

SCIENCE-FICTION
ADVENTURE IN
THE FAR FUTURE

TRAVELLER

Referee's Aid 4: A Guide To Star Systems

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REFEREE'S AID 4: A GUIDE TO STAR SYSTEMS

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INTRODUCTION

Traveller is a game, not a cosmology textbook. For this reason we have tried to simplify the astrophysics to the point where it creates a useable and interesting adventure environment with a hard-science feeling. Beyond a certain point things get very complicated, so a certain amount of simplification seems justified in the interests of having fun. What follows is workable and based in Real Science, but it is hardly comprehensive. Players and referees are of course quite welcome to explore the mysteries of the universe and add their knowledge to the game if this seems desirable.

Much of the time, the characteristics for the mainworld generated by Traveller's world creation system will be all that is needed to run an adventure. This supplement is intended for those times when more is necessary... for when players start asking about the outsystem asteroids or exactly what it means if the mainworld's star is a type M0V. It is intended to assist the referee in creating a logical and consistent game universe where the players can make predictions about the conditions on a world using their knowledge of science.

A star system can be randomly generated, either completely or partially. A degree of randomness is useful in assisting creativity and ensuring that the referee does not subconsciously make all planets more or less alike. However, any random result can be set aside in favour of something that better fits the adventure environment the referee wants to create. Advances in our scientific knowledge have shown that a number of things that were previously thought impossible can actually exist, like huge gas giant worlds orbiting very close to a star. Many of these phenomena cannot be generated by any currently existing system, but they could be there in the Traveller universe if the referee wants to place them.

Which is a roundabout way of suggesting that it's okay to just put stuff into a star system if you want it there, whatever results the system generation rules produced.

As a general rule, so long as the core data for a system is not contradicted, anything goes. If the data says there are gas giants, then the referee is not breaking any rules by deciding how many and where they orbit. Additional inhabited worlds are possible, though as a rule if there is a more populous world than the current mainworld in the system, there needs to be a reason why it is not the mainworld. That in turn might lead to some adventure ideas...

And finally, let us not forget that tools like the random star system generation rules in the Traveller rulebook are just that – tools. They are useful but it is the craftsman who decides how to use them and when to set them aside. If the referee prefers to invent an entire star system without any die rolling

at all, there is nothing wrong with that. So long as it is logical and consistent (this is a science-fiction game, after all), and an interesting and a fun place to have adventures, then it does not really matter how the setting was created.

The following data is provided for the benefit of the referee. How much of it can be determined by the players, and with what degree of accuracy, is a matter for the referee to decide. In many cases a simple search on the ship's computer or any library terminal will suffice to provide at least the bones of the information.

THIRD IMPERIUM: CHARTED SPACE

The region of space known to humans of the Third Imperium is referred to as Chartist Space. It is not a particularly large area in cosmic terms, but even so it is hundreds of light-years across. Even the fastest starships available would take months or years to cross from one side to the other. Towards the fringes of Chartist Space, data becomes rather sketchy. Those who dwell in these regions probably know a lot more about them than Imperial scientists do; information filters slowly into the Imperium from foreign space.

The Imperial borders mark the boundary of the areas where data can be easily gathered – Scout ships can be sent to any place within the Imperium if it is desirable to do so, but this is rarely possible in the territory of other states. Even where relations are cordial, it is rare to see full astrographic and survey data freely available. Potentially or historically unfriendly powers such as the Solomani Confederation or the Zhodani Consulate are secretive about their data for strategic regions. Some information is of course available but it can be fragmentary, old, inaccurate or even deliberately misleading.

Data on what lies beyond these foreign powers is even harder to obtain. Distance and politics make first-hand expeditions problematic, and those who live closer may not be interested in exploration. Thus, there is no cosmic line where 'Chartist Space' stops. Instead there map becomes increasingly vague and the datafiles ever more sparse. Rumours abound of anomalies, advanced alien races, regions where there is no life whatsoever and all manner of other strange things. In all probability there are also many thousands of star systems with the same sort of planets, moons and asteroids that exist in Chartist Space. Most of what is out there is pretty mundane, and no different from what lies within known territory. Yet there could be wonders beyond imagining just over the horizon....

UNIVERSAL WORLD PROFILE

It is easy to become mesmerised by the big picture, straining to see ever further, and to forget that Imperial space (and that of the surrounding powers) is huge. The standard Imperial starmap can give the impression that Imperial space is rather like a railroad network, with starports as stations. Ships hop between mainworlds and their crews never see more than the starport at each, creating the impression that Charted Space looks a lot like the inside of a starport concourse.

This is a very false impression; planets are huge! The mainworld of a star system might be described in the Imperial Atlas by a couple of paragraphs and a code created by the Scout Service, but a person could explore a world for their entire lifetime and still not exhaust its mysteries. And of course a mainworld is just one of the bodies in a star system. There are moons, inner-system planets, outsystem worlds, gas giants, planetoids, comets and all manner of other bodies. As showcased in Referee's Aid 1: Among the Trojans, it is possible to have a wealth of adventures without ever visiting the mainworld of a star system.

The Universal World Profile (UWP) is a useful shorthand that gives an indication of what a system's mainworld is like. Even in its extended form it provides only basic and somewhat general information. This is a good starting point, telling a starfarer the sort of things he or she really needs to know – is there a starport at all? Is it any good? Can I breathe the air? How populous is this world? Will there be oppressive laws?

This very useful information, but it is general – no two Size Code 4 worlds have exactly the same diameter, and few representative democracies are exactly the same. Similarly, the UWP only gives an indication of what the mainworld is like, and other than the most basic (but highly useful at times) information such as whether there are gas giants in the system, the UWP tells us virtually nothing about the rest of the star system.

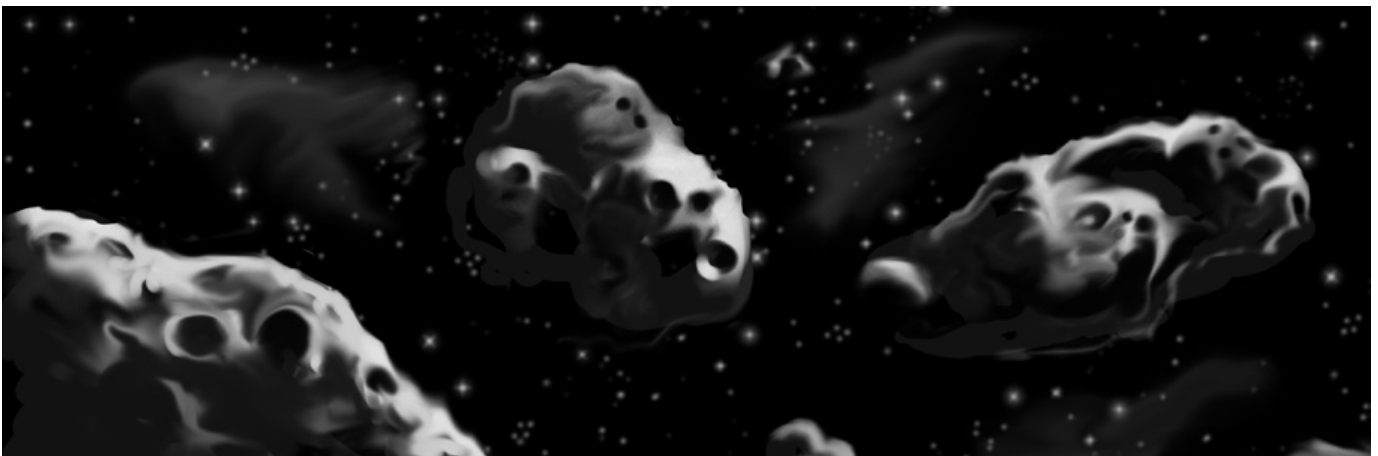
The UWP is often expanded upon to give a basic overview of the mainworld (or sometimes a little about the rest of the system) in a few paragraphs, but other than the tiniest of settlements or the most barren of worlds is it simply not possible to encapsulate an entire society in a few lines. Thus the data must be extrapolated. We move from dots on a map to UWP data, and from there we zoom in. And in. And in. As we get closer, we perceive that Imperial Space is no less wondrous than the far distance. There is endless variety and myriad adventuring opportunities within the Imperial borders or just beyond them. Indeed, despite thousands of years of interstellar travel much of Imperial space has not yet been properly mapped, charted and studied.

Wonders lie without, perhaps. But wonders there are within, as well.

DETAIL LEVELS

It is not possible to detail every place that characters might go, nor is it desirable. The starmap and UWP codes provide entirely enough data to quickly form an impression of a star system the players are interested in – 'low-population airless world with a modest starport; it's little more than a stopover point, probably with a single city around the starport and not much else' and if they just bounce through then there is no real need to detail more than this.

Greater detail becomes desirable when the characters start to spend some time in a place, or for variety. If the characters are rushing from planet to planet and their minds are on what they are doing, then a general description like 'it is a desert world with three suns' or 'it is a water world' will suffice, perhaps with some local quirk to keep things interesting. However, something is lost from a game when the setting fades into the background. It is well worth ensuring that adventures take place in an interesting locale once in a while – an arctic water world where mid-tech airships are the main form of transport; a giant super-high-tech arcology, or among the remote planetoids of a backwater star system. Setting detail does add depth, and can make an adventure more memorable. The environment can also create new challenges and opportunities for the travellers.



STAR SYSTEMS

A star system consists of one or more stars plus whatever planets, comets and asteroids orbit it. Composition can vary a lot but for every star system there is a designated mainworld. This is almost always the most populous planet in the system, and will have this status for some good reason. Usually this means good habitability or resources, though there are sometimes other reasons why a world is settled. Where there is no obvious mainworld, one is usually selected based upon its relative position to the system's primary (star). This might be an airless rockball in some systems, and another world could in theory be designated mainworld if the system is later settled and a different planet is chosen as the main location.

Many starfarers move from mainworld to mainworld, and in some cases starport to starport, without going elsewhere in the system. The starport and nearby cities tend to be the economic hub of most worlds, so this makes a lot of sense. However, there is a lot more to a star system than this region. The mainworld may be very varied, which multiple societies or at the very least different types of terrain. And of course there are other bodies in most star systems.

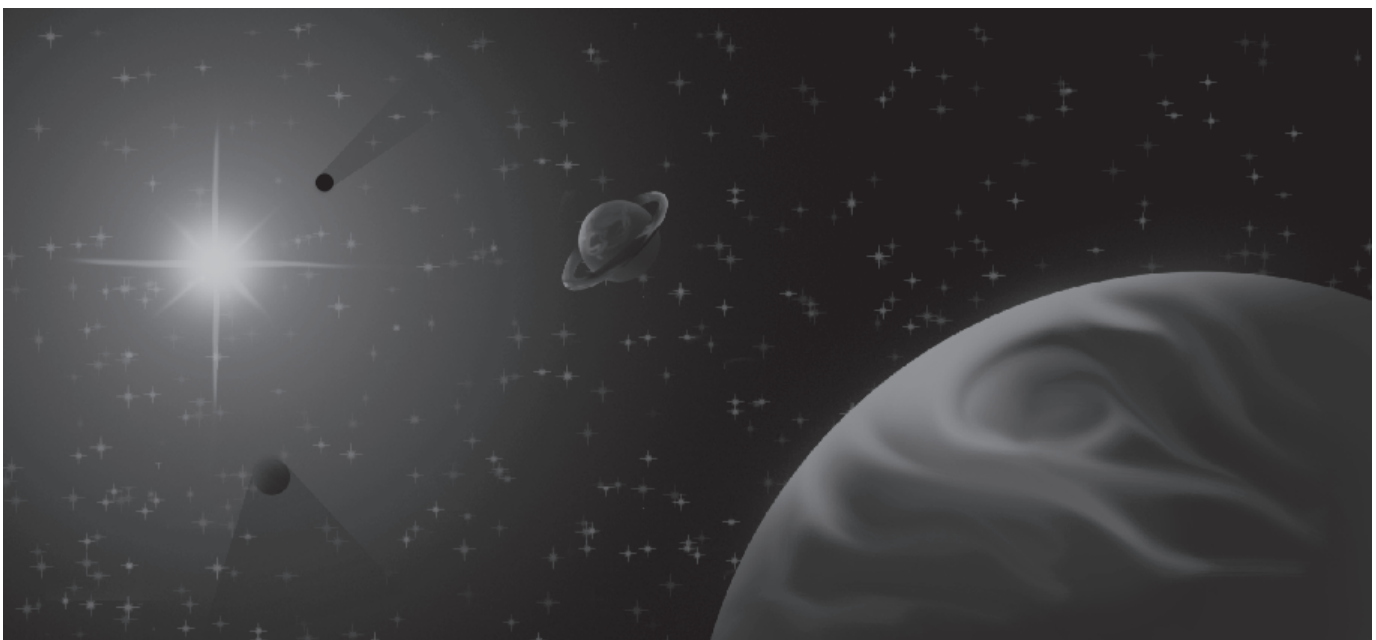
Take for example the Sol system not long before jump drive is invented. There are multiple nations on Earth, orbital stations, and the Lunar cities within easy reach from any spaceport. Also in the inner system lie the Mercury mining station and the orbital laboratories studying Venus, plus settlements on Mars. There are cities on some of the larger Belt asteroids and those at the Trojan points of Jupiter, plus more cities on various moons and planetoids right out to the Oort cloud. Only mining ships and the odd scientific vessel make the journey all the way out there, so much of the cloud remains unexplored.

With all these places to go it should be possible to get a lot of adventuring time out of the Sol system alone, and the same can be said of many star systems. There is no need to dash from starport to starport, 'doing the adventure' and then moving on to the next system, when there are so many interesting places to visit right here.

Each star system is a unique place filled with smaller unique places. A world description is a bare-bones guide to the place. If a world is listed as having 112 million people living under a benevolent dictatorship, that is the barest overview. The offworld religious group who have set up their main temple in the mountains somewhere may not even get a mention in the guide book, but when the characters go there and start actually experiencing the place they may run into them. There may be other little groups not listed in the guide, troubles not mentioned and unexpected quirks that only become apparent when the characters start adventuring there. And do not forget that just because the characters have seen the capital and the main spaceport, they have NOT seen everything about the world.

GRAVITY AND STAR SYSTEMS

Gravity is one of the fundamental forces of the universe. It attracts objects towards one another in a manner that is not understood in 2015 but which has probably been simply explained by the time the events of the Traveller game universe take place. Essentially, the more matter is in a given area, the more strongly other objects are attracted by gravity. Very dense objects pack a lot of mass into a small space and this have a greater gravitational effect than more dispersed matter.



Even gas particles and odd molecules floating about in space have at least some gravitational attraction to other particles. This is not much but it can hold a gas cloud loosely together in interstellar space, and can eventually cause the particles to drift together. This increases the density of the gas (and also its temperature) which in turn increases the gravitational force exerted on other molecules. If enough gas drifts together, it can begin to coalesce into a protostar and might eventually form a star system.

Gravity obeys an inverse square law. That is to say, if you double the distance between two objects, gravitational attraction decreases by the square of the increase, i.e. it is four times less. One consequence of this is that gravitational attraction ceases to be significant fairly quickly as one object moves away from another, though attraction never ceases entirely. It is possible to think of gravitational attraction as being similar to a curve in the fabric of the universe, with the object sitting at the bottom of a 'gravity well'. A very distant object is not affected very much, but anything close by will tend to slide down the gravity well and join the heavy object at the bottom.

Note that gravitational attraction is a two-way street; objects attract one another. However, the difference in mass between a star and a planet is such that whilst the planet might be locked into an orbit around the star, the effect on the star is negligible. Very massive planets close to a star can cause it to 'wobble' as they orbit, and objects of similar mass that are close together will tend to both orbit about a common point rather than one orbiting the other.

Gravitational forces have important implications for the Traveller game universe. The jump drive is adversely affected by gravity, to the point where jumping whilst deep in the 'gravity well' can destroy a ship. The rule of thumb is '100 diameters' for a typical planet, i.e. it should be safe to jump if the ship is more than 100 times the diameter of the planet away from its surface. However, gravity is a function of mass, not size. As a result, the effects of a very dense planet on the jump drive might be felt beyond 100 diameters whilst a less dense world might allow safe jumps closer to its surface. The 100 diameters rule of thumb is generally safe to follow, but a clever astrogator can shave some time off a trip by plotting his jump as close to the planet as gravitational interactions allow.

Some areas are subject to 'jump shadow', i.e. it is not safe to jump into or out of them (or even possible, in some cases). This is due to the gravitational effects of the system's star(s) and planets. Jump shadow can be very inconvenient, as it can make long normal-space transits necessary in order to make safe jumps into and out of the system. In many systems, however, jump shadow is restricted to the usual 100-diameter region around each planet.

Gravity is also what holds star systems together (and indeed, what causes them to form). If all the objects in a system were stationary, they would of course accelerate inwards towards the star due to its gravitational attraction and soon there would be no star system any more. However, star systems form out of a rotating disc of gas and debris, so planets and other objects that form are moving and thus have momentum. The balance between gravitational attraction and the momentum of an object determines if it will settle into a stable orbit. If not, it will either fall into the star or its momentum will carry it out of the system.

As a result of the way star systems form, most of the planets of a system will have a stable orbit, which will be generally along the ecliptic (the plane in which most of the bodies of the system orbit) and in the same direction. Some bodies will have extremely elliptical orbits, passing close to the star and then far out away from it; most orbits are somewhat elliptical but not excessively so. However, the gravitational attraction of the various planets and star(s) in the system can create some very complex interactions. A moon or planet can be pulled into an unstable orbit and eventually escape whatever body it orbits.

Interstellar space contains an unknown number of rogue planets and moons ejected from star systems in this manner. Sometimes a body is captured by another and enters a stable orbit – so a moon that once orbited a gas giant might eventually settle into a stable orbit around the system's star, essentially becoming a planet.

The time frames that star systems exist over are immense compared to human history. It really does not matter all that much to most people if a moon of one of the system's gas giants is in an unstable orbit that will eject it from the system in five million years' time. However, gravitational interactions can cause quite sudden effects, and a moon leaving its orbit would be a serious event for anyone in the system as its gravity might upset other objects and cause further instability.

On a more day-to-day basis, gravitational interactions mean that objects generally do not follow a simple and easily plotted path. A gas giant's several moons might perturb one another's orbits enough that astrogation in the area becomes complex, and planetoids in a belt are generally subject to quite complex motion that can make it hard to find a particular one. Large planets, particularly gas giants, often collect asteroids at their Trojan points, which lie sixty degrees ahead of and behind it on the same orbital path.

All of this gravitational interaction can be safely ignored much of the time, especially when the characters are busy doing something on the mainworld. It can become important when searching for a particular asteroid that supposedly has a crashed starship on it, or when plotting a course across the system. More importantly, perhaps, it is what causes a star system to be how it is, and keeps it that way. Gravitational interaction both ensures that the mainworld has a stable orbit and causes that rogue moon in the outsystem to have a crazy elliptical orbit at a very sharp angle to the ecliptic. It causes the system's asteroid belt to remain together, yet can result in any given asteroid having a very complex orbital path.

THE 100-DIAMETER LIMIT

The 100 diameter limit is a game mechanic, and it is really up to the referee how strictly it is applied. As noted above, gravitational effects depend on density, so a small but very dense planet would exert more gravitational influence over a greater distance than a larger but not very dense one. If the referee prefers to use the rules-as-written then the 100-diameter safe jump limit must be observed. However, it is entirely permissible to impose more variation if this suits the plot of the adventure being played. The general result of this is more complexity and a greater feeling of realism along with some additional plot opportunities. For example, an area with quite a lot of sparsely-distributed asteroids might be unsafe to jump into or out of due to low levels of gravitational interference, even though the ship is more than 100 diameters from the nearest asteroid. So the crew have to make a transit through normal space, and of course that is where the pirates lurk...

STAR SYSTEM MECHANICS FOR BEGINNERS

For the most part, a few rules of thumb will suffice to understand how star systems and their components act. At the centre of the star system is a large mass with a strong gravitational attraction. This can be a single star or two or more close companions. In the latter case, these stars will orbit around a common point, with the major objects in the system orbiting them. These major objects may include one or more distant companion stars, but are more commonly a mix of rocky planets, gas giant planets and clusters or belts of asteroids.

These major objects generally follow a roughly circular to somewhat elliptical orbital path, in the same direction and not angled very steeply, so that the major bodies of the system can be considered to occupy a plane called the ecliptic. Minor bodies such as moons may orbit the major ones, or may orbit the system's central point. Minor bodies are far more likely than major ones to have a highly elliptical orbit or an unusual one. 'Unusual' in this case can mean a sharply angled orbit or a retrograde orbit, i.e. one that is in the opposite direction to the rest of the system's general motion.

Some bodies, including major ones, can have unusual or highly complex orbits. A world might spiral in towards the star over several orbits, becoming hotter, and then out again. Other changes in conditions might be caused by alignment in a multi-star system – this can create extreme circumstances when everything lines up just right, perhaps rendering a world temporarily uninhabitable, or the opposite.

Close in to a star, worlds receive a great deal of stellar energy – sometimes too much. Close to the star is the 'hot zone' where conditions are too harsh for liquid water to exist. Life is unlikely to evolve on such worlds. There is then a region where the amount of stellar energy received is about right to allow liquid water to exist. This 'goldilocks zone' (not too hot and not too cold) is the most likely place for life-bearing worlds to be found, and often the mainworld of a system is located in this region even if it does not have life or even water.

Farther out, little stellar energy is received and worlds tend to be cold. Any water present will be locked up as ice, making life unlikely to develop, and in many cases any atmosphere that a world might have had will be frozen. It is possible for bodies in the 'cold zone' to obtain energy from other sources (e.g. the moons of a gas giant might be heated by its emissions) but even so life is unlikely.

The hot and goldilocks zones, and sometimes a region a little farther from the star, are collectively termed the 'inner system'. Worlds in this region are relatively close together, making normal-space transits between them fairly rapid. The outsystem consists of bodies farther from the star, which tend to be much further apart. The 'far outsystem' is a term sometimes applied to very distant objects such as the comets and planetoids of the Oort Cloud which surround some star systems. This region is very distant from the inner system and is unlikely to be visited.

DISTANCES IN A STAR SYSTEM

The Traveller rulebook provides a list of typical distances in a star system and transit times between them. This, like the 100-diameter limit, is a simple game mechanic and does not reflect the complexity of the situation. Planets and other bodies orbit at differing speeds, so at one point a world in the inner system and one farther from the star might be on the same side of the star and relatively (as these things are measured) close together. At another time they may be on opposite sides of the star and will be much farther apart. The distance table in the rulebook is intended to keep things quick and simple, but if the referee prefers a greater level of realism it should be noted that distances vary constantly as bodies move in their orbits. This is best dealt with on a 'needs of the plot' basis – if a long transit is required by the storyline, then the worlds are on opposite sides of the star. If not, they can be assumed to be at or near their closest point of approach and a short transit can be made.

DEEP SPACE

The region between star systems is referred to as 'deep space'. It is not entirely empty of course. Even the most remote region has the odd hydrogen atom floating around, and there are occasional comets, rogue planets or planetoids, gas or dust clouds and unusual phenomena. Some of these objects are very hard to detect from within a distant star system, and may come as a surprise to starfarers passing by.

For the most part, deep space is empty and therefore not very interesting to starfarers. It is a region of nothingness that starships pass through (or more accurately, bypass using jump drive) to get to where they are going. It is also very, very isolated. A disaster in deep space can easily be fatal, as rescue can be weeks away even for a fast starship.

It is hard to say exactly where a star system ends and deep space begins. There is no real boundary line as such, just increasing dispersion of light from the system's star(s) and of matter such as comets and asteroids. Nor is it entirely clear where in-system space begins, i.e. where a starship has entered a star system. People draw arbitrary lines on star charts to show who 'owns' an area of space, but space itself doesn't care. All that can be said with certainty is that close in to a star, the planets and asteroids of the system are relatively close to one another, and further out they are more distant from each other.

The dividing line is not really important in a universe where the jump drive exists. It is exceedingly rare for ships to visit the far outsystem, let alone the point where in-system space and deep space meet – if such a place exists as anything more than a handy convention. Ships jump to and from a point fairly close to

their destination rather than crawling through normal space for long periods. However, regions of deep space are sometimes visited.

Vessels that do not have sufficient jump capability to cross to another star system (e.g. a jump-1 ship seeking to cross to another main that is two parsecs away) either have to carry spare fuel and make a second jump, or refuel en route. This requires jumping to deep space and finding a source of fuel. If the crew know where to find a comet or planetoid whose ice can be cracked for hydrogen, then this is a possibility. There is virtually no chance of achieving this on the fly however; a ship that jumps to deep space in the hope of finding fuel is doomed.

It is, however, possible to use a tanker or pre-positioned refuelling station in deep space, a method that allows military and exploration ships to cross otherwise inaccessible areas of space. Locations of deep space refuelling stations are usually closely-guarded secrets and again, a region of deep space is sufficiently huge that knowing that there is a station in there somewhere is not enough – a ship needs a precise set of coordinates to jump to.

Any given region of deep space could contain all manner of things (though they would be hard to find), including comets, rogue planets and moons ejected from another star system long ago, wrecked starships or debris fields and so on. Another possibility is that a region of interstellar space might contain one or more brown dwarf stellar objects; bodies that were not quite big enough to become stars but which are larger (and give out more energy) than a gas giant. A deep-space brown dwarf star might have moons of its own, creating a miniature solar system in deep space.



STARS AND STELLAR OBJECTS

Details of a star system tend to become apparent a certain order. Some can be determined using instruments from a considerable distance. The presence of a star and its type are easy to determine, and it is possible to tell whether a system has planets from a parsec or more away if a vessel with good enough sensors is available. Most other information requires lengthy remote study of the system or a visit to it.

A star system is made up of one or more stars plus various planetary bodies, moons, asteroids and the like. Rogue planets, comets and asteroids exist outside solar systems, too, but these bodies are difficult to detect and are less likely to be encountered.

A star system may have more than one star in it. It might conceivably also contain other phenomena such as dark matter accretions, black holes and the like but this might drastically affect nearby systems. There are no black holes within Imperial space, and any such major phenomena should be placed carefully by the referee if they are to be used at all. Many phenomena would have adverse effects such as wiping out all life for several parsecs so cannot be casually tossed into the middle of the setting for a one-off adventure.

In Traveller universes, all star systems denoted on a map are accompanied by a UWP listing, indicating that they have at least one planet. However, some stars do not have a planetary system. Such 'barren' systems will still contain comets, planetoids and the odd gas cloud but there will be no rocky or gas giant planets. This can happen for various reasons such as the destruction of the system by a star that has expanded to giant size. Some systems simply never formed properly and contain nothing but dust, gas and the odd comet. It is possible that such systems do exist in the Traveller universe but are not marked on the map (probably because since there is no real reason for most starfarers to go there), and could be added for the purposes of an adventure.

Stellar Phenomena

For the sake of completeness we will mention a number of objects which are of the same general scale as stars. These might be used or referred to in adventures, though it is unlikely that travellers in Imperial Space would encounter most of them as such. However, the fear that a star might 'go nova' in the near future could be part of an adventure background.

A nova is a sudden and massive increase in the luminosity of a star, fading back again soon after. The star may eject material at the time. A nova is unhealthy for anyone in the vicinity but will not destroy the star. Some stars 'go nova' on a frequent basis. A supernova is much more destructive, and normally occurs when a massive star 'dies', blasting out a cloud of radioactive gas and debris while briefly putting out vast quantities of energy. A supernova may shine brighter than a whole galaxy.

Supernovae can also be caused when a white dwarf star's gravity draws off material from a companion star. If the dwarf star reaches a critical density, this can trigger what amounts to an explosion. Depending on the size of the star, the remnant of the stellar core after a supernova may become an extremely dense neutron star or collapse further to create a black hole

A hypernova is a theoretical version of the supernova where an extremely large star dies in the manner of a supernova, but bigger and better. A hypernova will, for just a few seconds, put out more energy than everything in the rest of the universe combined. Supernovae and hypernovae will wipe out everything within many light-years with radiation, though the gas ejected from them may be responsible for the formation of new stars.

A neutron star is the remnant of a star about twice as big as Sol (Earth's sun) or larger, which has undergone a supernova explosion. The core of the star has collapsed into a very dense body composed of neutrons; one with the mass of Sol would be about 10km across. Neutron stars spin incredibly fast. A less common type of neutron star is a Pulsar, essentially a neutron star that emits a beam of radio waves (or sometimes X-rays) which is swept around by the rotation of the star, giving the impression that the star is pulsing.

A black hole is thought to be caused by a massive object which has collapsed to a single point. Its gravity is so powerful that light cannot escape, though some other forms of radiation can. The most likely means of black hole formation occurs when a star collapses as if to create a neutron star but keeps on going, ending up with all its mass in an impossibly tiny space. Black holes can swallow planets and stars effortlessly, and there are thought to be supermassive black holes at the core of some or all galaxies. A black hole would be a major astrographic feature to be steered well clear of by interstellar travelers.

A nebula is a cloud of interstellar dust or gas. It may appear bright or dark depending on whether it is lit by stars within or behind it. Nebulae are very large, with the smallest being about a parsec (3.26 light-years) across and larger nebulae being much larger. Nebulae are not normally particularly dense, but in some cases a 'shell' of material ejected by a supermassive star can hide it. More commonly a nebula would not hide a luminous object like a star, though it would make it harder to detect a hiding starship, a rogue planet etc.

STARS AND SIMILAR OBJECTS

A star is essentially an enormous fusion reaction going on constantly at the centre of a vast ball of plasma. Thermonuclear fusion converts hydrogen into helium during most of the star's lifetime, causing it to radiate energy. The balance between gravity due to the mass the star and the energy of its reaction causes the star to have a generally stable size and output, though stellar flares can temporarily alter the energy output of a star.

A protostar is a cloud of interstellar gas which is beginning to coalesce into a star. As yet, while the cloud is becoming more dense at its centre, it has not yet begun to undergo nuclear fusion in the core, and thus is not luminous. The only real difference between a protostar and a gas cloud is that there is enough mass present that someday the protostar will be a star, and it has begun this journey. A protostar forming in Imperial Space would attract scientific vessels to study it.

A brown dwarf is essentially a very large gas giant or Jovian (Jupiter-like) planet which almost became large enough to ignite into a star, but not quite. Brown dwarfs are massive and hot by planetary standards, but dim by the standards stars are measured by. They are difficult to detect as a result and might be found in star systems as well as far out in interstellar space. In the latter case they may sometimes be accompanied by the debris of a 'failed' star system that did not quite form.

Brown dwarfs in a star system may have satellites (moons or planets) of their own. In stellar classification a young, relatively warm brown dwarf is given the designation L while older, cooler brown dwarfs are designated T. The L designation comes from the fact that the coolest true stars are designated M, and a Brown Dwarf is quite a bit cooler than that.

Main-sequence stars have a roughly average ratio of luminosity (energy output) to temperature. They are sometimes referred to as 'dwarf' stars although there is nothing subnormal about them. Most of the stars in the universe are main-sequence stars; giants and subgiants are typically dwarf stars that have expanded at the end of their lives.

Main-sequence stars are the most likely to have habitable planets. A star will cease to be part of the main sequence when it begins to die and ceases fusing hydrogen; at that point it expands and cools, becoming a giant. When that phase is over it will contract into a white dwarf (unless it becomes a neutron star or black hole), and thence fade away and die completely. Main-sequence stars can be considered to be 'adult' stars and normal in most ways.

The star at the heart of a solar system is referred to as the system's primary. Solo stars are common, though multiple-star systems are not unusual.

- A star that orbits another star (or, occasionally, a black hole or similar object) is referred to as a companion star or just a companion.
- A close companion orbits at a very small distance from its primary, close enough that it is within the area where planets could form.
- A distant companion has a much larger orbit and might have planets of its own.

All objects affect one another due to gravity, but in the case of a planet and a star the effects on the star tend to be negligible unless the planet is very large, such as a Jupiter-like gas giant. Stars, on the other hand, have sufficient gravity to create a far more complex system. Two or more stars might mutually orbit about a common point if their masses are similar. This twin-star (or multi-star) system may have planets orbiting it, or (especially if the primary star has a much greater mass than its companion) the companion star and the planetary system may all orbit the primary.

A close companion usually prevents planets from forming close to the primary, but sometimes planets will orbit between a star and its companion. For distant companions this is not a major problem but where a planet's orbit takes it between two fairly close stars, conditions tend to be harsh.

A giant star is an evolved star that has run out of hydrogen to burn and begun to fuse helium instead. Some giants and supergiants are very old; others have reached this stage more quickly depending on their original mass. The shifted balance between gravity and the outward pressures generated in the star results in expansion to vastly greater size. Giant stars destroy their inner planets as they expand. Most are red or red-orange in colour and relatively cool by the standards of stars. When the helium fuel runs out, the star will begin to collapse to become a white dwarf and enters the final stage of its life.

Depending on their mass, some giant stars burn hotter and others expand to enormous size, becoming supergiants that can grow to the size of the entire solar system. Planets orbiting such a body are extremely unlikely. When a supergiant star dies, it undergoes a supernova explosion and collapses to become a black hole.

Subgiants are hotter and brighter than so-called dwarf stars, but are not large or bright enough to be classified as giants. The subgiant phase is a transitory one as the star expands to become a true giant. Subgiants start off more or less the same color as the original main-sequence star and change color as they become cooler, becoming orange or red just before entering the stage where they are considered to be true giant stars.

A white dwarf is a small, dying star which is running out of fuel. In fact so-called white dwarf stars range in color from white (hottest) to red (coolest). A white dwarf star will not have habitable planets around it, having destroyed the inner ones and scorched those farther out during its death throes. After a few trillion years a white dwarf may have cooled sufficiently to become a 'black dwarf' which are almost totally non-luminous. There are no stars in our universe old enough for this to have occurred yet – at least not naturally.

BINARY AND MULTI-STAR SYSTEMS

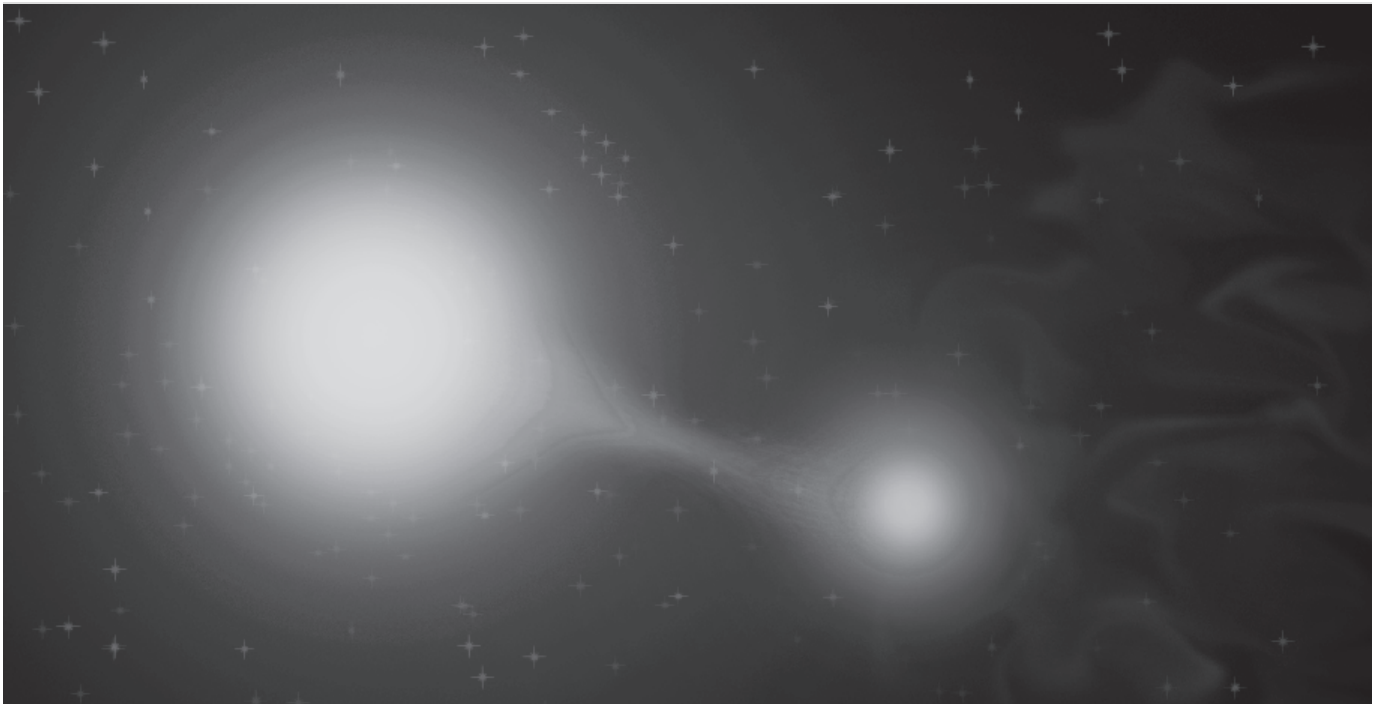
Many star systems have a single star, referred to as the primary. However, many star systems contain more than one star. Usually this is two, creating a binary star system. In a binary system, there will often be a primary star and a smaller companion, which may be located close to the primary (i.e. a 'near companion') or very far from it (i.e. a 'far companion' or 'distant companion'). Less often, two stars of approximately the same size will orbit one another around a common point. Planets may or may not be present in orbit around any given star, and there is no reason why a binary system might not have inhabited worlds orbiting both stars.

A multiple system, with several stars, is entirely possible. The most likely configuration is a binary pair (or a primary with a close companion) and a distant companion. However, it is possible for a system to contain more stars. For example, a pair of binary pairs might orbit about a common point, with an additional distant companion star in a far orbit. This makes for a very complex set of orbital dynamics, but it also means that the system might have several habitable worlds. As these habitable planets would be much closer together than worlds in different star systems, sublight travel between them would be possible.

Such a system would be a very attractive site for colonization, and might be worth bypassing many other systems to get to. It would also be an excellent self-contained adventuring environment, where the characters could experience several different worlds without needing a jump capable ship. Indeed, this setup has the advantage that the referee can give the players a large sandbox to play in but still restrict their ability to go charging off the edge of the map whenever they feel like it.

STAR CLASSIFICATION

Stars are classified according to their luminosity and size. Spectral Class is determined by the temperature of the star, while Luminosity Class is determined by its energy output. A combination of these two systems allows a star to be classified and its general characteristics to be presented in a form of shorthand. These characteristics can be used to predict what conditions will be like in a given star system, at least to some extent. This may or may not be important to a Traveller campaign. Characters involved in a high-speed chase through the streets of a city will not be too bothered about the stellar classification of the sun overhead, but a group scouting star systems will care a lot more.



SPECTRAL CLASS

Stars are given a classification letter (O,B,A,F,G,K and M) with a subtype of 0-9 indicating how far along the scale towards the next classification the star is. Thus an F5 star would be average for its type, while an F9 is close to becoming a G type. As previously noted, brown dwarfs – which are quasi-stellar objects rather than true stars – are usually designated L or T.

In the table below, temperatures are given in Kelvin (0 Kelvin is –273° Celsius and one Kelvin is equal to one degree Celsius), Mass, Radius and Luminosity are relative to Sol, Earth's sun, which is given a nominal value of 1 for all three.

YERKES LUMINOSITY CLASS

Star type does not give a complete picture of a star's characteristics. Two stars of the same energy output (luminosity) may be very different in terms of size and mass. The Yerkes Luminosity Class groups stars of the same temperature range into size classes.

Type	Description
Ia	Very Luminous Supergiants
Ib	Less Luminous Supergiants
II	Luminous Giants
III	Giants
IV	Subgiants
V	Main Sequence (Dwarf) Stars
VI	Subdwarfs
VII	White Dwarfs

A combination of these two systems gives all necessary information on a star. Thus a type AII star would be a bright blue giant while a type G5 V would be main-sequence yellow dwarf (much like Sol).

STARS IN THE THIRD IMPERIUM

The above luminosity classes are given mainly for reference, to aid in converting known stars into terms that are useful in running a game or creating a setting. For the purposes of the typical game it is not necessary to know the exact surface temperature or classification of a star, just its general characteristics.

Star Type	Colour	Surface Temperature	Average Mass	Average Radius	Average Luminosity
O	Blue	25,000K or more	60	15	1,400,000
B	Blue	11,000 – 25,000K	18	7	20,000
A	Blue	7,500 – 11,000K	3.2	2.5	80
F	Blue to White	6,000 – 7,500K	1.7	1.3	6
G	White to Yellow	5,000 – 6,000K	1.1	1.1	1.2
K	Orange to Red	3,500 – 5,000K	0.8	0.9	0.4
M	Red	Under 3,500K	0.3	0.4	0.04

Most stars encountered in a game will be main-sequence or 'dwarf' stars (class V) of various types. The commonest, in order from hottest to coolest, are F (Blue-White), G (Yellow), K (Orange) and M (Red). These main-sequence stars are identified by their type and classification, e.g. a G5 is an average G-type 'yellow dwarf' star.

Type D ('white dwarf') stars account for a fair proportion of the stellar population. These are burned-out, dead stars that have gone through their giant phase, swelling up and destroying their inner planets. There is virtually no chance of a naturally life-bearing world orbiting a white dwarf, though spacefaring cultures may colonise the worlds of such a system.

Type L and T ('brown dwarf') stars are not really stars at all, and thus not classified in the sequence above. They are extremely large gas giant worlds that have not quite gained the mass or temperature needed to become a true star. They are however considered to be stellar rather than planetary bodies and may have planetary bodies orbiting them. Type L brown dwarfs are much hotter than type T, and could perhaps provide enough heat to their planets/moons to allow some form of life to develop.

Giant and Subgiant stars (class III and IV) will normally be of the F-M classes. Such stars are old and have passed through their main-sequence stage. They have swollen up to gigantic size (passing through a Subgiant phase) and may fling out high-energy matter from time to time. Their inner planets will have been destroyed and there is little chance of life on the surviving worlds. Eventually giant stars collapse to being white dwarfs or, if they are massive enough, black holes.

Luminous Giant stars (type I and II) are very rare. They are simply very hot giant stars which are capable of exploding in a supernova. Luminous Giants are extremely rare.

Other stellar objects such as black holes and the like are extremely rare and, like Luminous Giant stars, will be placed by the referee wherever they seem appropriate. This should be far from anywhere inhabited.

PLANETS AND OTHER NON-STELLAR BODIES

Some stars are orbited by nothing more substantial than dust and gas clouds, especially those that have expanded and destroyed their planetary system if they ever had one. However, some systems contain large numbers of bodies including planets, moons, asteroids, comets and meteoroids. These bodies are composed of various combinations of rock, ice, dust and gas.

Scientists still struggle to agree exactly what a 'planet' is, and whether or not a given body qualifies as a planet, a dwarf planet or an asteroid. Rather than settle on a precise scientific definition that may change in the future, we will use our own working definitions for the purposes of these rules, allowing us to use a definition suitable to our purposes. For example, the 2006 scientific definition of a planet did not agree whether an object of planetary size but not orbiting a star or the remains of one is a planet. Common sense suggests that these objects should be considered to be planets – otherwise a planet that is ejected from a star system by gravitational effects would suddenly need to be redefined.

We have decided that such objects are indeed planets for our purposes as they fulfil the criteria of our in-game environment. For the purposes of this book, a planet is a body that does not have sufficient mass to begin nuclear fusion and become a brown dwarf or a star, but which has sufficient mass that its own gravity has caused it to assume hydrostatic equilibrium, i.e. it has a more or less round shape, and in addition has sufficient surface gravity that it could maintain a measurable atmosphere, whether or not that atmosphere is actually present. Planets are subdivided into various types, as noted below.

Objects of planetary size that are in orbit around non-stellar bodies are not considered to be planets; they are termed moons instead. We use the term moon rather than satellite to avoid confusion with artificial satellites. We use the term asteroid belt for a belt that is designated as the system's mainworld and planetoid belt for a belt that is not the mainworld. An asteroid belt or planetoid belt may contain one or more dwarf planets. These are extremely large planetoids, in some cases big enough to rival some planets but which are contained within a belt.

Dwarf planets are typically rated as Size code 0 in the UWP data. Any body of this size tends to achieve a roughly spherical shape during formation. A body which is smaller than a dwarf planet (and usually will not be even roughly spherical) but which does not display the behaviour characteristics of a comet or meteoroid is termed an asteroid or planetoid depending on whether it is part of a mainworld belt or some other group of planetoids.

GAS GIANT (JOVIAN) PLANETS

A gas giant is an extremely large object mainly composed of hydrogen compounds, which may or may not have a solid core. The upper atmosphere is thin, but pressure rapidly increases to levels intolerable by creatures not native to such environments. Far enough down in the atmosphere, it becomes liquid due to the pressure. The weather systems of such superdense atmospheres are very violent. The strongest winds in the Sol system are encountered on Neptune and have been estimated at over 2,400kph.

Most gas giant planets are, to a greater or lesser degree, high-radiation environments as a result of their strong magnetic fields. However, if they possess moons (many do) then it is possible for people to live on them in the majority of cases. Gas Giant planets are categorised into three groups. The smallest are still huge by the standards of other planets and are referred to as Subjovians or Small Gas Giants. Examples include Neptune and Uranus. Larger gas giants are known as Large Gas Giants or as Jovians. Examples include Jupiter and Saturn. The very largest are known as Superjovians. There are no examples of this type in the Sol system, and they are likely to be rare. Superjovians should be placed by the referee where desirable, perhaps to create conditions suitable for an adventure he has in mind.

No UWP size code is given for Jovians. They are simply noted as Small Gas Giant (SGG), Large Gas Giant (LGG) or Superjovian (SJ).

Some Superjovians are sufficiently large as to be considered 'failed stars' known as brown dwarfs. Such bodies are hot and the area around them is very unhealthy due to high levels of radiation. The presence of a brown dwarf will alter the characteristics of the system. The majority of large gas giants or even Superjovians are nowhere near massive enough to become brown dwarfs.

ROCKY (TERRESTRIAL) PLANETS

Rocky planets, sometimes called Terrestrials as they are of the same general nature as Terra, are the most suitable for human habitation. This is especially true if they possess an atmosphere of some kind and, ideally, liquid water. The latter is only likely in a narrow zone of a star system. Other worlds tend to be either frozen or scorched wastelands, though of course with technological assistance most worlds can support some kind of colony. Planets may or may not have satellites (moons), which may themselves be the site for a colony. Rocky planets are subdivided into various types by spacefarers. This jargon has evolved over the years and is sometimes used rather loosely.

Most planets spin and also precess about their axis of spin, creating night and day as well as seasons if they are close enough to a star to receive a reasonable amount of energy from it. However, some worlds do not rotate at all, as a result of the gravity of their primary (star). These worlds are referred to as being tidally locked. This means that they always have the same face towards the primary, receiving all the energy from the star on that side. The far side is in permanent night, with a thin strip of constant twilight between the day and night sides. This is usually the most habitable part of the planet. Almost all moons are also tidally locked, though the difference in conditions is less extreme since planets do not give off massive energy in the way that stars do.

Whilst the scientific community may have a range of specialist terms for different world types, spacers have evolved a quick-and-dirty jargon which generally conveys the necessary information. The following terms are in common use throughout Imperial space and in many other regions as well. Designations are typically one or two words indicating the primary type and any additional considerations.

PRIMARY DESIGNATIONS

Most of what travellers need to know can be summed up in the primary designation: **Garden, Habitable, Non-Habitable, Rockball or Asteroid**. These terms cover a wide range of specific local conditions but give travellers an idea of what to expect.

Garden worlds are like Earth to a great extent. You can breathe the air and live relatively comfortably without artificial aids. The rule of thumb when determining 'Garden' status is that there are extensive areas where you can go outside in your shirtsleeves, and maybe some places where you might like to go for a holiday.

Habitable worlds are can support human life without much in the way of artificial assistance but are not 'comfortable'. The rule of thumb for a Habitable World is that it can be colonised using nothing more than huts, hand tools and suitable clothing but is not particularly welcoming. This definition is quite broad and includes worlds which may also fit into other categories such as water worlds, desert worlds and planets with a breathable but tainted atmosphere. Some apparently Garden worlds turn out to be only Habitable due to the effects of temperature, weather patterns or local wildlife. The Habitable designation may be combined with another to give an indication of conditions, e.g. Habitable Water World.

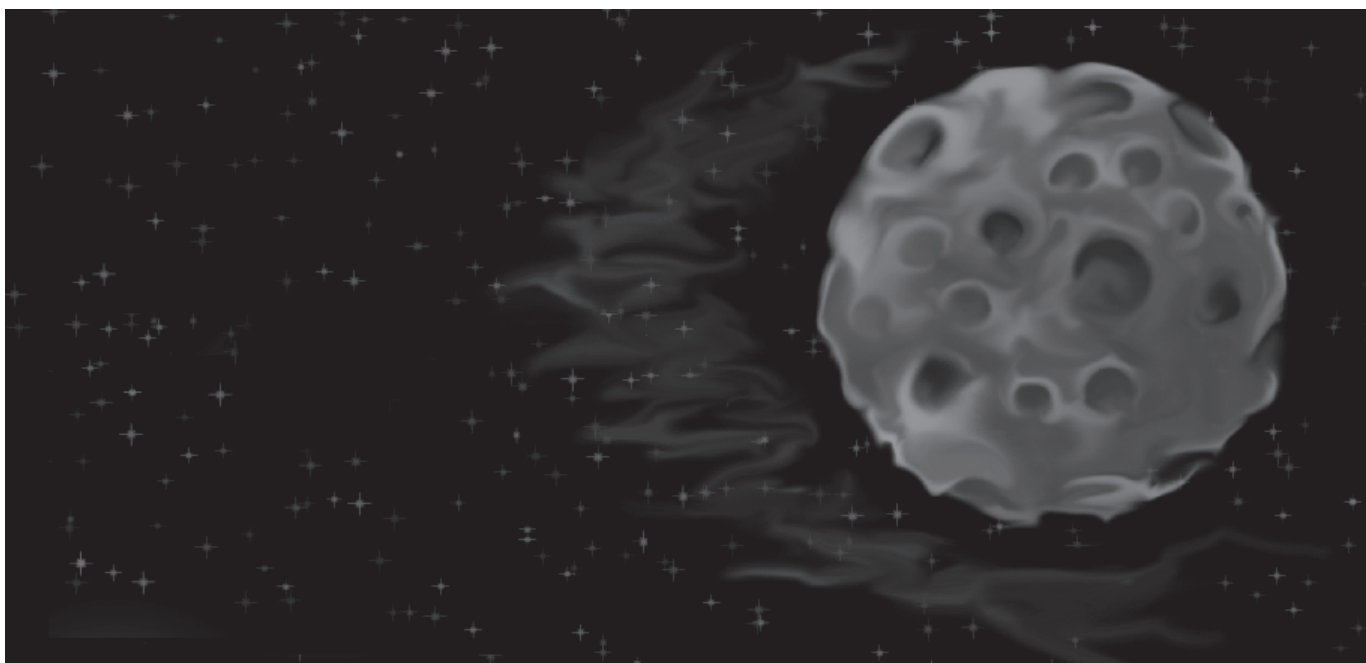
Non-Habitable or Borderline worlds vary considerably. The definition is normally applied to pretty much any world that cannot be settled without artificial aids, but which does not fit into another category. One rule of thumb is that 'it has an atmosphere of some kind but you can't breathe it.'

Rockball worlds have no measurable atmosphere, or a minimal (trace) atmosphere. Very cold outsystem rockballs are sometimes termed Iceballs and those that are very close to their primary are occasionally referred to as 'fireball' worlds.

Asteroid or Belt designations mean that the 'world' is in fact a group of asteroids occupying the same orbit.

SECONDARY DESIGNATIONS

Secondary designations are often missed out entirely. When used, they give a little more detail. These terms are similar to but not exactly the same as the standard trade codes listed with a world's UWP. Secondary designations include Desert, Dry, Giant, Hell, Wet, and Water. These designations are normally only applied to Habitable planets; most others are summed up by their primary designation.



Desert worlds are more or less habitable but for an almost total lack of water in any form. This means that there will be little life and that water for colonists will have to be imported and carefully recycled. Some desert worlds have a breathable atmosphere and might be considered Habitable; others are Borderline or Non-Habitable - Mars is a Non-Habitable Desert world.

Dry worlds have relatively little water (usually Hydrographics 3 or less).

Hell worlds are in the right size and gravity class for habitability, usually have an atmosphere and/or water, and yet are extremely hazardous. Reasons for this vary, including exotic atmospheric gas mixes, extreme weather, highly dangerous wildlife and a range of other hazards that make habitation a dangerous business. Venus is a fairly extreme example of a hell-world in the Sol system. Some Hell worlds have a breathable atmosphere and could be easily settled but for whatever conditions make the world so unpleasant.

Water worlds almost or entirely covered in liquid (which may be in frozen form), with little or no usable land above sea level. All water worlds have some kind of atmosphere but it is often not breathable to humans. A breathable-atmosphere water world would be designated Habitable, The oceans of a water world may sometimes be of unusual composition, but if this is the case then the atmosphere will definitely not be breathable.

Wet worlds have a lot of surface water (usually Hydrographics 7 or more) but do have significant land masses.

Giant worlds are simply unusually big. Surface gravity tends to be somewhat high (1.2g to 1.6g commonly). There will usually be an atmosphere of some kind but type varies from surprisingly thin to (more often) very dense. Giant worlds are sometimes termed Super-Earths. There are often given a special size code of G to indicate their enormous size. Giant worlds are usually also Non-Habitable.

DWARF PLANETS, PLANETOIDS AND ASTEROIDS

A dwarf planet is a rocky body not capable of maintaining a useful amount of atmospheric gas, and an asteroid (or planetoid) is a similar but smaller body. By convention, in the Traveller game universe, the term asteroid refers to an asteroid that is in a belt that is designated as a system's mainworld whereas a planetoid is a similar body not located in a 'mainworld' belt. Dwarf planets may occur more or less alone or may be part of an asteroid or planetoid belt or cluster.

Asteroid and Planetoid belts (and clusters) are not particularly dense, but contain a range of bodies from dust particles to (occasionally) dwarf planets. Some belts are effectively made up of nothing but gravel while others may have several large (and thus habitable) bodies. Most asteroids consist primarily of rock and ice, with metals and other useful minerals (including carbon compounds) deposited among them. Some belts are unusually rich or poor in useable minerals; most have at least some useable deposits though these can be difficult to find or to extract.

Asteroids are also sometimes found in very loose clouds near planets. A large world tends to clear its immediate area of asteroids, and one definition of a dwarf planet is that it does not have sufficient gravity to do so. However, in most cases there will be a few free-floating rocks near any planetary body. Large planets (i.e. gas giants) tend to accumulate asteroids and other debris at their Trojan points, which occur 60° ahead of and behind the planet along its orbital path.

Within the Sol system there are three dwarf planets. Of these, Ceres is a rockball while Eris and Pluto are iceballs. If it is desirable to set up an outpost in a given area of a star system then large planetoids and dwarf planets are most suitable as they are more stable than smaller bodies.

Asteroid Belts are sometimes summed up spacers using four designations.

- Debris Belts are very sparse and uneven in composition, and generally contain tiny fragments of ice and rock. 'Gravel Belt' is another term used by spacers.
- Sparse Belts are, as the name suggests, very sparse but contain a normal proportion of large and small asteroids. Dwarf planets are very unusual in such belts.
- Dense Belts are more dense and generally contain more large asteroids. Dwarf planets are still uncommon but are more likely.
- Superdense Belts are unusual. As the name suggests they contain a far greater than usual composition of asteroids and may have more than one dwarf planet.

Note that density of a belt is still relative. A Superdense belt in the far outsystem will be very widely spread out compared to one in the warm zone where it can occupy a shorter orbit. No belt, not even a Superdense one, is so thick that space vessels have to twist and dodge between the crashing rocks. They are a significant hazard to navigation however, and greatly reduce sensor range due to the large numbers of contacts to resolve.

MOONS

A rocky (or rock/ice) body that orbits another non-stellar body is termed a moon or satellite (we use the term 'moon' here to avoid confusion with artificial satellites). Moons can be very large – sufficiently so that they would qualify as a planet were they in orbit around a star. Most moons are desolate rockballs or iceballs but some receive sufficient energy from the star or other sources (such as heating by a gas giant they orbit) to be fairly habitable. Water is likely to be in the form of ice if it is present at all, and may be an exotic compound that can be processed with appropriate equipment.

The very smallest of 'moons' are nothing but bands of dust, ice and small fragments which can form ring patterns around a planet. These are sometimes dense enough to pose a hazard to navigation. Larger moons exert a gravitational effect on their parent planet, which can be important if it has a lot of water and much low-lying land. Even small bodies like asteroids can have 'moons', in the form of small fragments orbiting them. These are usually of negligible size.

Some moons can be very large – big enough that they would be a super-earth or giant planet if they were a major body. It is also possible that a Superjovian might be orbited by another (small) gas giant. This would be an unusual situation to say the least.

COMETS, METEOROIDS AND OTHER OBJECTS

A comet is a small body that orbits the system's star, often in a very eccentric and extremely long path. It consists of a small nucleus of rock, dust, ice and frozen gases, and when the comet is close to a star this gas sublimates off to create the distinctive cometary 'tail'. Comets far out from the star do not have a tail and can be difficult to detect. A meteoroid is simply an object orbiting a star, which is too small to be considered a comet. Even smaller meteoroids are known as micrometeoroids. Meteoroids that strike the surface of a planet, moon or asteroid are termed meteorites.

There may be very distant objects associated with a solar system, some as far out as halfway to the next star. These are mainly comets, though there is a fair amount of gas and dust floating about in interstellar space too. Some systems are surrounded by a 'shell' of cometary bodies (some of which are large enough to be considered dwarf planets), known as the Oort cloud. The volume of space occupied by the Oort cloud is enormous, however, so these objects tend to be very far apart and difficult to detect even if they are being deliberately sought.

While the Oort cloud is normally spherical, there may also be a disc of debris – gas, dust, asteroids, comets and meteoroids – along the ecliptic (the plane of rotation of the system). Named the Kuiper Belt, this area is more dense than the Oort cloud, but that does not mean much when the ratio of matter to space is considered. The Kuiper Belt lies inward of the Oort cloud.

Out beyond even the Oort cloud there may be deep-space comets and other bodies, some of which are large enough to be considered planets. Such 'rogue planets' may have been ejected from another star system long ago by gravitational effects and may have been on their lonely, frozen voyage across the universe for eons. When a rogue planet approaches a star system, there is a chance that it will be captured to become a moon or a planet in the new system.



ENVIRONMENTAL FACTORS

The major factors that determine what a given environment is like include atmosphere, light/heat, availability of water and the local gravity conditions. These factors can create very different environments depending on their interactions.

GRAVITY

Gravity is a force which attracts objects to one another. Local gravity conditions can be very important to someone who is falling from a height, but there is more to it than that. Some high-technology societies have learned how to create artificial gravity and even to shield objects from its effects, allowing the creation of 'contragravity' vehicles. Correctly speaking such vehicles are not 'powered by gravity' but make use of it as a final drive system. Other 'final drive' systems include wheels, tracks and so forth; gravitic drive systems replace wheels rather than the engine.

We will define different gravitic conditions by the strength of local gravity relative to that found on Earth. '1g' or '1 gravity' represents an equivalent to the conditions found on Terra, where an object which is dropped will accelerate at approximately 9.81 meters per second, every second.

It is perhaps surprising how little gravity conditions vary from one planet to another. The 'surface gravity' (assuming such a thing as a surface existed) on Jupiter would be only 2.33gs. Gravity is a function of density; extremes of gravity would be experienced on the surface of something like a neutron star, but it is unlikely that people would go there.

Correctly speaking, zero gravity is impossible since all objects exert some gravitational attraction. However, it is not unreasonable to refer to an environment away from significant masses (like planets and moons) as microgravity; the gravitic forces on a person or object are minimal. However, this does not mean that mass goes away. While objects are 'weightless' (weight is a product of gravity and mass), they are still there and thus still possess mass. A cargo crate that has started moving for some reason will still crush a character it hits him and will require some force to get it moving or to stop it. Operating in microgravity can be tricky and is sometimes dangerous.

Microgravity is encountered aboard space craft without artificial gravity (or devices like spin sections to simulate it) and when operating on or around very small bodies like comets or small moonlets. For example, Deimos, one of the moons of Mars, has a surface gravity of 0.0004gs and can be considered a microgravity environment.

The following classifications apply to the gravity conditions experienced by characters:

Microgravity is defined as 'no significant gravitational effects' such as deep space or distant orbit around a planet, far enough out that its gravity does not significantly affect objects or people. Note that it is possible for a space vessel to be held in orbit by gravity but still experience no significant gravitational effects on the crew. A size 0 body, e.g. an asteroid, can be considered to be a microgravity environment.

The most important factor when operating in microgravity is that objects and people will just keep going once they are moving. It is possible to leap off the surface of an asteroid and just drift away forever. Losing contact with a starship hull is a death sentence unless the character is tethered or has a means of thrust available. The hapless astronaut may eventually drift back into contact as a result of the very small gravitational attraction between himself and the asteroid or ship, but he will be long dead by the time it happens.

Minimal Gravity is defined as where there is a significant (noticeable) gravitational pull but this is less than 0.2gs. In the Sol system, the surface of Pluto has a gravity of 0.05gs; Titan has 0.14g and the Moon (Luna) has 0.17g. Worlds of average density, of size code 1-2 can be considered minimal gravity environments. A minimal gravity world is not likely to be able to retain a measurable atmosphere. Minimal gravity poses hazards to characters – they are not likely to bounce off into space, but great care must be taken when moving to avoid a loss of balance.

Extremely Light Gravity is between 0.2-0.4gs and might be encountered on a small planet like Mercury (0.39gs), or a larger but not very dense one like Mars (0.38gs). Extremely Light gravity is sufficient to retain an atmospheric envelope, though not much of one. Worlds of size code 3-4 typically have extremely light gravity. Worlds of this type never have a breathable atmosphere. If one exists at all it will be trace (UWP code 1) or some exotic gas mix (code A).

Very Light Gravity is between 0.4-0.6gs and is sufficient to support a decent atmosphere, though it will normally be too thin for humans to breathe unaided. Atmosphere types 1-3 (trace or very thin) are common, or type A (exotic gas mix). The latter is likely to have a very low pressure, but might consist of very heavy gases. A pressure suit is useful for operations in such low-pressure environments. However, although it would be uncomfortable it is possible to operate with just an air mask, at least for a time.

Light Gravity falls in the range 0.6-0.8gs and is the minimum necessary for a standard atmosphere. Worlds with a size code of 6 (assuming normal density) are the smallest with sufficient gravity. Light gravity and lower imposes the low-gravity effects discussed on P170 of the Traveller core rulebook.

Terra-Normal, or Standard, Gravity falls in the range 0.8-1.2gs and allows the normal range of human activities without many problems. Earth's gravity is rated as 1g, with Neptune (1.14g) and Saturn (1.11g) being higher and Venus (0.91g) and Uranus (0.88g) being lower. A size 8 world of normal density will have Terra-Normal gravity.

Heavy Gravity, ranging from 1.2-1.4gs, is tolerable by humans for extended periods, but unaccustomed individuals will tire quickly and accidental injuries are likely. Worlds of size code 9-A fall in this category. A Heavy Gravity environment imposes the high-gravity effects discussed on P170 of the core rulebook.

Very Heavy Gravity (1.4-1.6gs) is hazardous and poses long-term risks to people not evolved for it. A very dense, high-pressure atmosphere is likely. These conditions are only encountered on very dense worlds and/or large super-earths, or may be artificially induced using grav plates.

Extremely Heavy Gravity (upwards of 1.6gs) is highly dangerous and not commonly encountered (Jupiter's 'surface' gravity of 2.33gs is an exception, but it is not possible for humans to survive there so the point is academic).

Note that people can tolerate much higher forces for short periods, especially if they are oriented properly or have the correct equipment. For example, a race driver may walk away from a crash in which he momentarily experienced as much as 250gs and fighter pilots can remain conscious in a brief 9g turn. However, just a couple of gs in the wrong direction (forcing blood into the brain instead of out of it) can cause 'red out' and render the same pilot helpless. Low and high gravity conditions are primarily important to adventurers with a propensity for falling off things, but unusual gravity makes all manner of tasks increasingly tricky. It also affects the sort of plants and animals that can exist in a given environment.

ATMOSPHERE

Not all worlds have an atmosphere, and in many cases it will be composed of something that humans cannot breathe without serious ill-effects. There is more to atmospheric conditions than composition, however. Pressure, temperature and an assortment of other factors have to be right before an unprotected human can breathe and function in a given atmosphere.

PRESSURE

While it is possible in a science-fiction universe that creatures evolved to live in a vacuum may exist, most living things need some kind of fluid (gas or liquid) around them to maintain balance with their own internal pressure. Most creatures can stand a fair amount of imbalance but major changes of pressure, especially sudden ones, can cause severe harm.

A suitably graphic example occurs when a human being is exposed to hard vacuum without protection. The body can resist the effects for a (very) short time but soon internal pressure will burst blood vessels and force tissue fluids out through the skin. Unconsciousness is rapid and death follows soon after. Much the same thing happens to deep-sea high-pressure creatures brought to the surface. Some will literally burst. Thus there is more to a suitable atmosphere than breathability; it must also be dense enough to support the creature's bodily functions, or else some kind of pressure suit will be needed.

High pressure is as much of a problem as low. High-pressure atmospheres can make it difficult to breathe and have a tendency to force their way into suits and vehicles through seals that would keep atmosphere inside against a vacuum. This is why spacecraft do not make good submarines – keeping air pressure in against a vacuum means operating at a differential of one atmosphere (i.e. the mean pressure of Earth's atmosphere at sea level), whereas even just a few tens of meters down, water pressure on the hull of a submerged vessel (and all of its weak points) can be many times as much. Extreme pressure can flatten a hull, but seals will normally fail long before this occurs.

ATMOSPHERIC PRESSURE RATINGS

The baseline for measuring atmospheric pressure is that of Earth's atmosphere at sea level, a measure imaginatively known as one Atmosphere. The following general levels of pressure are used in these rules:

Hard Vacuum means that there is no (or virtually no) gas pressure. Hard vacuum will render humans unconscious in 10-15 seconds or so and will kill them within 2-3 minutes. Hard vacuum is considered equivalent to atmosphere code 0.

Partial Vacuum means that there may be some air or other gases present but full protective gear is needed. Partial vacuum will kill a human about half as fast as hard vacuum, basically just ensuring that the victim suffers for a while longer. Partial vacuum is considered equivalent to atmosphere code 0 (none) as the difference is very small.

Minimal atmosphere is not breathable by humans but will not kill them quickly. Enough gas pressure exists that an unprotected person could function for a few minutes so long as an air supply was available. Prolonged exposure will be harmful, however, so pressure suits are advisable except in extreme emergencies. Life is possible in these conditions, but not in forms commonly encountered on Earth. Minimal Atmosphere is considered equivalent to atmosphere code 1 (trace).

Extremely Thin atmospheres are experienced on Earth in places like the top of Mount Everest, where pressure is about 1/3 of an Atmosphere. This is enough to support respiration for a period but not indefinitely. Effects such as nausea, disorientation and dizziness become gradually worse until

the subject becomes incapable of functioning coherently. It is possible that creatures could develop which are adapted to these conditions. Extremely Thin is equivalent to atmosphere code 2-3 (very thin) or possibly E (thin, low) if there is enough pressure to make the air just about breathable at low altitudes.

Thin atmospheres (UWP code 4-5) can be tolerated indefinitely by humans who have become acclimatised but those who are not used to the thin air may be prone to altitude sickness, which can cause confusion, headaches and nausea. Even individuals not affected by altitude sickness will tire quickly and not rest well until they become used to the conditions. The equivalent on Earth is encountered at altitudes from about 2,000m to 4,000m, in pressures of around 2/3 of an Atmosphere.

Normal atmospheres are roughly comparable with that found on Earth at sea level, to within about 30-40% higher or lower pressure. This is optimal for the comfort and well-being of most Terran humans, though those adapted to different environments may be uncomfortable. Normal atmosphere correlates to code 6-7.

Dense atmospheres with a pressure up to 2 Atmospheres can be uncomfortable for normal humans but are breathable. The combination of dense atmosphere and high humidity produces a sensation rather like drowning, which can make an otherwise breathable atmosphere intolerable. Dense atmosphere correlates to a code of 8-9.

Extremely Dense atmospheres of greater than 2 atmospheres pressure can be coped with for short periods with careful compression and decompression and a suitable air supply (in the manner used by divers), but without careful pressure adjustment and support equipment humans cannot survive in this environment for long. Extremely dense atmospheres may correlate to UWP code 8-9 but are likely to be unbreathable and thus qualify for code A (exotic) or D (dense, high D).

Superdense atmospheres such as those found on Venus or gas giant planets are totally unbreathable to humans, no matter what the composition may be. The pressure may cause physical damage long before breathing becomes an issue. A superdense atmosphere would qualify for UWP code F (unusual).

Note that pressure change can be extremely dangerous. While a human can cope with a thin atmosphere given time to adapt, rapidly changing altitude (or being in a depressurising space vessel) can cause serious short-term and long-term effects. Pressure changes are carefully controlled wherever possible to avoid such problems, though things do go wrong from time to time. Normally, a starship's internal environment is slowly adjusted during a jump to match the destination world; often passengers do not even notice. When this is not done it can be necessary to undertake a period of acclimatization at the starport before venturing out into the wider world, or else to operate in a pressure suit from an environmentally controlled vehicle equipped with airlocks.

ATMOSPHERE TYPES

Worlds that possess an atmosphere will tend to have one of several general types. Composition may vary slightly due to the presence of volcanic gases, unusual chemical compounds and the like, but for the most part the basic composition will be the same.

OXYGEN-NITROGEN (STANDARD) ATMOSPHERES

Oxygen-Nitrogen atmospheres are similar to that found on Earth. There are other gases present in small quantities but the vast bulk of the air is made up of these gases (roughly 80% nitrogen, 20% oxygen). An oxygen-nitrogen atmosphere may not be breathable due to pressure or composition, but extracting gases to support life is a simple matter for technologically equipped colonists. Oxygen-Nitrogen atmospheres are almost always the result of life, so planets with this atmosphere type will be Garden or Habitable worlds, or perhaps some kinds of Hell world. Variants on the Terra-norm oxygen-nitrogen atmosphere include high-oxygen, low-oxygen and contaminated types.

High-Oxygen atmospheres can be very dangerous. Once the partial pressure of oxygen gets above 25-30%, the resulting gas mix becomes hazardous to breathe and supports combustion rather too well, making fire a serious risk. High-oxygen environments can corrode metals quickly (rust is iron oxide; more oxygen promotes faster rusting...) and shorten the life of equipment.

Low Oxygen atmospheres may not be able to support humans unaided even if the pressure is acceptable and the other gases in the atmosphere are not harmful. Combustion is difficult, too.

Contaminated atmospheres contain something in an otherwise breathable atmosphere that makes it harmful. Effects can be mild to fatal. Possible contaminants include chemicals like sulphur and chlorine or pollutants from industry, volcanoes or other sources, or might be biological, such as airborne spores. It is usually possible to process a contaminated atmosphere to extract useful air from it for a colony, making contaminated worlds a better prospect for colonization than airless planets. The Contaminated designation is sometimes applied to otherwise 'garden' worlds but is more commonly used for habitable worlds.

The UWP designation 'Tainted' (indicated by codes 2,4,7,9) is generally used for fairly mild contaminants, and is generally taken to mean 'you need a filter mask but brief exposure is survivable' by starfarers. More serious contamination merits re-designation as or A (exotic), B (corrosive), C (insidious) or F (unusual) depending on the circumstances. A previously breathable atmosphere can become Contaminated due to nuclear fallout, volcanic gas or many other conditions. Contamination can be temporary or permanent (or at least, long-term).

COMMON UNBREATHABLE ATMOSPHERE TYPES

Worlds with a minimal atmosphere may possess quite unusual gas mixes due to local conditions, but where there is a significant atmospheric envelope, it will usually be one of the following types.

Methane breathing creatures, i.e. those that use methane instead of oxygen in their life processes are a staple of science-fiction. A human could not survive unprotected in a methane atmosphere as it would not support respiration, but methane is not intrinsically toxic – a human would die for lack of oxygen in a methane atmosphere rather than from any harm done by the methane itself. A mix of oxygen and methane will combust or explode readily, so methane leaking into an oxygen-supplied space can be a serious hazard. Gas giant planets will usually have a methane or methane/hydrogen atmosphere.

Carbon dioxide, like methane, is not intrinsically harmful to humans, but it cannot support human life. A person could work on a world with a carbon dioxide atmosphere of sufficient pressure, using just a breathing mask. If plant life exists, it will tend to convert an atmosphere of this type into an oxygen-nitrogen one over a very long period. Carbon dioxide (and carbon monoxide) atmospheres are likely for many non-habitable or borderline worlds. Some of these may be in transition from this atmosphere type to another, perhaps eventually becoming Habitable. The atmosphere of Mars (such as it is), is a very low-pressure Carbon Dioxide atmosphere. Venus is another mainly carbon-dioxide atmosphere (96%) but as it contains corrosive gases it might also be considered an exotic atmosphere type.

Nitrogen is inert and not harmful to humans. It makes up about 80% of Earth's atmosphere. However, it will not support human life. Indeed, being very inert it is unlikely to support life of any sort unless mixed with other, more useful, gases. The atmosphere of Titan is mostly nitrogen, with some methane.

OTHER ATMOSPHERES

Other atmosphere types are possible. Minimal atmospheres may be composed of volcanic gases and other very minor traces of chemicals, and thus can have almost any chemical composition. Mercury's 'atmosphere' contains oxygen, sodium and potassium but not in quantities sufficient to matter very much.

Worlds with a thicker atmosphere will usually have a base type (one of those listed above in most cases), which has been altered by the presence of other compounds. Venus' atmosphere is 96% carbon dioxide but the enormous pressure (90 times that on earth at sea level) and clouds of corrosive sulfur vapor make it much more hazardous than a simple carbon dioxide atmosphere. Which compounds are present in addition to (or in some cases, instead of) the base type will determine the nature of the hazard.

Ammonia is toxic to humans and will dissolve readily in water to form an alkaline solution that can be corrosive.

Chlorine is toxic to humans and other Terran creatures, though it could be useful to some alien creatures.

Fluorine is toxic and also highly reactive, creating additional hazards as it reacts with suits, vehicles etc.

Hydrogen is not toxic but hydrogen compounds combust or explode readily in the presence of oxygen. Hydrogen molecules are small enough to seep through walls and suits.

Nitrogen is inert and not harmful, but nitride compounds can form nitric acid which is very corrosive.

Sulfur is also corrosive and can form hydrogen sulfide, which is explosive.

Extremes of pressure are also considered to be 'exotic' atmosphere types.

WATER AND OTHER FLUIDS

Water is vital to life; at least life of the Terran sort. It is rarely found on worlds without an atmosphere as it tends to be quickly turned to gas by stellar radiation and then lost like the rest of the atmosphere. Ice and even liquid water might be found in caverns or deep crevasses, but this is unlikely. On worlds with unusual atmospheres, water will normally either be replaced by other fluids or present as compounds which might be hazardous, corrosive or have other unwanted effects.

Water (or its equivalents and parallels on other planets) has profound effects on worlds. Obviously, it supports life, but it does more than that. Water erodes the landscape as a liquid and carves deep valleys in frozen form. It carries sediment and washes debris out to sea, creating fertile flood plains and deltas around major rivers, but only if there is enough of it. A world with little water is likely to have little life and will display different patterns of erosion than a wetter planet.

Water also helps regulate the planetary temperature. Ice reflects sunlight, reducing the amount of energy that is retained by the planet and effectively lowering the global temperature. Water, especially in large bodies, retains heat and gives it up slowly. It takes a lot of energy to heat an ocean up appreciably, and it will take time for this energy to be released, mitigating large temperature changes between the seasons and between night and day.

Water runs downhill, and can seep through rock and soil, so tends to collect in basins and depressions, creating lakes and seas. The location of these bodies of water depends greatly upon the planet's topography; the same amount of water collected in a few very deep but narrow seas might cover the entire surface of a very flat planet to a depth of a couple of meters. While the surface area of water exposed to stellar energy is important to a planet's weather and ecosystems, these rules are more concerned with the actual amount of water that is present on the planet, including that comprising ice caps and glaciated regions.

TERRAIN

No planet is entirely covered by the same terrain type. Most worlds are a mix of mountains, plains and hills or broken lands, possibly with swamps, seas and oceans or forests and jungles. Even an airless rockball will usually have flat areas, mountains and cratered regions. Each of these different environments presents its own challenges and dangers.

SPACE AND VACUUM TERRAIN

The absence of an atmosphere is the main characteristic of these terrain types. Adventurers will need some kind of protection to survive there.

DEEP SPACE

Deep space is considered to be far from any star or planet. Other than odd wisps of gas or dust motes, there is a very great deal of nothing much in deep space. Comets and even rogue planets do exist and can be found, but the amount of empty hard vacuum between them is such that the chances are very small. Deep space is a dangerous place, far from rescue. There may be a chance for spacefarers suffering disaster in orbital space but out in the deeps there is little chance to limp home in a jury-rigged space vessel.

ORBITAL SPACE

Orbital space, i.e. somewhere near a planet or moon, is only slightly less hostile than deep space. Indeed, there may be an additional hazard from stellar radiation and the heating effects of direct starlight. The incidence of asteroids and other objects is somewhat greater near a world or moon, but the vacuum is just as hard and the space just as cold. This is not a forgiving environment.

VACUUM TERRAIN

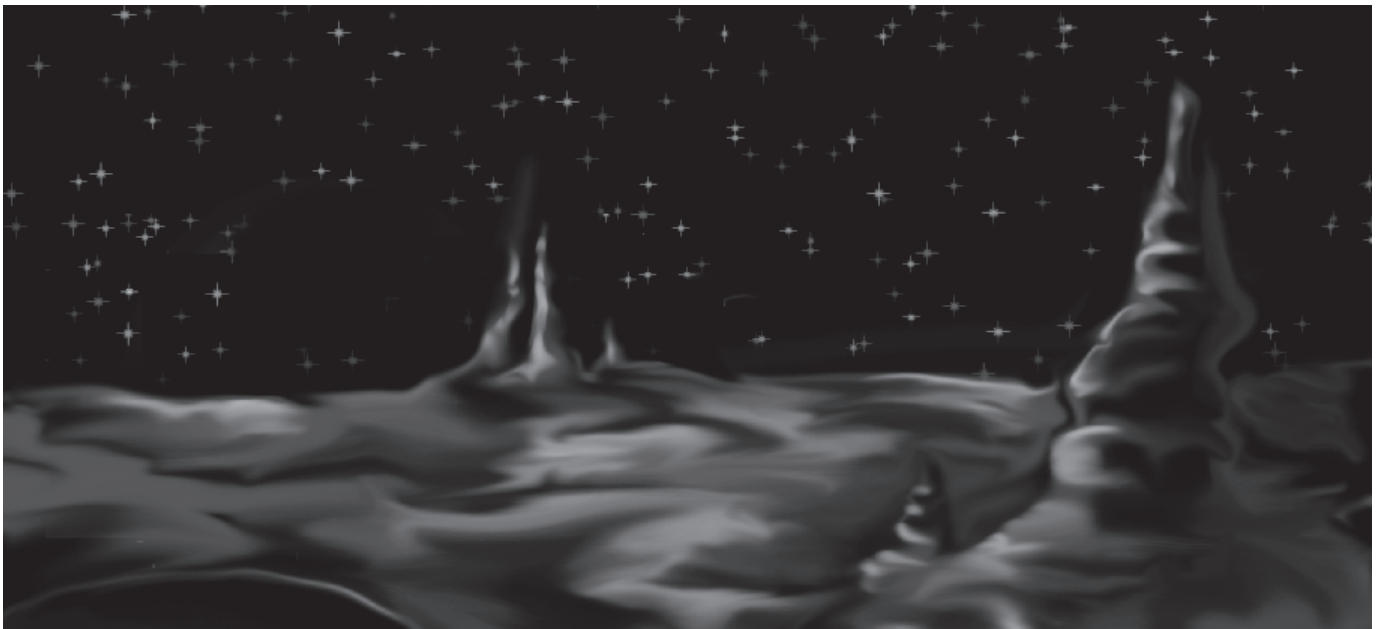
A vacuum plain exists where there is little or no atmosphere and relatively flat land. It is likely to consist of rock and dust, and be pitted with craters where meteorites have struck the surface. Going is usually fairly uneven, and there are plenty of hazards to endanger a vehicle or party on foot. These range from craters, seas of soft dust and crevasses to sharp rocks that can snag tires and rip suits. Meteor showers are a possible threat, too. It is extremely unlikely that life will be encountered in such an environment.

Rougher terrain, whether very broken or actually mountainous, poses much the same hazards though in greater concentration. On a world with significant volcanic activity there is a chance of encountering lava flows and so forth.

Vacuum terrain is exposed to the cold of space and the glare of stellar radiation. The 'day' side (facing the system's star) receives hard radiation and a lot of energy – sometimes enough to melt metal. The 'night' side drops to very low temperatures. This effect is very pronounced on tidally locked worlds but on those that rotate the constant baking/freezing cycle can take its toll unless the world is far from the star.

PLANETARY TERRAIN

Where there is an atmosphere, it will have an affect on the terrain. Erosive effects may form soil and create terrain features, while an atmosphere will help keep out meteorites and protect any life on the planet from harm. Obviously, any life there is will depend on the atmospheric composition. The 'forests' of a methane world may be very strange to humans, but most of the general comments will still apply.



OPEN TERRAIN

'Open' Terrain includes grasslands, steppe and semi-desert regions where the land is mostly flat. If there is plant life, there may be bushes or trees, possibly in fairly large groups, but for the most part visibility is good and navigation should not prove a problem. On worlds with water there may be watercourses and small lakes in open terrain. These are important to the local wildlife (if any) and can be a barrier to or a means of navigation for people. Open terrain can be very windy on worlds with an atmosphere.

URBAN TERRAIN

Urban terrain includes any area that is or has been significantly altered by habitation. This includes ruins as well as areas outside the immediate settlement but which have been heavily influenced by people. This would include, for example, a belt of small settlements and farmland extending for a considerable distance around a major city. Even though there are relatively few people there, the land has been 'tamed' to support an urban population and is thus counted as Urban terrain. Such a region usually has obvious roads (or the remains of them) as well as bridges and similar improvements. A particularly ripped-up road, a sea of rubble or a ruined city where the surrounding flora has begun to move back in can actually be slower going than natural terrain. Urban areas are usually fairly obvious unless they are deliberately concealed or have been abandoned for a long time.

FOREST

Forest terrain includes the obvious deciduous and coniferous forests but also thick forests of bushes and other non-terrestrial plants which block sight and make navigation difficult in the same manner as trees. Forests can be truly vast on untamed worlds, and may conceal other terrain. It is not uncommon to encounter lakes, rivers, marshes and swamps in a forest, plus hills and even mountains rising from one. It is up to the referee to decide (for example) whether the adventurers are in a forest or a marsh at that particular moment, if it matters. Forests are assumed to be temperate, as distinct from jungles.

JUNGLE

Jungle terrain includes rainforests and the like, and as a rule occurs in warmer and wetter terrain than forest. Jungle is on average, thicker and more hostile than forest terrain, but follows many of the same general rules.

SWAMP/MARSH

Low-lying marshy terrain is often encountered around the edges of a watercourse or lake but can also be found on its own. The estuary or delta of a river may also be marsh terrain. It presents a range of challenges, not least of which is finding a route through for vehicles. Travelling on foot through marsh is hard work, and such areas are notorious for parasites and diseases. Marshes tend to have rampant plant and animal life. It is worth noting that a world's hydrographic percentage indicates surface coverage, not depth. A 'water world' could in fact be a vast tidal swamp, or could be covered in deep oceans.

BADLANDS

Badlands, or broken terrain, represents a rocky region which is hard work to travel through and is not much good for anything but getting lost in. Vegetation may be fairly plentiful but more commonly badlands regions have poor or thin soil broken by many rocky outcrops and steep ridges. Such areas are often fairly dry as well.

HILLS

Rolling hills or steeper rocky ranges offer a curious mix of exposure and shelter to any life that exists. Valleys may have lakes, watercourses and marshy areas while many hillsides are too steep for trees. Less rugged terrain may be buried under vast forests. Hills can be a barrier to or a channel for navigation, and settlements often grow up along convenient routes through them. Hills may rise up from almost any other terrain and share its characteristics to some extent. They may or may not be the foothills of a mountain range.

MOUNTAINS

Exactly where a range of hills becomes a chain of mountains depends very much on perspective. What would be thought of as a mountain in one region would be considered laughable elsewhere. As a rule, mountains are steep and rugged, with exposed rock and little in the way of vegetation. There may be hidden plateaux and fertile valleys tucked away in a mountain range, but it is equally likely that there will be nothing but glaciers or icy mountain rivers between the peaks. Mountains may be a range or a single lonely peak, and may be volcanic in origin. Indeed, such a volcano may be active, which will affect the surrounding terrain considerably. Some mountains are tall enough that they push up out of the breathable atmosphere – the air may be too thin to support humans at the top. Moving through mountainous terrain is often hazardous and is always a time consuming undertaking.

DESERT

Deserts are not always composed of sand dunes. Rocky or dusty areas also qualify for the title, as the factor that makes an area a desert is lack of rainfall. Some borderline areas (semi-desert) may be interspersed with true desert and be more habitable. It is entirely possible for quite a variety of life to exist in a desert; conditions are harsh but not impossible, even though it might look that way to visitors from more pleasant regions. Deserts, especially hot deserts, pose many hazards to travellers. The obvious one is lack of water but there are other problems these include glare and distortion caused by heat-shimmer, and the possibility of soft sand or that what appears to be firm going is in fact a dried-out crust over a lake bed... i.e. in effect quicksand.

TUNDRA/ARCTIC

Arctic terrain obviously refers areas similar to the polar regions of Earth, but the term can be extended to encompass any region of frigid, icy or rocky terrain. Pack ice, glaciers and so forth can be considered to be arctic terrain even if they are actually located near the tropics (presumably high in a mountain range or perhaps on a very cold planet). There is little to be found in arctic terrain besides ice, snow and rocks, though some creatures live quite happily there. Tundra is essentially subarctic terrain; it is a region with permanently frozen subsoil and little vegetation, but more than would be found in true arctic conditions. Where there is just a little more warmth, Tundra may give way to Taiga; sub-arctic forest which is more amenable to life, though still very harsh. Taiga can usually be considered to be Forest terrain.

RIVERS AND LAKES

River/Lake terrain refers not just to the lake or watercourse itself but to the immediate surroundings which may include flood plains and steep valleys. River terrain is by definition well watered and will be a center for life (of the planet, wild and sentient varieties) even if there is little of it elsewhere. Rivers are a means of navigation for some societies and a barrier to others. Settlements tend to grow up at river crossings, though in the case where a world was settled by technological colonists this pattern is less common.

SEA, COASTAL

The shore region on land and the shallows offshore represent two sides of the same coin, with some crossover between the two environments. Nutrients are often washed off the land by rivers and natural runoff, creating a zone of very fertile seabed conditions that, being shallow, receives a great deal of light and can thus support rampant seabed plant life. This in turn supports aquatic animals which are food for others, some of which live on the land and some in the sea. The land/sea interface also creates a number of weather conditions including increased rainfall. Shore areas are sometimes, however, flooded or wracked by storms originating out at sea, so the shore region is a rather turbulent and dynamic place.

SEA, DEEP

Many factors affect the deep seas. Water pressure increases vastly as depth increases, creating zones that some creatures cannot survive outside of. The seabed actually contains a variety of terrain including plains, deep trenches and chains of mountains, some of which reach almost to the surface. Special terrain such as geothermal vents can create unique conditions found nowhere else. It is, however, fairly unlikely that adventurers will spend all that much time exploring the bottom of oceans, so it should suffice to use a general 'deep sea' terrain type as representative of the general conditions.

SYSTEM DATA

It is often sufficient to list the UWP data for a mainworld, or to use an extended form that indicates star type and whether there are gas giants or planetoid belts present in the system. Sometimes a whole star system must be listed in a concise manner; the following system is recommended for those occasions.

Stars and stellar objects are named in capitals, planets and moons are named in lower case. Significant bodies are listed in order out from the system's primary, based on average orbital distance. Those orbiting a distant companion star are listed separately. The positions are relative to one another rather than being an indication of actual distance, so a body that is listed as '1' is not necessarily right next to the primary. 'Empty orbits' are not uncommon, and there may be huge gaps between significant bodies.

Thus a system might be listed as having three bodies.

Primary (the star)

1. A Planet
2. Another Planet
3. Another Of Those Planet Things

This does not mean that the three bodies occupy 'orbits one, two and three' and are close to the star. It may be that A Planet might be quite far out from the star, with Another Planet just a little farther out, then a huge gap until Another Of Those Planet Things, which is located in the far outsystem. Exact position is noted in the write up for each body.

Note also that system data cannot list everything in a star system. There may be outposts on various moons, enclaves on habitable worlds that are not listed in the main world write up, and possibly even secret bases hidden on remote planetoids. The system data is an overview of what is listed in the navigational databases, and is not necessarily an indication of every single thing found in the star system.

Some systems feature multiple stars, either in the form of a twin-star pair or primary and its companion(s). A companion star is one that orbits another star or, occasionally, a black hole or similar object. There are no such phenomena in Trojan Reach sector. Companions can be close or distant. Sometimes planets will orbit between a star and its companion. For distant companions this is not a major problem but where a planet's orbit takes it between two fairly close stars, conditions tend to be harsh.

Whilst most star systems are known by the name of their mainworld, some use the primary (star) name as their map designation. Whichever is the case, uninhabited worlds are often not named and instead use an official designation of (primary name) (number). Thus Mars would be Sol Four under this system if the local name had not found its way into the stargharts.

ANNON STAR SYSTEM

The Annon system orbits a Brown Dwarf stellar object – often referred to as a star but actually much smaller and dimmer than a ‘proper’ star. Brown dwarf objects sometimes have a planetary system; those that do can find their way into the starmaps but are often omitted if they are not inhabited.

The Annon system is not really on the way to anywhere and there is little in the system to attract traffic. Thus the system is rarely visited except by those with a good reason to go there. The charts contain little more than physical data on some of the main bodies in the system. This ‘system’ could in fact be located in an existing star system, with the brown dwarf Annon being in effect a distant companion of the system’s primary. Annon could also be a dim point of light in between listed star systems, a place rarely visited or even known about...

Annon: Brown Dwarf Stellar Object

- | | | |
|--|----|--------------|
| 1 Almost-Nearly (Superjovian) | Lo | |
| Ibria: (D326266-9) | | |
| 2 Annon Two: (7FA000-0) | | Wa Ba |
| 3 N-E-N (Large Gas Giant) | | |
| 4 Annon Four (Small Gas Giant) | | |
| 5 Annon Five (Medium Gas Giant) | | |
| 6 Notevenclose (X800000-0) | | Ba Va |
| 7 Annon Belt (Sparse Belt) | | |

ALMOST-NEARLY

Almost-Nearly is a Superjovian, i.e. an extremely large gas giant of a sort that occurs from time to time. Its tongue-in-cheek name refers to the fact that it is almost big enough to be a brown dwarf, and a brown dwarf is a stellar object that nearly got big enough to be a star. Physicists often point out that the Superjovian is well short of brown dwarf mass, and a brown dwarf would need orders of magnitude more mass to be an actual star. But despite this, the name was given and stuck.

Almost-Nearly has an impressive collection of moons. There are around three dozen significant bodies, i.e. large enough to be considered a very large planetoid or a dwarf planet, and seven of those are of planetary size. The only one known to be inhabited is Ibria, a planet-sized moon. Ibria is a ‘borderline world’, i.e. it has an atmosphere of sorts but not one that can be breathed by humans.

The rather small amount of solar energy radiated by Annon, and the influence of Almost-Nearly, prevents Ibria from becoming an iceball. The world is tidally locked, so that one side always faces Almost-Nearly, and is largely covered in ice sheets. The extremely thin atmosphere is composed mainly of nitrogen and carbon dioxide.

Although rather less than welcoming, Ibria is home to a small outpost operated by Frontier Minerals, Incorporated. FMI is interested in extracting useful chemicals from the world’s ice sheets, which contain a considerable amount of dissolved mineral wealth. The only settlement is a ‘corp town’ with a population of around 950 workers and their dependents. The settlement is supported by regular supply ships, most of which are subcontracted merchant vessels.

Although Ibria is the only ‘officially inhabited’ body in the system, i.e. it is the only port marked on the starmaps, there is also a modest population of Belters working the planetoids and moons that orbit Almost-Nearly. Most of these are itinerant, i.e. they live out of their ships and come into Ibria’s port to trade and rest up, but there are rumored to be permanent Belter settlements in the system.

Belters are welcome on Ibria, and there is a semi-legitimized trade setup whereby friendly Belters can buy vessel maintenance and supplies from the company stores maintained by Frontier Minerals. The firm has benefited from this arrangement by being able to buy up a number of Belter claims and bring in specialist mining ships to undertake large-scale exploitation of the find. This arrangement is by no means universal – some Belters dislike the corporate miners of Ibria – but overall it has proven a mutually beneficial partnership.

Locally sustainable tech level is 9, but the colony at Ibria has modest stocks of items of TL 10-12, and most of its equipment is of this tech level. High-tech items are available in the shops, and are plentiful enough to sell at normal prices when available. Locally made items are produced on a very small-scale basis and are actually in the minority compared with imported high-tech equipment.



ANNON TWO (7FA000-0)

Annon Two is a Non-Habitable Water World, totally covered in oceans that remain semi-liquid due to the feeble heat of Annon. Annon Two has a dense (but unbreathable) atmosphere composed mainly of carbon dioxide and nitrogen. There is some primitive life in the oceans, but the world has been little studied or even visited.

N-E-N

NEN is a large gas giant, whose name is a set of initials. N-E-N allegedly stands for 'Not Even Nearly'. This was presumably applied by the same wag as gave Almost-Nearly its title. NEN has nine largish moons, most of which are rockballs or iceballs. None are known for certain to be inhabited but it is quite likely that if there are Belter settlements in the system, the moons of NEN are the most probable location.

ANNON FOUR

Annon Four is a fairly unremarkable small gas giant. It has at least fourteen moons worthy of the name, but little is known about them. At least, there is little in the official star charts. There may be Belters dwelling among these moons, and if so they might have names for them, but to most spacefarers they are just specks on the map.

ANNON FIVE

Annon Five is a medium gas giant remarkable only for having just a single moon. This is obviously a captured object, whose orbit is not yet stable. Five's moon is probably a rogue planet ejected long ago from some other star system, and may or may not ever have been visited by humans.

Notevenclose (X800000-0) Ba Va

Whoever charted the Annon system was following a theme when they named this rockball planet Notevenclose. Notevenclose has no atmosphere, no water and no life. It might have useful minerals which could be mined, but no official survey has been undertaken. Orbiting so far out from a Brown Dwarf, Notevenclose is scarcely warmed by its primary and differs from deep space only in that it has a solid surface to stand on and gravity to keep you there.

Annon Belt (Sparse Belt)

Annon's planetoid belt is little more than a scattering of small asteroids and chunks of icy debris. Belts of this sort are not a good prospect for mineral extraction, so it seems likely that the belt has not been disturbed in centuries.