft.

**Engine Class 7**  Neptune Mark I Engine The Neptune is a well armoured and efficient propulsion system.  For its power, the Neptune is relatively fuel  efficient.  It's generally a better choice for larger ships requiring powerful engines and with a high level of assembly resource needed to accommodate its size.

**Engine Class 8**  Neptune Mark II Engine The Mark II Neptune is substantially larger and more powerful than the Mark I.  It also includes a much larger cooling system with bigger heat vents for improved efficiency and reduced exposure to damage. The Neptune is also well shielded and is a popular choice for mercenaries who frequently engage in heavy combat.

**Engine Class 9**  Quantum Ion Mark I Engine The Mark I Ion engine is the civilian version of a classified military propulsion system offering far more power than other engine types.  It includes 2 compression cells which improves performance for rapid speed changes and 4 sub-outlets for stability.

**Engine Class 10**  Quantum Ion Mark II Engine The Mark II is essentially two Mark I engines joined together. It includes 4 compression cells and 8 sub-outlets.  While not the most fuel efficient engine by any measure, its output is unmatched and provides remarkable speed even for the heaviest spacecraft.

| ENGINES (Provided By Marvin) | | | | |
|---|---|---|---|---|
| NOMENCLATURE | ASSEMBLY | THRUST | FUEL USAGE | INCREASE* |
| Illumine MK I | 15 | 150 | 36 | 0.0 |
| Illumine MK II | 25 | 300 | 60 | 32.5 |
| Voyage MK I | 45 | 450 | 84 | 65.5 |
| Voyage MK II | 70 | 600 | 108 | 98.5 |
| Richton Ion | 90 | 750 | 132 | 131.5 |
| Clan Richton Ion | 115 | 900 | 144 | 164.5 |
| Neptune MK I | 145 | 1050 | 156 | 197.5 |
| Neptune MK II | 155 | 1200 | 168 | 229.5 |
| Quantum Ion MK I | 170 | 1350 | 180 | 262.5 |
| Quantum Ion MK II | 200 | 1500 | 192 | 295.5 |
| * Amount of increase (+/-0.5) to a Ships Base Speed. | | | | |

## Wing data:

**Wing Class 1** (assembly points: 10) The standard entry level wing system is the *StarGlider*. It provides moderate performance for small ship frames and requires a very low level of assembly resources. Combined with a low cost, its features result in this wing and thruster set being a common choice for pilots who want to compromise on agility. This system includes the weakest thruster set available to mercenaries.

**Wing Class 2** (assembly points: 20)The *Archer* wing system is a minor increase in overall performance compared to the StarGlider, but it does offer its improvement at a minimal cost in assembly resources and credits. It works best on smaller frames, but is also useful on larger frames to recover needed assembly resources for pilots who want to reduce manoeuvrability for other options.

**Wing Class 3** (assembly points: 35)  The *Raptor* wing is unique among small class wings. It provides a much higher level of performance and stability compared to other wings in the same class and even some in higher classes. It's twin pylon design for its 4 tail fins only needs to be attached to a frame at the front two wings, which keeps assembly resource consumption to a minimum.

**Wing Class 4**  (assembly points: 55) The *Falcon Mark I* wing is ideal for light and medium frames. It provides improved thruster performance needed for heavier frames and doesn't require a lot of assembly resources. It's original application was on Alliance military spacecraft and is now being sold in the free civilian markets of Evochron.

**Wing Class 5**  (assembly points: 70) The *Falcon Mark II* wing adds a one piece tail section to the original design, further improving agility. A good upgrade for small and medium frames.

**Wing Class 6** (assembly points: 80)  The *Falcon Mark III* wing adds two middle fins to the Mark II design along with additional thruster coils further improving agility. Recommended for small and medium frames.

**Wing Class 7**  (assembly points: 95) The *Razor Mark I* wing is a good choice for medium frames as it includes two thruster packs to assist the inertial dampening system for improved manoeuvring performance. It's additional weight and connections for the thruster system do require substantially more assembly resources, but most pilots consider the advantages it offers to be worth it.

**Wing Class 8**  (assembly points: 110) The *Razor Mark II* wing adds vertical stabilizers to the wings for improved performance. Not an essential upgrade, but a minor improvement for frames with a few assembly resources remaining.

**Wing Class 9**  (assembly points: 120) The *Razor Mark III* wing adds a tail section, offering additional thruster coil space for improved performance and stability. Another minor improvement to the Razor design.

**Wing Class 10**  (assembly points: 135) The *Razor Mark IV* wing adds two middle stabilizing wings. While the individual enhancements offer minimal improvements, collectively they provide a substantial upgrade compared to the MKI design.

**Wing Class 11**  (assembly points: 150) The *NightHawk Mark I* wing may look very small in comparison to other wing designs, but it features a revolutionary advancement previously only used in military applications. Mounted on each wing is an anti-gravity pod that is used to generate additional power and agility. It's design provides a higher level of performance than even the bulky Razor.

**Wing Class 12**  (assembly points: 170) The *NightHawk Mark II* wing adds rear vertical stabilizers to the original design, offering additional stability and anti-gravity emitters. It retains the same low visual profile and overall size as the Mark I design.

**Wing Class 13**  (assembly points: 180) The *NightHawk Mark III* wing adds middle stabilizer wings to the Mark II design, offering additional stability. It continues to provide a low profile appearance with its stealthy design. This wing is generally considered the best performing model available to mercenaries.



WING ENHANCEMENT CHART (Provided By Marvin)

**WING ENHANCEMENT CHART**

WING TYPE
- Basic (C1-C3)
- Standard (C4-C7)
- Improved (C8-C10)
- Advanced (C11-C13)

TURN RATE *

BASIC AGILITY

\* Turn Rate indicates the length of time, in seconds, for the ship to complete a 180° turn.

Depending on the ship's basic agility rating, an upgrade to the wing will enhance, more or less, the ship's turn rate.

\* All military ships are fitted with five equipment slots and 4x25 CM Packs.

# Weapons Data

## Particle Cannon

| PARTICLE WEAPONS (Provided By Marvin) | | | | | |
|---|---|---|---|---|---|
| NOMENCLATURE | CLASS | YIELD | CYCLE RATE | RANGE | NOTES |
| Flare Beam | C1 | 10 | 120 | 750 | |
| IceSpear | C2 | 25 | 120 | 700 | |
| FireFury | C3 | 35 | 120 | 600 | |
| StarGuard | C4 | 45 | 120 | 570 | |
| Stalker | C5 | 70 | 100 | 550 | |
| *Eclipse* | C6 | 50 | 100 | 540 | Kinetic force weapon |
| StarForge | C7 | 100 | 100 | 580 | |
| Maxim-R | C8 | 120 | 100 | 700 | |
| *SunRail* | C9 | 40 | 90 | 550 | Depletes energy |
| Razor | C10 | 140 | 90 | 450 | |
| Predator | C11 | 150 | 90 | 480 | |
| *Trebuchet* | C12 | 55 | 90 | 550 | Depletes shields |
| Atlas | C13 | 200 | 90 | 500 | |
| Phantom | C14 | 220 | 90 | 570 | |
| *Banshee* | C15 | 80 | 90 | 520 | Kinetic force weapon |

## Beam Cannon

| BEAM WEAPONS - LASERS (Provided By Marvin) | | | |
|---|---|---|---|
| NOMENCLATURE | CLASS | YIELD | RANGE* |
| Refractor | C1 | 10 | Linked |
| Metal Vapor | C2 | 25 | Linked |
| Coil | C3 | 40 | Linked |
| Neodymium | C4 | 55 | Linked |
| Fusion | C5 | 75 | Linked |
| * The range of a beam weapon is linked to its particle weapon counterpart. | | | |

## Missiles

| MISSILES (Provided By Marvin) | | | | | |
|---|---|---|---|---|---|
| NOMENCLATURE | CLASS | YIELD | RANGE | SPEED | NOTES |
| Echelon | C1 | 1000 | 3800 | 1400 | |
| Viper | C2 | 1200 | 3500 | 1200 | |
| Rockeye | C3 | 1400 | 3400 | 1000 | |
| Starfire | C4 | 1800 | 3000 | 500 | |
| Exodus | C5 | 2500 | 2400 | 700 | |
| *Leech* | | 200 | 3500 | 1000 | EMP Disruptor |
| *Excalibur Pack* | | 800 | 4000 | 1800 | Regenerative (3 minutes) |
| *Fulcrum Torpedo* | | 110000 | 2000 | 250 | Mass Destruction |
| *Lynx* | | 900 | 2700 | 800 | Targets engines |
| *Rage* | | 950 | 2800 | 850 | Targets weapon systems |
| *Cyclone* | | 1500 | 3100 | 1000 | Kinetic missile |

## Other Weapons

| SECONDARY DEVICES | |
|---|---|
| NOMENCLATURE | NOTES |
| Stealth / Cloaking Device | Time per device: 60 seconds |
| Proximity Mine | Cloaked detonation weapon, ~2000 range, ~100,000 yield |
| Probe | High power sensor device, 25,000 range |
| Station Detonator | Destroys player built stations, ~8,000,000 yield (equivalent) |

# System Data

**Sapphire**: This is the main trading centre in Evochron and is firmly in Alliance control. It has jump gates to all 4 sections of the Evochron system. Sapphire is considered the launching point for new mercenaries due to its strong Alliance presence resulting in a well protected system with a positive reputation level. Very few major conflicts ever occur in this system, mostly minor fighting between individual mercenary ships. Because of a saturated market, commodity values and contract pay is generally very low, but the safety of the system makes it a good starting point for new mercenaries to learn basic skills in trade, ship control, racing, equipment cleaning, mining, and other activities.

**Economy Classes**: Energy, Agricultural, Industrial

**Faction Details**: Energy Companies - Strong presence and influence, main economic factor. Navy/Military - Strong presence, central system of Alliance military. Rebels - No significant presence. Guilds/Clans - No significant presence. Miners - Moderate presence, works with energy companies.

**Lambda:** Lambda is a lightly populated system, but was once the home of the Federation Military Command Center. Most of the system's population departed in the late 24th century due to increasing living costs, high Federation taxes and the resulting decrease of opportunities for freelance mercenaries. By the turn of the century, most Federation companies departed the system and Lambda now primarily consists of just a few scattered independent colonies. While not a particularly hostile system, the quest for survival does lead to several small scale conflicts. A good buy can sometimes be found here, but Lambda is not considered a good place to make a profit. Although in Richton space, a division of Federation territory, Lambda is now primarily independent.

**Economy Classes**: Technology, Agricultural

**Faction Details**: Energy Companies - Moderate presence and influence, main economic factor. Navy/Military - Moderate presence, scattered and not well organized. Rebels - Light presence, mostly independent groups that reject local leadership. Guilds/Clans - Light presence, occasionally engage local forces for resources. Miners - Unknown presence, likely a few scattered ships, not a significant faction.

**Sirius:** Sirius is a distant system with a good economy similar to Rigel's. A few key difference between Sirius and Rigel are the low cost of operations (typically no docking fees) and high paying contracts with relatively easy objectives. The gate system between Sirius and Sol was destroyed in the last war and has not yet been rebuilt, cutting off the main supply line to this system. So supplies are somewhat scarce resulting in fairly high prices paid for needed commodities and equipment. The planet Sirius B is generally considered a very good trade location for selling.

**Economy Classes**: Energy

**Faction Details**: Energy Companies - Strong presence, dominate political and economic force. Navy/Military - Moderate presence, primarily protects energy interests. Rebels - Light presence, primarily opportunistic explorers who remain reclusive. Guilds/Clans - Uncertain presence, rumoured to patrol low traffic areas. Miners - No significant presence.

**Emerald:** Emerald is arguably one of the most beautiful systems in Evochron. A bright green planet orbits a warm yellow star with a soft blue-green nebula backdrop. It's a peaceful setting for a system with a moderate level of conflict. Emerald has a relatively strong economy with good opportunities for independent ship owners, but reports continue to come in about attacks from rogue groups ambushing traders in the area. Emerald is also subject to high Federation taxes for local residents, which frequently drives away trade to nearby systems and has created a somewhat low end market for such a distant system. Emerald was one of the staging areas for the Alliance during the last war and played a critical role in providing the Alliance with the resources it needed to hold back advancing Federation forces from reaching systems closer to Sol. As a result, some older military weaponry and technology sometimes makes its way into the market here.

**Economy Classes**: Technology, Agricultural

**Faction Details**: Energy Companies - Strong presence and influence, involved in government. Navy/Military - Light presence, little protection/defence capability. Rebels - Moderate presence, occasionally attack local traders for cargo. Guilds/Clans - Moderate presence, active in smuggling and attacking traders. Miners - No significant presence.

**Rigel:** The Rigel system is the primary trading centre between Sirius and Emerald. It is free of most Federation regulation, so many mercenaries from Emerald enjoy travelling to Rigel for tax free trade with local companies and other mercenaries from Sirius. Rigel is fiercely independent and does not identify itself as an Alliance or a Federation territory, so stations and planets here often charge docking fees and other fines to any outside mercenary regardless of where they came from. Most mercenaries agree that the minor cost in fees is largely offset by the higher market values found here.

**Economy Classes**: Industrial

**Faction Details**: Energy Companies - Moderate presence, controlled by industrial factions. Navy/Military - Moderate presence, defends local interests, protects local traders. Rebels - Moderate presence, hostile and well equipped, against Energy companies. Guilds/Clans - Moderate presence, generally united with rebels, oppose navy. Miners - Limited presence, works with energy companies.

**Orion:** Orion was one of the earliest Federation controlled systems, dating back as far as the late 23rd century. It has several well established colonies and companies that support its local economy. Orion is largely self-sufficient with most local mercenaries working for one of the energy companies, so there isn't much demand for outside assistance in trade. On the positive side, this means low prices for available items and ship construction is similarly affordable. This makes Orion a good location for buying and it's a fairly safe system for new mercenaries who may not be ready for more hostile systems with more advanced technology.

**Economy Classes**: Biological

**Faction Details**: Energy Companies - Strong presence, dominate political and economic force. Navy/Military - Moderate presence, primarily protects energy interests. Rebels - Light presence, primarily opportunistic explorers who remain reclusive. Guilds/Clans - Uncertain presence, rumoured to patrol low traffic areas. Miners - Moderate presence, works with energy companies.

**Thuban:** Thuban is the home of the Federation and although the war has ended, tensions remain high between the Alliance controlled system of Sapphire and Thuban. Local mercenaries here are known to attack ships from the Alliance without provocation. As a result, Alliance command continues to warn against travelling to this system. Thuban is often in conflict with various companies and military factions battling for control of the system's abundant resources. For well equipped mercenaries interested in combat roles, this system offers some of the most attack, patrol, and spy contracts.

**Economy Classes**: Energy, Biological

**Faction Details**: Energy Companies - Strong presence, owned by military and government. Navy/Military - Strong presence, aggressively attacks Alliance ships. Rebels - Moderate presence, frequently attacks many civilian Thuban ships. Guilds/Clans - Moderate presence, disrupts energy shipping, wants own territory. Miners - Limited presence, mostly independent ships.

**Pices:** Pices is a neutral system that is often used as a trade centre between Thuban and Pearl. Mercenaries looking for a central meeting point without the risks of attack common to both Thuban and Pearl often use Pices as the location to meet in. The economy is low here, but there are no docking fees for most mercenaries and expenses are equally low, including some of the lowest prices for fuel in the lower region of Evochron.  It's industrial economy is one of the leading suppliers of low cost ship components and  weapons in central Evochron.

**Economy Classes**: Industrial

**Faction Details**: Energy Companies - Light presence, primarily serves industrial energy needs. Navy/Military - Moderate presence, maintains peace between trade factions. Rebels - Moderate presence, unaffiliated mercenaries, unpredictable. Guilds/Clans - Light presence, mostly independent mercenary groups. Miners - No significant presence.

**Pearl:** Pearl is a large system consisting of several planets and is the site of the Arvoch Conflict that took place a few years ago. Abundant resources and numerous opportunities make Pearl a system with some of the wealthiest and best equipped mercenaries in all of Evochron. Even though resources are readily available, shipping them in this system is extremely risky, so premium prices are paid for even the most basic supplies and equipment. Survival here depends on skill, wealth, and a powerful ship. Rumours suggest there is a remote research facility in this system that provides the advanced and experimental technology.

**Economy Classes**: Biological, Technology, Energy, Agricultural

**Faction Details**: Energy Companies - Strong presence, dominate political and economic force. Navy/Military - Moderate presence, primarily protects energy interests. Rebels - Light presence, primarily opportunistic explorers who remain reclusive. Guilds/Clans - Uncertain presence, rumoured to patrol low traffic areas. Miners - Moderate presence, works with energy companies and for own interests.


**Rucker:** Rucker is named for the admiral of the Alliance fleet in the first Alliance-Federation war. It is a large system filled with asteroids, making jump drive navigation dangerous. While not a common stop for mercenaries due to the difficult navigation conditions, it does offer a moderate economy with no docking fees and low prices. It is considered a potential gold mine for well equipped mercenaries interested in mining due to its vast asteroid fields and its close proximity to the high paying Pearl system.

**Economy Classes**: Industrial

**Faction Details**: Energy Companies - Strong presence, includes miners for harvesting ore. Navy/Military - Moderate presence, primarily protects energy interests. Rebels - Light presence, occasionally seen joining with Guilds/Clans. Guilds/Clans - Light presence, primarily opportunistic explorers. Miners - Joined with energy companies for common energy supply goals.


**Virgo:** Virgo is a lightly populated system of mostly colonists. While the system is technically in Federation controlled space, it was given independence in 2374 and has been almost entirely self-sufficient since that time. Its inhabitants pride themselves in their abilities to live off their own resources and typically discourage outside trade. As a result, they offer very little for most items and commodities. How this system has remained to survive for so long without outside assistance and do so well has been a continuing mystery. Rumours suggest they control a hidden world somewhere nearby that supplies resources they would otherwise not have access to.

**Economy Classes**: Agricultural

**Faction Details**: Energy Companies - Light presence, serves agricultural industry. Navy/Military - Moderate presence, well equipped for such limited resources. Rebels - Light presence, elusive, mostly remain outside of traffic areas. Guilds/Clans - Light presence, also mostly remain outside of traffic areas. Miners - No significant presence.

**Aquila:** Aquila consists of one planet in orbit around a blue-white star. While it may seem like an empty system, it does provide a high paying trade location with several stations and a relatively strong technology based economy. It is the central trade location between Alpha Centauri, Deneb, and Rucker.

**Economy Classes**: Technology

**Faction Details**: Energy Companies - Moderate presence, devotes production to technology. Navy/Military - Moderate presence, high ship and weapon technology. Rebels - Moderate presence, battles outsiders frequently. Guilds/Clans - Light presence, shares common interests with energy companies. Miners - No significant presence.

**Alpha Centauri:** Alpha Centauri has the distinction of being the first system to be colonized outside of Sol. The open trade between this system and Aquila results in it having a strong exchange of energy for technology. The planet AC528 is known for paying slightly more for most items. There are also no docking fees for most mercenaries in this system, giving it a cost advantage over both Aquila and Deneb.  Most ships are friendly to outsiders, but occasional trade blocks and attacks do occur.

**Economy** Classes: Energy

**Faction Details**: Energy Companies - Strong presence, primary faction with economic control. Navy/Military - Strong presence, well equipped and controlled by energy companies. Rebels - Uncertain presence. Guilds/Clans - Uncertain presence. Miners - Light presence, short trade runs from asteroids to planet.

**Deneb:** Deneb is a remote system that has only one gate exchange with Alpha Centauri. Resources are scarce, so premium prices are paid for commodities, but the system has very advanced technology. Deneb has admitted to having an advanced weapon research facility, but refuses to reveal the location. They've likely constructed it well outside the range of most navigation sensors and long range scanners.  Political and faction disputes have resulted in frequent conflicts throughout the system.  Outsiders are generally treated poorly.

**Economy Classes**: Agricultural, Industrial

**Faction Details**: Energy Companies - Light presence, works to provide resources to agriculture. Navy/Military - Moderate presence, advanced technology, monitors outsiders. Rebels - Moderate presence, fights against Federation control, rejects local laws. Guilds/Clans - Light presence, shares isolation interests with Rebels. Miners - No significant presence.

**Fauston:** Fauston borders on being a hostile system, but most ships generally leave each other alone. It's low economy makes it an unpopular trade stop for selling, but a common one for buying and refuelling. Many new mercenaries visit this system first once they leave Sapphire and try some of their first combat contracts here. The level of technology is very similar to Sapphire, so most ships have limited capabilities and don't pose much of a threat to rookie mercenaries with entry level ships. Fauston is known for its amazing scenery, especially its icy blue world with liquid methane lakes, and is a significant supplier of medical supplies with a vast bio-research network.

**Economy Classes**: Biological, Agricultural

**Faction Details**: Energy Companies - Light presence, primarily supplies military and research. Navy/Military - Moderate presence, low level technology and lightly armed. Rebels - Moderate presence, strongly against Alliance control and influence. Guilds/Clans - Moderate presence, shares anti-Alliance interests with Rebels. Miners - Minimal presence, mostly remain neutral.

# Asteroid Cave Plan

The cave is made of merged boulders so the passages and chambers are lumpy

There are no guarantees that all of the passages have been found!
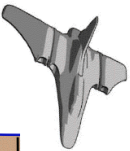
The passages are 3D - the map can't show the Y coords

You can jump directly into the main chamber but you need very accurate coordinates to jump into to between the others

You can get through "squeezes" by wriggling - there are other "peep holes" that are a bit too small!

squeeze can be wriggled through

squeeze can be wriggled through

squeeze can be wriggled through

squeeze can be wriggled through

squeeze can be wriggled through

Left Click in Nav Map
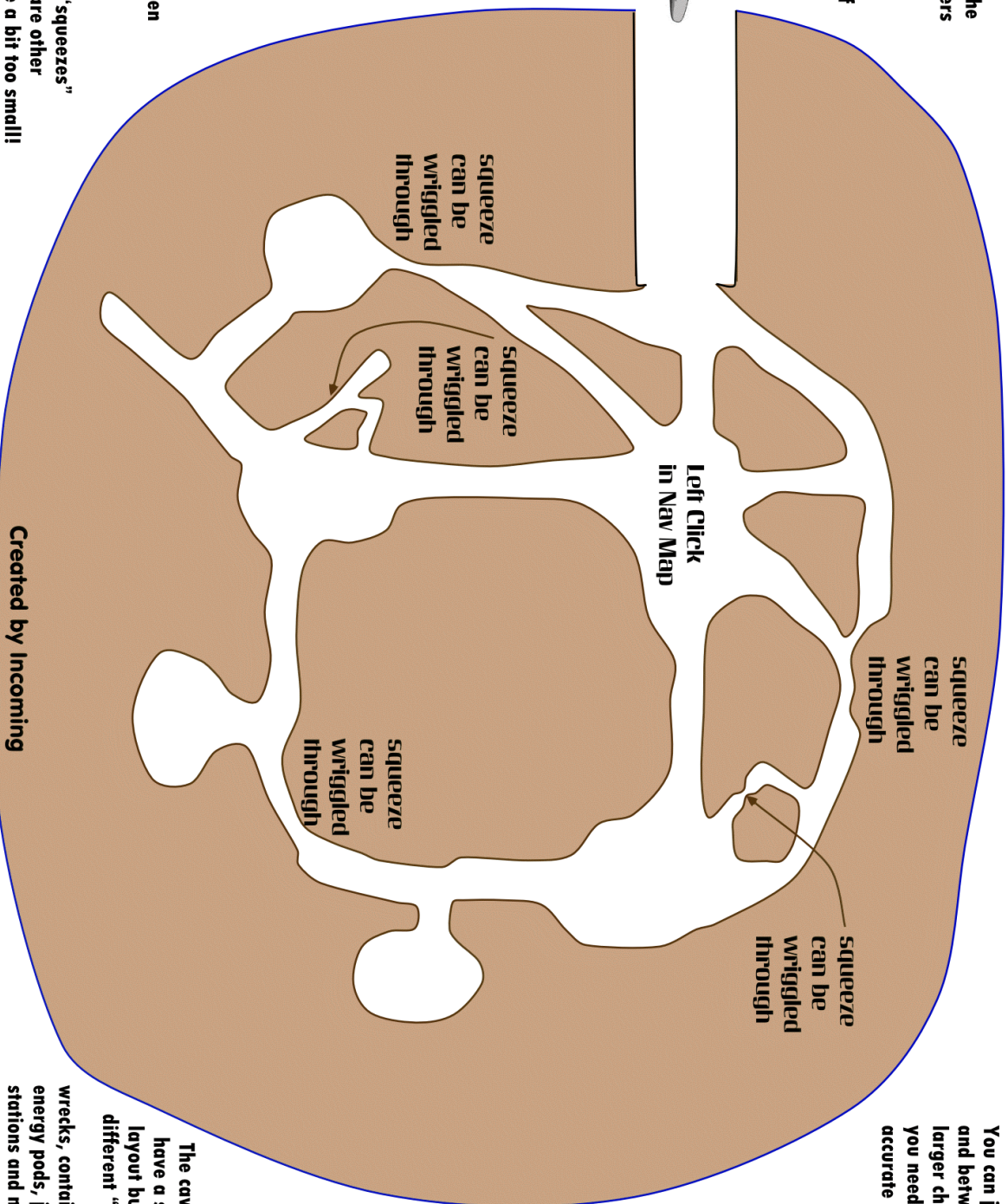
You can jump into and between the larger chambers but you need very accurate coordinates

The caves have a similar layout but contain different "treasures": wrecks, containers, energy pods, jump gates, stations and more

Created by Incoming

# Calculating Velocity when using Inertial Mode

(Acknowledgements to Vice for this explanation)

Think of it this way. If you move in any given direction 1.0 units, your distance is obviously 1.0. Now if you start at the same point, but turn 45 degrees to the right, then move the same 1.0 units, your distance is the same, but in relation to the original direction, you have not moved out as far on the Z axis (forward/reverse) as you original did at a heading of 0. Plus, you've moved farther out than just 50% of the distance even though you are halfway to 90 degrees. So in an exchange of velocity values for 3 direction values (XYZ), this factor has to be accounted for in the calculations.

If you were to start at a point and drew equal lines from that point around a full 360 degrees, you would wind up with the end of those lines forming a circle. To achieve the same distance at 45 degrees as you would at 0 degrees, your direction floats (the two velocity values referred to earlier) will each generally be at around 70% of the original speed value (for a speed of 1000, each at around 707). Perhaps this diagram will help:



Forward Velocity: 1000
Slide Velocity: 0
Total Velocity (FW + LS): 1000

Forward Velocity: 707
Right Slide Velocity: 707
Total Indicated Velocity
(FW + RS): 1414
Total Distance Rate:
The same 1000 overall

Forward Velocity: 500
Left Slide Velocity: 500
Total Velocity (FW + LS): 1000

Forward Velocity: 0
Right Slide Velocity: 1000
Total Velocity (FW + RS): 1000

Forward Velocity: 0
Left Slide Velocity: 1000
Total Velocity (FW + LS): 1000

Difference in velocity between the two methods

Difference in velocity between the two methods

This is the accurate method.

Purple represents the curve calculation method, total indicated velocity varies from the original starting velocity, but the actual travel distance is the same.

Green represents the 1:1 calculation method, total velocity is always close to the original starting velocity.