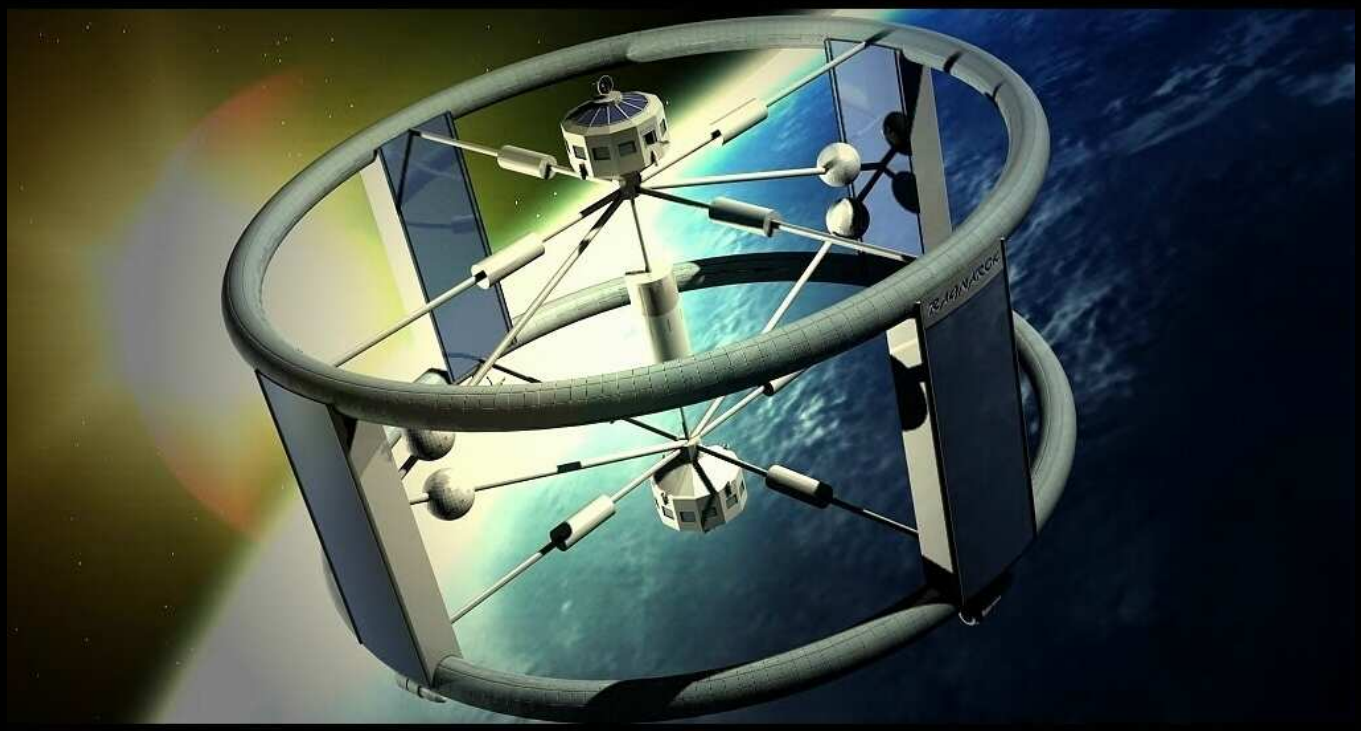
RAGNAROK



SPACE STATION

Dimcica Tudor
Izverceanu Dragos
Omer Erol
Popescu Sebastian
Rizea Mihai

Coordinating teacher: Nicolescu Adrian

Colegiul National Mircea cel Batran
Constanta, Romania

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We have become very fond of our project, Ragnarok, and enjoyed every step taken for its completion, from research and 3D design to typewriting and checking the spelling. During this process we have learned scientific facts about outer space and life support, how to work as a team, how to be innovative and original, how to respect opinions and work hard for your goals. This project helped to our development as humans and we hope, that one day, our ideas will help the evolution of the human species.

Further, we would like to thank our physics teacher, Adrian Nicolescu, who trusted our initiative and saw our potential and who helped us through encouragement, suggestions and references.

Special thanks are required to our families for the moral support they offered.

Last but surely not least, we would like to thank God, Who watched over us guided us to our decisions.

Table of Contents

1. Introduction 6

- Choosing the name Ragnarok
- Scenario
- Why Ragnarok? Reasons and goals

2. Location 9

2.1 List of possible locations 9
2.2 Choosing the location 11

3. Design of the space station

3.1 Torus 11
3.2 Industry 17
3.3 Research laboratories 17
3.4 Agriculture 18
3.5 Space Port 18
3.6 Central Axis 22
3.7 Transportation Channel 22
3.8 Oblique transportation channel 22
3.9 Variable G Entertainment 23

4. Phases of construction

4.1 Phase 1 – Gathering funds 26
4.2 Phase 2 – Preparation Phase 27
4.3 Phase 3 – Construction Phase 38
4.4 Phase 4 – Adaptation Phase 47

5.Life Support System 48

5.1 Environment 48
5.2 Gravity 49
5.3 Oxygen production 52
5.4 Water recycling 53
5.5 Energy 57
5.6 Food and nutrition 60
5.7 Waste disposal 65
5.8 Thermal control system 65
5.9 Illumination 67

5.10 Anti-radiation measures 68
5.11 Anti-vibration 69

6.Protection 70
6.1 Standard evading procedures 70
6.2 Asteroid deflection 70
6.3 Outer shield 70

7.Demography 72
8.Political System 73
9.Institutions 74
10.Economical system 75
11.Education 76
12.Leisure quarters 77
13.Industry 78
13.1 Metallurgy and construction 78
13.2 Spacecraft construction 78
13.3 Robot construction 78

14.Research laboratories 80
14.1 Aerospace engineering 80
14.2 Robotics 80
14.3 Space exploration 80
14.4 Genetics 80

15.Communications 81
15.1 External communications 81
15.2 Internal communications 82

16.Final expenses 82

1. INTRODUCTION

"Imagination is the beginning of creation. You imagine what you desire, you will what you imagine and at last you create what you will."
George Bernard Shaw
Irish dramatist & socialist (1856 - 1950)

In norse mythology, Ragnarok represents a series of events, starting with the death of several major gods, which led to various natural disasters, and finally to the subsequent submersion of the world in water but continued with the resurfacing of a new and fertile land, a meeting of the remaining gods and the repopulation of the world by two human survivors.

The space settlement was named so, because it was created under similar circumstances. In the year 2010 several world leaders met to discuss the future problems of the planet and to find the most adequate solution for them, continued by creating a new habitat for humans, in outer space, which will be populated by a selected number of people.

"The great French Marshall Lyautey once asked his gardener to plant a tree. The gardener objected that the tree was slow growing and would not reach maturity for 100 years. The Marshall replied, 'In that case, there is no time to lose; plant it this afternoon!"
John F. Kennedy (1917 - 1963).

The program is funded by several countries. The idea is to create an extension of planet Earth, a human inhabited space station that imitates the life on Earth with the purpose of researching and finding ways to expand the habitat of humans into outer space, and to gather energy and resources for mother planet. Also, Ragnarok will be a research centre for nanotechnology, technology that will be used on both the station and back on Earth. Research is probably the most important aspect of the station and has two goals: creating new, advances technology for the benefit of the station and the planet, and find ways of expanding and improving the outer space human civilization. It is a community that must be able to support itself and to also exploit the surrounding elements (sun, moon, asteroids) and help the mother planet. It is an outer space community that must be able to support itself and find solutions for Earth. The importance of the work done on Ragnarok and the work load of the inhabitants are huge, therefore every aspect of this station must be efficiently managed and designed, so that the work environment is as pleasant as possible.

The process of creating Ragnarok is a long and difficult one. The technology required for this is unavailable in 2010; therefore the creation of the space settlement is divided in two:

- a 50 year long research and design stage. Ragnarok will become the main focus for every country that contributes in the program. All science

departments will focus their attention on the project and invest time and money in creating the technology necessary to imitate life on Earth.

- a 50 year long construction stage. This consists in gathering up the required materials, processing them to the desired shape and assembling the whole station.

Ragnarok is thus a radical solution to major concerns. The reasons for creating an outer space human settlement are various:

- Environmental: the planet is polluted and because pollution will inevitably continue because of the growing industry and growing population. Predictions are that the greenhouse effect will aggravate, the air will contain less oxygen and more deadly gases, smog clouds and acid rains will happen on a regular basis. Intense agricultural activities and harvesting will damage the soil and make it impossible to grow enough food. Another environmental aspect is the expansion of the human habitat on the expense of the wildlife habitat. Daily, a large number of plant and animal species become extinct. Ragnarok aims to resolve these problems by creating a new habitat, life friendly, and assuring that it will not fail to the same dares. Being a research centre, it will also look into the possibility of creating new techniques the recycle air and water.

- Economical: with a growing population and a growing demand for goods, industry on Earth is intense. The natural resources mandatory in the economical process are getting scarce and an alternative is needed. Ragnarok brings two: exploiting resources on asteroids and on the moon and creating new technology that requires a smaller amount of resources that do not regenerate.

- Life sustaining and social aspects: the planet becomes too crowded. Advances in medicine which led to a smaller mortality rate, and birth rate estimated (in 2010) at 20.3 births per 1,000 population lead to the overpopulating of the planet. In the future, this could result in the impossibility of satisfying the necessities of life for many humans. Also, the environmental and economical aspects listed previously will have a definite impact on the quality of life. The most important aspect is the impossibility of generating enough energy for the entire population, an alternative is needed. One of the short term goals of the project is to create enough electric energy from solar energy to send back home on Earth. The main goal of Ragnarok is to create a new environment that the man will learn to respect and use, with the purpose of populating outer space and saving the mother planet Earth. Not only that Ragnarok offers a healthy, friendly environment to live and work in and researches the further possibility of expanding the outer space habitat, it is also host of a series of leisure activities and can be a destination for space tourism.

Ragnarok is able to sustain up to 76,000 inhabitants, 38,000 for each torus. We estimated that the population growth rate is 1.1% per year (this is the growth rate for planet Earth in 2009 - according to wikipedia.org). To reach the maximum population in 100 years we must send an initial population of 25,452 humans.

People on the station are selected after rigorous testing, to see if they can adapt to life in outer space, in a new born community. Mental and physical health is mandatory, and other important aspect is the ability to handle pressure and large work loads. It is very important that they adapt to the living and work conditions and help to achieve the goals of the project. Before embarking on the space settlement, they will undergo training, so that they learn what to do in critical situations, how to take care of the space station, how to react in this new environment.

2. Location

2.1 List of possible locations

The position where our space station is placed is a key factor,which is going to influence a lot of other characteristics of Ragnarok and in its choosing we take into account the following criteria:

- distance from Earth(influences the models of spacecrafts used for transport and the quantity of fuel)
- distance from Moon(influences the feasibility of exploiting the Moon's raw materials)
- stability
- density of space debris surrounding the location
- sun exposure

The following orbital locations are taken into consideration:

Low Earth Orbit

L.E.O. Is generally defined as an orbit within the locus extending from the Earth;s surface up to an altitude of 2,000 km.Given the rapid orbital decay of objects below approximately 200km,the commonly accepted definition is between 160 and 2,000 km above the Earth's surface.[Wikipedia]

Advantages:

- Very close to Earth, which implies a reduction in costs of transportation.
- Easy communication with Earth.

Disadvantages:

- large number of L.E.O. Satellites.
- high density of space debris(over 8,500 objects larger than 10 cm and approximately one million objects larger than 2mm,existing an imminent risk of impact due to the revolution period of just 90 minutes).

Geostationary Earth Orbit

A geostationary orbit is a geosynchronous orbit directly above Earth's Equator(0 latitude),with a period equal to the Earth's rotational period an an orbital eccentricity of approximately zero, which determines to appear motionless in the sky. (Wikipedia])

Advantages:

- relative close to Earth(36,000 km),which implies a reduction in costs for transport

- because the station is on a geosynchronous orbit,it requires just one antenna for communications
- easy access.
- it partly respects the day-night alternation,a beneficent fact for agriculture.
- long exposure to sunlight.

Disadvantages:

- a limited number of free spots in the orbit's circumference due to the radio interferences that arise if two objects are too close.
- high density of telecommunication satellites.
- all the spots on the orbit are proportionally distributed to all the countries in the world. Therefore,it will be difficult to obtain the legal certificate to build our station.

The Lagrange Points

They were discovered by French mathematician Louise Lagrange in 1772 in his gravitational studies of the "Three body problem":how a third ,small body would orbit around two orbiting larger ones. (**http://www/esa.int/esaSC/SEMM17XJDIE_index_0.html**)

In the Earth-Moon system,like in the Sun-Earth one,there are 5 libration or Lagrange points,numbered from L1 TO L5.These points marj the spots where summing all the forces exerted over an object with a negligible mass is almost zero,as a consequence maintaining it's orbit relative stable compared with the system of the two larges objects.

The libration points are divided in 2 categories:

- partly stable(L1,L2,L3)

Advantages:

- L1 and L2 are called "parking lots" or halo orbits because they are ideal to place space probes to examine the rest of the Universe.

Disadvantages:

- are just partly stable because at the smallest deviations from these trajectories,the space station will be getting further and further awat.It can be corrected with a minimal effort from the engines but just within the first minutes while the escape velocity is still low.On the other hand,if left uncorrected,the velocity grows exponentially.

- stable point(L4,L5)

Advantages:

- the only 100% stable points of the Lagrangian system.Two gravitational forces pull the space station,their intensities depending on their masses and distances within the respective point.Because the distances from

"Ragnarok" to Earth and Moon are both equal(384,000km),the ratio of the gravitational pullas are equal with the mass ratio.Therefore,the resultant force has as a mark the centre of mass between Earth and Moon,that is the rotation point of the entire system.Adding to this,the centrifugal force exerts an attraction equal in module to the resultant force,but in the opposite direction.Summing them,we obtain a state of total equilibrium.Even if we experience small deviations due to external interferences,the space station won't thrust away.Instead,it will effectuate some ellipitical circles till it gets back on the initial orbit.

- permanent exposure to Sun.

Disadvantages:

- long distance from Earth and Moon(384,000 km)

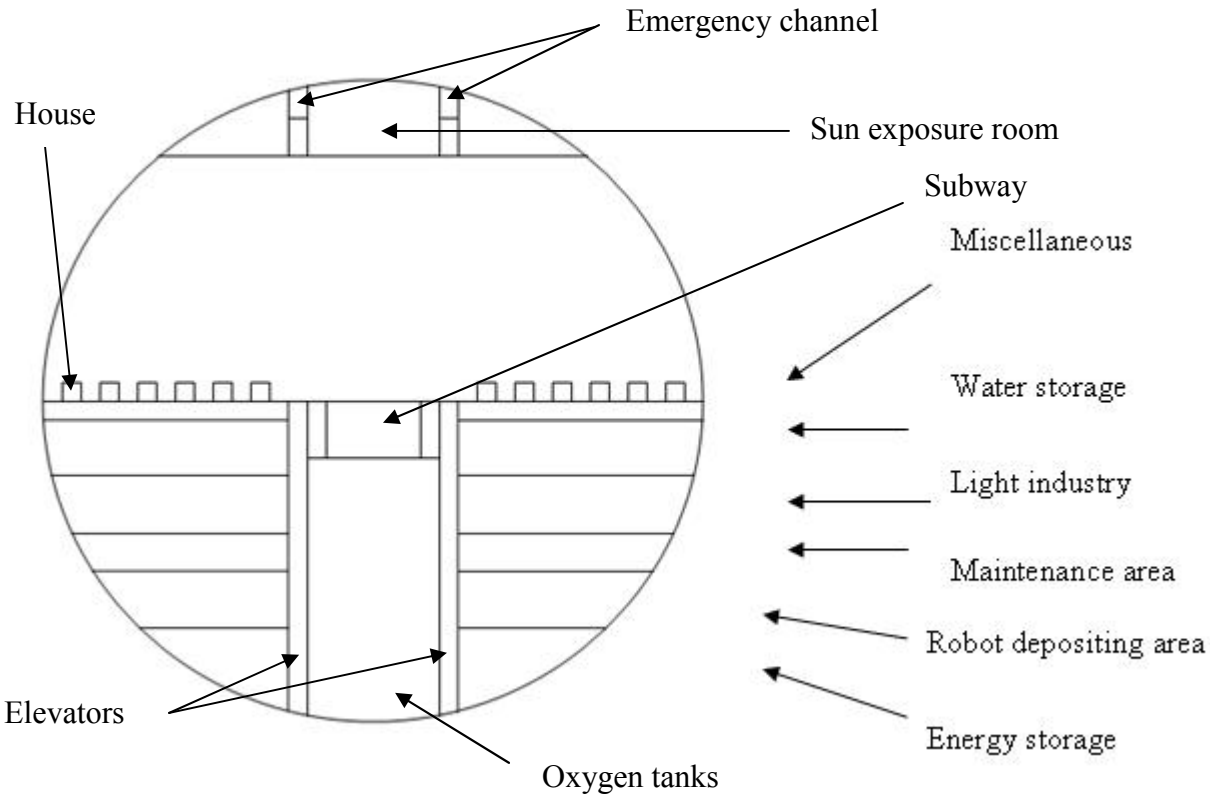
2.2 Choosing the location

Due to the insignificant percentage of space debris and stability, we have decided that L5 suits our requirements the best.

3. Design of Ragnarok

3.1 Torus

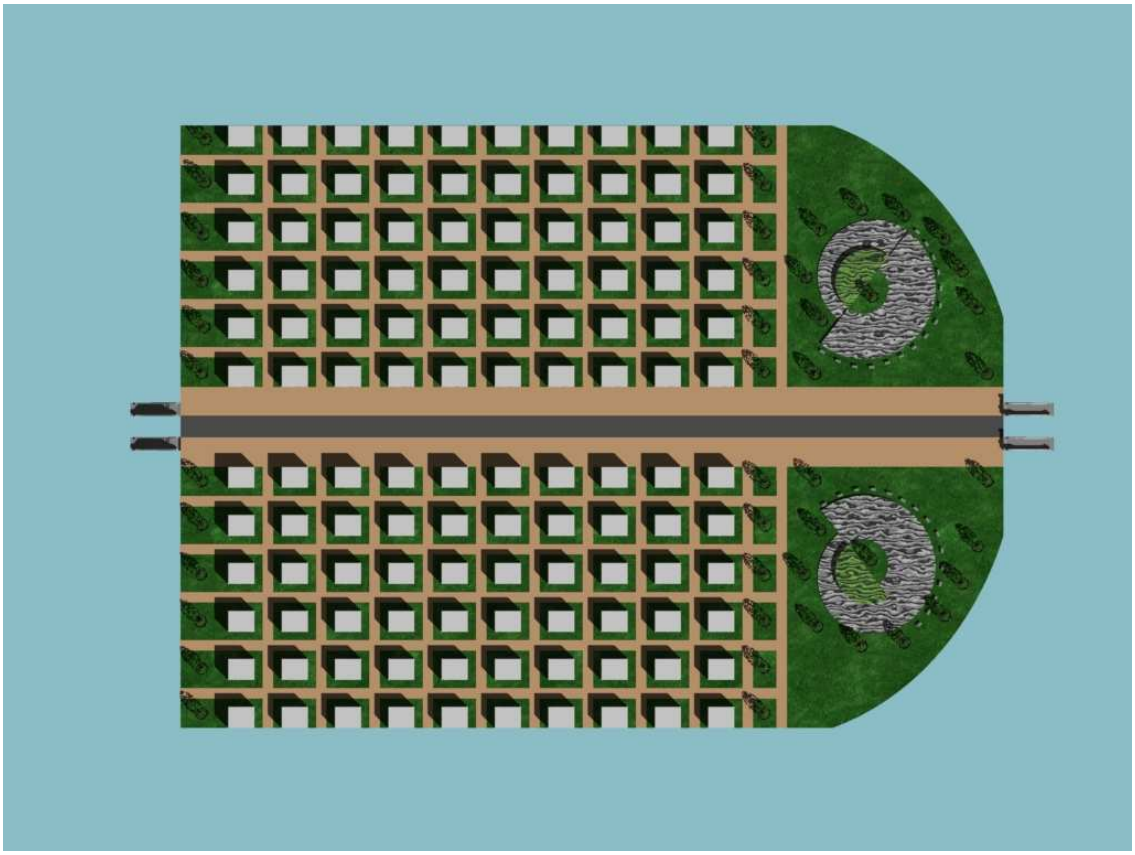
The vast majority of the activities conducted on our space station are held at the level of the two identical toruses. There are a lot of different components varying from social and entertainment habitats to working places and depositing halls, all conglomerated in a multi-leveled torus that has the following compartments as shown in the picture.

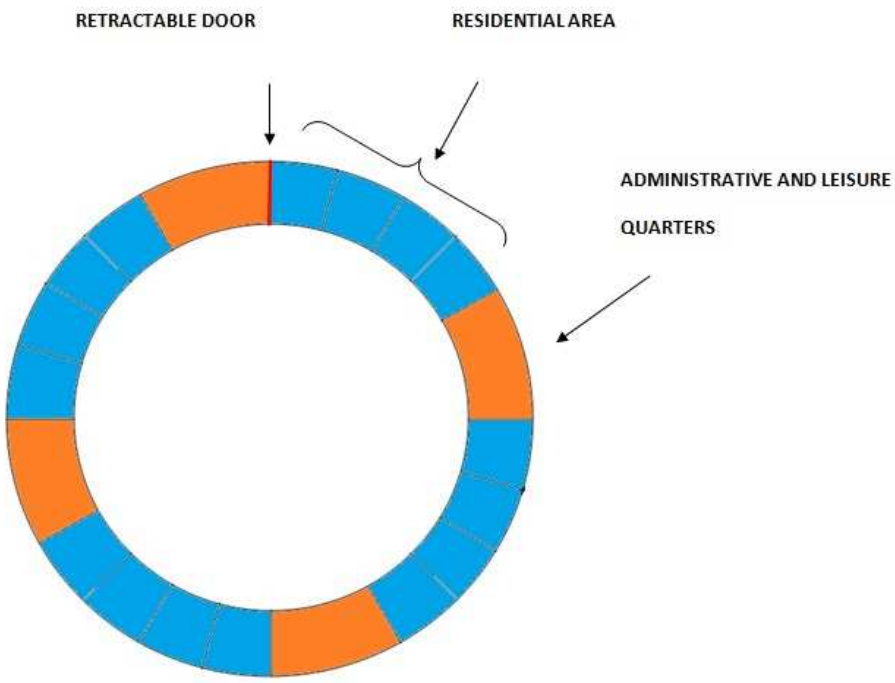


Moreover, the torus is equally divided into four identical compartments, each sealed off by giant retractable doors, with a circumference of 5,628 meters each. Again, this section has been territorially divided in four residential areas with a circumference of 1000 meters each and a multilateral area with an circumference of 1,628 meters that consists of administrative, political and economical institutions and not to mention, entertainment facilities.

3.1.1 Residential Area:

It is mainly consisted of 600 houses and 5 parks, which can be divided in 5 residential subdivisions with a circumference of 200 meters like in the following image:





The distances between the houses are of 10 meters, consisting in routes and gardens.

Plan of a house:

The main road has a width of 20 meters and is only used by bicyclists or any other non-polluting transports, whereas the 10 meter space separating the house quarters from the main road is used only for jogging. Beside that, every residential area has its own underground station situated in that space with two staircases that enables inhabitants to use the subway as a mean of transportation.

Every subdivision has its own park with a width of 20 meters and a length of 300 meters. It is surrounded by vegetation and in the middle is conglomerated with benches and fountains.

3.1.2 Sun Exposure Room:

In order for people to avoid diseases like rickets, osteomalacia and various types of cancer,it has been proven that a higher percentage of Vitamin D decreases the chances of contracting the above mentioned dysfunctions. Vitamin D can be synthesized through sun exposure or by eating fortified foods in vitamin D2 and D3 such as milk, yogurt, cereals, pastries and bread.

Based on this hypothesis, the Sun Exposure Rooms will enable people to spend the daily required 10 minutes interval to assimilate vitamin D in a comfortable and relaxing environment at 30 degrees Celsius while sitting on a chaise lounge.

On every residential subdivision there will be a 52 meters length sector on top of the transversal section of the torus and with a width of 40 meters. Each Sun Exposure Room is consisted of 240 chaise lounges with a surface of $2m^2$ each. During one day, there will be 10 switches.

3.1.3 Emergency Channels:

In the extreme cases of childbirth, excruciating pains caused by severe illness, accidents or other unwanted incidents we are obliged to offer fast and easy access to specialized medical care. Consequently, we have devised two rectangular channels

located in the top section of the torus, with the following dimensions: L=22513m, W=10m and l=10m.

We are to use the Maglev transportation system that consists of a train suspended and accelerated using the magnetic levitation of numerous magnets. This phenomenon is based on the fact that the magnetic pressure from the magnetic fields counteracts gravitational acceleration. Compared to the classic rail system is faster, quieter and the overall power consumed is far smaller, taking into consideration that he only force to beat is air resistance.

3.1.4 Maglev Lift:

Every residential subdivision has two maglev lifts, placed in the two far extremities of the transversal torus section. The lift has a slightly curved trajectory due to the shape of the exterior wall, to which is attached through the maglev transportation system described earlier in the Emergency Channels. The main priority of the lift is to transport people in need to the emergency channels.

3.1.5 Subway system:

Due to the large number of inhabitants that need to arrive in time to their work offices and the long distances between the residential and work sectors, it is imperative that we have a steady and easy transport method between the sections of the torus. Based on this concept, we have devised a subway system situated 10 meters below the residential area and with a width of 20 meters that consists in two-way directed maglev rails. Every residential area has its own subway station that can be accessed through automated staircases situated between the first row of houses and the interior highway.

3.1.6 Inter-Level Elevator:

Transporting materials for the light industry or robots to the respective sectors is needed and an easy way to achieve that is by implementing an elevator across the whole sub-residential multi level sector. It functions according to the same principles enunciated before at the Maglev Lift. It will consist of 2 compartments, one smaller for crew transportation, and one bigger for robots or materials. Technically speaking, it has a height of 150 meters with a width of 10 meters, being sporadically placed from 100 meters to 100 meters.

3.1.7 Miscellaneous Sector:

With a height of 10 meters and a width of 240 meters it is mainly composed of:

- electrical wires for residential houses
- plumbing pipes for residential houses
- redirected pipes to the water treatment system

- waste disposal system
- vibration absorption shield
- phonic shield

3.1.8 Water Storage:

A volume of 162,099,360 m^3 is comprised in this sector which has a width of 240 meters and a height of 30 meters, enough to satisfy the daily needs of inhabitants for approximately 300 years. Pipes are linked to this sector to supply the residential area, whereas the pipes inputted bring purified water from the water treatment system.

3.1.9 Light Industry:

Pondering the same height as the Water Storage Area, but with a length of 220 meters, the Light Industry area is destined to repair domestic furniture or any other related object regardless of its provenance. Beside that, it is also used for manufacturing clothes.

3.1.10 Maintenance Area:

With height of 20 meters and a length of 220 meters, the Maintenance Area is vital to the reparation of damaged robots.

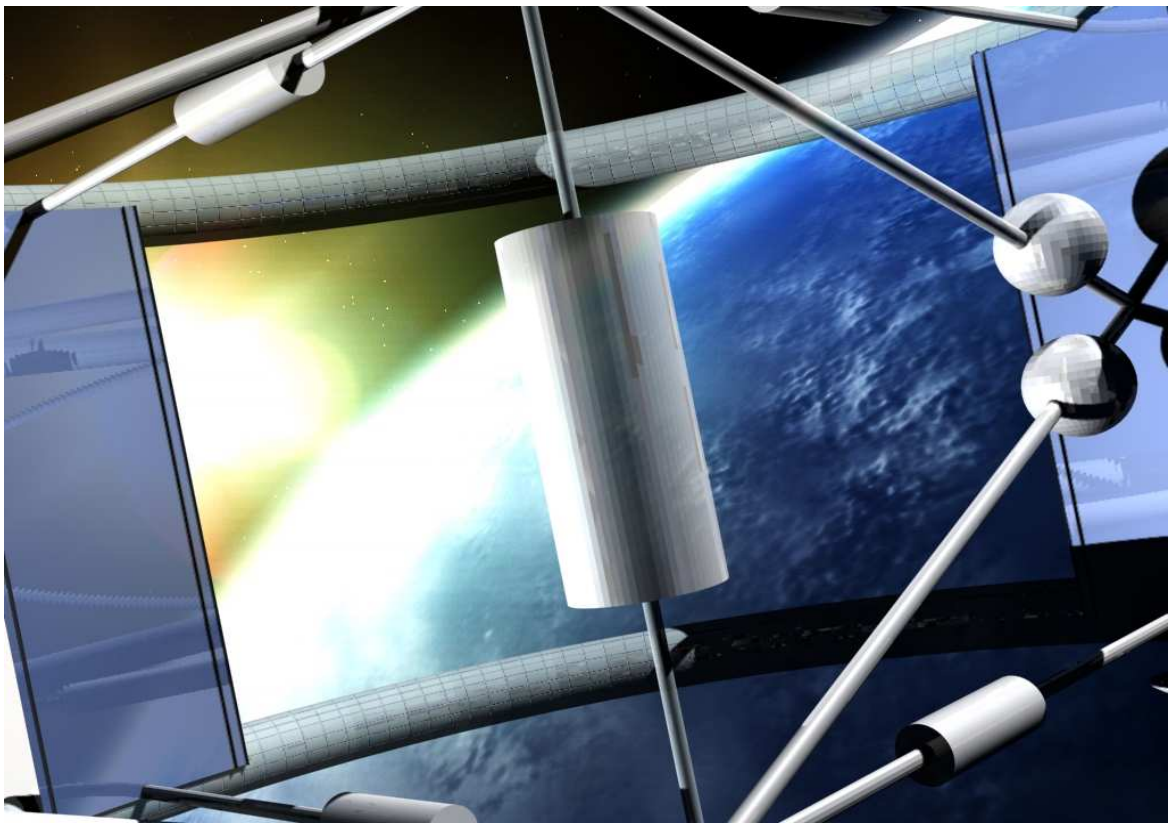
3.1.11 Robot Depositing Area:

Numbering a height of 20 meters with a length of 160 meters, the Robot Depositing Area is destined to accommodate outdated or retired robots.

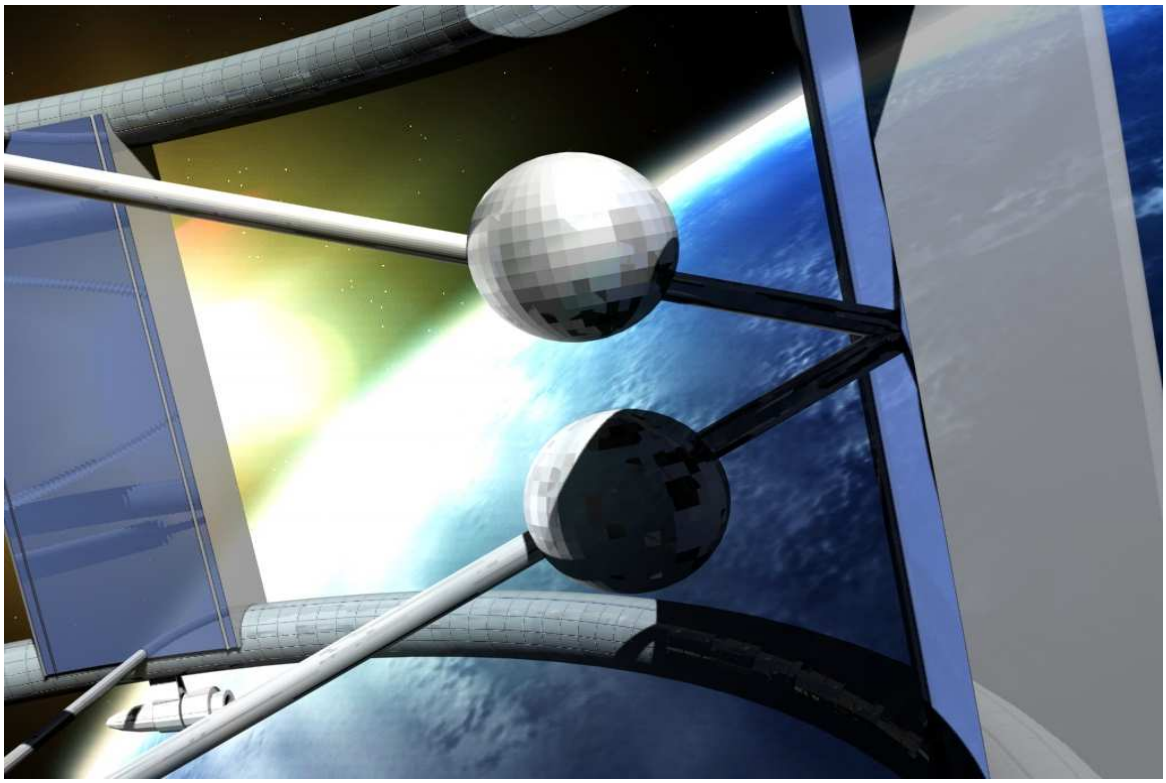
3.1.12 Energy Storage:

Energy obtained through the photovoltaic cell situated on the exterior wall is deposited in this sector, from where the energy is transferred to the station, whereas the other percentage stocked is send through microwaves to Earth.

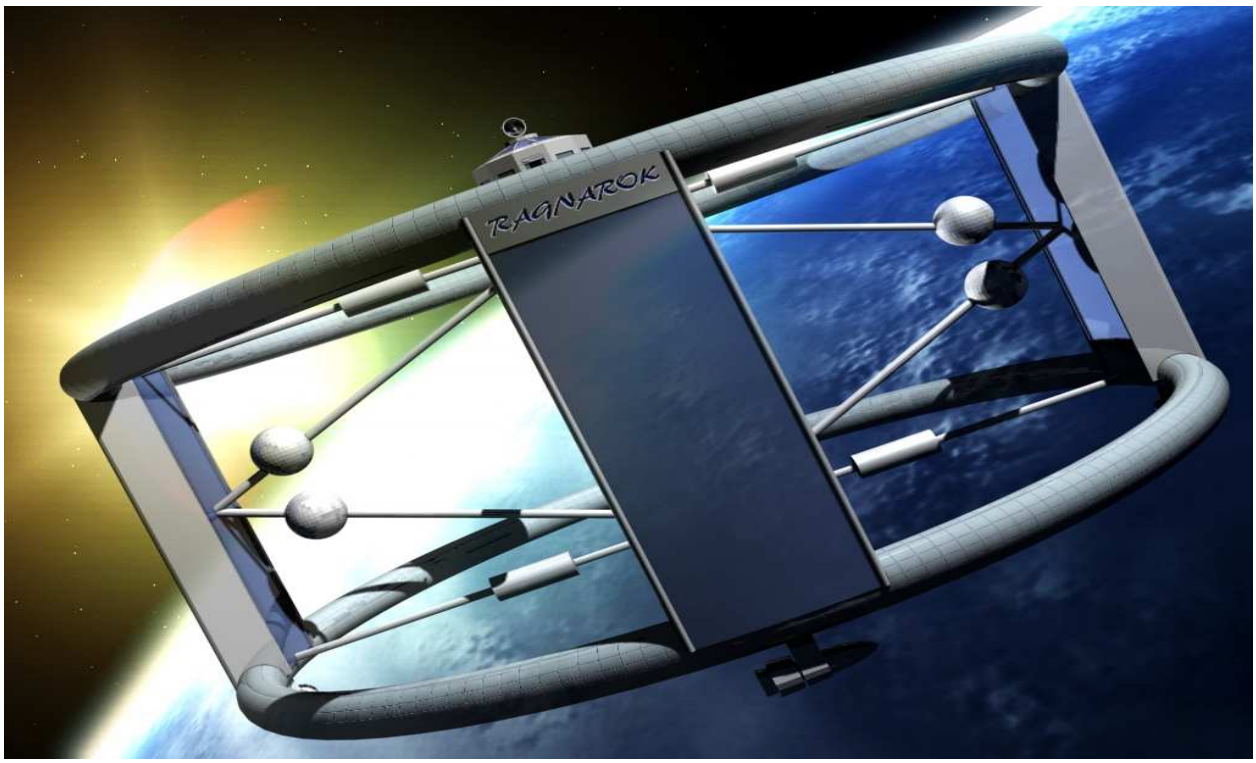
3.2 Industry



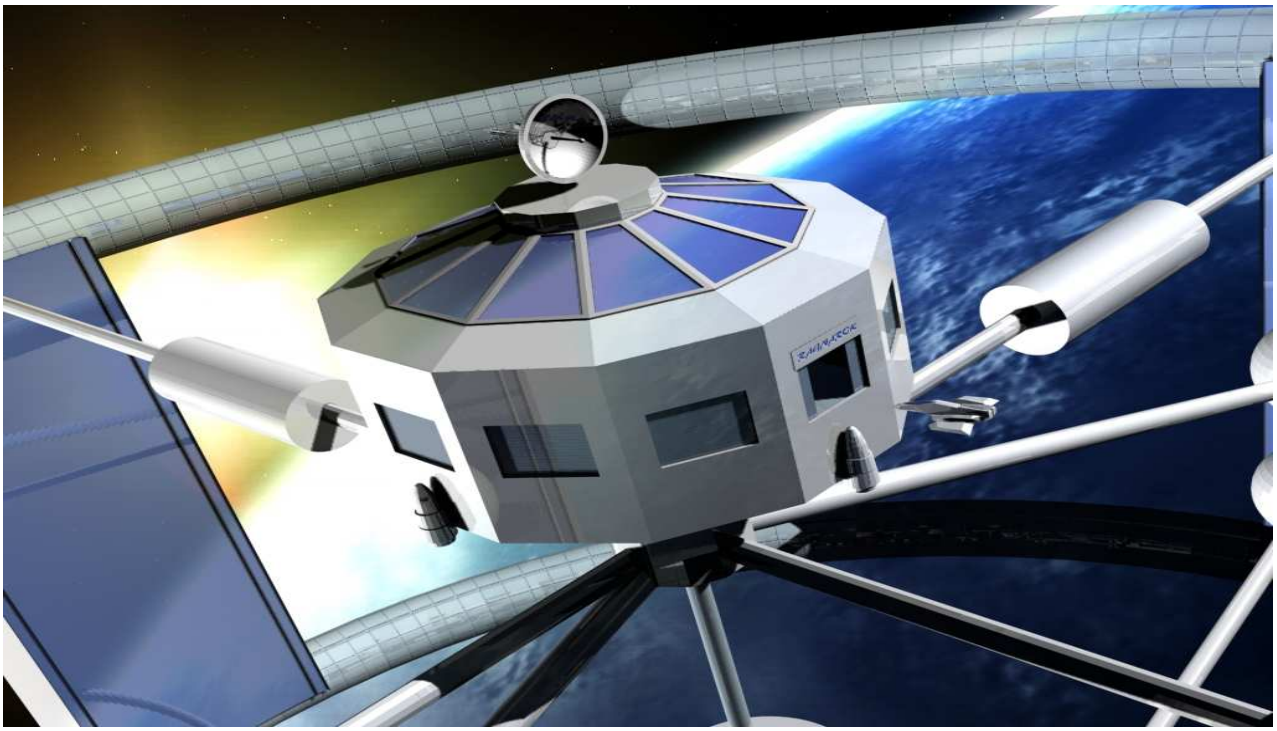
3.3 Research Laboratories



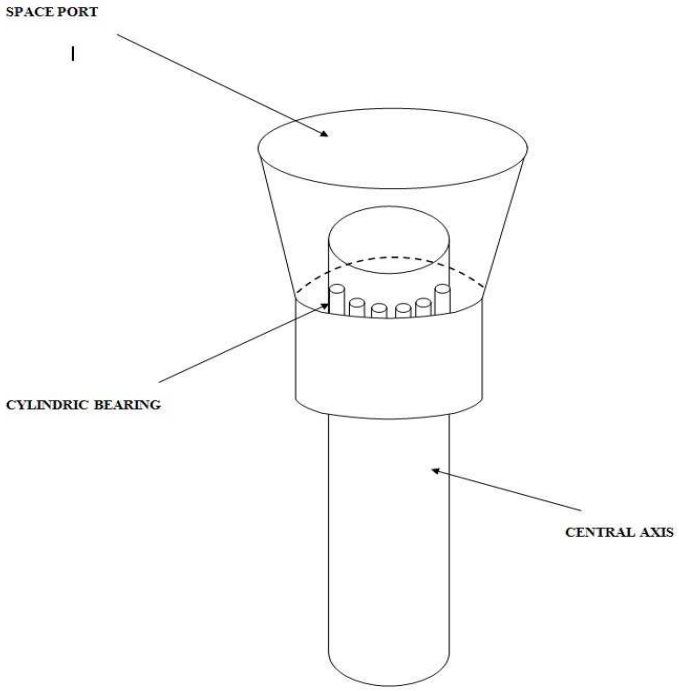
3.4 Agriculture

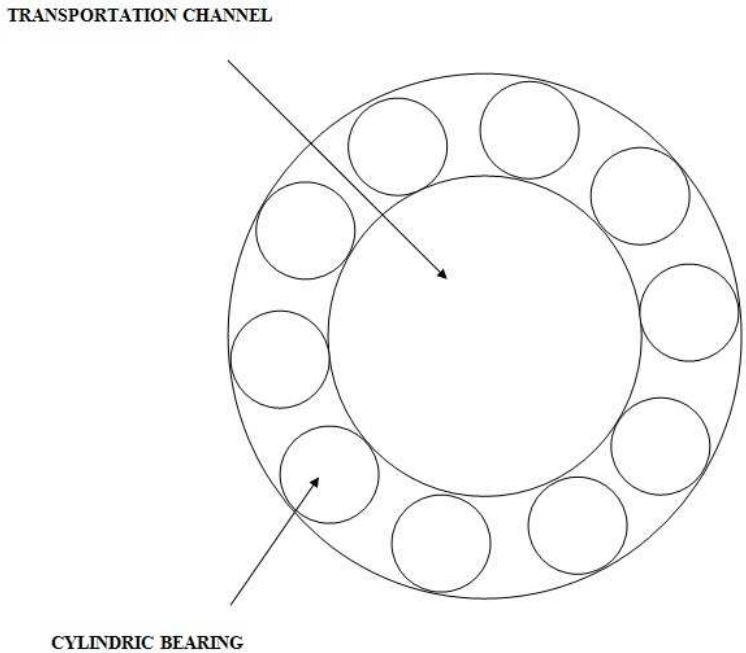


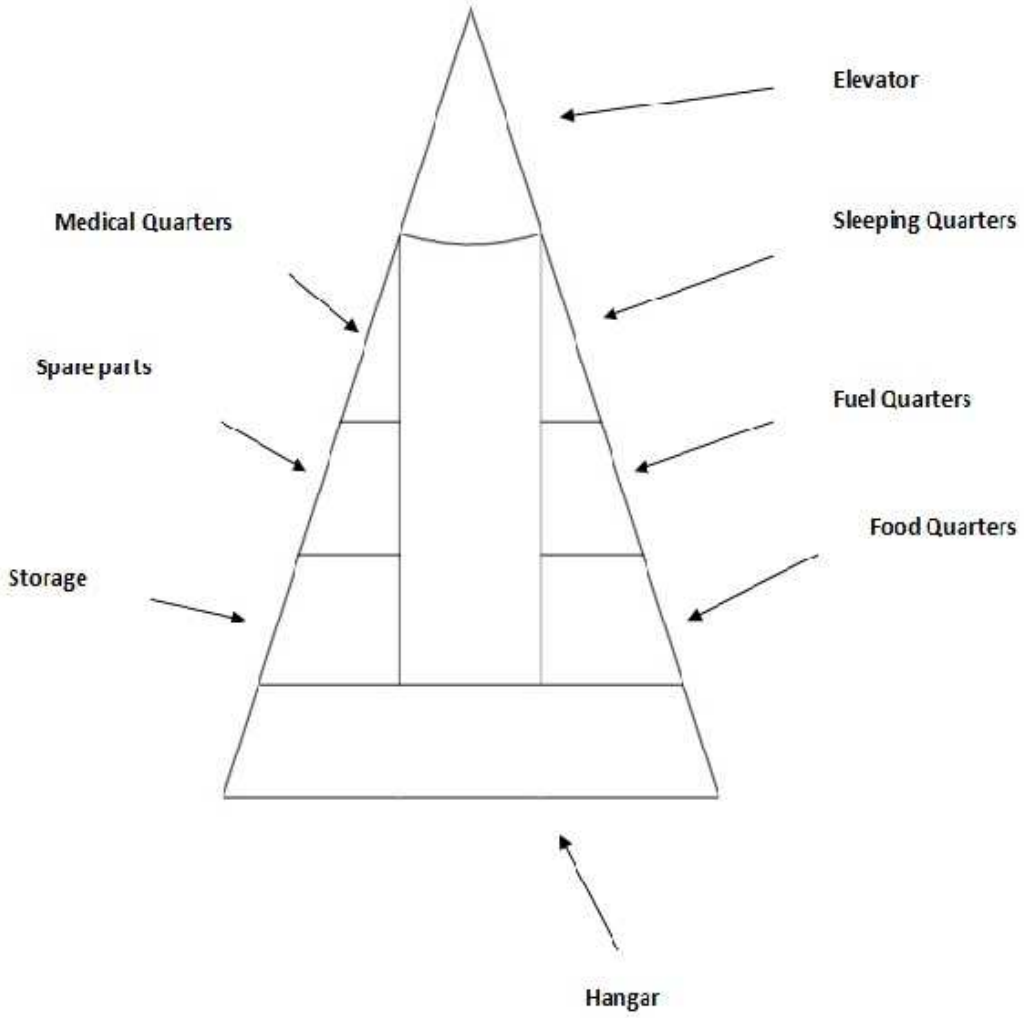
3.5.Space Port



Here lies the epicenter of the space traffic, spacecrafts coming in and out, bringing materials, goods, crew, tourists, robots or spare parts. To cope with all the necessities inducted by this type of operations, we have devised a regular polygon with twelve sides, on each side being placed a sliding door that opens when space shuttles arrive. Upon landing in the hangar, the crew is transferred through a tunnel that is connected to the upper exiting aperture, whereas the cargo is pulled out with the help of a robotic arm that comes out through a trap door situated below the spacecraft. The space attributed for the hangar is 50 meters length, 100 meters height and 130 meters width. This room is depressurized.







Moving on to the pressurized rooms, we have divided that room in the following way, as shown in the picture below:

In the fuel quarter we have plenty of liquid oxygen or liquid hydrogen tanks in order to supply the incoming spacecrafts. Moreover, in the food quarter, pilots can have a break and eat or drink something. Besides this facility, long voyage pilots can rest in the sleeping quarters.

Not to mention that if any passengers are injured or experience the “space flight syndrome”, they immediately receive medical care in the medical quarters.

On a more technological view, we have the storage and spare parts quarters, from where damaged spacecrafts receive the parts in need of. The ships are repaired in the hangar by a crew of astronauts.

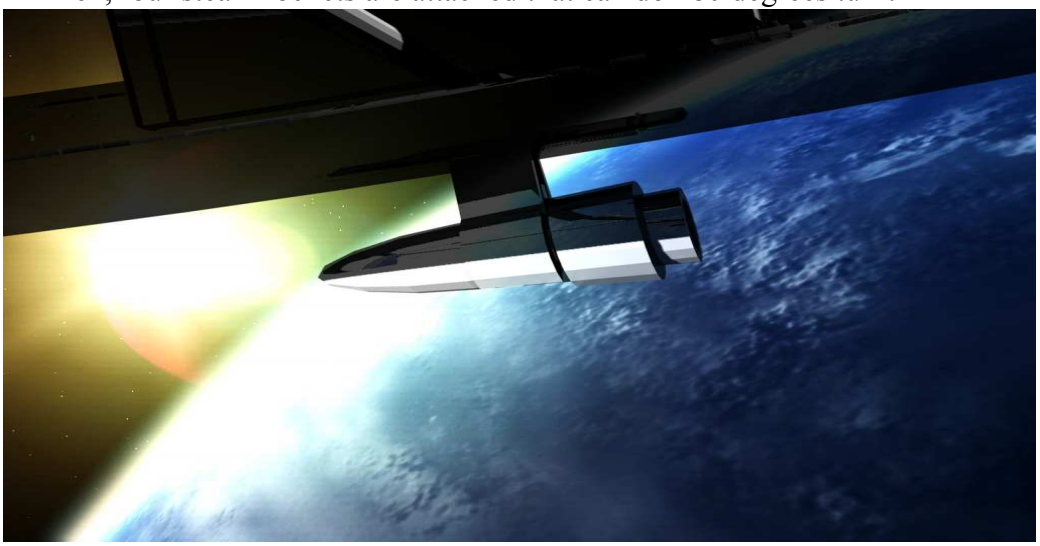
The circular section delimited by the hangar and lift has a radius of 180 meters. The last component is represented by the elevator, which has the aim of transporting passengers and crew to the rest of Ragnarok.

Above the regular polygon, there is an observatory room with a height of 30 meters which is provided with windows made of fused silica to remove UV infiltration.

It’s used by temporary visitors as a location from where to see the Universe in its splendor.

Moving upper on the vertical scale of the space port, we have a communications room which contains 4 communication servers: 2 for Earth to Ragnarok communication, 1 for Moon to Ragnarok communication and 1 server for communication between the space ships that are boarding the station and the miscellaneous communication requirement as mining crews on asteroids. Operating this communication room will be 21 operators.

Then, four steam rockets are attached that can do 180 degrees turn.



To avoid any accidents that are most likely to disintegrate the whole hangar sector, it is imperative that we maintain the space port motionless with respect to the rest of the space station to ensure the pilots of incoming spacecrafts an easy and steady landing, without further calculations due to angular velocity. Consequently, we are obliged to introduce cylindrical bearings between the 5 meters lateral gap that is left from the transportation channel to the space port. Therefore, the circumference to which bearings are needed to be attached is of 125 meters, which means 25 cylindrical bearings with a radius of 2.5 meters and height of 10 meters.

Adding to this system which significantly decreases the space port's angular velocity, we also use the four steam rockets situated on the space port.

Technical details:

- high pressure heated water tank
- pump
- nozzle

Process: High pressure water heated at values of over 250 degrees Celsius is pumped out through a nozzle, where the water turns into steam and releases a strong thrust that under the laws of recoil, pushes the body in the opposite direction.

Based on these facts, the steam rockets are used to exert a counter spin that makes the upper section motionless

3.6 Central Axis

With a length of 960 meters and a radius of 20 meters, the central axis is the key element of “Ragnarok”, connecting all the other elements together. Inside, there are four maglev elevators.

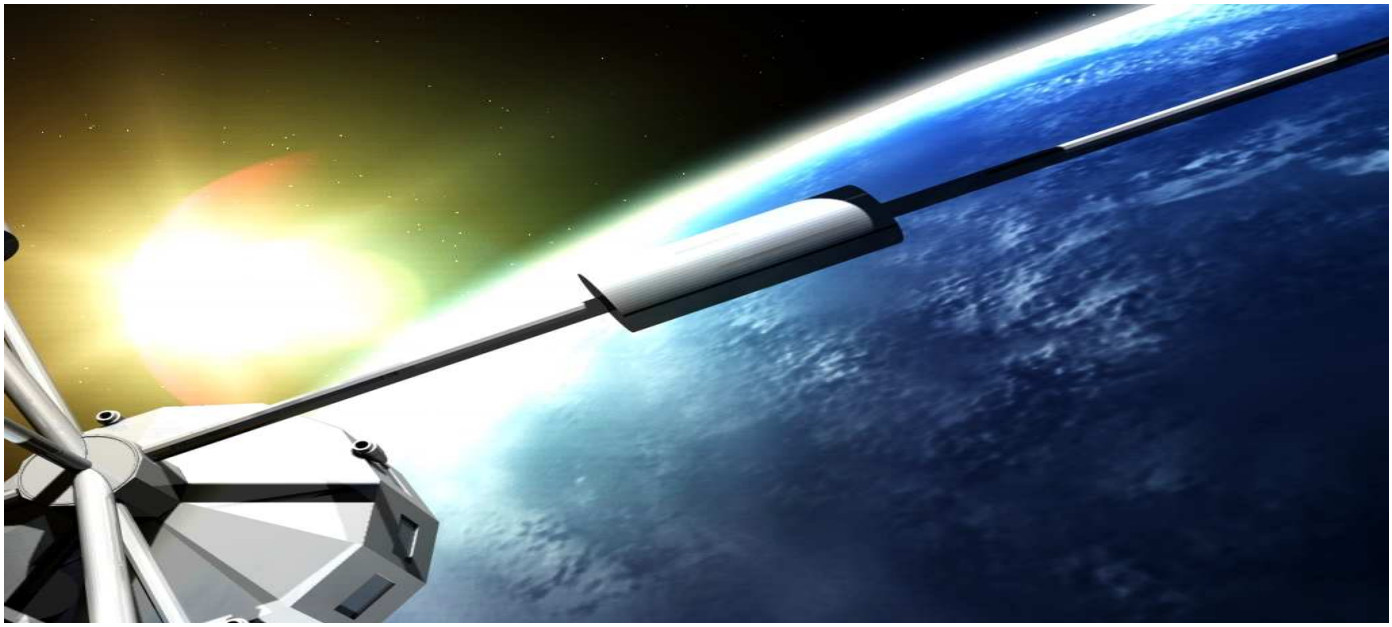
3.7 Transportation Channel

Having a length of 3,435 meters with a radius of 20 meters, the transportation channel is composed likewise the central axis.

3.8 Oblique Transportation Channel

Totaling a length of 3,616 meters and a radius of 20 meters, the oblique transportation channel is constructed similar to the earlier mentioned channel.

3.9 Variable G Entertainment



Element	Symbol	Formula	Value	Unit
Torus1 Large radius	R		3,585	m
Torus1 Small radius	r		150	m
Torus1 Exterior radius	R_e	$R+r$	3,735	m
Torus1 Interior radius	R_i	$R-r$	3,435	m
Torus1 Shield thickness	a		12	m
Torus 1 external area	A_e^T	$4\pi^2 Rr$	6,757,566	m^2
Complete Torus 1 volume	V_{cT}	$2\pi^2 Rr^2$	1,592,213,930	m^3
Netto volume of Torus T1	V_{net}^T	$2\pi^2 R(r-a)^2$	1,347,649,870	m^3
Torus 2 Large radius	R		3,585	m
Torus 2 Small radius	r		150	m
Torus 2 Exterior radius	R_e	$R+r$	3,735	m
Torus 2 Interior radius	R_i	$R-r$	3,435	m
Torus 2 Shield thickness	a		12	m
Torus 2 external area	A_e^T	$4\pi^2 Rr$	6,757,566	m^2
Complete Torus 2 volume	V_{cT}	$2\pi^2 Rr^2$	1,592,213,930	m^3
Netto volume of Torus T2	V_{sh}	$2\pi^2 R(r-a)^2$	1,347,649,870	m^3
Central axis radius	r_{ca}		50	m
Central axis heigh	h		960	m
Central axis external surface	S_{ca}	$2\pi r_{ca} h$	301,593	m^2
Central axis volume	V_{ca}	$\pi r_{ca}^2 h$	7,539,822	m^3
Sphere radius	r_s		100	m
Sphere surface	A_s	πr_s^2	125,663.7	m^2
Total sphere volume	A_{sT}	$4\pi r_s^2$	502,654.8	m^2
Sphere volume	V_s	$4\pi r^3/3$	4,188,790.2	m^3
Total sphere volume	V_{sT}	$16\pi r^3/3$	16,755,161.1	m^3
Parallelipiped heigh	h		20	m
Parallelipiped length	l		960	m
Parallelipiped width	w		480	m
Parallelipiped volume	V_p	hlw	9,216,000	m^3
Total parallelipiped volume	V_{pT}	$4hlw$	36,864,000	m^3
Cyllinder radius	r_c		120	m
Cyllinder heigh	h_c		480	m
Cyllinder volume	V_c	$\pi r_c^2 h_c$	21,714,688	m^3
Cyllinder internal volume	$V_{c-\text{int}}$	$\pi(r_c - r_{ca})^2 h_c$	7,389,026	m^3

Entertainment cyllinder radius	r_{ce}		50	m
Entertainment cyllinder heigh	h_{ce}		100	m
Entertainment cyllinder volume	V_{ce}	$\pi r_{ce}^2 h_{ce}$	785,000	m^3
Oblique channel radius	r_{oc}		20	m
Oblique channel length	l_{oc}		3,616	m
Oblique channel volume	V_{oc}	$\pi r_{oc}^2 l_{oc}$	4,541,696	m^3
Total air volume	V_{air}	$2V_{cT} + V_{pT} + V_{sT} + V_{c-\text{int}} + V_{ca} + 8\ V_{ce}$	2,770,127,749	m^3

4. Phases of Construction

4.1 Phase 1 – Gathering Funds

Due to the astronomical amount of money required to builad a concept of this scale,we will practically need several years just to accumulate the money,which will represent a grueling duty for the thousands of people implied in fund raising. That can only be accomplished through a long and various series of actions.

Actions:

- The production of an official website of "Ragnarok",which is specialized in oline donations. On this site,everyone will have the chance of contributing to our cause,regardless of the sum of money donated.

- A series of world tours where international music artist will be singing in front of thousands of people. The tickets sold at the concerts will be transferred to our bank account. In addition,all merchandise products with the singers name on them will also end up in our bank account,whereas people who appreciate our contribuition to humanity will have the chance to further contribute at special donation stands.

- Broadcasting adverts on every TV post or radio frequency,in which we make the masses aware of the importance of our project's success in determining humanity's future and existance.

- Enormous bank loans with non specified deadline reimbursement will be mandatory. Given the proportion of the numbers of our equation,we have to cooperate with almost all the banks in the heavy industrialized countries. These banks will receive the guaranty that all the money will be re-funded based on the highly feasible economical prospect of mining the Moon and Near Earth Asteroids for minerals and metals,which will later be sold on Earth,thus regaining their loaned money.

- An economical company is created named after our space station,which has two major departments:space turism and mining.This company will be enlisted at the stock exchange market.In this way,paymasters will contribute with an initial fee on our project and relying on the fact that the one with the highest entry sum will have the highest percentage of stock holdings,the company is going to be divided proportionally between the paymasters.

- Merchandising products with the Space Stations's logo.

- Funds from the world's goverments based on the fact that future space

technologies elaborated in Ragnarok's research facilities will be made public to the respective ministries.

4.2 Phase 2 – Preparation Phase

The construction of the space station begins firstly on Earth,where Ragnarok's Head Quarters will be built. From ground base,all future manned or unmanned space missions will be planned,conducted and analysed by different scientists specialized in their respective area of expertise.In addition,it will contain multiple launch pads for the Ares 5 and X-33 missions.

From here,a new stage undergoes that is prone on gathering raw material,processing it and combining the finishing products in order to assemble the space station.

Taking into consideration the huge delta-v required to escape Earth atmosphere compared to the one needed to take off from the Moon and correlating the fact that our natural satellite does not have atmosphere,consequently the lack of friction,it is imperative that we harvest and porcess the materials from there,thus gaining an economic advantage and nevertheless an ecological one.To sustain this point of view,we have to think of the ecological impact on our habitat done by rockets that use an ammount of 29 tones of fuel per second. Besides that,the gravitational force sensed on the Moon represent just a sixth of the value of our gravity.To sum it up,the energy required to shift materials from Moon to L5 represents merely 0.5% of the one required from Earth to Ragnarok's location.

Previous lunar space expeditions from the last century have shown that the lunar soil is abundant in necessary materials vital for the construction and life sustaining system of Ragnarok.In the next table we present the most important elements composing lunar regolith.

Elements	Percentage
Oxygen	43
Silicon	21
Iron	13
Calcium	8
Aluminium	5
Other(Titanium dioxide, Aluminium oxide, Iron oxide, Magnesium oxide, Calcium oxide)	4

(with reference to **http://www.wisegeek.com/what-is-the-content-of-lunar-soil.htm**)

Shiping cargo and crew to the Moon:

Ares 5 is part of the next generation project of space vehicles called "Constellation", that is due to replace the existing "Space Shuttle" program in 2010, making it a feasible option.

This is a heavy pay load launch vehicle,that can carry up to 60 metric ton of cargo to the moon. Comparing to its sibling, Ares 1, this vehicle is unmanned. It's itinerary consists of two phases: from terrestrial crust to Earth Orbit and from there to the lunar landing.

Components:

- two 5.5.-Segmented R.S.R.B.(Renewable Solid Rocket Boosters)
- single central booster elements(core stage) that contains liquid oxygen and liquid hydrogen propellants. This is linked to a cluster of six RS-68B rocket engines.
- interstage cylinder(booster separation motors) that connects the core stage to the Ares 5 Earth departure stage.
- Earth departure stage that contains a J-2X engine that is also propelled by liquid oxygen and hydrogen.
- Altair Lunar Lander.
- composite Payload Shroud.

Stages of the journey:

- the two R.S.R.B. and the central booster power the vehicle into Low Earth Orbit till they are jetted.
- the J-2X engine hrusts the vehicle to break free of Earth's gravitational pull and then travels to the moon.
- upon reaching lunar orbit,the Altair Lunar Lander descends to the surface.

X-33 -- Was a visionary project developed by NASA and Lockhead Martin Shok Works that was due to revolutionize the concept of traditional flying procedures. Therefore, it was planned to take off vertically like a rocket and land horizontally like an airplane.

In 1995, it was announced as an unmanned, reusable test vehicle. Before it's cancellation in 2001, the construction of the X-33 was 85% complete, with the liquid oxygen tank, avionics bay, flight umbilicals,reaction control system thruster controller and landing gear installed. (**http://www.aerospaceguide.net/space_planes/x-33.html)** This makes the concept of space planes a feasible reality for massive crew transportation to Ragnarok or to the Moon.

Tehnical detalis:

- length:69 feet
- width:77 feet
- take off weight=285,00 lbs
- fuel=LH2/LO2
- fuel weight=210,000 lbs
- Main propulsion=two J-2S Linear Aerospikes
- Take-off Thrust=410,000 lbs

- Maximum speed=Mach 13+

Lunar base and mining facilities

The cargo shipped from Earth predominantly contains automated excavation machines required for lunar soil mining,lunar transporters,haulers,habitat modues,processing plants and manufacturing devices.All of this materials are to be assembled on the Moon,creating the proper conditons to fabricate the components of the space station.

For further exploatation of the available resources and based on the concept of colonizing the Moon,we are to build several other lunar camps just like the original,relying just on the finished products obtained from lunar elements.Therefore,we are going to build partial under-surface lunar bases beacause the regolith that predominantly covers the base is regarded as a solar and cosmic radiation proof material.As well.it actis as a good thermal isolator against the freezing temperatures recorded at lunar crust level.

The following materials are needed in order to successfully build a lunar base from the ground,as shown in the table.

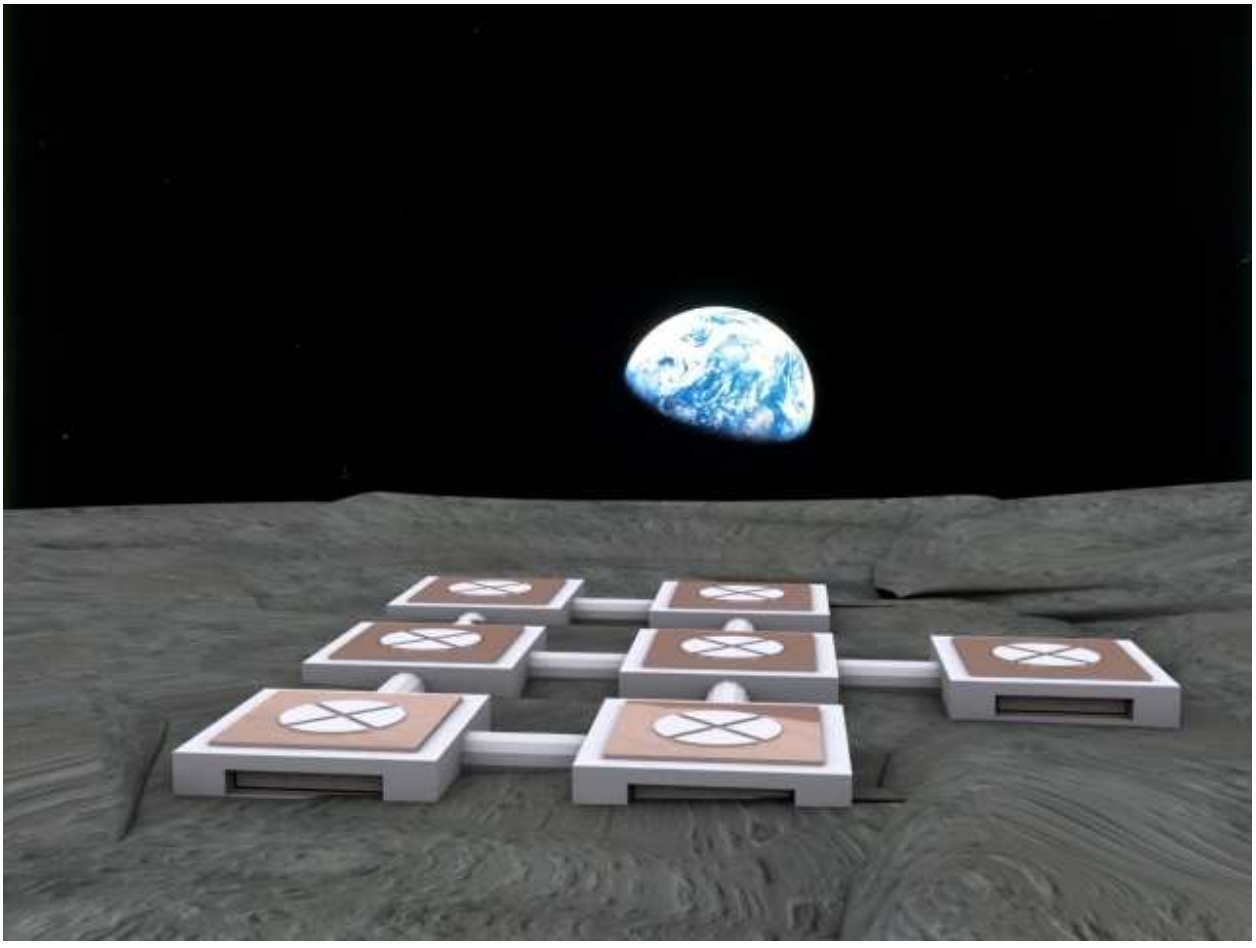
Material	Purpose	Method of processing
Lunar glass Silica glass Fiber glass	Windows	Anorthite
Lunar aluminium	Mirrors Solar ovens	Anorthite
Fiber	Walls	
Ceramics	Walls	
Aluminium	Electrical wires	
Lunar basalt	Walls	
Lunar iron	Walls Processing plants Automated machines Manufacturing devices	
Sulfur concrete	Resistance structures	
Calcium metal	Wires	Anorthite(heated)

Lunar base facilities

The under surface base conists of a series of modules connected all together.The modules range from:

- habitat modules,where the crew eats,sleeps and conducts daily activities.

- central control module,a computerised room from where all the automated machines are controled.
- maintance module,a room where the automated machines are daily cheched up and eventually repaired by engineers.
- warehouse module,where all the lunar transporters and machines are kept over the night.
- smelter module,a thermally over-heated room where anorthite and silicates are discomposed in order to obtain pure aluminum metal,oxygen,silica glass and iron.
- fuel production module,a special room where atomized alumiun powder is burned with oxygen,resulting fuel.
- oxygen production module,where a mineral found in lunar basalt,named ilemenite,is reduced,obtaining oxygen at a very high rate of approximately 10% of the mass of ilmenite introduced in the proces



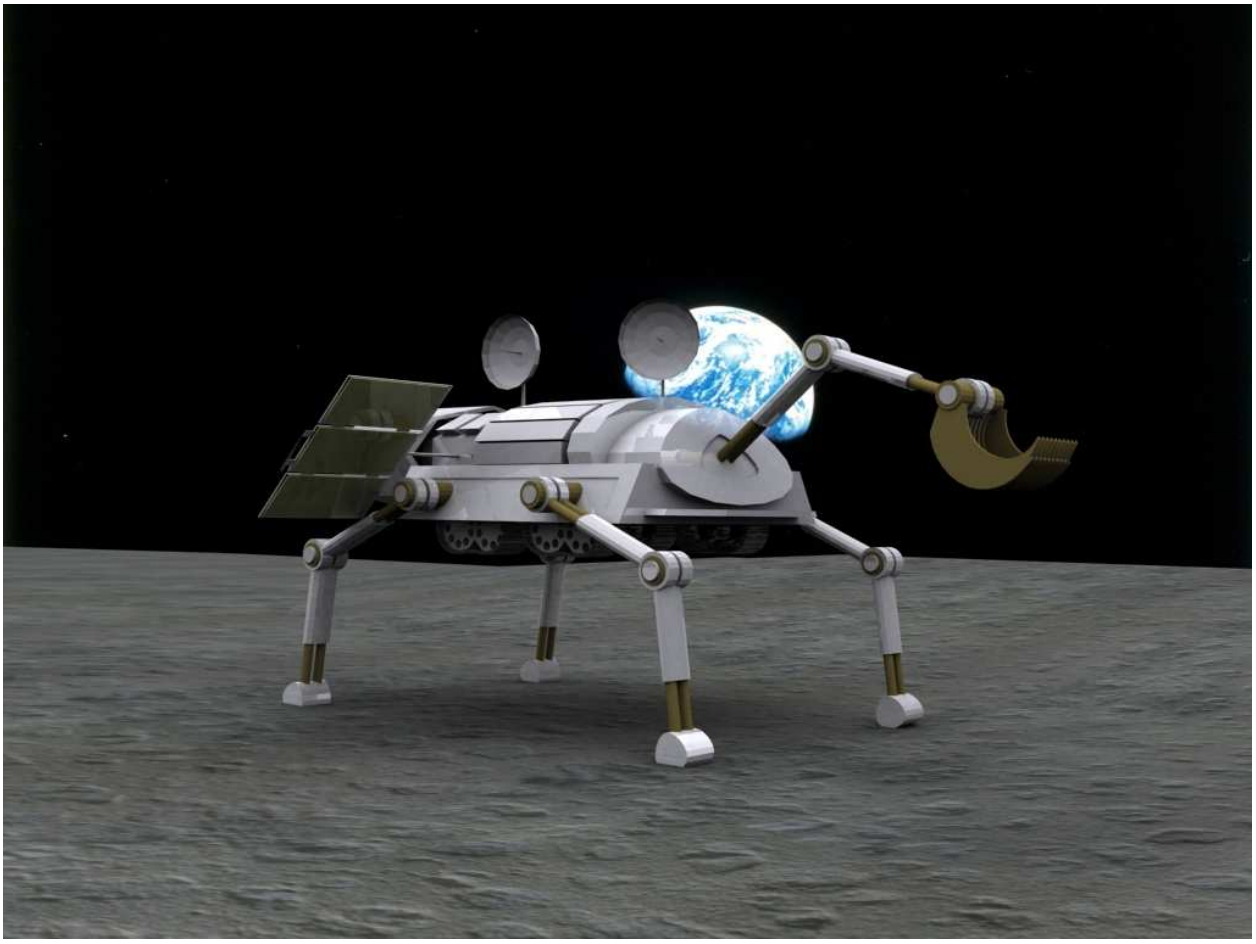
Lunar Robots:

Excavator

Technical details:

- solar panels attached on the laterals for fuel autonomy

- antenna
- four mechanical legs, each with 2 joint points for better maneuverability.
- the joint point connecting the mechanical leg with the body of the robots can perform a 180 degrees rotation in order to switch from standing mod to track mod.
- tank-like tracks for stability during movement
- a frontal extension containing at it's extremity an excavator used at scooping lunar regolith.
- length of 10 meters
- height of 6 meters
- width of 4 meters



Driller

Technical details:

- it has the same technical characteristics as those mentioned earlier, with the particularity that at the top of its extension there is a series of jagged wheels used to crumble the regolith.

Lunar mining

The whole mining process is fully automated due to safety concerns and harsh weather conditions.

Before the start of this operation,the lunar soil must be topographited because we are obliged to pick the most appropriate track regarding the flatness of the soil in order for the automated excavation machines and haulers to pursue their orders.

The mapping is going to be executed by K10 scout robots,which are hightly effective and can perform long duration tasks. They use 3-D scanning laser

system(LIDAR) to create topographic maps.Also,they use ground-penetrating radar to recognize under surface structures.

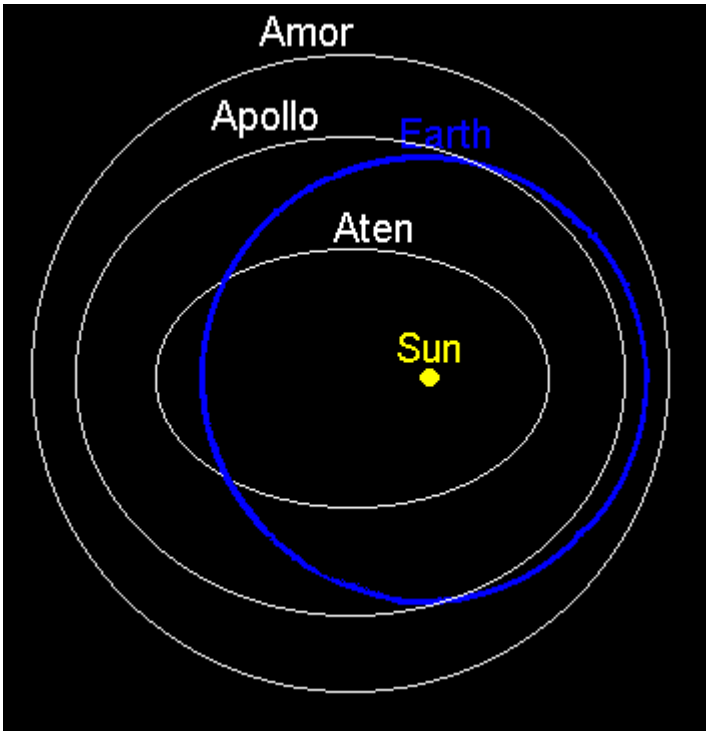
After this process is completed,the excavators are sent out to scoo up the regolith and to put it in a container,that is mounted on top of an A.T.H.L.E.T.E. Hauler.When the container is full,the A.T.H.L.E.T.E. Hauler returns to base,where he deploys the lunar soil in the processing modules.

Asteroid mining

Besides lunar mining,another cost-effective way to gather the required materials is the use of Near Earth Asteroids as mining facilities. N.E.A. Are asteroids that intersect Earth's orbit or approach
it.

Based on thei trajectories,we can classify asteroids in four classes:

- Main Belt asteroids,which are located between Mars and Jupiter.Due to this major disavantage ,they are economically unattractive.
- Amor asteroids are a group of asteroids that don't cross the Earth's orbit,orbiting further away from the Sun than that the Earth does.
- Apollo asteroids cross Earth's orbit two times,making them easy to trace and intercept.
- Aten asteroids are the only group of asteroids that spends most of their time inside Earth's orbit.They intersect it two times.



(http://www.permanent.com/a-geolog.htm)

Feasible asteroids for mining purposes

In the Apollo category there are a lot of suitable asteroids for our gouls and to name just a few:

- 2007 TU24:it has a period of one year and a diameter of 250 meters.
- 2006 FU35:it's attractive due to the low delta-v requirement for rendezvous,its period of one year and its diameter of 100m.
- 2006 SU49
- 2004XP12:it's extremely attractive due to its enormous diameter that varies from 300 to 900 meters and its period of 397 days.

With respect to the efficiency of this kind of operation,we can stat that an asteroid that's only 100 meters wide contains about 3 million tons of processable materials,which represents roughly about 100,000 Space Shuttle payloads.Besides that,another major advantage of mining asteroids is the fuel efficiency. Getting off the Moon requires a delta-v of 2,5km/sec,while getting of Earth requires a delta-v of over 11km/sec,whereas an ordinary asteroid requires a delta-v of only 0,1km/sec. This astronomical difference implies a consistently fuel reduction. Adding to this,fuel propellant is abundant if oxygen and hydrogen are processed.

Asteroidal resources are unique and diverse,being very different not only from the ones that we mine on Earth,but also those from the Moon. Asteroids are very rich in metal,most of them having free metal,which can be used without industrial processing. However, they are not as enriched in oxides and silicates.

Mining and processing the materials

The consistency from asteroid to asteroid varies from pure metal to pure powder,thereby we ought to take into consideration two mining procedures.

Most of the asteroids are consisted of silicate dirt embedded with sand-sized metal granules of nickel-iron metal and volatiles,such as hydrogen,water and carbon which are bonded to the minerals under the surface.

Relying on these facts,the most efficent method is to separate the metal granules with magnets,while the dirt is deposited into a rotating room with walls containing magnets.In this way,the remaining metal granules are separated.The rest is transported into a solar oven made from aluminum foils,which decomposes the dirt into hydrogen,water vapors,carbon.Then,they are refrozen separately for easier transport.The depositing tanks are located in a cold shadow place in such manner that the furthest one is the coldest.In this way,water condenses in the warmers one,carbon and the others in the colder ones.

In the unlikely case of a tough asteroid we are to use the following method.Ore is scooped up and arranged by size in mechanical grinders,that crush the boulders.The

streams of materials are placed through magnetic fields,which separate nickel-iron metal grinders from silicate grains.The non-magnetic material is treated as described eariler in the first procedure.

Asteroid composition and uses

Water is plentiful in many asteroids.Besides the mogic meaning,water can be decomposed through electrolysis into oxygen and hydrogen,the two main ingredients for rocket propellants.Oxygen makes up about 30% of the mass of asteroids.Carbon is also common.It's used as propellant for hydrocarbon powered rockets.Other materials can seem useless at the first glance,such as the excess dirt resulted from the solar ovening process.It represents a good shield against space radiation.Silicate material is used for fabricating glass,fiberglass and ceramics ,which are construction materials for further mining camps.And last,using the thermochemical Carbonyl process,the nickel-iron granules are separated in iron,nickel,cobalt and platinum metals.

(with references from **www.permanent.com**)

Means of transportation from Asteroids:

Solar sails

Pushing the fuel efficiency to a maximum never to be reached by any other transportation method,the solar sails rely on the concept of a continuous force that pushes the vehicle to a target,obtaining a far better velocity on the long term that any chemical rocket.

Basic facts

Practically speaking,it's a big mirror that reflects the sunlight. On the other hand,one a more technical point of view,an intermittently flow of photons bombard the sail and bounce off,transferring momentum,which produces a constant acceleration on the spacecraft. On a certain degree of exposure to sunlight,this mean of transportation exceeds in velocity even fuel propelled rocket vehicles.

Technical details and design

To withstand the extreme thermal amplitudes and space debris,we ought to use a thin,ultra -light weight,metal-coated,durable plastic,such as Mylar or Kapton. Furthermore,these have to be folded until depolyed and have to be resistant to ionizing radiation,solar particles,x-rays,ultraviolet light and mangnetically trapped charged particles. For our asteroid-Moon missions we are going to use a derived Cosmos-1

vehicle,which in addition has a massive container attached. We'll be using the same compositional properties as the earlier mentioned prototype and also an additional layer of chromium with a thickness of 5 microns.This has been selected due to it's higher emissivity than that of the aluminum and because it radiates heat more efficiently. A standard model has a surface area of 600 square meters,Size can vary,depending on the mass of the cargo,based on the fact that the velocity grows exponentially with the surface.The exterior layer is composed of aluminum-coated Mylar,which has a thickness of 5 microns.

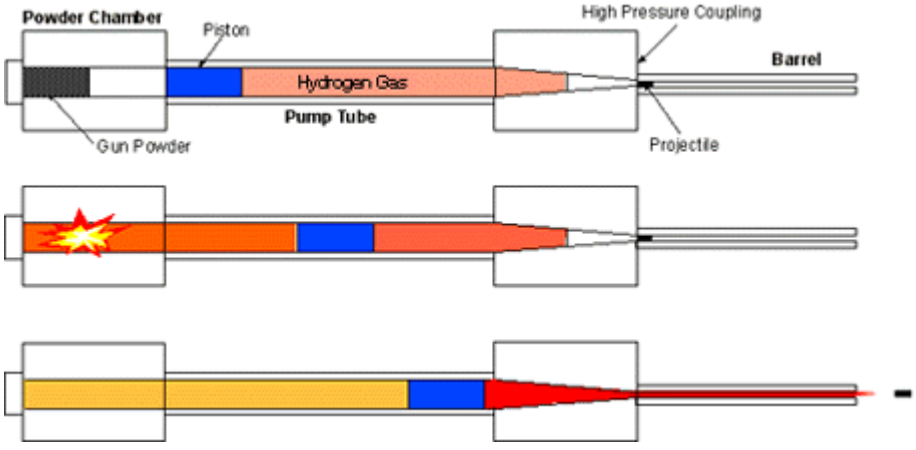
As design,the solar sail is a combination between a sqaure and a heliogyro sail. It is a rounded sail that is dividen into eight triangular blades with inflatable booms for support.The sail does not have to be rotated for stability.
(with references from **http://science.howstuffworks.com/solar-sail1.htm**)

Light Gas Gun & Ram Accelerator

After creating the mining facilities on the moon and the storage warehouses we need to find a way to transport the materials into the location where Ragnarok will be built. The major drawback of the conventional rockets is that they have a huge lunch costs. A cheaper alternative is represented by the Ram Accelerator, a device used for accelerating projectiles launched by a Light Gas Gun.

The NASA Light Gas Gun

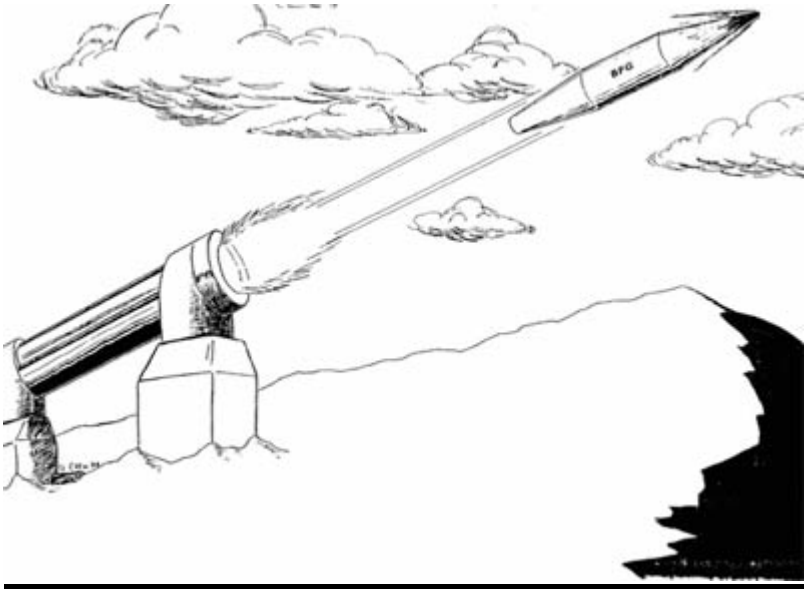
The cannon uses gunpowder to propel a large diameter piston which forces a gaseous working fluid through a smaller diameter barrel containing the projectile needed to be accelerated. This reduction in diameter acts like a lever, increasing the speed while decreasing the force. At the end of the conical section of the cannon barrel stands a rupture stainless steel disk. When the pressure builds up to the desired level behind the disk, the disk tears open, allowing the high-pressure light gas to pass into the smaller barrel and accelerate the projectile to a velocity of about 6km/s in about a meter.



(**http://ares.jsc.nasa.gov/education/websites/craters/lgg.htm**)

The Ram Accelerator

In a ram accelerator, a projectile having a shape similar to the ramjet center body is fired, (often from a conventional gun), into the accelerator barrel, causing compression between the projectile and the barrel's walls. The barrel contains a pre-mixed gaseous fuel-air mixture. As the ram accelerator projectile compresses the fuel-air mixture, it is ignited and the combustion is stabilized at the base of the projectile. The resulting pressure differential generates a prodigious amount of thrust that can accelerate projectiles to in-tube Mach numbers greater than 8.



(**http://en.wikipedia.org/wiki/Ram_accelerator**)

The Technology Readiness Level of the Ram Accelerator is 6, making it a more viable , developed and cost-efficient solution than the other non-rocket space launches.

4.3 Phase 3 – Construction Phase

After all the required materials are sent with the ram accelerator to L5, the actual construction of "Ragnarok" begins. Due to the external forces exercised on every little particle situated in this location, in order to maintain a balance so that the temporary work site won't drift away, we are obliged to build it in a symmetrical and modular manner.

Firstly, we are to start with the central axis because as it name says, it's the key element of our stations that binds all the other elements together.

Using the following lateral surface formula for cylinders: $2\pi r^2 h$, where r is the radius of the circle and h is the height and introducing our data, r=20 meters and h=960 meters, we obtain a lateral surface of 120576m^2 which we can divide in 2411 sections with a width of 5 meters and a length of 10 meters. These modular sections are to be binded together by astronauts using rivets. Every piece of the exterior wall has on every extremity holes, with the particularity that one side is larger that the other so that it can encompass the smaller one. Then, rivets are screwed by astronauts and the gap between the two layers is sealed. On the other hand, for further protection, the astronauts can solder it.

Then, we move to the Industry cylinder. Using the mathematical formula for circular surfaces($2\pi r^2$) and adding the lateral surface area for a cylinder we obtain a value of 1105280m^2 which be divided in 22105 parts with a width of 5 meters and a length of 10 meters. These elements are also to be binded by astronauts using the same riveting method described earlier.

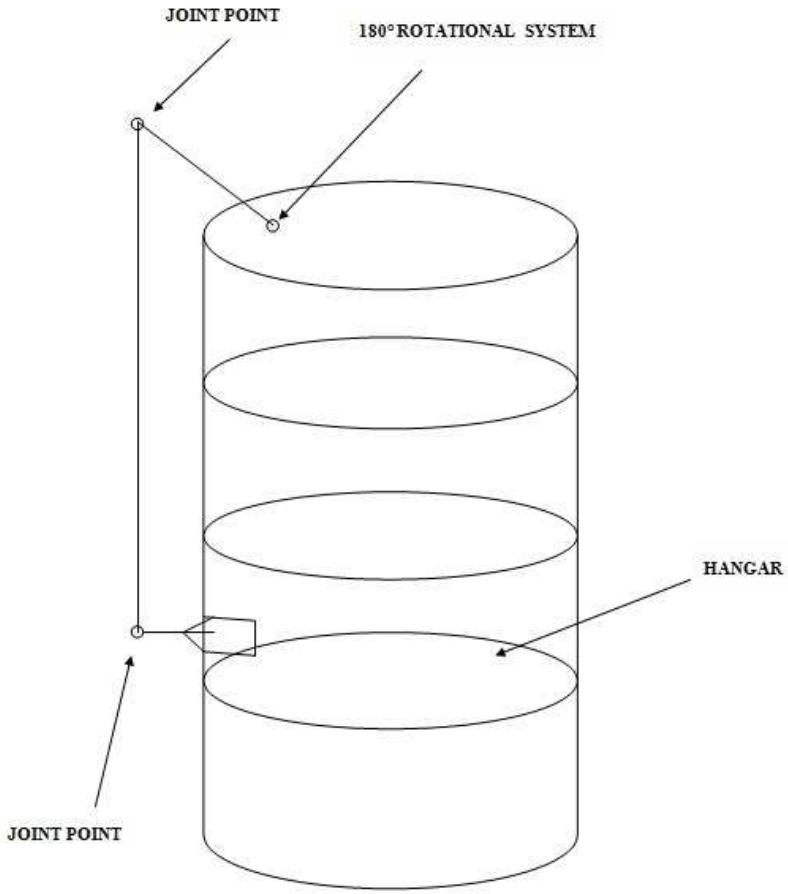
After this, we divide the Industry cylinder in 4 equal horizontal compartments, the third being temporary used as a hangar where space shuttles with payloads unload their cargo.

Four robotic arms are installed on the cylinder, two on the upper extremity and two on the lower one.

Technical details:

- it has 3 joint points that enables the arm to move freely in order to grab the cargo from the temporary hangar and mount it on top of the rail robots.
- it can perform a full 180 degrees turn in order to perform it's actions to several hangars.
- it has the following dimensions as seen in the table.

Location	First segment length	Second segment length	Third segment length
Upper area	70 meters	350 meters	50 meters
Lower area	70 meters	230 meters	50 meters



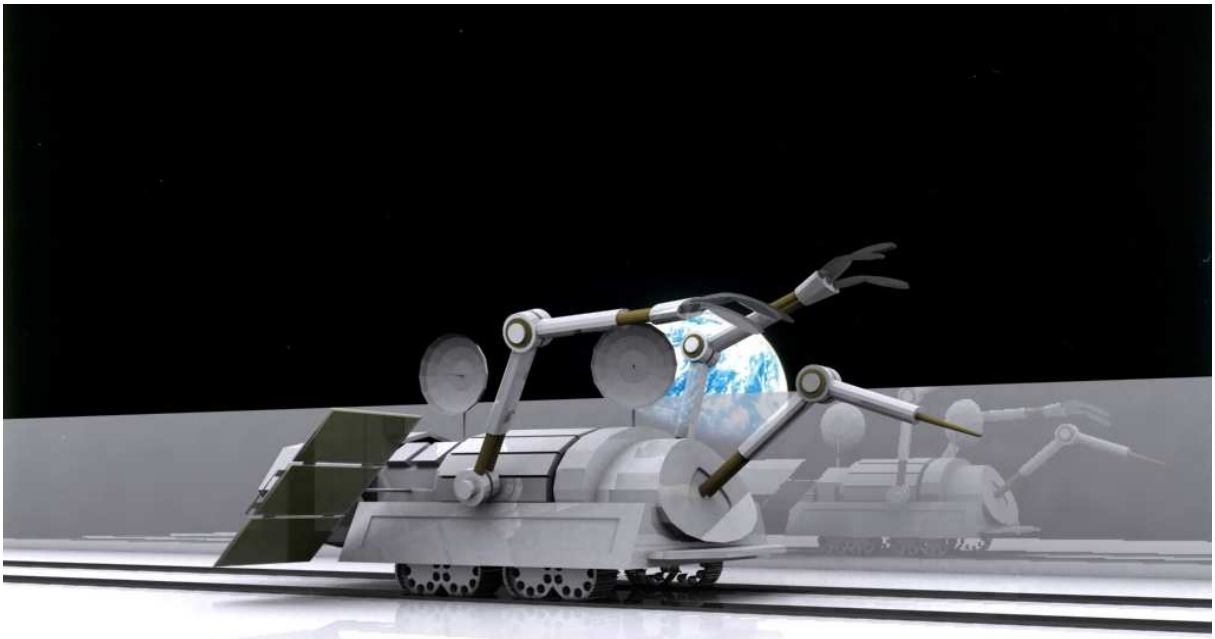
The metallurgy & construction sector and robot construction sector are equipped with all the necessary machines to process the raw material brought from our lunar mining camps, this sector becoming active in providing the elements of our station.

Moving on to the transportation channels we can now rely on automated construction due to rail robots. They rely on rails as a mean of transportation and due to their dimensions, can move in every little corner of the space station. Using their arms to carry the exterior wall layers, whereas their wielding and screwing system to bind the layers together.

Technical details:

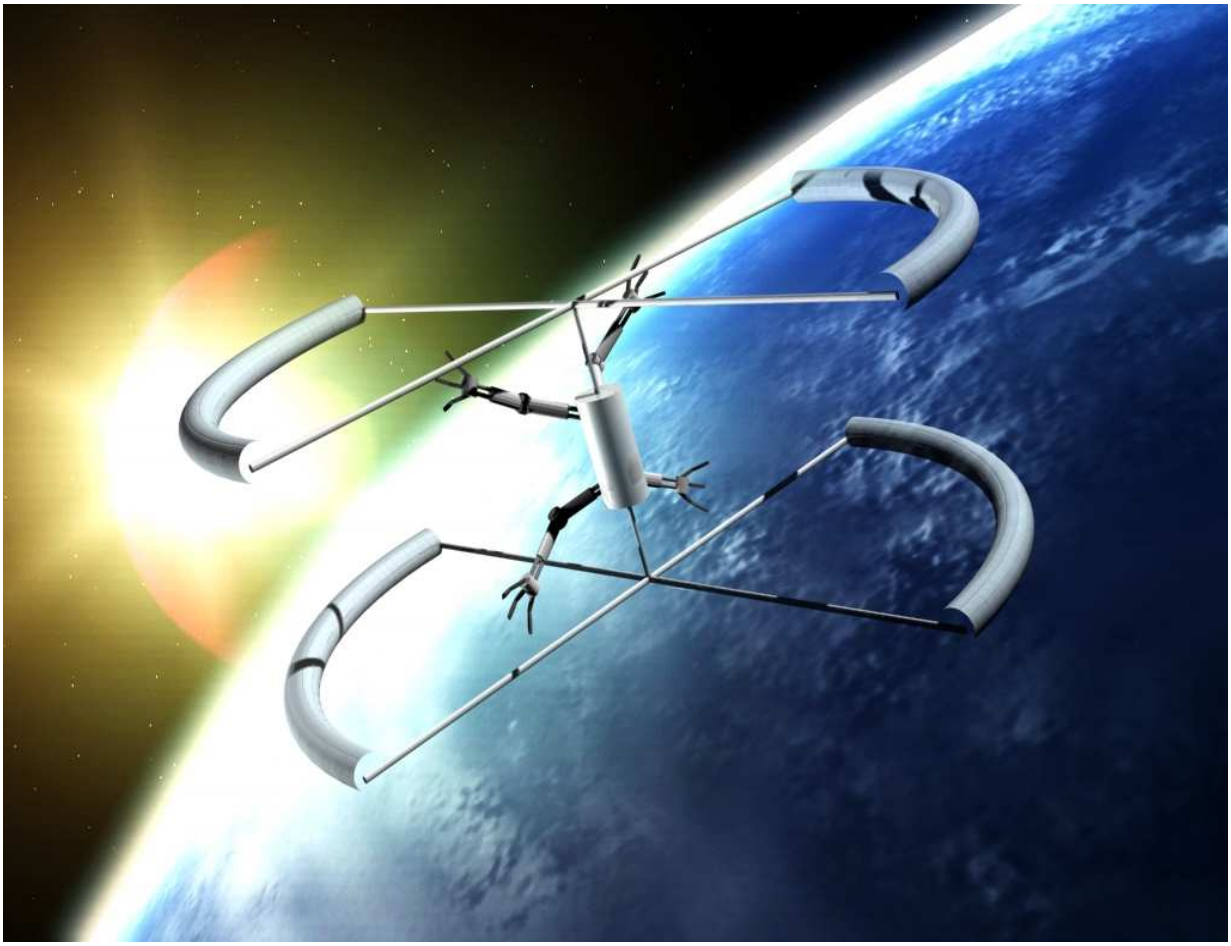
- 5 meters width
- 5 meters length
- series of locomotive wheels that can rotate 360 degrees in order for the robot to move bi-dimensionally throughout the rail system.
- solar panels for fuel autonomy
- two mechanical arms
- antenna to coordinate its actions from the command center.

The technique consists in transferring the composing elements form the hangar with the mechanical arm to these robots that can virtually cover every inch of the station

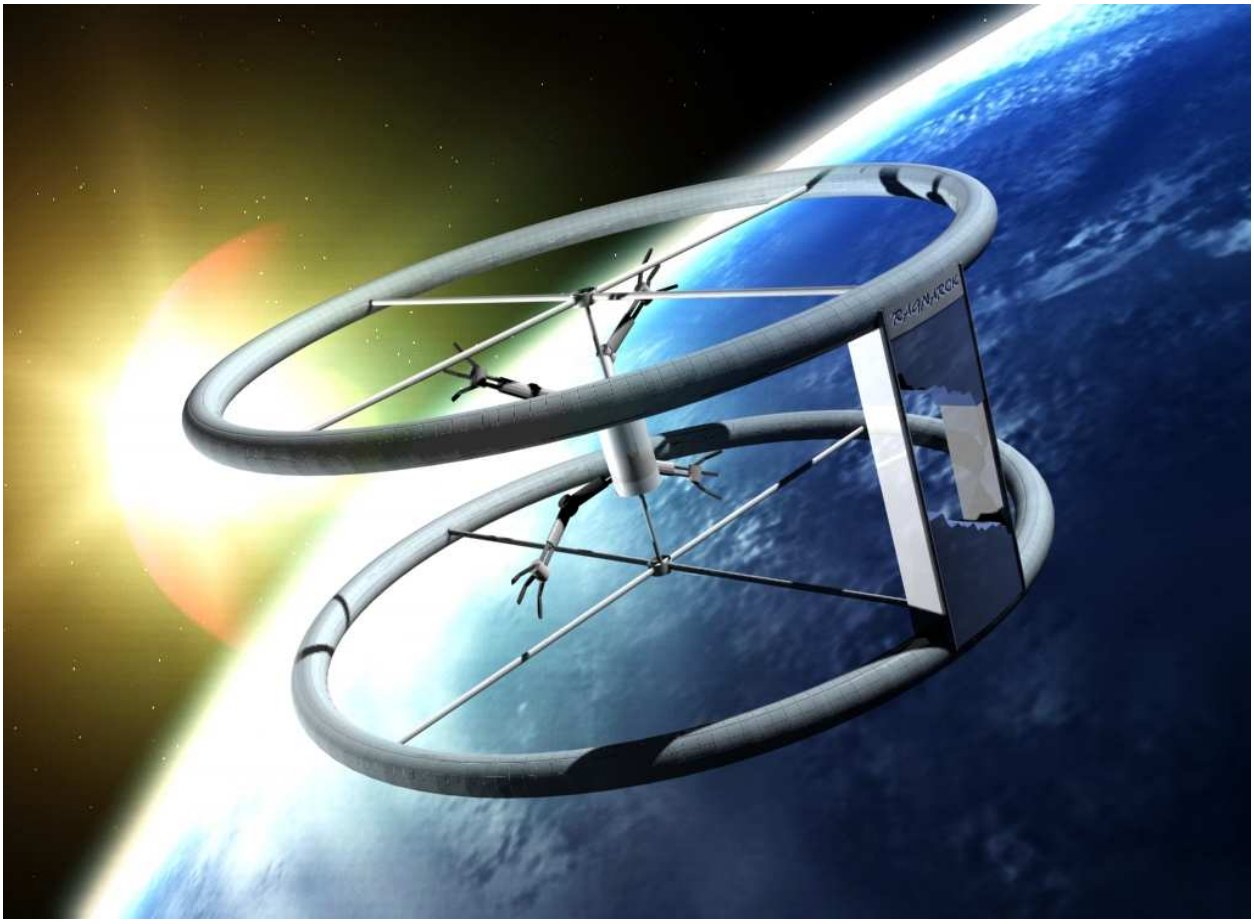


The next step is adding the Variable-G Entertainment cylinders. Two lateral passage ways with the length of the cylinder's radius are to be erected on the left and right side, from where upon reaching the far extremity, a robot will bind an exterior wall layer perpendicular with respect to the passage way. Then, another rail robot will be attached to the last layer and will start building the rest of the circle ,moving in front till completion and in lateral afterwards to complete the cylinder. The necessary materials are brought by the first robot that transfers the cargo to the other robot in the joint point made by the passage and the cylinder, using their 300 degrees rotating arms.

Reaching the torus stage, we use the same method by erecting a single layer perpendicular with respect to the transportation channel and attaching a rail robot that undergoes the same commands mentioned earlier. Upon completing a torus section with a circumference of 1km, we seal that sector with retractable doors. From this point on, we give Ragnarok a spin with steam rockets in order to obtain artificial gravity so that the interior construction of the residential area can undergo.

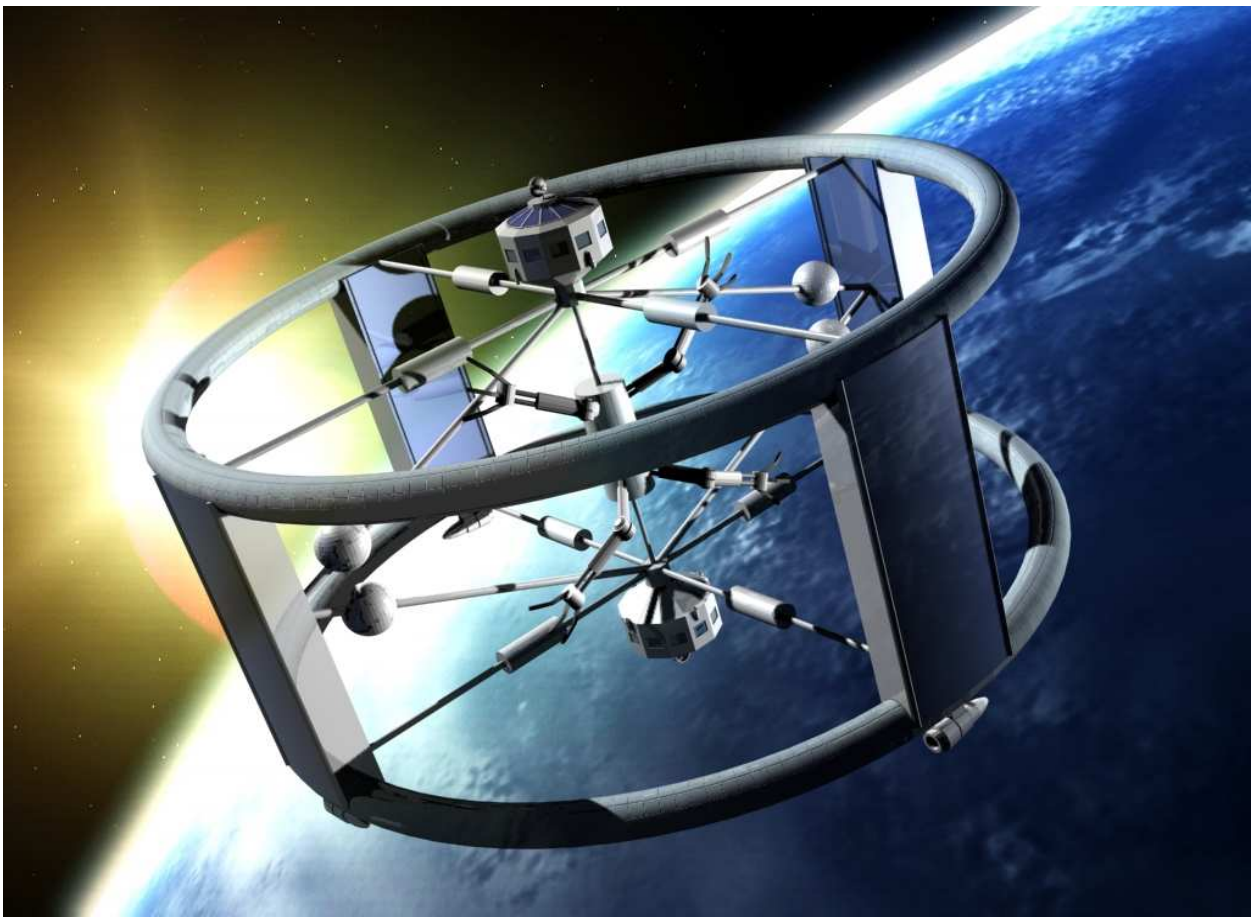


Afterwards, we add the Agriculture sectors by erecting a single layer and then adding to that till completion.



Same process is applied to the construction of the oblique transportation channels, with the difference that the erected layer is at an angle of 80 degrees with respect to the plan of the parallelepiped.

Moreover, the next stage implies adding the research laboratories, which are manually built by astronauts using the riveting method.



Not to mention that the same process occur with the space ports.

Area	Quantity of Elements	Element Dimensions	Layer Dimensions	Quantity of Layers	Layer Description
Central Axis	1	H=960m r=20m S=120,576m^2	5m*10m S'=50m^2	2,411	Parallelepiped with small curve
Transportation Channel	8	L=3,435m r=20m S=3,451,488m^2	5m*10m S'=50m^2	69,029	Parallelepiped with small curve
Residential Area	2	Circumference=22,513 m r=150m S=42,374,700m^2	5m*10m S'=50m^2	847,494	Parallelepiped with small curve
Alternative gravity Entertainment	8	H=100m r=50m S=376,800m^2	5m*10m S'=50m^2	7,536	Parallelepiped with medium curve
Agriculture	4	L=960m l=480 h=20m S=3,840,000m^2	5m*10m S'=50m^2	76,800	Parallelepiped
Industry	1	H=480m r=200m S=1,105,280m^2	5m*10m S'=50m^2	22,105	Parallelepiped with small curve
Oblique Transportation Channel	4	L=3,616m r=20m S=1,816,678m^2	5m*10m S'=50m^2	36,332	Parallelepiped with medium curve
Research Laboratories	4	R=100m S=62,800m^2	10m*10m S'=100m^2	628	Parallelepiped with medium curve
Space Port	2				

4.4 Phase 4 – Adaptation Phase

Once the last symmetrical components of our space station are binded all together,our project undergoes the next stage,which consists of populating “Ragnarok” with a small amount of inhabitants in order to test the adaptation to artificial habitat and all it's life sustaining characteristics.

Withing the first 5 years, a quantum of 25452 individuals are to be brought. This number has been elected based on the following growth formula:

$X2=X1*(1+i)^n$,

where X2 is the anticipated amount of population,whereas X1 is the initial.”i” is the increasement rate,which currently valued at approximately 1,1% worldwide. Not least,”n” represents the years passed.

Therefore,

$76.000=X1*(1,011)^{100}$,

$76.000=X1*2,986$

Consequently, X1=25452 inhabitants.

In 100 years, Ragnarok will reach its maximum capacity of 76.000 inhabitants, leaving it with enough time to expand in the imminent case of exceeding it's cap limit.

During the 5 year probation period, all inhabitants will conduct their regular daily activities and on a 6 month period they are obliged to have a full body CAT(Computerized Axial Tomography). Likewise, all Ragnarok-born children will be scanned for any malformations caused by artificial gravity.

If no problems appear, the adaptation phase is declared successful and “Ragnarok” is declared life- sustainable. Otherwise, all inhabitants are evacuated and the project is aborted till further analysis.

5. Life Support

5.1 Environment

Atmosphere

One of the most important aspects of the station is to create conditions for human living. In order to do so we must recreate the atmospheric conditions present on Earth. The Earth dry atmosphere contains:

- 78% Nitrogen
- 21% Oxygen
- 0,93% Argon
- 0,038% Carbon dioxide
- 0,032% Other gases

Besides the dry air, the Earth's atmosphere contains in average 1% of water vapor.

Changing these concentrations generate many health problems to the people living on the station. Exceeding Nitrogen leads to the increase of nitrates and nitrites in soil and water, substances known to cause several health problems, oxygen carrying capacity decreased, decreased functioning of the thyroid gland , Vitamin A shortages and even cancer. Also increased dioxide carbon concentration causes headache, dizziness, sweating, restlessness, disorientation, visual distortion developed, increased pulse rate, dyspnea and heart affections. Exposure to high concentration leads to unconsciousness, asphyxiation and death.

Creating the atmosphere

1. In order to take advantage of what the Moon has to offer, there will be a facility built on the Moon that will gather all the elements needed (water, nitrogen, oxygen, argon, carbon dioxide).
2. After gathering them, the elements will be processed and will suffer phase transformations if needed in order to maximize the efficiency of transporting to the station.
3. Every module of the station, after being finished, will be filled with air.

Total air volume	V_{air}	$2V_{cT} + V_{pT} + V_{sT} + V_{c-\text{int}} + V_{ca} + 8\ V_{ce}$	2,770,127,749	m^3

Material	%	Volume(m^3)	Mass(t)	Quantity(kmol)
N_2	78	2,160,699,645	1,728,560	61,734,276
O_2	21	581,726,827	407,087	12,721,458
Ar	0.93	25,762,188	14,440	361,018
CO_2	0.038	1,052,649	532	12,083
Other gases	0.032	886,441		

To ensure a comfortable environment for the inhabitants, the air temperature will be 21C with a relative humidity of about 50%.

The relative humidity is the percent of saturation humidity calculated in relation to saturated vapor density. At a temperature of 21C the saturated vapor density is approximately 18,3gm/m^3. To reach a relative humidity of 50% the actual humidity in the air must be at around 9,15gm/m^3. Based on this number we can calculate the mass and volume of water vapor needed in atmosphere.
(**http://hyperphysics.phy-astr.gsu.edu/hbase/kinetic/relhum.html#c4**)

Material	%	Volume(m^3)	Mass(t)	Quantity(kmol)
H_2O	0.0009	25,392.38	25,347	457

5.2 Gravity

Definition:

Gravity is the natural physical phenomenon by which two or more bodies attract each other with an intensity that depends on their masses and the distance between them,

Why do we need it?

The space station is build with the key goal to reproduce with precision the vital conditions that our planet offers to us. Among them,gravity is one of the most important characteristics of our ecosystem.

Consequently,recreating gravity on "Ragnarok" becomes imperative in order to sustain an adequate habitat. Otherwise,we would experiment zero gravity. The consequences on the long term are disastrous,being proven on several occasions by astronauts embarked on long voyages that led them to physical and mental temporary alterations,but untreated can result in permanent diseases and dysfunctions ,all depending on the length of exposure to weightlessness.

The most common problem in the first hours of weightlessness is the space adaptation syndrome,which has the following symptoms:

- nausea
- headaches
- lethargy
- dizziness

It subsists for maximum 72 hours.
On the other hand,we mention the untoward effects on the long term:

- muscle atrophy

- skeletal damage
- loss of bone mass
- slow down of the cardiovascular system
- weakening of the immune system

How do we obtain it?

To eliminate the negative consequences stated earlier,it is imperative that we create artificial gravity(pseudo-gravity). It can be obtained throughout a series of methods:

- Linear acceleration: It is not available for the design and the objectives of our space station. This method is used to obtain pseudo-gravity just in the case of rockets for a short amount of time due to the limited fuel capacity and actual technology that does not permit a continuous acceleration.
- Mass: Presumes an object of high density that creates in it;s perimeter a natural gravity. This method is not feasible due to the astronomical mass required to obtain a tiny percentage of normal gravity.
- Magnetism: An optimal degree of gravity requires an equipment that weighs thousands of tons and the utilization of uncountable amounts of energy. Besides that, another great disadvantage is represented by the negative impact on inhabitants due to the magnetic fields.
- Gravity generator: technology currently permits the creation of an insignificant quantity of gravitation.
- Rotation: Is the only plausible method. It consists in the circular movement at a certain period of time, which triggers off an effect of thrusting on the objects to the exterior side of the station. It gives a false sense of gravity at the exterior level. This phenomenon is called the centrifugal force and dictates the movement of the objects in a rectilinear trajectory due to inertia,wich virtually throws out the objects, but because of the centripetal force that ensures the circular uniform motion of the objects, that remain in a circular trajectory.

Based on this hypothesis,we attach to the four agriculture sectors,four steam rockets that thrust the space station at the right angular velocity.

Conditions and consequences:

The circular spin of the station brings with itself a number of disadvantages such as the Coriolis effect, an apparent force that applies only to the objects in motion. This force tends to curb the movement of the objects in the opposite direction with respect to the station's spin. Initially, a man standing does not sense the spin, but if he turns his head in a direction,the fluids from the inner ear spread in unpredictable directions due to the combination oh the earlier mentioned forces. The consequences include nausea, dizziness and disorientation. Therefore, we are obliged to maintain an acceptable angular velocity to eliminate the negative impacts on the population. Numerous tests have been taken over the ability of humans to adapt to high velocities. The most important findings are shown in this table.

4 rpm	Hill and Scnitzer
6 rpm	Gilruth
2 rpm	Gilruth
6 rpm	Gordon and Gervais
6.4 rpm	Stone
3 rpm	Cramer

The results obtained by Grabyel in a spinning room:

- at 1 rpm, all candidates adapted without any discomfort
- at 3rpm, cadidates experienced minor symptoms but without any major dysfunctions
- at 5,4 rpm, just a small percentage of the candidates handled
- at 10 rpm, not even special trained pilots did not manage to fully adapt in 12 days.

To calculate Ragnarok's value we are to use the following formulas:

$A_{cp} = V^2 / R$
Knowing that $V = w * R$, we introduce it in the equation and obtain
$A_{cp} = (w * R)^2 / R$
Where w equals $2 \pi \nu$,
Consequently we obtain $A_{cp} = (2 \pi \nu)^2 * R = g$
Therefore, $\nu = \sqrt{g / 4\pi^2 R}$
Where, A_{cp} is the centripetal acceleration,
g is the gravitational acceleration,
w is the angular speed of the torus,
v is the speed of the torus
R is the large radius of the torus,
ν is the frequency of the rotation.

Using our data, R=3585 meters and the desired g=9,81 m/s^2 we obtain a frequency of 0,0083 Hz which is equivalent to 0,5 rotations per minute, which judging by the observations of Grabyel represents an optimal parameter.
(with reference to: **http://varchive.net/space/spacecraft/artificial_gravity.html**)

5.3 Oxygen production

Oxygen represents 21% from the atmospherically composition of the air on the station. For the comfort of the inhabitants it is important to maintain the percentage of the gas at the same level. The need for oxygen of human beings is due to the cellular respiration that produces carbon dioxide. Therefore we need a system that recycles the oxygen keeping the percentage of gases intact.

The first method for recycling the oxygen is the photosynthesis of the plants. Photosynthesis is the process by which autotrophic organisms synthesis their food from carbon dioxide in the presence of light and eliminate oxygen in the atmosphere .the general equation of the photosynthesis is the following:

$2n\ CO_2 + 2n\ H_2O + photons \rightarrow 2(CH_2O)_n + 2n\ O_2$

Through the use of an atmospheric control room the excess of carbon dioxide will be directed to the agriculture. Therefore by raising the concentration of carbon dioxide in the agriculture zone we will raise the efficiency and volume of the oxygen produced by the plants. Than the atmospheric control room will direct the resulting oxygen to the population of the settlement.

The second method for recycling oxygen is through the use of water electrolysis but this is only a back-up solution. This is made using a Hoffmann voltmeter. Through the water electrolysis in acidic conditions hydrogen will form at cathode and oxygen will form at anode in a 2:1 rapport.

Cathode Reaction :

$2\ H(+) + 2e(-) \Longrightarrow H_2$

$4\ H(+) + 4e(-) \Longrightarrow 2H_2$

Anode Reaction :

$2\ H_2O \Longrightarrow O_2 + 4\ H(+) + 4\ e(-)$

Overall Cell Reaction:

$4\ H(+) + 2\ H_2O \Longrightarrow 2\ H_2 + O_2 + 4\ H(+)$

For every ion of hydrogen formed at the anode, an ion of hydrogen will form at cathode. The result is maintaining the concentration of sulfuric acid constant. Therefore electrolysis is the process of decomposing water after the following equation:

$2H_2O \Longrightarrow 2H_2 + O_2$

A part of the oxygen recycled will be stored in oxygen tanks found under the residential area. The oxygen reserves will be used when problems occur until they are fixed.

5.4 Water recycling

Water is the essence of life, the environment is which the very first organisms in the history of humanity appeared and without which the survival of the human species would be impossible. On Earth, there is a continuous flow of precipitations which represents the result o water evaporation from the atmosphere. Nevertheless, this scenario is excluded. Therefore, we rely on continuous recycling of the water amounts available.

Water on the station is divided in two categories:

Greywater is water generated from domestic activities such as dish washing, laundry and bathing. Greywater gets its name from its cloudy appearance and from its status as being neither fresh, nor polluted. Greywater contains significant food residues and high concentration of toxic chemicals from household cleaners. (Wikipedia)

The greywater system contains all the pipes linking with the sinks, bathtubs, showers and washing machines from the modular habitats and thei respective alternates from the labs, offices and industry.

Blackwater este wastewater care contine urina si fecale.Sistemul greywater este alcatuit din toate conductele conectate la toilets.

5.4.1 Reverse osmosis

In the case of greywater we are to use the process named reverse osmosis. This principle consists on allpying an external pressure,in addition to the osmotic pressure,in a region with a high concentration of soluble,so that the solvents pass through a semipermeable membrane to the region with a small concentration of soluble.

This purifying method relies on osmosis,a process that highlights the solvent's migration tendency in order to equilibrate the concentration ration from the two different regions. Based on this,because of the impossibility of solubles migrating between compartments due to the membrane,only the solvent,precisely the one from the compartment with lower concentration,will migrate to the other compartment.

In our case,an external pressure is applied on the compartment with higher concentration ,which binded with the osmotic pressure enables just the water molecules to pass into the next compartment. Therefore,all pathogens,viruses,bacteria and germs are left behing.

The reverse osmosis's efficacy depends on the soluble's concetration,pressure and water flow. (Wikipedia)

Technically speaking,the device has the following components,as shown in the table:

Quantity	Material	Spore's length	Length	Purpose
2	Polypropylene	5 microns and 1 micron	10 inches	Disposes of dust,particles and rust
2	Activated carbon	5 microns and 1 micron	10 inches	Removes residual chlorides and odors

2	Thin film composite	0.001 microns	10 inches	Eliminates pathogens,germs and viruses
1	Activated carbon	1 micron	10 inches	Further removal of odors

(http://www.globalsecurity.org/military/systems/ground/rowpu-3000gph.htm)

5.4.2 Ultraviolet treatment

Ultraviolet germidal irradiation is a method of filtrating greywater that has gained a lot of popularity in recent years, being used not only at a residencial level,especially in emerging countries, but even at an industrial scale(companies, aquariums and swimming pools).

The basic element of this purfying process is represented by the ultraviolet light,which at a certain wave length varing from 100 to 280 nanometers becomes a mutagen agent at a cellular level.

Therefore, causes adjacent thymene molecules with DNA to dimerize, leaving the micro-organisms(pathogens, germs, viruses) with the inability to replicate.

This phenomenon does not affect the biological processes on Earth due to the atmosphere and ozone layer, which blocks excessive penetration of UVC(short wave/germicidal) waves and UVB(medium length)waves. Approximately 98,7% of the ultraviolet light that penetrates our atmosphere is UVA(long length/black light), having values over 315 nanometers, consequently non being mutagen agents.

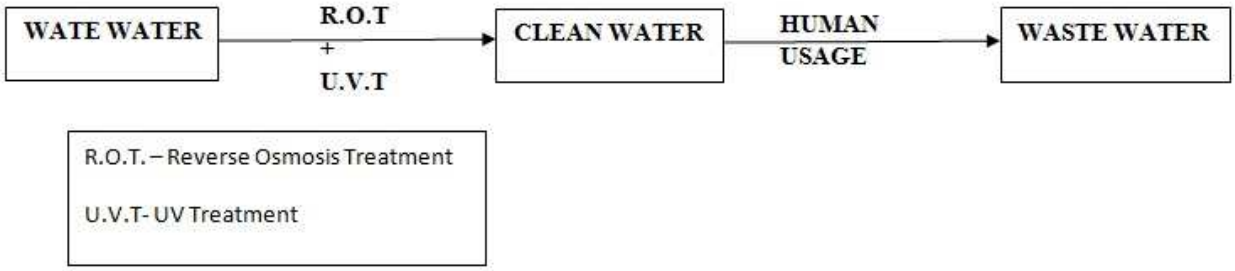
Whereas in space, where there is no atmosphere and ozone, this process can be continuously exploited at optimal parameters due to the permanent exposure to sunlight. Therefore, there is no need to artificially recreate the irradiation conditions using mercury-vapor lamps.

The ultraviolet treatment system is composed of a series of pipes attached on the exterior wall of the agriculture sections. Maximum efficiency is reached when sunlight has a wave length of about 185 nanometers or 265 nanometers. Experiments have proven that normal glass becomes more and more opaque with the reduction of the wave length. Therefore, fused silica or quartz remains the only feasible solution.

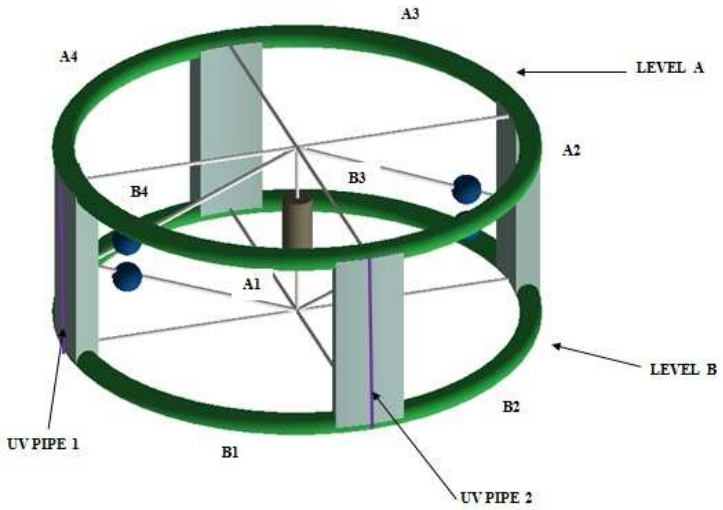
The pipes have a shape of a semi-circular cylinder and a length of 960 meters per agriculture section, with a width of 0.5 meters.

Clean water/waste water circuit throughout the station

Water is the key element to our existence so therefore we can't survive without it, but water alone is not enough it must be drinkable and clean. On Earth the process of recycling water isn't as life-threatening as it is on the station. To maintain a constant supply of clean water to the population water needs to go through a cycle meant to bring it to the normal standards of sanitation. How will we do so? The answer lies in our method of treatment, water is going to be subjected to a series of phases that transform it from waste water to clean water.



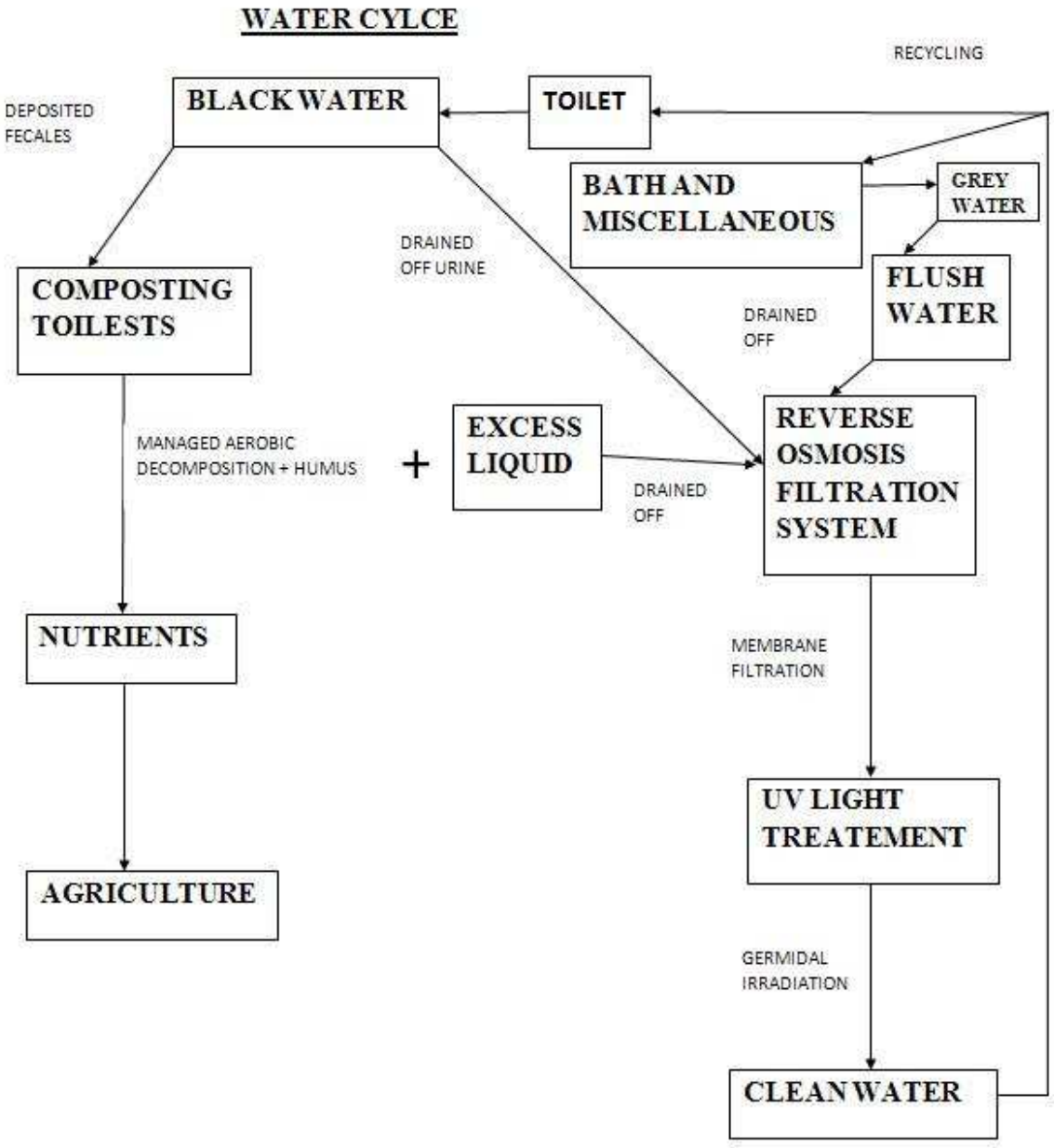
Water also has a cycle throughout the entire settlement, each torus has been divided into four sections, waste water will circulate through UV pipes that are located on the agricultural structures and arrive on the other torus as clean water.



Below is the path that water follows in its cleaning cycle:

A1	→	**PIPE 2**	→	**B2**
B2	→	**PIPE 3**	→	**A3**
A3	→	**PIPE 4**	→	**B4**
B4	→	**PIPE 1**	→	**A1**
B1	→	**PIPE 2**	→	**A2**
A2	→	**PIPE 3**	→	**B3**
B3	→	**PIPE 4**	→	**A4**

A4	▶	**PIPE 1**	▶	**B1**


WATER CYLCE
RECYCLING
DEPOSITED FECALES
BLACK WATER
TOILET
BATH AND MISCELLANEOUS
GREY WATER
DRAINED OFF URINE
FLUSH WATER
COMPOSTING TOILESTS
DRAINED OFF
MANAGED AEROBIC DECOMPOSITION + HUMUS
+
EXCESS LIQUID
DRAINED OFF
REVERSE OSMOSIS FILTRATION SYSTEM
NUTRIENTS
MEMBRANE FILTRATION
UV LIGHT TREATEMENT
AGRICULTURE
GERMIDAL IRRADIATION
CLEAN WATER

5.5 Energy

5.1 Energy production

One of the major aspects of life support on Ragnarok is the production and storage of electric energy. Because almost all devices and appliances use electric current to function this aspect is very important. A large amount of energy must be created, one of the purposes of the project being to send back to Earth part of it.

Being placed on the Earth's orbit, in the Lagrange point 5, Ragnarok benefits of permanent exposure to the sun (except for 2 hours per year, one in the spring and one in the autumn equinox). Also, the space on the settlement is limited, therefore the construction of traditional power plants (coal fired, hydroelectric, atomic) is not a viable option. It results that most efficient way of producing electric energy is through photovoltaic technology.

Photovoltaic is the direct conversion of light into electricity at atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current results that can be used as electricity. (**http://science.nasa.gov/headlines/y2002/solarcells.htm**)

Photovoltaic cells are grouped in modules which form solar panels. Ragnarok has two torus shaped residential areas with an exterior wall surface of 6,757,566 m^2 each. For simplicity we will calculate dimensions and energy values for each torus, and we will double to obtain the values for the whole settlement. The solar panels will cover half of each torus, the outer part, that faces the sun (half of the exterior surface: 3,378,783 m^2), for optimum synchronization with the sun. Being under rotation with a speed of 0.5rpm, half of the solar panel covered area will be permanently exposed to sunlight (a quarter of the total exterior surface: 1,689,391.5 m^2). This means that 1,689,391.5 m^2 will continuously create electric energy. The equivalent in kilowatts of the amount created is 196 440kw per day by each torus. This results in a total of 392,880 kW per day.

Advantages of using solar panel technology:

- They can create large quantities of energy without using unstable or dangerous equipments.
- They are relatively easy to take care of (a cleaning mechanism is required) and the risk of malfunction and mechanical failure is minimum due to lack of mobile parts and because they do not use fuel which can cause explosions.
- They do not use consumable fuel which in the given conditions could be hard to find or expensive.
- They do not produce waste which means they will not pollute, and a separate drainage system on the station.

- They require a small volume but a large surface (8-12 m^2 for 1kW) which the station can provide.

Each torus can hold, up to 38,000 inhabitants. Considering 1kW the average need of energy per day for one man, a surface of 326,800 m2 will be required on each torus. This results in surplus of 1,362,591.5m^2 that can produce 158,441 kW for each torus, which means a total of 316,882 kW per day. This surplus energy will be divided:

- 40 % industry and public services within residential area (illumination, public buildings, the subway)
- 60 % are to be sent to Earth via microwave technology.

(calculus made with the help of
http://lifesci3.arc.nasa.gov/SpaceSettlement/designer/sphere.html)

5.2 Energy storage

An energy storage system is mandatory on Ragnarok.

First of all, because of the alternation day/night in the residential area, energy consumption levels will fluctuate according to time (more energy is consumed during the day). Therefore an energy storage system is required to manage the way it is used. This also applies to the industry section of the settlement, a storage system being required to supply the machines and robots.

Secondary, in case the principal electric network malfunctions, back-up generators will have enough supplies to control the situation until the repairs are finished.

An energy storage system is also needed in the transportation of electric energy back to Earth. Because the space station is going to produce high quantities of energy, it must be temporarily stored before being sent to Earth.

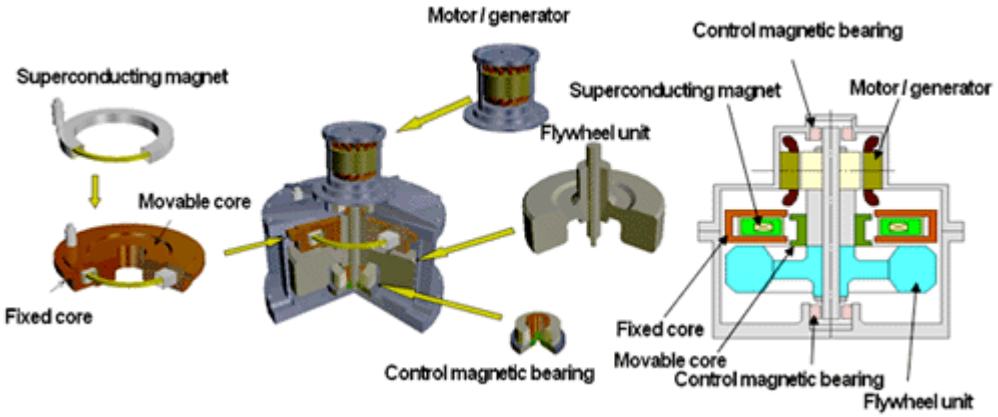
There are 3 possible options for energy storage.

Rechargeable batteries convert electric energy into chemical energy. There are 4 types:
(**http://www.rechargeable-battery-review.com/articles/consumer-batteries/pros-and-cons-of-battery-technologies-used-in-cameras.html**)

- **nickel cadium**: it is an old technology and although they are inexpensive and can be recharged fast , they have a low capacity and suffer from "memory effect", which means that the battery can be recharged to it's full capacity only if it is completely discharged before**.**
- **nickel metal hybrid:** an improvement to nickel cadium, with a 50% increased capacity.
- **lithium ion:** the alternative to nickel batteries, have a bigger capacity, no memory effect, thus they can be recharged at any time.
- **lithium polymer:** is an upgrade to the lithium ion battery, has a bigger capacity and are smaller and come in any shape possible.

Lithium polymer will be the kind of batteries used on Ragnarok. They come in different sizes and have a considerable capacity, so they will be used to supply robots and mobile device in the industry processes.

Another method suitable for the space settlement is the flywheel.



(**http://english.jr-central.co.jp/news/n20050701/index02.html**)

The flywheel energy storage system works by accelerating a rotor to a very high speed and maintains the energy in the system as rotational energy. When energy is extracted, the rotational speed is reduced as a consequence of the principle of conservation energy. In the same manner the speed of the rotor increases when energy is added to the system. (Wikipedia 2010)

Because of its size (Approx. 2 meters in diameter), weight (Approx. 20 tons) and energy storage capacity (50kW/hour=1,200kW/day) they will be used to supply the residential area and the industry zone. In the industry zone they will be placed in each industrial component (factory, laboratory centre, etc) in a system similar with the one used in factories on Earth. In the residential area (toruses) they will be placed at the bottom of the habitat, near the exterior wall, therefore next to the solar panels. Energy transmission will be fast and occupy a small volume.

The residential area of each torus is divided into 32 districts, each has a maximum capacity of 600 houses and 2,400 inhabitants. Energy consumption will come not only from the houses but also from public buildings such as hospitals, schools, the space hotel, leisure centers and public illumination. To avoid blackouts in the entire torus, each district will have its own power supply. This will consist of 5 flywheels, 2 for the private housings, 3 for the public use.

The third type of energy storage is superconducting magnetic energy storage device. Although the most advanced of all three with no moving parts, no chemicals and a 95% efficiency this is not a proper solution for Ragnarok because it converts electric energy into magnetic energy by flowing electricity through a superconducting wire. The problem is the length of the wire which will occupy to much space (limited resource on the station) and will also create a magnetic field that might affect humans and nearby machinery.

5.6 Food and nutrition

5.6.1 Nutrition basics

Food products are a mix of organic and inorganic substances. This mix contains substances required by the human body (nutrients), but also neutral substances and even anti-nutrients.

To use this complex substances found in food, the human body hydrolyzes them by using its own enzymatic equipment (which exists in the juices of the oral cavity and gastrointestinal tract) until they reach their basic form. The substances with nutritive value are not completely assimilated by the organism.

The energetic value of a food product represents the capacity of the nutriment to satisfy the daily energetic necessities of the human organism. This section conditions the quantitative aspect of food and is expressed in kcal or kJ (1kJ=4,184 kcal)

Thereby the essentially nutritional equilibrium can be represented like this:

1. energetic contribution – repartition of the caloric sources
    - calories of fats 55-65% of total calories
    - calories of carbohydrates 25-35% of total calories
    - calories of proteins 10-15% if total calories
2. energetic foods represent 90% of the ratio
    - fats 300-400g/24 hours
    - carbohydrates 60-90g/24 hours
    - proteins 60-90d/24 hours

These 3 substances and water are the macronutrients, with daily requirements exceeding 1 gram. The human body also needs micronutrients, essential in the chemical processes of the organisms. These nutrients are ingested in small amounts. They are divided in vitamins and minerals. As seen in the list below, they are contained by the next vegetables which are going to be grown in the agriculture zone of Ragnarok.

Vegetables List with Vegetable Nutrition Facts

VEGETABLE	NUTRITIONAL VALUES IN ORDER (considerations)
Arugula	carotenoids, fiber, A,C,K, folate
Asparagus	K, folate, C, A, tryptophan, B1, B2
Beets	flavonoids, folate, manganese, potassium (glycemic)
Bell peppers	carotenoids, C, A, B6, fiber (pesticides, nightshade)
Bok choy	cruciferous, A, C, K, B6, folate
Broccoli	carotenoids, cruciferous, C, K, A, folate, fiber
Brussels sprouts	carotenoids, cruciferous, K, C, folate, A, manganese, fiber
Cabbage	cruciferous, K, C, fiber, manganese, B6, folate
Carrots	carotenoids, A, K, C, fiber, potassium (glycemic when cooked)
Cauliflower	cruciferous, C, K, folate, fiber, B6
Celery	K, C, potassium, folate, fiber (pesticides)

Collard greens	carotenoids, cruciferous, K, A, C, manganese, fiber, calcium
Corn, yellow	A, iron (glycemic)
Cucumbers	C, molybdenum, A, potassium (wax coating)
Dandelion greens	carotenoids, A, C, E, folate
Eggplant	fiber, potassium, manganese (nightshade)
Garlic	allicin, manganese, B6, C
Green beans	flavonoids, K, C, manganese, A, fiber, potassium, folate
Green peas	K, manganese, C, fiber, B1, folate
Kale	carotenoids, flavonoids, cruciferous, K, A, C, manganese, fiber
Leeks	manganese
Mustard greens	carotenoids, cruciferous, K, A, C, folate, manganese, E
Okra	carotenoids, fiber, A, C, K, thiamine, B6
Onions	sulfur compounds, flavonoids, chromium, fiber
Parsnips	fiber, C, K, folate (glycemic)
Potatoes	C (pesticides, nightshade, glycemic
Pumpkin	carotenoids, A, C, E (glycemic)
Spinach	carotenoids, K, A, minerals, folate, iron, C, B2, B6, fiber, B, E
Squash, summer	manganese, C, magnesium, A, fiber
Squash, winter	carotenoids, A, C, potassium, fiber
Swiss chard	carotenoids, K, A, C, manganese, potassium, iron
Tomatoes (fruit)	carotenoids, C, A, K, molybdenum, potassium (nightshade)
Turnip greens	carotenoids, cruciferous, K, A, C, folate, manganese, fiber
Yams	(glycemic)
Zucchini	carotenoids, C, magnesium, A, fiber

5.6.2 Food production basics

Ragnarok has a maximum population of 76,000 inhabitants (who will receive 85% of food production), plus the tourists from the space hotel and traveling pilots (5% of food production) and some of the food (10%) will be temporary stored into industrial refrigerators under the residential area. The stored food will be used in case of emergency, but because food may alter over time the supplies will be permanently refreshed and the stored food put in use. Food will be divided between animal products (eggs, milk, and meat) and products of vegetal origin (fruit and vegetables).

The food will be produced in the agriculture modules.

They are in number of 4 and are represented as parallelepipedic structures between the two toruses. Each module has its own specific function. 3 of them are used to grow plants (each module for a specific seasonal agriculture –spring/autumn/summer) and one for synthetic meat production.

The 4 modules do not differ in size, with a volume of 9,216,000 m^3, and a usable surface of 460,800 m2.

5.6.3 Plant growth and harvesting

Because of the limited space offered by the space settlement, a natural, Earth-like method of plant growing is not an option. Therefore the best method to obtain vegetable food products is the hydroponic method.

Hydroponics is is a method of growing plants using mineral nutrient solutions, in water, without soil. Plants will be grown with their roots in the mineral nutrient solution in an inert medium, such as perlite, gravel, or mineral wool. On Ragnarok we use rock wool, expanded clay pellets and perlite for different types of plants, each type of medium having its advantages.

This type of agriculture brings many advantages.

- The principal advantage is that no soil is needed; therefore more space is obtained to grow plants. Also, in this using this method, plants can be grown closer one to another.

  To illustrate more efficiently we will show the difference of quantities of specific plants that figure in our list that can be produces on an acre using soil/hydroponic technique.

	Hydroponic	Soil
Cucumber	28,000 lb.	7,000 lb.
Cauliflowers	30,000 lb.	15-35,000 lb.
Tomatoes	400,000 lb.	12,000-22,000 lb.
Potatoes	156,000 lb.	18,000 lb.
Beetroot	20,000 lb.	9,500 lb.

(Wikipedia 2010)

  Another consequence is that the soil must not be transported from Earth to the space settlement. (If soil were to be used, a primary transport is needed in order to prepare the settlement for agricultural activity and also, soil alters over time so it must be changed) thus saving more money
- Plants can be grown year-round. (3 modules equal 3 different types of agriculture that can be used year-round, this means a variety in the menu of the inhabitants)
- Weeds can not grow and there are also no natural pesticides
- Although this technology uses water and nutrients, less water is used than in traditional agriculture and none of it is wasted.
- Most plant diseases are eliminated.

(**http://en.wikipedia.org/wiki/Hydroponics**)

Because we plan to grow various types of plants we will use 2 methods of hydroponics each having a different way of providing the plants with nutrients, oxygen and having a different approach on the circulation of water.

The main method used in plant growth on Ragnarok is passive hydroponics because the labor required to crop the plants is minimal. On the other hand it may produce salt accumulation and a high humidity in the air, which will create an unfriendly environment for plants that require a dry space.

In passive hydroponics, an inert porous medium transports water and fertilizer to the roots by capillary action. Water and fertilizer are held in a reservoir and conducted to the roots as necessary. In the simplest method, the pot sits in a shallow solution of fertilizer and water or on a capillary mat saturated with nutrient solution. The plants take just enough water and nutrients as they need. (Wikipedia 2010)

The other method used is Deep Water Hydroponics System usage.

This method uses rock wool in which the plants germinate. Then they will be put in baskets with clay pellets. The system is filled with water and fertilizers that rise up to the point of contact with the base of the baskets.

In this way, the clay will be in contact with the solution that will be absorbed by the plants roots. Soon the plant will develop a large root system that will naturally immerse in the nutrient solution.(Wikipedia 2010) This method will require work and permanent monitorization: the nutrient solution must be replaced once a week. Also the pH levels must be between 5.5 and 6.8. Because the environment is very well oxygenated and has plenty of light algae growth will occur. This might seem as an impediment but the algae will be transported into algae tanks and then sent into grinder and compost machine to produce fertilizer.

5.6.4 Synthetic meat production

The last agriculture module is used to create synthetic meat. Therefore it is divided into meat production laboratories.

Synthetic meat or in vitro meat is the meat grown without needing the living animal. This is done by taking muscle cells from animals and applying a protein to help them grow. Except for collecting the muscular cells, the actual animals have no use in growing the meat.

This type of meat production presents several major advantages:

- Because we don't need animals, we can use the space more efficiently. Less space, more meat.
- Needed substances by the organism can be added easily to the meat
- Fat and nutrients level controlled so that meat is healthier, reducing the risk of having health problems such as heart disease or obesity.
- Fewer greenhouse gasses

In present, the costs of producing in vitro meat are very high but according to the experts, in the future, the costs will be reduced to only twice the price of producing conventional meet. This is a big economic advantage because the costs of bringing animals in space exceed the ones for producing synthetic meat.

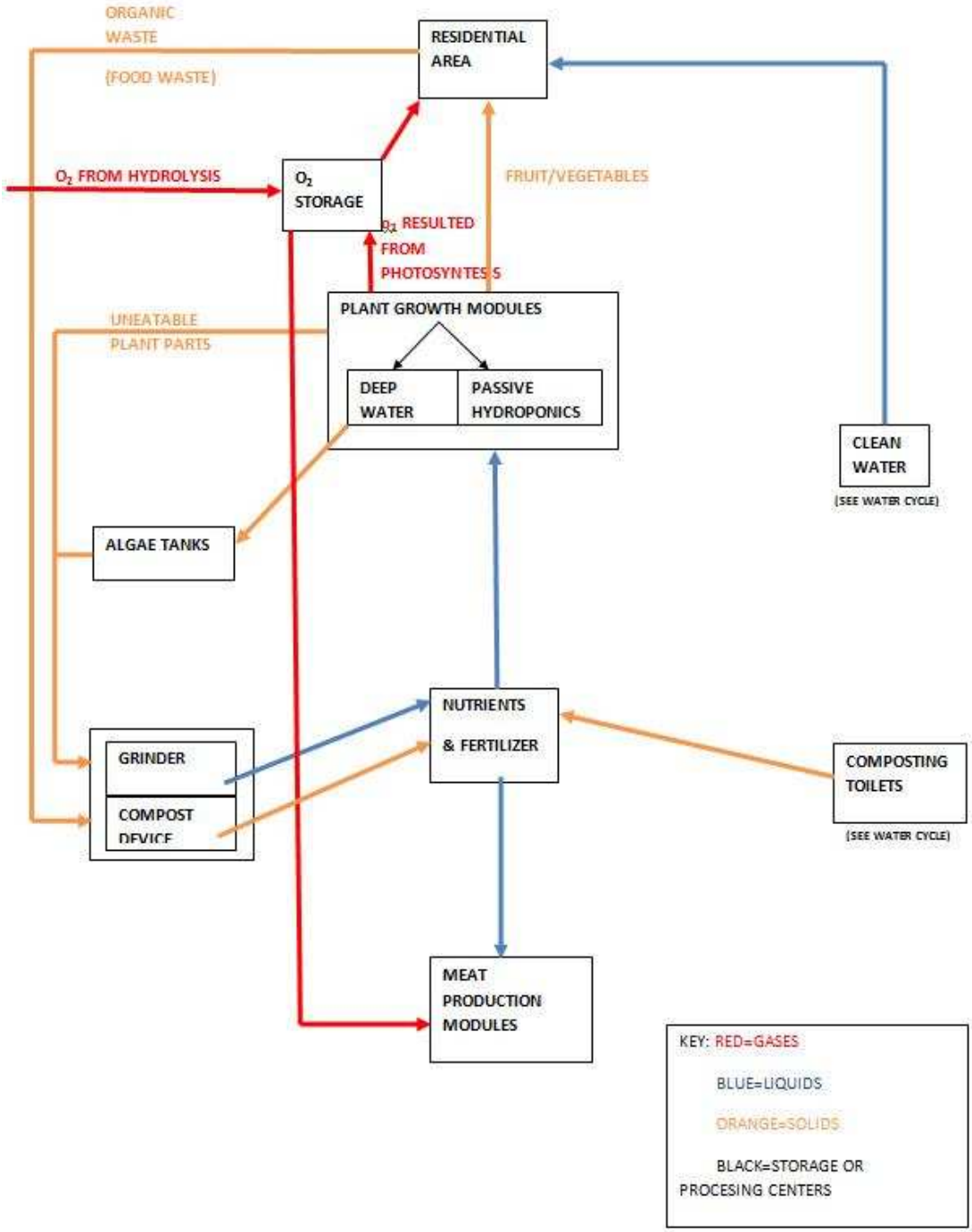
5.6.5 Nutrients cycle

The agriculture system is correlated with the water and the oxygen cycles in the station. The meat production module must receive nutrients and O_2 required in the process of creating synthetic meat. Photosynthesis has a major role in the production of O_2. Therefore all 4 agriculture modules are dependent on one another.

Ragnarok produces its own fertilizer which result from organic waste, algae

debris, unusable plant components and other waste resulted from the human processes.

The following sketch represents the journey of food, nutrients, fertilizer and other necessary substances (water, O2) in the agricultural process:



5.6.6 Food consumption

Nutrition is an important aspect on Ragnarok. Having a proper alimentation the residents of the station will maintain healthy and fit, thus being constantly able to work. This is an important aspect of life in such a remote location, the settlement depending on every one of its 76000 inhabitants.

To make sure that nutrition rules are respected. People will have their meals delivered at home in accordance with their nutritional needs. Menus will vary from day to day and the residents will have the possibility to choose from a various category of food products so that they do not feel limited in any way.

5.7 Waste disposal

Waste is a problem in modern days. We should focus most on diminishing the amount of waste we produce, mainly the waste that can not be recycled or reused.

We will recycle and salvage everything because life in space can prove a challenge to the disposal of the waste because we don't have space to deposit it and we have a limited amount of materials we can use to create new products.

On Ragnarok the waste collection will be a Stationary vacuum system. This system will have inlets placed alongside the main road and the ducts will go underneath the subway. Every person will have the responsibility of sorting the garbage and throwing it in the collector inlets and the ducts will bring it to the waste collection point. The system works by creating a vacuum in the ducts that sucks the garbage. When the inlets are full, fans start to suck the air from the pipes; after that an air valve behind the inlet is opened and then the garbage falls in the pipe system and is sucked to the collection point. Each type of inlet will be connected to a different set of pipes as to avoid different types of waste to be mixed.
(**http://www.envacgroup.com/web/Stationary_vacuum_systems.aspx**)

Plastic, glass, paper or metals can be easily recycled with modern day's technology, but the problem is non recyclable waste. We can not burn it and burry the ashes as fertilizer because we do not use soil for agriculture. Therefore to get rid of waste we cannot recycle we will burn all waste that we are unable to recycle and then compress them as much as possible, afterwards the ash that results from incineration is loaded into projectiles and put into a collision-course to the Sun.

5.8 Thermal control system

The thermal control system for Ragnarok will be a rather simple one. Our torus is divided in 4 large sectors which are also divided in 4 other sections of 1km each. Every small section of 1km will have its own independent thermal control system.

The water system is composed of a solar oven. The solar oven is a device which uses sunlight as its energy source. A set of mirrors is used to concentrate light and heat from the sun into a small area, making the energy more concentrated and therefore more

potent. The solar oven is situated in the middle of the torus so that it will always receive light from the sun. The mirrors will rotate so as to always receive as much light as possible.

The water tank in made out of a outer shell that is a good insulation material and a layer of void and after that there is a layer of radiators that will heat the air, when it gets to cold.

The solar light will be transported to the water tank through fiber optic cables. The fiber optic cables will pass through the walls of the water tank and then open up inside the tank projecting light on the walls of the tank from the inside. Because the inner wall of the tank is made out of heat absorbing material the water will start heating from the walls.

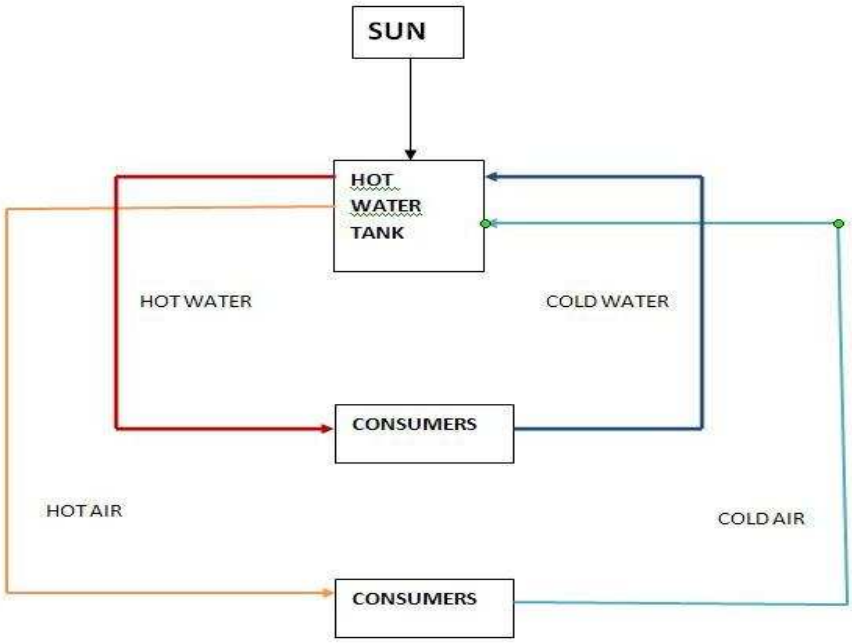
An innovation of the Ragnarok thermal control system is the fact that the water tank will not only heat the water but it will also heat the air through the radiator panels that cover the inner layer of the tank. This air heating system will not only be means to heat up the air but also means to cool down the water.

The tank will be maintained at about 60 degrees Celsius. When the temperature raises above 60 degrees some of the fiber optic cables will automatically shut down so that the water will not overheat. And another safety measure against overheating is the cooling through the use of the radiator panels, when the tank is too hot air from the storage rooms will be taken and cycled through the panels until it will cool down.

The cold water tank will be situated in the storage area near the hot water tank. It will have the same casing as the hot water tank but smaller amounts of optic fiber cables it only needs to maintain the temperature between 8 and 10 degrees Celsius.

The temperature control system will be made out of air ducts that then the temperature is higher than 23 degrees Celsius it will take hot air from the ceiling of the torus, the hot air will then be transported through the use of fans to the storage area where it will cool down and after that it will be brought inside the living quarters through the ground level. When the air is too cold (lower than 20 degrees Celsius) the air will be taken from ground level and through air ducts brought to the solar oven to heat it up until it reaches the desired temperature and than dispersed through the roof. In the houses the people will be able to select their desired temperature varying from 16 to 30 degrees Celsius

The air ducts will be placed under the subway rails it will be a massive amount of ducts there but we must our people living in the best of conditions.



5.9 Illumination

For illumination and also to maintain the impression of the environment on Earth light will be provided using the Light Emitting Diode technology (LED's) as they have the highest energy consumption efficiency of all artificial light sources that emits light in a similar specter to that on Earth (130 lumens/watt). Whilst trying to simulate natural conditions on Earth LED's will be placed on the interior walls that show images similar to the ones found in any natural habitat which will also be accompanied with actual sounds that you may find in any earthly environment.

To maintain the health of the inhabitants each family will have a Xenon arc lamp in their living room so that they can get the necessary amount of natural sunlight daily. What is a Xenon arc lamp?

A Xenon arc lamp is an artificial light source that uses electricity and can mimic natural daylight using ionized xenon gas.

To reflect a more similar life style, the ambient light on the interior walls are going to simulate the phases of light similar to that on Earth, this will also help maintaining the natural biorhythm of the inhabitants. Furthermore as to maintain a constant functioning of the station the phases of daylight and night will alternate on the toruses, when on one torus the Illumination is simulating daytime on the other torus nighttime will be simulated.

5.10 Anti-radiation measures

Radiation exposure represents one of the highest risks that may endanger human lives on Ragnarok. Potential life-threatening radiation that can be found in space is: -alfa(α) radiation, this poses little threat to biological systems as it can be easily blocked with a sheet of paper

- -beta(β) radiation requires only a few centimeters of metal on the hull to be easily absorbed
- -gamma(γ) by far the most dangerous form of radiation, it's a high frequency (10^{19} Hz)

The material that will be used for shielding will be polyethylene as it's high in hydrogen, hydrogen atoms are good at absorbing and dispersing the radiation. Another use of polyethylene blocks is that of deflecting micrometheorites (**http://www.nasa.gov/vision/space/travelinginspace/radiation_shielding.html**).

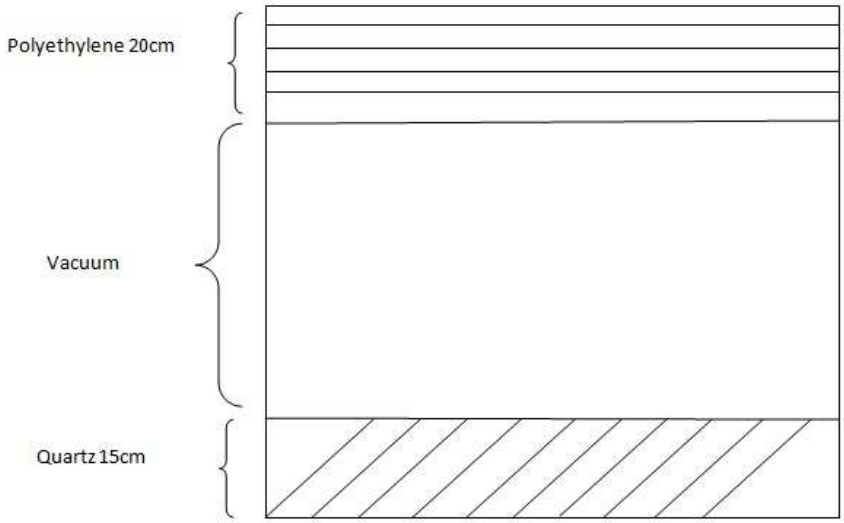
When required, a transparent layer that can also absorb radiation, can be installed.

5.10.1 Special protection

The research laboratories, industrial areas and the different areas where robots are going to be used will be protected by an aluminum lair that acts similar to a "Faraday Cage" which must shield the inside environments from electromagnetic radiation.

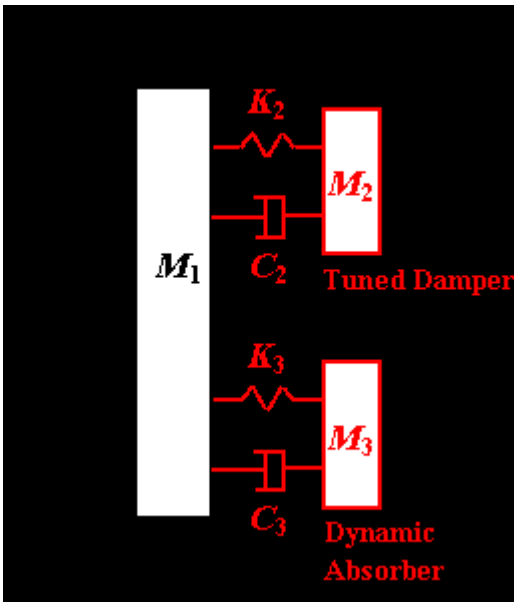
There are areas where sunlight is let into the settlement, but this may pose serious threat to the health of the inhabitants since there is no shielding as that found on Earth, from the planets electromagnetic-field. To counteract to this threat we chose to use layers of polyethylene since it is transparent on the areas exposed to the sun, the layers of polyethylene will be followed by layers of quartz because of its properties to shield from UV.

The transparent anti-radiation protection shield will look like this:



5.11 Anti-vibration

Tuned Absorbers/Dampers are reactive devices used to absorb or damp oscillations and are used in structural and acoustic systems. The devices are in most part the same and are made of an inertia element, a compliant/resilient element, and an energy dissipating element.



The parameters of a tuned absorber/damper are selected such that their resonant frequencies match the disturbance frequency or resonant frequency of an structural/acoustic system being treated.

Another important factor directly affecting the effectiveness of tuned absorbers/dampers in structural applications is the size of the inertia element. The larger the inertia element, the more effective the device.

(with reference to http://www.deicon.com/tuned_abs_damper.html)

6. Protection

6.1 Standard Evading Procedures

The most accessible method of escaping from the path of an asteroid is not by moving it's trajectory, but by moving the space station's coordinates. Adding to this, in case of an imminent threat from an asteroid we are to use our space port's steam rockets, which will thrust our space station in the right direction in order to avoid it. Due to the location's stability, we don't have to worry about the building momentum that occurs with the thrust. Consequently, a minimal counter thrust is required to regain its location and perfect stability.

6.2 Asteroid Deflection

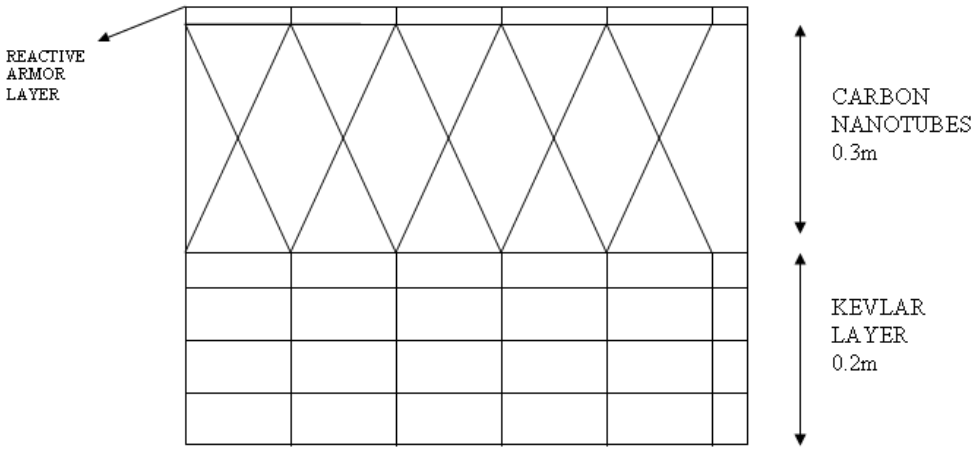
A proper method is to nudge the asteroid of the station's path using several nuclear explosions near the asteroid, but not destroying it. Instead, the radiation from the explosions thrusts away the asteroid in the opposite direction that can vary .Depending on the situation, we can give it a lateral push, drifting it away off it's course, or by giving him a front push that can decrease it's speed, therefore it's orbital period ,missing our space station.

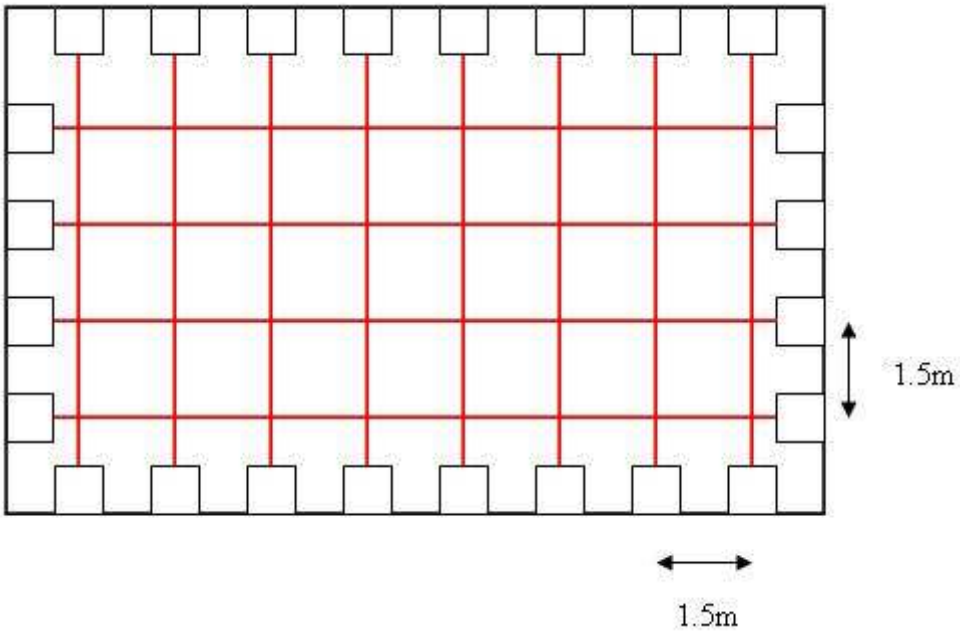
6.3 Outer shield

Protection from space debris is vital for the settlements and its inhabitants' safety since even the smallest meteorites are faster than a speeding bullet. The first protective layer will be reactive armor plated, this technology is currently used on tanks, particularly explosive reactive armor, between to metal plates is squeezed an explosive material which detonates upon impact from a projectile and forces the thrust of the generated explosion towards the incoming projectile reducing its penetrating strength. For its incredible strength carbon nanotubes sheets are going to cover Ragnarok, tests have been made showing that these nanotubes can hold weights of 50000 times heavier than their own weight Following the carbon sheets layer is Kevlar which is 5 times stronger than steel. Beneath these protective layer lay the polyethylene blocks meant to protect the station from radiation.

The thickness of the outer shield will be: 30cm of carbon nanotubes, 20cm of Kevlar armor and one layer of reactive armor.

For projectiles that might be to large to be stopped by the above mentioned security measures two extra devices will be used: a "laser wall" that can reduce the incoming meteorites and other debris that might be threatening the hull. Secondly in the scenario in which large projectiles cannot be avoided by the stations' evading maneuvers rocket launchers will be placed on the exterior of the hull.





(Laser protection system)

7. Demography

Ragnarok will be home to about 76,000 people, the living quarters will be separated in four section on each of the toruses of the space station. The inhabitants are going to be given a home in one the sections depending of the race that they belong to following a certain ethnical and geographical classification:

1. Caucasoid race
2. African and Near East
3. Sub Saharan
4. Asian
5. Oceania and Australia
6. Latin America
7. Middle East and India
8. North America

The selection criterion for the inhabitants is going to consist of a degree of tests:

1. An IQ test is required for all those who wish to carry on their lives on Ragnarok; a coefficient of over 120 is the minimum requirement for the selection.
2. Every single future inhabitant is to be tested for any possible diseases and hereditary diseases.
3. A fertility test is going to be carried on every single candidate.
4. A physical strength test will also be carried to prove that the inhabitants will be fit.
5. A psychological test.
6. The final test will consist of an aptitudes test that can give the candidate a series of possible future job prospects on the station.

Another challenge is maintaining the population at a constant number as to avoid overcrowding on Ragnarok, to do so only 60,000 people are going to be sent the first time, there will be only adults, as to give a merge of 16,000 vacant places for the future births that will take place. But this will not be enough to keep a constant population so the number of deaths and births must be constant so therefore all couples are going to be restricted to having only a child.

After a certain number of generations genetic complications might occur, to avoid this from happening a third of the population has to be moved back to Earth and another third is going to be sent to Ragnarok following the same criteria of selection named above.

8. Political System

The political system that is going to be adopted on Ragnarok will be democracy exercised by popular representation, this will consist of a representative elected by the inhabitants with a minimum of 50%+1 votes, this representative will act similar to a governor for the space station, he will be in charge of the well being and functioning of the institutions subordinated to him. This "governor" will be elected for a period of 4 years with a maximum of 4 terms, for avoiding autocracy. Only citizens that are over 18 are allowed to cast their vote for electing the head of the settlement. The governor also is responsible for the political link between Earth and Ragnarok.

Due to the relative small number of inhabitants political parties are not going to be allowed, but parliament is going to function for the decisions regarding the issues concerning the well-being of the station and its citizens and will consist of one eighty politicians who will be chosen by inhabitants from each living quarter of both toruses.

The executive system will consist of several departments; each run by a minister nominated by the governor and is responsible for the functioning of the department he is running. The departments are going to be:

1. Department of Justice- responsible for the normal functioning of the laws implemented on the settlement.
2. Department of Economy- responsible for the economical activities carried on Ragnarok such as the exchanges between Earth and the settlement.
3. Department of Education- it handles the educational system for the citizens.
4. Department of Security- this department is responsible for the security of the inhabitants, the police are subordinated to this department, but it also handles external threats.
5. Department of Health- is in charge of the medical system on board.
6. Department of Research- this should be responsible for the development of new technology within Ragnarok.

Before the first time Ragnarok will be settled into, a political leadership will be selected on Earth, this first regime will be installed for the first eight years so that the social bonds can be tightened aboard Ragnarok and the inhabitants get used to this new form of living. Laws meant to governate the living on the settlement are going to be established before the inhabiting on Ragnarok, this laws will be enforced by the Department of Justice and the Department of Security.

Should the system fail, it will be immediately replaced by a temporary government selected from Earth, which will have the same attributes as the original form.

Every section of the eight ones is going to have a local leader, responsible of the administrative issues of his section. This representative is similar to a mayor; he will be elected by the residents for a four year term, but with not limit of terms.

9. Institutions

Ragnarok is a self sufficient settlement not requiring any help from Earth so this community has all the facilities and institutions the home planet could provide, even each section of the torus has everything necessary.

The institutions are found on each section near the leisure quarters in the 1.65km smaller section of the quarters of the torus.

The police section and the firefighting department are close to one another, these two institutions provide the need for security each and every human being has, making life more secure. The police will be spread through out the torus to prevent misbehavior and the firefighters will be able to have a short response time in the case an emergency.

We will also have a court. This will ensure that crime does not go unpunished and that no one is above the law. Because there are laws on our settlement the also is an institution that ensures they are respected. Here everything will be judged and saw to that justice will be served.

These sections of the torus also have health care facilities a hospital for general medicine where you could come for anything from a bruise to a fracture and any kind of illness.

Another important type of hospital is the contagious disease hospital; this hospital will be just one for each torus. The need for a hospital for disease is because we can not mix people who just have a flu with people who have a potentially contagious type of illness.

This space settlement also has a mental health care hospital because people aren't used to living in space, in confined spaces, so their mental health could pose a problem for a good and healthy population.

We will also have an administrative building for each section of the torus. This is the place where people will be able to address and solve their every day problems and monitor the well being of the other institutions. This building will also have included the control center. The control center is located in the administrative building so that the response time, if something were to go wrong, would be minimum. The control center will monitor every aspect of the mechanically operated systems on the torus such as robots, elevators and life support system.

The space ports will also have a traffic control institution that will monitor the arrivals and departures looking for every possible miscalculation in the spaceships trajectories trying to avoid collisions or other errors.

The space ports will also have custom services, this will prevent known criminals from trying to enter and also prevent contraband. Here you can also find a police section and a firefighting department to improve the security of our citizens and any other travelers who visit our settlement. This firefighting department will also have a paramedics unit, in case of an accident happening.

Schools will be in each section of the torus, because Ragnarok puts accent of its education system it will have a playground, fitness rooms and a place where sports will be practiced. Although schools are on every section of the torus the space settlement will have only one University with all the necessary facilities for a proper high level education.

10. Economical system

The economical system on Ragnarok is going to be organized like a "Hands-off" system, this means that the executive power of the settlement has full control over its economical enterprises and manages its own resources. No monetary currency is going to be used on the Ragnarok, every person will do their part of the job they're assigned to do and therefore will receive every single accommodation that they require such as food, clothing, transport means and health. Although upon the Ragnarok no currency will exist the inhabitants will have a monthly payment delivered to an account on Earth in case they choose to leave the station or leave for their family.

Where will Ragnarok get money from? To answer this question we have to look at what the station produces, due to the big distance between the station and Earth items with high volume are not able to be sent back on Earth. To solve the economical issue Ragnarok is able to send a part of the energy is acquires from solar power back to Earth as "green energy" via microwaves, this can be done because the amount of solar energy accumulated by the solar panels is much higher than the requirement for the station.

Another way to improve the economical situation a "Space Hotel" will function aboard the station where enthusiasts can have a vacation in outer-space.

One advantage of this station is it's positioning, since it is in space satellites can be constructed and sent into orbit over the Earth, thus reducing the cost of sending satellites and space crafts into space from Earth because of the fuel consumption.

Research on the Ragnarok should help the research into different technologies that can be later sold to Earth, one technology will particularly be developed and later sold back to Earth and that is "nanotechnology". And also there is going to be used the method of growing crystals at 0G.

This methods should help repay for the cost for the construction of the station, we hope that the station can fully recover the amount spent on construction in about 150 years.

Space tourism is said to come at a launch cost of about 200$./kg, adding extra expenses for accommodation will come at about 10,000$/day adding the transport to the station expenses of roughly 20,000$, every person willing to visit the space hotel has to book a minimum of 10 days of accommodation. There will be 2 hotels aboard the station each having a capacity of 400 guests, in total the hotels will give a profit of 2,920,000,000$/year.

The energy produced by the solar panels is more than enough to sustain Ragnarok so therefore the excess of energy is going to be sold to Earth via microwaves. At a cost of 19cents/kWh, the excess of energy of about 190,130 kW/day. This will provide the station with and income of about 14,000,000$/year.

Mining from the moon will bring a large deal of money to the station, mining will be done on the moon as well as on meteorites. Mining on the moon will provide us with:

1. Helium-3, rarely found on Earth, it is a requirement for nuclear fusion and at a price of about 1 billion dollars a tone, there is an estimated 1,000,000 tones of Helium-3 on the Moon's surface. At an estimated production of 1 tone/ day of Helium-3 this method can bring about 365,000,000,0000$/year.
   (**http://fti.neep.wisc.edu/presentations/glk_isdc.pdf**)

2. The second mining prospect would be that of mining the metallic contents of asteroids (titanium, cobalt, platinum), it is estimated that a small metallic content asteroid with a diameter of about 1 mile can contain $20 trillion worth of metals.

The total profit that Ragnarok should have/year is estimated at about $1 trillion/ year.

11. Education

Ragnarok's population starts at about 25 thousand residents and it should reach maximum capacity in about 100 years. One of the main problems will be the education system. The education should be top notch because in 100 years almost all the residents will be raised and educated on the settlement, except for the people who just moved there. The education should cover all domains and make the people fully prepared to live and work in space on the settlement.

All forms of education are compulsory for all the residents the people will get out of school well prepare for life. The first eight grades will have the same curriculum this consists of two foreign languages (the most used languages on the globe) and the option to study even more but this just after you have learned the first two, mathematics, physics, engineering, chemistry, biology and IT. This are the basic must have curriculum but the residents can also choose to study history, geography and arts.

After the first eight grades the students will have to enroll in high schools which will be only two per torus, the high schools will live up to the students to choose what they want to study.

There will be only one university on the settlement and it will prepare the students for all the jobs needed on the settlement. The University will have different selection methods than the previous forms of education. Because of the limited number of jobs on the space settlement and the fact that we can not have people who are unemployed the University will prepare you strictly for the job you will take after finishing your studies so when you enroll in a branch of the University you will automatically have chosen what your job you will have. The selection method will be the following: the number of jobs free in a field of activity will be equal to the number of places in the section of the university that prepares you for those jobs; the high school graduates will receive a psychological test, followed by a preferences test and a test of skills showing which fields of activity you are good at. From the results of this test you will have to choose what you prefer. Then from your choices you will be distributed at the field you are best suited for that still has free places.

12. Leisure quarters

Each section of the torus will have its leisure quarters. It will be situated in the residential area no.4. A place for people to have fun is very important for the mind and body. A study has showed that children who play a lot when they are small will be smarter than children who do nothing all day.

The leisure quarters will have a shopping center, with the same facilities as a mall. It will have bowling, pool tables, arcade games, shops and 2 cinemas. It will adapt on the requirements of the public. This will be the "in door activities" but the most important things of the leisure quarters will be the out door activities: the park and the sport courts.
In the leisure quarters there will be a main park of about 400x 200 m with a lake, benches and a fountain a mainly a place to relax after a hard days work. In order to live a healthy life sport is the one of the most important factors. The sport facilities will be ten tennis courts two football pitches, one rugby stadium, two swimming pools and five basketball court.

As for the people of the space settlement to maintain themselves fit we also have in the leisure quarter two gyms.

As a cultural activity each torus will also have a theater and an opera.

Each section of the torus will have the following attractions: one main football pitch, one baseball stadium, one rugby stadium, one carting racing track, two hotels and two amusement parks.

The amusement parks will have a Montaigne rouse, bungee jumping cords, fairy wheel, carousels and sweets stand.

The best leisure activities will be "Variable g entertainment" located in the cylinders that are located on the transportation channels. The cylinders will have a radius of 50m and a height of 100m. As the name suggests this cylinders can move along the transportation channels creating whatever gravity you would like. There are a total of eight cylinders each of them having two sections each with its own attractions, each attraction occupying a section. There will be two sections for swimming pools, two for basketball courts, two for football pitches, two for dodge ball arenas, one for badminton, one for volleyball, one for handball, two as playgrounds for smaller children and three for paintball fields.

13. Industry

The heavy industry will be an important part in the development of Ragnarok. The main industrial activities that will take place on Ragnarok will be spacecraft construction, metallurgy and robot construction.

The cylinder located on the central axis will consist of 4 independent modules, equal in dimensions, that will connect through a clamp-based system.

Element	*Radius(m)*	*Length(m)*	*Quantity*
Cylinder	200	480	1
Module	200	120	4

Each section of industry will benefit from resources mined from the moon or produced within the industry. Each load of cargo brought from the moon will be discharged into the spaceport and then distributed mainly to the heavy industry through the central axis.

Module 1—Offices and labs
Module 2—Metallurgy and Construction
Module 3—Spacecraft construction
Module 4—Robot construction

13.1 Metallurgy and Construction

The ore mined on the moon will be transformed into ingots and then transported to the station. Here the ingots and the raw materials will be processed and transformed into usable materials needed to build robots, spacecrafts and elements of the space settlement.

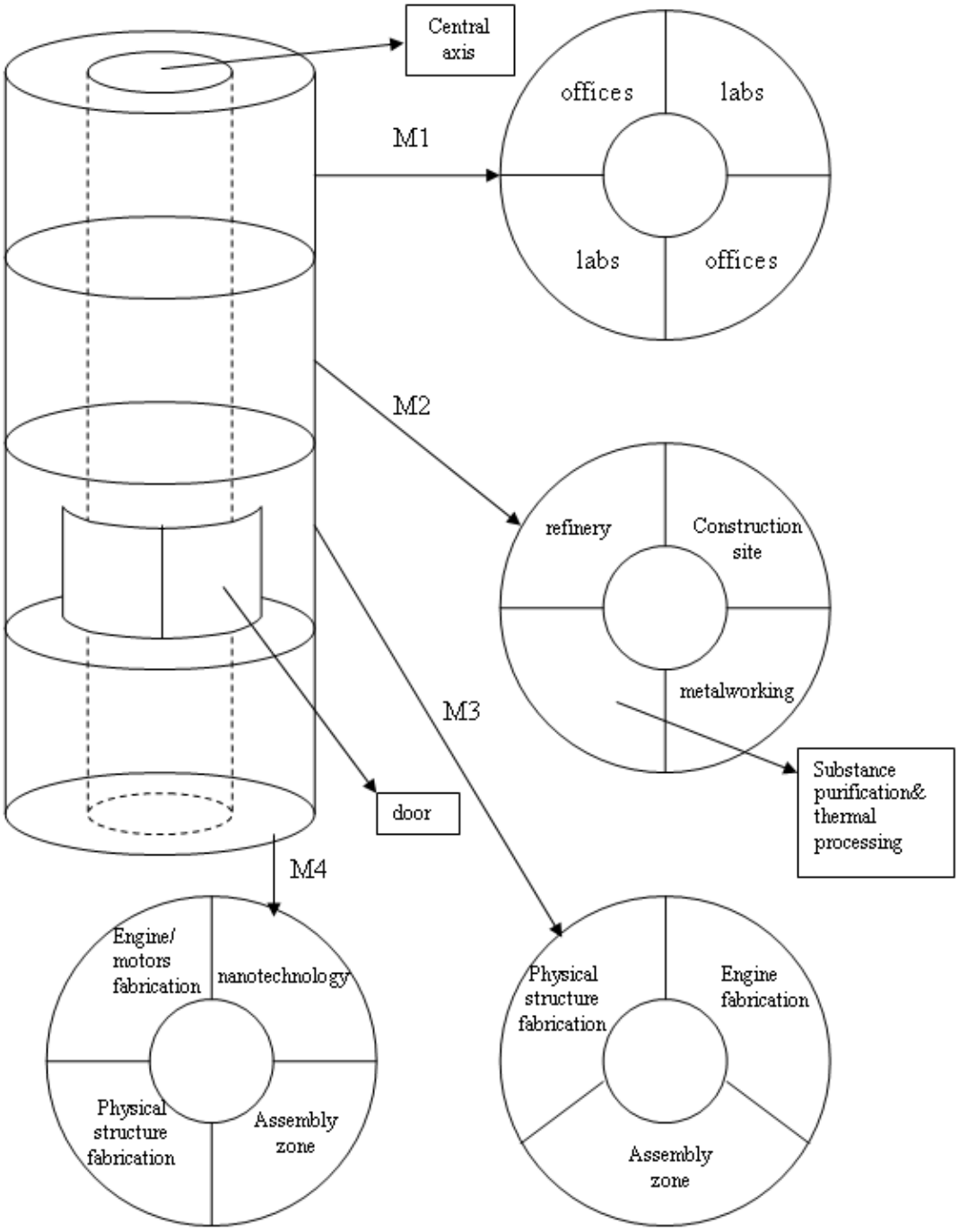
13.2 Spacecraft construction

The main resources will be provided by the metallurgy branch. The module will contain several automated plants that will fabricate pieces of the spacecrafts and an assembly zone. It will have also a sliding door that will make it possible to take out the already-built spacecrafts into outer space.

13.3 Robot construction

This area will provide robots for every kind of use: maintenance, construction, assembly, exploration, household, humanoid, and spacecraft electronics. The technology needed for fabricating each type of robot will be researched within the variable gravitation labs.

After finishing the process of building the space settlement, the purpose of industry will be to produce valuable goods that will be sold on the Earth in order to generate income that will be used to pay back the money loaned for building the station.



14. Research laboratories

14.1 Aerospace engineering

Aerospace engineering is the branch of engineering behind the design, construction and science of aircraft and spacecraft. These vehicles are products of various technologies such as aerodynamics, aviation electronics, materials science, propulsion. This lab will be led by the best engineers in the world that will research new ways of upgrading the existing technology or create and develop more efficient ones.

14.2 Robotics

Robotics is the engineering science and technology of robots, and their design, manufacture, application, and structural disposition. The scientists will research in electronics, mechanics and software providing new or improved technologies and new uses to robots in ordinary life.

14.3 Space exploration

The location of the station favors an easier exploration of the outer space. This can be achieved in two ways, by observing it from the station and by doing space missions with human crew on board of spacecrafts. The second Lagrange point is a good space-based observation point. Any object will maintain the same direction regarding Earth and Sun, making it easier to shield and calibrate.
The necessity of space exploration can be explained by the possibility of human race extinction, Earth destruction or by the lack of resources.

14.4 Genetics

The biologists researching heredity and variation in living oraganism will try to provide the best answers to the nature's enigma and make important discoveries while trying to elucidate problems that bugged human society along the time, human cloning or finding cures to lethal diseases such as cancer.

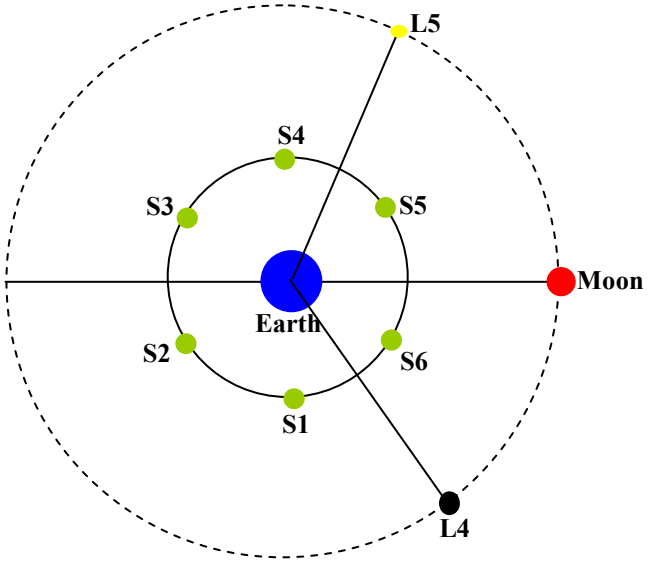
15. Communications

Communications on Ragnarok are very important between the space station an Earth, but also between the Moon and the station as well as internal communication between the inhabitants and different sections.

15.1 External communications

15.1.1 Ragnarok-Earth communications

Communications between the Earth and the station are very vital to the settlement so a series of satellites will be placed on a geostationary orbit (36,000km above sea level) so as the revolution period of a satellite is approximately the same as the Earth. As our station is located in L5, Earth will have to be orbited by 6 geosynchronous satellites. The information required to be sent will go from Ragnarok to the closest of the 6 satellites and then the signal will be further sent from satellite to satellite to the one hovering closer to the destination of the information.



15.1.2 Ragnarok-Moon

As important as having to communicate between the Earth and the station is the communication with the Moon this will be done by placing a satellite in L1 which if necessary will further send the information to two other geosynchronous satellites so that coverage can be made on the entire surface of the Moon.

15.2 Internal communications

The internal communications between the inhabitants are going to be done by intranet, most devices requiring to be connected to a series of optic fiber and eight servers, one for each section of each tor. To minimize the risk of interference caused by wireless networks the usage of these networks will be kept at a minimum and mostly as a bypass to the optic fiber network in case it should stop.

16. Final Expenses

Element	*Cost*
Outer Shield	**$5*10^{12}$$**
Houses	**$760*10^{6}$$**
Satellite	**$2*10^{9}$$**
Lunar base	**$30*10^{9}$$**
Transport	**$7,6*10^{6}$$**
Robots	**$2.5*10^{9}$$**
Settlement materials	**$14*10^{12}$$**
Earth base	**$2.8*10^{9}$$**
Photovoltaic cells	**$600*10^{6}$$**
Salaries	**$1.5*10^{9}$$**
Total cost	**$19.1*10^{12}$$**

Bibliography

1) http://science.nasa.gov/headlines/y2002/solarcells.htm

2) http://lifesci3.arc.nasa.gov/SpaceSettlement/designer/sphere.html

3) http://ares.jsc.nasa.gov/education/websites/craters/lgg.htm

4) http://www.nasa.gov/vision/space/travelinginspace/radiation_shielding.html

5) http://www.thespacereview.com/

6) http://www.spacefuture.com/archive/the_technical_and_economic_feasibility_of_mining_the_near_earth_asteriods.shtml

7) http://www.ucc.ie/academic/chem/dolchem/html/dict/electrol.html#ElectrolysisSulphuricAcid

8) http://www.globalsecurity.org/military/systems/ground/rowpu-3000gph.htm

9) http://dspace.dial.pipex.com/town/street/pl38/sect2.htm

10) http://www.msnbc.msn.com/id/8976160/ns/technology_and_science-science/

11) http://fti.neep.wisc.edu/presentations/glk_isdc.pdf

12) http://www/esa.int/esaSC/SEMM17XJDIE_index_0.html

13) http://www.deicon.com/tuned_abs_damper.html

14) http://www.rechargeable-battery-review.com/articles/consumer-batteries/pros-and-cons-of-battery-technologies-used-in-cameras.html

15) http://www.envacgroup.com/web/Stationary_vacuum_systems.aspx

16) http://www.freemars.org/l5/aboutl5.html

17) http://yarchive.net/space/spacecraft/artificial_gravity.html

18) http://www.esa.int/esaSC/SEMM17XJD1E_index_0.html

19) http://www.globalsecurity.org/military/systems/ground/rowpu.htm

20) http://www.aerospaceguide.net/spacerocket/aresv.html

21) http://www.area51zone.com/aircraft/x33.shtml

22) http://www.permanent.com/a-index.htm

23) http://www.wisegeek.com/what-is-membrane-filtration.htm

24) http://www.censusscope.org/us/chart_age.html

25) http://english.jr-central.co.jp/news/n20050701/index02.html

26) http://en.wikipedia.org/wiki/Demography

27) http://en.wikipedia.org/wiki/Hydroponics

28) http://en.wikipedia.org/wiki/Xenon_arc_lamp

29) http://en.wikipedia.org/wiki/Kevlar

30) http://en.wikipedia.org/wiki/Ram_accelerator

31) http://en.wikipedia.org/wiki/Photosynthesis

32) http://en.wikipedia.org/wiki/Economic_system

33) http://en.wikipedia.org/wiki/Ultraviolet

34) http://en.wikipedia.org/wiki/Steam_rocket

35) http://en.wikipedia.org/wiki/Reverse_osmosis

36) http://en.wikipedia.org/wiki/Composting_toilet

37) http://en.wikipedia.org/wiki/List_of_noteworthy_asteroids

38) http://en.wikipedia.org/wiki/Greywater

39) http://en.wikipedia.org/wiki/Blackwater_%28waste%29

40) http://en.wikipedia.org/wiki/Vitamin_D

41) http://en.wikipedia.org/wiki/Maglev_%28transport%29

42) http://en.wikipedia.org/wiki/Magnetic_levitation

43) http://en.wikipedia.org/wiki/List_of_orbits