Spaceutopia

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Contents

INTRODUCTION

1.1 Executive Summary

Spaceutopia is a space settlement in the Mars orbit which has a capacity to hold more than 12,000 people along with 2,000 species of plants and animals. The Earth will soon be unable to sustain life on it due to the exploitation we humans are causing and Spaceutopia is the first among many settlements which would help humanity to survive.

The settlement will be created in 5 phases which would result in the construction of a central cylinder around which would be 5 tori with each having a different purpose. The central cylinder would be the hub around which the tori rotate.

The residential torus would be the innermost tori and would be equipped with the latest technologies in order to fulfill every need of the people. Water and food - two of the most important things for survival - would be generated on the settlement itself instead of bringing it from Earth. As Spaceutopia is designed primarily for the settlement of human beings, the settlers would be provided everything essential for them to live happy lives, including facilities like healthcare, education and even entertainment.

Spaceutopia would be filled with advanced technology to maintain communication and transportation facilities. It would also conduct special excavation tasks in order to obtain more resources. These resources would be allocated to industries that manufacture goods for people and inter galactic operations.

For Spaceutopia, to survive in outer space it must have a proper defence mechanism for protection from both charged particles (like sun rays) and other astronomical objects. This is done in a variety of steps to ensure maximum safety of the people.

Lastly, Spaceutopia will be a new beginning as it will lead to better knowledge of space. It would also prove to be a huge asset in the building of other space settlements.

1.2 Acknowledgement

First of all I would like to thank the judges who have spent so much time reading all the submissions and thanks to NASA AMES for organizing this contest and creating a platform for space enthusiast students. I would also like to thank my parents for encouraging me throughout the project. Finally this project would not have been possible without the support of my teachers.

1.3 Background

As we humans continue to design and develop Earth to make it a better place, we are actually making it a bigger version of Venus. With the huge amounts of CO_2 released, we are giving rise to global warming which is making our planet hotter and hotter each day; it is not too far-fetched to say that in the near future we will have to evacuate this planet and seek another home. Spaceutopia is made in order to tackle this problem and create a safe place where humans can reside.

1.3.1 Naming Philosophy

Looking at the current scenario it is clear that our home planet will sooner or later no longer be a place to live and thus we have to find an alternate place we can inhabit and make our new home.

The name is chosen with a similar view in mind. Spaceutopia is made from the words ‘Space’ and ‘Utopia’. Space is the location of the settlement and Utopia literally means paradise. So Spaceutopia is a paradise in space which is created for humans to live on. Spaceutopia is referred to as a paradise because it would provide all the things that a paradise has. Right from the beginning people in Spaceutopia will encounter a comfortable and joyful life. The advanced technologies helping them out at every step would make them feel special and thus will provide an unimaginable experience.

1.3.2 Orbital Location

Location is considered to be the most important aspect of a settlement as it determines its success. The location must be resource-rich, as the resources are used for not only its construction but also for the daily needs of the settlers and thus aid the future life. Thinking of the most economically feasible and practical ways we must find a place in our galaxy not far from Earth which can provide the essential resources while keeping the safety of the settlers as the topmost priority -

I. Lower Earth Orbit

A settlement here would be very insecure because of the deteriorating atmosphere and there won't be enough resources apart from Earth (which is already over exploited), thus ruling it out.

II. Lunar Orbit

Although lunar orbit proves to be a resourceful place to reside with close proximity to Earth, there are better settlement options (like the Mars Orbit).

III. Venus Orbit

Though rich with resources we still haven't found ways to harvest these resources. Further, Venus orbit does not have any moon from which resources could otherwise be extracted.

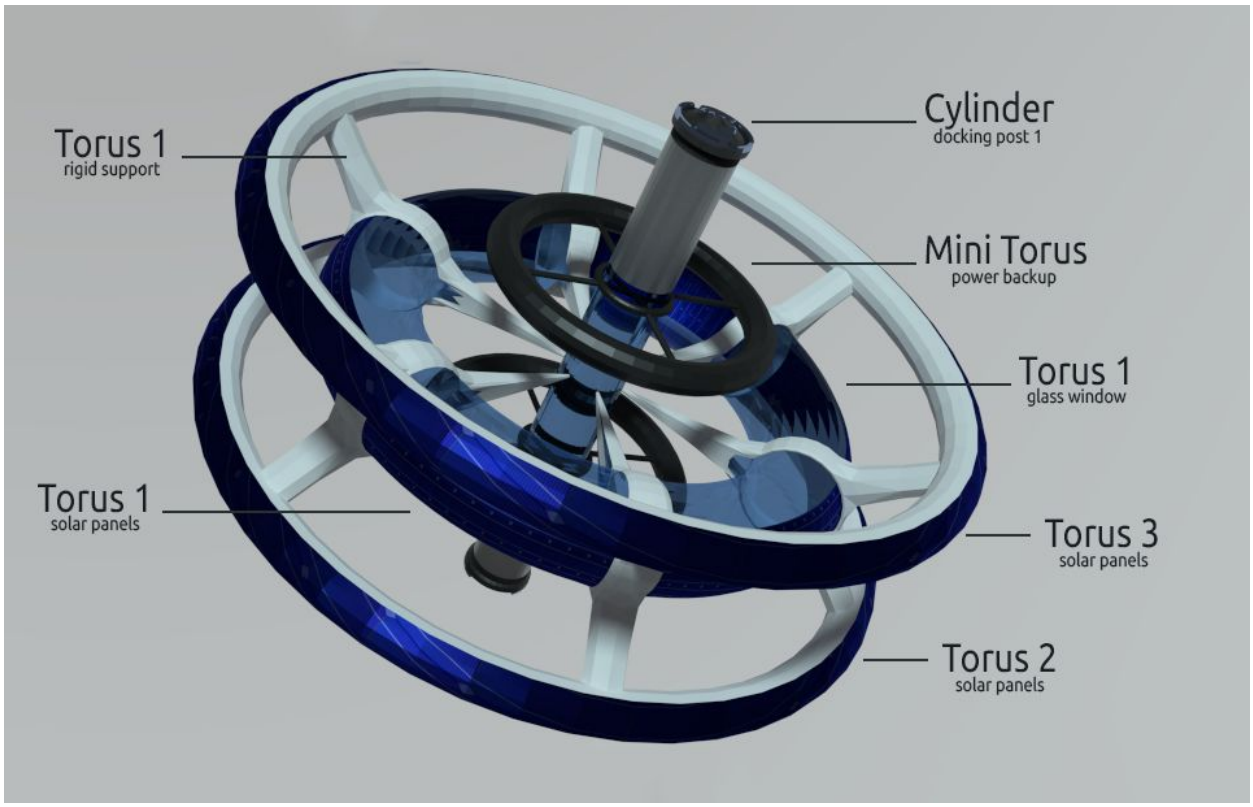
IV. Mars Orbit

With Mars closely resembling Earth in many aspects and the discovery of frozen water deep under surface, it seems to be a good place to settle. It also has two moons (Phobos and Deimos) which prove to be good resources for various useful minerals. Finally, the location is in close proximity to the asteroid belt present between Mars and Jupiter which can further prove to be very beneficial with all the resources that can be excavated from these asteroids.

STRUCTURAL DESIGN

2.1 Structural Overview

Spaceutopia is divided into three main rotating tori which are connected to each other with rigid supports and the central torus is connected to a stationary cylinder. At the ends of this cylinder are docking ports which can get attached to a docking station in case of surface landing. The structure is designed laterally symmetrical in order to maintain its balance.



2.1.1 Central Cylinder

The central cylinder is a key component of Spaceutopia as it brings together all the components into one body and has the engine which provides electricity from the mini tori to other segments. This cylinder is designed to be stationary while all the other sections revolve around it.. To the ends of this cylinder are fixed two docking posts.

Further this part of the settlement has zero gravity and is thus a suitable place for conducting research as well as performing certain zero gravity activities.

2.1.2 Residential Torus

The Torus 1 is the residential torus and is relatively bigger than the other tori with an inner radius of 321m and an outer radius of 780m. With its massive size it can accommodate a population of 12,000 people with a space of around 400 non-residents. It also has a transparent glass like surface so the residents could enjoy a clear view of the outer space.

Managing Zero Gravity

The mass of this torus is equivalent to the total mass of the other two tori and rotates in the direction opposite that of the other two in order to avoid the gyro effect. The pseudo-gravity here is approximately 0.9g (g = gravity on Earth) which is sufficient for human beings to adapt to without causing harm to their health.

According to Newton's Second Law –

$$g = a_c = v^2/r$$

where g = acceleration due to gravity acting on torus,

a_c = centripetal acceleration,
v = velocity of torus,
r = radius of center of mass

With this expression we can calculate the minimum speed with which the torus should move in order to provide the necessary acceleration due to gravitation. Calculations show that the torus must move with a speed of approximately 60 meters per second to achieve the optimum gravity.

2.1.3 Agricultural Torus

The Torus 3 is divided into two parts. The bigger part (approximately 68%) is assigned for agricultural use. This torus is also maintained under pseudo-gravity of 0.9g although this torus rotates with a larger speed than the main torus to counter the larger radius.

Sun rays cannot reach every crop as some part of the torus will be under the shadow of the other structure. This will cause unequal growth of crops and thus give a lower yield. Therefore, the torus has been entirely covered so that sun rays cannot pass through at all. Instead the interior is lighted with glow light (commonly

called plant light) which is an artificial light source. It emits an electromagnetic spectrum similar to that of the sun rays in order to foster plant growth. This increases the yield product.

2.1.4 Wildlife Torus

The rest of the Torus 3 is devoted to wildlife. This torus is inaccessible to the general population and a forest ranger can only go inside. This torus has around 2,000 different species of living organisms, both microbial and large mammals. This place is equipped with security cameras to monitor the animals for changes that might develop due to the artificial gravity and the enclosure.

2.1.5 Industrial Torus

The whole of Torus 2 is used for industrial activities apart from a few quarters which are used for research and development purposes. This torus, unlike other tori, is not at a constant gravity. The gravity changes between a few fixed values over a period of a week which is useful for both the industries and the researchers as they can perform some tasks easily at certain gravity.

2.1.6 Mini Tori

Two unique tori have been set up in order to create a power backup for the system. These two tori are oppositely placed on the center cylinder and are accessible only by the officials. This part is the powerhouse of Spaceutopia and has a power backup of 120 terawatt (TW). Apart from this, the tori is uniquely designed to convert the thermal energy directly into electrical energy by using a thermal generator. This is very effective in power management and saves a lot of energy which can be used elsewhere.

2.1.7 Administrators Sector

At the center of the main cylinder is the administrators sector. Everything in Spaceutopia is controlled through this structure and is thus accessible to only the senior officials. Although the system is designed in such a way that it can operate on its own without the aid of humans, engineers still pay frequent visits to this sector to check the proper working of the system. This sector also has its own propellant system as this will be the first component to be built (discussed in section 2.2).

2.1.8 Storage Sectors

The storage sectors are located in the main cylinder and are accessible only by the officials. These sectors hold the bulk food grains at low temperature to conserve them for longer periods of time. In case the plants fail to grow due to crop destruction, these food grains could be used instead.

2.1.9 Transport Sectors

There are seven transport sectors in all, which are located at the central cylinder. These are designed to be very big as they have to store more than 40 mini space ships, 20 larger ships and 4 heavy expendable launch vehicles. This sector would be constructed much later only after the research and development processes start taking place.

2.1.10 Connecting Channels

These connecting channels are an important part of the structure as these keep the structure together and also allow easy movement between the different tori. The channels are designed in such a manner that every place is accessible from the residential torus to facilitate easy access to the residents.

These channels are fixed to the central cylinder and are thus stationary. There are special channel paths developed inside the tori which take you to these connecting channels. Otherwise, travelling between could have not been possible due to the difference in speed and direction of different tori.

2.1.11 Microgravity Sector

The microgravity sector is made in order to provide recreational activities for children where they can learn more about zero-gravity by exploring it. There is one big sector and inside it are 4 sub- sectors called chambers where various activities are performed. These systems are under constant development in order to make a more effective learning experience for the visitors.

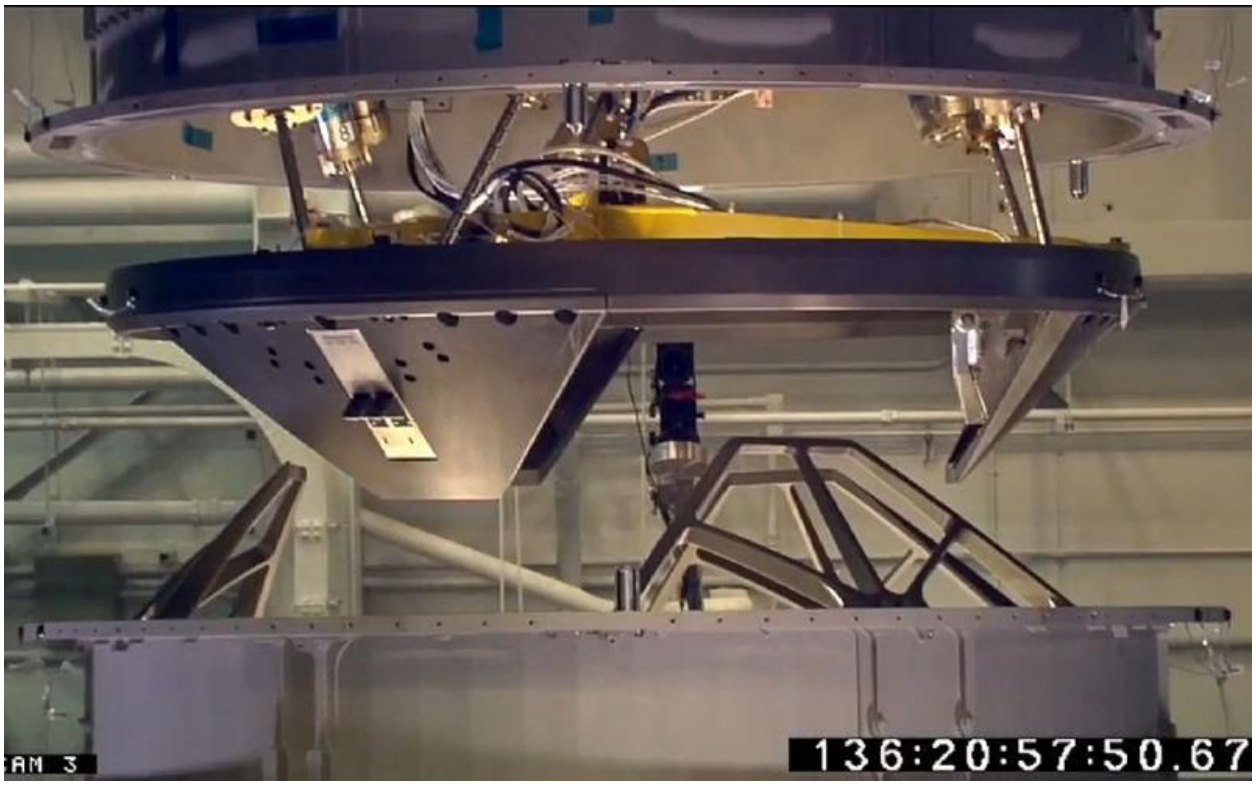
2.1.12 Docking Posts

These are located at the poles of the central cylinder and play a crucial role for landing on a planet or any other heavenly body. Once the posts come in contact with the docking station, they get attached to it. This docking station can be placed

beforehand on the surface in order to dock the settlement later. Initially the docking station would be set up on both Phobos and Deimos and docking will take place after every few months in order to take in useful construction material from them.

Docking Mechanism

The docking mechanism uses the NASA Docking System which is designed for the sole purpose of docking of human space flights. It uses low impact technology to transfer power, fuel and many more useful things.



NASA Docking System (active androgynous variant on top, permanently passive variant on the bottom)
Photo Credits - NASA

2.2 Construction Phases

The settlement is supposed to be constructed over a period of 9 years and is planned to be executed in five main phases. The earliest of construction work will begin around 2050.

2.2.1 Phase I

Construction of Central Cylinder on Earth

The central cylinder (which is the base for the settlement) will be constructed in two parts out of which one part will be constructed on Earth along with some sub-parts of the other structure which otherwise would not be possible to create in the outer space. This would approximately take 2 years for construction. The administration sector would be the first to be built as this would be used to control every other part and as a result would have the maximum strength in order to withstand the harsh conditions of outer space. This part will also be equipped with powerful thrusters in order to facilitate its movement once it reaches the orbit.

Construction of Launch System on Earth

A launch system consists of a launch vehicle, launch pad, and other infrastructures. Initially there would be several requirements for the purpose of construction, including food, construction material, and the engineers who would make the settlement. So we must find a heavy lift launch vehicle which can carry all this is one go.

For a heavy lift launch vehicle we plan on using Space Launch System (SLS). The SLS is similar to Saturn V in its payload capacity and will thus be suitable to carry both the crew and the construction material in a relatively lesser time to the destined Orbit.

But even with the use of one SLS, there won't be sufficient amount of construction material available to build the settlement. Thus we must build two SLS to have sufficient material for construction as well as ample amount of food for a whole year.

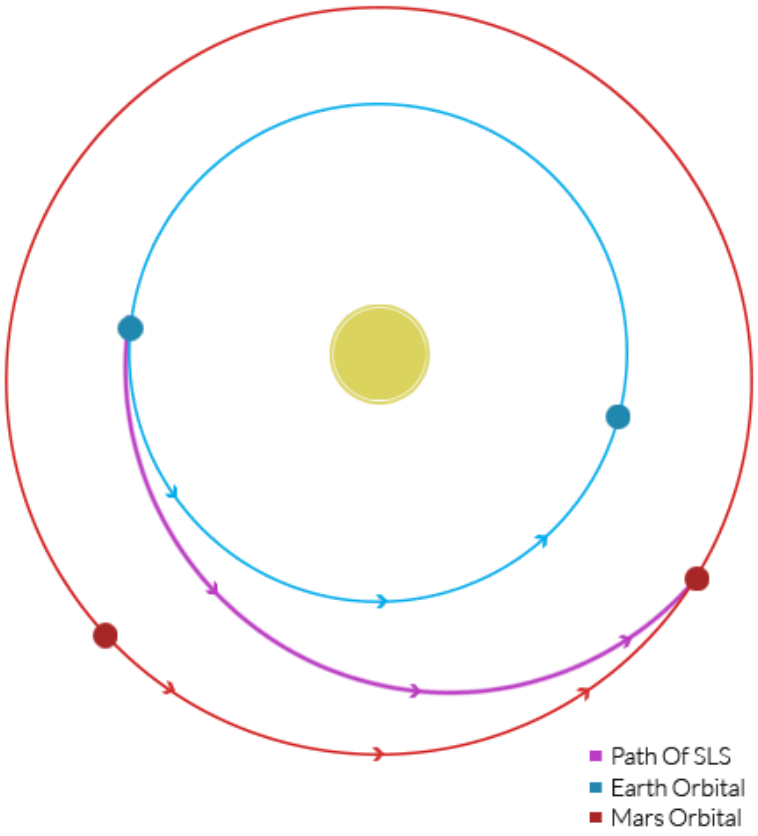
Construction of Central Cylinder on Mars

On Mars the engineers would construct the remaining parts of the central cylinder which would take approximately eight months. They would also make changes to the SLS so that they could send the components in the Mars orbit for attachment with the main components of the cylinder that will come from the Earth.

2.2.2 Phase II

Orbital Insertion

Once the upper stage of the rocket completely burns away, the SLS sets to the Mars Orbit in the Hohmann transfer orbit which is an elliptical orbit used to transfer between two circular orbits of different radii. This process approximately takes another eight months for the SLS to reach and join the Mars orbit. After the insertion is complete, the components from Mars are deployed in order to join to the main cylinder. The engineers also come to the main cylinder in order to help with the rest of the construction work.



2.2.3 Phase III

Assembling the Central Cylinder

After the components of the central cylinder arrive from Mars, the construction on Spaceutopia will begin. The first leg will be connecting the components of the central cylinder so that the main cylinder is complete. This would comparatively require lesser time and would be completed within a month.

Construction of Mini Tori

After the central cylinder is ready the next important thing will be the power source of the structure which would come from the mini tori. This would be a very important and expensive task as this holds the future of settlement. This would further take another year and a half for its construction. And after construction is done this would be connected to the central cylinder.

Sending back 1st SLS

Now the SLS which was stored after repairing and fueling would be sent back Earth with the statistical data collected and some engineers who have completed their work and are no longer needed at the settlement.

Construction of Rigid Supports

Construction of the Rigid Supports would be the next part of the construction. The material for these would be brought from the Earth during the initial launch. These must be designed with lightweight yet strong material to support the other three tori. This would approximately take six months of time to be fully constructed.

Construction of Outer Residential Torus

This part is one of the most time consuming tasks but initially only the outer structure would be constructed. Some of the construction material for this would be taken from the ongoing mining and resource extraction processes which would already have been in progress by this time. The solar panels are set up as early as possible in order to get maximum energy which was earlier obtained from the power backup of mini tori. After setting up the solar panels, the windows are made

from which residents can see artistic views of space. These windows, although they might look like ordinary glass, are actually made up of many layers of a combination of tempered glass and other strong materials to bear the pressure difference created inside. It would take approximately one and a half years to complete just the outer parts of this torus.

2.2.4 Phase IV

Replenishing Resources

By this time the food reserves would have completely finished, so in order to get more food and more construction material the SLS that came back to Earth will be again repaired and fuelled. Some more engineers would be sent to the settlement to make the process faster.

Construction of Inner Residential Torus

Once the outside surface of Residential Torus is complete, the working on the inside would begin. This process is also time consuming as it requires the building of houses as well as places for entertainment, educational institutions and commercial quarter. This construction will continue even after the inhabitants move in. So to avoid wasting all the time in constructing this part, the construction of this torus will thus happen simultaneously with other construction work.

Construction of Other Two Tori

After the Residential torus is ready, the work on the other two tori would commence. Much attention would be paid to the outer surface first in order to get more energy from the solar panels present there. The conditions in these two tori will be made according to the basic requirements for their specific functions.

The Agricultural Tori would be filled with grow light and would have a well-designed water supplying system in order to avoid wastage.

The Wildlife Tori will also have a special underground water system so that the plants growing in this area can take in sufficient amounts of water. There would also be ample amounts of plants with fruits growing by the time wildlife actually steps in the place. There would also be an artificial pond for the animals.

The Industrial Tori would likewise have an integrated system for controlling the waste and the pollution caused by it.

2.2.5 Phase V

The last phase does not require any construction work but is still a very crucial part of the development of the settlement. This phase requires the testing of all the components to avoid problems for the inhabitants that would be soon joining.

Thus it would take 13 years at a stretch to make Spaceutopia a true paradise.

2.3 Construction Materials

A lot of construction material would be required for the production of the settlement. On the basis of the requirements for the settlement a list was prepared and an estimate was made on how much volume of material would be required. The table below summarized the list.

MATERIAL	VOLUME REQD.	USE
Carbyne	2,500,000 tonnes	Construction
Diamond	500 tonnes	
Graphene	1,500,000 tonnes	
Carbon Nanotubes	2,000,000 tonnes	
Carbon Fibers	1,000,000 tonnes	
Silicon Carbide	500 tonnes	Industrial
Aluminium Oxinitride Glass	1,000 tonnes	Windows
Palladium based Metallic Glass	1,000 tonnes	
Borosilicate Glass	1,000 tonnes	
Aluminosilicate	1,000 tonnes	
UHMWPE Fibers	1,000 tonnes	Radiation Shielding
HDPE Fibers	1,000 tonnes	
Polyethylene Terephthalate	500 tonnes	
Teflon	75 tonnes	Spacesuits
Kevlar	75 tonnes	
Titanium Carbide	100 tonnes	Industrial
High Speed Steel	1,000,000 tonnes	

OPERATIONS

3.1 Communication

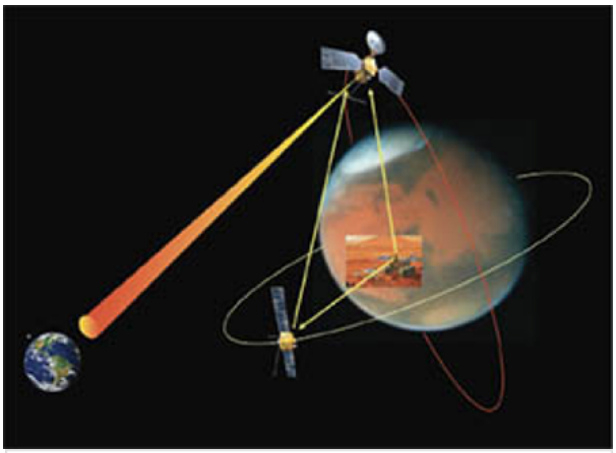
Communication is a very vital technology that must be well established both internally and externally with Earth and other space-crafts.

3.1.1 Internal Communication

Power-line adapters and optical fibers will be set in order to facilitate internal communication. A Power-line Communication (PLC) uses an internal wiring system to transfer data and electrical current at the same time and the optical fibers help create a local network. These local networks would be provided to portable devices throughout Spaceutopia using a suppressed light fidelity (SLi-Fi) which is a better version of the original light fidelity. This newer version would be designed to avoid the usage of ultraviolet rays which are bad for human health and instead uses advanced infrared technology.

3.1.2 External Communication

To overcome the enormous distance between Earth and Spaceutopia, deep space optical communication (DSOC) would be preferred over Radio Frequency (RF) as they can provide mass, power, and volume allocation benefits along with bandwidth allocation restrictions. The biggest challenge for DSOC is that it requires the detection of extremely faint signals, but this problem can be overcome by using atmospheric correction techniques.



Interplanetary laser communications concept demonstrating links from a Mars orbiter to Earth, and proximity links from Mars surface assets to orbiters. Photo Credits - NASA

3.2 Transportation

The next important thing is the transportation of people in space. The settlement will have its own SLS in the initial years and with the growth of both technology and economy, within the next 10 years of its placement it will have approximately four independent SLSs. These would not only transport the goods and people to and fro from Earth but would also provide the Earth with newer data from the findings of the space settlement. These new SLSs would be designed to capture most of the

Sun's heat to generate electricity and would also have hydrogen combustors to reduce the pollution caused by the SLS. Further there would be newer technology to recycle water from the fuel cells to ensure saving of resources.

3.3 Energy Generation

Energy is fairly considered to be one of the most important things as it is used for every activity that is performed on Spaceutopia. With such high demands for electricity there must be a lot of energy generated in order to meet the needs of every individual. This is done mainly in two ways –

3.3.1 Solar Panels

This concept is nothing new and requires the use of solar panels to trap the solar energy which is converted into electrical energy using the photovoltaic effect. The solar panels are located around the rim of the three main tori to capture most of the energy falling on them. This energy system is also prudent as the solar panels are 95% recyclable and in case of any damage they can be recycled easily. These solar systems are designed in such a way that they can generate approximately 27,400 terawatt (TW) of energy per year which is much higher than the electricity production on Earth.

3.3.2 Radiant Energy Power Generation

Nicola Tesla has been one of the greatest inventors of all time and had proposed a method to harness electricity from the atmospheric air. The idea is to first store the static electricity from air using unique rectifiers and then efficiently convert it into useable energy. Although the current produced is small, this current can be amplified in order to produce more electricity.

This system of electricity generation would be constantly developed as this method does not require much of cost and is fairly easier to establish.

3.3.3 Nuclear Power Plant

Some of the energy generation also takes place through nuclear reaction. The energy produced during the nuclear reactions generates a lot of heat which is used to rotate turbines and thus produce electricity. These power plants are located in the industrial torus and play an important role in providing electricity to this torus.

Strict rules have been made for disposing the nuclear waste and regular inspections are conducted in order to maintain the safety of everyone.

3.4 Protection

3.4.1 Structural Shielding

The shielding of the structure is a very important step as objects in space like asteroids might strike it. Thus a proper shielding mechanism must be there to protect it from both small and big asteroids. A proper Approaching Danger Detection Mechanism (ADDM) would be used to identify the type of object that is approaching the settlement and accordingly different mechanisms would be used to deal with them.

The larger asteroids cannot be destroyed and thus the settlement must move out of its way. In order to achieve this, the thrusters present along the central cylinder and at places on the rigid support would reduce or increase the speed depending upon the situation. Calculations based on the path of the asteroid and the settlement would tell which one is better between reducing and increasing the speed. Although increasing speed will be preferred as reducing the speed might displace the settlement of its orbit.

The smaller asteroids are comparatively easy to deal with. These can be captured by the asteroid excavating engine (AEE) and then propelled to a different location. This method is also beneficial in cases where the asteroid has useful minerals, these minerals can then be extracted from it. But in situations where there is not enough time for AEE to change the asteroid's course, the AEE would shoot lasers on it. These lasers would blast the asteroid and make it into dust.

3.4.2 Repairing

Special robots will be designed to fix any external damage. Although these robots will be programmed to fix up anything, in the rare cases they are not able to understand the fix required, a human engineer will be contacted for the job. This engineer would either guide the robots or would himself go to do the repairs. The primary advantage of these robots is that they do not require a space suit and can carry massive construction material on the go.

3.4.3 Radiation Protection

The main concern in space is particle radiations which are very dangerous for humans as they can damage the cells and DNA as they pass through their bodies. Luckily, these radiations are blocked by the magnetosphere which lies like a bubble around the Earth. But for Spaceutopia we don't have any layer of protection from these radiations.

There are mainly two sources of these radiations, one being the Sun which radiates constantly as well as the solar flares which occur due to large burst on the Sun. The other source is all the stars present in the Milky Way which radiate Galactic Cosmic Rays (GCR). To tackle these a systematized structure is essential.

A possible solution for this problem is using Hydrogen as a protection material in the construction, in addition to plastic which is also good at absorbing radiation. Hydrogenated boron nitride nanotubes (Hydrogenated BNNT) which are tiny, nanotubes made of carbon, boron and nitrogen with hydrogen occupying the empty spaces between the tubes can be created. These nanotubes can easily be generated with the trash that is generated, which makes the repair of these protectors easy. A fiber made from these nanotubes can also be used to make the spacesuits, vehicles other things which require radiation protection.

3.4.4 Heat Rejection

The heat energy from all the tori is transferred to the two mini tori through the method of conduction. The heat in the two mini tori is converted directly into electrical energy with a Thermoelectric Generator (TEG) which works on the principle of Seebeck effect. Not all of the heat is converted through this method, however, and the rest of the heat much be ejected. So an integral planar variable conductance heat pipe (VCHP) is used for the rejection of the remaining heat.

3.5 Resource Excavation

3.5.1 Mars Excavation

Mars contains huge amounts of useful material present in the soil as well as atmosphere. Though these earlier could not have been used due to enormous distance between Earth and Mars, with Mars now very close to home, mining it for resources becomes feasible. Now we can send big robots called Soil Excavation

Gigantic Bots (SEGB). These robots will be a bigger version of the current small Mars rovers and instead of being controlled by the humans would be controlled by their own artificial brains. They would use sensitive equipment which would predict the location of craters and volcanic regions where useful material is often found. Also with the gravity and magnetic measuring devices in-built in these robots, they will be able to better find the location of mineral deposits. These robots will also be equipped with a shielding mechanism from the dust storms that are common at Mars.

Soon a hub at Mars will also be set up from where the engineers can communicate with the Robots and can also help in mining on Mars. This hub would be chosen after dedicated studies at a place where the dust storms are not very frequent.

3.5.2 Asteroid Excavation

As the settlement is situated close to the asteroid belt, asteroid mining can be very useful. The extraction process does not require people to go on asteroids to extract useful resources, which could endanger their lives. Instead, robots which are specially designed for this purpose are used. There would be primarily 2 types based on the size of the asteroids.

Large Asteroid Mining

But not all asteroids can be captured by the ACM due to the size restrictions. Thus robots must be sent to the surface of these larger asteroids to extract useful resources. The robots would be consisting of two different types of robots. The first type of robots called Space Resource Detecting Robots (SRDR) would scout the asteroid one by one for resources using a special detector to find useful materials on the surface of the asteroids. After finding useful materials they would signal the second type of robots called the Space Resource Extracting Robots (SRER). These robots would then go to these asteroids and calculate the percentage of asteroid composition and then accordingly select the best way to extract them. These robots are designed with in-built drills and other essential tools for resource collection and sometimes they would also bring a piece of the asteroid back with themselves which can be studied by the scientists and can even be kept in the observatory.

All these robots will work on solar energy along with a power backup of 7 days in order to reach back home safely.

Small Asteroid Mining

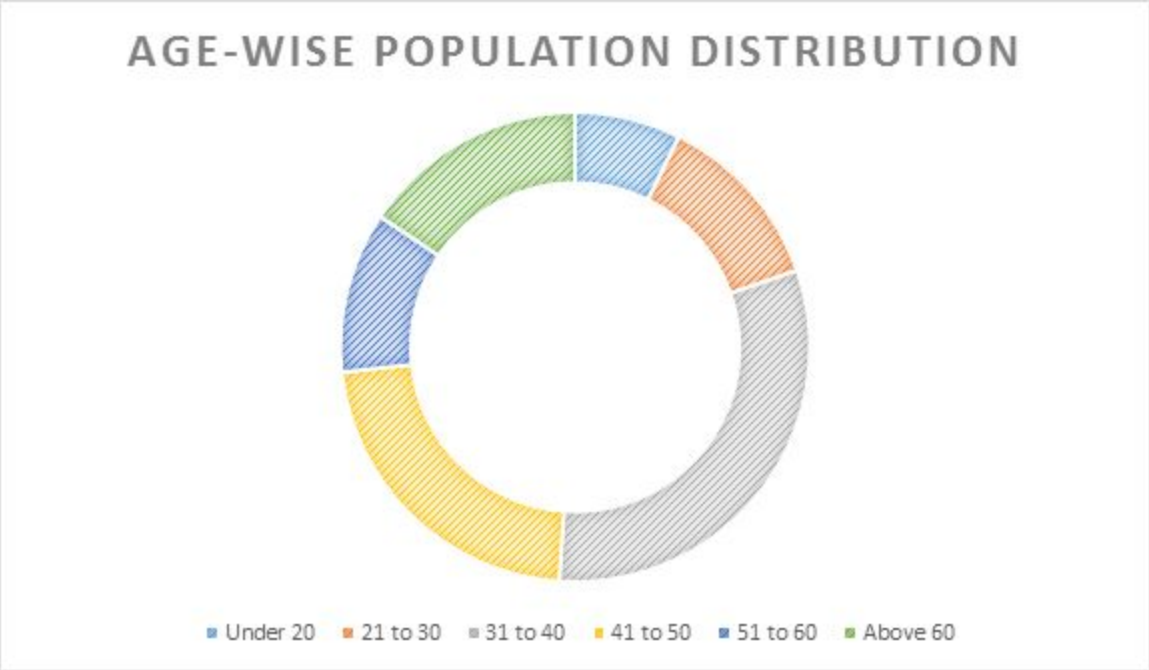
The Asteroid Capture Module (ACM) will be designed in order to capture small asteroids (up to a radius of 500 meters). The ACM will consist of an adjustable capture ring, carbon nanotube clamps and hydrogen propellers. Depending upon the size of the asteroid to be captured, the radius of capture ring will be adjusted. Once the asteroid is within the capture ring, the carbon nanotube clamps will be used to clutch the asteroid. Hydrogen propellers will be then used to navigate the ACM and decelerate the asteroid.

The ACM will be deployed from the launch pad hours before the approach of the asteroid to be captured. The ACM will therefore have sufficient time to align itself accurately according to minor deviations in the predicted trajectory of the asteroid to be captured in the final moments.

Image of the Asteroid Capture Module

HUMAN FACTORS

4.1 Residential Quarters



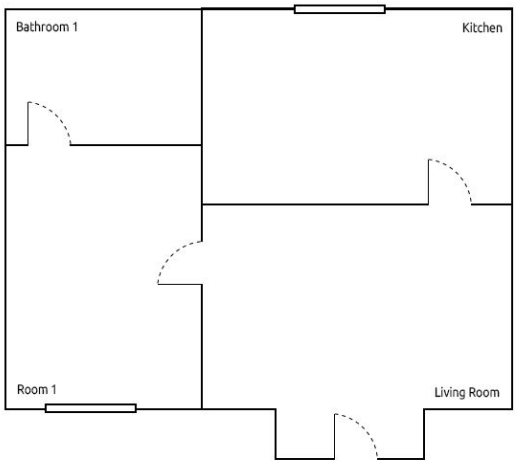
The Anticipated Demo-graph was created and a rough of the age distribution of people living on the settlement was calculated. According to the figures, four primary types of houses which would differ based on the family size were planned. But the house designs won't be restricted to only this as the inhabitants can rebuild their houses anytime according to their own requirements. The homes are designed keeping in mind all the basic requirements of the residents and follow the modular housing standards and are equipped with the latest technology to ease the life of people on the settlement. Although the houses might look simple at first, the modular approach makes them much more than simple homes.

The base walls of the homes would be created with stronger material for protection purposes while the other walls would be created with lighter material and would allow remodeling at lower costs.

Family Size = 1 or 2

Category = small

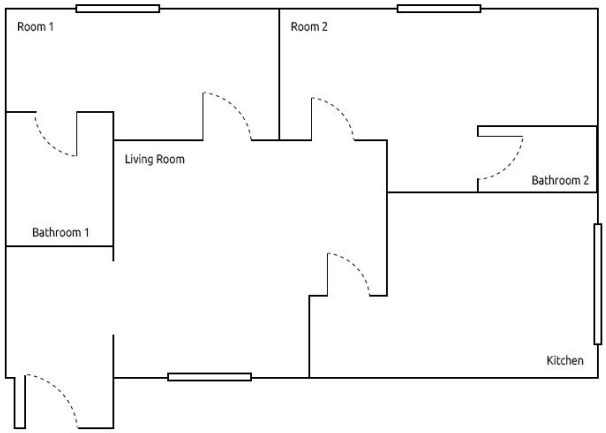
Plot Size = 800 sq. feet



Family Size = 4

Category = medium

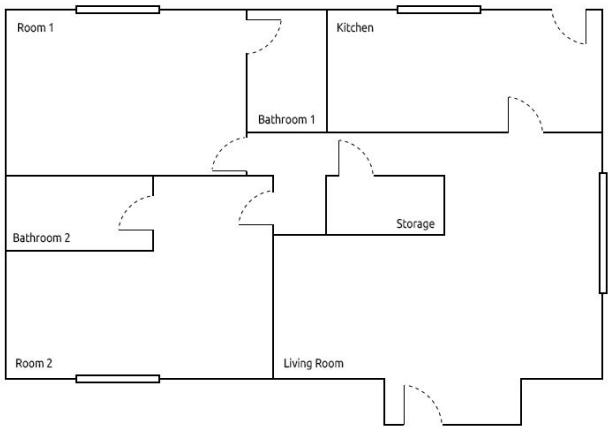
Plot Size = 1100 sq. feet



Family Size = 4

Category = large

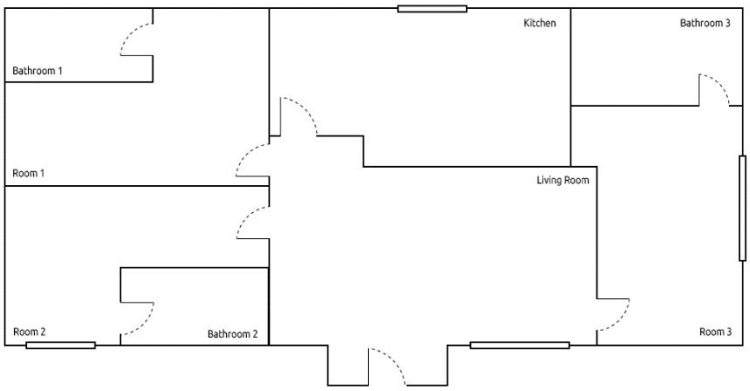
Plot Size = 1300 sq. feet



Family Size = 6

Category = very large

Plot Size = 1700 sq. feet



4.2 Home Automation

4.2.1 Personal Home Assistant

The personal home assistant is a conceptualized idea based on Artificial Intelligence. It is expected that Artificial Intelligence would have already been achieved by then. The assistant is supposed to manage all other appliances and help you with everything and anything you desire.

It also manages the security system of the house. Security will be based on an advanced system which works on a combination of factors like body heat, motion sensors, and face recognition systems. And if there is any intruder detected, the police force is immediately informed along with the other family members. Further if the intruder is detected to be alone in a specific room, the intelligent security system goes in a lock down mode thus not allowing the intruder to escape.

4.2.2 Surroundings Manipulator

With this system the inhabitant can easily make changes to their surroundings meaning that the people can change the wall paints anytime they like. But this is not the limit, they can also turn on the artificial sky mode which changes the roof of any specific room to appear just like the sky. This system is not based on real-time but is based on a previous recording, and people can use it to explore massive portions of the space (this only includes the places for which the data is available). The lighting is ambient and changes according to the surroundings.

4.2.3 Thermostat

A thermostat is a device which helps in maintaining the room temperature. Every room will have a separate thermostat so that different members of the family could have different room temperatures according to their preference.

4.2.4 Smart Mattresses

The mattresses will be designed on a simple principle – “everyone must feel comfortable” - and in order to achieve this the mattress changes its hardness according to the person’s preferences. The mattress also helps in giving a comfortable sleep by releasing a pleasant odor and controlling the body temperature - factors which are considered to be important for a good sleep.

4.2.5 Basic Household Work

Robots will be designed to complete basic household work like cooking, cleaning, watering and even feeding pets. These robots will reduce the workload on the residents who can then concentrate on their work, in turn leading to their success.

4.3 Improvised Accessibilities

4.3.1 Transportation

Public Transportation

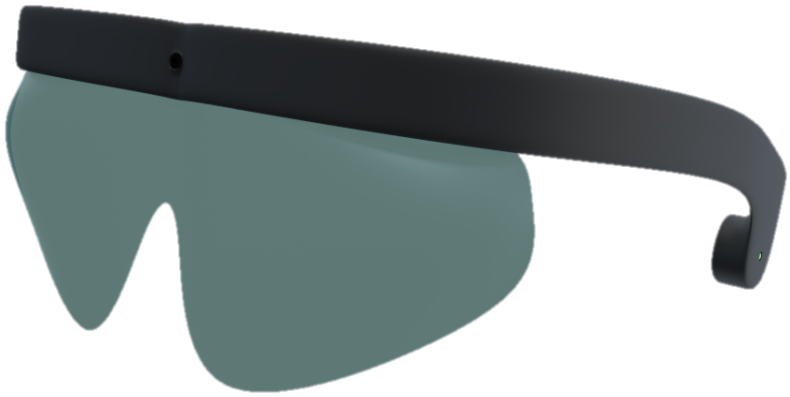
The Public transportation system is designed in such a way that people can have a safe yet faster transportation making it the most preferred mode of transport. For nearby places, people can use the self-driven bikes which are compact and can be ordered with a click of a button just like regular cabs. These can also be changed to manual whenever the person feels inclined to exercise. For greater distances, the self-driven cabs can be used, which allows the people to pool in making the transport cheaper and allowing social interaction. For travelling to much greater distances like the opposite part of the city or to some other tori, people can use the high-speed self-driven trains which work on the basis of magnetic levitation. All these would use electric power to run in avoid causing pollution.

Personal Transportation

People can buy electric pods for their regular commute which are self-driven and are designed to transport a maximum of 4 people. These pods would be programmed to take the people anywhere between the various tori and the passenger has to only enter the destination and it will take him there. The route is decided based on a number of factors and the one which requires the least time is chosen automatically. The pods also do not make any noise and are much safer modes of transport.

4.3.2 Glasses

Every individual will be issued a pair of glasses which work as a key to everything on the settlement. It is like a passport without which they have no identity. The design of the glasses would be such that they work only when worn by the person to whom they belong to so no one can steal your identity. The glasses also have a feature of reading your body's vital stats in order to keep track of your health, based on which it can tell you the right food to eat or advise you on other health related issues. The glasses can, further, do almost any task for you and work as a personal assistant.



4.3.3 Airlocks

Special airlock chambers will allow people to travel back and forth from the pressurized and unpressurized parts of the structure. The airlock would consist of two doors and none will be open at the same time. Before the airlock doors are opened, the pressure inside it is equalized to that of the adjacent structure for the protection of the environment in both the parts.

4.3.4 Spacesuits

There is a single type of spacesuit designed for both intra and extra vehicular activities which is accessible to only the crew members. The suit is similar to the Gemini G4C suit with its six layered structure of nylon and Nomex. A few changes with the technology of the space suits are made in order for clear vision and communication. Instead of winding tubes of water to keep the wearer cool, the space suits are equipped with a special type of thermostat which maintains the optimum temperature. The boots of the space suit are designed to have thrusters at the bottom for mobility. And the backpacks are equipped with oxygen tanks.

4.4 Healthcare

4.4.1 Distribution of Health Care Centers

The health of the residents is considered to hold the highest priority and to provide the people with the best of health there are several levels of healthcare centers available.

The primary level is the general health checkup which can be very easily conducted by the glasses that people wear. These can precisely tell the wearer about the problems he is suffering and prescribe which medicine to take. Thus there is no need for small clinics. For mild diseases, there are 9 small hospitals, and for major diseases 7 large hospitals are set up evenly across Spaceutopia. There are, additionally, a few specialized hospitals including a rehabilitation hospital, children's hospital and psychiatric hospital.

4.4.2 Emergency Procedures

Airlocks Malfunction

In case the airlocks malfunction, the pressurized parts of the settlement may be badly damaged. Therefore, any airlock malfunction must be swiftly addressed. If anything like this happens the tori would go into lock down mode so that other tori are not affected. The problematic parts will be immediately fixed by the engineers while the pressure is restored in the tori. In case a person is being is affected by the pressure difference, his glasses would inform the nearby task force which would come within seconds to take him to the nearby hospital.

Fire Controlling

Fire is also a rare occurrence because of the materials used in the construction. But still cases may arise where fire must be dealt with and that too, quickly. In case of a fire, the affected area will be quickly evacuated by the robotic task force who are unaffected by the fire. After the evacuation process is complete, the fire site will be flushed with carbon dioxide which cuts the supply of oxygen and thus reduces the fire.

Damage from Outside

Although unlikely to happen, astronomical objects like asteroids if collide with Spaceutopia, they can pose a huge risk for the people on-board and thus must be handled quickly. The people are immediately evacuated from the damaged tori unit and a single unit goes down into lock down instead of shutting the whole tori down (which would have been very difficult). The engineers first repair the damaged portion from the outside of the ship and then from inside to do the repairs as quickly as possible.

Catastrophic Disaster

The possibility for the settlement striking a huge object is already minimized by the shielding and repairing system. But there might be cases where the settlement is no longer inhabitable and must be evacuated. In this case, all the people living in the settlement can use the emergency pods which are the regular cab pods turned in emergency mode. These pods will provide oxygen to the residents by using its own oxygen tank and will take the residents to the transportation sector. From the transportation sector, everyone will be taken to the Mars settlement or back to Earth via the spaceships. Many may even use the administration sector to fly back to Earth, as it was designed in such a way that it could detach itself anytime in order to fly as a separate unit.

Location Destruction

Although this has negligible possibility but we must be ready when it comes. There might be another time when we have to change our homes once again. The cause can be anything from shifting of the asteroid belt to the place exhausted of the resources; in all these cases we must find for a new place to live. The best place after the Mars Orbit would be the Lunar Orbit which has sufficient amounts of resources.

4.4.3 After Death

There are several ways to dispose of the dead body but it must be done in a way such that the minerals from the body are not lost and is environmentally friendly at the same time. Biocremation is considered to be the ideal way for the disposal of the dead body on the settlement. In this process, the body is placed inside a chamber filled by a mixture of water and lye. The chamber is then subjected to high temperature and pressure in order to break down the body into chemical components. This process thus produces much less carbon dioxide.

People can also donate their organs to other people or institutions for research works after their death.

4.5 Education

The education system won't be anything like that on Earth. Instead of teaching children a variety of subjects in kindergarten, children will play games in order to develop creative and innovative minds. This will not only help children tackle the problems of life but will also make them an asset for the future.

Besides these the children will also develop social skills and value based skills from their parents in the initial years of development.

According to a well-known saying – "Everyone is a genius. But if you judge a fish by its ability to climb a tree, it will live its whole life believing that it is stupid". Following this adage, children will be taught a variety of subjects since early days and, based on the result and the interests of the child, the teachers and parents would evaluate the right subjects from the very beginning. But as the child grows, he himself will take on the task of choosing his subjects according to the career he wants to take in future. Children can also opt for vocational courses available at most schools.

This will allow the students to find their actual interests which will make them do better at their preferred careers and eventually lead to their personal success.

4.6 Entertainment

4.6.1 Theaters

There will be 7 major movie theaters spread throughout the residential tori and there watching a movie would be free for everyone. Apart from this there would be small theaters where plays would be organized and enjoyed by the people.

4.6.2 Shopping Malls

There would be 11 huge shopping malls designed to cater to all the needs of the residents. These malls will also include small places of entertainment (like a ghost house and mystery rooms).

4.6.3 Amusement Parks

Every child has to have fun and what's better than an amusement park? There would be 4 different amusement parks designed with a separate theme and some rides would even teach the children the varied laws of physics. The parks will also have a variety of rides based on virtual reality which would further introduce the children to the advancing technology.

4.6.4 Dine-in Restaurants

There are a lot of dine-in locations set for the people which also offer services like home delivery. These places create a feeling of belonging in the people and allow them to enjoy the best of food. There are also many popular brands from Earth available here.

4.6.5 Space Races

Every 4 years the government would organize a special race which would require every participant to make their own space ships and run a race of over 3,000 kilometers. This would be conducted in order to promote development and find the best minds who could contribute significantly to Spaceutopia.

4.6.6 Microgravity Recreations

The microgravity chambers are designed for entertainment, but also are a great educational tool for children.

Microgravity Swim

In the micro-gravity chamber children can swim around just like swimming in a sea and spend a joyful time with their friends. The place is like a pool where children can play a variety of games with their friends. And for their safety they are under constant surveillance of the chamber guards.

Microgravity Football

Football is already a loved sport and the microgravity component just takes it to the next level. Children would find new ways to tackle the difficulty of scoring goals and feel entertained at the same time.

Microgravity Quidditch

Playing Quidditch has always been like a dream but at Spaceutopia dreams actually come true. The people will be sitting on a long metal would have thrusters at the bottom end to facilitate the movement. The player can navigate by pulling or pushing the front end to move and a small button located at the upper end of the rod could be pressed to control the thrusters. The ball would be designed to detect body heat and will thus move accordingly using small propellants.

Microgravity Observatory

People can visit this observatory to see the outer space with a much clearer view. This can be accomplished by sending people outside the ship in spacesuits connected to a rope. There the people can move and explore the outer space.

People can also see the ongoing research that is being conducted inside the observatory. This will show them the progress that has been made.

4.7 Life Support

The life on the settlement will initially be a very big change for the settlers and thus to make their lives easy all the basic and essential conditions would be made available.

4.7.1 Power Supply

Once the electricity is generated in the mini tori, they will send it through huge underground wires which would join a small power station. From these power stations, the electricity would be transferred to the houses through well planned underground wiring system. The vehicles would be charged through the special charging road track which will use inductive charging to transfer energy. The people can also go to electric stations for getting their vehicles charged.

4.7.2 Water Production

Although initially the water will come from Earth, there won't be enough water to satisfy the needs of all once the inhabitants start moving in. Bringing water from Earth is an option but that is too inconvenient and very expensive. So water must be extracted from someplace else.

Water extraction from the surface of Mars is a suitable option, and special soil water extraction machines (SWEM) would be generated in order to perform this task. The SWEM would search for water content in the Martian soil. On finding a suitable water content in the soil, it would put it inside its heating chamber where the soil is heated and the water vapors are made to condense. With this method massive amounts of water can be produced which is more than enough for everyone.

4.7.3 Atmosphere

The atmosphere is an integral part of the survival of human beings and thus there should be an atmosphere at the settlement as well. The climatic conditions would be kept much like that of Earth except that there won't be any seasons and the temperature will be set around 15^{O} C. The humidity will vary between a range of 35% - 45% which is considered ideal for the human body. The atmosphere will mainly contain oxygen, carbon dioxide, and nitrogen. These must be separately

generated and must be present in the same ratio as that on Earth.

Oxygen

Now as the water is substantially available we can generate oxygen from it. The best way to do this is electrolysis which requires passing electricity through water resulting in the production of Oxygen and Hydrogen gas.

$$2\ H_2O \quad \rightarrow \quad 2\ H_2 + O_2$$

The oxygen gas is separated from the Oxygen and is filled in the tori accordingly while the hydrogen is liquefied to liquid hydrogen which is used as a fuel. Achieving liquid hydrogen is difficult but it is much easier to do this in space where the low temperature favors its production.

After the ratio of oxygen is established in the different tori no more oxygen is supplied to it and is instead recycled.

Nitrogen

Being a strong reducing agent, nitrogen gas helps in the elimination of oxidation of living organisms. Apart from this it is also used to make fertilizers which play a significant part in plant growth. Further liquid nitrogen has immense uses. Thus we must maintain a fixed ratio of nitrogen in the atmosphere. Some traces of nitrogen have been found on Mars as well as on Phobos and Deimos; this can account for some of the nitrogen requirements but still won't be enough. The rest of the nitrogen can be brought from Earth which, although it might be expensive, is the only possible solution.

Carbon Dioxide

There would be no need for the production of carbon dioxide as only plants require carbon dioxide and human beings can produce enough of carbon dioxide for the plants to perform photosynthesis. Although a level of carbon dioxide must be maintained as excess of carbon dioxide is not suitable for the living organisms. This will be done by the Sabatier reaction in which carbon dioxide reacts with hydrogen gas to form methane and water with evolution of energy.

$$CO_2 + 4\ H_2 \quad \rightarrow \quad CH_4 + 2\ H_2O + \text{Energy}$$

This reaction is very advantageous as the methane formed can be used as a fuel and the energy can be used to generate electricity. The water can be again electrolyzed to produce oxygen and hydrogen as discussed above.

4.7.4 Food Production

Soil, which is a natural substrate of plants, is no doubt the best to way grow plants as it has all the necessary nutrients and is spread throughout the Earth thus facilitating food production all over the world. But growing plants in soil at the settlement will pose a lot of problems including the burden of carrying massive tons of soil from Earth to the settlement. Thus we must find another way to grow plants.

Techniques like hydroponics tackle this problem very wisely. This is a method where the essential nutrient are provided to the soil using mineral nutrient solutions in a water solvent. Using this process also seems to be a benefit as not too much sunlight is essential and a little which is required is fulfilled using grow light. Also this system makes plant growth very easy as it as it prevents the growth of pests.

A NASA researcher checking hydroponically cultivated onions, with Bibb lettuce to his left .and radishes to the right. Photo Credits - NASA

The food produced can be bought by the residents from the nearby shopping malls and the extra food is stored in the storage tori.

4.7.5 Waste Management

Organic Waste

Waste Management is a very important step in any colony because if this is not treated properly, it may soon cover large portions of the colony and it won't be long until everyplace will be filled with filth. Thus a proper Waste Management System (WMS) must be devised. The WMS consists of two primary machines: one of which uses high temperature and low pressure to make a small tile out of the waste which proves to be useful for radiation protection, the other machine converts the organic waste into fertilizers through the process of composting.

Other Wastes

Other wastes like the metallic waste would be primarily recycled and reused to avoid wastage of useful minerals. Reusing can be specifically useful as it does not require the material to undergo recycling; instead, it can be directly manufactured into useful goods.

Contaminated Water

Water must also be recycled in order to keep the cycle flowing. So a new system called the Water Recycling System is generated which would recycle water from urine, oral hygiene, and even from the humidity of the air. It will also recycle water from the settlement's fuel cells.

The system will clean water through a three step process. The first step would require the removal of the solid debris which can be removed by a few steps of filtration, then in the liquid left a substance would be added which would help remove organic and inorganic soluble impurities. The last and final step is decontamination which is a very crucial step as it not only kills viruses and microbes but also removes volatile organic components

Space Junk

A lot of debris has been left in space due to human beings which poses a great threat to both manned and unmanned spacecraft and can even harm the settlement by striking it or coming in its orbit. Thus these debris must not be produced and if produced should be removed as quickly as possible. But before that, tracking these existing debris is important. This can be done by using specially designed optical detectors. After detection, there are several ways to deal with space debris, but at Spaceutopia this is done by External Junk Allocators and Remover (EJAR). EJAR is a special device designed for this specific purpose which firsts locates the debris and then it brings it back to the settlement where the debris are analyzed and then recycled if possible.

4.8 Religion

The settlement has no official religion and no one can force the other to practice a specific religion. People from all religions reside together and there is no separation of community based on the religion. This measure is taken in order to avoid communal riots. Also there is no public place of worship as there are millions of religions in the world and not everyone can be satisfied. People can instead make small rooms of worship in their homes itself.

4.9 Governance

The democratic government established at Spaceutopia will be designed in such a way so that people can feel their true power in controlling and managing their administration. At the top-most level would be a chief under whom will be seven ministers who would be specialists in their respective fields. All the eight officials (7 ministers + 1 chief) would be directly elected by the people. These ministers would then appoint a few more people who would work under them.

4.9.1 Chief

The chief would be directly answerable to the people in case of any issue and can be anytime removed from his position if the people pass a draft with a signature of at least 70% population stating that they no longer have confidence in him. Unlike in many democracies, the people who have qualified to a certain level will only be allowed to become the chief as it requires a greater deal of knowledge to keep everything in place. Every four years a new chief would be appointed by a voting system and a person can become a chief as many times as possible provided he is winning the elections fairly.

4.9.2 Ministers

The seven ministers that follow and are appointed to take decision of different fields in which they excel. All of them would be answerable to both the people and the chief and would appoint a few cabinet members under them to help them in maintaining peace and order. The fields would be –

1. *Law Minister*

   This minister would be responsible for making general laws including those related to property, crimes, other civil disputes, etc.

2. *Health Minister*

   This minister would be responsible for the health of the people and would make laws accordingly. She/he would also order find newer ways to make better medicine for the people.

3. *Education Minister*

   This minister would look into the education system and would make laws related to that. She/he would also devise new ways to make children creative and innovative.

4. *Environment Minister*

   This minister would ensure that the environment is suitable for the people and, in addition to making laws, ensure there is no breach in an part of the structure.

5. *Food Minister*
   The Food minister would be the one who would decide the amount of production of various food crops along with laying down laws for farmers and vendors in order to protect the consumer.

6. *Industrial Minister*
   The industries minister would make laws for the industries so that they do not manufacture faulty products as well as they treat the radioactive waste, if any, properly.

7. *Research Minister*
   This research minister would play the most crucial role in the development of Spaceutopia. She/he would be the one allocating funds for research purposes and would make systematized laws so that researchers assert precaution while doing any research.

All these ministers must have desired educational qualifications and experience in their respective fields which would enable only educated people to be elected to the administrative body, thus fostering better decisions in order to help the people.

4.9.3 Judiciary

The judiciary would be the government branch to punish the people in case the laws are broken and to resolve their personal disputes to establish the rule of law on the settlement. But, rather than just sending a person to jail if she/he has committed a crime, he judges will use his intellectual to intricate moral values among the wrongdoers. For example, if a person steals someone's bicycle then instead of sending him behind the bars, he could be ordered to walk a few hundred miles for a charity. This would make the person understand his mistake and turn into a good citizen. But this ideology is not applicable for all cases and one needs to be punished for heinous crimes.

4.9.4 Executive

The police force would not consist of humans, instead it would consist of Artificially Trained Police Robots (ATPR). These ATPR would be artificially intelligent robots who would work just like normal human beings but would be better as they would not fear death, would not be biased, cannot be bribed and are more apt to handle adverse situation like fire. These robots would be designed in such a manner that they must also understand human emotions and limitations and will never harm the humans any cost.

INDUSTRIES & ECONOMY

5.1 Space Manufacturing

Once the construction material is allocated there must be places where these raw materials can be processed. This is done by space manufacturing, which is the manufacturing of goods in an environment with microgravity. This environment is expected to be beneficial for the production of a variety of goods. This type of manufacturing is mainly useful for the industrial processes that are not readily achieved in normal gravity. Industries will be thus be set up in order to utilize the maximum of the microgravity environment.

Mining huge chunks of asteroids will provide materials that have strong structure and great metallic characters. As a result, the machines created at the settlement out of these mined materials won't be the ordinary types. They would be much more advanced and faster. This will also give a boost to the economy of the settlement.

And with the advanced technology, we can go to higher reaches of space to explore new things and advance our knowledge. All the data collected would also be shared with Earth in order to make further improvements in technology.

5.2 Cost Estimation

5.2.1 Construction of Launch Systems

Spaceutopia depends largely upon funding in the beginning as the starting processes require the creation of the heavy launch systems along with two SLS.

PART	COST
Space capsule with service module and escape system	$1 billion x 2
SLS first stage, second stage and upper stage	$1 billion x 2
Operating and maintenance costs	$2 billion x 2
Total	**$8 billion**

5.2.2 Construction of Central Cylinder

The construction of central cylinder is very important as it is considered the base of Spaceutopia. This cylinder, apart from being strong, also has several sectors inside it, including the administrators sector, storage sector, transportation sector and the microgravity sector.

PART	COST
Structure	$10 billion
Administrators sector	$5 billion
Storage sector	$0.2 billion
Transportation Sector (with space vehicles)	$100 billion
Microgravity sector (with various chambers)	$5 billion
Total	**$120.2 billion**

5.2.3 Construction of Residential Torus

The construction of residential tori includes the construction of all public places along with the houses apart from the outer structure of the torus.

PART	COST
Residential Quarter & Automation	$10 billion
Parks and Recreation	$0.4 billion
Entertainment	$0.2 billion
Transportation (both public and private)	$3 billion
Healthcare	$1.5 billion
Security	$0.8 billion
Total	**$15.9 billion**

5.2.4 Construction of Other Structures

The agricultural tori would be fairly cheaper as compared to the industrial tori. And the wildlife sector would have negligible cost of construction.

PART	COST
Agricultural Torus	$0.6 billion
Industrial Torus	$8 billion
Wildlife Torus	$0.8 billion
Mini Tori	$11 billion
Support System	$7 billion
Total	**$27.4 billion**

5.2.5 Initial Transportation and Machinery Costs

In earlier years of Spaceutopia, substantial amounts of food as well as construction material would be needed. This requires significant funding as both the material and the fuel costs are very high and must be taken into consideration. Also several machines would be required initially from Earth which would help in building Spaceutopia.

PART	COST
Food Reserves	$0.5 billion
Water Reserves	$0.6 billion
Oxygen Reserves	$0.9 billion
Small Machinery	$3 billion
Large Machinery (including Robots)	$16 billion
Total	**$21 billion**

5.2.6 Production Costs

At Spaceutopia many things are produced to improve and facilitate life. These are produced with huge machinery and thus require construction as well as maintenance costs.

PART	COST
Atmosphere Maintenance (annually)	$0.1 billion
Water Recycling (annually)	$1 billion
Waste Management (annually)	$0.6 billion
Electricity Generation (annually)	$3 billion
Total	**$4.7 billion**

5.2.7 Operational & Maintenance Costs

Operations are an integral part of Spaceutopia which would also require frequent repairs. All these operation costs are very high, not to mention the massive maintenance costs that would be required each year. Thus these costs must be considered.

PART	COST
Communication (annually)	$0.7 billion
Off-board Transportation (annually)	$2 billion
Protection & Repairing (annually)	$2.5 billion
Research & Development (annually)	$5 billion
Mining and Resource Allocation (annually)	$2 billion
Total	**$12.2 billion**

5.2.8 Total Evaluation

PART	COST
One Time Costs	
Construction of Launch System	$8 billion
Construction of Central Cylinder	$120.2 billion
Construction of Residential Torus	$15.9 billion
Construction of Other Structures	$27.4 billion
Initial Transportation and Machinery Costs	$21 billion
Sub – Total	**$192.5 billion**
Annual Costs	
Production Costs	$4.7 billion
Operational & Maintenance Costs	$12.2 billion
Costs Incalculable	$10 billion
Sub – Total	**$26.9 billion**
Total Cost For 12 years	**$515.3 billion**

5.3 Income Estimation

After the settlement is complete and the mining starts taking place on Mars and the asteroid belt, Spaceutopia will be filled with materials of rare quality which would hold a market value of over a trillion dollars. Taking an example, mining on the Germania (an asteroid located in the asteroid belt) alone would prove to have materials of market value of a $100 trillion alone. This can be easily used to pay back the initial funding and still there would be much more left to fund new research in order to extend to new heights.

CONCLUSION

6.1 Future Plans

Spaceutopia would prove to be a new beginning for humanity and would be an even greater asset to our knowledge of space. With Spaceutopia well established, it would be much easier to establish more settlements on other planets. It could even be in the asteroid belt which would make resource extraction much easier. For these new settlements, Spaceutopia would help in similar ways as Earth did for the building of Spaceutopia. Thus all the construction material and funding would be done by the Spaceutopia. This would be relatively easier and faster as both the economy and technology at Spaceutopia would have developed to a height unimaginable. Further, after a few more settlements around the solar system, we could even go in deeper space and make a new colony there which would help in the exploration and discovery of many secrets of the outer space.

6.2 Bibliography

Everything in this project is my own and nothing has plagiarized. Although I have read a few other space settlement designs including the Freyr Project and the Project Maui in order to understand the requirements of the contest in a better way but in no way have copied their work. I have also used my earlier research - “Astoria” and if needed can also send you a copy of that research.

Below is a list of places which have proven to be good sources in making this project.

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