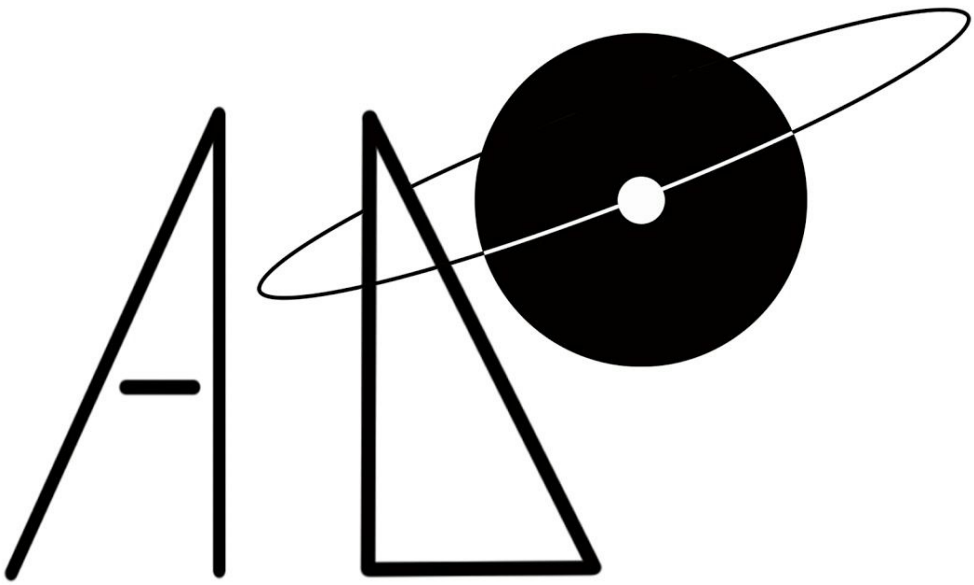

AFRODITA 1.0

"The future belongs to those who prepare for it today"

- Malcolm X (1925-1965)

Maria Disli

Andrei Lu

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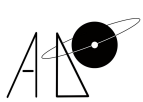
George Valtas

Nicolas Mantescu



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Introduction

For more than 50 years, humanity has been gradually wrecking the Earth with careless choices and actions. There will be a time in which Earth will no longer be able to sustain us and we will have to rely on the universe surrounding us. One option is moving humans on a well-designed spacecraft with an exceptional impediment between us and the crushing forces of space. Damages we have caused on Earth include: too much pollution, conflicts between countries or different cultures (which could result in wars), natural disasters, poverty, a rapid increase in population, resource scarcity and climate changes. These factors have pushed us into finding a new method of living so we can continue our race for more generations. It is useful for us that we are not in a critical state right now which would mean we need to leave our planet immediately and have less time to come up with a solution.

CHAPTER 1

1.1 Why we explore?

When we look at Earth from up in space, we see a perfectly designed and protected living area, for thousands of years we are discovering Earth, finding out new continents, climbing Everest, crossing Antarctica, caves. Curiosity is one of the biggest factors behind many innovations, it is in Human's nature to explore what surrounds us. Today, humanity should open their vision to space, beside many economical and political reasons, to continue our journey of exploration, space should be our next target. There are many unknowns waiting for us up in space, from asteroids to planets, new materials, new life forms, chances of touching with extraterrestrials and finally new places to inhabit and continue our civilization.

1.2 Pollution

A large-scale problem that humanity has dealt with for the past century is pollution. Pollution not only causes us an inconceivable amount of trouble but also harms animals,

plants, rivers, soil and most importantly: our Earth. There are many types of pollution which all fall under three main categories: air, land and water; all of these are equally harmful and need to be kept under control before it becomes too late. Roughly about 6,350,293,180 kilograms of plastic waste are dumped into oceans and rivers annually, killing more than one million birds and 100 million mammals and fish; plastic is the major constituent in water pollution and kills seven million people per year. Land pollution is mainly induced when waste is not properly disposed of or can occur when humans bombard soil with noxious chemicals such as pesticide, fertilizers and insecticides during agricultural practices. These cause various problems in the respiratory system of animals (including humans), skin and can even contain cancerous cells. If our main source of food, soil, is not well looked after then we will have a complication with nutrition leading to starvation. Last but not least is air pollution which harms something crucial to life: the atmosphere. When toxic gases (such as carbon dioxide/monoxide, nitrogen oxides, sulfur dioxide, hydrocarbons, etc…) enter the atmosphere, it makes the air we breathe in more and more contaminated. Over 131 million Americans - more than forty percent of the population – live in area with dirty air and asthma brings the nation to approximately $2 billion per year. What is more worrying is that average ground-ozone levels have decreased by 28% since 1980.

1.3 Wars

Another main addition to the human struggles are wars. Whether they are over resources, culture, nationalism, imperialism, militarism or alliances; wars can kill millions of people and damage our planet a great deal. It is speculated that in the future decades, wars over resources and clean water will break out, wiping the Earth's population by at least 10 percent. A small nuclear exchange could ignite colossal firestorms and completely wreck the Earth's atmosphere. Even about one hundred Hiroshima-sized bombs could tip Earth's temperature balance which is a small amount compared to the military power stock today.

1.4 Natural Disasters

For the huge reason that natural disasters cannot be predicted or prevented they are very dangerous and lead to the death and harm of millions of people. Even if we can live with the disasters of our planet which never wiped out our human race we do not have the power to deal with disasters such as an asteroid colliding with Earth and wiping out our entire population. Having a space settlement can provide us chance to determine asteroid collision threats much earlier and take precautions.

1.5 Resources

Another serious problem on our planet is the scarcity of resources. The world's population increases day by day and statistics convey that by 2030 we will need 2 Earths to support us. We have lost half of the planet's original forest cover mostly in the last 30 years. We consume resources faster than they can be replaced, which in some years will result in a lack of resources. Nowadays millions of people lack access to clean water, in the future billions of people will lack access to clean water. We cut down trees in order to build factories or houses, which further have negative effects on the atmosphere such as the release of CO2. Trees absorb a great amount of carbon dioxide from the atmosphere but we neglect this and demolish them. The world's population increases rapidly which can result in even fewer resources allocated per person, more rubbish, more pollution, less space, which would further result in additional deforestation. If there are more people, the education and health systems are likely to crash as they cannot cope with innumerable individuals. What is the best solution for preventing and lowering the risks of these inevitable problems?

Building a space settlement allows us to save space on Earth which leads to less deforestation as new buildings will occupy areas in space, not on our beloved planet. Food is another major problem. We do not have enough area for cultivation as space is a scarce resource. If we do not have the necessary land for growing plenty of crops, the outcomes are starvation and famine. In space we will have all the cultivating land in order to satisfy everybody's needs. If the population rises, unemployment is another issue as there are not enough jobs available for everybody. This leads to no income and further to poverty. In space we can develop different communities with different firms and organizations, offering all the citizens jobs and incomes in order to live a decent life.

1.6 Climate Change

Climate change is an additional issue that Earth has to deal with. Since the existence humanity, humans have been harming the atmosphere with carbon dioxide, carbon monoxide and other gases by campfires, production of electricity, factories and in many other ways. Due to humanity's irresponsible and ignorant actions, heat radiations received from the sun are being trapped by the greenhouse gases we have been releasing. This has led to one of the most severe trouble for Earth, climate change. Climate change has many negative effects but no positive
effects. Ice in the north and south poles has been thawed by the climate change and that caused an increase in the water levels in seas and oceans, creating floods and in the same time destroying natural habitats. Climate change is basically a trigger to a chain reaction of a series of major issues for our dear planet. Furthermore, climate change has also brought droughts

and damages to mankind. Statistics convey that about 300,000 people die yearly due to global warming.

1.7 The Solution

Scientists have been pondering ideas on how to save humanity and have come up with quite a few ideas. One of these includes space colonization. There will be a time in which Earth will no longer be a suitable habitat for humans and we will have to rely on another gift from nature: space. This is where our projects comes in place. Moving to space would mean that all citizens would have to leave our home for the past six million years and live in the vast space. The spacecraft would have to be air-tight and produce pseudo-gravity by constantly rotating. Our project will illustrate an idea about how we could establish a new and improved home.

A colony in space can extend our knowledge of outer space and also solve many of our problems. We can find resources in space that can fix our problem with the scarcity of resources. We can also discover a hospitable planet that we can shift to because Earth will soon be unable to support us anymore. Recently NASA has discovered that there is water on Mars (Acidalia Planitia). That can be a major game changer to our issues. If we find a way to colonize in space, we will be able to start from scratch and create a more promising and safe community that will save us from a future of struggles and starvation.

1.8 Cost

Constructing a settlement has two main challenges: the cost and finding enough materials. We could imagine that the settlement is 12,742km (this is the diameter of Earth) and 2.54 centimeters equals to about 5 tons of material. The total amount of materials needed expected to be millions of tons; to put this in perspective, Earth weighs 5.972 sextillion tons (5,972 with 15 0's). If we find a method of getting all the materials needed, we also need to get unimaginable quantities of money. Extracting components from asteroids can be a very high-costing method that could cost us about $2.6 billion for a seven meter wide asteroid. Gathering enough money for asteroid mining or construction in space requires a coalition of countries/governments. Although it has a very high cost, asteroid mining will become a necessity because transporting things from Earth to space costs $14,000-$20,000 per 453 grams. From a seven meter wide asteroid we could extract approximately:

- 700, 000, 000, 28 liters of water
- $406, 000 ,001, 6.2 worth of platinum

So constructing Afrodita 1.0 at a stable orbit somewhere close to the Moon remains as the best choice to decrease the overall cost.

1.9 Inspiration for the name

The name “Afrodita 1.0” is one word yet the meanings behind it are way more than you would expect. Afrodita originates from a Goddess’s name which was in the Greek Mythology. Afrodita was considered the Goddess of Beauty. “1.0” signifies two meanings: the continuance of this project since there will be many newer models after this one. Secondly, it also represents the one and only electron found in a Hydrogen atom. We believe that the atom Hydrogen is important to our project because it is the primary fuel of Afrodita’s engines.

1.10 Executive Summary

Afrodita 1.0 will be an original project that will take into consideration our contemporary era’s ideas as well as future concepts. We gathered the best research we could obtain and the most innovative ideas we could think of in order to design a space settlement in L4, which will be the home of 10,000 people. In the future, a space settlement is essential for discovering the outside world and to combat many inevitable problems such as : wars, population increase , climate change, pollution, natural disasters and lack of resources. We chose the name “Afrodita 1.0” as Aphrodite was, in the greek mythology, the goddess of beauty, representing the beauty of our settlement. “1.0” conveys that our project has a continuity and also represents hydrogen, as it has an atomic mass of 1.

Our settlement base will be constructed in L1. Our main materials will include: aerogel, aluminium, titanium, carbon nanotubes, carbon fiber, microlattice, RXF-1 and RTV adhesive. The settlement will consist of 3 toruses, each of height 200m, radius of 890m and pipe radius of 100m. Each torus will be made of 48 ring segments and will be connected to the main tube by 12 intersecting tubes. In order to be efficient and use as many natural resources as possible, we will place solar panels on the outside of each torus.

Afrodita 1.0 will have new innovations which will improve the lifestyle of the citizens as well as the settlement. Afrodita 1.0 will introduce new construction materials such as microlattice which will make the settlement significantly lighter and in the same time increase its strength (see chapter 2.6 Construction Materials for more information on this topic).

The settlement will take advantage of the properties of the main tube to create zero gravity research centers and zero gravity theme parks. Those facilities will develop new sports which will attract many people on earth to visit the space settlement.

The toruses will be divided into 2 sectors: The agriculture sector and the residential sector. In this way the transportation of the food will be faster and cheaper instead of having a separate torus only for agriculture.

Also , we will launch a new system where everyone will have an Afrodita Identity card that they can use to make payments in the settlement and use it as an ID. The Afrodita Identity of every citizen will also be saved in the Citizen Data supercomputer (see Chapter 4.4 Computing and Network) so everyone can be safe and can be contacted if something occurs.

There will also be a new system in the laws of the settlement called “Sanctions and Rewards” where there will be punishments when an individual does not conform in the society of the settlement (see Chapter Laws and Government) . On the other hand there will be rewards for the individuals who can conform in the norms, values and laws of the society. This method will make the citizens of the settlement follow the rules of Afrodita 1.0 thus decreasing significantly the violation rate and making life for the citizens more simple and easy.

1.11 Acknowledgements

We would like to thank Mr Al Globus for organizing this contest and offering students the privilege of making their ideas significant to many highly qualified people in the domain, the judges for allocating time to examine our projects and most importantly, we want to thank all the NASA team for showing their respect and support towards students thirsty for knowledge. Ali Cabas was our teacher and we are very thankful for all his useful guidelines, his help throughout the whole 5 months, his understanding and his valuable advice. Last but not least, we want to thank our beloved parents who encouraged us to move on and do our best when the going was tough. We really hope you enjoy reading about Afrodita 1.0, humanity’s first creation that eclipses the beauty of space.

2.1 PLACEMENT OF THE SETTLEMENT: L4

The placement of Afrodita has to be meticulously placed in a way that it does not endanger itself and is not prone to meteoroid showers. The ideal location would be outside the Earth's gravity, in order to not consume an awful lot of fuel trying to escape from it. The place, preferably, should have an atmosphere in order to protect the settlement from radiation, should also be relatively close to the Earth and Moon, so we are able to get valuable resources, and should be a stable position so the settlement won't drift away. Obviously there are no such perfect positions therefore we need to eliminate these factors in order of importance.

It is important to note that final location of Afrodita 1.0 and construction base need different requirements. During the construction, we will need millions of tons of materials and **construction near space resources** play an important role. However, the final location of the settlement has two main requirements: **Safety** and a **Continuous and Reliable Power Source**.

Low Earth Orbit (LEO) is the current location of International Space Station offers us Earth's magnetic field protection and close distance to Earth. However in terms of safety LEO has some minor points. Firstly it is not stable, gravitational pull requires continuous orbiting of the settlement. Secondly, space debris resulted from more than 50 years of human space junk has a high potential threat to our settlement.

Lunar orbit is also not a good candidate for us due to the fact that in stable lunar orbit solar power cannot be accessed continuously and another source of power should be used. Another problem with lunar orbit is that Moon mass is not uniformly distributed and any small deorbiting results high threat of colliding into lunar surface.

Afrodita 1.0 is a self-producing pseudo-gravity space settlement which will be kept in orbit by the Earth's and Moon's gravitational force. For the settlement to be in orbit safely, it needs to be placed in one of the Lagrange points. There are 5 Lagrange points in our solar system. Each one of them is a specific place in space which allows objects to orbit just like planets.This is because the different gravitational forces of the Moon, Earth and Sun create some permanent equilibrium points (Lagrange points). Lagrange points 1,2, and 3 are not stable or reliable because any small space influence can cause our settlement to drift away making it easy to lose orbit the Lagrange points. The Lagrangian points 4 and 5 are the safest options and are relatively close to resourceful bodies such as the Moon and asteroids. Lagrange 4 is located on the left of the Earth and Moon while Lagrange 5 is on the right.

Lagrange 4 would be the best point to place Afrodita 1.0 because it will always be ahead of Earth's orbit.This will make it harder to reach L4 (you will have to use more fuel) but it will be easier to go back to Earth (you will use a small amount of fuel).This is very important because if you don't have a lot of fuel and a complication forces the colony to leave Afrodita 1.0 urgently (which will be located on L4), you can go back to Earth without

running out of fuel. However, if you want to go from L4 to the moon then you will have to use a small amount of fuel alternatively when you want to go back to L4 you will need more fuel.

L4 obtains its stability due to the 4 forces acting on an object at that position: the gravitational pull from the Earth, the gravitational pull from the Moon, the push away from the center of rotation, called the centrifugal push, which is located between the two massive bodies, and the Coriolis force. The Coriolis force is perpendicular to the velocity of the object and proportional to the speed. The Earth and Moon move anti clockwise so the Coriolis force curves the motion of the objects to the right. If an object at L4 tries to escape the point with a slow, gentle speed, this force curves its trajectory so much, that the object cannot get anywhere therefore remains in its initial position.

2.1.1 L1 Construction base

The construction of the settlement requires an abundant amount of materials and continuous power. With current technological advancements, cheap access to space won't be available in the close future. Any large scale space mission must depend on resources in space. Rocket propulsion systems are almost same as the rockets first appeared. Constructing space elevator currently seems to be science fiction due to very high needs of technological advancements. If the space elevator idea can be achieved, it will play a significant role in space exploration. However, we cannot depend on assumptions and should be as realistic as possible and follow current technology. Earth based construction is not feasible due to high cost of space access. We have to choose a location in space for construction which will combine two factors; **proximity to space resources** and **ease of construction**. L1 lagrange point has both of these properties, close to lunar resources, relatively close to Earth resources and zero gravity or desired low gravity with rotation can be acquired for easier construction. Lunar resources, including titanium, aluminum, magnesium, iron, silicon, calcium and most importantly helium-3 can provide the necessary materials and energy required for settlement construction. Helium-3 can be used in nuclear fusion reaction with deuterium and can produce clean nuclear energy for business with Earth. Helium-3 can be a significant source of energy and has potential to afford cost of settlement construction. Considering the immense cost of the settlement, converting space resources into economy is crucial. It is estimated that 25 tons of Helium-3 can power up entire USA for a year. Harvesting He-3 from lunar regolith is not an easy task however. Millions of tons of He-3 should be processed under very high temperatures to obtain necessary amount of He-3. However, considering the expected profit and energy requirements, we can easily say that He-3 processing is one of the most important tasks for us. As well as construction, L1 base can also be used as a space factory in which Moon resources can be processed for construction and also solar panels can be built from silicate which is found in Moon. L1 base can produce array of solar panels with silicate mined in lunar base, solar arrays can be located on GEO orbit and initiate energy business

based on space based solar power with Earth. L1 location can also decrease the delta-V budget since it's close proximity to Moon and Earth is very good. This proximity helps us avoiding use of rockets for transportation of mined elements from Moon. Considering in space delta-V is calculated by change in velocity, electromagnetic mass drivers can be used to transfer mined elements as payloads directly thrown to the L1 base. Sending a packet in 2.8km/s will be enough to escape from the Moon's gravity. Lack of atmosphere, low gravity on the Moon and short distance make the use of mass drivers available and easy. This will save us launching cargo rockets from the Moon which are highly costly and can sometimes be more expensive than the total acquired profit. Communication in L1 location is another advantage of our base choice. **Communication delay to lunar base and Earth will be minimum and direct communication will also be available, it means use of remote robotic operations will be available**. Considering the harsh and extreme conditions on the Moon, robotic mining with remote control can greatly help us. Settling workers on the Moon require too much extra energy like protection from space radiation, low gravity, high thermal cycles, long nights without solar power, crop growing. Remotely controlled mining robots can potentially eliminate the required human life support factors. Being close to Earth also will help us significantly since at initial phases we will depend on materials launched from Earth. A relatively small rotating habitat located on L1 location can be used with 5-10 people working on robotic lunar mining for construction of our settlement.

2.2 ROADMAP OF AFRODITA 1.0

Colonization in human history started with small and progressive stages and developed into a real colony. We cannot expect to construct a society with 10,000 people just by moving them into a huge closed system. Constructing a habitat and moving 10,000 people in it, is not realistic and looks like a science fiction idea. A better and more realistic approach would be gradual development, starting with smaller steps, improving life conditions and population step by step, dividing the settlement design into sub smaller sections and progressively completing each section. **Afrodita 1.0 will gradually grow into a colonization by a long period of time**. The population will start with a small number of 120 people with high qualifications at many fields including mechanical and electrical engineering, life support system, communication, medicine. The initial 120 people will both work for construction of the settlement and will also form the colony basics, life support systems, agriculture, population dynamics, education and health system.

- Afrodita 1.0 will be 1 big torus, constructed part by part, at 10 sections in about 27 years in total.
- The torus will be constructed step by step as sections. Each section will be symmetrically located and will be identical.Each section will be part of the entire torus as if it has been cut into pieces.

- Construction of the settlement will be made by 120 highly qualified people from many fields including mechanical and electrical engineering, life support system, communication, medicine.
- Construction base with 120 people is one of the most important steps of entire torus habitat. These 120 people will actually start the base of colonization.
- Number of required workers and engineers will increase based on the progress in settlement construction.
- Initial part of the torus (1/10 of the entire torus) with all life support systems actively working will hold 1000 people.
- Estimated time period for the initial phase will be 12 years.
- After completing the first torus in 27 years, construction of second and third toruses will start.
- Each section will have life support system, 1g artificial gravity, radiation protection, waste management and other specific human needs in space.
- After completing and testing first section of torus, selected people will gradually be moved and colonization will start in all fields of life including education, health, entertainment, industry.
- Completion of first section will open the second phase, testing and transporting small number of inhabitants to start colonization.
- First section of the settlement will be a kind of demo of the entire settlement, it will have all the properties in much smaller scale so we will have testing period and fix the unexpected problems. Due to uncertainty in space, there can be always unexpected situations, testing these events in a much smaller settlement is a great advantage.
- After completing the first section of torus (1/10 of the entire torus), construction of following sections will be easier. There will be more engineers, more workers, space resources will be harvested at larger scale and technological innovations in material science, propellants and active shielding technology will lead us different approaches.

2.3 ASTEROID MINING

Mining asteroids is critical for both constructing and sustaining our settlement. During construction we will need materials both from asteroid mining and Moon mining. Afrodita 1.0 will be as independent as possible from Earth. Asteroid mining is already becoming an industry as some private companies work seriously to mine the first asteroid. This industry is also one of the reasons why some might choose to invest in our project. Profit oriented investments are necessary because the overall cost will be huge and it must be somehow returned back to our investors including governments and private companies. We will mine

asteroids to initiate the in-situ propellant production by means of electrolysing water. Platinum is a metal which has a high demand on Earth, as it is very rare. As it is known by many studies, it is found on asteroids at immense amounts. We will aim for both profit and resource gaining on our space, asteroid mining, missions.

Size of the target asteroids is a factor as well as its composition since even a small sized Asteroid can contain immense amount of resources and clearly mining a small asteroid after capturing it will be much easier compared to a big sized asteroid. Most asteroids, in our solar system, are located in the asteroid belt between Mars and Jupiter. There is one problem with the idea of mining asteroids situated in that belt and that problem is that they are too far away. Our focus is the so called near Earth asteroids. There are about 10,000 of them discovered to this point.

On some small asteroids we will mine the gravity produced is close to zero and therefore different mining devices. The mining device will surround the asteroid in order to not get detached and work effectively. For more information visit the construction sequence asteroid drill (2.7.8).

The closest thing up until now to asteroid mining has happened during the Apollo program. During the program, 382 kg of rocks were brought to Earth at the cost of around 125 billion dollars. Mining resources from asteroids is easier than mining resources from the moon. It would decrease cost if we used unmanned spacecrafts. 3D printing would have a huge use in asteroid mining, if it is developed efficiently. Rich in water asteroids are a source of propellant because water can be broken down into hydrogen and oxygen.

2.3.1 Asteroid Selection

When deciding what asteroids we should aim for we will take in consideration the following factors:

- Proximity of orbit to Earth - the asteroid will need to be a near Earth asteroid because it is very difficult to reach the asteroid belt.
- Useful raw materials - we are obviously searching for metals which we can use on our settlement, but also metals which will bring us profit when trading with Earth (such as platinum). Other, resources such as water, are very important to us due to their necessity for Afrodita’s sustainability.

It should be noted that during selection target Asteroid, space based telescopes should be since our atmosphere will deform the Asteroid composition data. Similar to Planetary Resources, small sized telescopes might be used to determine the target Asteroid. This will save the cost of launching very large space telescopes.

2.3.2 Mining procedure

The fact that there is no gravity on small asteroids means that we will need to apply special techniques in order to successfully extract the wanted resources. Our mining system will consist of automated machinery which is programmed to dig the desired materials. The metals and minerals located on asteroids are concentrated in one small part of the asteroid. When the digging starts, the larger metal and mineral deposits will then be roughed into smaller pieces. The miners will then direct the materials upwards, towards a pipe, which will absorb water and a canopy to catch the other solid materials. Water will go up the pipe and metals will be trapped in the canopy in order to further be stored in another place. The canopy needs to be durable so nylon might be a good choice of material.

2.4 LUNAR MINING

Since the construction of the settlement will be at Lagrange point L1, the Moon will be our main source of construction materials and energy production.

A very valuable source of resources would be the moon as it is very convenient to extract resources from it. From the moon, we can mine several elements such as: Helium-3, Magnesium, Aluminium, Silicon, Iron, Titanium and Methane. The metals in the list can be used for the construction of Afrodita 1.0 and methane can be used as fuel when hydrogen is not widely available or when strong thrusts are needed. NASA has also discovered water on the moon. Water is a precious substance because we can extract both oxygen and hydrogen from it by electrolysis to add to the supply of breathing air (oxygen) and fuel (hydrogen). There could also be undiscovered precious materials hiding under the surface of the moon such as uranium or thorium (both can be used as fuel for nuclear reactors).

2.4.1 Helium-3 Mining

Helium-3 is an extremely useful resource for our settlement as it can produce nuclear power without creating radioactive waste and the moon also carries relatively much of it as the solar winds blew helium-3 onto the moon because the moon does not have a magnetic field like Earth. Tritium (hydrogen-3) can also be used to produce helium-3 by decaying it which could be useful as it does not have an extremely long half-life(12.3 years). Even though helium-3 can be found in lunar regolith, which can be found anywhere on the moon, the concentration of it in the lunar regolith is low so we would need machines to process massive amounts of lunar regolith to obtain helium-3 approximately one million tonnes of lunar regolith to obtain seventy tonnes of helium-3. This requires us use vacuum based new types of mining vehicles which can process lunar regolith by heating up to more than 1000 C degrees. The lunar poles could be richer in helium-3 according to the moon samples Apollo

brought back from the areas closer to the lunar poles as Ian Crawford suggested: "*It's possible that helium-3 and other solar-wind–implanted ions, like hydrogen, may be in a higher abundance in the cold regolith near the lunar poles. That would be an important measurement to make and would require a polar lander*". We also have to consider the transportation of the element in the profit calculations. Helium-3 is the only resource we can extract from the moon that will bring profit to the colony because the other elements are not valuable enough to overcome the transportation price. Helium-3 can be used to exchange with Earth for other important materials as well due to the plentiful amount of the helium isotope located on the moon.

2.4.2 Transportation of Mined Resources to L1

Normally, we would use a type of transportation that will require fuel and other materials to transport the resources to Afrodita but we can use mass drivers to send the resources to the settlement without using a significant amount of precious materials we need. A mass driver is a type of catapult functioning with powerful electromagnets that send objects travelling at high speed in a straight line. Estimated speed of a payload should be 2.8 km/s to escape the Moon's gravity. Mass drivers can be very useful as it will save the colony a remarkable amount of resources. A type of catching device secured to the settlement will be required to be able to extract the resources sent by the mines on the moon.

We will also utilize rockets to transport resources as there is no strong gravitational force to make the rocket transportation difficult like on earth. If we are going to use rockets, the consideration of types of propellants will be a necessity. In-situ Propellant Production (ISPP) is rocket fuel production from regional resources which will be extremely useful due to the plentiful amount of resources on the moon. Substances that can be used as fuel and can be found on the moon are: Hydrogen, Methane, Silane, Sulfur, Aluminium and Silicon. Among these alternatives, methane can provide us sufficient impulse as propellant in cases of mass drivers won't be available.

2.4.3 Remotely Controlled Robots

As explained in the construction base, moon mining will be mostly made by remotely controlled robots. Close distance to L1 lagrangian point enable us to use robots and avoid use of life support system in the extreme conditions of the Moon. However, to maintain all mining operations, human presence will be required after first phase is completed. In the first phase:

- Small rovers will be sent for discovery and research
- Mini rovers will install solar panels.
- Mini mining rovers will be sent to mine the best available places determined by research rovers.

- Mini mining rovers will prepare first human shelter under 3 meters of surface of the Moon. 3 meters under the lunar regolith will provide enough protection from both radiation and meteoroids
- Remotely controlled robots will install electromagnetic mass drivers.
- First human presence will be needed for maintenance and error checking, 5 highly qualified engineers will be sent with necessary life support systems for 6 months.

Maximum working period for an engineer is set to 6 months due to radiation exposure and low gravity factors. In every 6 months, the working crew will be replaced with new engineers. Even if this replacement is expensive, it will be required for the safety of the crew.

The primary mission in Moon for the first crew is to start In-situ propellant production and provide closed life support system under the regolith. Radiation exposure level of engineers will be checked continuously. In our Moon base, the maximum dose will be accepted as 20mSv. There will be an emergency shelter under 7 meters. The crew will sleep in these shelters. In cases of Coronal Mass Ejections, which may happen 0 to 5 times a year, if an engineer remains outside, he/she will be sent back to Earth. Our main purpose is to limit the human presence on the Moon base as soon as possible and automate all mining and transport operations by means of robots.

2.4.4 Energy Requirements on The Moon

The energy on the moon will be primarily based on solar power. However, during long nights that can reach to 14 days, solar power won't be available and even the best battery system won't be sufficient for such a long period of time. Energy consumption during long nights will be minimized, all mining operations will stop. We will not need a huge amount of power in those days. Obviously a large nuclear reactor will be very difficult to install and operate. But a solution to energy problem during lack of solar power would be to create a mini nuclear reactor on the moon that will use some of the helium-3 that will be mined. Small Modular Reactors (SMRs) could be an option for the mini nuclear reactors as they shouldn't be very costly or time-taking to build. SMRs also save water needed for cooling as it is not large in size to create high amounts of heat. Its small size also allows it to be compact and be built underground to prevent asteroids from crashing into it. Small reactors already operating on Earth such as: VK-300, CNP-300, IMR can have around 300 MWe. There are 2 main different types of SMRs the lunar miners are going to use: fast neutron reactors (requires fuel that is extremely fissile compared with the fuel for thermal reactors), light water reactors (uses water to control temperature and moderates neutrons). The type of reactor the lunar mine will use is fast neutron reactors as a lot of water will be needed for the light water reactors.

The craters on the moon created by the collisions of asteroids, meteorites or comets with the moon could also contain precious materials for our settlement as asteroids, which we know that carry important resources (such as platinum), crashed to create the craters.

The transportation of mined elements will be made by mass drivers and the construction will be done in L1 location by using lunar resources. Unprocessed payloads will be sent to L1 base in the speed of 2.8 km/s to escape the Moon gravity. We cannot send all the mined elements by mass drivers like Helium-3. Such valuable elements must be carried with a cargo rocket. To decrease the cost of fuel, we will not use any rocket for transportation until Moon based propellant production will be available. After propellant production is succeeded, Helium-3 will be transported by cargo Rockets.

2.4.5 Health and Protection of Moon Miners

Another aspect of the lunar base is the health of the workers on the moon. Long periods in low gravity leads to bone and muscle loss that will decrease their productivity. Therefore, we are obliged to consider the medical and psychological factors of the lunar workers. The workers will have to consume certain calcium-rich medicine, foods (dairy products, seafood, certain vegetables and drinks) and doing large amounts of exercise daily. As a result, we will have to include a gym section in the lunar base. The amount of exercise each worker will have will depend on how important the worker is so the more important it is for a worker to return to Earth, the more exercise he will do. The lunar gym will be ovally shaped that contains exercising machines on the inner wall. The gym will produce its own gravity by rotating at around 1-2 rpm to prevent the coriolis effect. The pseudogravity is an essential part of the gym as the workers cannot exercise properly in 0 gravity.

2.5 COMPARISON OF POSSIBLE MATERIALS

Afrodita 1.0 will need advanced engineering materials, light, strong, damage tolerant, corrosion resistant, temperature resistant and radiation protective infrastructure so it can survive in extreme conditions of outer space. Materials will be acquired from Earth and space resources by asteroid and lunar mining. Using conventional materials in construction will result in huge mass and mass in space cost. Material choice should focus on combination on many properties together but most importantly density.

In space weight means cost, decreasing the cost and keeping the overall structure strong enough for harsh space conditions redirect us to search materials which are good at stiffness to weight ratio. Currently, “composite materials” are the best options for space missions with perfect properties and very low density.

Composite materials are two or more specific materials which are combined together (without losing their original properties) to make a product with improved properties and

sometimes lower manufacturing cost. They are usually consisted of a *matrix* or a base material and a reinforcement material.

The matrix is used to stick/bond to the reinforcement and manipulate the physical dimensions of the final product. In some cases, the matrix is used to protect the reinforcement.

The reinforcement is needed for its mechanical properties such as strongness, flexibility and so on. It is usually in a form of carbon fiber.

Composite materials are becoming very efficient for aerospace uses since you can combine two materials with very good physical properties and form a composite material that will have even better properties.

The table below compares the properties among the candidate materials.

Comparison of Possible Materials for Settlement Construction					
Materials	**Price ($)**	**Source**	**Properties**	**Density g/cm^3**	**Predictions**
Multiwall Carbon Nanotube	95 per kg	Earth	Unique geometry (small diameter and high aspect ratio) high stiffness, high strength	1.33	Multiwall nanotubes already in practical use, in high demand, will be available in vast amount in low cost
Titanium and its alloys	5 per kg	Moon mining	Resistance to corrosion and high temperature performance, able to resist on micrometeorite collisions, good for entire integrity	4.43	Excellent properties associated with space environment makes titanium one of the best candidates for most outer layer.
Aerogel	400 per kg	Earth	Excellent thermal conductor one of the best materials for thermal	0.02	Currently too expensive to use vast amounts but expected to become cheaper in the future

			insulation		
Aluminum and its alloys	2 per kg	Moon mining	Very light, quite strong and malleable	2.7	Aluminum alloys especially with lithium has great features and more accessible compared to composite materials, abundant in Moon.
Carbon Fiber	20 per kg	Earth	Carbon fiber has a high strength to mass ratio and it is very light. However it is a bit brittle	1.6	Carbon fiber is relatively expensive now but it is expected that in the future the price will decrease after vast uses.
Platinum	42 per kg	Asteroid mining	Very strong and dense	21.5	Too expensive in Earth, can be used only if obtained from Asteroid mining
Microlattice	NA	Earth	The price might be high but it will be useful due to its lightness	0.9kg/m^3	In the next decade , microlattice will be available in higher supply and it will be used widely in aerospace.
Tungsten	27 per kg	Earth	very strong and it has a high melting point	19.35	Strongest natural metal. It has to be used only in some places of the settlement because it is rare.
RTV adhesive	10 per kg	Earth	Bonds materials efficiently	1.29	Can be used to bond different layers
RXF-1	NA	Earth	Very light, so effective on radiation protection	1.04	Great success on radiation protection with its low density makes it a perfect choice but not used

					practically yet, more tests needed.
Steel alloy	0.8 per kg	Earth	It is one of the strongest alloys and it is cheap in comparison to its properties	7.85	Steel can be used to create many object , the only problem is that, it doesn't exist vast amount in Moon need to be imported from Earth

2.6 CONSTRUCTION MATERIALS

There will be a rich variety of construction materials that will be used to construct Afrodita 1.0 . Layers of materials model will be chosen. To provide the total protection and sufficient toughness, the cost factor will be minimized. Each constructing material has its own speciality: lightness and strongness (+ malleable). The Anti-Radioactive materials are on the "2.10 Radiation Shielding" sub-chapter. Even if we try to avoid predictive choices, some material choices depend on small predictions like Moon and Asteroid Mining will start and composite materials will be more available at lower cost. Almost the materials we used have already some practical uses in aerospace applications.

This table shows clearly all the materials that will be used in the construction of the settlement:

Construction Materials			
Materials	**Density g/cm^3**	**Thickness**	**Total Mass (tonnes)**
Carbon Nanotubes	1.33	18 cm	~ 837 900
Aerogel	0.02	25 cm	~ 17 500
RXF-1	1.04	55cm	~ 2 002 000
Aluminium-Alloy	2.7	25 cm	~ 2 362 500
Microlattice	0.9kg/m^3	7 cm	~ 220.5
Carbon Fiber	1.6	15 cm	~ 840 000
RTV Adhesive	1.29	30cm	~ 1 354 500
Titanium-Alloy	4.43	25 cm	~ 3 876 250

2.7 CONSTRUCTION SEQUENCE

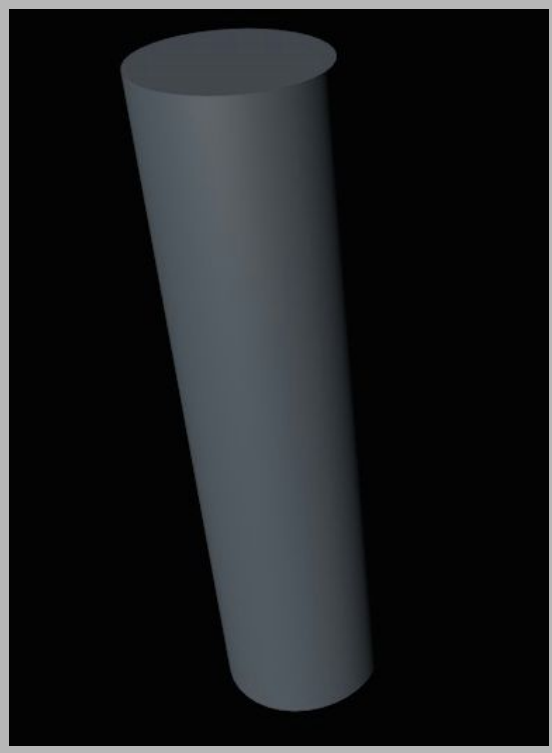
Afrodita 1.0 will be formed from 4 main parts: the **Main Tube**, the **Intersecting Tubes** , the **8 Torus Engines** and the **3 Toruses**. Each part has many important specialisations and with one part missing the settlement will not be able to work properly. The construction will take place in space and in the Moon mostly, that is because we will take the advantages of the zero gravity in order to create the settlement and the Moon has many resources that are necessary for the construction.

There will be humans helping to build the details of the settlement but most of the difficult jobs will be done by remote controlled robots/specialised machines.

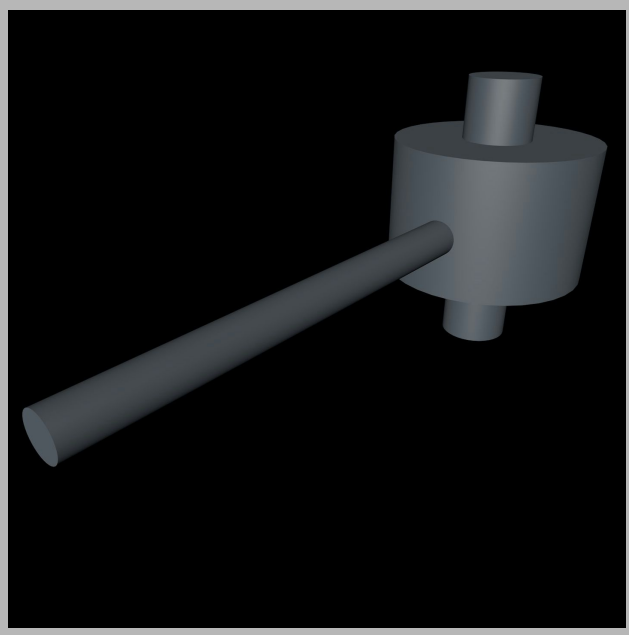
All the workers will wear “shrink wrap” space suits instead of suits that act as pressurized balloons. Those suits will be light and flexible so it can be easier for them to perform physical activities. They will also be as anti-radioactive as possible so they can work for a longer time period. The maximum amount of a worker staying in space will be 1 year due to space radiation which is harmful to the human body.

Our aim is to create the first torus successfully and once everything is under control we will allow tourists and visitors to stay. While the visitors/tourists will stay in the first torus, the second and third torus will be built. In this way , we can earn money from visitors by having only one functional torus. The construction of the settlement will consist of small modules, built and connected to the main structure one by one so there will be a slow build of people instead of a mass migration. The agriculture of the settlement will be very important as it is Afrodita’s main source of oxygen. The other source of oxygen is water. Hydrogen and oxygen can be extracted from water, providing atmospheric pressure, a human need and fuel in the same time.

This are several diagrams which explain the construction sequence in a chronological order:

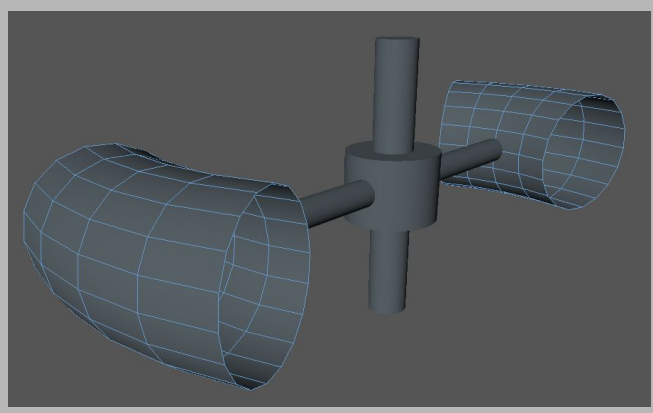
Details	Image
Main Tube	
The Main Tube will be the first part to be constructed but it will *not* be completed until the whole settlement will be finished. As you can see this will be the first part of the main tube that will be constructed, it will be 400 meters. As more toruses will be built, the height of the main tube will gradually increase until the maximum height of 3000 meters. In the end, the Main tube will be connected with 2 ion propulsion engines, one at the top and one at the bottom. It will also include an elevator in which heavy materials can be transported around the settlement as well as many people at a time. Also many cables and pipelines will pass through this tube. Since the main tube will have no gravity, we can take advantage of that by making a "zero gravity" park (where people can float around and have fun) and even a science laboratory where scientists can make experiments with zero gravity.	
Intersecting Tube	

After the partially built main tube, the next construction will be the first intersecting tube. They are called “intersecting” tubes because they connect the toruses with the main tube. These tubes will be used to transport people , food, water and more objects from the main tube to the toruses. Each torus will be consisted of 12 intersecting tubes.

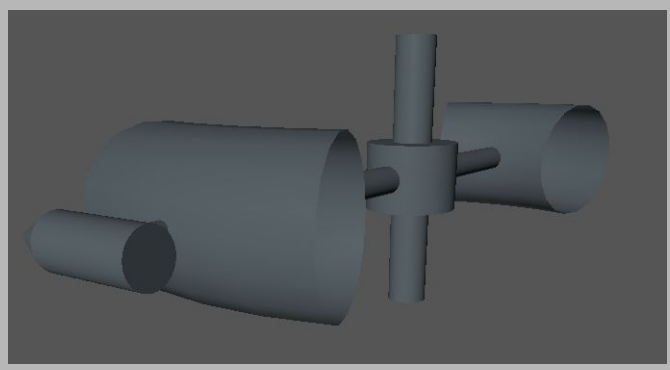


Construction of a Torus

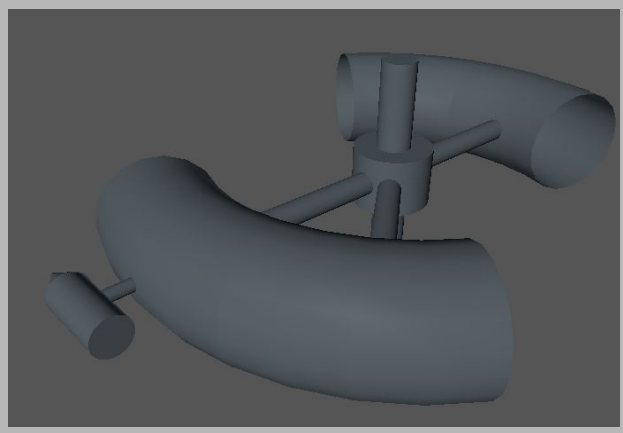
1.) The construction of the torus will be a long-lasting procedure. Each torus will consist of 48 ring segments. After 2 intersecting tubes are build, 4 ring segments will be placed.
In the first diagram there is one intersecting tube which holds 4 ring segments of the torus.



2.) After the two pairs of 4 segments are constructed, two rocket fueled engines will be installed, one on the left side and one on the right side. When that is completed the uncompleted torus will still be able to spin, maintain its artificial gravity and allow visitors and tourists to stay.

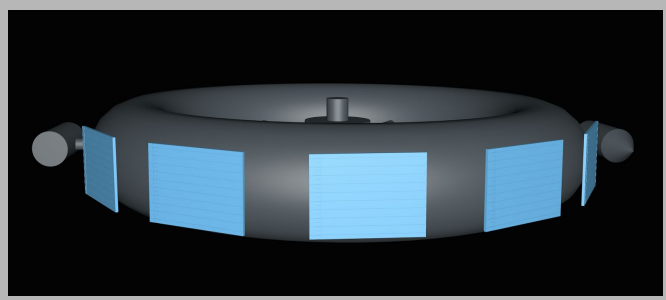


3.) The construction procedure will continue with the same procedure, which is to add 8 torus segments at a time, 4 segments on the left and 4 on the right.

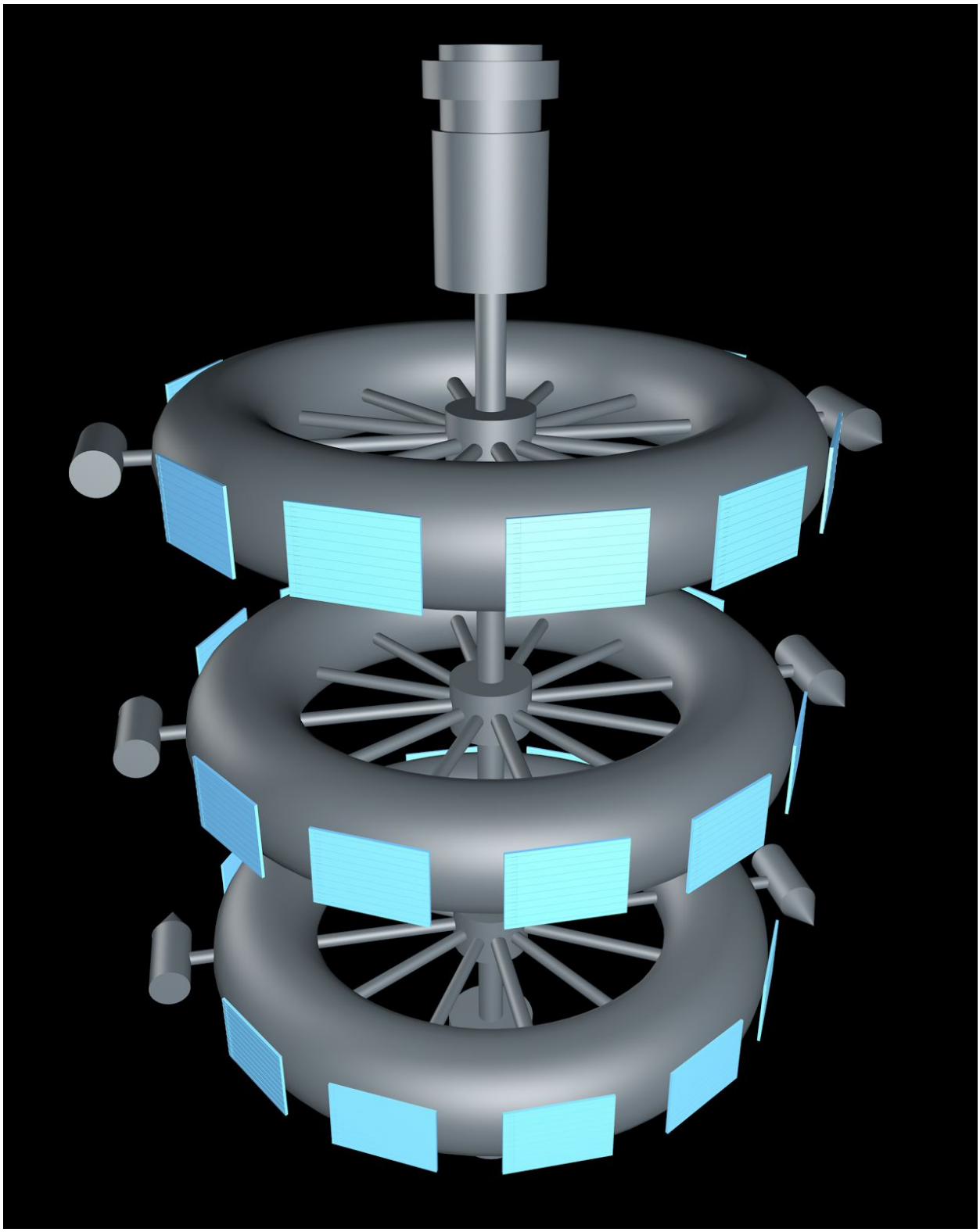


4.) Once the first torus which will be constructed, **solar panels** will be added on the outer surface of the torus to absorb light.

Each torus will be divided in two compartments: The **agriculture sector** and the **residential sector**.
In this way, the transportation of food in the settlement will be faster and cheaper



since there will be a smaller usage of the elevators. Visitors and tourists will be able to come and stay in the uncompleted settlement. As they stay, the second torus will be under construction while the main tube will expand. So basically, as the construction continues, we will earn money by the tourists/visitors who will stay.	
Finalization of the Toruses	
The construction will be fully completed when the settlement will have the 2 ion propulsion engines (one on top and one on the bottom) which will allow the settlement to escape the L4 orbit.	



The final phase of Afrodita 1.0

2.7.1 Specifications of a Torus

Specifications of a Torus	
Population	10 000
Area / person (m^2)	112
Surface Area	3 510 017
Volume (m^3)	1.76
Water daily (tonnes)	200
Food daily (tonnes)	31
Oxygen mass (kilotonnes)	42.9
Nitrogen mass	64.5
Solar panel area (m^2)	86 000

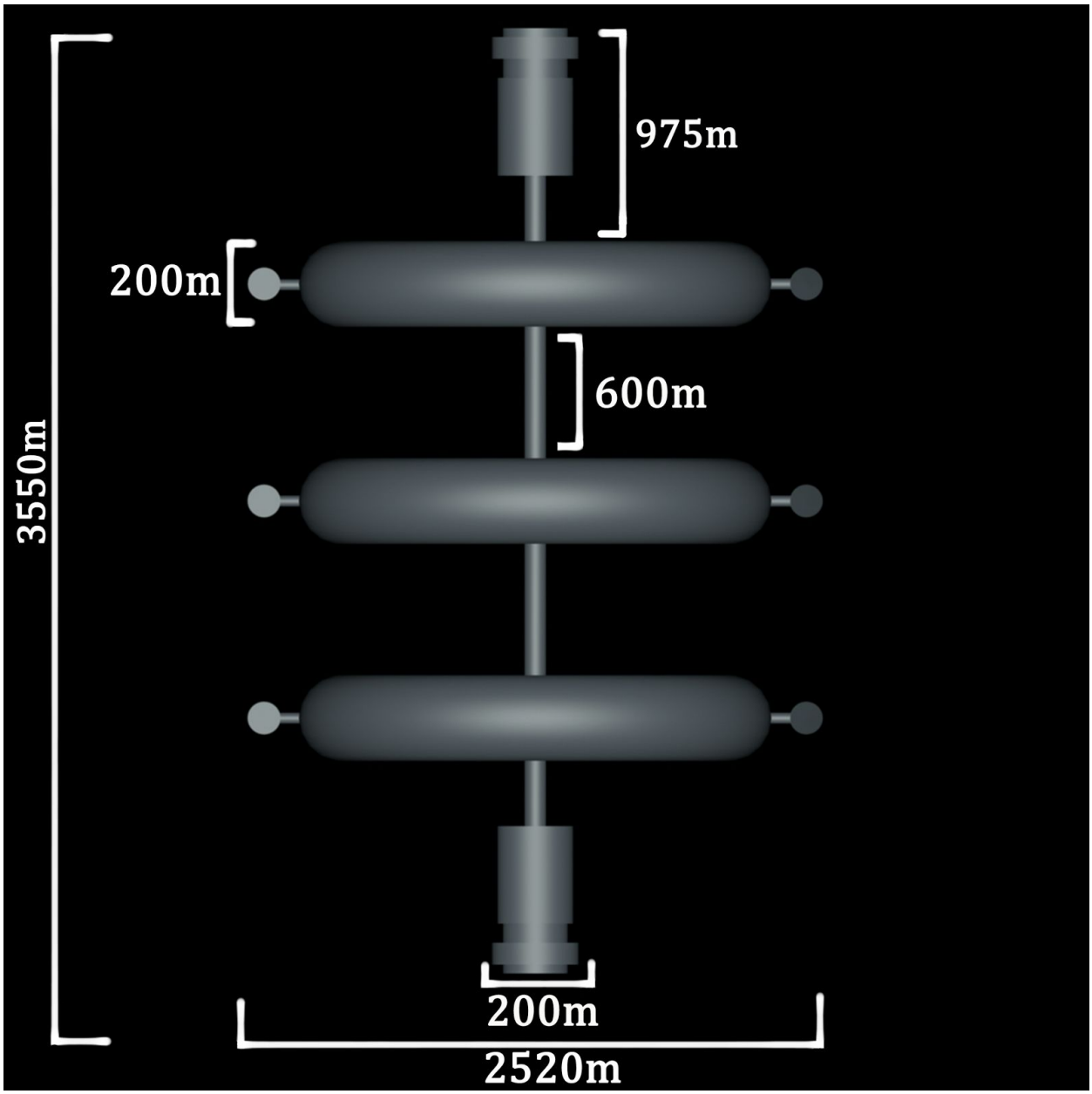
2.7.2 Measurements of Afrodita 1.0

Here is a table which clearly shows the radii and sizes of the different parts of the settlement:

Construction Part	Technical Details of Afrodita 1.0	
Torus	Radius	890m
	Pipe radius	100m
Main Cylinder	Pipe radius	50m
	Height	3000m
Intersecting Tubes	Length	690m
	Pipe radius	25m

Here is a diagram of the settlement shown from the front-view. Unlike the table of specifications from above, this diagram shows some unusual measurements that are not found

in the table such as the height of the main tube between two toruses, the total height of the settlement etc.



2.7.3 Asteroid Spaceship

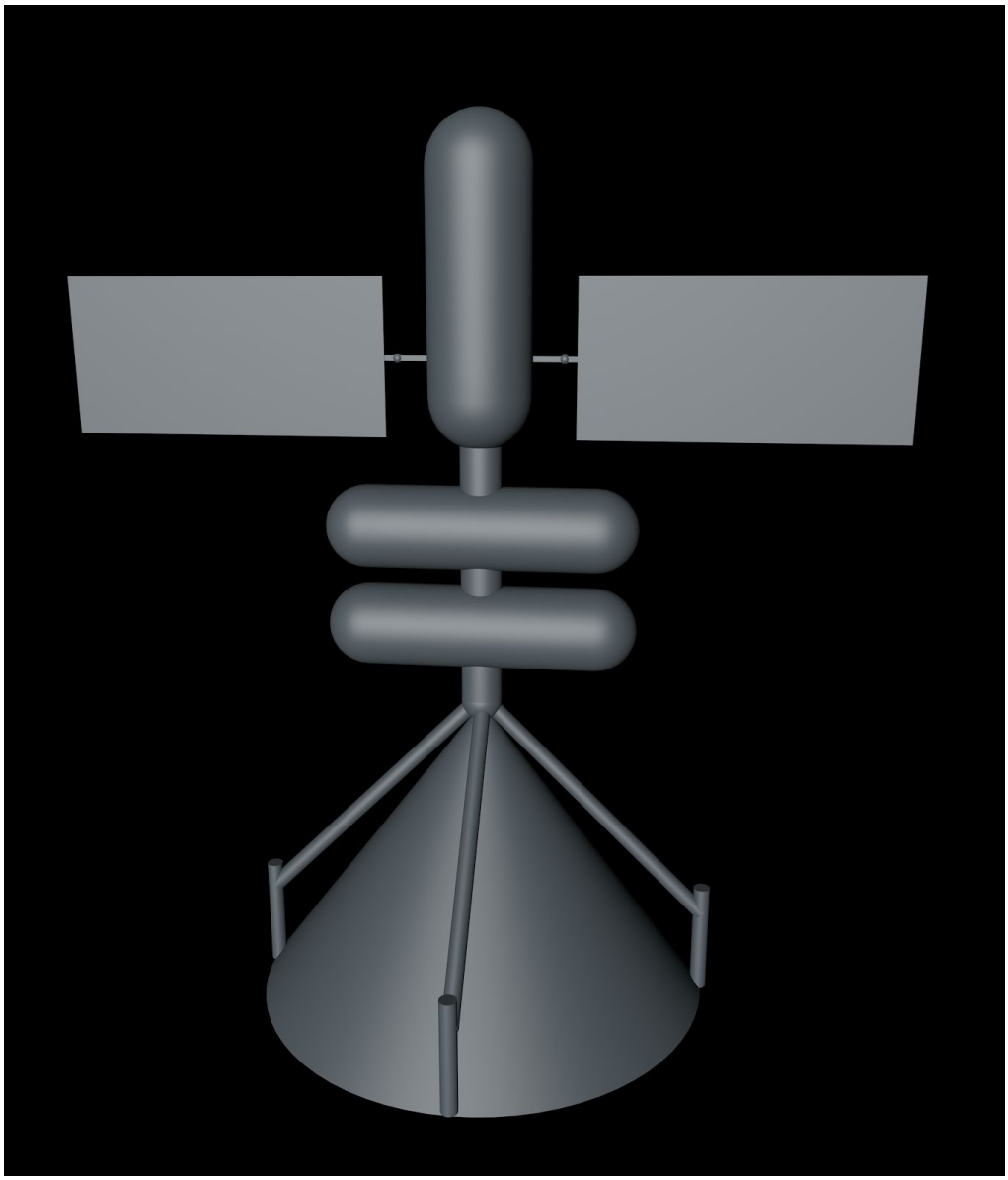
Current advanced space rockets like Falcon Heavy, Space Shuttle can transport around 20-30 tons of materials to Low Earth Orbit. We are going to need a specially designed rocket which will allow transporting materials from asteroids. It is obvious that so many trips that target asteroids will have a high total cost and a low the delta-v cost. We need a rocket which combines two properties: **transporting large payloads at once**, and **cheap propulsion system**. These 2 factors lead us to search for propellant alternatives. Between

very efficient traditional chemical rockets and less efficient but space mining based propellants like solid propellants. We decided to choose aluminium based solid rocket propellant as we will use this rocket only for space transportation and it won't need to launch anything from Earth. However, this rocket will be constructed and assembled on Earth because it will require specific details which will need a lot of human work. Its supplementary energy will be obtained by the sunlight using the 2 solar panels. Next to the each solar panel there will be a “ball and joint socket”. This is important for two main reasons: Firstly, the ball and joint socket will help the solar panels “fold” in a way so the spaceship can reach in the docking stations (which will be located in on the outer surface of the main tube). The second reason is that the ball and joint socket will help the solar panels capture as much sunlight as possible. This will happen by rotating the solar panels perpendicularly to the sun so they can absorb as much light as possible.

The main part of the spaceship is the long “capsule” which is between the 2 solar panels. The dimensions of the capsule will be radius = 49 meters and height = 300 meters so there can be enough space for 4-8 specialised workers and enough space to store any machinery that will be needed in the mining and food & water for the workers.

The spaceship also has 2 more capsules which will be the storages for the resources that will be mined. The first capsule will be the water storage and the second capsule will be the metal storage (mostly platinum).

Except from the solar panels and the capsule, this spaceship has another special feature: a drill and a pipe which will be located inside the empty cone (see the image below). This will be used so the spaceship can attach on an asteroid securely. The drill, which is not visible in the image below, will mine the asteroids to find the resources. The pipe, which will be inside the cone, will be used to extract the water from the asteroid. The extraction of metals and other heavy materials which cannot be absorbed by the pipe, will be collected by the space workers with the help a canopy. As you can see in the picture below the cone is big compared to the actual spaceship. Since it is long and wide, it can attach to different kinds of asteroids which have non-uniform grounds.

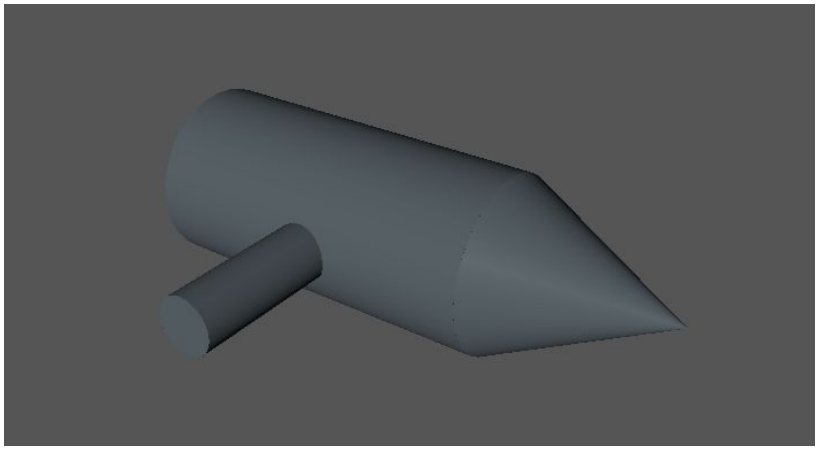


2.8 GRAVITY AND IMPULSE ENGINES

2.8.1 Rocket Fueled Engines

The settlement will have 6 rocket fueled engines (gravity engines), two for each torus, symmetrically positioned to rotate the settlement according to central location to generate artificial gravity. The engines will have the power to rotate their toruses to 2 rpm but they will be clocked-down to approximately 1 rpm so it will feel like being on the earth.They will also have the ability to slow down if needed. The overclocking of the engines will occur only in extreme circumstances (for more information see the sub-chapter 3.5.6 Rocket Fuel

Engine Failure). The image below shows how a Rocket Fueled Engine (Gravity Engine) will look like:

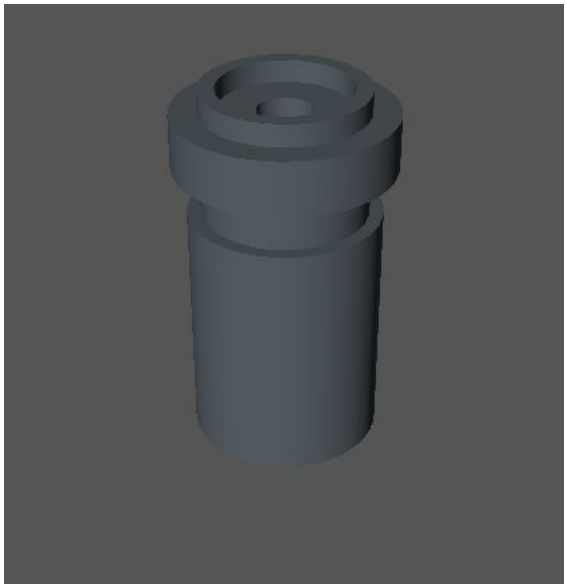


2.8.2 Ion Propulsion Engines

Ion propulsion engines work with electric power and use a gas (Afrodita 1.0 will use xenon) which will then be ionized and move the torus when it needs to escape the L4 orbit.

One big advantage of the ion propulsion engines is that the ionizing gas (that will be used in order for the engines to work) is non-flammable unlike other chemical rocket engines, and don't require expensive chemical propellant. They will also have a long life which is very useful since the engines will work non-stop for many years in space. The engines will be powered by a nuclear reactor and also power that will be obtained from the solar panels of the toruses.

Similar to artificial gravity engines, we will also need impulse engines in order to gain maneuver capability to escape from high radius space debris threats. Compared to artificial gravity engines, impulse engines must provide high thrust. The image below shows how an ion propulsion engine will look like:



2.9 ARTIFICIAL GRAVITY

Artificial gravity is an obligation for Afrodita 1.0 as exposure to low gravity can be harmful for the inhabitants of the settlement but the influence towards the bones and muscles of humans is not entirely known as no person has been affected by low gravity exposure to be examined. Artificial gravity can be produced in a number of possible ways: linear acceleration, rotation and magnetism. The most feasible option is rotational gravity as it does not require a lot fuel to maintain it due to the lack of friction in space. In addition, rotational gravity suits the shape of our settlement (3 toruses). The minimum amount of gravity needed is not certain either but Afrodita will maintain as much similarity to Earth as possible (1 g).

2.9.1 Rotational Gravity

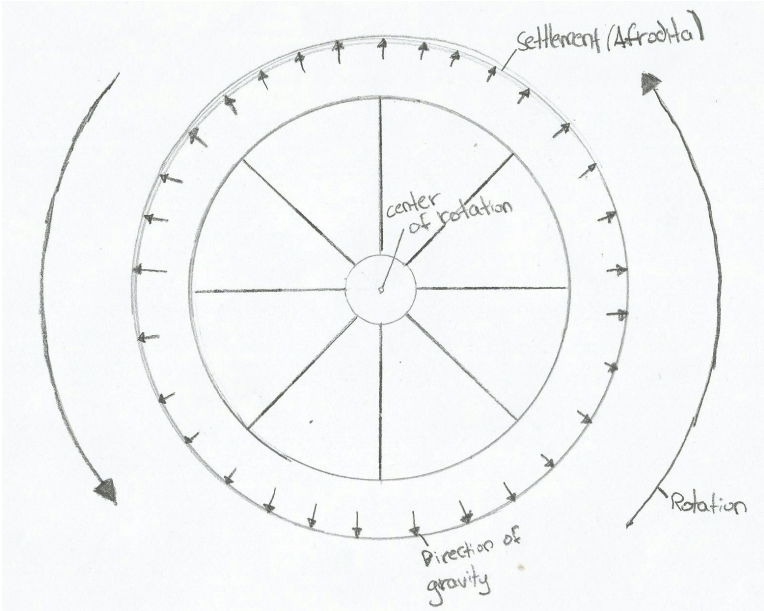
This type of artificial gravity will be used in our space settlement as it is the most efficient one out of the three and different than real gravity, which pulls objects towards the mass. Instead, this pseudo-gravity pushes objects away from the center of rotation and is appropriate for Afrodita 1.0 due to its shape. This type of gravity will be created by applying enough force to make Afrodita 1.0 rotate at a suitable speed for the inhabitants (1 rpm) so it does not influence the occupants with the "Coriolis effect". The Coriolis effect is basically a force influencing a human (or any other animal) by affecting the inner ear and cause nausea or dizziness. Another issue that can be easily solved is the additional strength of the settlement needed to prevent certain parts of the spacecraft from drifting away. The way we will make the settlement rotate is by using one or more of its thrusters. Once the settlement starts rotating, it will need extremely small amounts of fuel to maintain its rotation speed as

there are very small forces acting on the settlement to slow its rotation down in space. To use rotational gravity for Afrodita, we need to consider the calculations for the radius of the settlement so it would work in harmony with the rpm Afrodita will have. To obtain approximately 1g, calculations that include: the radius of the settlement, revolutions per minute and the gravity. The equation that will be needed is the following:

$$g = \frac{R \times (\frac{\pi \times \text{rpm}}{30})^2}{9.81}$$

where: g=gravity
R=radius
rpm=revolutions per minute.

The following diagram shows how the rotational gravity will work on Afrodita:



The equation tells us that the larger the radius of the settlement, the rpm and energy will be required for the artificial gravity production. There is an infinite number of different combinations of rpm and radiuses that can be used to create 1g for Afrodita.

Rotational gravity will also be used for entertainment and scientific research in the central cylinder where 0 gravity occurs. Entertainment is a very important aspect of the inhabitants' lives due to mental and physical factors. Humans need relaxation and fun to improve productivity which would be another advantage for rotational gravity. Scientific research will use 0 gravity to make experiments and researches on how different materials act in certain conditions in 0 gravity. This can improve our knowledge about certain materials and discover new properties that can upgrade our technology.

2.9.2 Linear Acceleration Gravity

Linear acceleration acceleration gravity is extremely unsuitable for the space settlement because it will constantly consume fuel and the settlement could escape the lagrangian point where Afrodita 1.0 will be located. Linear acceleration is produced by accelerating in a straight line, thus being named linear acceleration. The acceleration of the spaceship will be directly proportional to the gravity produced by it, giving : a=g

where: a=acceleration

g=gravity

For linear acceleration gravity, low impulse thrusters such as “Hall Effect Thrusters” could be used as we can create gravity with a very low acceleration and we also need to save fuel as well. The only situations where linear acceleration gravity could be useful is when the settlement needs to travel someplace else or for the transportation of the new inhabitants or visitors of Afrodita.

2.9.3 Magnetic gravity

Magnetic gravity consumes massive amounts of energy to maintain which will be a very inefficient way of producing pseudo-gravity. This is the mainly why we will not use it in Afrodita. The way it works is by using magnets with remarkably strong magnetic fields. Scientists only managed to levitate a mouse using diamagnetism so we cannot rely on magnetic gravity. Even if engineers could produce enough gravity for Afrodita through magnetism, the safety of the settlers would still be uncertain and could harm them.

2.10 RADIATION SHIELDING

One of the major problems we need to combat is radiation shielding. The average amount of radiation humans can tolerate is 20 mSv per year. 80% of our total cost is mainly from the materials needed for radiation protection, therefore, we need to chose the most efficient method. In order to protect our settlement from dangerous galactic cosmic rays (GCRs) and solar particle events (SPEs), we should put thick layers of shielding. Solar proton events are when protons are released by the Sun and accelerate either close to the Sun during a flare or between planets due to coral mass ejection (CME) shocks. Lacking thick shielding, SPEs are strong enough to cause acute radiation poisoning and death.

We can use active shields which include magnetic or electric fields in order to repel or trap the radiation particles. The problem with this is that there is a limit in the momentum and energy of a particle. If the particle exceeds the limit, it will be able to penetrate beyond the fields. We need to take into consideration the protection against difficult particles such as the heavy ion cosmic rays (Z primaries). In order to do that, we need a magnetic field with a

cutoff of 10 or 15 GeV/nucleon. This would protect the settlement from strong solar flares and high energy particles but,the structural mass needed to resist the magnetic forces between superconducting coils makes any design impossible to build. On the other hand, electric shielding seems beyond the bounds of possibility as it desires a 10-billion-volt for even reasonable shielding.

Passive shielding includes different layers of metals that don't allow harmful particles to pass through, such as: gamma rays, x-rays, Alpha, Beta and neutrons. Lead is reliable for protecting against Gamma and X-rays due to its high atomic number. Its electrons block most rays but an absolute barrier is not guaranteed. Usually, denser materials are used for radiation protection but materials which are less dense can compensate with thicker layers. For Alpha and Beta particles thick layers are not necessary. For example, a single centimeter of plastic is enough for shielding against Alpha particles. Plastic can produce an efficient barrier in dealing with high-energy Beta radiation. Below you will find a radiation shielding materials table:

Comparison of Materials for Radiation Shielding

Materials	Density (g/cm3)	Price ($)	Place of extraction	Conductivity	Protection against...
Liquid Hydrogen	0.07085	5.50 per kg	Moon or Water	Good	Neutrons
Water	1.0	1.0 per L	Moon	Poor	Neutrons and Beta Particles
Aluminium	2.7	1.48 per kg	Earth	Good	Beta Particles
Lead	11.36	1.76 per kg	Earth	Good	Gamma and X rays
Lithium Aluminium Hydride	0.917	200-400 per kg	Earth	Good	Protons and Neutrons
High Z steel-steel	6.0	0.94	Earth	Good	Neutrons, Gamma and X rays
Polyethylene	0.91-0.96	1.4 per kg	Earth	Poor	Alpha and Beta Particles

Alpha particles are the least worrying as they are not strong and do not penetrate through easily. Polyethylene would be best suited for them as it has a very low density. Beta particles are stronger but a thin shielding of aluminium can defend Afrodita 1.0. If there are emitted high energy Beta particles, lower density materials are more convenient, such as water or plastic, in order to reduce secondary radiation. Neutrons are very strong and have a high penetration rate. Mostly, hydrogen based materials are suitable for neutrons such as water or liquid hydrogen. Also a relatively new material was composed from steel and tungsten, named “High Z Steel-Steel”. It can be used for protection against neutrons. Atoms with heavy nuclei are best against Gamma and X rays. The most frequent material used is lead but it is not very convenient as it has a high density. We could use High Z Steel-Steel as it helps protection against more particles but is also relatively dense.

In order to have an efficient radiation shielding we must have a couple of layers. The first layer could be made out of thin water layer as it is hydrogen rich, good at radiation protection and also an effective thermal insulator. Following, could be a layer of Polyethylene as it is also a good insulator so it won’t allow any heat to escape and also does not allow alpha and beta particles to pass through. Next could be a layer of liquid hydrogen as it has a very small density and protects against neutrons.

2.11 ENERGY

Our space settlement will depend on solar power as it is more efficient in space and not affected by atmosphere, day/night cycle or cloudy days. The only limit to space solar power is the efficiency level of solar cell technology as it is currently around 30%. Constructing and installing solar cells in Earth cannot be afforded as it will be very costly to launch. Our Moon base will be used also as a source of solar cells since silicate is found in the Moon and can be mined to make solar cells in L1 construction base.

Estimated energy use in Afrodita will be 50kW per person, 40kW for agriculture, and 30kW for other purposes, for total population of 10000 this requires us to generate 600MW. Around 80,000 square meters of solar arrays will be enough to provide 600MW. In order to utilize the solar power more intense solar arrays will be able to rotate. During shadowed times, batteries will be used as secondary energy source. During the use of batteries, power usage will be limited. Batteries must be charged by using solar power. Nuclear energy won't be used due to its high danger level and difficulty of maintenance. In case of an energy collapse, an emergency energy source which are solar array satellites will be installed on GEO stationary orbit as it is considered as the optimum place for acquiring higher level of sun power. Solar arrays installed on GEO can be used for energy trade with Earth by microwave beaming and in case of an energy failure in the settlement, it can be used as a backup energy source.

Photovoltaic cells will be used to convert light directly into electricity and their primary application is to power satellites in space. Photovoltaics rely on the sun as an energy source therefore they don't release gas emissions that can harm the environment. Burning fossil fuels in the space settlement isn't a very good idea because firstly, transporting the fossil fuels would be very costly and secondly, the settlement is a very isolated space and it will be difficult to release the emissions into space before they cause harm to the citizens and the crops in the agricultural zone. One main drawback which may cause several issues in the near future is the fact that they are very expensive.

2.12 COMMUNICATION

Communication is another key factor as we need to communicate with Earth, lunar workers and other spacecrafts. A communication network within the settlement will be needed as well so there will be convenient contact between inhabitants just like on Earth. Fast, reliable communication is essential. Due to the high distances we experience a delay of the information sent. The data transfer rate is also very important to us because we need to download and upload a lot of data at a high speed, we need this because people will want to make direct communication with Earth.

2.12.1 Radio Bands

Radio bands are currently used in most space missions at this time. There are three types of bands. These are S, X and Ka bands. S-band was used in the earliest types of spacecrafts, throughout the 1960s. In the 1990s people then started moving to X-band, as a faster and better way of communication. Right now, in the 21st century, Ka-band is the most used way of communication in space missions.

Band	Uplink Frequency (MHz)	Downlink Frequency (MHz)
S	2110-2120	2290-2300
X	7145-7190	8400-8450
Ka	34200-34700	31800-32300

These are the radio frequency values of the different bands.

2.12.2 Laser Communication

Laser communication is a must have for our settlement due to the high demand of data transfer to and from Earth. The rates of laser communication are about 10 to 100 times

faster than radio based communication and offer six times the bandwidth of standard, space mission, radio communication. Our communication system will mostly be based around laser communication because at some point we will need to transfer large amounts of data in a short time and also because when communicating with Earth a delay/lag might cause big problems for our settlement.

Laser light has a shorter wavelength than radio waves and therefore the energy spreads over a smaller area as it travels through space. One more advantage of laser communication is that less energy will be wasted. This improvement in technology will allow high quality and resolution data to be sent to Earth from around the solar system allowing scientists to study other planets in more depth, similar to the study of our own planet. Antennas are shrinking in size as technology advances. In the first years of space missions antennas on spacecrafts measured a diameter of around 2 metres. The diameter then decreased in 2009 to a size of about 80 cm and now with optical communication available antennas can be as short as 10 cm. During the Apollo missions NASA had a ground antenna measuring 55 metres in diameter, which would send and receive data. Later, the antenna diameter size shrinked to about 17 metres. Laser communication will now allow ground antennas to be as small as 1 metre in diameter.

2.13 THERMAL CONTROL

Thermal control is an essential concept for the space settlement and will be needed in order to maintain a decent climate inside the colony. Heat insulation is one of the keys which will lead to the success of this project. This specific system can be used to protect the settlement form too hot temperatures such as external fluxes or solar flares and can be used to protect equipment from too cold temperatures by enhanced heat absorption as well. The thermal control system will be composed of passive and active items.

Passive thermal control system

- thermal insulation composed of multiple layers
- radioisotope heater units to produce and store electrical power
- layers that influence the thermo optical characteristics of outer surfaces
- heat washers to decrease the thermal coupling at specific surfaces

Active thermal control system

- liquid pipes to transfer the heat dissipated by equipment to radiators
- thermostatically controlled resistive electric heaters in order to keep the equipment temperature above its lower limit during the mission cold phases

The main material we will be using as a thermal insulator for Afrodita 1.0 is aerogel. Aerogel is a fabricated, porous and ultralight material that has been composed of a gel in

which the liquid substance has been replaced with a gas. We decided to use this material due to its extremely low density and its extremely high heat insulating capability. Despite its name, aerogel does not resemble any kind of gel but is a solid, rigid and dry material which is composed of 98.2% air, allowing it to be almost weightless. Also, another characteristic which proves its excellent thermal insulation is the fact that the aerogel represents all three methods of heat transfer (convection, conduction and radiation). Aerogel can be produced with different materials such as iron oxide, carbon, chromia etc.. However, the most extensively used and manufactured aerogel is made out of silicon. The lowest density of aerogel ever recorded was 1900g/cm3, which, in comparison with air (1200g/cm3) is extremely low. The three dimensional silica solids consist of intertwined clusters that comprise only 3% of the volume, allowing the rest 97% to be only air. Conduction through the solid is therefore considerably low but the air inhibits both convection and gas-phase conduction.

On the other hand, this revolutionary material has a few drawbacks that have to be taken into consideration. First of all, the aerogel will have to be transferred from Earth and installed rapidly in order to thermally insulate the settlement. As we move on however, silicon might be discovered in our solar system which will allow us to manufacture aerogel in outer space. Secondly, aerogel is a fairly fragile material. While transporting and installing it, people will have to take special care of it. Pressing slightly firmly on an aerogel might leave a permanent depression which can possibly alter its characteristics. Additionally, pressing extremely firmly on it will cause a catastrophic breakdown in the sparse structure-causing it to break like glass, a property commonly known as friability.

2.14 DAY/NIGHT CYCLE AND LIGHTING

It is important to consider how we will produce a reliable day and night cycle similar to the Earth's cycle. We also need to use LEDs which are going to replicate the Sun's rays because we want to farm our food and this is possible only when having sunlight. Humans need to have a day and night cycle because it is critical for the sustaining of life. We will use the same cycle around the settlement because we are going to have the same time for every part, this means there will be night in all the parts of the settlement except for the agriculture torus where it will always be day in order to maximize the amount of food produced. If the agriculture torus will have a day and night cycle, meaning that it will have points where it will not experience light, we are not using the full potential of the crops. We will gradually dim the light supply which represent the sun is setting and we will also gradually brighten the settlement which represents the sun is rising in the residential torus'. We will change the day length and night length according to what time of the year it is in order for our inhabitants to accommodate faster. The people living on Afrodita 1.0 would be advised to go to sleep when

the lights in the settlement are turned off because it is the best time in which you could sleep and also the most healthy. An artificial sky will be the ceiling for the comfort of the people.

2.15 ATMOSPHERE

Citizens in Afrodita 1.0 will require an atmosphere of acceptable composition and pressure. The air composition will be identical to Earth's (nitrogen- 78%, oxygen- 20%, argon- 0.9%, carbon dioxide- 0.03% and water vapour- 1%) as well as the air pressure (14.696 psi). Atmosphere and gas levels has a profound effect on human health and the well being of the inhabitants of our settlement. This is why maintaining a specific atmospheric pressure and the right amount of each gas in the air is an essential aspect.

The best way to provide the colony with the oxygen they need (apart from the oxygen the plants in the agricultural zone will provide) will be by using a new technology called Algae Bulb. For the past years, scientists have been devising a way to create bulbs that are environmentally 'green' and the Hungarian scientist Bodonyi Gyula has created a lightbulb that is literally green due to the algae it contains inside it. The Algae Bulb is a LED light bulb that emits light that it produces itself. It uses a small air pump compressor, tank and hydrophobic material to create just enough electricity to power the light bulb for limited durations. It relies completely on the algae inside it and does not need any electricity from any outer source in order to work. The algae bulb is basically a mini light bulb that is mostly used indoors to recycle oxygen for a more pleasant atmosphere. However, this bulb can modified and manufactured in bigger scales where it can be used as street lamps and in other sources of light for a cleaner atmosphere.

"Algae Bulb is some kind of oxygen generator which uses natural and high tech components. The head part contains a LED lamp and a little air pump. This pump compresses the air into the algae tank covered with a hydrophobic material, that keeps the fluidic content in the tank and lets the air flow free. The cover of the tank is a matte translucent polycarbonate shell that leads the LED's light through the body and illuminates both the algae and the interior that it's placed in." ***- Bodonyi Gyula's original description of the product.***

Adaptation of human beings in the space colony will be a fairly hard and long-lasting process. Due to this, scientists have been devising ways in order to substantiate and maintain a climate identical to the one on Earth. This includes the four seasons of the year; winter, spring, summer and autumn, and specific weather appropriate for each season. For this, methods such as "cloud-seeding"are available. Cloud-seeding is a process used in order to produce artificial rain or snow by releasing chemicals in the clouds. It can change the amount and type of precipitation that falls from the sky and alter weather patterns for an appropriate climate. There are three main ways cloud-seeding can be done.

Static cloud-seeding involves dispersing silver iodide in the clouds which provides a crystal on which moisture and water particles can condense on. The moisture is already

present in the clouds but the silver iodide helps it condense and then fall from the sky as water.

Dynamic cloud-seeding is the process which aims to boost vertical air currents leading to more water being able to pass through the clouds and transforming into rain. Around 100 times more ice crystals need to be produced in dynamic cloud-seeding than in the static method. This is why it is considered more complex as well as the fact that it requires a series of events working properly and in order.

Hygroscopic cloud-seeding is the last method which consists of dispersing salts through explosives or flares in the lower portion of the clouds. The salts then grow in size as the water merges with them making it easier for the water to fall as rain or snow according to the temperature.

However, cloud-seeding is considered a far-fetched prospect mainly due to the absence of clouds on the space settlement. The presence of clouds is a key factor but producing and maintaining them can be extremely difficult. To this, there is another solution. In order to produce artificial precipitation we will be using tubes that will run through the walls of the settlement. One end of these tubes will be connected to the water conservatories and the other end will run upwards in a slight curve. There will be a pump which will help push the water upwards through one end of the tube and out of the other as precipitation. The temperature of the water used will be altered according to the seasons of the year so the climate can feel as realistic as it is on Earth.

Another major problem the people of the settlement will probably encounter, is the removal of certain levels of carbon dioxide from the air. As we mentioned above, algae is an ideal plant in order for recycling the air and producing oxygen while absorbing carbon dioxide.

2.16 INTERIOR DESIGN

2.16.1 Housing

Housing is very important on our space settlement as it reflects the lives of the people. Thats is where they will spend most of their lives, obviously, with the opportunity to move. Our space is limited so people won't be able to build their own houses and the moving process will take some time. The people would have to complete some documents including their contact details, their demand for their new shelter, the price they allocate for the new house and after, if there is a suitable house available, we will contact them for more details.

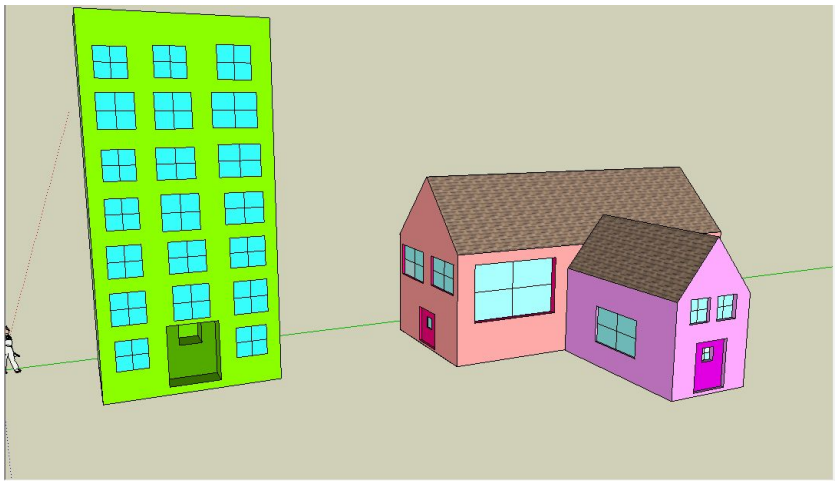
Houses will be modern and very practical. The furniture will be hidden in the walls, in order to give space for different events. If you have the boys' night out, you will probably only need a couch and a TV, with no wardrobes or other furniture items. When you are with the whole family, you will probably have to exploit the whole furniture but if you are the

guest of a party, a table would be enough in order to have more space for dancing or other activities. This gives flexibility and multifunctions to a room. You will also be able to change the view from the window if you get bored of the old one. It could either be a sunny beach, a forest or simply a garden. Biometric watches will become your best friend. If you finally arrive home after a long day at work and you are exhausted, your biometric watch will report your higher-heart rate to your home computer, which will then turn down the lights and play some calming music. Due to the fact that the population will vary in nationalities, the houses will have a wide range of architectural styles.
Below you will find some examples:

Japanese:

German:

Basic:



2.16.2 Colour Preferences and Mood Effects

The colour choices are very important as they can control people's perceptions and moods. Colours are used to create feelings of coziness and spaciousness. Blue is the top choice of 35% of Americans, followed by green. Colour differences may depend on ambient temperature. People who are hot prefere cold colours such as blue and green, and people who are cold prefer hot colours such as yellow and red. Bright colours give a sense of life and happiness, but dark colours such as grey and black give a sense of sadness and depression. Therefore, the colours of the houses will be bright in order for everyone to live in harmony.

In order to help people reflect on what they feel, the walls inside the houses will be made out of LEDs. This will give anyone the ability to change the colour of the walls anytime they want. They can add patterns and pictures whenever they desire to. This helps them discover themselves emotionally. If they had a great day at work, they could change the colour of the walls into white or purple as they show happiness and power. If they just met the love of their life, they could change the colour to red. If they had a horrible day at work with their boss, they could change the colour to black, and so on. In this way, people will have a better sense of liberty and dominance.

2.16.3 Sound and Fire Proof Insulation

What is more is that the houses will have a really strong and effective sound and thermal isolation.This will prevent noise from entering the house and heat escaping the house. Also, in case of a fire nearby, the isolation will prevent the fire to spread towards other buildings and areas and it won't disintegrate easily. The best material to do so is Roxul AFB. It is a lightweight, cheap material that is both sound and thermal proofing. It is made from

natural and recycled materials and it does not rot or deteriorate easily. For fireproofing fiberglass and cellulose are recommended as they are strong and do not emit hazardous gases in contact with fire.Cellulose is one of the cheapest materials and eco-friendly. It comes in loose form and is made from recycled cardboard paper or other similar materials.

Fire insulation is essential for a safe life. In case of a fire, the insulation will reduce the spreading time, giving the people more chances to escape with no injuries from the building. The materials used for insulation do not emit hazardous gases when burning which is very important, due to the fact that in a fire, many people actually die from inhaling poisonous gases, not from the actual fire.

To sum things up, the houses on Afrodita 1.0 will be architecturally diverse and will contain both villas and blocks of flats. They will be very similar to the ones on Earth and will consist of two layers beyond the walls. The first one will be made of cellulose for thermal insulation and the second with Roxul AFB for sound proofing.

2.16.4 Parks and Gardens

Having life on the settlement is essential in order to maintain the right amount of oxygen in the atmosphere. However, the space is limited and the green areas would have to be relatively small. The parks will consist of children areas with swings, merry-go-rounds etc, but also fountains, ice-skating rinks and benches for everybody.Parks are great as they allow people to interact with each other and develop their social skills in harmony.

Every house will also have a small garden in front for people to use however they want. In order to encourage planting trees or plants but also keeping them neat and organised, we will arrange competitions for the best looking garden. There will be garden designers who will work on each garden once a week and make sure to design attractive garden arrangements. The winners of the competitions would receive generous prizes such as a trip to Earth.

2.17 SCIENTIFIC RESEARCH

2.17.1 Zero Gravity Research Center

Zero gravity environment can be used to test many different materials and experiment their behaviours under zero-g. This can lead to discovery of more resistive materials to extreme space environment. Zero-g can also experiment different plants and their growing models. Agriculture in zero-g can change the way traditional crop growing necessities.

2.17.2 Space Life Science

The space life science is a research facility providing long-term experiments inside a microgravity lab. There are three main goals to space life science and the space biology program. These three goals are:

- to apply the knowledge gained to improve the quality of life on Earth
- to augment our understanding of key biological processes through the use of microgravity and other space environment characteristics
- to advance scientifically and technologically in order to provide a safe and beneficial human presence in space for longer periods of time

These three goals will be achieved by research using three program aspects, which are:

- **cell and molecular biology** (the study of gravity and space environment effect on microbial, cellular and molecular processes)
- **organismal and comparative biology** (the study of the different responses in whole organisms and their system)
- **development biology** (the study of spaceflight affecting development, reproduction, maturation and ageing of multi-cellular organisms

2.17.3 Shrink-Wrapping Spacesuits

For astronauts nowadays, spacesuits have been causing several problems when it comes to mobility and time spent to get suited up. Spacesuits that are currently being used are extremely bulky and fairly heavy. Scientist have devised way which solves these two problems resulting in the astronaut to feel more comfortable and move move easily. This will improve efficiency during space missions or when a problem is encountered. What scientists have invented is a lightweight, stretch garment, filled with muscle-like coils that contract on the astronaut's body when connected to a power supply. This would provide safety to the astronaut as well as more freedom during a planetary exploration.
"We want to achieve that same pressurization, but through mechanical counterpressure — applying the pressure directly to the skin, thus avoiding the gas pressure altogether. We combine passive elastics with active materials. ... Ultimately, the big advantage is mobility, and a very lightweight suit for planetary exploration."- Dava Newman, professor of aeronautics, astronautics and engineering systems at MIT.

2.17.4 In-Situ Propellant Production

In-situ propellant production is a crucial step in space exploration. This will bring a massive advantage to the settlement mainly because lunar resources are a lot easier to access from the settlement than from Earth. These resources can later be sold to various companies back on Earth which Afrodita 1.0 will benefit greatly from. Below are a few resources which we will be able to acquire from the moon during this industrial operation.

Hydrogen- A disadvantage of hydrogen is its scarcity on the moon as it is mainly available in the poles as water ice and in the moon regolith but in fairly low concentrations. Another concern is the depletion of hydrogen on the moon because the exact amount available is unknown. Extraction of this resource from the lunar regolith is a massively energy intensive process which is costly as well. Nevertheless, the specific impulse is the greatest of any chemical rocket ever flown (450 seconds). This means less mass of fuel is needed compared to other fuel types. Also, hydrogen rockets have been used since the first days of spaceflight therefore are more developed than the others.

Methanol- Even though methanol does not naturally occur on the moon, volatiles can be used to produce it. Carbon monoxide and hydrogen are both difficult to store so they can be released together with certain catalysts and burning them at 644K. Like this, methanol will act as a very efficient rocket fuel.

Ammonia- Likewise, ammonia doesn't occur on the moon naturally therefore it should be synthesised using two other substances. The moment volatiles are extracted, a large quantity of hydrogen will be extracted with a low quantity of nitrogen. Hydrogen and nitrogen can be heated in the presence of specific catalysts to produce ammonia. Ammonia can then be used as a reaction mass for solar thermal rockets. It also has several other uses, such as a refrigerant fluid, important for heat engines and temperature control on the moon.

Methane- Methane is another substance that has been proposed as a fuel for lunar use. Carbon is present in the lunar regolith several times more than hydrogen, and heating it will result in methane being produced, alongside with carbon monoxide and dioxide which can then be converted to methane by reacting with hydrogen. It has a slightly lower specific impulse than a hydrogen rocket but methane is a lot easier to store and is much more plentiful which increases its efficiency greatly when being used as a reaction mass for solar thermal rockets.

2.17.5 Asteroid Mining Companies

Construction of Afrodita will start another era of Asteroid Mining. Composition of asteroids will be identified in much higher certainty and targeting a high value asteroid will be much easier. Catching small and middle sized asteroids, re-orbiting them into high elliptical orbit of Earth and mining their valuable elements will initialize many private companies interested on this business. In this task, our settlement can be used a fuel depot and target asteroid research center.

2.17.6 Waterless Washing Machine

Water consumption on the space settlement is a critical issue we may encounter because the water must be distributed accordingly to every need. One main use of water which the citizens of Afrodita 1.0 will depend on will be in the washing machines. For this problem to be solved a new method of dish washing will be necessary. This method consists of using a new device rather than a basic hot water machine. This new device is a carbon dioxide based machine which does not rely on water. The liquid carbon dioxide has a low surface tension, which means it spreads widely to cover all surfaces unlike water. The liquid CO2 removes the solid particles and moves them to the filter. The filter should be removed and cleaned when it is full. This process allows people to wash even a few dishes and not be forced to wait for them to pile up in order to not waste water.

2.18 DOCKING SYSTEM

A docking system will be necessary in order to attach other spacecrafts to the settlement such as the asteroid spaceship and other spaceships so inhabitants, tourists and resources can enter the settlement. The docking system will be similar to other spacecrafts due to compatibility issues. Like other spacecrafts, the docking procedure will consist of “soft” docking and “hard” docking which involves connecting the two spacecrafts using the latch of spacecraft with more mobility (soft docking) and then air tightly seal the two hatches together to enable safe movement between the two spacecrafts. Spaceships will attach themselves to Afrodita 1.0 by adjusting its velocity, position and orbit in order to obtain no movement relative to Afrodita 1.0. After the preparation stage is done, the spaceship will slowly approach Afrodita 1.0 to the point where soft docking will be enabled. Afrodita 1.0 will use both androgynous and non-androgynous docking mechanisms which will be located on the main cylinder. The settlement will have: two male non-androgynous docking stations, two female non-androgynous stations and two androgynous docking stations.

There will be a male androgynous on the outer surface of the main tube between the top ion propulsion engine and the 3 third torus (top torus) while on the bottom ion propulsion

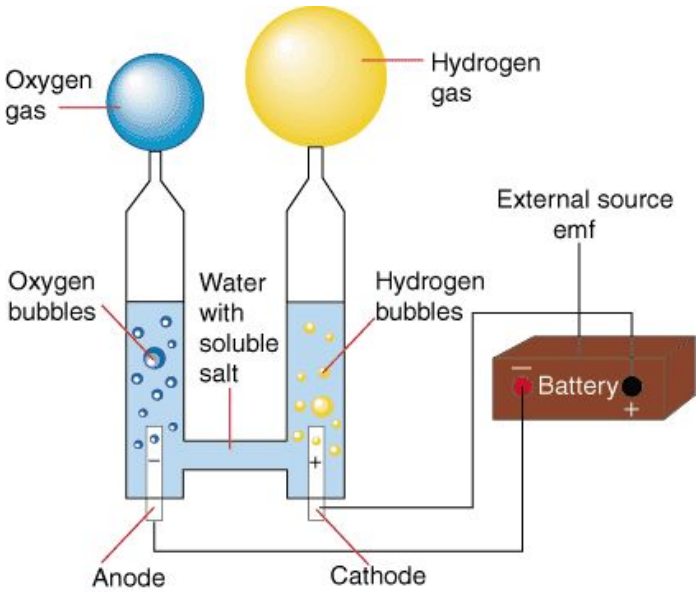
engine there will be a female androgynous. On the main tube between the third and the middle torus there will be two non-androgynous, one on the left and one on the right. Between the middle and the first torus, there will be a male and a female androgynous. In total there will be 6 docking systems in the whole settlement which will be located in the outer surface of the main tube as mentioned above.

Afrodita will use Nasa Docking Systems (NDS) for the androgynous stations which include both autonomous and piloted dockings. The NDS also supports berthing and docking as well as data sharing and resource sharing between the two spacecrafts. NDS have a diameter of 800 mm for the crew and cargo to pass through. The low-impulse rockets that we will use to transport lunar resources will be unmanned and autonomous so the workers can remain on the moon without being obliged to pilot the rockets. NASA is still developing the autonomous mechanisms that will most likely be used and fully developed by the time the construction of Afrodita will start.

3.1 WATER

Water management is a critical process because it is essential for human life so a safe and efficient water system will be required. The water will be collected by using an underground system (like sewers) that will send all the used water to the recycling center where the water will be passed through a filter. The water will be passed through three filtration stages. The first filtration stage will separate the water from larger impurities such as human waste. The second filtration process will consist of a more profound filter that will separate the water from smaller impurities that have managed to pass the first stage. The last stage will be the most important stage which will filter the water using active carbon that will remove any impurities left. The water will not remain in the active carbon for a long period of time as microorganisms will start to grow in the water and contaminate it. The residue from all the stages will be collected and sent out as space debris.

Our main source of water will be asteroids. Once we mine the asteroids for water, we will keep recycling water. In our system, water will not only be a used as a basic human need but will also be used to produce oxygen and hydrogen by separating the compound using electrolysis. The hydrogen obtained from electrolysis will be used as rocket fuel and oxygen will be used in the atmosphere of the settlement.



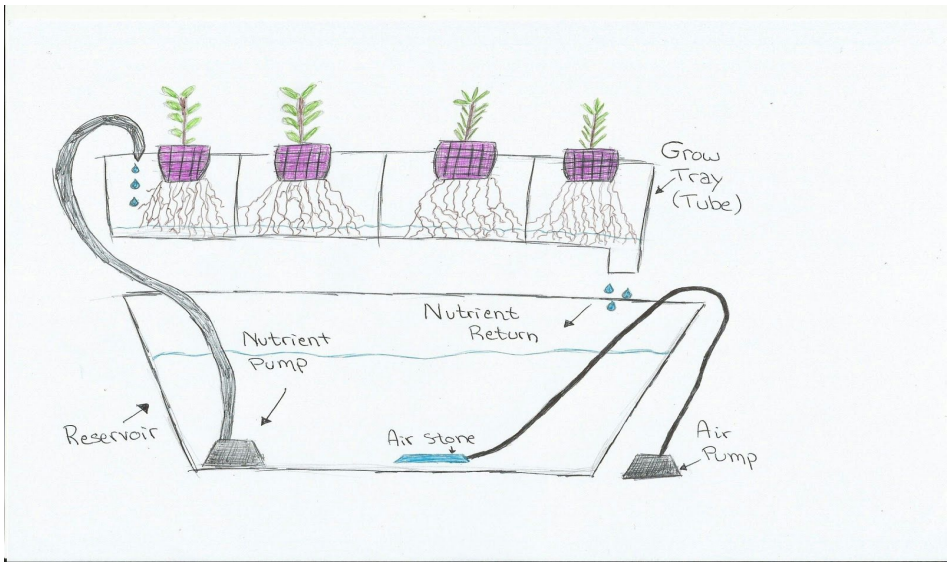
For a healthy diet, a human must consume around 2000g of water per day. This is the equivalent of 2 litres of water and 2000 cm cubed of storage per person per day. Our main water storages will be located on the outer layer of the settlement. We will have more independant water storages, so in case one of them gets contaminated we will not lose all our supply. This will also help to protect the people of the settlement against radiation due to the fact that water contains hydrogen.

3.2 AGRICULTURE & FOOD

Agriculture in space has two alternatives; hydroponic or aeroponic methods.

3.2.1 Hydroponics

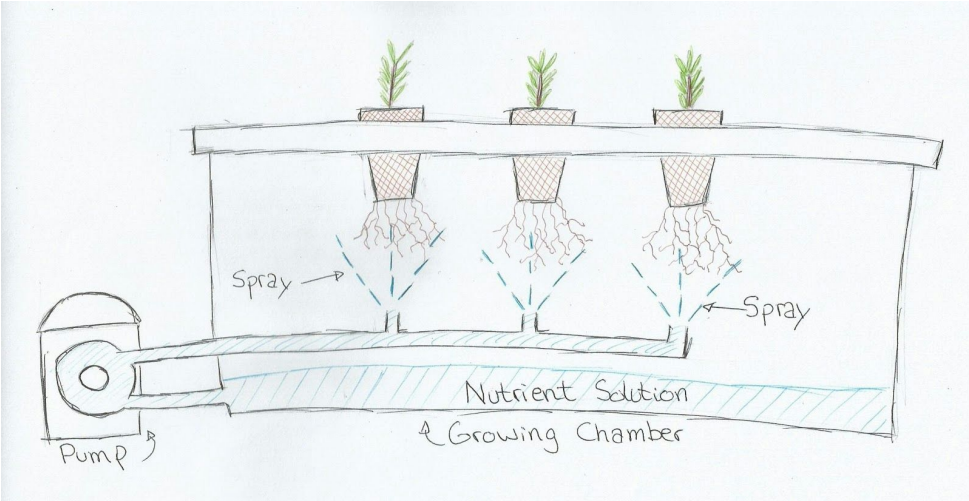
Hydroponics is the process of growing plants without soil. The plants are grown in a motionless medium and a balanced, pH adapted nutrient solution is brought to the plants' roots. This allows the plant to consume less energy as it receives the demanded nutrients. Otherwise it had to search for the nutrients in the soil and extract them. This method helps the plant grow healthily but they require too much space and they are heavy. Below you can find a simple drawing of a hydroponics system.



3.2.2 Aeroponics

Aeroponics is the process of growing plants suspended in air without the need of soil. It is clean and very efficient. Crops can be harvested throughout the year without interruption. The crops do not get contaminated from pesticides, leftovers or soil. This system reduces the use of fertilizers by 60% and water consumption by 98%,which is exactly what we need for agriculture in space, as water is a scarce resource. Plants growing this way are healthier as they absorb more nutrients and vitamins, resulting in more nutritious plants. The spread of plant diseases and infections are widely reduced as there are no media involved. Aeroponics method allows more yields per year as the plants grow faster. In normal farming, tomatoes are first planted in pots and after 28 days, they are moved into the soil but with aeroponics, they can be transplanted just 10 days after they are firstly planted. In this way, you can achieve six tomato crops per year, than the usual one-two crop cycles. Also, the flowers of

the plant do not wilt or stretch while their roots are growing and after that, they can be moved in any media, without the risk of transplant shocks (stress occurring in plants that have been recently planted--their roots cannot adapt to the new media.) Below you can find a simple drawing of an aeroponics system.



3.2.3 Hydroponics vs Aeroponics

Using the aeroponics method, you are able to save space by arranging the plants vertically as they just concentrate on giving the plant its needed nutrients, excluding the foam aspect. Hydroponics require a lot of space and they are heavy so they are not very convenient. Aeroponics system is easier to set up as you can easily find the pieces needed at any hardware store but for hydroponics you would have to make special offers in order to receive the demanded pieces. With aeroponics method you can observe the plants without disturbing them and adjust the concentration of the nutrient mix provided which helps you prevent any problems. It contains completely programmable technology therefore it reduces energy consumption and the roots of the plants are more exposed to oxygen. Also, by all being programmed and lacking the need of farmers or people for constant supervision, the labour costs are massively reduced as money is our greatest problem. Afrodita 1.0 would only consist of Aeroponics systems as they are more convenient than hydroponics. They cost less and are more resource-friendly.

3.2.4 Food Selection

Lettuce is the most suitable plant to grow with Aeroponics as it doesn't normally grow underground, like potatoes, beets and carrots. Quinoa will be part of Afrodita 1.0's agriculture as it is a gluten-free grain. It is very healthy as it contains all nine essential amino acids, together with fibers and minerals such as iron, magnesium and calcium. Quinoa is essential

for a healthy life and is suitable for space agriculture as it strengthens the people's health so other issues such as space radiation won't leave a massive impact on the human bodies. Avocados are also important for our diets as they are densely packed with vitamin E, folate and anti-inflammatory, healthy fats. Another nutrient our space settlement must cultivate is Kale. Being rich in calcium, lutein, iron and vitamins A, C, K, it prevents many illnesses that could easily develop in space. Afrodita 1.0 will have land that will only grow plants that release the most oxygen such as Areca Palms, Mother in Law's Tongue and Money Plants. Also, CAM (crassulacean acid metabolism) plants as they consume less water and are the best plants at avoiding photorespiration. Some examples are: Aloe Vera plants, Jade Plants and Pineapples. Agriculture on Afrodita 1.0 will be both effective and sustainable.

3.3 HEALTH

3.3.1 Health Issues

A major problem we need to combat is radiation. We will do our best to offer as much radiation protection as possible, but even the Earth's atmosphere doesn't keep away all the dangerous particles. Protons, high-frequency electromagnetic waves, X-rays and Gamma rays can damage biological cells by ionizing molecules inside them. Most of the time the damage is repaired automatically but if a lot of radiation is absorbed the cells may die or become cancerous. At some point during the year, the sun would release much more radiation than it usually does, which is called "solar flares". This flares can be seen minutes before reaching the settlement so, in order to not cause more damage to the population, we will immediately announce the people and they would be asked to enter a building. All buildings would be made from thick walls in order block the hazardous particles from entering.

Often health problems faced in space are muscle and bone damage. Due to 0 gravity, the muscles do not make as much effort as they do in 1 gravity so they become weak. Also, your bones would lose mass. Bones continually take calcium from the blood and release calcium into the blood, but when the stresses on the bones fall in 0 gravity, less calcium is taken from the blood as the cells sense less need for it, decreasing their mass and making the bones weaker. On Afrodita 1.0 there would not be such muscle and bones problem as we will try as much as possible to obtain 1 G.

3.3.2 Medical System

Due to the higher quality food, from aeroponics, certain diseases won't be so common on Afrodita 1.0. Despite this fact, we will still be obliged to offer a good and effective medical system for the citizens. There would be approximately 1 hospital per torus section so

about 36 in total. The cost would be similar to the one on Earth and hospitals would offer service for any type of problem.

We will do our best to create artificial rain so life would be similar to the one on Earth but snow is too difficult to make and it also requires a lot of water. Due to this, people would not get sick as much. We will have special caring centers for people who have special problems or require medical gymnastics. Pharmacies will be found everywhere and will include every medicine possible, but we will try to base them on natural products and less antibiotics as they can be dangerous if not properly used. Schools will have their own medical room in case students injure themselves or other problems intervene. Vaccinations in schools would be compulsory as they strengthen the immune system and prevents children from developing certain diseases and viruses. Animal owners would benefit of animal hospitals and vets. In order for our activity to be productive, we will have a driving band exclusively for ambulances, fire trucks and police, in order to get the people as fast as possible to the health centers. In order to reduce the rate of illnesses in the settlement we will carefully pick the people using specific selection criteria. We will make analysis on people and select the most strong and healthy ones. Also, smocking will be totally forbidden in the settlement, as well as the selling of junk food.

Every Sunday people will be encouraged to exercise in special centers that produce energy. People will exercise and energy will be produced. At the end of a day/ half day, people will be paid according to how much energy they generated. Natural medicine is essential for a sure cure without consequences. We will grow a lot of medicinal plants that are used to make tea or other natural remedies. Selling the seeds would attract people to buy these instead of pills made out of chemicals. We could advertise these products on tv commercials and on huge posters around the settlement.

Health is our main priority and we will do our best to keep our citizens as safe as possible. There will be hospitals for all areas such as cardiology and orthopedics. Hospitals would be separate for adults, children and pregnant women. All utensils will be sterilized after each patient in order to prevent the spread of viruses. Animal hospitals would have all the resources need and will offer the best conditions for the small ones. Health is a serious business and it's not something to play with.

3.4 RECYCLING AND WASTE MANAGEMENT

Recycling will benefit the colony significantly because we want to save the resources in order to maintain the settlement. As Julie Girling quoted *"It is a key file and needs to be ambitious but balanced so that we can tackle the transition to a more sustainable future, tackling climate change and energy needs whilst stimulating EU jobs and economic growth,"* recycling is one of the main keys to saving resources and keeping the environment clean. Pollution would be extremely harmful to Afrodita and the waste would build up rapidly

because the space available in the settlement is very small compared to the Earth's. Recycling would save the colony's resources and also keep the settlement clean as well as offering more space in the settlement's interior. Afrodita will not use plastic to help prevent contamination and also save crude oil for other purposes. In order to recycle the materials that can be recycled, garbage separation will be critical so there will be three types of bins: metal, organic and non-organic. The bins will be smart bins which will scan the materials before accepting them in order to make sure the right type of waste is introduced. The garbage will be collected twice a week and will be taken to recycling centers where the recyclable materials will be entered in recycling machines and the non-recyclable materials will be compressed by large machinery to create "missiles" that will be used against asteroids. The compressed waste will be propelled towards the asteroids by using a mass driver to either change its trajectory or split it into smaller pieces. Once enough compressed waste is produced, the unrecyclable waste will be sent outside the settlement as space debris. The bins will be used by every inhabitant of Afrodita and will place their trash outside for the garbage collectors to pick up. The time of collection will be on mondays at 8:00 am and thursday at 8:00 am as well. The recycling center will be completely isolated to prevent the spread of odour as odour can be a serious problem in a confined space. The recycling center will be located in the torus with all the inhabitants due to ease of transport. The recycling center will consist of three parts just like the smart bins. Each part will be dedicated to one of the types of bins.

The metal recycling center will firstly grind the scrap into small pieces in order to separate the metals into two groups: ferrous and non-ferrous by using a magnet which will attract only the ferrous metals. After the stage of separation is done, the two groups of metals will both be melted separately and molded into either required objects or ingots (which will be stored to be used when needed).

The organic waste recycling center will produce one type of resource: fuel. The fuel that will be produced will be methane (possibly carbon dioxide as well if future technology allows the use of carbon dioxide as fuel). The fuel will be produced through anaerobic digestion which firstly breaks down the organic waste into smaller parts (aka monomers) to prepare the waste for the second process. The second process (acidogenesis) introduces the use of acidogenic bacteria which will process the organic waste and give out ammonia and carbon dioxide along with other products. The third process (acetogenesis) includes acetogens digesting the products of acidogenesis into mostly acetic acid with smaller amounts of carbon dioxide and hydrogen. The last stage (methanogenesis) will use methanogens to convert the products of previous stages into methane, carbon dioxide and water. There will also be unwanted products after the last process which will be thrown away as space debris.

Non-organic waste will be compressed into dense pellets that will be used against destroyable meteors in emergency cases. The pellets will be shot by powerful mass drivers that will send the compressed waste towards the target meteor in order to break it apart into smaller pieces to avoid any serious damage.

3.5 EMERGENCY CASES

In case of an emergency the settlement will proceed in performing immediate actions so the citizens can be safe. One of the biggest problems that could occur in the space settlement or spaceship is *fire***.**

3.5.1 Fire

There are 4 different types of fire also known as *fire classes*:

1. **Class A** fire is the an ordinary combustion which is usually created by burning wood/paper and many kinds of trash. In case of a Class A fire , it will be extinguished by water since it is the best way to do it. Class A fires are relatively small so using a bit of water to extinguish them will not be a problem.
2. **Class B** fire is when the fuel is flammable. The fuel can be in a form of liquid such as gasoline and alcohol or in the form of gas such as natural gas. In case of a Class B fire, it will be extinguished by a chemical called Heptafluoropropane also known as **FM-200.** We will not use water since it can spread the flames.
3. **Class C** fire involves an electrical equipment which went on fire such as old electrical cables. In this case, the fire can be extinguished with FM-200.
4. **Class D** fire is made of metals that are combustible, usually *alkali metals* and *alkaline earth metals.* In this final case, the fire will be extinguished with dry powder agents (sodium chloride, graphite powder, powdered copper etc.).

Most of the extinguishing agents listed above are expensive and hard to find but it is important that the fire will be extinguished as soon as possible, especially in space.

There will be smoke detectors installed in many places of a torus especially next to houses where civilians will leave. In case of a fire in the settlement there will be a certain actions that will occur. Since fire spreads quickly and can form harmful gases, the doors in the torus that lid to the agriculture sector will close so the food and plants can be in a safe environment.The walls of the houses will be well fireproof so if there is a fire in a room, the fire will not be able to spread.

3.5.2 Damaged Settlement

In case of an explosion in torus (exterior or interior) or an uncontrolled fire, civilians will be forced to leave the torus *segment* that is damaged and move to the other part of the torus. The emergency and fire department will then try to stop the fire or re built the the damaged area of the torus. If extinguishing the fire or repairing the damage from the explosion will be proven impossible then the damaged torus segment will ejected and abandon the other settlement. This is an extreme occasion and it will be very rare and maybe will never happen. There may be cases where more than 1 torus segment will be ejected from the settlement. That will obviously make the torus spin differently than it did before and the transportation will be harder. If a whole torus is damaged it can also be ejected but in that case of scenario the rest of the settlement (what will be left) will return to Earth immediately since the settlement will be over populated and the food will not be enough for everyone.

3.5.3 Infectious Disease

In case of an infectious disease, the infected patients will be isolated from everyone else to prevent the disease from spreading. Doctors will try to cure the patients and find out from where the disease came from. If it is not possible to cure the patients then they will be send to Earth.

3.5.4 Air Pollution

There will be air sensors that will detect any contaminated gases. The citizens will move to a safe area that will provide breathable air until the contaminated gases are removed completely from the settlement. If the air purification will not be done fast enough then the citizens will have to wear gas masks.

3.5.5 Water Pollution

If the water is contaminated then the primary source of water will shut down until the water is purified. The citizens will use the backup source of water which will be clean. The water purification should be completed quickly so the backup water tank will not run out of water.

3.5.6 Rocket Fuel Engine Failure

In case of a rocket fuel engine failure, the torus with the engine failure will not be able to rotate properly. If one of the engines in a torus fails then the other engine will be overclocked to 2 rpm so the gravitational force can be maintained meanwhile the damaged

engine is being fixed. If both engines of a torus fail, then the citizens will have to move immediately to the other toruses since there will be no way to maintain the gravitational force.

3.5.7 Ion Propulsion Engine Failure

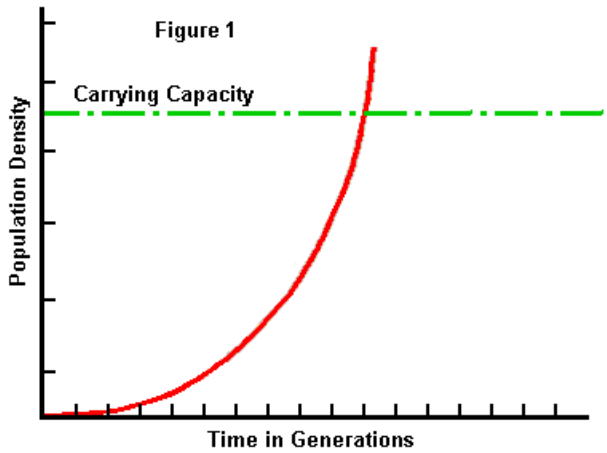
In case of an ion propulsion engine failure, the settlement will move significantly slower if it will need to avoid an asteroid. If there is such kind of engine failure, the staff will need to check the radars more frequently so if there is an incoming asteroid they can be alerted quicker. If by any chance both ion propulsion engines fail then half (3 engines) of the rocket fuel engines could rotate so they can push the settlement towards the Earth. The other half of the engines will be overclocked to 2 rpm to maintain the gravitational force in the 3 toruses.

3.5.8 Power Outage

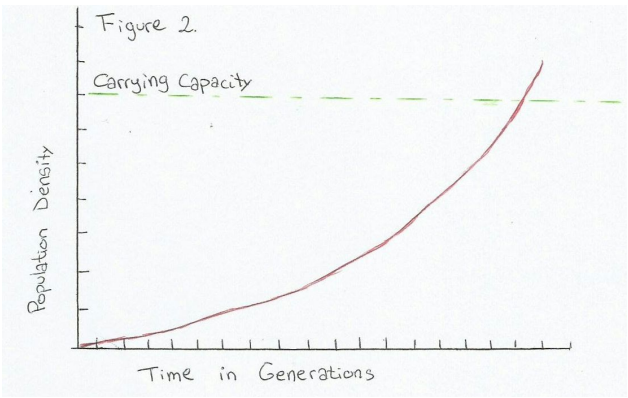
If there is an electric failure, the citizens will stay in their houses and wait for further instructions. There will be a backup power source but it will be used only by the workers (who will be fixing the electric failure) and for the health facilities.

4.1 POPULATION

Population is very important as it is the base of an equally spread colony. Children and pregnant women are not encouraged to live in another environment; the space. There are many health risks deciding to live there such as radiation. We will gradually add people to our settlement. Firstly, there would live 100-200 people which are high skilled: such as engineers, doctors and scientists. We will have an equal proportion of males and females in order for families to bond and colonization to increase. There would be both couples living in the first stage and single people in order to find their partners. As we will have limited space and resources, we need to control the population growth, so we gradually add people every 5-10 years. A normal population growth graph looks like this:



Once the place is overpopulated, the resources are becoming fewer and fewer so there is a carrying capacity. This is how many people can a specific place carry. In Afrodita 1.0 we should prevent this and keep the population growth under control, resulting in slower and more steady growth, in order to obtain this graph:



People will be willing to make a radical life change and live in Afrodita 1.0 as they will have a better lifestyle. We will offer all the conditions necessary for a life identical with the one on Earth. From a perspective we can even say that life on Afrodita 1.0 will be

healthier and more sustainable than the one on Earth. There would be no pollution which is hazardous and no risks of natural disasters. People will be able to enjoy an interesting experience with education, politics, entertainment and many more. It is a very important decision to make but they will learn and experiment unbelievable things such as zero gravity areas (for entertainment) or spatial elevators that travel from torus to torus. Afrodita 1.0's colony would not face major world problems such as unemployment or wars. They would have a sustainable life as they would be encouraged to exercise and the nutrients would lack pesticides or other chemical substances. The construction of a space settlement is a long term project. By the time we will succeed to build such wonders, Earth would have already started its resource crisis. Water is one of the compounds we cannot live without. What is worse, is that it is scarce. For our space settlement we would extract water from the Moon so Afrodita 1.0's population would not worry about the lack of water or other resources.

Selling everything and starting a new life in space is not an easy step, but it is surely an act of curiosity and the privilege of living an interesting life. People have the opportunity to meet other people from all around the world, share cultures, traditions, religions and many more. Most people would be high skilled such as doctors, teachers, engineers, scientists, nutritionists, astronomers, astronauts, economists, PRs, politicians, lawyers and psychologists, so they can exchange knowledge which they can later relate to large patterns of meaning. Afrodita 1.0's main goal is to offer its people all the necessary conditions and make them feel like home. They will start a new, more sustainable and better life.

4.1.1 Selection Procedure

In order to accomplish this project, we will have to consider what qualifications a person needs to become a member of the settlement. Afrodita will need a variety of different types of qualificated people such as: doctors, plumbers, engineers etc. to supply all the demands of the inhabitants. The people who want to join the project will have to complete an application form on the internet which will include the candidate's qualifications,VC and physical conditions. There will be a minimum requirement of qualifications and physical conditions. The application forms will then be evaluated and the qualified candidates will be invited to an interview and further evaluation of health conditions. Every candidate will thoroughly examined before being accredited the permission to become a member of the settlement. A complete health check will be crucial for the selection procedure because a contagious or any other health problem will be a troubling issue for the settlement so the health check will have to be extremely meticulous. The candidates will require the ability to endure long periods of time in space psychologically and physically. After the selection of candidates is completed, the selected candidates will be announced by email and invited to interviews and examinations. The minimum requirements for a member are:

- minimum 4 years of professional experience
- 20/20 vision (glasses allowed)

- master's degree-1 year of experience
- doctoral degree-3 years of experience

One of the most crucial segments of the selection criteria will be the potential member's health condition. Once the construction of the first segment is finalized, the first group of people will travel to the settlement which will be set of 1000 people. We are mostly interested in degrees that will be beneficial for the settlement.

4.2 EDUCATION

Due to the fact that we want to offer the citizens of Afrodita 1.0 a life as similar as possible to the one on Earth, education will be a well thought industry. We will start by offering 1 school per 2 torus sections, which is about 18 schools in total. We are aware of the fact that many people will deny the idea of taking their children to live on Afrodita 1.0. Children are more vulnerable to radiation and other dangerous exposures but gradually, the children population would increase and if necessary, we will build more schools.

4.2.1 Courses

Education on Afrodita 1.0 would be much more developing and enhancing than the one on Earth. We will offer caring centers from a young age, starting from nursery and ending at highschool. Astrology courses would be compulsory in order to answer few of the many questions children at their age would require. They would learn about the position of Afrodita 1.0, star constellations, possible problems that could occur such as meteor attacks and many more. They would have many practical lessons during astrology courses which would include observing the stars, observing Earth and other planets. We will teach children about our purpose of building Afrodita 1.0 and telling them how life on Earth is. Other interesting course like recycling and energy saving will be taught. Children will understand the importance of not wasting and that we need to protect our environment as much as possible as resources are scarce. They will be highly encouraged to recycle and bring all the materials to school on a specific day. In return they will receive green cards, which help their academic result or house points, which help their team to win the big cup. Children will learn about energy saving bulbs, they will understand its purpose and why all the school is full of them. On a specific school day, all classes, one by one, will spend a day in the nature in order to save energy in the school but also understand different aspects of life.

Health and emergency cases lessons are very important. Once a week, in PE lessons, the children would benefit of free doctor consultations and they will be taken to a special center in order to exercise, so that their bones and muscles would be in the best condition. Also, once a month, an expert would come and make a presentation about the actions needed to perform in emergency cases. This would include fires, torus damages and anything that puts

the lives of people at risk. Children need to learn what their duty is in serious cases and that they need to be calm, together with trying to help the ones in need around them.

4.2.2 Extracurricular Activities

The spirit of competition would be massively sustained. Each school would have their own team which will compete with each other. Generous prizes would be offered such as medals, cups, money and for the big winners, a trip to Earth. The PE lessons would be very diversed. Children would learn how to play football, basketball, cricket, golf, ping-pong and so on.

Trips would be very warmly embraced in the students' hearts due to their fun complexity and well thought mind developing. We do not want our students to be stressed while white hairs grow from their young scalp. We want them to be relaxed, enthusiastic and always show a smile. Frequently, we will organise trips with the class in order to promote communication and make friends. It could either be in 0 gravity entertainment areas, at a movie or simply walking through a park.

4.2.3 Finnish Education System

The education system in Finland is one of the highest ranked in the world. Afrodita 1.0's will be very similar to Finland's. Children would start school at 7 years old (but of course, we offer kindergartens and nurseries for parents who cannot take care of their babies 24/7), they will have to complete a 9 year course and when they are 16 they will be able to chose where they are heading to: vocational school, where they learn certain skills for the career they want to take on and upper secondary school, where they would continue with the same courses but in more depth. The 9 year course includes a primary school (year 1 to year 6) and a secondary school (year 7 to year 9). Classes would start at 9pm in order to promote sleep which is essential for a healthy brain and they would end at 2pm, so a total of 5 hours. Holidays would be based on more nationalities. There would be a 1 week holiday between every half term, together with Christmas and Easter holidays. There will also be 1 day vacations for the national days of all countries that the children come from. Holidays will also be given for any significant religious or non-religious event that took place in one of the countries our students come from. The summer holiday will always be approximately 3 months long but we will offer summer school for the children eager to learn more.

Homeworks would mostly consist of practical demonstrations, not tons of paperwork and questions. Exams would be held but not too often (about 2 exam sessions per semester). There would be extracurricular clubs for every passion waiting to be sculpted. Arts would be encouraged and there would be expositions with the children's works but also performances in theatres with the drama team. Courses would be exclusively held in english but to the request of many parents of the same nationality, we could introduce schools for their own

nationality too. Children will have the choice to decide on one or more (max 3) foreign languages to study from the following list; spanish, french, chinese and arabic.

4.2.4 What We Are Aiming For

Our aim is for the children to understand themselves and discover their hidden abilities. That is why during the 9 year course we offer them a wide variety of lessons; in order to discover themselves. For more confident children, who were able to discover their abilities from a younger age, we will offer schools exclusively for their passion. If a person is good at art, he can attend an art school where he will learn architecture, sculpture, music, acting etc. If a person is really good at math, he can attend a math school where he will learn quantum physics and mathematics. If a person is good at sports he can attend a sports school where he can learn and become better at a wide variety of sports.

Being international schools, they could include similar activities to the International School of Bucharest. It could include international fairs, where all nations bring their traditional food and dress in their traditional costumes, science fairs, in which all nations bring and show concepts from their country and art fairs, in which all nationalities produce a work of art significant to their home country.

We will offer children tablets in lessons in order to take notes and research in class. Wood is difficult to provide in order to make paper and if we plant trees, we'd better use them to produce oxygen. We want to produce as little waste as possible and we can do this with the help of modern technology.

Students will be sanctioned for any inappropriate behaviour. Some punishments could include exercising in the energy generator centers, without anything in return, red cards, which affect them academically or staying after the school programme and help at cleaning or other jobs.

4.2.5 High School and College

After finishing secondary school, when children will be 16, they will have to take a certain exam in specific subjects, depending on what they want to do in the future, in order to be accepted at a vocational school or, they can continue with high school (upper secondary). After finishing high school, they will have to take a more complex exam, such as the IB at their chosen subjects. Their IB grade will allow them to enter an university.

When we first open Afrodita 1.0 to the eyes of people, it won't be completely finished. There would be only 1 university per torus section which is about 36 in total. As children will grow up and advance educationally, we will build more universities for all types of careers. There would be tuition fees for universities but not too exaggerated. Universities will mostly have 4 year courses. Engineering will last 5 and medicine 6. The range of different faculties

in the university will be huge. From medicine, to architecture, to business, music, theatre, sociology, psychology, journalism and so on.

To sum it all up, education on our space settlement would be exclusively for the benefit of children, with no other interests. It will be purposed for the developing of minds, with the use of different efficient techniques such as presentations, demonstrations, experiments but also written work. Children should be looking forward to going to school, not disliking every second of the 5 hour school time. Students should have a good time, laugh, make friends and most importantly, learn.

4.3 TRANSPORT

Transport will be required inside the settlement as well as outside the settlement so there will be two types of transportation: internal and external.

4.3.1 Internal

Internal transportation for Afrodita will have to be small and less space occupying as the settlement is already fairly small. Thus, the internal transport will not include automobiles such as cars or trucks as they require a lot of space to be used but there will be a special ambulance system that will be used in emergency cases. The ambulance system will be very important and will have to be very efficient in order to maintain the inhabitants' health. This system will provide a fast travel to the destination of the emergency by alerting the inhabitants that are in the route the ambulance will take so there will be enough space for the ambulance to pass by quickly. The alert will be sent out by streetlights that will turn red and also produce an alarm to help alert the people. Another exception would be waste collection trucks that will collect the waste every monday and thursday. The settlement will have narrower streets in areas that are covered by mainly houses and will have wider roads for areas with more traffic. Ambulances and waste collection trucks will both function using electricity in order to prevent air pollution. By using electrical automobiles, resources will saved and greenhouse gas emissions will be minimized. The costs to maintain the electrical cars are also less than ICEVs (internal combustion engine vehicles) and are continuing to decrease due to the development of technology that constantly increases the efficiency of the vehicles' motors. The roads that will connect the workplaces and entertainment areas will have be wider in order to prevent traffic because traffic will significantly decrease the productivity of the inhabitants. The roads will consist of :one lane dedicated to ambulances and waste collection trucks, two lanes for cycling and two sidewalks for travelling by foot.

Cycling will play a major role in the internal transportation as it is extremely sustainable, cheap and healthy. As a result, the bicycles that will be used by Afrodita will require more developed technology than the average bicycle because cycling will be the main

transportation for the members of Afrodita. One of the issues that bicycles will produce is the identification of the bicycles. This issue will be solved by adding license plates to the bicycles and also by providing the owners of the bicycles with a remote that will be able to lock and unlock their bicycles as well as locating their bicycles. The bicycles will also include lighting systems that will help prevent incidents from happening during the night. The electric components of the smart bicycles will be powered by a battery which will receive its energy from an electricity generator using turbines that will be spun by the user when he/she will cycle. The gym will also contain such generators in its machineries in order to maximize the amount of benefits we receive from our machineries.

4.3.2 External

The external transportation will provide transport for mined resources, exploration and transport between the settlement and earth. The mined resources from the moon will be sent to Afrodita by using mass drivers in order to save fuel and resources. The mass drivers will use powerful electromagnets to send the resources at high speeds in a straight line. Low impulse rockets will also be utilized as transport for lunar resources because little fuel is required to escape the moon's gravitational pull and even less fuel is required to maintain the rockets' speed in outer space. The low impulse rockets will use in-situ propellants such as hydrogen, methane and sulfur. Transportation for potential visitors and trades between earth and Afrodita will also have to be considered because this will contribute in the settlement's business and trades. The revenue from a visit will at least reach the break-even point of the trade so the visits will not bring the settlement losses.

4.4 COMPUTING AND NETWORK

4.4.1 Computing

Each house will include a default computer where the individuals in the house can use for any purpose (research , entertainment etc.) . We do not know exactly what brand and what specifications those computers will have but this will be decided when the settlement is going to be built (after many decades).The transmission of data will occur through fiber optic cables so it can be faster and more accurate.

The settlement will have 4 supercomputers. Each one of them will have to calculate complex algorithms and do multiple computer tasks simultaneously, something that normal computers cannot do. Here is the list of the 4 supercomputers and what they will do:

1.) Citizen Data Supercomputer

This supercomputer will store personal information of the people in the settlement.

Afrodita Identity

Each individual is obliged to have an identity called Afrodita Identity which will be saved in the database of the Citizen Data Supercomputer in the settlement. This table analyses what an Afrodita identity is consisted of:

Afrodita Identity
Personal Information of individual ● Date of Birth ● Gender ● Medical Information ● job occupation
● How long the individual will stay on the settlement
● The individual's house
● Communication Information (internet accounts of the individual)
● Law Violation Record
● Credit card informations

Except from the identity, an individual will also have an AI card with their name on it. Instead of banknotes (paper money), people will use their AI card to make all the payments because paper money will be hard to produce in space. Credit cards are better than banknotes because they are a better store of value (cards do not take up too much space), well built and can survive harsh environments (unlike banknotes which can be ripped easily). Also , not having banknotes will decrease the rate of stealing since the AI cards will require a password for the transactions to happen.

It is very important to have all the Afrodita Identities stored on a database because in case of a problem, the staff or the police can easily access someones AI and find where they live and contact them. The people will have an AI card which they can use in order to enter public buildings and do certain jobs with the card such enter the library and rent/buy some books, enter the bank and make transactions, buy food from a restaurant.

2.) Scientific Research Supercomputer

In the main tube there will be a place for scientists to perform experiments and do researches with zero-gravity. Scientific researches will also occur in the moon and sometimes on asteroids. For this concept to be successful, there should be a supercomputer which will calculate
complex formulas and save results from observations.

3.) Space Supercomputer

The third supercomputer will be used for space calculations. It will calculate the time for spaceships to reach the settlement, find the speed of space junk and alert the people if any asteroids will intersect the settlement's orbit.

4.) Agriculture Supercomputer

This supercomputer will calculate the answers to: how long plants will take to grow, how many plants and animals will be needed for each torus, how long it will take for animals to grow so they can be used as food and more similar questions. Furthermore, it will use algorithms to find out how many plants will be needed in the next week/next month. This will be useful so the farmers can plant vegetables/plants accordingly and in case of an emergency the food can be divided equally amongst the people.

Security

Security is a term which we will take in consideration in Afrodita 1.0. There will be several security cameras all around the toruses and some cameras in the tubes/elevators. The cameras' recordings will be saved in the file servers and will be deleted after a full week so the servers will not be overloaded with unwanted data. Our aim is to place the cameras (especially the ones in the streets and parks) in hidden places where the people cannot see them so they will *not* feel like they are being watched instead they should feel free and confident.

4.4.2 Network

The network will have a firewall to protect the files and data from unauthorised users. The people that will live in the settlement will be able to communicate with each other using an internet connection. However, the social networks available in Earth will not be available in the settlement's location. That is why there will be specific social networks which will be used only by the people in the settlement. An individual will be required to use his Afrodita Identity to enter in those social networks.

Those networks will be accessed by **Wi-Fi** and **Li-Fi**. Wi-Fi uses waves that can penetrate through walls however the speed is relatively slow compared to Li-Fi. On the other hand, Li-Fi cannot penetrate through walls and it can only be detected from 10 meters (perimeter) however it is the cheapest and quickest wireless communication.

In conclusion, Wi-Fi can be available in each torus by routers which will be installed in various public places such as roads, hospitals, restaurants etc. Li-Fi can be installed in the houses and in some important places where fast internet will be needed. Having available Wi-Fi and Li-Fi in the toruses is important not only for entertainment but also as a fast and dependent communication system that everyone can use.

4.5 BUSINESS AND INDUSTRY

In order for our project to be a successful and a profitable business, we must consider how we will be able to make money. The main advantage we will have over people living on Earth, are the resources available in space. Therefore, by extracting natural resources from asteroids or the moon, we will be able to trade them with companies on Earth, thus expanding our project and orientating the people on Earth towards a brighter future.

4.5.1 Rocket propellant production

As mentioned above, scientific research will consist of extracting substances such as hydrogen and methane from the moon. These resources will then be able to be sold to Earth, making a business and gaining a profit. Resources that can be used as rocket propellants are plentiful on the moon which means that this can help the settlement develop on a great scale. Also, an advantage of locating industrial resources on Afrodita is due to low gravity. Therefore, materials which are processed in specific parts of Afrodita will have a much smaller weight according to the mass, and will be able to be transferred from place to place more easily.

4.5.2 Asteroid Mining

This is the extraction of natural materials from asteroids or other smaller planets. These minerals and resources could be mined and then used for space for settlement utilization such as construction materials and rocket propellant or traded to Earth. Trading them to Earth while keeping a large proportion of our gain for settlement-development causes, is another major business Afrodita can rely on.

4.5.3 Space tourism

Space tourism is a reality, it is viable and it is something that we can build our foundations on. It promises a profitable market and can expand our knowledge of our galaxy as it develops. Space tourism will be a main industry we will be working on.. Currently, studies suggest that the cost for one person to fly to outer space is approximately $100,000 dollars, meaning that this specific market will be able to sustain thousands of flights per year. As the prices decrease, the amount of flights that will be able to happen increase. This project is extremely optimistic according to published market researchers who state that “the space tourism market may become very large if the price is right.” As humanity and technology progresses, space tourism will become affordable even for middle-class citizens in countries such as the U.S. and Japan. The launch capacity available today is not sufficient enough but as mentioned before, this concept has tremendous potential benefits. The estimations below are referring to the amount of tourists that will visit space following the completion of the settlement.

- Within 5 years, 3,000 tourists will have been to the settlement.
- Within 15 years, suborbital tourism will be affordable and 50,000 people will have flown.
- Within 17 years, expensive orbital flights would have happened.
- Within 25 years, orbital flights to the settlement would be affordable.

Just as computers costed thousands of dollars many years ago, space tourism is the discipline of the more fortunate. Computers are nowadays an important item in people’s lives. Space tourism is currently rather expensive but promises to do something similar and it might as well begin the spread of life throughout the solar system.

4.5.4 Robotics in space

Applications in outer space suit robots perfectly. Since it is arguably dangerous for

humans to exit the Earth's atmosphere, certain robots can remain permanently in outer space and complete tasks. Robots can have a massive impact on outer space activities since there is no gravity. This means that engineers will not need to use lubricants for robots to function smoothly and they will be able to support their own weight. This is an opportunity for new, original and revolutionary designs since the range of ideas that can be applied is unlimited.

The utilisation of robots in outer space has already begun, one of which includes the 'Sojourner' which is is the R/C car that explored the surface of Mars. Some people might consider this is not a robot since it was controlled from Earth, but NASA supports that it is. The same concept of robots could be used in the case of mining asteroids that have not yet been examined carefully. R/C cars could be used in order to approve if an asteroid has the necessary materials to satisfy the settlement's needs.

Apart from this use, robots can be used as utility tools. For instance, robot arms can be developed in order for them to be able to be controlled and follow a given software provided by an engineer. Several arm robots have flown on space flights for the past twenty years and they proved to be a great success. This can decrease the amount of labour humans have to go through, decrease the risks, and increase productivity at a scaling level. Tasks these robots can perform range from moving satellites around and fixing antennae that have been placed incorrectly.

4.5.5 Biotechnology

Biotechnology is the utilisation of living organisms in order to manufacture or develop products. It often relates to bioengineering, biomedical engineering and biomanufacturing and humans use it in agriculture, food and medication. Most people might be wondering why people research biotechnology in space rather than on Earth. Many studies have indicated that certain organisms grow faster in space, saving valuable time and money as well as the fact that bacteria can express themselves in different ways. This happens due to the absence of greater levels of gravity which relieve stress and pressure on these organisms. The ideal location in which this can become a reality on our space settlement is the main tube. The main tube will consist of areas exposed to zero or very low gravity. Along with entertainment parks, a biotechnology research lab can be constructed and utilised to its greatest extent.

Millions of people are surprisingly afraid of biotechnology developing. However, these people are already being widely exposed to biotech in their everyday life from the clothes they wear, to the food they eat and medicine they take. Genetically modifying certain species can essentially satisfy all our requirements and bring phenomenal discoveries to the world. For instance, spider silk is an amazingly durable substance that can be used to create bullet proof vests but is it nearly impossible to milk spider due to economic reasons. On the contrary, there are specially bred spider goats that produce milk which contains spider

protein. This can be utilised to produce very valuable substances which can have applications in aeronautics, aerospace and medicine.

4.6 RECREATION AND ENTERTAINMENT

Recreation and entertainment will consist of a huge part of life for the inhabitants of Afrodita. Activities will be organised on the settlement in order to entertain the people in the same way as they would on Earth. Ordinary activities such as cycling, playing sports, walking, socializing and spending time with friends will make Afrodita's citizens feel more like home.

On Afrodita, mainly due to the fact that some parts of the settlement will be exposed to low gravity, many revolutionary sports could be invented. The zero gravity facilities will be located towards the center of the settlement, most possibly in the main tube, and the inhabitants of Afrodita will have complete control over what activities they desire to do and play. They have the final say over the maintenance of the activity which will possibly lead to a discovery of new sports which might be revolutionary in the future. It is nearly impossible to predict the types of sports that will evolve on Afrodita in those conditions which makes it thousands of times more interesting. Of course, in the zero gravity location, the Coriolis effect can be recognised by people at different levels; some stronger, some weaker. This will help improve games by providing interesting dynamics such as running up walls at big heights without falling downwards.

In addition, another very important aspect for the inhabitants, is their health condition. Gyms will be setup across the settlement so all the citizens have a access to one in order to maintain a healthy lifestyle. This facility is free to access. However, every single person on the settlement will possess a unique card for themselves which will include a photo of them, their full name and their address. The card will have a chip inside it which has to be scanned so access to the gym is available. Each person will be assigned to a certain gym according to where they live and to avoid large crowds in one gym, while another one is empty.

The gymnasiums will be able to fit up to 25 people at once and will have different machines. Water will be provided at the gym and also it will have a shop for sport related purchases and a bathroom. There will be 10 treadmills installed in each gym; this will help provide the inhabitants with a good physical condition, and weights which will be only for strength. The weights will have the following masses: 2kg, 4kg, 6kg & 10kg. There will be several weights for each size as well as a bench for bench pressing exercises, again, with specific weights. Furthermore, bicycles are going to be able to be accessed by all inhabitants at a certain price which will be slightly low in order to encourage cycling in the settlement.

4.7 LAWS AND GOVERNMENT

4.7.1 Government

Afrodita 1.0 will be a direct democratic society. Every 3 there will be a new election for a new president. Everyone within the range of 18 to 80 will be able to vote.

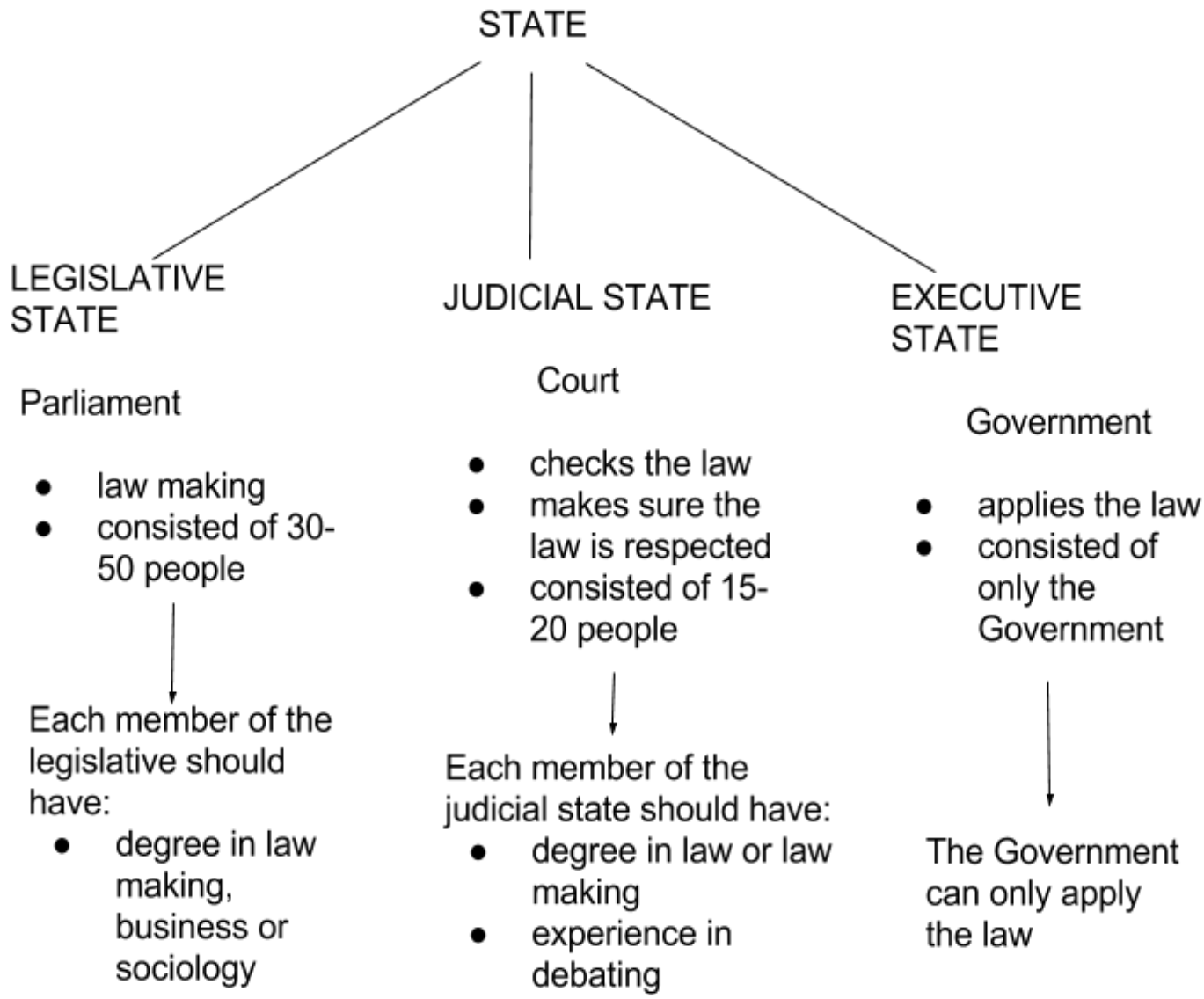
A president will be able to be voted only 2 times in a row (3 + 3 = 6 years). If the people will vote the president for the third time he will not be able to rule and the president will be the person with the second most votes.

We believe that being the president of a space settlement is a very serious and responsible job. Therefore there are many requirements that an individual will need to have so he/she can become a president. On the table below are listed all of the requirements for a president.

Requirements for President
• University Education
• Needs to be voted by 56% of the settlement's population
• Above the age of 40
• Needs to live at least 1 year in the settlement

4.7.2 Law: In General

The law will be voted by the people. There will be two types of laws: normal law and forced law. To vote for a normal law you will have to be within the age range of 25 to 75. For a law to be created it will pass 3 states : the legislative, and judicial and executive state. The legislative will create the law and let the people vote. The judicial will check the law and make sure that the law will be respected. Lastly , the executive will apply the law. Each state will be consisted of a certain amount of people except from the executive. Here is a diagram showing the 3 states:



The forced law will be equivalent in terms of power with the normal law. The forced laws will created, checked and applied by the Government itself. This will only occur only in extreme circumstances like economic failure, political failure etc.

4.7.3 Law: Sanctions and Rewards

For a superior social control and conformity, the settlement will need to have sanctions and rewards.

Sanctions

Sanctions will be necessary for the settlement. Individuals who disobey the law will be given a variety of sanctions depending on the level of the broken law. Law violation and sanctions will be divided in 3 categories:

Law Violations

Minor Law Violation	Moderate Law Violation	Major Law Violation
• theft	• murder (second degree)	• arson
• violence	• illegal substances	• vandalism
		• terrorism
		• murder (first degree)

Sanctions

MiLV Sanctions	MoLV Sanctions	MaLV Sanctions
• money penalty	• prison time in the settlement	• ostracism
• banned from certain activities in the settlement	• money penalty	• prison time on Earth
		• money penalty

Rewards

Rewards will be necessary and will be given to individuals with positive behaviour or who obey the laws.

Rewards

Rewards for positive behaviour
• Promotion
• increase in individual's wage

4.8 ADVERTISEMENT

We kept on "talking" about creating a new life in a new environment; space. But, how can we reach our goal if we do not have volunteers? Advertisement is probably the most important industry we need to conquer as it brings our project to the world's ears. It helps people understand everything about Afrodita 1.0, as well as making them WANT to be on Afrodita 1.0. Advertisement may also help us raise funds from optimistic countries and people, as well as new innovative ideas.

Film industry is the biggest advertisement method we can exploit. We can promote our ideas and convince people that this settlement will be the best choice they will make. The Martian movie is an excellent example as it shows the audience how agriculture works, how we can obtain water and it is very realistic. A 2001 Space Odyssey from Stanley Kubrick is one of the best examples of space colonization themed movies, it gives many technical details to the audience and increases the awareness on space colonization. Technology evolved and films are of great success nowadays, which means that our project can be easily promoted to a very large audience. Also, the space-universe movies are becoming more and more popular as people are willing to explore and discover the wonders of the outside world.

Another method of popularising the space settlement concept and increasing awareness is social media. We can promote Afrodita 1.0 through Facebook, Twitter, Instagram and YouTube kinds of social media tools. Nowadays, most people have access to the internet and are owners of at least one of these accounts. It is not difficult to access millions with a single post and attract social attention. Articles and reports may also have their rate of promotability.Most people own at least one TV so TV adverts are recommended for promotion.

To sum it all up, advertisement is one of the methods to increase popularity of space settlement and convince people to the benefits of investing on a space settlement. We will try our best to promote it through every and best way possible. Some methods can be costly but the returns are profitable. Advertisement is the best way through which we can let people know about our plans and ideas for the future.

5 TOTAL COST

All the costs of the well known space programs always consisted of many digits. The Apollo program was first estimated at around $7 billion but the final predicted cost was $25.4 billion in 1973. In 2009 NASA held a presentation on the total costs of the programs, including research and development costs, which added up to roughly $170 billion. Another example is the Mars One project. It has been estimated that the cost of putting the first 4 people on Mars is around $6 billion. This includes the cost of all the hardware, operational expenditures and margins. The International Space Station (ISS) is the most expensive single item ever constructed. Many countries contributed to the production of it, including Russia, Japan and Canada. Its total cost was around $150 billion. Below you will find a table with the approximate costs for building Afrodita 1.0:

Name	Quantity	Cost($)/Quantity	Total Cost ($)
Materials			
Carbon Nanotubes	837,900 tonnes	50/kg	41,895,000,000
Aerogel	17,500 tonnes	50/kg	875,000,000
RXF-1	2,002,000 tonnes	-	-
Aluminium	2,362,500 tonnes	1.5/kg	3,543,750,000
Microlattice	220.5 tonnes	-	-
Carbon Fiber	840,000 tonnes	10/kg	8,400,000,000
RTV Adhesive	1,354,500 tonnes	30/kg	40,635,000,000
Titanium	3,876,250 tonnes	5/kg	19,381,250,000
Total Cost:			~$115,100,000,000
Technical Details			
Research	-	-	50,000,000,000
Radiation Shielding	-	-	12,000,000,000
Docking Stations	6	300m/station	1,800,000,000
Solar Panels	30	40,000/panel	1,200,000
Asteroid Spaceship	1	2,000,000,000/unit	2,000,000,000

Atmosphere	-	-	65,000,000,000
Communication	-	-	5,000,000,000
Houses	900	725,000/house	652,500,000
Parks	15	1,000,000/park	15,000,000
Elevators	2	5,000,000,000/unit	10,000,000,000
Infrastructure	-	-	7,500,000,000
Total Cost:			~$168,951,200,000
Life Support			
Agriculture	-	-	1,500,000,000
Water	3 filtration stages	3,000,000/stage	9,000,000
Recycling	-	5,000/torus section	180,000
Total Cost:			~$1,509,180,000
Social Life			
Hospitals	36	200,000,000/unit	7,200,000,000
Schools	18	70,000,000/unit	1,260,000,000
Universities	36	20,000,000/unit	720,000,000
Super computers	4	390,000,000/unit	1,560,000,000
Transport	-	-	15,000,000,000
Industries	-	-	2,500,000,000
Advertisment	-	-	7,000,000
Entertainment	-	-	5,000,000
Total Cost:			~$28,332,000,000
Wages			
Engineers	500	30,125,000/year	301,250,000
Construction workers	1,500	54,000,000/year	540,000,000
Scientists	300	24,750,000/year	247,500,000

Architects	400	20,000,000/year	200,000,000
Other workers	-	-	100,000,000
Total Cost:			~$1,388,500,000
TOTAL AFRODITA 1.0 COST			~$315,280,880,000

TOTAL COST OF AFRODITA 1.0: ~$315,280,880,000

BIBLIOGRAPHY

CHAPTER IMAGES:

Chapter 1 Introduction:
<http://img.freepik.com/free-photo/notebook-spiral_2256729.jpg?size=338&ext=jpg>

Chapter 2 Technical Details:
<http://image2.redbull.com/rbcom/010/2014-07-02/1331662886228_18/0010/1/550/366/18/peugeot-2008-dkr-first-test-pre-dakar-2015-16.jpg>

Chapter 3 Life Support:
<http://7550-presscdn-0-42.pagely.netdna-cdn.com/wp-content/uploads/2015/09/bigstock-Water-Drop-butterfly-Leaf-95640518.jpg>

Chapter 4 Social Life:
<http://cdn-media-1.lifehack.org/wp-content/files/2013/11/6-Most-Important-Social-Skills-You-Can-Have-To-Make-A-Great-Social-Life.jpg>

Chapter 5 Total Cost:
<https://wallpaperscraft.com/image/bills_dollars_pile_crumpled_money_9266_1600x1200.jpg>

1 WHY DO WE NEED A SPACE SETTLEMENT

-no sources-

2 TECHNICAL DETAILS

2.1 Placement of Space Settlement

1.<http://wmap.gsfc.nasa.gov/media/990528/990528.jpg>
2.<http://www-spof.gsfc.nasa.gov/Education/wlagran.html>

2.2 Roadmap of Afrodita 1.0

-no source-

2.3 Asteroid Mining

1.<http://www.scienceclarified.com/scitech/Comets-and-Asteroids/How-Humans-Will-Mine-Asteroids-and-Comets.html#ixzz3z2wvrvvs>
2.<http://www.permanent.com/asteroid-mining.html>

2.4 Lunar Mining

1.<http://space.alglobus.net/papers/LunarMines.pdf>
2.<http://www.lunarpedia.org/index.php?title=Lunar_Settlement>
3.<http://www.lunarpedia.org/index.php?title=First_Base>
4.<http://www.lunarpedia.org/index.php?title=Mass_Drivers>
5.<http://www.lunarpedia.org/index.php?title=In-Situ_Propellant_Production>
6.<http://www.lunarpedia.org/index.php?title=Lunar_Aluminium_Production>
7.<http://www.lunarpedia.org/index.php?title=Lunar_Titanium_Production>
8.<http://www.lunarpedia.org/index.php?title=Hydrogen>
9.<http://www.lunarpedia.org/index.php?title=Helium>
10.<http://www.lunarpedia.org/index.php?title=Lunar_Life_Support_Parameters>

2.5 Comparison of Possible Materials

1. Microlattice-
<http://www.boeing.com/features/2015/10/innovation-lightest-metal-10-15.page>

2.6 Construction Materials

1. <http://www.calculator.net/mass-calculator.html>
2. <http://www.engineersedge.com/volume_calc/torus.htm>

2.7 Construction Sequence

-no sources-

2.8 Gravity and Impulse Engines

1. <http://www.buildtheenterprise.org/engines>

2.9 Artificial Gravity

1.<https://en.m.wikipedia.org/wiki/Artificial_gravity>

2.10 Radiation Shielding

1.<http://www.thomasnet.com/articles/custom-manufacturing-fabricating/radiation-shielding-materials>
2.<http://webbook.nist.gov/cgi/fluid.cgi?Action=Load&ID=C1333740&Type=SatT&Digits=5&PLow=.5&PHigh=1.5&PInc=.1&RefState=DEF&TUnit=K&PUnit=atm&DUnit=kg/m3&HUnit=kJ/mol&WUnit=m/s&VisUnit=uPa*s&STUnit=N/m>
3.<http://www.coolmagnetman.com/magconda.htm>

4.“X-rays, Gamma rays and Neutron Shielding” by News Staff, July 27th 2015
<http://www.science20.com/news_articles/high_z_metal_foams_shield_xrays_gamma_rays_and_neutron_radiation-156579>
5.<http://www.britannica.com/science/polyethylene>
6.<http://www.roxul.com/products/commercial/products/roxul+afb>

2.11 Energy

1.<https://books.google.ro/books?id=1BG78utt6VUC&pg=PA12&dq=energy+%22capacity+to+perform+work%22&redir_esc=y#v=onepage&q=energy%20%22capacity%20to%20perform%20work%22&f=false>
2.<http://www.nrel.gov/learning/re_photovoltaics.html>
3.<http://ec.europa.eu/eurostat/statistics-explained/index.php/Consumption_of_energy>

2.12 Communication

1.<http://esc.gsfc.nasa.gov/assets/images/OpticalComm/LCRDFactSheet.pdf>

2.13 Thermal Control

1.<http://buildingscience.com/documents/digests/bsd-011-thermal-control-in-buildings>
2.<http://www.aerogel.com/resources/about-aerogel/>
3.<http://www.aerogel.org>

2.14 Day/Night Cycle and Lighting

-no sources-

2.15 Atmosphere

1.<http://www.allstar.fiu.edu/aero/fltenv2.htm>
2.<http://inhabitat.com/gyula-bodonyis-algae-powered-led-is-truly-a-green-light-bulb/>
3.<http://www.mnn.com/your-home/at-home/blogs/algaebulb-is-an-illuminating-oxygen-generating-led>
4.<https://www.newscientist.com/article/dn18848-laser-creates-clouds-over-germany>
5.<http://science.howstuffworks.com/nature/climate-weather/meteorologists/cloud-seeding1.htm>

2.16 Interior Design

1.<De Craen, A. J.; Roos, P. J.; Leonard De Vries, A.; Kleijnen, J. (1996). "Effect of colour of drugs: Systematic review of perceived effect of drugs and of their effectiveness">
2.<http://www.soundproofingtips.com/soundproofing-materials/>
3.<http://www.thermaxxjackets.com/5-most-common-thermal-insulation-materials/>
4.<http://www.superhomes.org.uk/resources/whats-best-insulation-material/>
5.<http://soundproofcurtain.com/fireproof-insulation/>

2.17 Scientific Research

1.<http://www.nasa.gov/directorates/heo/slpsra/>
2.<http://news.mit.edu/2014/second-skin-spacesuits-0918>
3.<http://arc.aiaa.org/doi/abs/10.2514/6.2007-345>
4.<http://www.bbc.com/news/science-environment-17827347>
5.<http://www.xeroscleaning.com/the-xeros-machine>
6.<https://en.m.wikipedia.org/wiki/Xeros_Washing_Machine>
7.<http://www.lunarpedia.org/index.php?title=In-Situ_Propellant_Production>

2.18 Docking System

1.<https://en.m.wikipedia.org/wiki/NASA_Docking_System>
2.<http://dockingstandard.nasa.gov/Documents/US%20Docking%20History%20Poster%20(2).ppt>

3 LIFE SUPPORT

3.1 Water

1.<http://www.nasa.gov/pdf/146558main_RecyclingEDA(final)%204_10_06.pdf.>
2.<http://settlement.arc.nasa.gov/75SummerStudy/Chapt3.html#Atmosphere>
3.<http://www.instructables.com/id/Separate-Hydrogen-and-Oxygen-from-Water-Through-El/>

3.2 Agriculture and Food

1.<http://www.doityourself.com/stry/aeroponics-vs-hydroponics#b>
2.<http://www.powerhousehydroponics.com/15-benefits-of-aeroponic-growing/>
3. <http://homeguides.sfgate.com/plants-aeroponics-systems-52438.html>

3.3 Health

1.<http://www.spacefuture.com/habitat/healthfitness.shtml>
2.<http://www.news-medical.net/health/Radiation-Exposure-Prevention.aspx>

3.4 Recycling and Waste Management

1.<http://www.epa.gov/smm/advancing-sustainable-materials-management-facts-and-figures>
2.<http://www.all-recycling-facts.com/recycling-benefits.html>
3.<http://www.iflscience.com/environment/urban-algae-farm-gobbles-highway-air-pollution>

3.5 Emergency Cases

1.<http://www.femalifesafety.org/types-of-extinguishers.html>

2.<https://en.wikipedia.org/wiki/Fire_extinguisher>
3.<http://www.femalifesafety.org/types-of-extinguishers.html>

4 SOCIAL LIFE

4.1 Population

1.<http://astronauts.nasa.gov/content/broch00.htm>
2.<https://www.myesr.org/html/img/pool/Radiation_Protection_ESR_Work_Sept_2013.pdf>

4.2 Education

1.<http://jupiter.plymouth.edu/~lsandy/education%20in%20Finland.html>
2.<http://fillingmymap.com/2015/04/15/11-ways-finlands-education-system-shows-us-that-less-is-more/>

4.3 Transport

1.<http://www.electroauto.com/info/pollmyth.shtml>
2.<https://web.archive.org/web/20140105043545/http://www.owningelectriccar.com/electric-car-history.html>
3. <http://www.hybridcars.com/tesla-model-s-was-worlds-best-selling-plug-in-car-in-2015/>
4. <http://www.nap.edu/read/12826/chapter/2#2>

4.4 Computing and Network

1.<http://aspg.com/mainframes-vs-supercomputers/#.VrovTjZ95PV>
2.<https://www.youtube.com/watch?v=wqH9KX9o0vg>
3.<https://www.quora.com/What-are-the-advantages-and-disadvantages-of-Li-Fi-over-radio-communication-And-what-could-be-the-maximum-range>

4.5 Business and Industry

1.<http://www.nasa.gov/mission_pages/station/research/experiments/180.html>
2.<http://www.nss.org/tourism/settlement.htm>
3.<http://www.nasa.gov/audience/foreducators/robotics/home/#.Vrhj2YhXerU>
4.<http://www.learnaboutrobots.com/space.htm>
5.<http://www.bio.org/articles/what-biotechnology>
6.<http://www.space.com/30213-asteroid-mining-planetary-resources-2025.html>

4.6 Recreation and Entertainment

1.<http://www.nasa.gov/audience/foreducators/stem-on-station/ditl_free_time>
2.<http://www.nasa.gov/mission_pages/station/research/experiments/180.html>

4.7 Laws and Government

1.<http://criminal.findlaw.com/criminal-charges/view-all-criminal-charges.html>

4.8 Advertisement

1.<http://marketingland.com/social-media-advertising-set-explode-next-3-years-121691>
2.<http://www.theguardian.com/film/2015/oct/06/how-scientifically-accurate-is-the-martian>

5 TOTAL COST

1.<http://www.hq.nasa.gov/alsj/APSR-JSC-09423.pdf>
2.<http://www.mars-one.com/faq/finance-and-feasibility/how-much-does-the-mission-cost>
3.<http://www.nasa.gov/mission_pages/station/main/onthestation/facts_and_figures.html>
4.<http://www.buy-aerogels.eu/index.php?route=product/product&product_id=80>
5.<http://www.alibaba.com/premium/carbon_fiber.html?uptime=20140901&ptsid=10120000
54235066&crea=47439966162&plac=&netw=g&device=c&ptscode=0110202010010001>
6.<http://www.aliexpress.com/price/rtv-adhesive-sealant_price.html>
7.<http://www.infomine.com/investment/metal-prices/ferro-titanium/1-year/>
8.<https://www.quandl.com/collections/markets/aluminium>
9.<http://energyinformative.org/solar-panels-cost/>
10.<http://www.buildtheenterprise.org/wp-content/uploads/2012/03/Gen1-USS-Enterprise-C
ost-and-Mass-Estimates-v2.png>
11.<http://www.prm.nau.edu/prm423/cost_analysis_lesson.htm>
12.<https://pwceducationreform.wordpress.com/2013/03/02/how-much-does-it-cost-to-build-
a-high-school/>
13.<http://www.crizmo.com/worlds-top-10-supercomputers-with-their-cost-speed-and-usage.
html>

Thank you for taking the time to read the Afrodita 1.0 Project.

- *Afrodita members*

[END]