Project OPTIS
Ayush Nayak
Grade 9 Individual Category

OPTIS

T w e n t y
T w e n t y

Foreword:

We were borne from the stars. Countless hydrogen molecules collided to create helium to create lithium all the way to mighty iron. Everything heavier than that was created in one of the most spectacular events in the universe. The Supernova. Carl Sagan once said, "We're made of star stuff" In reality, not only star stuff, but also the product of explosions with the power to outshine a galaxy. Think about it. Once, the atoms that make up me, and probably you two, were flying out of a star at unthinkable speeds, part of a mass collective event from one star to one up an entire galaxy. That one atom inside of me probably feels underwhelmed now. Carl Sagan stated in the same episode "We long to return [to the cosmos]. And we can, because the cosmos is also within us." As a species, we never really quiet were perfectly content with the Earth. It created us, sustained us for tens of thousands of years, but in the end, humans desire more. Not exploring space is like Columbus reaching the Americas, coming back, and hundreds of sailors not embarking on a quest to discover the new lands, and instead keep them shrouded in mystery. As a generation, me and you, we were too late to explore the world, and a bit too early to explore the universe. Right now, I'd say we're just about in time for the solar system. Not as glamourous, but after the solar system comes a wide large expanse of nothing. Interstellar space. AKA Nothing at all. Literally. You would be hard pressed to find Hydrogen atoms in a meter cube of the stuff. The next star...? Light years away. Even with futuristic technology, hundreds of years of space travel. Generations born and dead knowing nothing but the dark black of interstellar space, while trying to keep the vague old mission alive dreamed up by mankind generations ago. Maybe not mankind, however. Neil DeGrasse Tyson stated in the Cosmos, that the species that goes out and discovers the universe will not be ours. It will be one like ours, with fewer of our faults and more of our achievements. This dream is so far off, that we have to evolve to fit it. Yet every advancement however small comes closer to it. One thing that might come to fruition in our century, however, is the very root of those future generational craft. The space settlement. Humble, rotating, tied to Earth for water, air and resources. Sending out asteroid miners for materials. This rudimentary craft built purely for research in its early phases. A novelty for space enthusiasts. A grand experiment for biologists. A validation of our species' worthiness to continue its conquest of our universe. As we make leaps and bounds in technology, we come ever closer to the dream of a man-made rotating craft, able to emulate the Earth. All who design these craft claim they are purely scientific and created to house people as best as possible, but in reality, what all settlements are doing, is creating a little piece of Earth. A little piece of earth to traverse the universe. In the millions of years to come, when we finally start sending out generational crafts, I hope that all of them can carry a little piece of Earth. Maybe a rock, a flower a small block of dirt. As we outgrow our planet, and move out into our universe, we decide to stay humble to our beginnings. The Earth.

OPTIS 2020

Fully written solely by Ayush Nayak

Entered under the **9TH Grade Individual Submission** Category

Dedicated to my aunt Sunita Bal, for helping me discover anything, from kinetics reactions to the Kuiper belt.

CONTENTS:

EXECUTIVE SUMMARY

The settlement is essentially a large rotating torus, with a smaller warped cylinder inside of it, connected by bicycle – like spokes. These spokes make up a large part of the settlement and have a radius large enough carry material from the inner part of the settlement outward, within them. The shape and structure of the settlement is one of the most detailed and well written sections and is my personal favorite part to write about. In essence, the outer torus is created mainly and completely for housing, moving almost all industry that can function in microgravity away from this part of the settlement to create an extremely large living space. Marinating gravity on this settlement is done in the most logical way possible, through thrusters which utilize centrifugal force to in effect, slam settlers towards the outer face of the torus. The effects of gravity changes could have effects on settlers, and thus sensors and other technology is in place to keep the gravity level at a sustained level. The settlement even though should be shielded by earth in its low earth also utilizes shielding to maximize the safety of settlers. Creating and building the craft, will utilize space elevators to ascend and descend to different levels within the Earth's orbit. With the advent of nanotubes, once improved this easily becomes a viable technology for creating large space-ready elevators. Powering this behemoth of a craft is done through the use of the most technologically advanced system possible. The Fusion reactor. Although not in its final stage yet, it has generally been accepted that sometime in the not so far away future, fusion power will be achieved, and it will provide us on earth with virtually limitless power, to do what we please with. All settlements of the future will be powered by this technology, and it only makes sense to design this one with support for a fusion reactor in mind. The entire second part is dedicated to this, and the settlement in general relies on the massive amount of energy generated by this piece. With the hull and energy generating portions of the settlement done, human support systems and creature comforts come next. One of the most detailed and well thought out sections of the settlement in my opinion is the atmospheric section, which details all the different methods that the settlement keeps itself at an acceptable temperature and composition, so humans can literally breathe. After that, comes another interesting section, the Environment section, which details all of the different tactics that are used to create the feel of home. This includes $30,000 per square meter skylights, snowblowers, and rain jets, all in hope of creating the most earthlike experience possible, aboard the settlement. The dietary needs of the settlers is a main concern of keeping a rotating behemoth like the Optis in business, and this section outlines the different diets used (Mediterranean and Rural Japanese) as well as the meats (Lots of Fish and not really much livestock), as well as the way that all food is produced aboard the settlement, and is definitely one of the more well thought out sections, and for a settlement, it must be. Food needs are what bottleneck an almost massive settlement to just 1,000 passengers. Moving on, comes the blurb about waste, and how the settlement uses ISS reclamation systems to reclaim most water, and lots of waste from the settlers onboard. Health is a concern, although with the wide variety of chemicals to manufacture almost anything, it shouldn't create many troubles aboard the Optis. Next comes the section which needed renders, although my blender skills were just not at the level required. This is of course, the section which shows how all that space will be used. For populating the settlement with homes, businesses, and nature. The government, ruling and finances of the settlement are also addressed in the final section of the 3rd part. Then comes the final section. This is the section which outlines the different ways that craft are made to service the settlement. The main focus

of this section is to outline the different ways that the spacecraft not only enter and exit the settlement, but also how they are serviced, and the design for spacecraft. Finally, almost 65 pages after its start, the settlement is finally described in its entirety.

README.TXT[1] (NOTES)

This is a readme, although most people will know it as prerequisite notes. Most people do not read "README.TXT" files, but this one is pivotal for what is stated next[2]. This notes section will cover things which may be stated later but will be useful to know throughout the entire project.

Firstly, I want to address the length. I have entered the Contest 2 times so far, with success, back when it was run by purely AMES and not NSS although under the older rules, the limit for "don't go over this" was 100 not the revised 50. A goal of mine was always to cross 60 pages, while providing relevant and important information about the settlement. This year I finally managed to achieve the goal my 5th grade self always aspired for. Unfortunately, that pipe dream now is not exactly the best way to go about writing the settlement, and for that I hope reading through this that the 79 pages of content, that the extra utilization was for good reason.

1 AT THE RIGHT PLACE AT THE RIGHT TIME

This settlement is meant to be able to be modular, and thus work in a variety of locations, but in reality, this document will be mainly focused on an earth-based settlement. This means many problems such as micro impacts, cosmic rays and other solar system interferences, can be mitigated by the same protection that protects us here on earth, with the exception of certain phenomena such as solar radiation. LEO comes with a variety of benefits, chiefly proximity to the earth, which means that the settlement can be re-stocked from the earth and receive upgrades and other parts from the earth. With the thrusters found on the settlement, it should be able to maintain LEO without having to burn too much fuel. At the same time, since this settlement is designed to be modular, the ability to be at least semi self-sufficient is also there, so as many actions as possible that could be undertaken purely by the settlement, are undertaken purely by the settlement. The Fusion reactor, means virtually limitless electricity is available for consumption, furthering this process[3] Only tasks that must be done with the help of the earth use the earth. This is a recurring theme throughout the settlement, and if it were not for the notes, it would be confusing to the reader whether this settlement is interstellar, or earth based, and for the purposes of this document, it is the latter.

2 HARDER BETTER FASTER

The settlement is meant to be constructed in the future, not the far future, or the extremely near future, but around the 2050's today, its 2020[4]. Nuclear reactors are not fully formed, Carbon nanotubes are still unstable, and other parts of the settlement such as cutting-edge

[1] This is a footnote, not used for references, more in a *What If?* style of additional information or something interesting. References will be at the end in list format by section.
[2] Thinking about it, most readmes are actually pretty important. Still, this one is more so! (yes, even more than those where you have to edit the value: bool acceptTerms = 'false'; to 'true')
[3] This is helpful because lower efficiency tasks that could be undertaken on the settlement but require large amounts of electricity are now capable of working.
[4] Writing this its currently Thursday February 13th, 2020 to be exact

research is not fully ironed out yet. This settlement assumes these individual technologies to be working perfectly, and without any problems. This itself is a tall order, as even in their final forms the complexity of these system means that only far in the future, they will be viable. The main technology setting the time constraints for the settlement, is the Nuclear Fusion Reactor. Wendelstein 7X still fails to make a positive energy output, Iter is no closer, and both projects are years into development. Nuclear is going to be one of the hardest parts of the settlements to work with and is the only real technology that needs to be accepted as working on the settlement. In terms of other technology, currently Carbon nanotubes are too fragile for real usage, so steel and carbon reinforced Kevlar ropes were described instead, although later if they get, no a better word is when they get better, they can be substituted. In general, this is a settlement in 2020 written with technology that is either mostly 2020 based, 2020 cutting edge, or in one special case, 2050 tech. I think everyone accepts at this point that within the lifetime of most entrants to this contest nuclear fusion will finally turn a profit, if you will. Thinking rationally, almost all spacecraft in the future will be powered by nuclear fusion, which is the reason that it is used here. If it is the tech of the near future, then why not embrace it in concepts now? Hopefully, for all intents and purposes, this 30-year gap can be overlooked.

Part I

HEAVY METAL

This part bears the name "Heavy Metal", and deals with not rock, but with the "heavy metal" of the settlement. If you strip a car (preferably a manual with a manual parking brake) of all of its seats, cloth, leather, speedometer, ac/heating, dials, seatbelts, airbags, and all of the other worldly comforts we as humans require to feel as if the car is "drivable" and comfortably so, it is only heavy metal to us. With only the steering wheel, pedals, parking brake, and transmission left (as well as all of the actual stuff like the engine and wheels), it is perfectly "drivable", but not anything we as humans would want to inhabit for any reason or period of time. Even though it is still able to function completely fine[5] to most people it is just "heavy metal". The creation of that bare metal that works fine, but may not be great for a person to live in. It will emulate the planet before life, but with the air composition we are used to. This part, if followed, will outline the building, outline, propulsion and docking for spacecraft of the settlement. What it will not provide, is the human comfort, the houses, greenery and the other comforts of the pale blue dot. This part will be the blueprints for the behemoth to come. Much like the engineers who tell the designers of parts the limits of weight and size aboard a spaceship, this part will lay out the sizes that the settlement will allow, as well as the weights for everything that will be added on top of the underlying structure. These limits will be outlined throughout the part. In the final few sections, the final limits will be gone over in detail. The settlement design is designed to be modular and can be used with a variety of different designs instead of just one static design. This is why there will be limits and plans that may or may not be followed. There will also be parts in this section which outline the modularity of the settlement, and the parts that can be changed, and replaced. A premade example of the settlement is what the document outlines, is what I myself have deemed is the best example of the settlement that would fit today's requirements.

Sections & Subsections

[5] In this case the car will probably have better performance figures because of the lighter load. (You thought this was a detrimental footnote didn't you)

SECTION I

SHAPE AND STRUCTURE

The Optis needs a shape, otherwise it will only traverse the fabric of spacetime as an amorphous noninteracting blob. There are two sections to the Optis, in order to maximize the total living space on the craft. The first, is the actual torus that humans will be living in, while the second section is connected to the torus, and is where all machinery is housed. This design can maximize the livable space aboard the Optis, because all that is needed is the protective coating on the outside of the craft, to simulate the atmosphere, and on top of that, buildings, forests parks and the hallmarks of human inhabitation can be constructed. This section includes both a description of the shape (1.1.1) and the structure of the craft (1.1.2).

1.1.1 SHAPE

The general shape of the settlement consists of one torus, which is designed to house humans, which is elongated along the x axis, in order to have more livable space. The torus as a shape was chosen, due to its almost perfect shape for human inhabitation, and it was enlarged in order to fit more space for human civilization. Humans live on the outer edge of the settlement, and by enlarging this torus along the x axis, the torus would expand the total surface area that although a cylinder might serve this role as well, the sharp inorganic angles make the settlement feel less biological and earthlike which is the purpose that the settlement should serve. (Figure 1.1.0 does not display this well, but Figure 1.1.1 will) This torus is connected to a central cone shaped figure, with a steeper edge protruding from the top. This central "Trapezoid" almost, has spokes connected to it that anchor it to the outer torus. The inner side of the torus is flattened in 1.1.0 to make the picture neater, but in reality, not changed as pictured in the renders. This torus is anchored with 54 spokes, a 36 spoke design with an extra 18 spokes in order to anchor to the central cone better. This particular arrangement of spokes is used because of its strength and versatility. In terms of size, this torus is 1.2 kilometers long, (due to x-axis elongation) and 0.505 meters tall, providing for a very admirable large living space. The central part is 0.65 km long (this is in half size so the real size would be 1.30) which goes down to 0.10 km (again

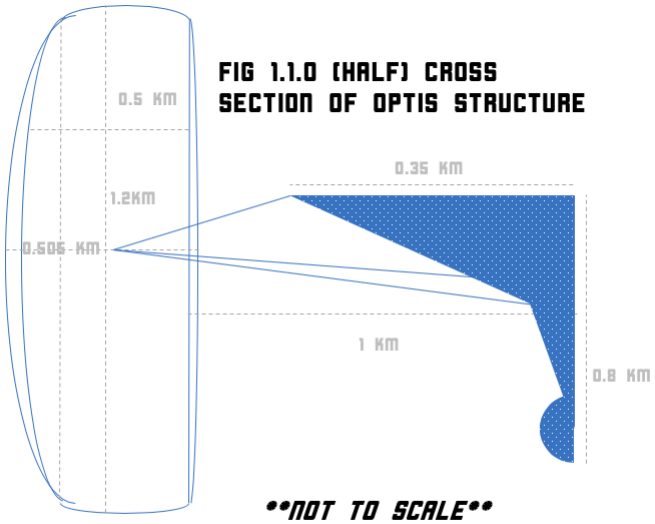
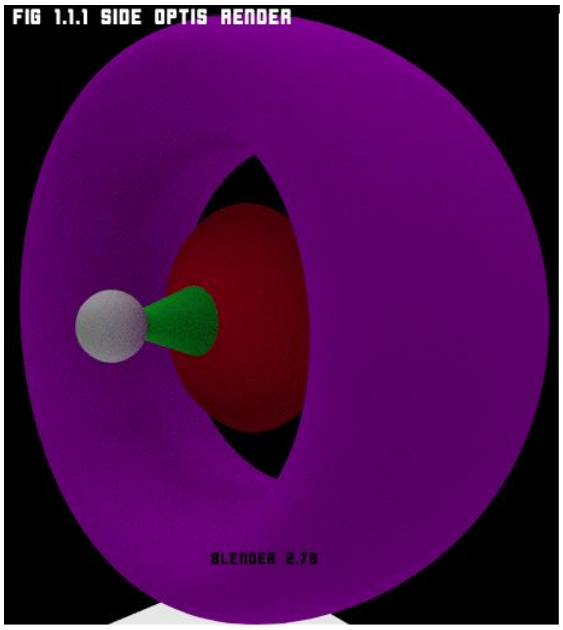


FIG 1.1.0 (HALF) CROSS SECTION OF OPTIS STRUCTURE



0.20 km in actuality). This central torus is used because it can act as a large area for extra machinery and storage, and comes down to a smaller size to a sphere where a fusion reactor is located, and due to the heat that could be generated, and due to possible concerns, there is a smaller area for the reactor, that is in between the large storage area and the actual living space. Modularity is a big factor in the construction of the craft and due to this there is an area in between the "industrial cylinder" and the actual living space, that can be expanded to as seen fit, while still being contained within the settlement. This settlement utilizes comet and asteroid mining, as well as personal craft that may be used throughout deep space, and the space port for this is on the side of the "trapezoid" that is facing out. The torus itself has a small area between the outer edge and the ground of the human settlement, which provides two purposes, firstly, it can be kind of a "cache" (in processor terms) where items like water and food can be kept in short term storage, as well as in case of a hypervelocity impact acting as a shield slowing down the particle so the craft is not fully breached. In addition, a sort of subway system near the top of this area, for travel throughout the settlement, as well as other habitable (although due to the shielding responsibility albeit small) infrastructure beneath the surface. The purpose of the aboveground area is to best represent the earth, in greenery and small living spaces, which can be used instead.

1.1.2 STRUCTURE

The structure itself is divided into three parts[6]. The first part is the structure of the outer "torus", which will house people inside of its many chambers.

The second part is the inner "trapezoidal cylinder", which will mostly be structure to hold the settlement together. The third part is the structure concerning the ropes/lines/spokes that will hold the outer and inner "tori" (neither of which are really tori) together. The fourth part is the cone and sphere, which serve as extra storage, and craft docking ports.

1.1.2.1 Outer "torus"

This outer structure consists of the structure of the outer shell of the spacecraft, as well as the bottom part of the structure of the torus. It also includes the small amount of living space structure that exists. I[7] will proceed to start with the shell structure. The shell itself needs to be able to protect the spacecraft from all of the negative impacts of interstellar space and is

[6] This will (Hopefully) be the only x.x.x.x section. There is just sooo much to cover about structure.
[7] Now have successfully split a section *again*

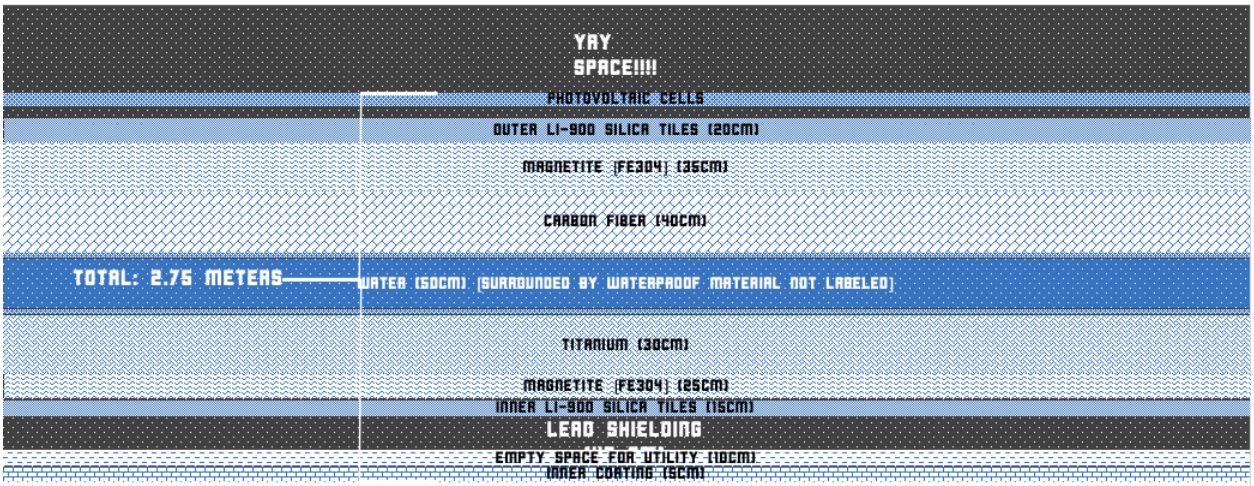


FIG 1.1.3 LAYERS IN THE OUTER SHELL OF THE SETTLEMENT

tasked with fitting about 480km of atmosphere and a magnetic field, into about 3 meters. The shell will include protection for cosmic rays, extreme radiation and other hazards. Magnetic shielding will not be adequate to protect this structure, so materials at the shell level must also be used. The electromagnets needed to create this field will be discussed later and are placed around the edge of the outer tori. Figure 1.1.3 shows that there is about 2.75 meters of outer shell protecting the spacecraft. This part is just the outer shell and not any of the other parts. For most parts of the settlement there will be more layers than just this one (depending on the area, there might be additional Lead for instance, if directly towards a radiation source, and the consequence of this will be more protection and a sturdier frame). This layer however will be placed on the entire wireframe, shown in 1.1.4[8], of the outer torus. The shell itself, has the necessary requirements to protect the inhabitants from the dangers of space itself. On the inside, is a special coating, the material of which is flexible, (there might be metal for structure, nothing if there is more need for utility [ac/s and such] or just a landscape like material where needed) the rest of the structure

FIG 1.1.4 TRUSS STRUCTURE FOR WATER/EMPTY SPACE

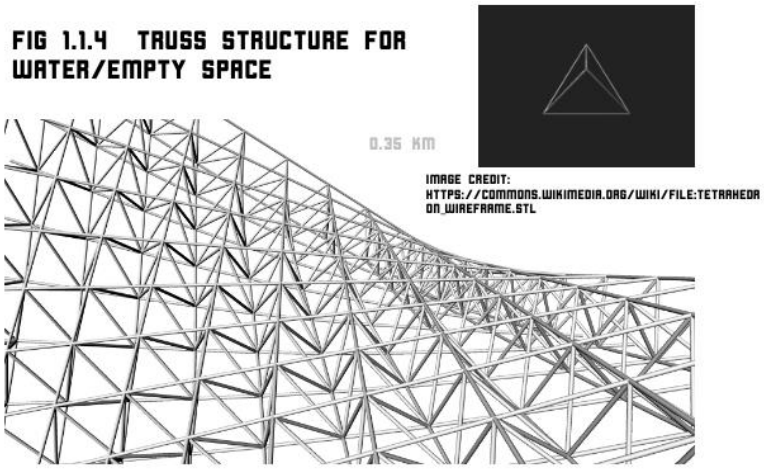


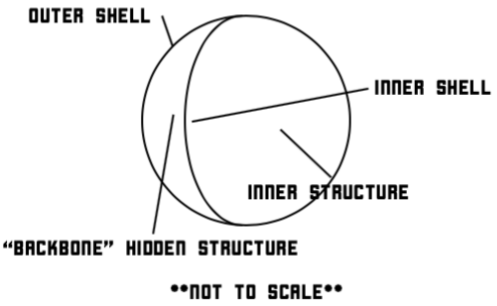
IMAGE CREDIT: HTTPS://COMMONS.WIKIMEDIA.ORG/WIKI/FILE:TETRAHEDRON_WIREFRAME.STL

IMAGE CREDITS: HTTP://THEPROVINGGROUND.WDFILES.COM/LOCAL--FILES/USC-ARCHS17-EXERCISE1/USC_S17_EXERCISE%201%20SPACE%20TRUSS.JPG

[8] Again, this is not actually the full shape, but it is very hard to model the actual shape, so for now this will be the shape shown.

however is outlined. The second part is empty space, as in the utility space, just above the inner coating, and below the lead shielding. This allocation is mostly so there is a space for the pipes, electrical wires, communications, and more utility above the actual shell can be routed[9]. The spaces between the water, as well as the utility and empty space, will be bounded be trusses as shown in 1.1.5. The trusses themselves, will have tetrahedrons as the "unit" of the truss. This will be to hold up the materials and avoid collapse. They are made of the aluminum alloy 2099 and are welded at joints. The third layer will be 0.45 meters of lead. Lead in large quantities, is instrumental to protecting against high energy dangerous gamma rays. Even high energy gamma rays are stopped by lead, and this is the reason that it will also be utilized here. It is connected to the trusses through riveting, and welding. Adhered to the layer of lead, is Li-900 heat panels. These are the best in insulation currently and will help protect the spacecraft from all kinds of heat loss. They are adhered through silicon bonding glue used on the space shuttle where these pieces originated themselves. Their thickness is to provide maximum shielding and is about 15cm in width. Below that, is Magnetite. Like the Li-900, this layer of material is not designed to be the sole material in shielding the craft, but however a mechanism for the defense of the inside of the craft. There are stronger materials on the outer edge of the craft, and these will be of more use in case the first layer is not adequate. Magnetite is useful in shielding the inhabitants from the potentially harmful effects of the magnetic field generated to block cosmic rays, and other interstellar "events" by directing the magnetic field through itself, being a better magnetic conductor, and shielding the other less potent conductors from the harmful effects of the field. There is a certain level of field, where the material moving the field becomes "saturated" meaning that there is too much magnetism in the area, and some of the field spills over to the other components, much like a river flood. This is why there are two layers, and they have a relatively large thickness to protect against this. Magnetite has a composition of Fe_3O_4 and is a great "conductor" of magnetism. It is adhered through spot welding, adhesives, and soldering. Above that layer, is a titanium alloy, Grade 5 or Ti-6Al-4V. This alloy is very strong and is influential to the underlying structure that holds all of the parts together. It acts as a backbone for all the parts. Teflon, or polytetrafluoroethylene has a low friction, and is the material that will be used to coat the titanium[10]. At a very large 3cm coating thickness, and the reason for this seemingly unnecessary amount, is because Teflon can sometimes wear out in some parts, and this will be aimed to be avoided for the most time possible. Above that, is about 50cm of water, for additional sealing, and this could be any water, preferably distilled, for the lack of nutrients that could deteriorate the Teflon faster. Above the layer of water, is carbon fiber, and this material is used mostly as structural support in a honeycomb pattern, horizontally, so that it could support the top layers better, and is composed of titanium and carbon, also called

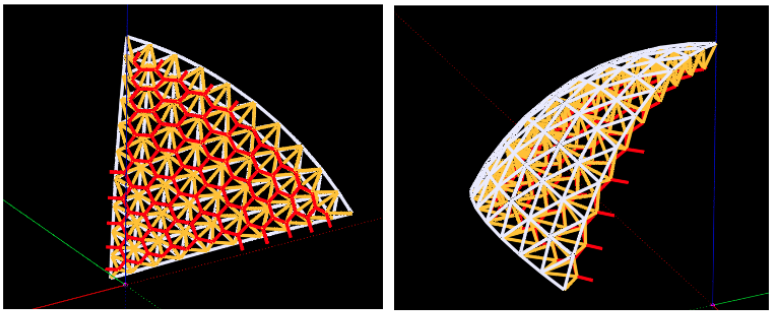
FIG 1.1.5 TRUSS STRUCTURE BELOW THE LIVING SPACE



[9] Although, most utility will be routed underground, this is still nice to have, especially for heating and cooling.
[10] New advances in nanotech say that nanoscale etching of hydrophobic patterns with a laser could prove more resilient to water than Teflon, but for now Teflon will be used, because that technology is more cumbersome, and requires large amounts of etched metal.

"carbonatium", and is also used in the automotive industry, mostly (not in quantity [they produce around 26 cars a year at over a million dollars each] but in advancement) for carbon fiber master Pagani who created this substance. 10cm of magnetite blankets that layer, followed by 20cm of Li-900 (again). The outer coating would be whatever the settlement makers decided to produce. My choice personally, would be an osmium coating, for the dark metallic sheen it would provide. The diagram also notes the possibility of photovoltaic panels on the outer part of the settlement, these of which would be best if it was in our own solar system (the current target destination) or any other place with a home star. The shell will also contain radial firing electromagnetics that are designed to block from cosmic rays. Slight modification to the materials, or amount of each in this shell, can create more possibilities for their use throughout the shell. A viable material to use for shielding of sun flares or other high energy interferences, is a fabric of Hydrogenated Boron Nitride Nanotubes, (BNNTs) which are a material being researched by NASA, with the aim to protect astronauts to mars from solar flares.

1.1.6 GEODESIC DOME STRUCTURE, FROM DIFFERENT ANGLES

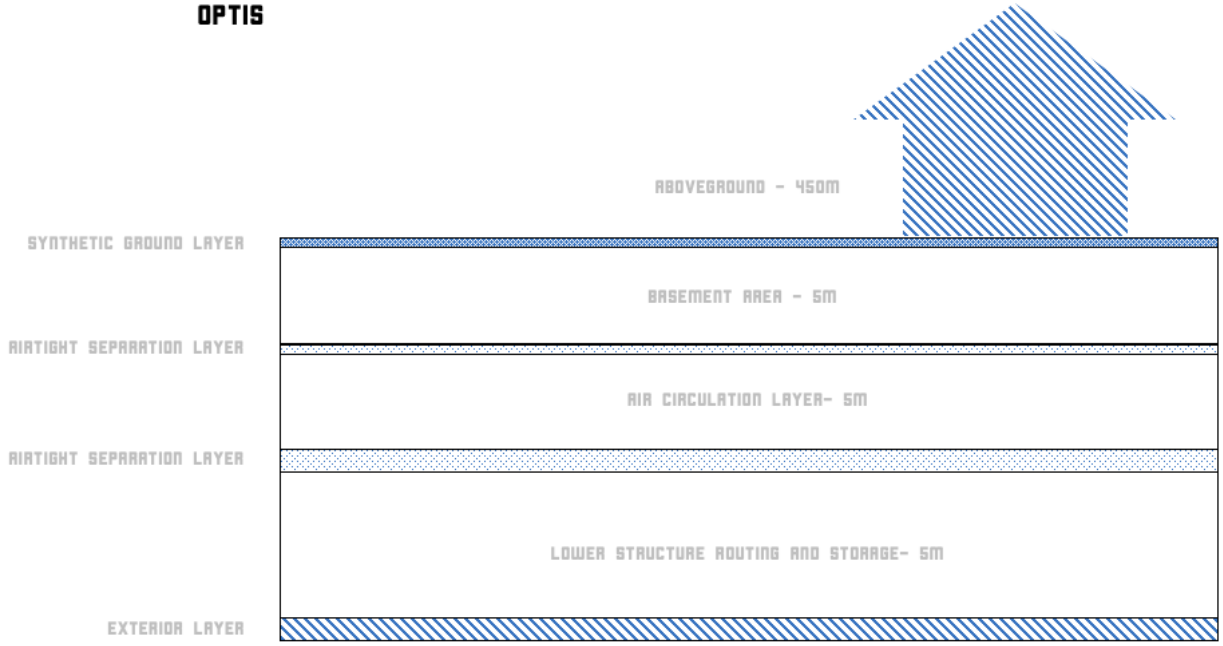


3D MODEL CREDIT:
HTTPS://3DWARREHOUSE.SKETCHUP.COM/MODEL/58A3C639CEC2AE758FC5761C4E5E82E0/GEODESIC-DOME-TRUSS
MADE BY USER (NOT ME): TAFFGOCH

The second structural related part is the structure for the section that lies below the actual living space. The diagram below, shows the different structural parts of the space settlement on the outer torus. The outer shell has been dealt with, and now, the Backbone/Hidden Structure will be addressed. The point of this part of the settlement, is to keep the rest of the settlement itself, upright and standing. It will house utility for the rest of the settlement, and will provide structural support, for the upper part of the settlement. Because gravity decreases from the settlements center to its inner shell, there will not be able to be many tall buildings above the inner shell, and therefore, there will have to be more utility underneath the inner shell. The place where the outer shell meets the inner structure, along an arc that spans between the two intersections of the inner shell and the outer shell, will have geodesic domed truss structure spanning it[11], for structural integrity purposes. This dome's structure, shown at the right, has triangle shaped trusses, with tetrahedral shaped trusses under them, connected by hexagonal trusses, and is a very strong structure, while being light, open, and airy. This structure, however, will only span the bottom part of the entire bottom part, although will not be truncated in parts closer to the intersection of the outer and the inner shell, due to space constraints. It will be consisting of Aluminum 2099, like other parts. The above figure shows

[11] If this language is confusing, it basically means that the structure will be placed inside of the outer shell (meaning under the inner coating, and attached to it), but only on the part of the shell that contains the backbone/inner structure).

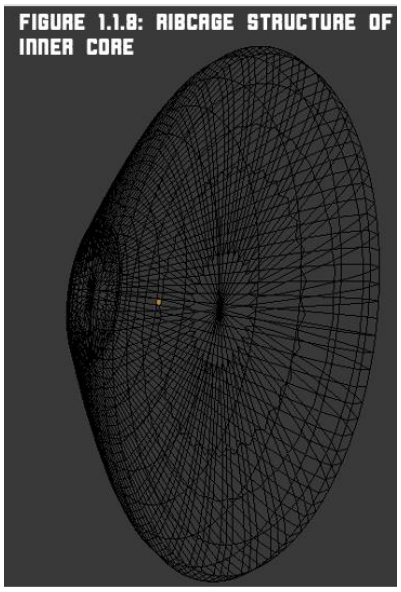
FIG 1.1.7 CROSS SECTION DIAGRAM OF OPTIS



the breakdown from the exterior to the ground level of the settlement[12]. There is a bottom "exterior layer" which was just discussed, as the 5 or so meter protection from radiation, to simulate 100 km of atmosphere. Above this, is a constant ventilation layer, which will house constant flowing air to regulate the temperature of the settlement. This area will contain ventilation equipment and exhausts to keep the temperature between the entire settlement similar and cool down the settlement from the bottom up. Ventilation from the top of the settlement will work less effectively at reaching the surface of the settlement. It can ventilate heat from machinery that is housed in the main torus (most heat generating, or potentially toxic machinery is in the "block" area of the settlement, so completely necessary hardware is kept in the basement or lower structure area. This area will also include heating systems, using heated filaments, powered by electricity, and A/C systems[13]. This layer as well as the rest of the atmospheric equipment will be covered more in the Life Finds a Way Part. This layer is bounded by airtight seals on both sides. The layer below it, the bare structure layer, includes the Truss Structure from a couple pages ago, inside of it, as well as wires and pipes able to traverse freely. The only potential drawback of this part is that it may have uncontrollable ventilation. Not much needs to be said about this particular part of the settlement, because it is mostly structure with the Grid routed along it (again more for Life Finds a Way). The basement area is what it sounds like. It is the underground hub of the settlement. It will house the transportation railway[14], as well as general storage and lower level infrastructure. This part will not really be covered here, as it is mostly already part of the settlement, and is considered one of the habitation layers. Above some synthetic ground, lies the Ground Zero of the settlement, where gravity is 1G

[12] Obviously not to scale
[13] Fusion Power creates virtually limitless energy, so the most powerful systems can be utilized regardless of electricity efficiency although efficiency creates less heat, so it is still prized.
[14] Even more cool stuff for Life Finds a Way.

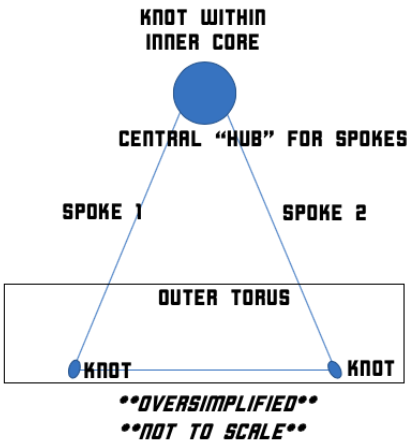
1.1.2.2 Inner "structure"



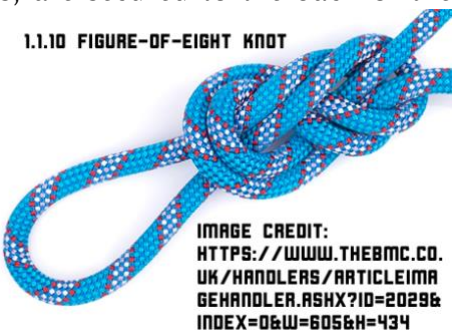
The inner part of the settlement, which houses the Stellarator reactor[15] is mainly constructed to carry this reactor as well as distribute the fuel for it, and thus is not well equipped for human inhabitation. This structure (Now called the "Core") is nevertheless constructed well, in order to house the reactor, as well as serve as a hub for the spokes. The outside is constructed from the same outer coating as the outer torus, with the same geodesic tetrahedral truss' attached to the inside of that. A ribcage structure is attached to that, and that is simply a structure of bent I Beams that adhere to the inside of the trusses and support the core. This is the place where the "knots" (1.1.2.3) that tie the spokes to the inner torus, are held. These knots are attached to each other, so they are looped around the different ribs. The ribs are shown in the figure to the left. Within the knot/rib layer, there is another truss layer, and then flat sheet metal, which creates a sort of base for the Stellarator reactor, as well as the other machinery and storage that this layer provides. Different materials can be stored based on the gravity requirements, as this part ranges from 0G to about 0.23G on the outer edge. The rib, and the sort of "triangle" in the cross section but cone in the 3d model, now attaches to the shorter end of the inner torus, and thus this side has no protection, and is freely connected to the protected environment of the cone. There is a space elevator that traverses the materials and stored assets aboard the inner core, to the outer torus, and it leaves the inner torus through an airtight hatch and travels up the spoke to another airtight hatch within the outer torus.

1.1.2.3 Spokes

The Settlement is a bit like a bicycle wheel in the fact that is has multiple spokes emanating from a center point, outward to other supporting parts of the settlement, in this case the inner part of the space to be settlement. The spokes themselves, are secured to the back of the settlement (the part that people stand on) and is connected to the inner central "hub" of the settlement. Kevlar is used as a buzz word for materials at the upper limit of strength, and that use is founded in good reason. It can make some of the strongest ropes in the entire world, and a diameter of around 1 Meter, would provide more than adequate for the job of holding the settlement together against the



1.1.9 SPOKE DIAGRAM "CROSS SECTION"



[15] Spoiler for next part :)

strengths of the world, that try to pull it apart. Kevlar's specific weave makes it so strong, and altercations to it are not needed, to maximize it carrying capacity. Because Kevlar rope can be cut, and humans will be humans, there will be a strong steel coating to protect the wire/rope, from outside forces, although this will be steel wire, with high strand diameter, as not to compound the load of the Kevlar strands by attaching it directly to the strands themselves. In order to hold the entire settlement together, these parts are fastened to structure connected directly, through trusses, to the geodesic dome structure on the inside of the outer shell, and not to the "floor" of the structure, (this will be discussed further, but for now think of it just as the part that is on top of the geodesic dome) for extra strength. The rope will then be tied in a figure-of-eight knot[16], to not need to be attached to any part of the settlement and will just need to be looped around individual geodesic trusses, (preferable ones that have higher strength than just the normal ones to not break under the intense pressures the rope will have to deal with. This - for a 1 meter diameter rope – would be extremely large, and very hard to keep completely under the structure, so a housing will be built above the settlement, where hooks that connect directly to the geodesic truss, protruding from it, and the bottom "loop" routed through the truss structure itself for increased fidelity. Notice, that there are two lines coming out of the Figure-of-eight knot, and because of the traditional 36 spoke design, these connect to the closest other "spoke entry point"[17], and form kind of a "triangle" where the first spoke is connected to the second one, and both point upward at the central hub, where the wire connecting the two ends. Spokes 1 and 2 are connected, 3 and 4, 5 and 6, and so on until 31 and 32. The reason for the closest spoke being chosen to share the same "rope length" is because if the spokes were entirely opposite from each other, first of all more line would be needed, and second of all, they would tense up against the settlement, and apply pressure for it to collapse in on itself. There are only 16 lengths of line needed, because of the bundling of the different points where the ropes are secured to the outer edge of the settlement. They form a triangle shape and intersect at the top of the settlement. Of course, no "VLK" exists, and instead spokes are "daisy chained" together. At the center, where it makes sense. The figure to the left, shows the way in which these spokes are combined, in the traditional bicycle 36 spoke design. The design is used to fasten the spokes using a robust method to ensure that the strength and fastening is distributed equally across different parts of the settlement's outer torus. The different colors correspond each to different height that the spokes are attached to, on the inner torus, because there are many different places they could be attached, and due to the density to avoid overlap, they are at different places along the inner torus. A Space Elevator will be used to transport materials between the outer torus, and the core, and it will reside on these spokes, but only at the central dark blue ones. It will use the same structure as the one outlined in section 3 (Building) of this part, where designs for a space elevator are used, although it is based around the earth, substituting the satellite in geostationary orbit for the inner edge of the settlement, and the base of the elevator as the inner part of the core, which is used for routing materials to the elevator. At its most basic, an elevator originating in the base part of the settlement, will travel up the spokes toward the entrance of the inner part of the settlement, with an air-sealed hatch at both ends, and will route materials up tractor tread crawlers, which traverse the rope. Different shipments, use different containers aboard the elevator, tailored to them.

[16] Not the same as the popular figure 8 knot, and much stronger than other kinds of knots.
[17] This would be the point where the spokes intersect the trusses.

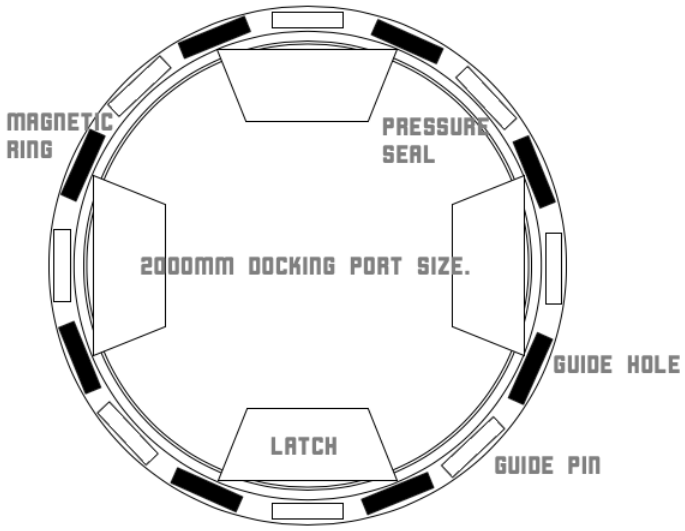
1.1.2.4 Cone & Sphere/Dome

The lesser discussed part of the settlement is the protruding cone and sphere which it is attached to. The reality is, this part is simple. It uses the same shielding as the rest of the settlement, however the sphere has many hatches which will be discussed, as the rest of the settlement uses similar hatches to transport materials and admit outer parts and pieces. The cone is mostly an extension of the core, without the reactor, housing storage, and heavy machinery that is potentially dangerous to humans, or is just bulky, and not a good idea within the outer torus. This part is not very interesting and uses the same "ribcage" structure as the rest of the inner core. It is virtually identical to the inner core, as stated without the elevator system, spokes, or Stellarator.

The Sphere (Dome), on the other hand, is more interesting. Although not pictured in the diagram outlining the sizes of the main parts on the Optis, the sphere has a 0.07km radius, for a 0.14km diameter. The sphere's main objective is to admit spacecraft, ranging from its own fleet of material collection and anti-debris craft (More in Survival of the Fittest) and incoming Human Craft. It has two types of admission in different sizes. Docking ports, and airlocks. Two large airlocks are actually large hangar bays, for potentially larger craft, while smaller, admit unmanned or small manned craft come in through small airlocks with no bays. Docking is more for very large craft, or shipments from earth.

First, I will discuss the Docking ports. Docking ports come in many different varieties, but all function on the same principle. Two ships (or in this case one ship and one "mothership") join at a certain universal port. There is also Berthing, where a spaceship is aligned through the use of a robotic arm, to a stationary ship. This will also be employed, to guide spaceship towards docking ports. There will be a host of universal, and proprietary docking ports. This is due to the spacecraft's location, in LEO over the earth. It must be able to accept existing spacecraft through the use of existing universal ports complying with the International Docking System Standard (IDSS). This leaves two potential options for existing ports. The NASA Docking System, with an 800mm transfer passage, which supports berthing in addition to Docking. The International Berthing and Docking Mechanism (IBDM) also exists, with the same circular transfer diameter as the Nasa Docking System. Due to compliance with IDSS both ports are practically interchangeable, and due to the larger volume of potential countries utilizing the IBDM, and the interoperability between the two ports, IBDM ports will be deployed for compatibility with existing spacecraft. Larger docking systems will also be

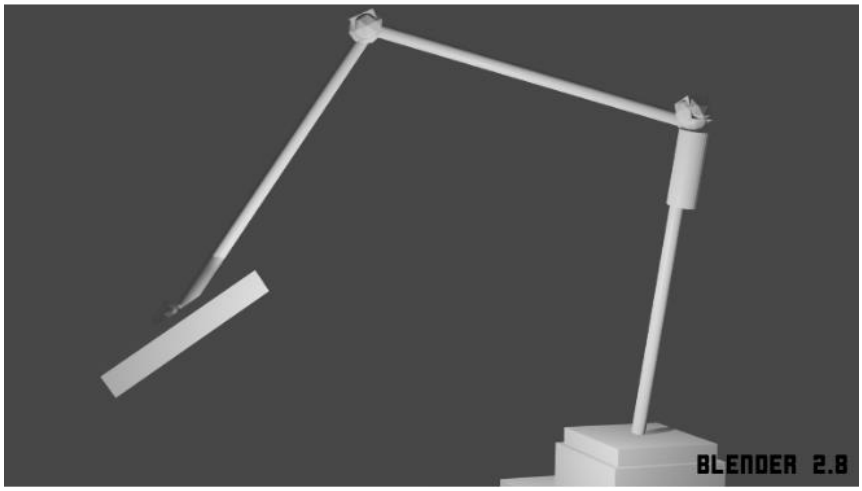
FIGURE 1.1.11: PDM 2K [PROPRIETARY 2000MM DOCKING MECHANISM]



PDM PROPRIETARY DOCKING MECHANISM

deployed, in order to provide more space for transports. Above, is a figure of the PDM2K 2000mm Docking mechanism, which functions through a magnetic pin-based system, and uses electromagnets to bring the crafts together, and then links them with 4 interlocking protrusions. This dock is Androgynous, meaning it uses the same dock on both the host ship, and the incoming ship, in this case, tilting the dock by 45 degrees creates an interlock between the two. There is also an air-seal, which creates constant pressure, so the inner 2-meter hatch can open. The PDM2K described can be scaled easily to larger sizes, or scaled down, although a smaller scale application would most likely be an upscaled IBDM, as it is suited for a smaller docking size. Due to the interlocking mechanisms, about 1.8 meters diameter of space, is the smallest point of the dock. For spacecraft that are docking frequently, and transporting materials, and running all the time, (Hydrogen collectors, or asteroid miners) there will be specialized docks tailored to them, as airlocks do not make sense for these crafts, and it is easier to dock/berth with a specialized port, and then deposit materials and then return to their jobs. For instance, for an asteroid miner, the inside of the dock will have a charger for the spacecraft's ion engines, as well as a port that connects seamlessly with the dispenser aboard the craft, so the craft can deposit its materials into the settlement. The design for these craft will be outlined in the "Survival of the Fittest" section. As for berthing mechanisms, inherently, berthing requires docking mechanisms, and there are already pre-existing docking mechanisms. A robotic arm is thus used to bring ships together. This arm is designed with compactness in mind. There are fewer berthing stations, but there is still a significant amount of docking and berthing systems aboard the settlement. The arm itself uses a modified Canadarm2 structure. The Canadarm2 is almost 2 decades old at this point, and with intermediary upgrades, that themselves are almost a decade old at this point, has proved to be a very robust platform for Berthing, and grabbing certain items for use on the ISS. With upgrades to all parts (modern powerful motors, new internals) the system could continue to use the same robust design. Canadarm3 will be implemented on the moon gateway mission, and due to its smaller size, a similar design will be deployed on the Optis. Candarm2 is a very large 17.58 Meters (57.7 Feet). A much smaller mechanism, about 5-10 meters can be used for most applications. The Figure to the right, shows a smaller robotic arm with two joints, as opposed to one with only two like the Canadarm. This allows for slightly increased mobility in the sense of Berthing. It uses powerful brushless DC motors in place of the arm, and is controlled through AI motion sensing, or in the case of less frequent crewed transports, through the actual craft docking, or an internal team within the settlement. With a combination of both berthing and docking of different sizes, the settlement is well equipped to receive craft all along the domed Craft area. Docking ports require more space,

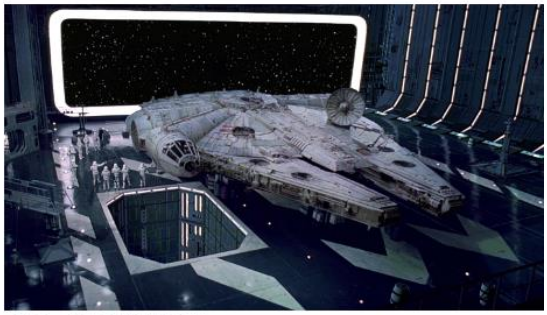
FIGURE 1.1.12: SMALLER ROBOTIC ARM WITH 3 JOINTS



as they are usually used for much larger applications than actual bays which are used for higher volume smaller craft. The purpose of docks is for resupply missions, as well as crewed contact. Emergency departure from the settlement also resides in docking, although most craft are stored within the dome.

As outlined, the settlement also employs a host of Airlock like ports, as well as hanger bays, for larger craft, or more important shipments. The airlock consists of two parts, first is the actual hatch through which craft enter. The second part is the actual bay, (in the case of larger airlocks, or the second door into the central bay in the case of smaller airlocks). Pictured above is a Star Wars™ hanger bay, containing the Millennium Falcon. This is essentially the same concept as the larger hanger bay on the Optis, with the obvious difference in a smaller Optis size, and also a closed hanger door[18]. While movies (especially this one) are not a good basis for science, in its most basic form, this is a hanger in space. There will be two hangers in this format. The hanger bay pictured shows both airlock doors open[19], to show the inner compartment, but the compartment will work in an airlock fashion during use. Taking this render, and minimizing the size of the compartment, and removing the "hanger" aspect, and increasing the size of the second airlock door, will yield the smaller airlock. For low priority jobs, due to the time required to vacuum seal, the compartment will wait until it is full, and then close the outer door, pressurize, and let spacecraft into the main area of the sphere, and vice versa. There will be two large airlocks, as pictured, and a multitude of smaller airlocks that work for the express purpose of releasing smaller craft. The hatch, which has been mentioned in this section, is merely a pressure sealed way, like a mini airlock, for things to move from the outside of the settlement, to the inside. The figure to the left, shows the hatch system, and this enlarged, is the "small airlock" that has been discussed throughout the section. It is just an airlock. Not shown, is the actual airflow infrastructure, that also exists at this stage, to pressurize and depressurize the system[20].

FIGURE 1.1.13: *STAR WARS* HANGER BAY

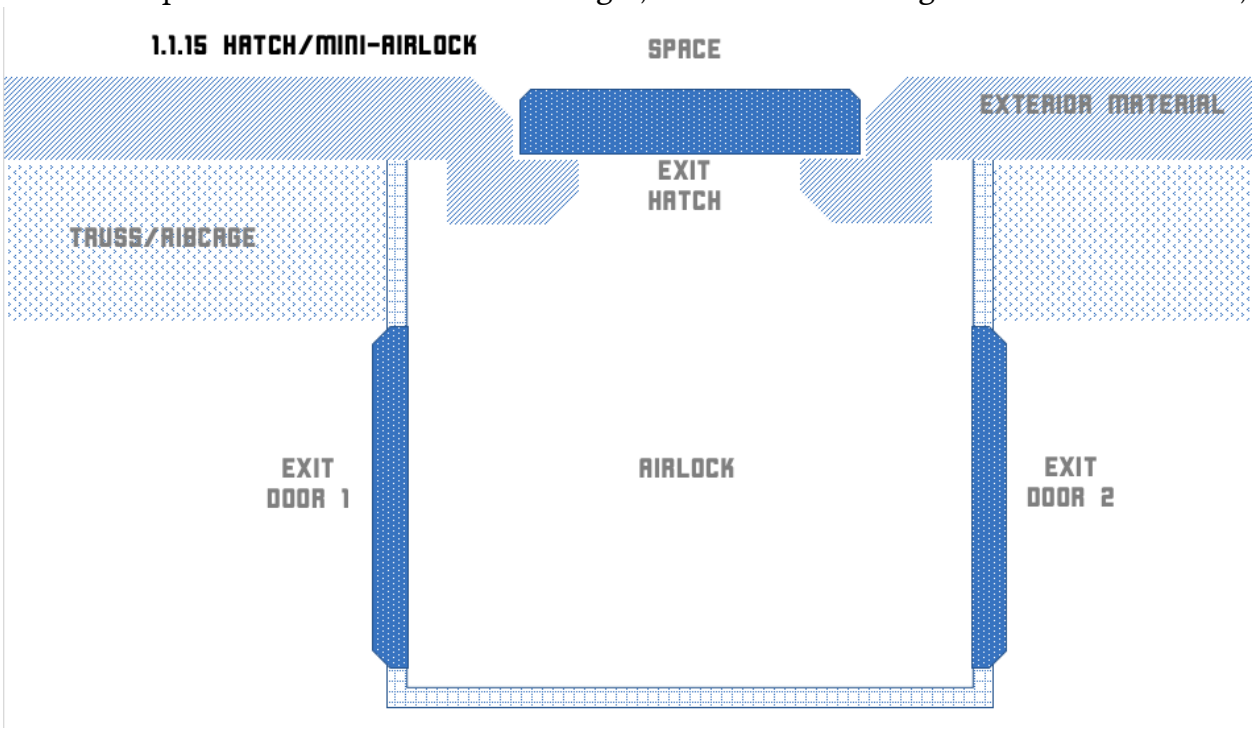


SRC: WOOKIEPEDIA

FIGURE 1.1.14: HANGER BAY

[18] A glaring hole in the science of Star Wars. Never mind the Kyber Crystal or the Faster than light engines, the hanger bays are the worst part. Still a 10/10 First Trilogy though.
[19] The weird looking spaceship is just and old render that is placed inside of the hanger.
[20] Pressurization is necessary, otherwise a vortex of air could negatively affect payload. While technically, depressurization is not *needed* it is better to conserve limited air. In emergencies depressurization/pressurization is not used, and instead the airlock is used without them.

Throughout the section, there may be some ambiguity as to what compartments there are in airlocks, the central compartment, as well as the docking ports. Put simply, airlocks and docking stations, cover the surface of the sphere. Connected to them, are their respective needed compartments. In the case of the hanger, this is an actual hanger. In the case of docks,



this is the infrastructure required for the dock to transport the materials that it has been given. Infrastructure is attached to the edge of the dome. For smaller airlocks, there is a kind of cache, which is the actual airlock, and then a door opens to the central compartment. This central compartment is an always pressurized compartment, which contains infrastructure, as well as storage for the craft that are deployed on the Optis. This is like a central hub and utilizes Maglev type "ziplines" which carry craft throughout this compartment, without them having to fire their engines. In fact, the central compartment is connected to the rest of the settlement's core infrastructure (Cone infrastructure, as well as the Central Core and reactor) and thus no engines fire within it. This central core has minimal gravity (<0.05G), meaning a system of Maglev's should have no problem transporting and keeping the craft in place. Due to the settlements size, it makes less than one rotation per minute, meaning that as long as a craft has reasonably powerful thrusters, it should be able to thrust to the Tangential velocity of 5.65M/S that the outer edges of the sphere rotate at. With the berthing arms and magnetic docking ports, it is then a simple task for the craft to dock together. The sphere itself has turned out to be one of the most interesting parts of this section on structure and is an integral part in keeping the settlement supplied and gathering materials.

SECTION II

GRAVITY AND PROPULSION

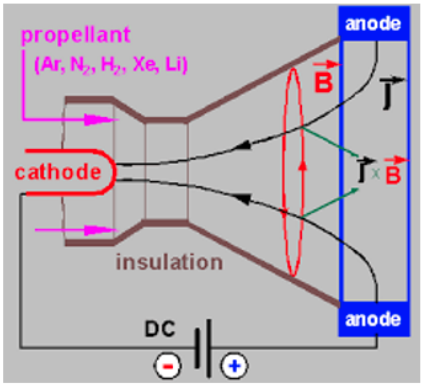
All of the humans onboard the settlement would have their heads spin and would lose lots of weight and undergo serious transformation as human beings raised in microgravity. As a

sustainable long-term settlement, it must provide the conditions necessary for life, as well as the conditions that life itself evolved in. One of the greatest things that this settlement can provide, that is pivotal to life, that is the *reason* for all of the odd shapes and pieces is gravity. Without providing gravity, it could be formed something like the death star, with levels inside of a sphere, and with maximum volume. Instead, the settlement provides gravity though rotation, and centrifugal force, to "push" objects and instill a sort of gravity. The design is slightly flawed, because the higher the building, would influence slower rotation, and a smaller radius, and thus will impact the gravity felt. The spinning of the spacecraft is provided by propulsion that is used as a sort of pulse rotation. Even though in space, friction is almost nothing, that small amount, paired with all of the objects inside of the settlement, will provide for a small amount of slowdown, which will require the settlement to periodically speed up, and it will need a renewable source to do so.

1.2.1 ARTIFICIAL GRAVITY LEVELS

The gravity levels inside of the spacecraft will attempt to most closely replicate the gravity on the planet that we evolved in and that we are used to. That gravity is 9.80665 m/s^2. However, in order for the gravity to always be in this range, there must be a large amount of constant fuel consuming boosters, and in the long term, it is not very practical. Therefore, what must be found is a range that humans can barely feel. Experiments with accelerations, show that 3 cm/sec^2 is about the amount where the probability only just start to gently curve up to the ~62.5% chance of correct guesses for whether the acceleration was increasing or decreasing. A lower value closer to the "golden" 50% chance of perfect comfort may not be feasible even for the size, due to fuel availability concerns. In the study shown to the left, the diagram shows that with varying amounts of acceleration, whether the subject was able to tell which direction the motion was in. This is perfect for the settlement because, at a set speed that the settlement will be moving at, decreases or increases in the rotational speed will be negligible at a certain amount of cm/sec^2. Although a determined value like the above is good, it may be unfeasible to maintain even this level of accuracy. The real difference between this test and the reality of settlement itself, is that there it in this test, the subjects were told to discern which direction the acceleration was at and were actively trying to do so. In the settlement, the inhabitants will be trying to live their lives, and an amount above 62.5%, will most likely not be very noticeable. With the friction for space accounted for, there is really no need to actually power up this spacecraft any time in the near future of its existence. More deceleration can be caused by running the opposite direction in the craft, than letting it spin in space. With docking and other hard lengthy decelerating process, there needs to be a reliable way to accelerate the craft when needed.

1.2.0 MPD THRUSTER



SOURCE:HTTP://TECHNAKED.BLOGSPOT.COM/2013/02/MAGNETO-PLASMA-DYNAMIC-THRUSTER_2734.HTML

1.2.2 MAINTAINING GRAVITY

This leads nicely into the maintaining of the aforementioned gravity. In order to maintain, the limit previously set at 4 cm/sec^2, will be the amount that the spacecraft will be decelerated for docking and other procedures. Maintaining the gravity will be done by a certain amount

of Very Large Thrusters[21] [22] which will provide enough power to spin the settlement, as well as the versatility to make small adjustments as needed to spin up and down the settlement as needed. As the Dawn spacecraft has shown, Ion thrusters, have high efficiency, as well as the power needed to turn the settlement. Because of the need of different varieties of thrust, as well as propellant availability, a combination of Pulsed inductive thrusters (PIT), and Magnetoplasmadynamic thrusters (MPD) will be used. There will be much less PIT thrusters, because they are not only more complex, but much more powerful per unit, and require fuel that is less readily available. The PIT thrusters are used in mostly in order to maintain LEO at around 24,841kmh at about 2000km above the earth, or less so to make large maneuvers (will be discussed later). Otherwise the MPD thrusters will be used. The MPD's offer a wide variety of benefits, except in the performance aspect. They use propellants such as Hydrogen, Argon, Ammonia, Nitrogen, and in the configuration that will best suit the settlement, even gasses in the earth's exosphere can be used.[23] These gasses can be found in all parts of the universe, and especially in the places where this settlement can be effectively deployed. The propulsion is based on electric fields and crossing magnetic fields accelerating plasma particles, and works with high efficiency, and well. They will be attached to the outer edge of the settlement, with a truss system, to securely fasten the boosters to the edges of the settlement. The power of the thrusters required, is not based on the weight of the craft, due to the nature of being in the vacuum of space but rather the size and desired gravity. The modular setup of thrusters means that a variety of thrust levels can be created from the array of thrusters provided. The amount needed is calculated as follows.

Calculating the Tangential and subsequently the Angular velocity needed for this craft with centripetal acceleration and the radius, is a fairly simple calculation.

Setting values of R (radius) as 1.5km[24] and a (artificial gravity) as 1G or 9.80665 m/s^2, equations are as follows.

The equation for radius from frequency, is:

$$r = 9.80665\left(\frac{60}{2\pi f}\right)^2$$

Solving with a 1500-meter radius, yields f as about 0.77212 rotations per minute. This value, according to the 1977 study by Graybiel, states that "at 1.0 rpm even highly susceptible subjects were symptom-free, or nearly so" stating that this lower value would create comfortable symptom-free no adaptation conditions for settlers aboard. Marinating the tangential velocity of about 121.285 meters per second also will not be a large challenge with the thrusters onboard. As said previously, thrusters will provide this, the majority MPD thrusters which are electrically driven. With MPD's able to create thrust up to 110km/s the thrust is not a problem, and as seen low levels of pulsing thrust from MPD's will be used to

[21] AKA VLT (Not to be confused with the Very Large Telescope [Also VLT]) Scientifically based projects require scientifically creative names.
[22] Actually, they are probably medium sized to small thrusters.
[23] https://en.wikipedia.org/wiki/Ion_thruster
[24] 1500 is the set "ground level" for the settlement and target for the 1G of gravity

maintain the gravity, instead of large pushes, because keeping the frequency between the past seen values of 5cm/s$_2$ keeps humans comfortable.

SECTION III

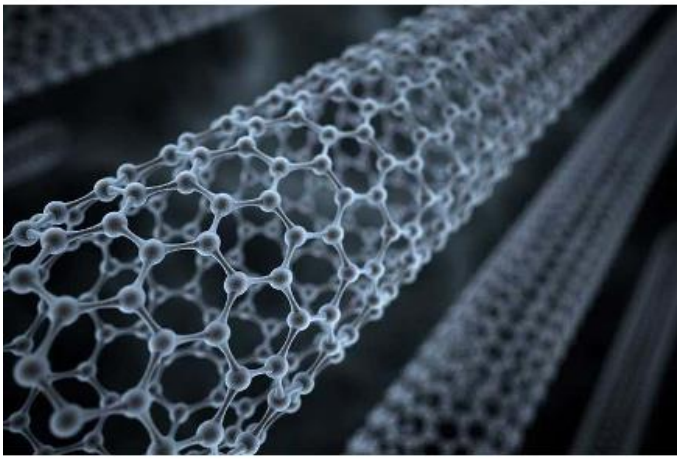
BUILDING & CONSTRUCTION

In order to function, all needs inception, and Optis is no different. It cannot come into being but must be created. This section will outline how Optis will be built. It will use an elevator system to propel objects upward, and to construct the actual settlement. This section outlines all mechanisms used to construct and build the spacecraft. It first starts off with the mechanisms for the way that the settlement gets parts into orbit. The next part is about how the settlement is assembled using parts.

1.3.1 INTO ORBIT

In order for the Optis to be built from multiple bases on the earth, requires first, a robust mechanism for propelling parts into orbit. Constructing as well as sending parts into orbit will require massive amounts of power, so an earth based fusion reactor will most likely be a prerequisite for the construction of the Optis[25]. With the current cost of 1KG into space at around $22,000USD, sending parts into space at this rate would become absurd and financially unfeasible. The most feasible way to send parts into space, would be to send them very high through the use of space elevators and then send them into orbit through the use of boosters. This strategy only requires about $200 USD per Kilogram, as opposed to a number about 2 orders of magnitude higher.

1.3.0 CARBON NANOTUBE STRUCTURE



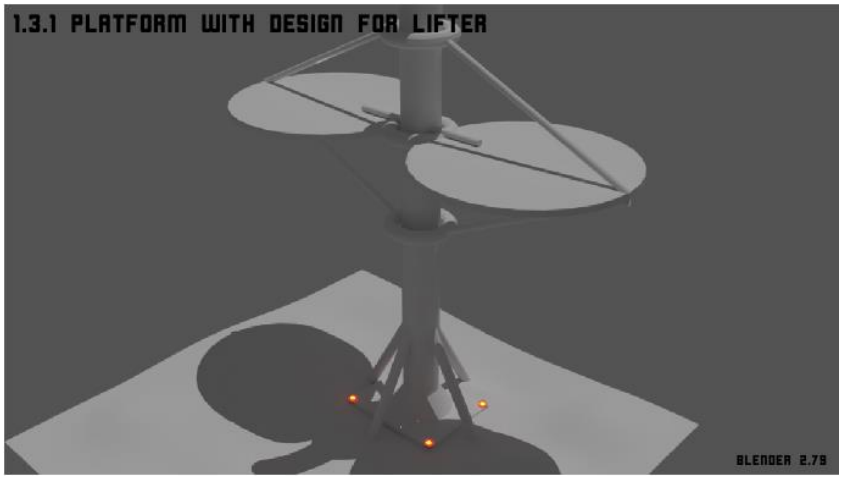
SOURCE:
HTTPS://IMAGES.NEWSCIENTIST.COM/WP-CONTENT/UPLOADS/2016/06/10170642/GETTYIMAGES-160380750.JPG?WIDTH=800

The question thus, is how do we construct one of these? The basic design concept for one of these devices is to keep a rope that is held taught by rotation, that spins around the earth. Due to centrifugal force, if a rope is extended from earth, any weight on top of it after a certain height actually keeps help it aloft due to centrifugal force, so a strong counterweight at the top of the geostationary area will definitely be used, to counterbalance any of the parts going up the elevator, which will weigh down on it. With carbon nanotubes, many super strong materials can be created, and used in a rope of this fashion. These really are extremely strong substances that form the backbone for many industrial applications. Setting a rope about 2000km, high, so that any crafts launched off of it could easily accelerate close to the site of the settlement. In order to create an effective taut rope, geostationary orbit must be used. This means that

[25] The Optis is also equipped with a fusion reactor, so in the future where one might be created *aboard a rotating space station*, this prerequisite does not seem very hard. I don't think we would be able to build a traditional fission reactor on board a space station right now, so at that point fusion would be quite improved.

satellites will orbit at the same rate that the earth does, keeping them in the same position. Unfortunately, this means that the best altitude is around 35,786km into the air, so an elevator would stretch that far, while only depositing payloads at about 2000km into the air. The craft which would hold up materials, would utilize electromagnets and tractor treads to move up and down the carbon rope. It would anchor at the top with a "platform satellite" which has thrusters to maintain geostationary orbit, but other than that would be mostly created to hold a rope taught. This system would hoist a rope system which contains a tread driven mechanism that hoists up payloads to areas where they can be released. This is one of the places where the

The mechanism would also be used to transport materials and payloads to the earth, so it is pivotal to know the details and the construction mechanisms of such a device. Every design including this one includes a base, cable, counterweight and climbers. It would be constructed in 3 stages. In the first stage, platform would be created (base). This platform would most likely be aboard a neutral country along the equator's land, because land-based systems mean that the logistical aspect of launches would be easier than sea-bound, and large pieces could be flown to the launch area and easily "launched". This station would just be close (or on the premises of) a fusion reactor, fabrication plant, large transport ready runway, and port. This would mean the infrastructure needed would be around the settlement. A good proposed location would be the southern part of Sao Tome and Principe, due to the equatorial proximity, as well as the island characteristic meaning large ships and other pieces could get there without the interference of land events. During construction and sending, the Island would probably be held by the militaries of joint countries working to construct the settlement to ensure security. In the figure, the platform is shown on terrain, with the large thick cable, and on top of it is a certain design for the lifter, that uses double platforms to hold smaller materials. Variations in lifter design could mean electromagnetic lifters for very large payloads, and other smaller more padded containers for electrical equipment. The same basic holding design of a tread mechanism creates infinite modularity for different parts that could be used. The top section of the elevator holds a large counterweight to keep the rope taut, as well as boosters to keep the rope in position. Construction of the elevator entails a satellite taking off from earth by conventional means, with a large cable behind it, which is spooled down to earth once it is in the allotted geostationary position.



Once content is released into space, due to the motion of the earth, it is launched out of the rope system at a speed which keeps the payload in orbit. This is a very useful property of space elevators and means that no extra measures must be taken to put objects that are lifted through

these means into orbit. The only real problem is the possibility that objects could crash into the actual rope after being deposited in orbit, and that there is no real control, and these objects could be lost to space or re-enter the atmosphere after being deposited. These, and other problems after the deposition of objects, can really be boiled down to one factor. Control. After objects are launched into orbit there is no real control over them, in the current configuration. This is where small "guide" satellites come into place. These satellites are made of propellant, thrusters, sensors, and communications with the earth and settlement. They exist to propel objects, and upon malfunction will just be simply re-entered into earth and disintegrate to avoid space debris. Space debris must be averted by tracking all parts and pieces

FIG 1.3.2 CRAFT WITH MANIFOLD'S TO HOLD MATEIRIALS

of spacecraft and using "kamikaze" spacecraft to remove large pieces of space debris or use lasers to vaporize smaller ones. Space debris is a large problem, and all spacecraft after use MUST be disposed of, or they risk making the earth impossible to escape from. These control craft are used in order to steer and guide large pieces of craft, in the building stage. The makeup, as said before is fairly simple, and consists of propellant as well as thrusters.

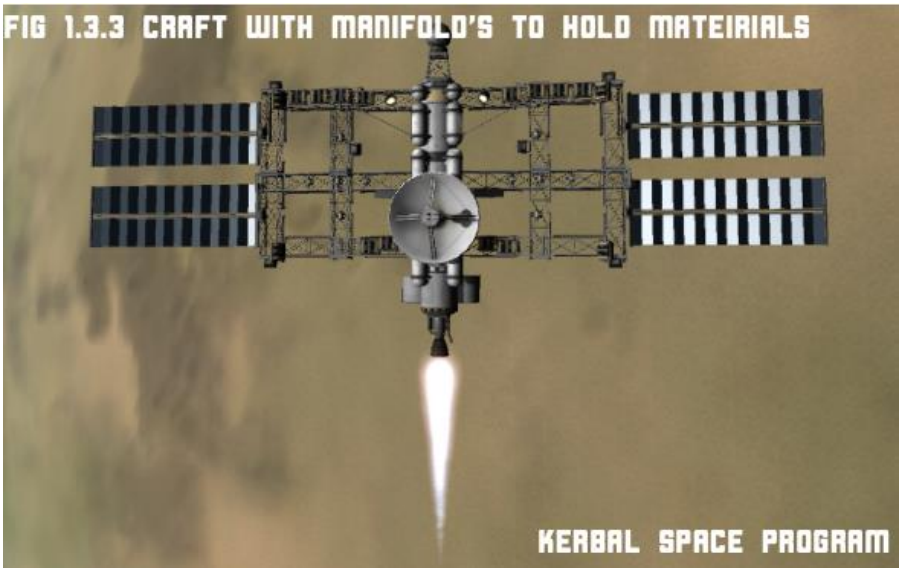


FIG 1.3.3 CRAFT WITH MANIFOLD'S TO HOLD MATEIRIALS

The Image shown (rendered with the finest in scientifically accurate physics engines) shows a larger version of the ship, with hydraulic

manifolds on a large structure that hold settlement parts together, while allowing the craft to move around in orbit.

These are launched from the space elevator, and immediately carry any lifted parts into place. Smaller modified craft with pods instead of structure for detachment mechanisms, can allow human transport. In the renders, RCS thrusters are shown, with fuel storage. In reality, these RCS are Ion Thrusters, relying on earth-based fuel flown up through the elevator.

The actual construction, and metals needed for the structure, can be mostly provided by the materials on the earth, but near-earth asteroid mining is a viable source for large sources of exploitable metal, and when the settlement is more established will be a source, as seen in the "Survival of the Fittest" Section, which outlines how the settlement will acquire materials.

1.3.2 STAGE 1: OUTER FRAME/INNER CORE

This is stage one of construction. The construction of the craft will be broken into 3 different stages, and now having already decided upon the methods for the movement of different parts into LEO.

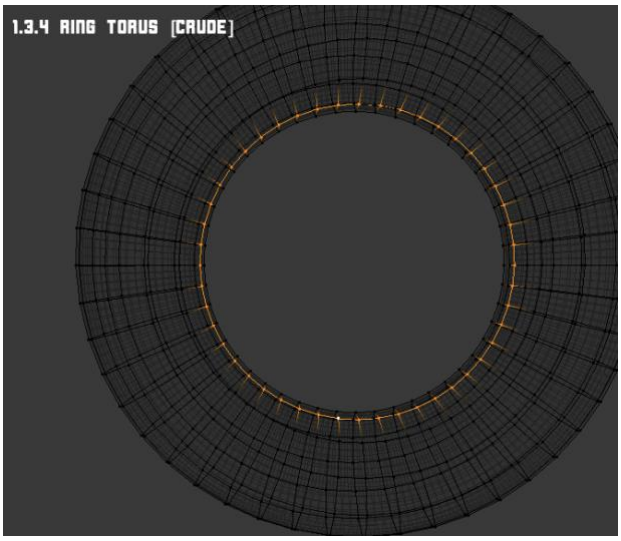
The first stage is the frame of the outer torus, as well as the inner core, ("trapezoidal cylinder"). Since it is smaller, it is also easier to create, than the larger outer torus, and since the outer torus is connected to the inner core, it is easier to create the inner core first, and then create a frame around it. The core, kind of like a foundation, consists of a tetrahedral structure, as outlined in the structure section, and also ribs holding it back. The combination of these two, makes for a strong structure, and the outer ribs will be constructed on earth first, in modular sections, and then transported up the elevator, where assembly craft using robotic arms will connect the pieces together to create full ribs, and then attach them together to create the actual ribbed inner core. After the creation of the inner core, the ribs for the cone and sphere will commence, and they will also come together in the same fashion, ground level fabrication, and then elevation into LEO. These ribs will be built of Carbon Fiber and connected with different carbon parts that use physical means to attach them to each other, such as interlocks, and latches. 3D printing will be a pivotal part of the manufacturing process of the settlement. After the initial "Ribcage" of the settlement is finished, then truss structure will be built around it, this time, 3d printed aboard the settlement. A sort of larger ISS will also be created but hosting machinery and docking points for the different craft that will connect together to construct the actual craft. This is also where an external 3d printing operation will commence, with ground-based shuttles resupplying the printers through docking ports. The construction of the Optis is a majority autonomous process, and this is reflected in the techniques that are used. Ground based control with a latency of <0.1s can be used, but for the most pivotal operations, autonomy will have to be used. In the early stages, most of the settlements power will come from solar, as it is used to power individual craft, as well as the "ISS" type temporary mothership. This system is used to construct the entire truss and ribcage. Once the truss and ribcage are completed, then the infrastructure for the internals can be constructed. In the same Ribcage fashion, a large part can be fabricated on Earth (The truss, because it is smaller can be constructed aboard the mothership) and then brought up to the settlement and adhered to it. After the internal support structure for the core, sphere and

cone is completed, then the structure for the actual knots can be fabricated. At this point, the 3d printers should be robust enough to print a large part, and then can be used to create the infrastructure for the actual knot. In reality, after the knot infrastructure is created, this stage of construction is completed. All that has been created is the frame and backbone of the inner core.

1.3.3 STAGE 2: OUTER COMPLETION

In the second stage of construction, the cone and sphere will be constructed in the same way the inner core was, frame first, and the big thing, is that the outer torus will start.

In terms of chronological order, the outer torus is created first. First, a ring is created, which spans the entire inner circle of the torus. It is created in the same ribcage style, however only one ring is created. At the left, a figure outlines what the ring is that is created[26]. This ring, only has the carbon fiber, constructed aboard the temporary space station, as well as structure to attach the knots. Now, with the outside structure created, spaceships such as the grabber outlined in the past section are currently holding on to it into place, as well as its smaller inner core. Neither of these parts are spinning, because that would create extra complexity. The knots are the next thing to be created. A diagram in the structure section shows many "ropes" emanating from the settlement. These ropes are large in quantity, and also attach at different places along the torus. At this stage, only the "dark blue" (Figure shown for clarity) are connected. The red which also correspond with the same ring, are attached after all of the blue ropes are secure, and the craft is secured. Note at this point, due to the, well, ropelike nature of the Kevlar ropes, the inner core would be able to move freely if not all ropes were attached from all sides, but once they are, it is impossible for the craft to move, and now both the inner and outer parts of the craft are connected, this is what is meant by securing the craft. The ropes are actually connected, by first ground-controlled spacecraft creating the knots shown in the structure section, on the inner core. Then, the ropes are flown out by small spacecraft, to the outer side,



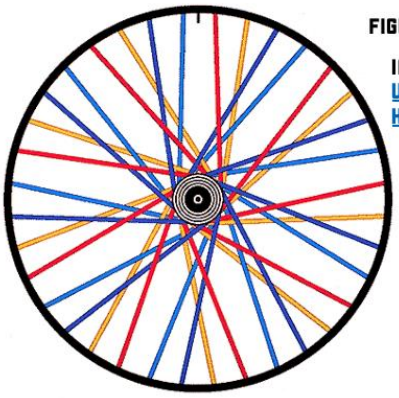


FIGURE 1.3.5: SPOKE OVERVIEW

IMG CREDIT: WWW.SHELDONBROWN.COM/WHEELBUILD.HTML

[26] This crude viewport screenshot of a torus does not show much, but the ring, and that is the point that the diagram is attempting to convey, and that is the purpose.

where the ropes are then re-knotted. Small spacecraft are essential in all parts of the creation of the settlement. After this outer ring is constructed, then the red ropes can be attached, and the actual full ribcage of the outer torus can be created. Once this outer cage is created, and then the non-highlighted parts will be built, the other ropes can then be attached.

Now with the frame of the outer torus finished, and the ropes attached, more of the structure of the inner core can be completed, with the shielding material, and inner routing and infrastructure. The temporary space station that has been used to create 3d printed parts, can now move its operations to the inner core, where machinery can be built. The outer and inner parts of the inner core will be completed, short of electrical and human ready components, but structurally the inner core is completed. The ribcage for the sphere and cone, can be now constructed, using the 3D printing infrastructure onboard the inner core, and built to the extent that it was in the first stage.

1.3.4 STAGE 3: FINALIZATION

In the third stage, the actual outer torus will be completed, as well as the cone and sphere, and then critical infrastructure ported over from earth, and the inner core, to the different parts of the settlement.

First, the outer torus will be finished. Using earth parts, as well as the machined parts from the inner torus, it will be completed, with interior and exterior structure to keep it together, and finally the exterior shielding material. The same thing will be done with the dome and sphere, with cutouts where infrastructure is to come.

After the shielding is complete on these parts, then the next stage of adding wiring, electricity and infrastructure will commence. These parts may be manufactured down on earth, where more established and robust manufacturing systems exist, and now that the actual large parts of the settlement are completed, the smaller bits that require more precise engineering and infrastructure to create that is not in space yet, can be built on the ground and flown up with the elevator, as they are relatively small. They can then be assembled to the craft.

Finally, with this stage complete, most of what has been outlined up till now has been assessed.

1.3.4 STAGE 4: TURNING ON THE CRAFT

In this stage, the reactor will finally be turned on, and the thrusters will rotate the settlement. For the first run of the settlement, the settlement will be powered from batteries that are charged from satellites with solar panels. These batteries charged can turn on the fusion engine, using the power to start the fusion reactor and heat it up to a critical heat. Once hitting this limit, the fusion generator can start working on converting this to energy. This energy can be used to power the MPD thrusters, which can then start the rotation of the settlement. Then, critical life support systems can be put in place, and the atmosphere can be put into life. Settlers with spacesuits could then set up the settlement, and in the end finally after testing, normal settlers could enter the spacecraft.

Part II

ENERGY CAN NEITHER BE CREATED NOR DESTROYED

All laws of the universe sit on a panel, overlooking the worlds at its most minor interactions, to its greatest. The laws all stand equally together in effect and in cruelty. The first law of thermodynamics however warrants a special job. Destroying the dreams of many a science fiction nerd. Its foreboding tone bears down unmoving and omnipresent. Energy cannot be created or destroyed. The total quantity of energy remains the same, energy can only be transferred or transformed through its various forms. For all of humankind's dreams of infinite power, Fusion comes closest to breaking the 1st law. Humans harnessing the stuff of stars. Wonderful. As Carl Sagan said, "we're made of star stuff". Fusion is how "star stuff" (us) came to be. It's how everything came to be and is arguably one of the most powerful energy creation systems in the universe. (unless you stay up late watching Kurzgesagt it should be most peoples acknowledged most powerful form of energy) At the moment, humans themselves have harnessed the power of fusion mostly in creating the largest explosions that man could possibly create. With the cold war over, attention has been turned to energy generation, and multiple teams have created sustained reactions, although none with energy gain. This is set to change, with teams at ITER and DIII-D using tokomak reactors and others like the Wendelstein 7-X using a Stellarator design along with powerful magnets. These fusion reactors require small amounts of hydrogen isotope fuels and provide large amounts of electricity far exceeding the needs of the settlement in theory. Projections state that in the mid 2020's Fusion power will become energetically positive, generating more energy than is required to fuel the machines, and thus this is the main fuel that the settlement will use. The large central space outlined in the previous section will provide enough space for a Stellarator or Tokomak reactor, although the more elusive and difficult Stellarator reactor has been decided for use on this settlement. Acquiring the materials needed to undergo this fusion reaction will be outlined in this section as well.

Sections & Subsections

SECTION I

FUSION POWER

Due to the futuristic nature of the settlement, as well as the need for reliable high yield low input power with raw materials relatively attainable, the utilization of Fusion Power is a staple in these kinds of designs. Even Earth based variations would benefit from a Fusion power plant. Unfortunately, only relatively recently have plants like ITER or Wendelstien-7X produced plasma and are still away from the 50-100 million Kelvin number, the lowest temperature to produce highest yield of energy. The location of this reactor is centralized in order to be accessible from all parts of the settlement, and because a centralized settlement allows energy to be equally routed to different parts of the settlement. There are two types of fusion reactors, Stellarators, and Tokomak reactors[27]. Both of them have their advantages and disadvantages, and these will be gone over in the first part of this section. The fuel required to power these settlements, deuterium tritium and lithium, can be collected from the outside of the settlement, and some of the heavy hydrogen seeded due to rarity. This will be covered in the third and fourth parts of this section. Finally, the longevity and sustainability of the reactor will be covered in the final part of this section.

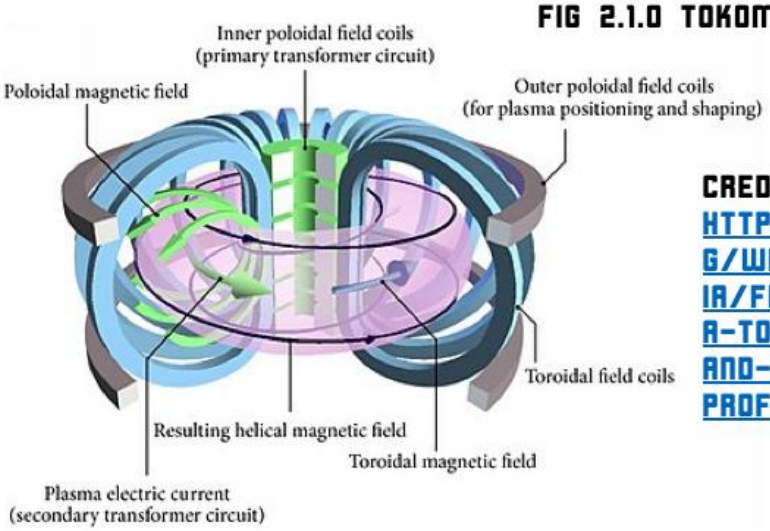
2.1.1 TOKOMAK VS STELLARATOR

The concept of fusion power relies on brining two atoms close enough that their nuclear forces exceed the electrostatic repulsion pushing them apart, fusing them. The nuclear force, acting over a much shorter distance requires much more energy to attain then the farther-reaching electrostatic force. Extreme amounts of energy are required to reach this point, and these can either be provided in superfast environments such as particle accelerators or with extreme heat. Fusion reactors as well as stars require the second method. Exothermic reactions occur at atoms smaller than Iron, and the easiest atom to achieve Fusion with is Hydrogen, specifically the Deuterium and Tritium isotopes. The minimum heat, around 50 million degrees kelvin for this to occur, being much higher than any element's ionization energy, means that these reactors house superheated plasma. The Lawson Criterion states that in order to reach 30% efficiency[28], a certain "Triple Product" must be met, to offset radiation and conduction. This is the balance between density, temperature and time. The magnetic confinement characteristics of both designs inherently create low density plasma, and this means a large temperature and confinement time must be achieved. Extreme temperatures have already been created, and so thus the final challenge is confinement time. Plasma in these conditions are unstable due to many different forces, and thus in order to mitigate these effects, the volume of most reactors is large.

The difference between the two reactors, thus is the way they confine the Plasma. In a tokomak, which is shaped like a donut, have magnets that confine plasma into a ring. Unfortunately, this creates a gradient in the charge of the particles of plasma with the negatively charged particles sinking and the positively charged particles rising. In order to counteract this, an induced magnetic field in a spiraling pattern is created. This forces the plasma in a spiraling pattern through the donut to allow uniform amounts of particles, although means that a sustained flow cannot be maintained, and instead a pulsing field must be used. Stellarators on the other hand, combat the gradient problem by shaping the direction

[27] The unconventional order in which I wrote them will probably expose my favorite. Also the last part spoiled the choice.
[28] While seeming like an inefficient number, this number is actually very large for the power of fusion reactors.

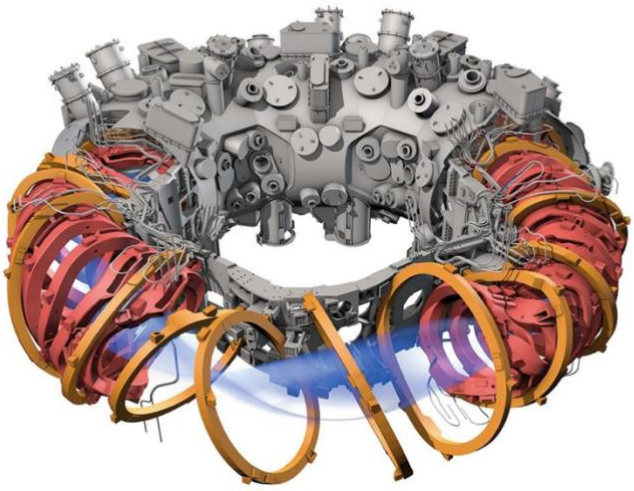
FIG 2.1.0 TOKOMAK REACTOR



CREDIT: HTTPS://EN.WIKIPEDIA.ORG/WIKI/TOKAMAK#/MEDIA/FILE:SCHEMATIC-OF-A-TOKAMAK-CHAMBER-AND-MAGNETIC-PROFILE.JPG

of the plasma with magnets, and by placing these magnets in a different shape which directs the flow of the plasma. This situation means that due to the lack of current, it can sustain fusion for large periods of time. The flow of particles complies very well with Lawson's equations as well. In addition, Stellarators can be controlled through the magnetic coils the contain the plasma instead of current, creating more stability. The major drawback to the otherwise superior Stellarator Design, is the incredible complexity required to create. While the concept for Stellarator type reactors is older than Tokomaks, until modern supercomputers came into fruition, it was impossible to conceive these reactors and the shape of the magnets required to contain the plasma. Due to the intrinsic stability, as well as the lack of an induced current needed to control the Stellarator reactor, it is the choice for this settlement. While the point about the lack of current sounds like a minor point, it means that Stellarators are extremely stable compared to the induced current required to sustain tokomaks, and also can be sustained instead of pulsed. Reliability also increases, because the induction of Tokomaks also means they have a possibility of destroying the reactor outright. The external energy for the electromagnets in the Stellarator in the Settlement will be provided from batteries at first, and then continued with power generated by the Stellarator. Currently, the Wendelstein 7-X is the most advanced Stellarator and is set to go on to 100

FIG 2.1.1 WENDELSTEIN 7-X SCHEMATIC



CREDIT: HTTPS://WWW.SCIENCEMAG.ORG/SITES/DEFAULT/FILES/STYLES/ARTICLE_MAIN_LARGE/PUBLIC/IMAGES/STELLARATORLEAD128OX720.JPG?ITOK=0YK4KWCG

million degrees Kelvin in the coming year, which is hot enough to sustain fusion, although the reactor has not been designed to create an exothermic reaction yet.

2.1.2 ELECTRICITY GENERATION & ENERGY CAPTURE

In order to capture the energy that is generated by these reactors, heating of a fluid is the most viable and easiest method[29]. Fusion heating a blanket of material surrounding the reactor core in this case lithium[30], means that the blanket will be heated by the exothermic reaction, and this heat will be transferred to liquids outside of the reactor which will then drive a turbine as with most energy sources. This energy capture source means that the heat capabilities will be harnessed, and with a robust and simple system for the capture, means that the stability and reliability of the settlement's energy sources will also be increased. This energy (after the turbine system now converted into electricity) can be then routed to different parts of the settlement through the spokes. The grid portion of this is relatively simple, with a step-up transformer in the small torus to minimize losses, and after distribution into different parts of the settlement, voltages are subsequently stepped down or further up to the application needed[31].

2.1.3 RAW MATERIALS & PREREQUISETS REQUIRED FOR FUSION

In order to create fusion, hydrogen fusion is used. Isotopes of hydrogen include Tritium and Deuterium. Both can be acquired from raw space, albeit in small quantities. Harvesting this fuel is relatively tricky, due to the density of the hydrogen. The amount needed to create 500 Megawatts of power, is about half of a gram, and with a quick back of the envelope calculation, the molar mass of hydrogen is 1.008, so .504 * 6.022*10^23 is about 3.035*10^23 hydrogen atoms needed for 500MW of power, and with an interstellar density up to 1000 hydrogen atoms per cubic centimeter of space, means 3.035*10^20 cubic centimeters of interstellar space must be harvested to create 500MW of power. In addition, only 0.02% of hydrogen is deuterium, meaning this is a very impractical method. A better method is to use natural water, which already has an amount of deuterium in it, albeit at the same amount as normal hydrogen. When the settlement is built around earth orbit, shipments of Earth Water could be used for the Girdler Sulfide Process, to separate out the "heavy water" which contains Deuterium, and then electrolysis to create deuterium from H_2O. Again, taking the half a gram to 500MW, if one kilogram of water was used, 20 grams of heavy water would be produced, meaning 2,240MW[32] could be produced from that heavy water. One Kilogram of water[33]. 2,240MW of power. This water, due to the natural (mostly seawater) property of the water that is easily convertible into heavy water. Shipments from earth will be covered in the Survival of the Fittest section. Fusion reactors are also hard to cool. This problem is mostly mitigated by the fact that a cryogenics system with a heatsink facing outward on an unshielded part of the settlement could easily create cooling levels for a large scale. The ITER project,

[29] Seems a little hypocritical after choosing the more complex design for a reactor, but other methods are not fully formed, and this is tried and tested

[30] This is because the neutrons given off by the plasma (which escape magnetic confinement through their neutrality) seed the lithium and create Tritium Hydrogen and contribute to the reaction

[31] The fact that the awesome power of nuclear fusion, the same stuff that powers the sun, will one day come out of wall sockets is amazing to me.

[32] 1 gram gives 1,000MW and 20 grams of $_2H_2$ Water would give (16.00+(1.008*2)) = 18.02
[20g]/[18.02(g/mol)] = 1.109877. . . (1.109877. . .* 2.016) = 2.2375. . . or about 2.24 grams of deuterium after electrolysis, so 2,240MW per kilo of water

[33] You thought this would be an asterisk saying, "actually no". In reality actually 99.98% of this water can be used for other purposes, and only 20 grams of heavy water is needed, creating even less need for water from the earth.

uses supercritical helium at 4 Kelvin, and with a CMB (and thus most of space) temperature of 2.73 Kelvin, space could act as a virtually limitless heatsink. For Fusion, there is one more prerequisite. That is, that all current fusion reactions require large amounts of energy to begin. This energy can be provided by a multitude of different ways, but most likely from large batteries on spacecraft that charge up the settlement's reserve power area and release the power to start the fusion reactor.

Part III

LIFE FINDS A WAY

Life always finds a way. Whether it was the bubbling carbon rich pools of primitive earth, or the smoldering vents of volcanoes, life managed to exit. Small animals and microbes manage to exist on every edifice and crag, from the deepest oceans, to the harsh extremities of outer space. Unfortunately for humans, we are made to only be strong in our minds. We are not tardigrades, or small bacteria. We require a perfect environment on which to live. The past couple sections have allocated nearly limitless energy through fusion, and space for whatever humans need to stay alive, going short of actually inserting what humans need into the settlement. This section is preparing the settlement for humans. Going back to the car analogy, the body and frame were outlined by Part 1, the Engine transmission and drivable parts by Part 2, and the upholstery, and the rest of the car in Part 3. The first part of this section outlines the atmosphere and making the settlement as close to the earth's atmosphere. It is solely concerned with keeping the concentration heat and other aspects similar to mimic the Earth's atmosphere. The second section deals with the different ways that the settlement attempts to mimic the earth. The Settlement also needs a source for its food to come from, and this is where the food section comes in which describes the different diets and ways that the settlement gains food. The next section is the Waste management section which goes over the different types of way waste is dealt with. The Health section deals with the medicine and different ways that health is maintained. Population and residences go into detail on how the different ways that people are housed, and they are able to live. Government and Economics is the final section, and which is where the descriptions of the way the settlement works and thrives is. From the deepest volcanic caverns, to the even the deep regions of outer space, life finds a way. Always.

Sections & Subsections

7.3 Jobs

7.4 Currency

SECTION I

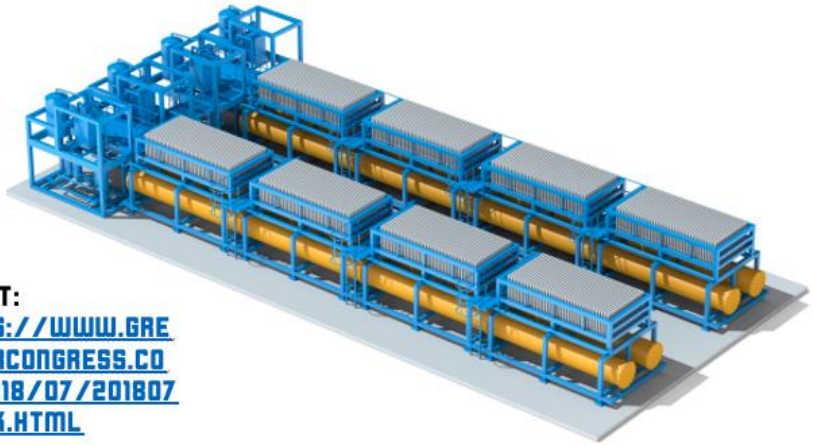
ATMOSPHERE

The Optis needs an atmosphere. This section will outline how the atmosphere functions, as well as its constituents and the way that it is made up. It will also outline the way that the atmosphere is created. The atmosphere is created through the use of a duct recycling system which recycles air from the atmosphere and treats it, heats it, and spits it right back out into the atmosphere revitalized and years chopped off its age! The storage and release of different chemicals is also gone over, as well as the process of making sure there is nothing bad, and purification. Fitting 100km of air into a little teeny bit is not easy, and that's not what this is about that what the shielding part was about. This is about the fun stuff. What we breathe. The Atmosphere. Wow.

3.1.1 COMPOSITION

The Earth's atmosphere is not made of purely oxygen. It is not even made of mostly oxygen. Instead, it is made of mostly Nitrogen. Second, is oxygen, and finally, Argon, which accounts for a whole one percent. Carbon dioxide and other elements account themselves in total under 1 percent of the atmosphere. Having a full oxygen atmosphere is not a good idea, because it can produce oxygen toxicity, which causes damage to cells, collapses alveoli and can even cause seizures. Altogether, an excess of oxygen is not a good idea. Since people have evolved under the concentrations of oxygen and nitrogen that has been on the earth for ages, it is a good idea to continue to have the same amount of oxygen and nitrogen. Argon which makes up about 1% of our atmosphere, however, is a hard to obtain gas, that actually turns out to be harmful to us as humans. Argon in the atmosphere is mostly radioactive argon-40. This can be contrasted to the argon-36 that is found mostly across the universe. Argon itself, is hard to produce compared to nitrogen and oxygen, and is not needed by the human body. Thus, in the atmosphere of the Optis, is made up of about 78% Nitrogen, around 22% Oxygen, and less than 1% of the other trace gasses. Carbon dioxide is actually an essential part of our environment, contrary to what most think, the excess is bad for our environment, but the little amount of it, and the largest greenhouse gas water vapor, allow the earth to trap heat. Also, for the settlement unlike the earth, gasses that trap heat don't create a greenhouse effect, Because most of the time, the effect that these gasses have is trapping infrared radiation from the sun, but in the case of the settlement, there is no sun, and the source of heat doesn't have to be constant. Thus, the composition of about 0.0407% Carbon dioxide, is an adequate

FIG 3.1.0 THYSSENKRUPP LARGE SCALE ELECTROLYSIS PLANT



CREDIT: HTTPS://WWW.GREENCARCONGRESS.COM/2018/07/20180728-TK.HTML

number to ensure that the settlement works properly. These values will translate to an atmosphere that is adequate for the settlement, and will allow it to function, and for Humans to feel at home with little to no adaptation

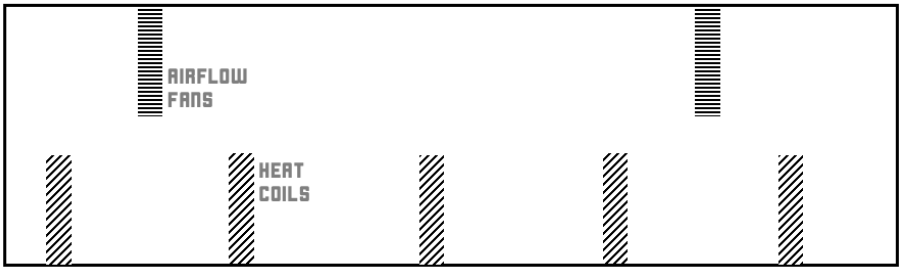
3.1.2 PRODUCTION

There are three main gasses that are needed (in addition to water of course) these are Nitrogen (N_2) Oxygen (O_2) and Carbon Dioxide (CO_2). Nitrogen itself is used for many purposes and can be used to create many compounds for a wide variety of industrial uses from pharmaceutical applications to glass manufacture. Another compound that is extremely useful on the settlement that can be used is H_2O more commonly water. Through the use of water electrolysis, hydrogen and water can be created, and water is an easier way to store the large amounts of hydrogen and oxygen that are needed. Furthermore, pure water that can be used for consumption can also be immediately diverted from storages for electrolysis, simplifying storage. Electrolysis can be performed in larges scales, for instance with Thyssenkrupp modules, which require energy and water. Large scale manufacturing and subsequent storage would happen in the inner core, with some amount of storage taking place in the outer ring of the settlement, in order to have on access oxygen for instant increases in atmospheric conditions. Nitrogen on the Earth is mainly produced through the use of cryogenic processes which distill it from our atmosphere. Unfortunately, just like water, this is one of the bare materials that is needed from the earth, due to the complexity of producing it. The good side is that with its cycle, it most likely will not need to be replenished.

3.1.3 EQUALIBRIUM INFRASTRUCTURE

This will mostly focus on the aspects of the settlement that focus on getting the gasses produced in the previous setting into the atmosphere, as well as contain other gasses. On earth, before the increase in carbon dioxide production, the atmosphere was kept at a constant rate by three cycles. These are the Nitrogen Cycle, Carbon Cycle, and the Oxygen Cycle. Starting with the nitrogen cycle, nitrogen is a vital part of plant life, and through processes of ammonification, and nitrifying bacteria, the soil is nitrified. Plants use this nitrogen and it is released back into the atmosphere as N2, upon which microorganisms take this nitrogen from the atmosphere and in turn saturate the earth with it this process utilizes rain to accelerate, and the mechanisms of rain will be discussed in the next section. This process is called nitrogen fixation. Through this cycle nitrogen is converted from the ground to the air and back. The process is much more complex, but is mostly concerned with plant life, and can be done through microorganisms and plants themselves, and thus is already supported by the settlement. If needed, additional nitrogen can be introduced into the settlement to keep levels of plant nitrogen high. The next cycle is the carbon cycle. This cycle is simpler, and in full concerns animal respiration, and the release of carbon. Trees and other plants[34] are able to

FIG 3.1.1 SETTLEMENT UNDERGROUND AIR LAYER



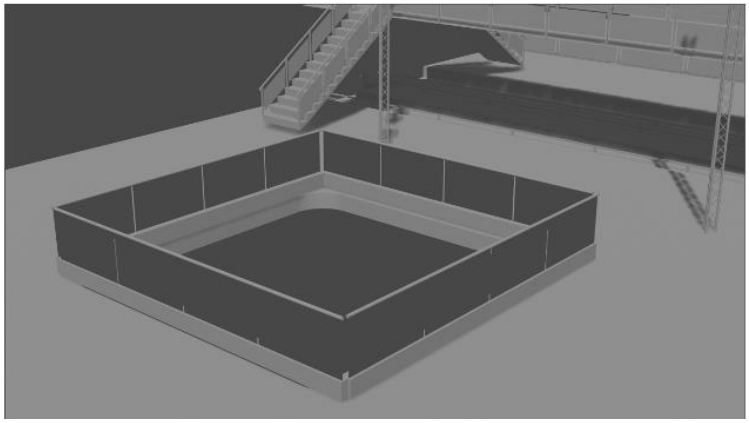
[34] Interesting how this section's name hints at human constructed infrastructure and instead proceeds to talk about plants. Actually plants are essential to all cycles, and an organic way to keep cycles and settlement process in check.

convert this CO2 into other forms, and also release it as organic compounds. Living organisms release it, and this allows there to be equilibrium. Due to the lack of infrastructure for manufacturing or other tools on the inhabitation part of the settlement, carbon capture systems will not need to be utilized, and the carbon cycle will keep carbon in check, although if homes or other needs release large amounts of CO2, then sinks will be available to keep the level under control. This would not require CCS (Carbon Capture and Storage) but rather DAC, Direct air capture. The way most CCS systems work, is by capturing air at energy plants which create greenhouse gasses, but due to the fact that none of these exist, it would be useless. DAC can be used to remove carbon dioxide from the air, although is a much harder. These systems mostly work by capturing carbon from the atmosphere in plants or other biological specimens, and then creating crystals and permanently storing it. These approaches are very last ditch and should only be used if all else fails. Turning to the last and most simple cycle, the oxygen cycle. This cycle is when oxygen is converted to CO2 by living animals, and back to O2 by trees. All this hint to the usefulness of nature and plants in the settlement. CCS or DAC more specifically, are last ditch measures that are not meant to be used as a daily measure. If there are significant changes to the proportion of the atmosphere <0.5% in any category, then there will be air that can be piped in through the underground layer. The underground layer is the main source of infrastructure, as it will have heating/cooling capabilities, as well as concentration of air capabilities. Heating coils will be described in the next section, but fans to do exist to circulate air around the settlement. This layer circulates all atmospheric based effects, minus weather that will be created in the next section. The previous figure shows the airflow fans and heat coils within this region, that heat air and transport it to upper ducts. Fans surrounding ducts can route air in either direction around the ducts.

3.1.4 HEATING/COOLING

The earth's ambient temperature is about 72 Degrees Fahrenheit[35]. In order to keep with the seasons of the earth, a pattern of seasons may be kept, with hotter summer temperatures and colder winter ones, to kind of keep the human cycle running, although this will be discussed more in the environment section about the specific temperatures, this particular section deals with heating and cooling (although mostly the former) for the settlement. The mechanism for heating and cooling such a large volume of air, is akin to an HVAC for a large warehouse, except on a massive scale. The first

FIG 3.1.2 SETTLEMENT AIR DUCT



[35] I have tried to keep it metric, and myself mostly do things with metric, although Temperature and Speed are the two things that my American upbringing retains.

stage is the underground airflow area, which – if you recall from Part 1 – exists to provide underflow heating, as well as circulate air underneath the settlement. This can be used to pipe air from the underflow heated area, upwards, and due to the buoyant air, turn the settlement into a convection area. Due to the difference in centrifugal forces, there will be a pressure gradient from the inner part of the ring to the outer part, but due to the small amount of variance in the actual gravity levels, this amount will be small. The convection will be able to create heat closer to the top of the settlement, and intakes near the bottom can be used to cycle falling cold air back into the circulation circuit[36]. These will have to have high speed airflow, to be able to circulate air from the entire settlement. Air can be heated/cooled in these air ducts, primarily through electric means. The layer uses electrical coils and a thermal conduction to heat up air, and large fans are used to pump air and keep it flowing through the air duct layer. This system allows air to be heated and cooled immediately, and to a precise level within the conduction layer, and full settlement convection can happen easily through this arrangement. The ducts as they poke through the bottom layer of the settlement, will be kept at specific to achieve conduction, and also to regulate the amount of air flowing. The diagram on the previous page shows that due to the slower and faster moving air, the air generally moves towards the direction of the settlement that is

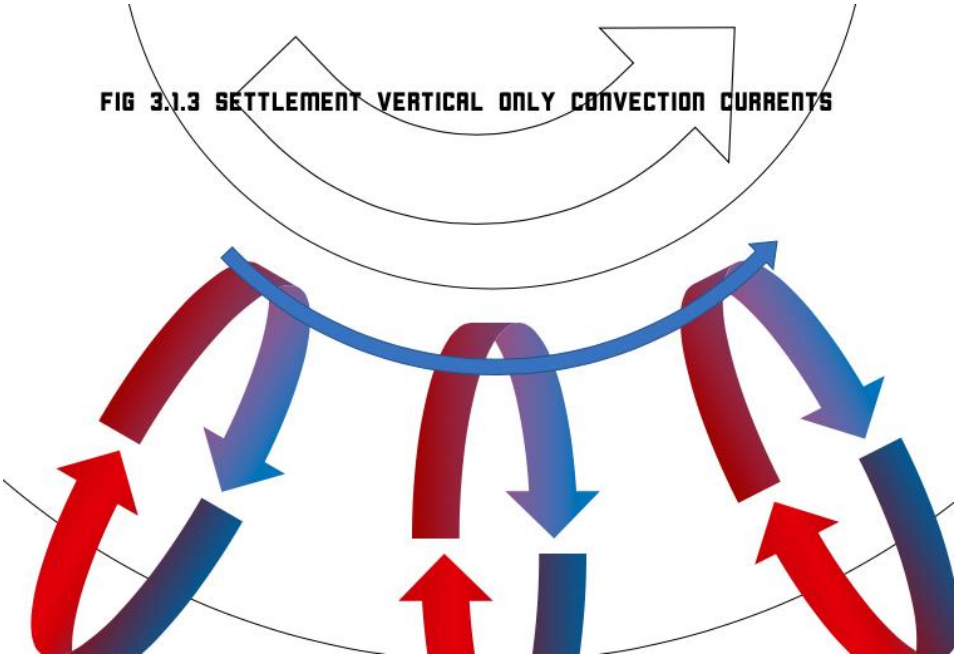


FIG 3.1.3 SETTLEMENT VERTICAL ONLY CONVECTION CURRENTS

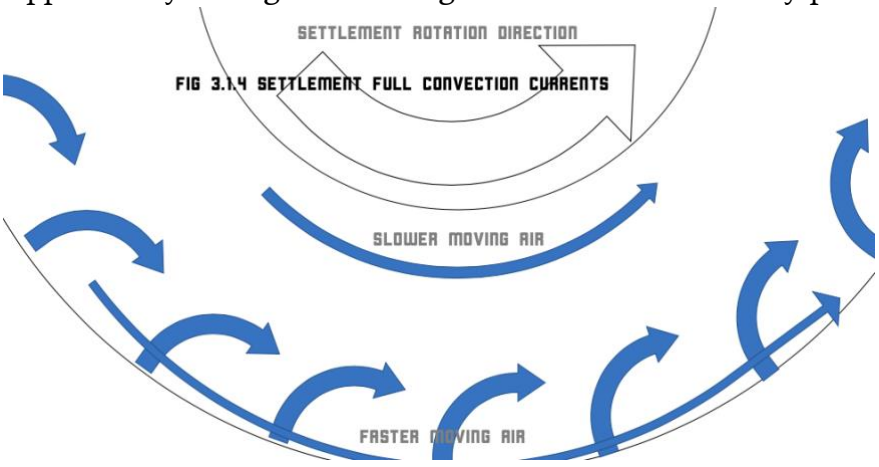


FIG 3.1.4 SETTLEMENT FULL CONVECTION CURRENTS

[36] A clarification, there are two types of pumps, those that suck air and those that release air, the suck air and release air correspond to different parts of the settlement based on expected conduction, see figure of conduction in action aboard settlement.

spinning, due to faster air moving at the same rate at a smaller diameter. The diagram at the left shows the way that warm air goes up and heats up the atmosphere and is not necessarily cooled, but cooler air is pushed down and absorbed heated and recirculated back into the atmosphere as warm air. This cycle keeps the settlement at the ambient temperature needed to function. This system is also used to cycle in air, to keep the composition similar, and this only follows the first figure, as its density is irrelevant to capture. An argument could be made that CO2 being the heaviest molecule might get picked up by cool air receptors, but since the airflow matters less, due to the ambient temperature being easy to maintain, and the low chance of this happening, due to the arguably similar molar masses, this is most likely a nonissue.

SECTION II

ENVIRONMENTAL [HUMAN COMFORTS]

The Optis is a spacecraft orbiting the Earth, or any other place where it is able to be. Humans will be humans, and we like the Earth. Therefore, this part of the settlement outlines creating the most realistic rendition of the settlement possible. This section will first start off with what makes up most of our vision, but what we increasingly fail to pay attention to. The Sky. Using fancy artificial skylights, the settlement will emulate the full set of sky, and then also rain snow and the sun to be able to douse the settlement into any setting. Seasons will be dealt with in the next part of this section, and after that, the way day breaks and ebbs. Day-to-Day weather is outlined after that, and how it is created. In general, the weather situation aboard the Optis is designed to emulate the Earth as best as possible.

3.2.1 SKY

When we see a brand-new world, planet, or moon, as humans we are drawn to the expanse of sky reaching across the settlement. The actual sky is built with microLED's and a massive diffuse panel across the top of the settlement. The aesthetic is to have the sky ringing across the top, and spokes seemingly "holding up the sky". The sky is paneled on top of the actual top of the settlement, on top of the utility. The way to create the effect, is to create diffuse panels, with the characteristic blue, of the atmosphere and shine LED's with the wavelength of sun you want. A quick google search for "Artificial skylight" will turn up many hits for CoeLux. This particular company is the only company that has managed to create an incredibly convincing, practically indistinguishable from the real sun. It can even flash the sun in a certain part of the atmosphere. It uses the same basic principle, although with a very fancy diffuser. Their diffuser is a special plastic, that is bombarded with nanoparticles to create the effect of the full atmosphere in a small solid. The diffuse effect is concentrated through microLED's in the place the sun is. Due to the fact that these lights have to reach a very large part of the settlement that is far away, the LED's will be relatively bright, compared to current CoeLux implementation. These will obviously draw power, but due to the Fusion generator, it should not make a considerable dent in the available power. The skylight assembly will be sufficient to create the effect of a sun, and at night, microLED's can be fired to create the effect of stars, or at least an ambient light of night, that due to the scattering effect, will be the perfect shade of night. The only real lost part from the real sun, is the epic sunsets that score the sky with beauty as the day comes to a close. On Optis, days are marked to a close with a subtle darkening of the sky. The LED's are full spectrum, with the frequency of light the same as the sun at sea level. They emit lower levels of UV however, to avoid sunburn. In terms of

clouds, to avoid looking extremely artificial as most implementations of clouds end up being, there will be no low clouds, and instead there will only be very high up clouds, that can stay stationary, or at least not move with the perspective of the viewer, to be able to emulate a more realistic cloud than a flat picture. During rain, a lighter gray shade will be casted. All of these measures in full create a great imitation of the sky for the settlement. Underground, on the large amount of underground settlements artificial skylights in the real sense of the word may be used. Not the massive number of diffuse panels ported from skylights but actual artificial skylights. Even though a majority we spend our time looking down instead of up these days, the time settlers on the Optis do, they will be greeted with something refreshingly ordinary. The Sky.

3.2.2 SEASONS

As a San Diego native, the word seasons means little in the way of actual change in the weather. Mostly it means whether or not I can go to the beach on weekends. It also dictates whether or not I will have to water the plants after sunset due to drought regulations[37]. I feel robbed though, of the symphony of fall, the snowball fights of winter, and the explosion of green of spring. After a while endless summer can get boring too. For the settlers aboard the Optis, a more San Francisco style weather pattern could be implemented. Of course, plants would grow on their own schedule, but temperature and rain (more about this in weather) would change. Snow is a little bit of a challenge, although with snowblowers and a low temperature it is possible to happen, and after melting, could be redone with ice. Seasons will be modeled after the earth, and what seasons are going on back home. If a predictable regular pattern of weather and rain and snow, then trees and other plants that adapt across the year will change themselves to adapt to these new conditions, and will create a sort of pseudo season, where trees lose their leaves in fall, and regrow in spring. The seasons will create a more regular cycle for humans aboard.

3.2.3 CIRCADIAN RHYTHM

This section about the day and night of the settlement. Humans require a regular time to sleep, and for the "sun" to rise and set at around the same time. Temperature must also go up over time, peaking after about 2:00, and falling to lower nighttime temperatures, to mimic the day and night cycle of the settlement. Ambient noise such as crickets or other nighttime noise, should also be piped into the settlement to give the humans aboard a feeling of night. Daytime sounds are more subtle, and against the noise created by humans, it should not be hard to create more animal and insect sounds, buzzing for summer, a slight breeze sound for winter, and more bird and animal noises in spring.

3.2.4 WEATHER

One thing that many people would realize quickly aboard the settlement, is the lack of weather. This section outlines the creation of rain, snow, wind, and humidity. These in themselves should make people more used to the settlement and make it altogether a more realistic environment. Rain and snow can actually "fall" from the top of the settlement, although the majority of snowfall will actually be piped in from the ground layer. What all precipitation needs is a place for it to emanate from give the appearance of falling. Due to the top end of the settlement being comprised of mostly large diffuser screens to create a sky, the only place where this rain can be shot out from is from the spokes that connect through the outer edge part of the outer torus, to the inner core (this is the "small" cylinder in the center

[37] Luckily for me, my family went for desert plants during the drought.

of the settlement). These spokes can be used for all sorts of purposes, because they are the only parts of the settlement that actually reach up into the sky. These are where snow and rain guns will be located to spray snow and rain across the entirety of the settlement. Rain can be shot out at different rates to be able to cover a large area over the settlement. There are spokes all over the surface of the settlement, and these can all independently spray over the settlement covering the full extent of the settlement. Water can be piped through these, through pressurized pumps, and once in motion, will be able to create a good impression of rain. As for snow, snow guns[38] can also be mounted here, giving the subtle effect of falling snow. Most real ground snow can be created through the use of on the ground snow guns, although snow would be limited to smaller amounts of snow about up to 10 inches, but no more. On average, 3-4 inches of snow could cover the settlement. These two effects create an acceptable amount of weather for humans.

SECTION III

FOOD

Humans need to eat. Food is a big part of human life, and this section will outline the creation of food, and consuming. On the settlement in order to stay healthy, a diet of fish and vegetables is cultivated, and small amounts of meat. Fish farms that are improved to be able to produce high quality fish are used to breed seafood, as well as complex robotic hydroponics for the plant matter that really matters, leaves herbs and the such, while grains and orchard fruit are tended to by robotic farmers and an army of drones. Finally, the chicken goat sheep and turkey situation are sorted out, and let's just say there aren't a lot of them on the settlement. So yeah. That's it. No McDonalds or Dominoes. But tons of fresh veggies and fruits straight of robot's metallic fingers? Of Course.

3.3.1 DIET

The first thing to settle about food, is diet itself. In order to have a whole full meal, there are two main extremely healthy diets that will occupy the settlement. The first is the Mediterranean diet, which is based around fruits vegetables grains and legumes that are grown locally, and an emphasis on fish, with sparse amounts of meat. This matches the demographic of the settlement almost perfectly. Large amounts of plants, with fish, and almost no emphasis on meat. The second diet is the Okinawa diet, which focuses on fruits and vegetables, with even sparser amounts of fish and very small amounts of meat. There is also less food encouraged to be consumed under this diet, and sharing is recommended. Starting off with the Mediterranean diet, it starts off with emphasizing different types of fruits and vegetables. It emphasizes natural oils, nuts fish and fresh produce, all which can be created easily with the settlement's available food resources and farming capability. Meats are not really emphasized much, and due to the cumbersome task of meat and livestock capabilities meat itself will mostly be based on lab grown meat for special occasions. Fish farming is possible, and easier than other types. The Okinawan diet consists of high amounts of carbs, although with more protein than the Med diet. It follows the same basic pattern of food needs, although preparation is different creating a different end result and product. Many Sea based plants are the main constituents, followed by wheat rice and other grains, and about 1-2% of meats. Both diets shy away from processed foods, many meats, and animal products, which are the hardest to produce, and rely on fresh fruit, which is easily obtainable by the settlement. In addition, these diets

[38] Snow machines operate on special

are known to be some of the healthiest, yielding extreme health benefits, and longevity, making the health process easier on the settlement. These are the best most balanced and easiest to obtain diets and happen to be optimal for the settlement. Preparation and distribution of food will be discussed later, but the foods available, are mostly fresh preparations.

3.3.2 FISH FARMING

The only way to eat fish on the settlement is to farm them. Many scientists cite farmed fish as being worse than wild fish for consumption. Most of these are because fish are not getting the same diet, or exercise as wild caught fish. Most measures are taken to farm fish because it is cheaper to feed them on a vegetable diet, or to limit their exercise. On the settlement, there is no other alternative to farmed fish, and thus the settlement is optimized to produced high quality farmed fish. This can be done through two ways, the first is to create a cyclone in fishing tanks to be able to increase their swimming rate. The second is to feed them with more meats and other fish. Going through each fish, I will outline the mechanism used to hold them, as well as their diet. First, is Sardines. The Sardines can be farmed on a traditional system, as pictured above, with feed in and waste out as well as a bed for waste collection, and constant water movement through water pumps. This system is almost perfect, although with a bad diet, fish can still be undernourished. For clarification there is a small "lake" (more like a pond) which there are multiple fish enclosures, however each type of fish has its own mini pond. There are 6 different enclosures for each type of fish. This can ensure double rotation for fish like Sardines, and triple rotation for fish like Salmon[39]. Sardines eat Zooplankton, which feeds on Phytoplankton. All needed, for the growth of phytoplankton, is carbon dioxide, sunlight and nutrients. CO2 and nutrients can be dispensed. Sunlight for all these applications, however, is different. An artificial sunlight source is needed. This time, no fancy skylight and diffuse panel is needed, but instead solely full spectrum lights. LED's that can emit UV and Infrared can be utilized, because they can be controlled easily to produce different colors and simulate different conditions. These can be used to grow Phytoplankton, and upon the growth of these, sardines can grow and multiply. Upon another cage being ready, sardines are transferred into it, and back and forth until they are fully grown, and harvested. Salmon feed on excess sardines, and have the same basic layout, although with

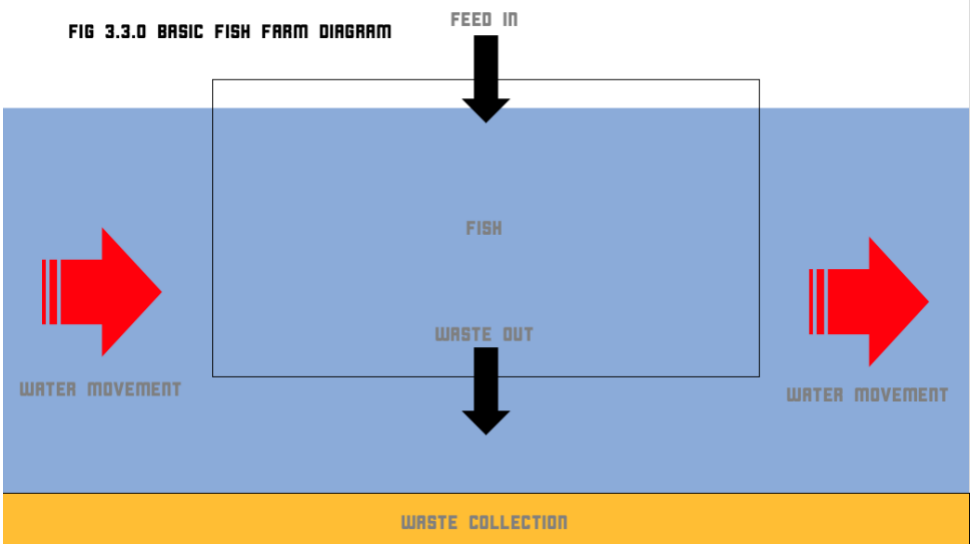


FIG 3.3.0 BASIC FISH FARM DIAGRAM

[39] This is because fish like Sardines only require zoo plankton and phytoplankton to grow, and while these are growing in one enclosure, sardines can be farmed in the other. For Salmon not only do plankton have to grow, but sardines have to grow for the salmon to eat and be fed from requiring triple rotation.

space to grow sardines that are less nourished and not fit for Human consumption (to save resources) but fine for Salmon. This is how salmon are farmed. To farm other fish such as mackerel and tuna, the same strategy is used. Nutrients and gasses are piped in, and smaller fish (mostly sardines because they are the easiest to grow) are piped in for a variety in diet. Waste is collected out the bottom of the cage and disposed. Due to the fact that feed is mostly natural, and not created by humans, it won't drop through the bottom, but most likely be dispersed through the pond. The moving water will be created by a multitude of pumps that route the water through the settlement. The Fisheries will be kept in the central trapezoid structure. Lower gravity will probably not have a massive effect on the fish[40], although to maximize waste collection the fisheries will be kept near the edge of the inner trapezoid to allow some pseudo gravity to function. These efforts combined will create a system which is available to farm all sorts of fish, and by feeding them with diets close to their natural diets, can also produce fish close to wild caught standards to add to the Mediterranean diet.

3.3.3 HYDROPONICS

The settlement will generate plant-based food in two ways. The first is through hydroponics. Hydroponics can be used to grow strawberries potatoes tomatoes mint basil lettuce, cabbage green beans and many other plants that need considerably less space to grow. Hydroponics cannot be used for tree-based plants (obviously) or large plants on the ground. For most other applications however, it can work very well. The way hydroponics work at their most basic, is that instead of growing in a large earthy environment, plants grow in a bed of nutrient water. The major advantages of hydroponics are massively increased growing times and yield, up to 25% faster maturity and 30% more production than soil-based plants. This is due to the fact that plants do not need to work as hard for nutrients, and do not need to expand root systems and instead can just pipe all their energy into upward growth, which is perfect for the settlement. The major disadvantages of hydroponics are all averted by their nature of application on the settlements. Cost is averted by the economics and need for the settlement (see Economics for more about finances of the settlement). The complexity of first-time setup is again averted by this, and finally the maintenance of PH and nutrient levels can be maintained through automation. There are different types of Hydroponic systems, and the ones that will be used are the Ebb and Flow system for larger plants, and the Aeroponic system for smaller plants.

The Ebb and Flow system works by releasing lots of water filled with nutrients at time intervals and then slowly draining it away. It allows during periods of short dryness plant root systems to grow, and then for them to grow larger, and during wet periods for them to be more efficient to suck in nutrients. The Aeroponic system is where plants are suspended in a vapor chamber, and plant roots are misted at certain intervals. This system suspends roots in the air, and small nozzles mist the roots. Both of these systems in conjunction can accommodate for the large amounts of plants needed to be grown.

[40] Fish in microgravity could be able to swim through a 100% humidity air, and not die out of water. These fish are obviously in a tank of water.

In the farms, there are different "greenhouses[41]" each at the same atmospheric conditions, for instance for tropical plants, at high temperatures and humidities, and this is achieved through HVAC and humidifier systems. These greenhouses that represent different climates, also have full spectrum lighting to simulate the sun. These allow there to be conditions ready for hydroponics. Different types of hydroponics mechanisms also exist for different types of plants, and these are alternated through hydroponic systems based on the exact type of plant that will be grown in that specific climate. This combination allows any plant to be grown in any situation. Different types of nutrient solutions are available in large tanks to be piped to the different places they are needed.

Pollination will be a problem, aboard the settlement, due to the lack of bees[42]. For the entire tending process, robotics will be used. This is because there are many different things needed to tend to, such as cutting off bad branches, and pollination through artificial means. There already currently exist robots for artificial pollination, and these can be used for pollination of hydroponics. These robots altered can also be used for cutting and disposing of plant waste. The Pollination robot will include a sprayer to spray pollen onto plants and will have a variety of pollen in its nozzle to be able to produce the required pollination. This robot is relatively simple, and will also include a self-driving system to be able to drive around on its own and navigate to different plants in the greenhouse, it will also include a tank for the nozzle, the nozzle arm itself, as well as batteries[43] to power the electric motors. Camera systems and LIDAR are also needed to identify obstacles and plants that need This is the pollination robot. For the task of clipping different plants and collecting leaves, a different armature is needed, and this is a more precise servo arm that can reach into plants and clip off branches, as well as a low power vacuum to vacuum up the leaves, without damaging the leaves, or the plant itself. For fruited plants such as tomatoes or other plants with fruits, the armature cuts off the fruit, and a small basket is raised from a separate armature specifically designed for fruits and the fruit is deposited into it.

Harvesting and replanting can also be done through specialized robots. As already outlined the pollination robot, there will be a different removal and replanting robot. For perennials, disposal is not needed often, otherwise a robot is used to harvest, and this robot has the same tools as the previous one in identifying and

FIG 3.3.1 PLASTIC MECHANISM FOR HYDROPONICS (CRUDE)

[41] The quotation marks are because these are underground and use artificial wide band lights discussed in the fish farming section for maintaining a set atmosphere
[42] Even with bees, due to the lack of variety in plants, artificial pollination is still needed
[43] Everything in the settlement is Electric. It's all Tesla or Porsche Taycan from here.

removing leaves and fruits, although in this case it identifies ripe fruit. For annuals and dying perennials, there is a separate robot to remove them and plant new plants. This system utilizes a universal planting mechanism. What this means is that in hydroponics each plant is suspended in a pipe of water, or and vapor chamber. In order to make it robot friendly, the seedlings are attached from the nursery to a plastic holder that goes into the pipe or vapor chamber, and the plant is connected to this piece, and once removed the plant comes out with this plastic piece. This allows robots to be able to insert and remove plants through this plastic piece. This is the system used for harvesting and replanting.

All of these hydroponic systems are at the underground level of the settlement, to maximize upper living space, and thus this is the reason that there is overhead full spectrum lighting.

With these various systems and methods for hydroponics, there should be sufficient space to get most of the plant content for both diets produced, and only larger plants as well as livestock remain to be farmed.

3.3.4 AGRICULTURE FARMING

The second way of farming, mostly for larger plants and trees, is through general agricultural planting. This can be narrowed down to orchards, and Fields. Fields are for large plants that need space and cannot be dangled off of a hydroponic setup. This includes crops such as melons squash and corn are not able to grow on hydroponics. Fields are injected with nutrients after each growth to be able to replant and regrow immediately. Nutrients include nitrogen and other plant nutrients that are needed. Most 3 field crop rotation plants are already grown through Hydroponics more effectively, and thus artificial nutrient injection is needed for growth of these plants. On fields themselves, overhead lighting is provided by UV lighting as – like the hydroponics – this system is underneath the settlement's floor. This is again, to increase living space aboveground. The same greenhouse system using humidifiers and an HVAC system to maintain a constant climate for the actual settlement. These areas of plant growth are separated from each other, and from the main settlement to avoid insect contamination. GMO's are utilized heavily on the settlement to be able to produce large crop yields. Contrary to popular belief GMO's actually do affect food, in an overwhelmingly positive way. While some argue they are not "natural", GMO's are really natural selection accelerated. This system allows for much better crop growth, and under all scrutiny's, a better crop. There are no downsides to GMO's and aboard the settlement. Even the Non-GMO project states that there is nothing known about the safety, and doesn't cite drawbacks, and other studies show that it there is no drawbacks to the foods. Harvesting plants due to the annual nature of these plants can be done by specialized robots that – for melons – grip the fruit and then cut off the stem and request a drone to come remove the gripper from its position, allowing large scale melon extraction. For corn and other field type crops, mostly small drones are used for harvesting. Autonomous Drones spray water, nutrients and other essential parts of the farming equation onto plants. Autonomous Robots are used for planting and sowing seeds into the ground.

In terms of orchards, these perennial areas require large amounts of water and other nutrients, and active measures are needed to prevent plants from brushing branches or intersecting each other. These can be done through the help of clipping robots, and drones can be used for harvesting fruits. Small trees imported from the earth are planted in an orchard style, and

subsequently watered. Due to the fact that orchards are planted only once in decades, specialized robots are a waste of space, and manpower can be used for the planting. Harvesting has already been outlined. Orchards that grow well in the San Francisco climate can be planted aboveground due to their aesthetic appeal, albeit in small quantity, while greenhouses with limits on humidity and temperature are used to house the trees in mass quantity.

Through the combination of these systems and hydroponics, the plant-based part of the settlement is accounted for.

3.3.5 LIVESTOCK FARMING

After the previous three systems, all sorts of foods are created, with one important exception, and that is Livestock farming. Fish, and every sort of vegetable fruit or herb conceivable can be easily planted and maintained, and subsequently yielded for food. Meats, however, are much harder to maintain, due to the larger commitment to raising and keeping animals, as well as essentially killing and processing them for use later. In terms of different animals, the only ones really feasible would be Chickens, due to their ease to raise, Goats, due to their ease to raise and hardiness, Sheep because they are similar to sheep, and Turkey as kind of a wild card. Cows are extremely hard to keep on any farm, and require large amounts of food, and waste management. Turkeys and Chickens will be produced on a small basis, and for meat and eggs, while goats will be kept for milk and meat, and sheep primarily for their milk which is useful in cheesemaking, and their wool, which could be used for textiles. Due to the herbivore nature of all of these, they could be kept in similar pastures, and the turkeys and meat chickens are kept together in free roam pastures, (underground and in small quantities aboveground) that although are open, still are mostly underground and lit by full spectrum lighting. Robots can dispense feed for chickens and turkeys. Hens can be kept in special hen houses where while they are roaming robots could remove eggs lain for use aboard the settlement. Goats and Sheep can also be kept in similar larger pastures, and aboveground as well. Waste will most likely be composted in both scenarios, and the basic feeding and exercise can be carried out by autonomous robots, although humans are still needed. Special types of grasses as well as large amounts of water are needed to sustain large pastures, which is why smaller pastures are used, and a smaller volume of animal's graze on them. Meat for killing, happens infrequently, and once it happens is processed and sent out fresh to consumers aboard the settlement, but only happens at specific intervals, about once or twice a month, instead of on a regular basis. Meat really is a novelty. Lab grown meats may be pursued, but due to the cost of the technology right now, it is hard to tell when it will become feasible, and instead low volume will be used. Eggs and limited Dairy are the main animal-based products. In the specific diets chosen, this makes sense, because the diets use less meats, and more fish and vegetables, and thus should fit in with the rest of the settlements diet.

SECTION IV

WASTE MANAGEMENT

Waste is a part of life, and it needs to be dealt with aboard the settlement. This section will deal with reclamation, as well as processing of different types of waste aboard the settlement. With 1,000 people, it's bound to get a bit hectic. Also, that industry really isn't helping. With a solid from the ISS that deals with liquids and a microbe from Penn State that changes feces into well food, (for animals) waste actually might be going somewhere. Farther than down

the drain that is. In terms of industrial, cool gasses that ignite, glow, react, and kill you are kept in snazzy storage containers, and complex gasses are broken down into simpler ones. Bigger is not better in this case. The last section outlined what goes in, and what goes in must come out (or is the saying what goes up must come down?) and what comes out is used pretty well I must say.

3.4.1 HUMAN AND ANIMAL WASTE RECLIMATION

While not the biggest source of waste on the settlement, human and animal waste still makes up a significant portion of the waste aboard the settlement. Solid and Liquid waste can both be reclaimed or disposed in the same ways that they are in the ISS. First focusing on Liquid waste and water through sweat and other means, this can be reclaimed through the use of the water portion of the ECLSS system aboard the ISS, except in a much larger way. The ECLSS uses filters that can catch water from the air, as well as urine to be able to convert both of these into drinkable water. In order to filter waste from liquid and solid, after claiming human waste, filters are used to separate solid from liquid waste, and extract water from remaining solid waste. After this, it is passed into the ISS style vacuum distillation chamber which spins a centrifuge to use density differences and create a difference between gasses and liquids, as well as separate them to make it easier to separate. This is then fed into a filter which removes particles and other waste. On the settlement, it is also fed through a reverse osmosis system for maximum filtration, and to eliminate possible waste that entered the wastewater. This system also has input from industrial waste sites (from the central industrial area) as well as from the atmosphere from atmospheric waste reclamation[44]. These means may have extra molecules and pollutants due to the nature of the origin of the wastewater, which can be removed by the process of reverse osmosis. All wastewater is routed to the central hub (this is the "trapezoidal" part of the settlement in the center, which is used for industry and storage) which is where a bulk of the water reclamation systems are. There are some systems on the outer torus, which are only used for small volume uses too keep a certain amount of waste on the settlement at an acceptable level.

As for solid waste, there is at least one interesting possibility for what it could be used for, and this is wide scale feed for animals, and in this case possibly fish, being able to divert more resources towards humans. This system first discovered at Penn State, uses a bioreactor to degrade feces into its constituents of salt and methane, and the methane produced is used to grow microbes, which grow extremely fast and consume most of the human waste. Using calculations of about 500 grams of human waste per person a day, and the targeted 1,000 people on the settlement, this creates about 500kg's of solid waste per day. While this seems relatively large, this is a small enough amount that it is easy enough for bacteria to break down and convert into food, and according to the researchers they can change about 96% of materials into food for animals, and if cleaned properly even for humans. In addition, some of this solid waste can be used for plant matter and can biodegrade in these orchards. Animal waste can be integrated into the pastures that make it up, and also if there is too much excess, microbes will work on it. Microbial plants are stored underneath the settlement floor, as

[44] If you remember, the atmosphere has to actually be kept at a certain humidity to ensure that the effects of heat and other trapping methods are working properly. These methods are actually used to help keep the purity of the water in the atmosphere at a certain level. Sensors are still able to keep the water at a certain level that is needed for the heat trapping to work properly.

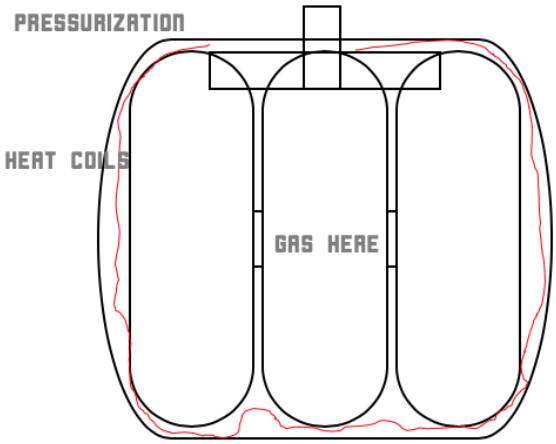
moving solid waste is harder than moving liquid waste that could be routed through plumbing systems.

With these combinations waste – both solid and liquid can be transferred into usable materials, other human waste due to the low amount that exists, can be biodegraded.

3.4.2 INDUSTRY WASTE RECLIMATION

Due to the nature of the settlement, industrial waste is low, mostly warm water from cooling systems, and byproducts such as chemicals, and due to the fusion reactor, any process that creates less waste at the cost of extra energy required is used. Carbon chains, complex molecules and molecules that are produced by industry can be routed into storage silos for alternate use, or through intermediaries can be broken into constituents, or more storable conventional materials, for long term storage or converting into new materials. Solid waste such as metals and plastics can be melted down into storage blocks or torn apart. 3D printing is a major part of the Settlement's infrastructures, so in general apart from laser cutting, this should be low waste. Converting materials through electrolysis and chemical byproducts are usually basic molecules, or volatile enough to convert easily to products that are easier to store such as ammonia, water, or carbon dioxide for long term storage or nitrogen hydrogen/oxygen and carbon respectively. Alternate more "valuable" chemicals such as helium argon and other gasses and liquids are mass stored, and industrial waste is converted into its basic elements and molecules to be stored with the rest. Large gas containers store this material and keep it at a set pressure and temperature to ensure that it stays pressurized and in a constant location. Heat coils maintain temperature, and pressure is maintained by vacuum pumps. The entire storage part of the settlement is in the antigravity portion of the center of the settlement, meaning storage of any liquid or gas easily. Toxic industrial waste may be released into space, if it's to toxic and stable to be converted.

FIG 3.4.0 PRESSURIZED GAS STORAGE



3.4.3 TRASH AND AVOIDING POLLUTION

The settlement only has one life, and this life should not be wasted on trash. There are no landfills, and thus major sources of pollution must be averted. Due to the fresh food situation, and the small area of the settlement, this means that pollution from food acquirement and food sources can be easily averted and reusable means can be used. Reusable glassware is used to transport drinks and other substances that are not foods into and out of settlement. Pollution from plastics and other substances shouldn't exist, because waste reclamation centers can reuse broken things. Food waste is biodegradable, and can be put back in as solid waste, although portion sizing per person makes food waste less. Ground waste is not a big issue, as the settlement is revolved around everything being re-usable. Any plant or food waste is biodegradable, and any other waste can be reclaimed and reused.

CFC's can be mitigated by outright banning them, although there is no ozone cycle, air pollution could be deadly, so all toxic chemicals are dealt with inside of the settlement's inner core, in separated airtight chambers where they can be released safely. Sensors are at all times sensing the air for pollutants and byproducts of chemical reactions that could be deadly and being ready to alert the settlement's population to wear gasmasks or disperse chemical agents to react with the pollutants and propagate towards the ground for collection. The air is recycled through the vents, at all times, and every couple of days, a completely new set of air has been renewed, and this has all been filtered through and perused by sensors for pollutants.

There is some water on the settlement (as outlined in the Nature section), and due to the absence of industry, should be pure. Algae blooms can be stopped through natural means, and the absence of large amounts of algae in the first place. In general, most types of pollution on the settlement can be mitigated. As for the smaller types of pollution such as visual, noise and thermals, building codes are extremely strict and regulations should mitigate the latter two.

SECTION V

HEALTH

Settlers aboard the settlement deserve to be healthy and happy, after all they chose to be on the settlement instead of on the earth where they could be enjoying their lives more fully, and this section is dedicated to keeping that dream alive. This section starts off with General health of the settlers and continues with general medicine of the settlers. It continues on with the hospitals and the situation around them, and how the settlers are able to be treated.

3.5.1 GENERAL HEALTH & MAINTAINING HEALTH

The Health of the settlers on the Optis is the top priority of the settlement, and without this there is no purpose for the settlement. Most articles and research about space and general health in space have to do with the effects of microgravity, and this is only really a problem in the Optis when the situation of the scientists and maintenance workers that man the central torus. Other than that, the psuedogravity of the Optis negates most of these effects. Settlers that do enter the central torus, can only do so for certain periods of time, and must exercise afterwards. In terms of radiation shielding, the settlement already has an adequate shield, able to block most types of radiation, and so this effect is already mitigated. Most of the effects of space that are physical are mitigated. As for psychological aspects, living on the ISS seems to not have any serious psychological effect on astronauts, and in the same fashion, the Optis is even closer to emulating the Earth, and thus psychologic effects should not be extremely great. In terms of general health, those with pre-existing noncontagious conditions, are allowed onboard, although those with severe conditions should not be allowed on. The first wave of settlers should be fit and healthy to be able to mitigate the job of the health personnel until the settlement is established, and then all individuals can come in. Diet based and food-based ailments such as obesity, overweightness and the negative illnesses that come with that, are mitigated by the diet of the settlement. Settlers have the metro, (discussed in the next section) although are encouraged to walk, and on certain days due to the small size of the settlement, the metro is turned off. The settlements small size makes walking all the way around it a very manageable task and thus there is only one metro ringing around the entire settlement. Exercise gyms exist and are open to all settlers. Settlers that develop autoimmune diseases

that are too severe for the settlement to control can be relayed back to the earth, or if they are less severe, can live out on the settlement. Hospitals and other establishments will deal with these in a later part of this section. Vitamin supplements are also available, although most of the settlements diet accounts for this. Checkups are provided each year, and settlers are heavily encouraged to use daily health apps that track health every day. They can also set up appointments if the need to get certain things checked.

3.5.2 GENERAL MEDICINE

In terms of medicine aboard the settlement, medicines will be available on a prescription basis, with very basic medication, for sleep regulation and other normal conditions available over the counter. The reason for the limited availability of, for example Cold Medicine, is that even though with an automated prescription system one can request and gain access to one quickly, it needed to track the spread of diseases on the settlement (later explained in a later part of this section). Automated prescriptions are for smaller normally over the counter prescriptions that control disease. Medicine can be mixed with chemicals obtained from the inner core, and in times of need, can be mass stored for easy dispense. Medicine and all health-related parts of the Optis are free. Denying medicine or health behind money, is like paying to live. It is morally and ethically wrong to charge for any medicine or health related product on any world[45], and on the settlement this natural right of humans. Medicine that is too hard to create aboard the settlement should be imported from the earth using funds from the settlement. Citizens that take prescription medicine (yes including Tylenol type medicine) have to record their daily doses to avoid overdosing and also to help keep track of their health on the settlement. A large database is kept tracking sleep, exercise, diet and medicine of every settler, and this is integrated with all medical related causes. In the hospital aboard the settlement, all needed medicines for any possible ailments are kept. Serious disease medicine can be mixed using basic chemicals.

3.5.3 HOSPITAL SITUATION

In order to have an effective central management of the settlement, there must be a central hospital that also can be a hub for medical research and outbreak info. This is an underground establishment, although still connected to the main part of the settlement, through a tunnel. The hospital as aforementioned contains enough spare chemicals and stored chemicals to be able to easily and reliably mix all substances necessary and do so easily. It also has the full cohort of needed equipment for a hospital, with no major drawbacks. It has a manned person count of about 10 people (this is a 1000 person settlement), with 20 people working on monitoring the health of the settlement, or other health related but less involved tasks, although can be called on and are in the same building as the main hospital. This hospital is mostly used for people that are either injured (more likely) or sick (less likely) as all hospitals, although all people are required to take at least one check in exam each year with an additional one recommended. Two people work on check in, while the rest of the personnel work on dealing with injuries and providing for procedures that are needed aboard the settlement. This area has active X-Ray and other equipment and is shielded. Hygiene is provided by general scrubbing and automated cleaning of the settlement at all times. In

[45] According to John Locke the natural rights are Life Liberty and Property. (called the Pursuit of Happiness in the US Constitution) In order to live, one must be healthy, and so health is a natural right as health is life. Under this, medicine and health services are key to life, so access to these resources is also a natural right. Natural rights should be provided to the citizen as part of the Social Contract of the government. Hobbes, Locke and Jacques all support this view. This means health and medicine aboard the settlement should be a moral right of citizens and is therefore free.

general, the hospital is disinfected, and any new pathogens are immediately researched. The hospital also deals with disease control. While Common colds and other types of Rhinoviruses are bound to make rounds, more serious sicknesses upon being found out, the entire population will be tested, and any positives will be quarantined in the hospital until recovery, or if too severe will be ferried back to earth. During periods of disease the entire settlement will be cleaned multiple times a day, and settlers will be forced to screen multiple times thorough the period of the breakout. The disease cure or any form of mitigation will be easily and openly accessible, as well as prevention immediately dispatched to all settlers[46]. In all forms, the medicine and resources of the settlement can be used, although for serious injuries or diseases, relay to earth is recommended. In general, however, the settlement is well equipped to keep a crew of about 1000 alive and healthy, minus serious conditions.

SECTION VI

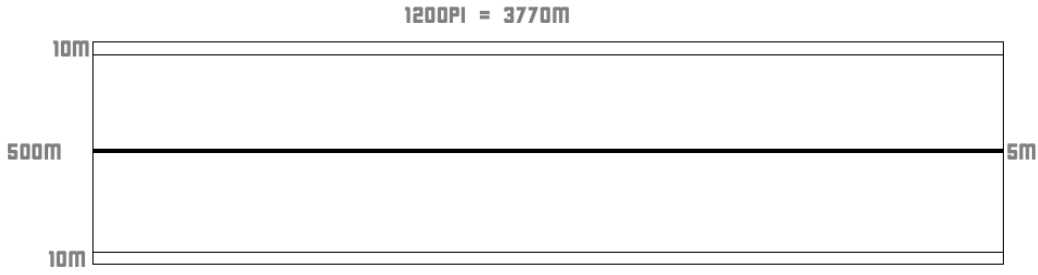
POPULATION AND RESIDENCES

The Optis has a set population. This population of about 1000 people must live over a certain area. The way that people are distributed, as well as the homes they live in is what this part of the settlement is about. This part of the settlement also deals with the other allocations for the settlement such as businesses, transportation, and in general the layout of the "city" type of the settlement.

3.6.1 LAYOUT

The basic layout of the settlement relies on three aspects. The first is residential areas, the second is business areas, and the third is natural landscape. These are all tied together through transportation. Residential areas are clumped together into two neighborhoods, and businesses are between both (on both sides due to the curvature). Looking at the empty diagram, the 1.885 Square kilometers[47] of space looks larger than it really is. In reality, some space is cut off, like the edges where 10 meters is left on each side for utility along the edges of the settlement, and the middle band of 5 meters which is left for central transport. The first thing to look at, is the space allocated for the different housing establishments. At about 1,000 people with a targeted demographic of about 4 people per house, with some apartments, 300 houses and 200 apartments should be a reasonable number for the settlement to support, minding that the apartments are designed for 1 person. 2 or more is for housing. There are 2 person houses, 3

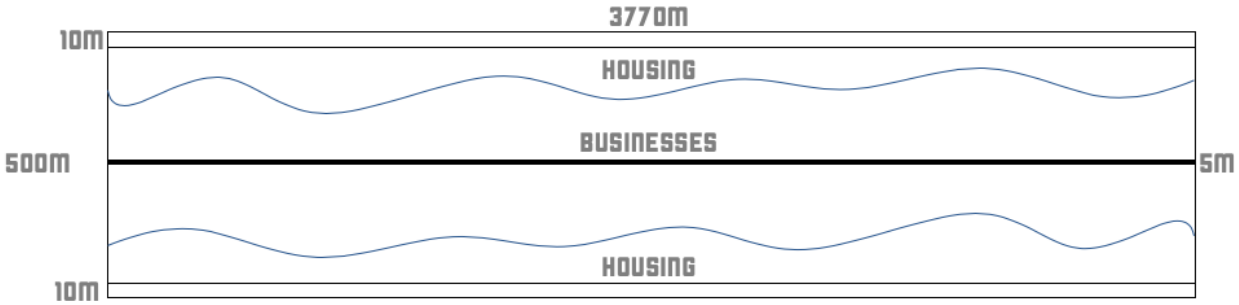
FIG 3.6.0 DIAGRAM OF EMPTY SETTLMENT



[46] Anti Vaxxers are not allowed aboard the settlement or forced to convert.
[47] This particular number makes the settlement look small. It has about 1.8 million square meters of space. That's about 20 million square feet, or about 20,290 square feet per person if divided evenly.

person houses, and finally 4 people, and these are all mixed in together, although this will be described later in the next section. If not, enough housing is available, some apartments can be combined to form larger spaces. Basic parameters show about 20 meters by 20 meters per 4-person house, 17 by 17 for a 3 person, and 15 by 15 for a 2 person (the metrics of apartments will be described later. If the entire settlement were to be made of purely 4 person houses, it would create about 120,000 meters of space, with no backyards. Backyard space and more will be discussed in the residential section, but what needs to be known is the sizing. Each 4-person house will be in total 35 by 35 meters, 3 person 30 by 30 meters, and 2 person 27 by 27 meters. This means that all houses will have ample backyard space. I will do calculations with the 35 by 35-meter number, because the unused space will be used for rolling hills, as well as spacing between the different housing to preserve beauty. 15% additional space will be given for this purpose, and for parks and other establishments within the residences. 35^2

FIG 3.6.1 DIAGRAM OF DIVIDED SETTLEMENT



is about 365,000 and adding 15% makes it 422,625 square meters in total for the neighborhood of houses. The apartment buildings each are 50 meters by 50 meters and can house 10 apartments, so 20 are needed. 15% is added to this for extra space. 50,000 square meters times 15 percent is about 57,500 square meters for the apartments. The way the settlement will be lain out is by having the ends as housing, and the center part as business and recreation, with the obvious large amount of nature sprinkled through both parts. This is so assets are concentrated at the center of the settlement. This is also where the central metro is.

Business areas are populated by different types of buildings, each with their own purpose. Most of these are stores or areas of similar fashion. There are also research areas and the central hospital in this area. This is mostly for places that people can congregate in and also includes space for nature and waterways. Business is concentrated close to the central metro and in general this is the place for humans to spend their day away from the residential areas. This is the way that the settlement will be divided up for population to inhabit.

3.6.2 RESIDENTIAL AREAS

The residential areas consist of two parts. Housing and apartments. Houses are in a modern style and represent contemporary architecture. They are large and spacious, with lots of open space for people to enjoy. Houses have their 35 by 35 meters all the way down to about 25 by 25, and around them there is space for paths, and other infrastructure. This includes lakes and pools, as well as greenery and grasses. There are also pools distributed throughout the settlement, for use on hotter days.

In terms of the different houses, the owners of the house can design it themselves, and get it built on the property, and basic needs will be provided to the owners, although modern 21st century contemporary design is suggested, and a height limit of 8 meters.

The apartment is built of a large building type establishment, which is close to other buildings and establishments. It is a 4-story building, and each floor contains a 3-room apartment, 2 bedrooms (one is designed as a study) and 1 living room, with 1 bathroom. The apartments are compact, and each floor can support multiple different apartments.

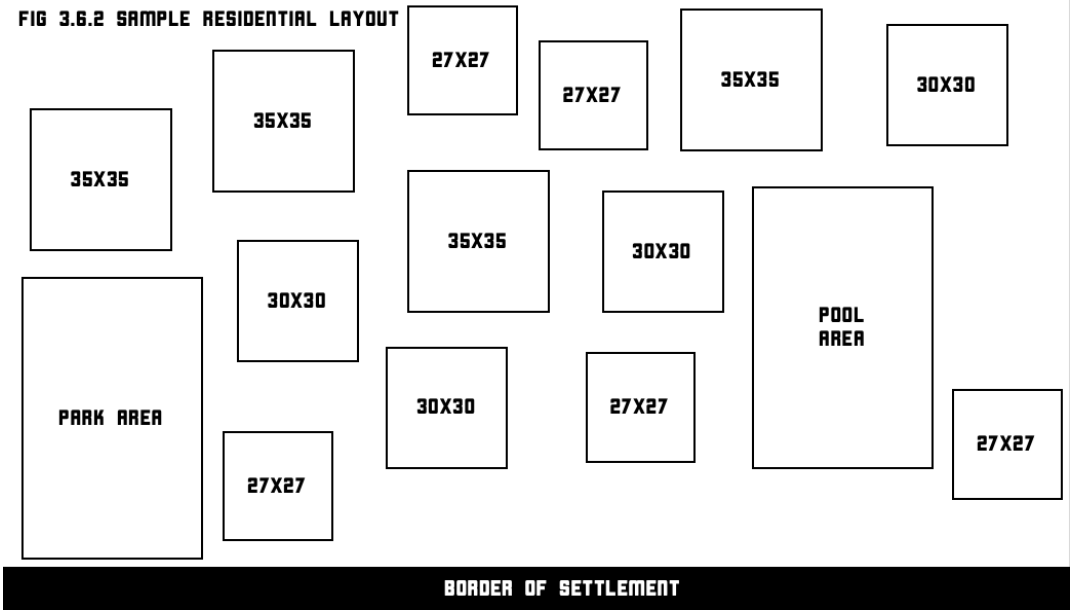


FIG 3.6.2 SAMPLE RESIDENTIAL LAYOUT

The buildings, due to their limited size, are in large complexes not unlike the apartment situation on earth. They include greenery in a sort of "courtyard" in the center of them all, and a large swimming pool and other amenities close to the apartment building, except supersized due to the concentrated population.

The houses are distributed across the 422 thousand square meter plot and can be shown here. They are not structured extremely rigidly, because there are no cars needed. Due to the small size of the settlement, walking at the maximum 250 meters, or about 3 football fields will get you to the central metro which with an additional 250 meters can get you to anywhere on the settlement. This will be discussed later but is the reason no real other transport is needed. Of course, there is a sidewalk between all of the homes, but they are otherwise scattered rather organically[48], with public pools and parks available. Due to consistent architecture, and the way the buildings are constructed with contemporary architecture, there should be visual appeal to the layout of the settlement. The housing area extends out about 125 meters from the base of the border of the settlement towards the center, leaving an even 942,500 square meters for housing[49], and 942,500 meters for business. Apartments are concentrated in a smaller part of the settlement towards the border of the settlement. This is ample space for lots of space and extra nature. Houses themselves are relatively similar in design and due to

[48] The diagram uses meters to show property 35x35 is 4 person house 30x30 is 3 person, and 25x25 is one person.
[49] Keep in mind there are large gaps between houses, and there are parks pools, and open spaces between houses to increase morale, and boost the greenery.

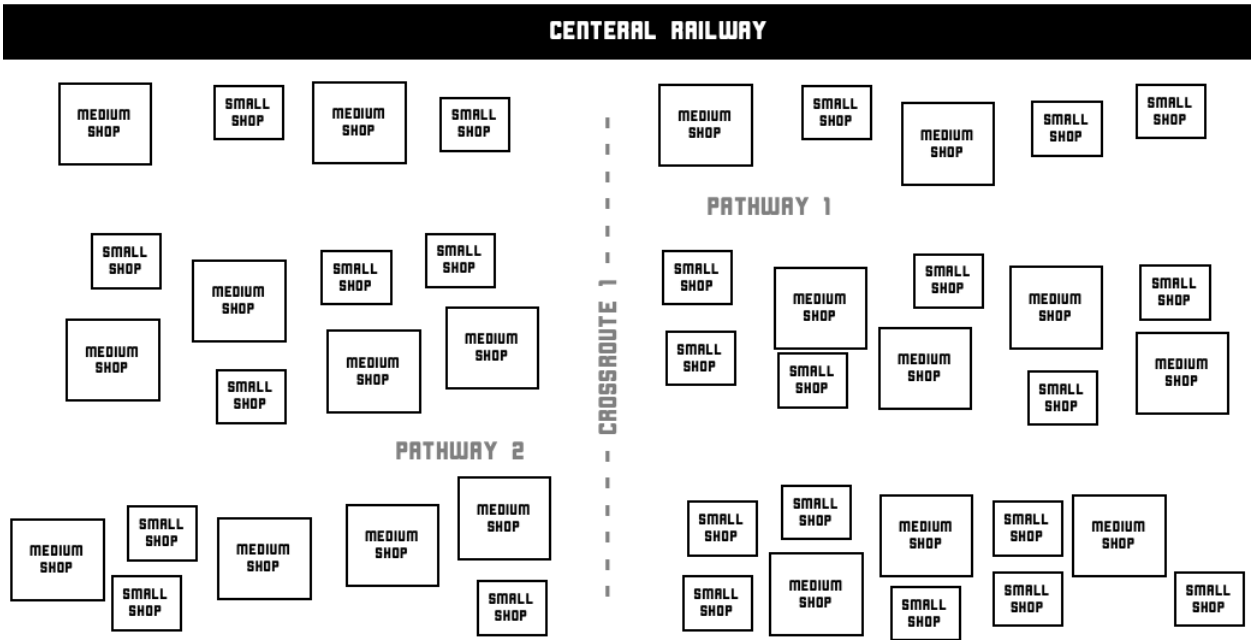
the redundancy of the builds, a settlement-wide GPS is in place to track location, as well as a large number of signs and direction posts for getting to different places. Spokes of the settlement can sometimes transport people to the inner core (central part) of the settlement, and these have stations and a clearing around them to allow people to queue to enter the elevators that carry setters to the inner core. Nature is a significant part and so are waterways, but these will be described more in the section about nature. Parks and Pools, as well as open space, is to create spaces for people to enjoy the settlement on time away from their house, and exercise. Parks include a multitude of game courts such as tennis, soccer, American football, badminton, volleyball, basketball, and other games. There is a sports stadium with seating for 800, that has a field that can change based on the game being played. It achieves this through a milled grass lawn with painted lines for different sports, and lights that illuminate which lines are used, as well as support for – for example – a clay tennis court that needed to be added to it. This stadium can be used for any gatherings. This is in the residential area, but other congregation areas are in the business part of the settlement. All settlers are at the same level in terms of housing aboard the settlement. If a councilmember is single, they will live in an apartment. If an exterior maintenance worker has a family of four, they will live in a 35 by 35 house. On a side note, at 25*25*10.7639 = 6727.44 square feet. Due to the double stacked building size, a theoretical 13.4 thousand square feet max, although due to the modern design of the house, the actual house square footage could be less than half of that. At 45% usage[50], the house is about 6054 square feet. For comparison, the average size of a house in the US (single family ~ 4 people) is about 1600 square feet. The settlement is an extremely luxurious place to live in terms of home size. This is because if the settlement was utilized to its full area, there would not be enough resources and food production for the settlement to be able to accommodate the people aboard the settlement.

3.6.3 BUISNESS AREAS

The second major area of the settlement is the business area. This part of the settlement is where people work, eat, and enjoy their lives with others aboard the settlement. This includes Office type buildings, although still with a contemporary touch. These more utilitarian buildings are around the edges of the business area and prioritize expanding over a larger area than increasing vertically. The max size for a building is about 3 stories. This is to avoid there being too many tall buildings. There are green belts towards the center of the settlement, and these are gaps in the office buildings, which normal citizens can use to enter the center of the settlement. Around the center is the downtown area of the settlement, where building height is one floor, and many shops and restaurants exist around the epicenter. This central area has ambient lighting and is populated at night and manned at all times. In the diagram, there are two types of shops, small and medium. These two types of shop dot along 4 pathways, which are shown in more detail in the below figure, (the below shows the downtown area in more detail). This figure shows the 4 different pathways that can be taken in order to move along the settlement. They are surrounded by shops and create a space for people in the settlement

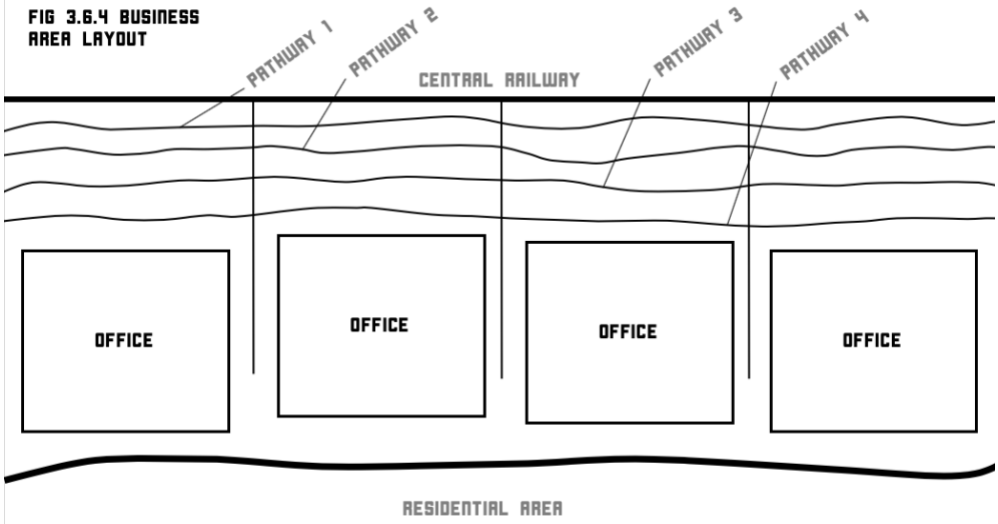
[50] This is because 35x35 is the entire property size. It is the house + driveway + garage, which is why .45 is used to denote how much of the property is used for the house.

FIG 3.6.3 DOWNTOWN LAYOUT



to hang out and peruse shops. There are also multiple straight causeways that go directly between different pathways and the office spaces in order to provide space for different people to move along the different pathways. This creates an atmosphere where there is a set place for citizens to shop and have fun, and a separate place for offices, and both are differentiated and able to function separately. The shops are placed organically along the different paths along the settlement, and this is to create a nicer environment, that is not mechanical, and fits with the dynamic of the rest of the settlement. These different measures ensure that there is a lot of space for people to live and work. The business spaces are allocated out but rented individually and built to specification of whichever shop utilizes the space, which is why architectural diagrams of the different shops do not exist.

FIG 3.6.4 BUSINESS AREA LAYOUT



3.6.4 TRANSPORTATION

Transportation aboard the settlement is fairly simple. As mentioned in a previous part of this section, If you live on the exact border of the settlement, it is only a 250 meter walk to the

central metro (called railway in diagrams) and this metro can carry passengers all along the entire settlement, where again if they have to visit a border house, it is only a 250 meter walk. In total, the max round trip walk is 1 kilometer, and for most will be less. This is why no major form of transport is needed apart from a central metro to dish passengers along different parts of the settlement. This is the main part of this settlement. While Electric scooters will be available, as they are in many major cities, at any given time about 500 will be available anywhere on the settlement, and these can charge, they are not the main form of transport, and only for those in a hurry. The metro is actually a maglev train, although it will not need that speed, as it will move relatively slowly due to the small size of the settlement. It is, nevertheless powered by maglev technology piped from the fusion reactor, and this levitates a train which is about 5 cars long, with each car being able to hold about 40 people. Although held on a maglev, the train is modeled more like a subway car with the layout being a standing design with benches for sitting, and this is due to the fact that the settlement train rides are relatively short. This ensures that all settlers are able to get to where they need to fast and on time. One may bring up the point that the cars can only carry 200 people max in a 1000 person settlement, and this is because due to the fact that people come and go at different stations, and the subway/metro comes back around from a full circuit of the settlement fast enough, that this smaller volume, will probably never be fully utilized. Each car can move independently, and because of this effect, at peak times, all five cars can alternate between stops, and at minimal times, only one car is needed and the other four can be stored until peak times. This also means they can perform individually and cycle around different stations at different times. All of this adds up to a fairly robust transportation system which can move along and ferry passengers. This tram is designed almost exactly the same way as a modern bullet train, although optimizing space over aerodynamics, because of the practically unlimited energy aboard the settlement and being able to maximize the speed that the train travels at.

3.6.5 NATURE

The final part of the population of the settlement, is the use of plants and other natural aspects will be integrated with the rest of the settlement to create a system which makes settlers feel at home. This includes different types of trees, as well as grasses and bushes. In terms of trees, to compliment the contemporary architecture and layout of the settlement, birch trees, maples, and bamboo will be used to create a modern feel to the settlement maidenhair trees will also be used for bush type uses. Boxwood will be used for bushes, as it is a plant that can add to the modern feel. Other less contemporary plants such as willows, and waterfront plants will be used to create landscapes for what is needed. Water landscapes such as small ponds and other water features will be peppered across the landscape, and used to create a feeling of home, and natural landscapes. Small rivers and rapids will be created with pumps and plants. Small animals will be released into the “wild” and the wild ecosystem will dictate their behavior and survival. These include frogs, fish, and other smaller types of fauna. In general, a pallet of different types of aspects of the settlement will be used to create a variable landscape which can support a wide variety of plants and animals. Nature is emphasized because it makes settlers feel at home. Dirt is shipped from the earth, as well as composted. Feces can be used as compost once treated for bacteria and smell. The nature aboard the settlement is made up of smaller plants, and more large plants as well as grasses which can help lower maintained for what is essentially the “public” part of the settlement. In terms of water, water is shipped mostly from earth due to the complexity of creating water in space, and this can be

used to water plants, although they will mostly survive through the use of situated rain and occasional water spraying instead of a constant source of water. The color white will be used a lot in housing and architecture, creating the feeling of openness and spaciousness, but in more natural areas, more brownish hues will be used to emphasize the feeling of earthiness. Plants are all around the settlement and they are complimented by a bed of buffalo type grass[51] for less maintenance and water needs and can survive in less rain. Pathways of concrete, wood and even dirt crisscross through the natural landscape creating an open landscape which can be traversed. Paths connect houses and all houses are built on a bed of the natural landscape of the settlement, in order to create a feeling of being immersed in nature. The response of the nature to the artificial sunlight's should be fine, due to the same full band sunlight being able to emulate an actual sun. Waterways will have benches and other infrastructure around them to help settlers enjoy them to their full value. In general, the settlement should have ample space for nature to be able to fill every nook and cranny of the settlement, making it feel like the earth.

SECTION VII

GOVERNMENT AND ECONOMICS

In light of the current political climate of the US[52], the Optis will function more like a large town than an actual city, let alone country. With a projected population of about 1000 people, it's about as much as the settlement can really function as, due to its relatively small size. Nevertheless, this section will go over the government and ruling body of the Optis. The next section will go over the money, and monetary part of the settlement and how economics work and are tied back to earth.

3.7.1 GOVERNMENT AND LAWMAKING

The government for the Optis relies on different bodies. Like in many earthen countries, it includes two branches for both Administering and Carrying out laws. This includes a Council for lawmaking and approving different measures, as well as a minister for administering over the population of the settlement. The council is 5 people large and is voted for by the population of the settlement every 6 months. Due to most actions being non-controversial, the council is also advised by a team of scientists back at home on earth, and also on the settlement. Since most decisions made on the Optis are for the good of the settlement itself, the council is very founded in science itself. There is a Full Transparency Protocol aboard the settlement, where every decision, as well as the plans for every planned revision and piece of software is available open source. This is due to the fact that by allowing society itself to peer review everything that happens within the government and every technological aspect of essentially their world, is their natural right. While one could argue that we don't know everything about our earth yet, the earth came out perfect for us[53] and isn't really planning on making decisions about much that we don't know about. In fact, the only real major change aboard the earth recently is one that needs more attention. Global Warming. On the

[51] Unfortunately, this grass can grow up to 3 meters without tending to, so it will probably be tended to in order to keep it at a generally good height by robotic means.
[52] Whichever side you support, the country is not unified.
[53] Technically we came out perfect for the earth thanks evolution!

settlement because it essentially a "planet" for these people, if they search, they should be able to easily find any information they need to know about the settlement. In terms of the constituents of the actual law enforcement, which carry out council wishes, it is constituted of mostly some officers about 20, as well as many methods of surveillance[54]. The main job of the council and minister is for making decisions as well as communicating the wishes of the settlement's population to the actual earth. The Minister is elected every year by popular vote, and only looks over the population and approves new laws, as well as talks to and realizes what each citizen wants and negotiates with world leaders to get resources and pensions for the settlement.

Due to the seriousness of crimes on the settlement, and the possibility of terrorism aboard the settlement, police must act quickly to be able to subdue threats. infrared and X-ray cameras can be deployed quickly, and constantly survey the part of the settlement under the bottom floor, to stop the possibility of bombings. Justice can be divided into three sections, Misdemeanors Felonies and Anarchist. Misdemeanors are smaller crimes that break smaller codes and don't really set the settlement back, and they are more like a slap on the wrist, than anything serious. Felonies can be anything ranging from stealing to murder[55], and are dealt with due to the severity. In the first "trial"[56] stage of the settlement, any felony crime is an immediate "back to the earth", and charges are dealt with whichever country wants to press them[57]. Suspects are detained immediately due to the severity of crimes. Anarchist type crimes are mostly Terrorism and settlement destruction are immediate detaining, and trial by military tribunal aboard the settlement and usually death. Juries are the Settlement Council, and only are for anarchists, as suspected or convicted felons are instantly extradited, and if wrongly accused, then can return with a compensation to the settlement. The immediate extradition upon arrest is due to the fact that any crimes are extremely bad for the settlement.

3.7.2 LAWS AND CODES

This section will look over basic laws and codes, as well as the rationale.
Main laws mirror the laws of the US, although with an important exception in the change of protections for those that are under suspect, because of the severity of crimes on the settlement. Amendments can be made to the code, and within the first year the way that the citizens want it shaped it is normally changed.

3.7.3 JOBS

The jobs aboard the settlement range from administration of the settlement, to the maintenance of the settlement. A majority of settler's work jobs that have to do with the management of the settlement. Due to the necessity of the different jobs, a semi socialist system is used, where the population gets a similar base salary, although bonuses are awarded

[54] I am just as "No Prying" as the next person, although if your planet is made by humans and needs to be monitored at all times, then there will already be cameras ready for sensing different aspects about the health of the settlement, and crime could have a massive effect on the settlement, so surveillance is justified.
[55] Due to the handpicked and mostly scientific nature of the first passengers on the Optis, the day a serious crime is committed is a serious milestone for the widespread availability of the settlement.
[56] This basically is when the settlement is first deployed
[57] The first and most Optis' surrounding the earth have widespread Extradition treaties, and if the perpetrator blocks extradition the judicial system of the victim is defaulted to.

very generously to those that do more work[58]. Either way, most unspecialized jobs are automated, and most jobs have people that are specialized. Education is provided through a central school from Preschool all the way to 12th grade, and after that all must take apprenticeships in place of colleges on the settlement. Going over the distribution of the different jobs on the settlement, the Government needs about 30 people, Law enforcement needs 40 people (Active and Desk Based) Food production needs about 70 people, Medical needs about 50 people, both nurses and doctors. Settlement Improvements the Harder Better Faster team,[59] will use about 600 people. This is by far the largest group and has subgroups. The first is the Protection team, which asses the exterior of the settlement. They also devise improvements and possible new amendments to the settlements outer shell. The Scientific team runs experiments on both the inside and outside of the settlement. The Robotics team deals with all autonomy and works closely with the Satellite team which monitors and controls the different spacecraft that are doing work with the settlement. After the Harder Better Faster Team, there are independent business and think tanks, as well as individual scientists that are conducting business. On the first settlement, an allocation of about 100 people is left open, first as a buffer if systems overload, and second of all as space for space tourism, which is where some independent business could capitalize.

3.7.4 CURRENCY

The Socialist nature of the settlement (described later) as well as the recycling of money, and lack of banking and other money establishments, means that currency flows often and needs a value. For this, the settlement uses a currency that in value is pegged to the USD and although the settlement has reserves in hard currency to back this up, the basic currency on the Optis is not USD, because the economics and finances on the settlement work differently, to not disincentivize certain careers. This means that the Optis has a different currency that inflates at the same rate as the US currency, and as the settlement becomes more profitable against the earth, and the GDP of the settlement increases, all citizens become wealthier in USD. To avoid over inflation, taxes increase as the value of the GDP increases, and can be used to improve the settlement, quality of life, and general quality of different things. This means that as the GDP increases and the settlement generates more revenue, the population general cash on hand and quality of life increases. Onboard the settlement, due to the semi-socialist system, food is free, and so is healthcare as well. Transactions are provided through luxuries from the earth, which means that because of basic needs being payed for, more people can buy what they want, and in general currency is not needed as much on the settlement.

[58] People that work harder, not people that have more complex jobs. All jobs are necessary on the Optis.
[59] Originally the name of Part VII but was nixed, and decided to make it part of the main occupation of the Optis.

Part IV

SURVIVAL OF THE FITTEST

With the plans for the settlement lined out, and living on it with required materials ready, all that remains is the plans for how the settlement will acquire materials that it needs to be able to function, not only from earth, but also from space. This section will include things like Asteroid Mining and the way that spacecraft leave and enter the settlement. It will outline the design for the different satellites that enter and leave the settlement, as well as the design for the different hatches and ports they use. The part will first go over the way that different craft enter and exit the craft. It will then go over the way that they are fixed and refueled. The way that Human craft are dealt with is different completely, and this will be discussing as well. The next section goes over the different ways that the settlement acquires most of its materials. From the earth. The settlement uses not only the space elevator, but also other different, methods to launch towards the earth. The next section is about the way that the different spacecraft are created and designed. Going on with the car analogy, at this point, this part represents the doors, the fuel tank, and the repair shop. This section is shorter, but has less to discuss, as in the future, there will be different more advanced technologies, in rocketry, and only the needed satellites are discussed.

Sections & Subsections

SECTION I

THE HUB

The name for this section might seem a bit … random. In reality, what it means is that there will be a hub for all spacecraft that enter and leave the Optis. A hub where all spacecraft are stored and stay. This particular part of the settlement was already discussed in the previous section about structure, where it was the large sphere at the end of the cone[60], this hub will have a large cube-shaped storage area at the center, which is for storage of the different craft that occupy the Optis. This section will go into detail about the entering through airlocks and how spacecraft are serviced, as docking was already covered in a previous section.

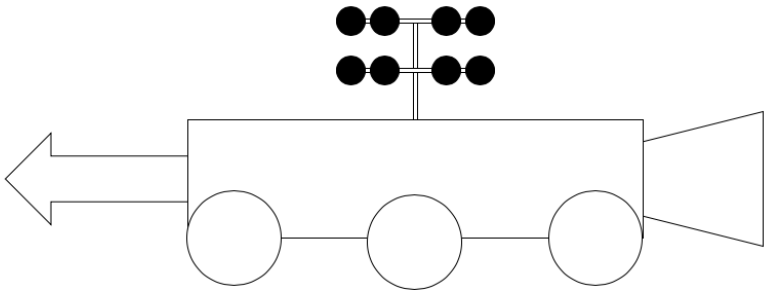
4.1.1 CRAFT ENTERING/LAUNCHING

There is a large open space for storing the craft that will operate and work upon the Optis. As described about 40 pages ago, (getting pretty long) there is a cavernous space within the sphere which is where most of the craft are stored. This space includes many bays for craft to be stored, refueled and restocked. That section many pages ago also describes a docking system for retrieving materials. This means that once the automated unmanned craft land, they will dock their materials and the inner bay only needs to focus on refueling and restocking craft. The first part, however, is getting craft into this hangar bay. For obvious reasons individual spacecraft will not maneuver themselves into the actual hanger bay and fire their engines. They will enter an airlock, and then be retrieved. Unmanned craft will first dock and leave their materials, before entering the airlock, and the docking procedure has already been outlined in the first part of this project. Materials that are docked with, will automatically be moved to the storage area through a series of pipes, pressurized pumps, and magnetic means to guide individual materials and packages to the other side of the settlement. Upon entering the airlock area, small autonomous "guide" craft will attach themselves using grabbers or nylon rope to the bigger craft, not unlike a tugboat. The spacecraft will then turn off any boosters or thrusters active and go into a state of shutdown. After the airlock opens and the latest batch of spacecraft is allowed into the hub, the smaller guide craft will move across the inner hub through a series of crisscrossing wires, each made of strong nylon and carbon fiber reinforced ropes, with a guide rail pattern, so the guide craft can use a special armature to attach to the universal guide ropes and move the spacecraft across into the main area of the hub. Craft will then be dispensed into set storage areas where they can be stored.

[60] Description of the settlement for reference: Outer Torus, connected with bicycle spokes connecting it to a central core area, shaped like a trapezoidal cylinder (if that's a thing) and connected to a cone, which is in turn connected to a sphere.

Going first over the individual guide craft, the craft pictured looks peculiar, as well as dysfunctional. The most reasonable part to be the actual craft seems to be the double wheel system which is made for holding up the individual guide craft to the nylon-carbon wire. The wheels on the bottom seem to be counterintuitive, as this part of the settlement has no viable gravity for wheels to work as they should, In this case, the actual floor of airlocks and most of the hangar is made of magnetized material, in certain patterns, This means that the wheels themselves have electromagnets in them, at different angles, and can fire at different times kind of like a motor to be able to pull the craft foreword, with the wheel acting like the armature of the motor, and the floor like the poles, except that the armature itself switches magnetic direction instead of the poles. A bit rigorous of an analogy, but this motor works by alternating the magnetic field across electromagnets pictured as bars within the actual wheel itself, and these alternate magnetic directions to be able to move the wheel across the floor of the airlock. There is also a weird looking arrow, and this is just a placeholder for what is actually the mechanism for retrieving craft, and this could be grabbers, magnets or other mechanisms that are all different for the different craft that each of these separate guide craft specialize in. The trapezoid at the end represents the fact that this craft does actually have thrusters that can enable it to enter the space around the airlock, and pick up and guide spacecraft that may be too cumbersome, or may have thrusters and main rockets too powerful for the airlock to handle, and these can be retrieved by the guide craft. Guide craft are powered by electricity and refuel on the actual nylon ropes themselves.

FIG 4.1.0 GUIDE CRAFT



Next, is the infrastructure for moving craft around the hub itself. Now that each craft has been moved into a guide craft and is connected to a nylon rope, it can use the upper wheels that are used for moving across the individual ropes. The ground electromagnet wheels are used for moving the spacecraft and guide craft to a space where they can easily clasp to one of the nylon rope contraptions. These ropes are of different sizes, although can be divided into a small, medium and large size. They use the same material as the spokes for the settlement and can carry the small craft to different various parts of the hub. The ropes themselves connect to the storage areas and are connected in ways that the individual guide craft can move across to different rope highways, kind of like the interstate system on an extremely small scale. After each smaller craft leaves the rope system, they can easily dispense into the actual storage units.

Launching the craft will be the exact reverse. Once a craft is scheduled for a launch, the craft itself will be retrieved by guide craft, (preferably refueled and ready to go) and will then be dispensed into an airlock, where they are then taken out into space by guide craft and released.

All craft are taken out first, by guide craft, because when starting their engines, they can risk burning the airlock, so they are taken out of the airlock by guide craft, and then subsequently started.

4.1.2 CRAFT STORAGE

Craft storage entails storing, refueling and repairing any craft that are needed to be used aboard the settlement. This part of the storage entails different machines that each have their own purpose and can repair and revitalize craft. The first part is refueling craft. Craft themselves are designed to require very little maintenance, and due to working in space, any craft that need to be repaired can be repaired by swapping out parts that are worn out, or in need of replacement. Human crews can undertake more complex repair. The storage area is like a cutaway cube with space for many craft to be stored. This system ensures that there is easy access to many craft that can be stored aboard the settlement. There are gaps so craft can be easily maneuvered out, although the size of the gaps has been exaggerated, and there are more bars and gaps, so two columns of craft are stored on each bar. The storage bays themselves have space for a craft to be dispensed, and held through means of ropes, as constant magnetic attachment could overheat. There is a universal port for each gas that is needed to propel the craft themselves. For instance in MPD thrusters, using hydrogen or lithium as a propellant is a viable strategy, and this means that there will be a universal nozzle for each craft that needs lithium, and each one that needs hydrogen, and the bays themselves will be specialized towards a specific type of craft and will have the nozzles ready to refuel the craft. Refueling is automatic and uses a very small docking type system as well as a small-scale drone to move a nozzle into place and lock it into place. Although a bit simplified, this diagram to the left shows the layout of a small part of the hanger, with the craft stored, a place for spare parts that could be used for quick fixes and patches for different parts of the craft, as well as the place where the gas nozzle (remember, not gasoline but any elemental gasses or molecular gasses that are needed in order to refuel the craft. One part that has not been discussed yet, is smaller robots that are armed with laser cutters and can easily retrieve any parts of needed for the individual craft from the craft storage area. Sensors aboard the storage area sense if a craft is damaged, but not damaged to the point where it needs new circuitry or more complex parts, and then these laser cutting robots can be used to remove and replace the

FIG 4.1.2 LOCATION OF STORAGE

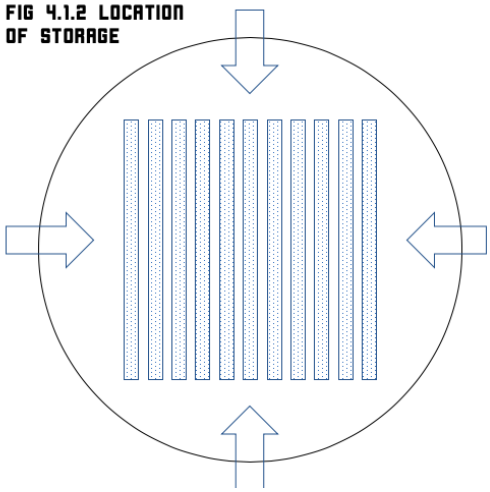
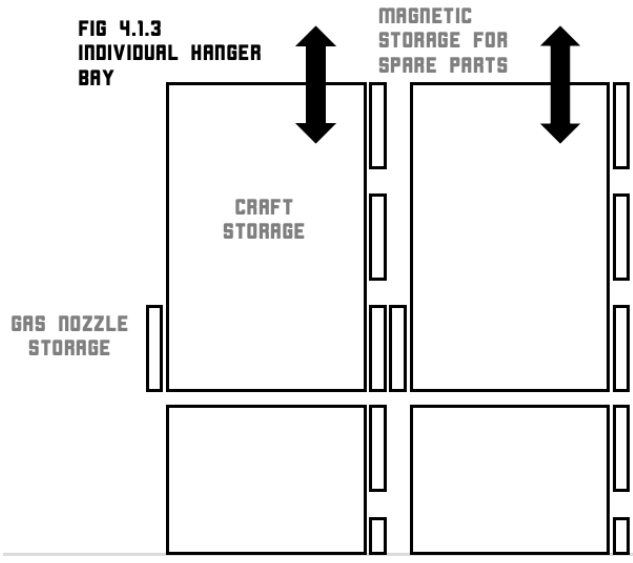


FIG 4.1.3 INDIVIDUAL HANGER BAY



different parts of crafts, critically damaged craft can be overhauled, and are transported out of the storage bay to a separate area within the core, where damaged craft can be replaced by humans. In general, once craft enter the part of the settlement designed for them, autonomy takes over and they can be repaired and refueled with almost no input from humans. Spare parts are ordered once used and are sent from the inner core which houses most of the material creation technology.

4.1.3 HUMAN CRAFT

Human craft use a completely different strategy for entering, exiting and storing craft. They have a separate hanger that is used for only human craft. There are two different types of crafts, temporary and permanent human craft. Temporary craft are visitors from earth, and did not need permanent lodging, and instead can be used through a single large hanger, connected to the largest airlocks which are used for human craft. Permanent craft that are property of the settlement and used for settlement business are stored in their own separate hangar, which is almost identical to the temporary, except is specialized to the specific craft that it hosts, instead of having general servicing features, and is also a considerable amount larger, to be able to hold many craft[61].

Other than being separated, and not using a mainly autonomous system for storage, the storage for human craft is also different in the fact that it is easily accessible by humans themselves. This means that humans can move from the inner part of the hangers, along a tunnel system all the way to the inner core, and finally back into the outer torus. This also means that a full-time crew can be used to ensure that all craft are working properly, and this is how craft are refueled and fixed. Instead of being fully autonomous, methods using humans for more precision and a sort of "fail safe" are used. Pilots are trained on earth and are also utilized instead of automation. Guide craft are used to guide human craft across the actual airlock, and out of the airlock to be released and started.

Human access to the actual Hub where automation occurs and not just to the hangars, is limited and mostly through modified guide craft that can move humans around within this part of the settlement. Although not entirely necessary, like the inner core the hub has a regulated atmosphere and temperature, to preserve spacecraft, and this setup uses the HVAC methods, although without fancy ducts and all, and with only Air conditioning systems and heaters, as well as no set composition regulation.

SECTION II

TO EARTH

Getting to earth is the main focus of this part. The settlement is usually refueled and resupplied through shipments to the earth. This includes the space elevator infrastructure that was

[61] Clarifying the actual system used for craft storage, a human based craft enters the settlement, through a special airlock designed for human craft, and then there are large tunnels where guide craft attach and carry the actual human craft along a tunnel to a large main hangar which is connected to all of the airlocks designed for humans. After reaching this hanger, humans aboard can disembark, and move into the settlement itself. This hanger is where all repairing, and storage of craft also occurs.

created in the first part, as well as human refueling. This section also shows the different infrastructure used to move different shipments up to the settlement from earth.

4.2.1 RESUPPLY

One of the main uses of the craft mechanism, is for sending craft to and from the earth for materials from the earth. These craft will carry a large variety of materials and will be carried in and out of the settlement at reasonable intervals. The first real resource that is needed by the settlement, is a source of fresh water. Water is needed not only for consumption, but also electrolysis for its constituent parts, as well as use in many other applications. Due to its high density, and the amount needed, water will constitute most of the shipments to and from the earth and the settlement. Water will also be shipped on the space elevator that was constructed to create the settlement. Water can be shipped in either seawater or freshwater concentrations, as the large-scale water refinement processor can refine all kinds of water, and sea water's minerals should be easy to remove for this preinstalled system (described in previous part), and it would also provide the settlement with a much needed resource: salt. This is why most water shipped to the settlement is shipped through autonomous rockets which carry sea water, are shipped up onto the settlement through the space elevator, which dispenses the craft at the height which the settlement is at, and then the water craft can use MPD thrusters to orient themselves with the actual settlement, and enter an airlock. The design for one of these crafts is one large central bay for water, surrounded by support equipment and a space for docking. Pictured at the left, this render shows the basic large area for water, the cubes represent the actual thrusters themselves, although the formation is not shown, they can fire in both directions to allow the craft to move in any direction, due to the layout of the thruster. This means that after being dispensed, the craft can move towards the settlement, and dock with it using the armature that comes out of the top. Protocol for water carrying craft is to dock, transfer the water, and then to return to the elevator and the earth, until needed again. Although extremely necessary, this particular craft is not needed at all times, due to the ECLSS system onboard, most water is recycled, and this craft is mostly only needed for the excess. As discussed, many sections ago, the actual elevator can have different attachments to carry different things, and there is a dedicated water attachment. Why stop at water? Any liquid can be transported by this system in large quantities, or in smaller quantities if the rest is filled with an inert gas and the sides are coated with a material that discourages the reacting of the liquids with the structure itself. All of these measures in tandem can create a robust system for transferring any liquids to and from the settlement. The next system in use is for transferring solids. If any elemental matter is concerned, it could be transported based on its description and use. For

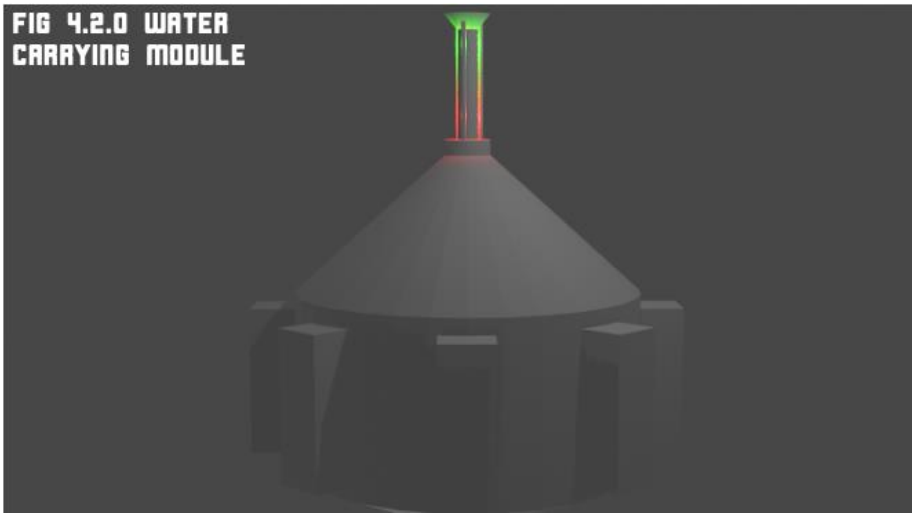
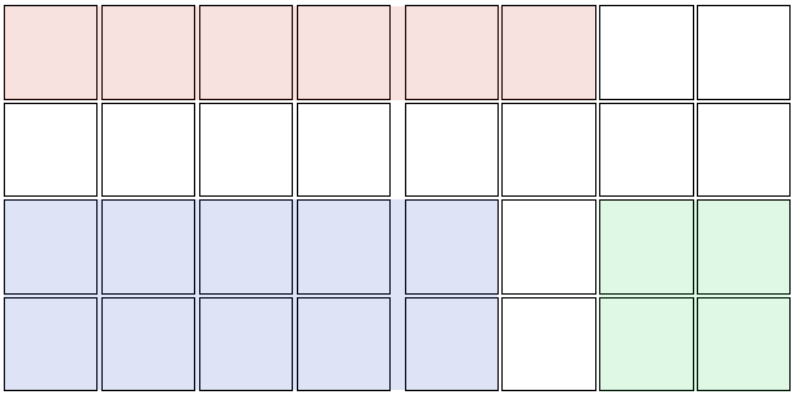
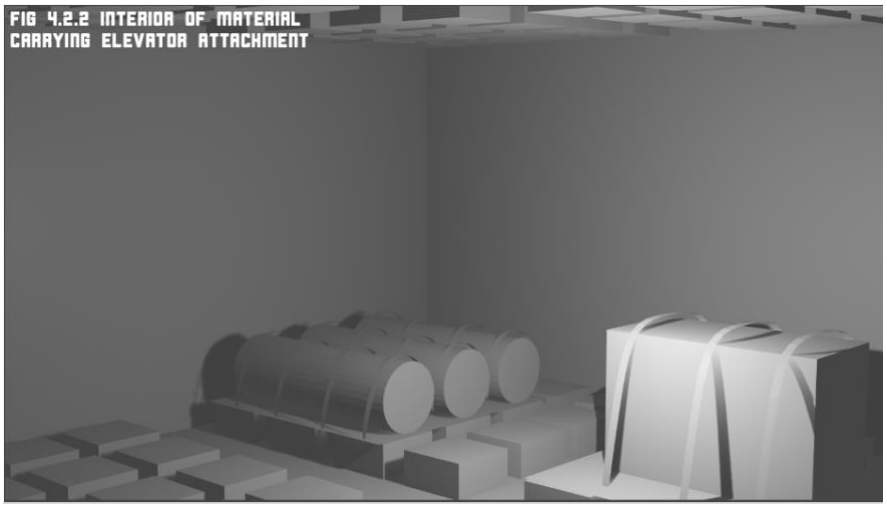


FIG 4.2.1 TILEABLE GRID PATTERN



any non-solution[62] matter, it is shipped through the use of larger hanger type bays, which can accommodate multiple different types of craft in each part of the settlement. These are larger craft that can support multiple different smaller parts within them, regardless of type. The diagram to the left, shows the method that these spacecraft use. The floor of the interior uses a pattern of square blocks and rails, and together these create a system in which almost anything can be tiled onto the floor and be secured through platforms. The render below shows the interior, although in this render the utilization of the craft is low, with only some cylinders and a nondescript box used, although in actual deployment much more cargo will be piled into this particular module. These modules must be put into airlocks to be unloaded, and due to the low frequency of their appearance, they can enter through the temporary visitor human craft airlock, be unloaded and then released back into space. Transferring solids can be done through the use of boxes like the one pictured, and the individual "pallets" themselves use rails to connect themselves with grid pattern, and while a bit simplified in the renders, these cubes are actually tapered at the bottom to allow a rail to pass between them and be secured to this method of transporting solid materials. Through this system any number of solid things can be transported throughout the settlement. For much larger shipments like very large prefabricated parts and shipments of craft, guide craft can be sent from the settlement to move the individual piece into the settlement, and for prefabricated parts, they must be split up to fit through an airlock, otherwise they may not be able to be transported into the settlement. (for exterior shielding it can be applied immediately but for any other use case the prefab must be split up) Through these two methods, any sort of good can be brought from the earth into the settlement.

FIG 4.2.2 INTERIOR OF MATERIAL CARRYING ELEVATOR ATTACHMENT



4.2.2 HUMAN CRAFT

[62] This means materials that aren't a solution or mixture, but are actually a solid constructed part, like a spacecraft or motor, as opposed to a solution being like say a solid block of iron, or hydrochloric acid.

The second type of craft from earth are manned spacecraft. This type of spacecraft entails carrying Humans all the way up to the spacecraft. The first type of human launch could be something like the SpaceX Dragon v2 launch, using a rocket to launch humans from a point on the Earth, rendezvous with the settlement, and dock and release passengers. The second type is more like a space shuttle which enters the airlock and is more like a special plane flight. While through the use of rockets, spacecraft can ascend to the level of the settlement, the space elevator can move humans for much less cost, and then they can follow standard docking procedure after being released from the space elevator. Spacecraft will not be designed here, but the ones that are used can originate from the country of choice, and just have to fit within the airlock of the settlement itself. In terms of carrying humans, the Crew Dragon from SpaceX is a very comfortable cabin with space for 8 new settlers and is the recommended method to ascend into the settlement, using the space elevator in order to get into the settlement. This method is cost efficient and can ferry large amounts of passengers and recycle crew cabins.

SECTION III

GENERAL SPACECRAFT DESIGNS

Getting craft to collect data, do different actions, and in general fly around the settlement and do what they need is described in this section. The satellites come in three sizes, a CubeSat size for smaller things, a larger spacecraft for most operations, and a very large almost mothership like spaceship for moderation and refueling the smaller craft. These three base designs are created to be general and expandable, because it is simpler to have a base design and generalize within that enclosure. This makes repair and maintenance easier. This section will also briefly gloss over the asteroid miners and debris clearing spacecraft that use a different design.

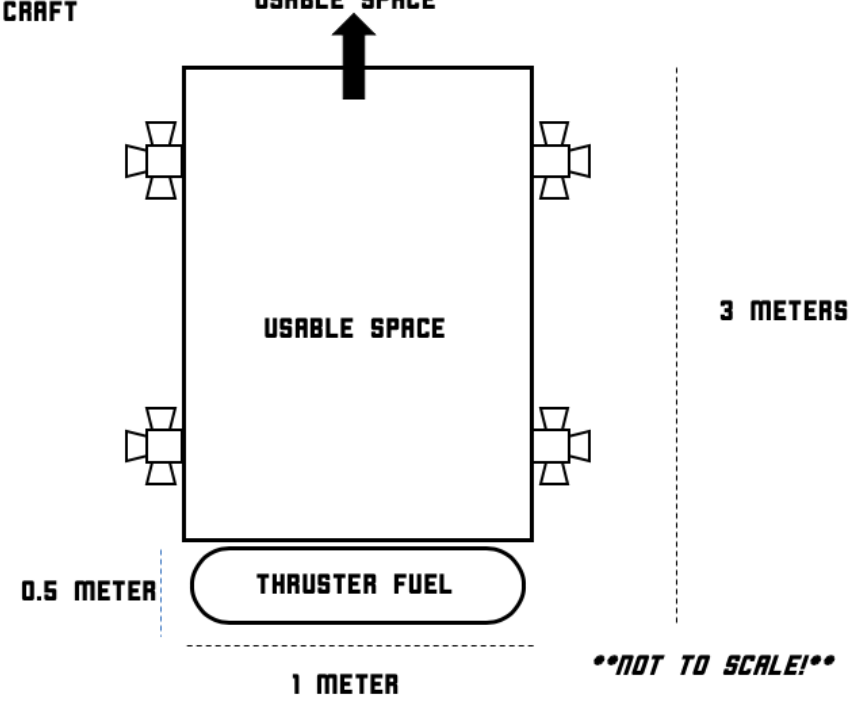
4.3.1 MODULAR SPACECRAFT

Making many different specialized spacecrafts is a waste of time and resources. A better idea is to create three different sizes of spacecraft for three different tasks. The first one is the miniprobe, more like a CubeSat, used for data collection, and is launched from a hub. This hub craft is the second tier, medium sized spacecraft that can be used for all sorts of purposes, and is built to carry a medium sized attachment, such as a CubeSat hub. The final size is a larger size that can be used for whatever is required of a larger size.

FIG 4.3.0 CUBESAT WITH SOLAR, COMMS AND BOOSTERS

Starting off first with the design of the smaller spacecraft, this is essentially a CubeSat, the design works well for smaller spacecraft that only have to orbit the earth. Unfortunately, the settlement needs a little bit more complex of a design in order to work well, due to the fact that there is no orbit. This is a small thruster that is low power and small, and almost the size of a penny. Conceived in MIT, there is a small enough ion-based thruster that can accelerate this small craft to speeds, and so the design for the CubeSat includes a multitude of these small thrusters to be able to propel themselves. Due to the thrusters being placed on the craft, solar panels must be move to extensions instead of on top of the craft. Scientific material is stacked on the inside, and thus an expandable antenna is on a separate corner. With these modifications, the CubeSat is definitely larger than before, although should be able to send more data and propel itself around the settlement. The inside of these craft has small amounts of propellant and batteries, but otherwise can carry any device needed. The design is robust and modular for modifications to be easily made. These modified CubeSats are about 20 centimeters cubed, with an additional 3 on each side t

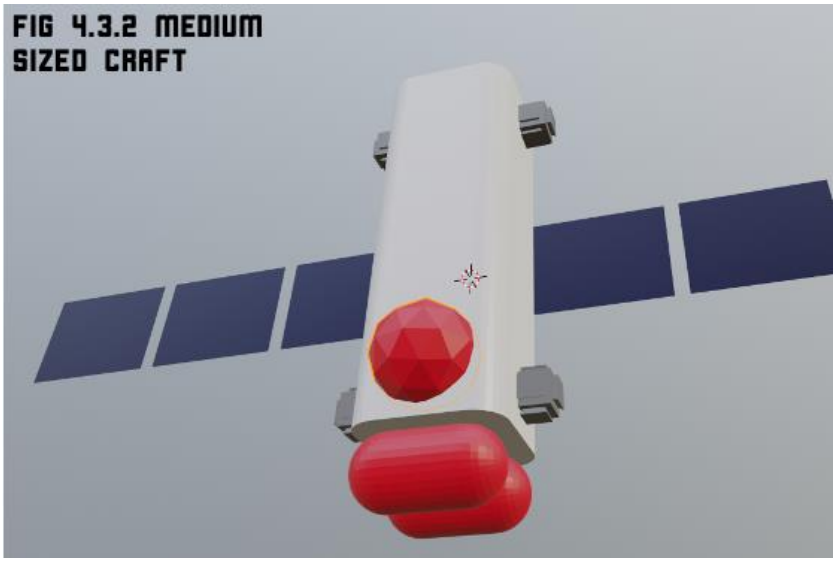
FIG 4.3.1 MEDIUM SIZED CRAFT



The second design is the mid-tier size. This size is perfect for doing many of the functions the settlement requires such as scraping the space for gasses, using lasers to dissolve rocks. The options are limitless. This spacecraft has a general design, and anything can be put inside of the frame. Looking at the figure, it can be seen that there are 4 omnidirectional thrusters straddling the sides of the probe, solar panels on both sides for in space power, and fuel tanks. In the render, the communication probe is also pictured in red, although this is only for communication.

The medium size spacecraft can be broken down into three main parts. The propulsion, the communications and the solar panels.

Going over the first part, ion thrusters will be used on the settlement due to their high efficiency. This has a tradeoff of lower acceleration, although due to the fact that only small maneuvers will have to made, it is not a massive deal. Very small amounts of fuel can carry the spacecraft for a long time, and about 100 pounds of pressurized fuel will be kept in the storage tanks, with energy provided by batteries and the solar panel array. The minuscule size of the thrusters also helps with efficiency. In terms of the insides of the spacecraft, that can vary. The dimensions are about 2.5 meters of space with an additional 0.5-meter fuel tank at the bottom which can carry what is needed. There is a communication device which contains not only radio devices, but also a laser which can send data at extremely fast rates from the settlement and each spacecraft. Not pictured in either picture is the docking system. This has already been described, and the part on the settlement is identical to the part on the actual docking part, and clasps together easily. It is extruded slightly from the body of the settlement in order to create a situation where the clamp can easily be utilized and built.



The final design is the largest spacecraft, which is built for large operations and mostly as a hub for other operations such as asteroid mining. This larger spacecraft is created as a much longer range and is built to be able to move parts around earth orbit. This is more of a hub type ship which can carry different spacecraft than a smaller spacecraft that can be used to move, per say, an asteroid mining operation towards an asteroid, or debris elimination towards an area where there is a higher amount of debris. It is more like a mothership. It is quite large at 5 meters by 2, and is in a cylindrical shape, and has 3 pairs of omnidirectional thrusters. The black bands pictured are places for spacecraft to dock on. It uses hydraulic manifolds to hold together different spacecraft. This system utilizes a single very large ion MPD Thruster, as well as a multitude of smaller thrusters. All of these use ion

FIG 4.3.3 LARGE
SIZED CRAFT

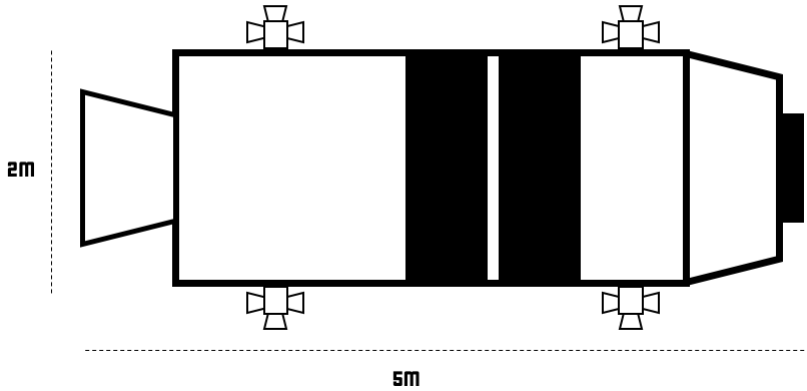
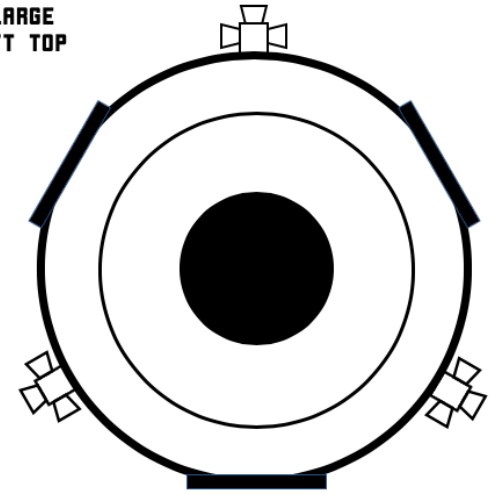


FIG 4.3.4 LARGE SIZED CRAFT TOP VIEW

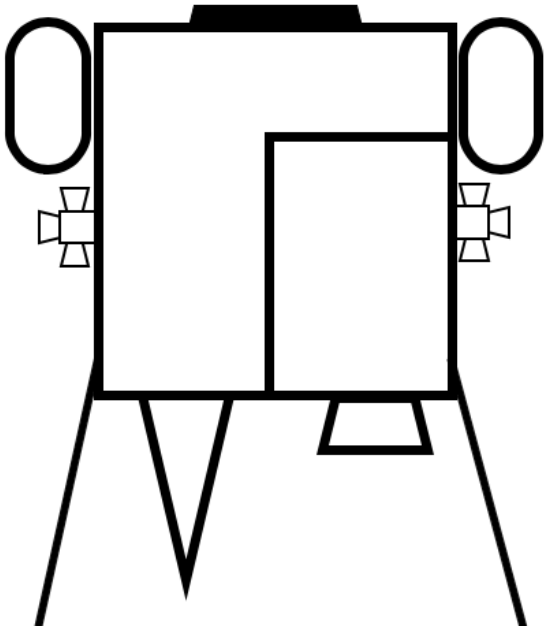


propulsions, although in this case the spacecraft not only has space for lots of internal infrastructure, but also has space to hold fuel and energy to refuel other craft. Because this craft can hold and dock with other craft, it can also carry fuel to refuel those other craft, as well as a large battery to quickly recharge craft if they don't have time to utilize their own solar panels. This design has a triple manifold setup as well as a frontal docking port. It also has space to hold materials collected and can be converted to hold any amount of materials and/or xenon gas for propulsion. The reason that ion thrusters are used for a majority of the settlement functions is for the reason that not only is it efficient, but it also makes it easier to refuel and maintain craft. With these three sizes, most if not all applications of rocket can be covered. There are two specific designs that will be glossed over in this section, Asteroid mining and Debris removal.

4.3.2 ASTEROID MINING & ANTI DEBRIS

One function that the settlement uses to acquire new materials and overall improve itself, is through the use of asteroid mining. This section will go over briefly the spacecraft and configurations that could be used to undertake this operation and successfully asteroid mine different assets. Asteroid mining is one of the exploits that is conducted from the larger spacecraft size, due to its mothership-like presence. This large powerful spacecraft can move the smaller asteroid mining craft, as well as carry what materials are important to them. Asteroid mining will be conducted with spacecraft that mine the asteroid, and discard any fragments that are not needed, and store what is needed, and once they fill up or are low on fuel, return to the mothership, dump their contents and continue until the mothership is full or the job is complete. This very simple illustration shows the different parts of the miner probe. There is a docking port. 2 tanks for carrying propellant. There are also 2 thrusters that are used for maneuvers, as well as one larger one for pushing off the asteroid. The drill itself is represented

FIG 4.3.5 SIMPLE GLYPHLIKE ASTEROID MINER DIAGRAM



in a cartoon style, but in reality, it is a pipe type drill which at the end grinds together and picks up different materials sucking them up. It is a fairly simple operation and is all stored in the end in the storage compartments.

The second craft is just to remove space debris. This spacecraft uses a pulsed electron gun to push space debris. This craft is also tied to the larger mothership, but in this case for energy requirements. The gun would be able to aim a beam of electrons to accelerate or decelerate the spacecraft that it is targeting. It can use this technology to block craft from the hitting the settlement, or fragmenting. This spacecraft also has high power lasers to dissolve small pieces of metal that could potentially hit the settlement and break parts of it or break shielding. This spacecraft are tailed by motherships and patrol the outside of the settlement. This arrangement of spacecraft can be used to carry most, if not all cargo needed, and carry out all operations. Humans can fit in the medium and large sized crafts, and modified versions of them are used to ferry around humans.

It feels wrong to end the entire project on a note about converting spacecraft, but there is not much else that can be said. So instead I'll leave you with a beautiful vertical line.

BIBLIOGRAPY

THE LISTS[63]:

https://www.nasa.gov/feature/goddard/real-martians-how-to-protect-astronauts-from-space-radiation-on-mars
https://www.esa.int/Our_Activities/Space_Safety/Space_Debris/Hypervelocity_impacts_and_protecting_spacecraft
http://www.digipac.ca/chemical/mtom/contents/chapter1/rotation.htm
https://www.artificial-gravity.com/sw/SpinCalc/
https://en.wikipedia.org/wiki/Magnetoplasmadynamic_thruster
https://planetcalc.com/6729/
https://science.howstuffworks.com/space-elevator1.htm
https://www.quora.com/Why-are-tokamak-fusion-reactors-designs-better-than-other-designs
https://www.quora.com/What-are-the-advantages-of-stellarators-over-tokamaks-in-achieving-sustained-fusion
https://en.wikipedia.org/wiki/Stellarator
https://en.wikipedia.org/wiki/Tokamak
https://space.nss.org/media/NSS-JOURNAL-Space-Farm-Electrical-Requirements.pdf
https://www.energy.gov/ne/articles/nuclear-101-how-does-nuclear-reactor-work
https://en.wikipedia.org/wiki/Fusion_power#Plasma_behavior
https://www.iter.org/sci/FusionFuels
https://www.livescience.com/62929-plasma-fusion-reactor-tokamak.html
https://www.iter.org/mach/Cryo
https://en.wikipedia.org/wiki/Deuterium
https://www.chemistryworld.com/news/graphene-sieves-deuterium-from-hydrogen/9308.article
https://www.chemicalforums.com/index.php?topic=27129.0
MIT-developed ‘micro thrusters could propel small satellites | MIT News
Spacecraft propulsion - Wikipedia
The Space Review: Small thrusters for small satellites: trends and challenges
NASA - Ion Propulsion: Farther, Faster, Cheaper
How to Build a Space Communication System Out of Lasers | WIRED
Marinaleda: Spain's communist model village | World news | The Guardian
Faecal Waste Flow Calculator :: IRC
How to House and Fence Goats
Easy Animals to Raise on the Small Farm
GMO Facts – The Non-GMO Project
Can You Grow a Tree in Zero Gravity? | HuffPost
What to Grow and What Not to Grow in a Hydroponic Greenhouse - Garden & Greenhouse
Hydroponic Systems 101 | Learn The Basics of Hydroponics
Full-spectrum light - Wikipedia
Artificial sunlight - Wikipedia

[63] Each of these links was accessed at a different time between July 2019 and February 2020, and if broken most likely have been taken down since those times.

Why mackerel has been taken off the ethical 'fish to eat' list - Telegraph
Vacuum distillation - Wikiwand
ISS ECLSS - Wikiwand
Waste Handling in a Microgravity Environment Challenge | NASA
Will We Still Have Fruit if Bees Die Off? | WIRED
This Robotic Pollinator Is Like a Huge Bee With Wheels and an Arm | WIRED
Sardine - Wikiwand
What's wrong with fish farming? | Aquaculture| health| environmental issue
What Do Rosellas Eat?
What Do Salmon Eat?
What are Phytoplankton?
Artificial Skylight
Skylight - Wikiwand
Galleries – Spacehabs.com
CoeLux: The $40,000 Artificial Skylight Everyone Will Want - CE Pro
A Nanotech Skylight That Looks Just Like the Sun Shining Overhead | WIRED
Atmosphere of Earth - Wikiwand
International Berthing and Docking Mechanism - **Wikipedia**en.wikipedia.org
NASA Docking System - **Wikipedia**
Apollo Guidance Computer - **Wikipedia**
Canadarm - **Wikipedia**
Deuterium - **Wikipedia**
Magnetoplasmadynamic thruster - **Wikipedia**
Stellarator - **Wikipedia**
Heavy water - **Wikipedia**
Graphene - **Wikipedia**
Fusion power - **Wikipedia**
Tokamak - **Wikipedia**
Wendelstein 7-X - **Wikipedia**
Triple-alpha process - **Wikipedia**
Pulsed inductive thruster - **Wikipedia**
Electrically
powered spacecraft propulsion - **Wikipedia**
Ion thruster - **Wikipedia**

IMAGE CITATIONS

1.1.4:
Image Credits: http://theprovingground.wdfiles.com/local--files/usc-arch517-exercise1/USC_517_Exercise%201%20Space%20Truss.jpg
Image Credit: https://commons.wikimedia.org/wiki/File:Tetrahedron_wireframe.stl
1.1.6:
https://3dwarehouse.sketchup.com/model/58a3c639cec2ae758fc5761c4e5e82ed/Geodesic-Dome-Truss
1.1.10
Image Credit:
https://www.thebmc.co.uk/Handlers/ArticleImageHandler.ashx?id=2029&index=0&w=605&h=434

1.1.13:
Image Credit: https://starwars.fandom.com/wiki/Docking_Bay_327
1.2.0:
Image Credit: http://technaked.blogspot.com/2013/02/magneto-plasma-dynamic-thruster_2734.html
2.1.0:
Image Credit: https://en.wikipedia.org/wiki/Tokamak#/media/File:Schematic-of-a-tokamak-chamber-and-magnetic-profile.jpg
2.1.1:
Image Credit:
https://www.sciencemag.org/sites/default/files/styles/article_main_large/public/images/StellaratorLead1280x720.jpg?itok=0Yk4KwCg
3.1.0:
Image Credit: https://www.greencarcongress.com/2018/07/20180728-tk.html

All other images created by me, simple graphics created in PowerPoint 2019, and 3D models and renders created in Blender 2.79 and 2.80

TECHNICAL NOTES

DIMENTIONS:

Paper Size:
- W: 8.5 inches
- H: 11 inches

PROGRAMS USED:

Text Editing:
- Word 2019: MacOS Edition
- Adobe Reader 2020

Diagrams:
- PowerPoint 2019: MacOS Edition
- Blender 2.79 & 2.80
- Kerbal Space Program November 2019 Update

Final Document: PDF Type

FONTS USED:
(All free for non-commercial use)

FRANKLIN GOTHIC DEMI CONDENSED - SECTION HEADERS AND TITLES
Castillo MT – Main Text
Zelda – Part and Document titles
CORNERSTONE – DIAGRAMS & headers

SPECIAL THANKS

First of all, I would like to thank NASA the AMES Research center, and the National Space Society for making this event possible. It is one of the things I look forward the most each year, and love creating a new settlement each year, so a massive thank you to all parties involved.

Thanks to my mom for sparking my curiosity at a young age and pushing me to continue discovering the universe.

Back in fifth grade, I got a special call from my aunt, telling me excitedly about a project that would fit my interests. One that I would do for the sheer fun of it. One that was, as it seemed, made for people like me. For this, I thank her every year. For the never-ending joy of dreaming up the next scheme to ferry passengers around. For the joy of creating the next diagram, the next paragraph, the next description, I thank Sunita Bal, utmost out of anyone else.

And finally, to you, for reading through this, or skimming, or pretending to read, I really appreciate it.

A PALE BLUE DOT

As I close out this project, I hope you have felt at least a little bit of wonder touring my take on the Space Settlement. While definitely not an ironed out ready to go every bolt accounted for technical paper written to build this thing, as with all submissions, it is instead a tour. A tour for the more scientifically adept about the mechanisms, functions and settlement itself. Only those that build the settlement spend hours poring through manuscripts of blueprints for coolant systems of MPD thrusters. Those that dream of it, inhabit it, envision it, and use it to pave the way to the stars, understand the function of every part of the settlement. Understand the ins and outs of the systems, their functions and reason for design. That's what this document is for. That tour. That's what every sub ten-thousand-page entry is for, and I don't think there ever has been a ten-thousand-page entry. A Settlement is humanity's dream of technical mastery. A little earth to live in, with less of earth's liabilities, although at the cost of less of its charm. With its $30,000 skylights to imitate the sun, incredibly complex heating system, the Optis does all in its power to emulate the earth. The truth is, almost all of us spend their entire lives on earth. Only Clyde Tombaugh's ashes can say they have been outside of its gravitational influence. But even as humanity progresses, it will never lose the earth's influence completely. Even far after the earth is forgotten as a planet, humans will always wonder why the artificial day lasts 24 hours. Or why every 60 days or so the weather changes on their generational craft. The earth will have an arm of influence outlasting itself by millions upon millions of years. I like to think that there will be one settler far in the future, that decides to believe the legend of Earth. The planet that the ancients said it all started on. A legend to most, but at least one I like to believe, will decide to visit our home. What they will find, is anyone's guess. Personally, I think that the world would have turned to anarchy in its last days as all humans fled their home planet. Hopefully the future human sees beyond this. Maybe finds an antique telescope. An ancient artifact – a metal box with a bit of glass across it. Maybe he finds the remains of earth life. Hopefully the ants are still there. If humans left the earth, most likely it would revert to its old ways. Plants taking over the planet, human structures all but destroyed. Maybe the settler would find an apelike species carrying a sharp stone. Maybe a society of these beings has established small towns. Maybe cites. Perhaps he finds a particular species with no hair on them, creating petty fights, with each other. In the grand scheme of things, the purpose of an intelligent species is to master its universe. For apes that was their forest. For cavemen, well, their cave. For the explorers and conquistadors, the earth. We stand here in this day and age on a brave new frontier. An exciting prospect. A leaping point between the Planet and the Universe. The Solar System. Our generation will be the ones to set foot on mars. To tour Titan. To collect Pluto's ice. Most likely though, there will be a settlement above our heads. Maybe two, three, four even. Science is expanding at an exponential rate. In the coming years, it is our duty to take charge of the solar system like we did to the continents. Tame the asteroid belts as we did horses years ago. Take on the extremes for resources, like we did with the frontiers. Every species has a home planet. Skywalker from Tatooine, Superman from Krypton. Hopefully Humans can gain that fame that prestige, that raw power, to the humble name of "Earth". A departure from Earth was always envisioned, from the second an ape sharpened a piece of obsidian. Our departure from this planet was pre-planned. But like any child to their mother, when they leave their loving arms, let's bring Honor to our Pale Blue Dot. Thanks for reading.

- *Ayush Nayak*