FOUNDATION SOCIETY

AURORIA

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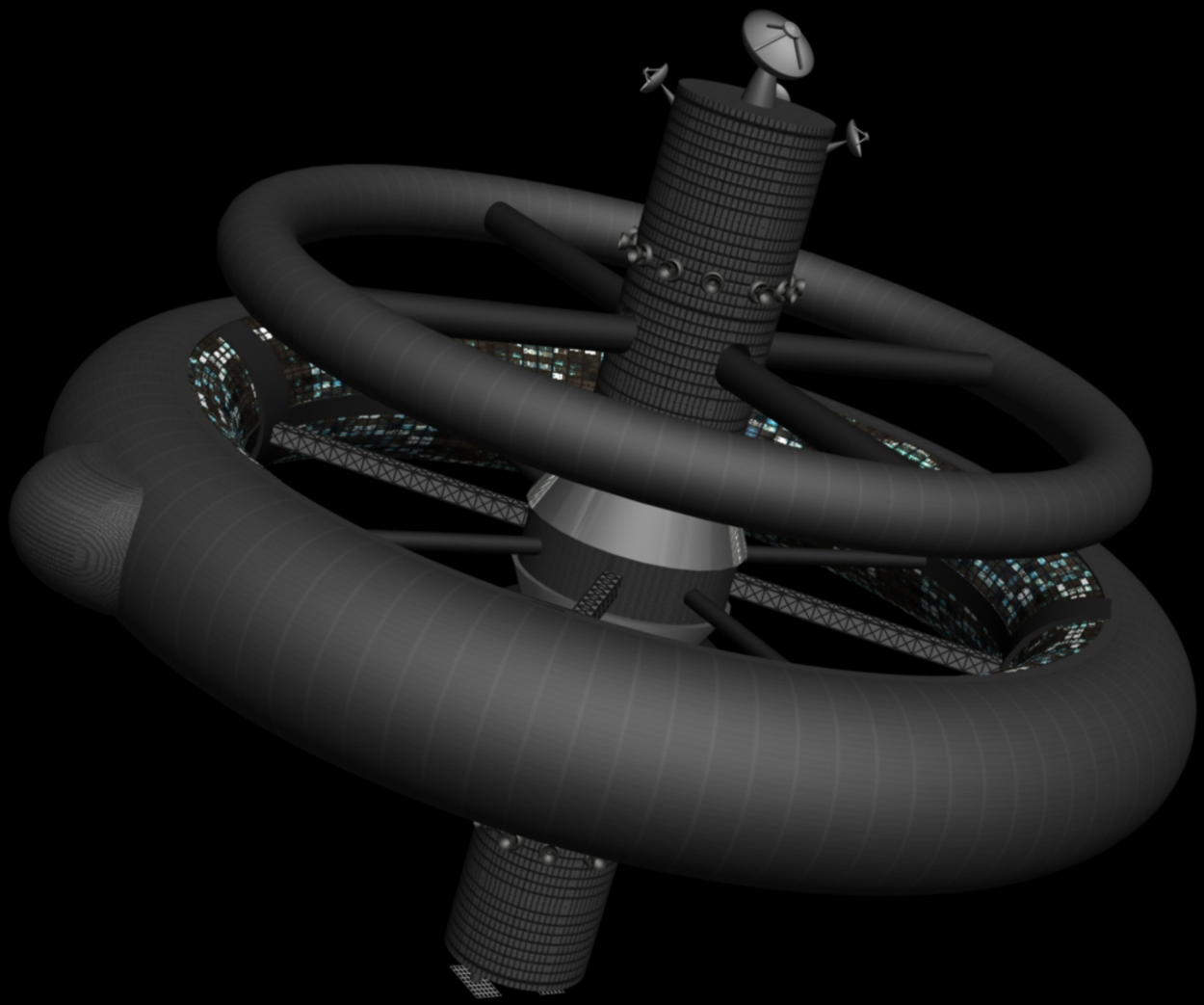

PM AEROSPACE

SURREY, BC, CANADA

18th Annual International Space Settlement Design Competition
Proposing Team Data 2011

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(we request that participants be at least 15 years old, and not older than 19)

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SMRUTHI NAIR	[12](17)	RUPALI MANN	[12](17)
NIKHIL DHINGRA	[12](17)	_____	[ ]( )
SESHAN NAIR	[12](17)	_____	[ ]( )
SINDI SHARMA	[11](16)	_____	[ ]( )
ANMOL SINGH	[12](17)	_____	[ ]( )

Names of two adult advisors currently expecting to attend the Finalist Competition:

JOE SIHOTA

BHUPINDER SINGH RATHORE

I understand that if our Team qualifies for the International Space Settlement Design Finalist Competition July 29 - August 1, we will be expected to finance our own travel to / from Nassau Bay, Texas, USA.

_____ MARCH 11, 2011

Responsible Teacher / Advisor Signature Date

EXECUTIVE SUMMARY

In response to the request by the 'Foundation Society', to propose the design, development, construction, and operations planning of the first large space settlement in solar orbit within the asteroid belt between Mars and Jupiter, our company deposits AURORIA. The name is derived from "Aurora", which represents the Roman goddess of sunrise.

At PM aerospace we believe that an ideal settlement needs to be self-sufficient in order for it to support its residents and to sustain itself over its life term.

The proposal is divided into six key sections which deal with diverse and important components of space habitation. The sections are Structural design, Operation and Infrastructure, Human Factors, Automation Design and Services, Schedule and Cost and Business Development.

Structural Design is what shapes the inner and outer core of the settlement. Hence, it serves as an outline for the settlement. The assembly is designed in a way to ensure that the settlement will be stable and offers protection to keep the residents safe and secure.

Operations and Infrastructure provides us with all the facilities and infrastructure required to sustain life at Auroria. It would state and how Auroria would meet various manufacturing and mechanical needs.

Automation Design and Services facilitate the technology, highly significant to the way of life in the settlement. Auroria, is without doubt, going to be a highly technologically advanced living space where every process from construction to repair will be managed and guarded by robots. These robots will be manipulated in the control center, which provides employment for many residents. Furthermore, we also have back up contingency plans that are there to be opened in case of emergencies. The networking among the residents, robots and technology is bound to produce a wide ray of communications. This networking is going to ensure that reliable and efficient systems are working efficiently. Schedule and Costs have the final imprint of the total cost and timing of the projects in order from most important and costly to the least. This schedule has every small detail in tact with a fine budget and appropriate space generated to produce exquisite results for the residents. Moreover, our company is proud is display such a wondrous piece of land in a manner that speaks extravagance and rationality at the same time.

We would like to conclude by thanking 'Foundation Society' for giving us a chance to participate in this esteemed and epic project. We hope that our proposal would satisfy the requirement, and would be competitive enough to provide us with the historical opportunity to be a permanent part of this contract.

2.0
STRUCTURE

PM AEROSPACE

2.1 External Configuration

Auroria would serve as a consummate settlement for 6,000 long-term residents, 5000 semi-term occupants, and up to 500 short-term visitors.

2.1.1 Design

Auroria is a two concentric tori system, which are located on different planes. The one on top is the Agricultural Torus and the bottom the Residential Torus. The two tori are interconnected and attached to the Central Cylinder, who center serves as the center for the two tori.

2.1.1.1 Exterior View and Dimensions

Image 2.1.1.1.1
External View

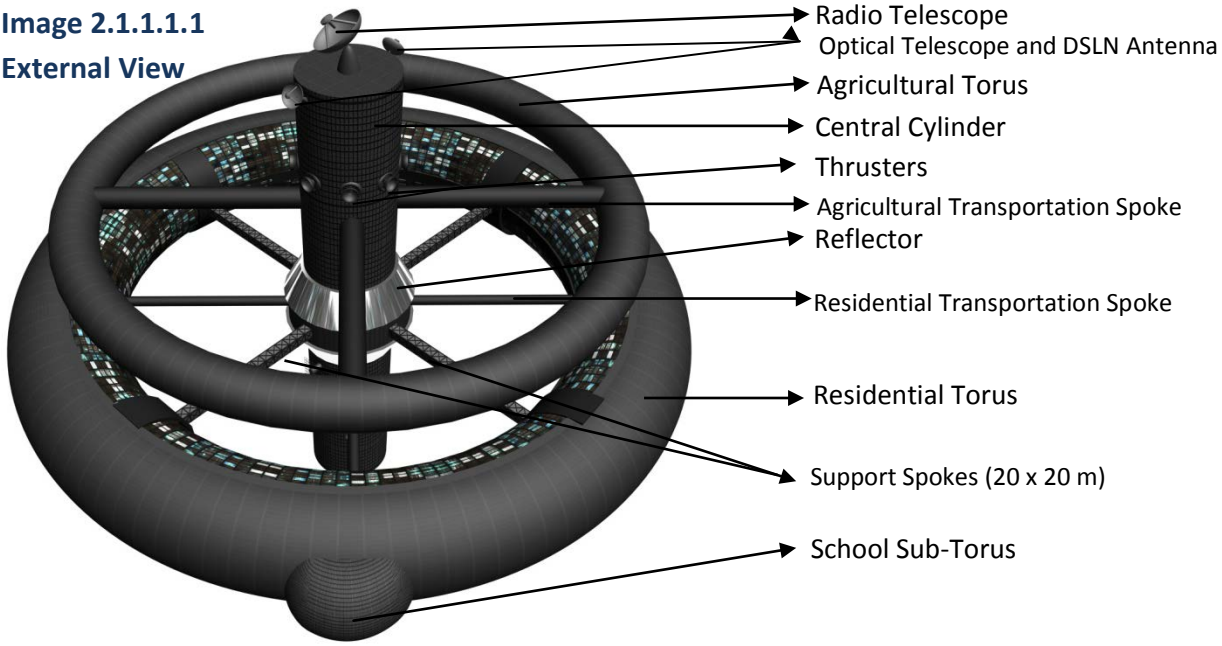
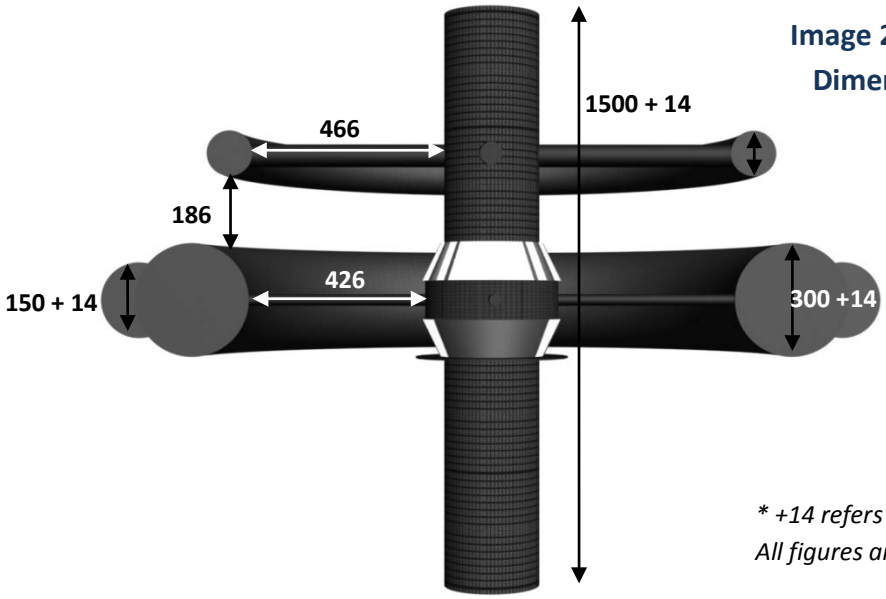


Image 2.1.1.1.2
Dimensions



** +14 refers to the material width.*
All figures are in metres (m)

Table 2.1.1.1.1

Section	Radius (m) ***	DS** Width (m)	DSA*** (m2)	Gravity at DS (g)	Volume (m^3)	Length Below DS (m)	Function
The Residential Torus	740	203.96	1.09×10^6	0.8578	3.35×10^8	40	Housing for residents
The Agricultural Torus	690	89.44 (DS1) 118.32 (DS2)	9.16×10^5	0.7367 0.6863	1.09×10^6	20 (DS1) 70 (DS2)	Facilitates plantation
The Central Cylinder	150	N/A	N/A	0 - 0.1514	1.09×10^6	N/A	Control and Manufacture Unit

***DS refers to Down Surface*

****DSA refers to Down Surface Area*

** Radius from center of the Central Cylinder to the center of the Torus Tube*

2.1.1.2 Specifications

The residential torus had four transportation spokes and four support spokes. The Support Spokes are necessary to bear the mass of the residential torus, and keep the transportation spokes' radius minimal. The Agricultural Torus has four spokes which provide support as well as transportation from the residential torus to the central cylinder. The large radius of the Agricultural Torus' spokes makes it possible for the same spokes to facilitate transportation. The transportation spokes have elevators which provide fast and easy transportation of cargo and residents between the different hull components. Shock absorbers, installed in all spokes where they join with the hull components, absorb any internal vibration in the settlement. The spokes can be sealed, if required, to isolate the Residential Torus, the Agricultural Torus or the Central Cylinder. This allows three different major hull components to be isolated separately or together, in case of any kind of emergency.

Most of the settlement is fully pressurised with stable 13.5psi pressure. The Central Cylinder is the only major component of Auroria which contains sections which are unpressurized or partially pressurized. The unpressurized and partially pressurized sections are stated in *Section 2.2.3.*

The entire settlement is rotated using the thrusters located on the central cylinder, eliminating the need for any structures between rotating and non-rotating sections.

2.1.2 Functions

The main purpose for the Residential Torus is to accommodate housing for the residents of Auroria. It would also provide commercial and recreational areas. The Residential Torus would consist of four communities, each identical but unique in its recreational areas.

The primary purpose of the Agricultural Torus would be to provide plantation area. It also has manufacturing industries, water storage, food packaging industry, food processing industry and animal farms. The Central Cylinder would be the Control Center of the settlement. It would have the ore processing industry, manufacturing industry, shuttle and robot repair, thermal radiator, zero-g recreation and propellant storage.

2.1.3 Construction Materials

Most of the construction materials come from celestial bodies like Moon, Mars and a selected Asteroid. These materials are transferred from the source to the "construction shack" located at the construction site of the settlement. The chosen construction materials protect the settlement against cosmic radiation and provide structural support, which also helps to protect against any space debris. This is further explained in *Section 2.4*.

Image 2.1.3.1

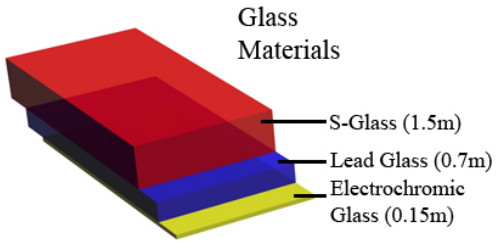
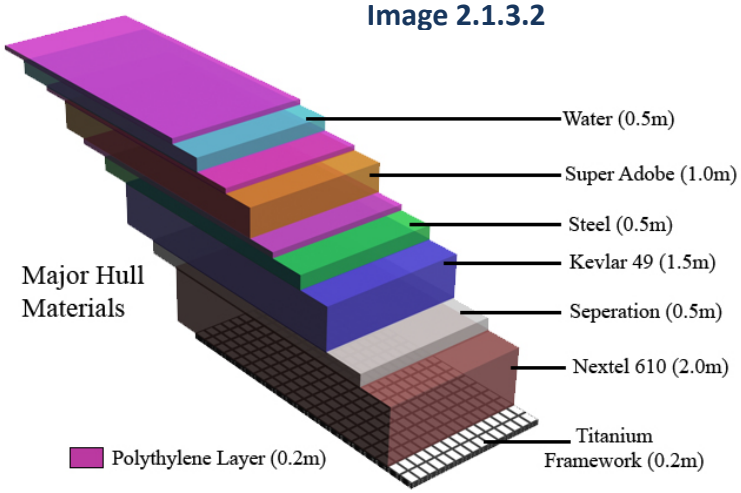


Image 2.1.3.2



2.1.4 Pseudo Gravity

Pseudo Gravity generation is facilitated by the centrifugal force produced when the settlement is rotated. The rate of rotation chosen is 0.95rpm. This rotation allows for gravity magnitude of 0.9g for the Residential Torus. It provides micro-gravity in the Central Cylinder and gravity ranging between 0.74g to 0.67g in the Agricultural Torus, which is optimum for plant growth. The 0.95rpm rotation rate minimizes the impact of the *Coriolis Effect* on the residents.

2.2 Internal Arrangement

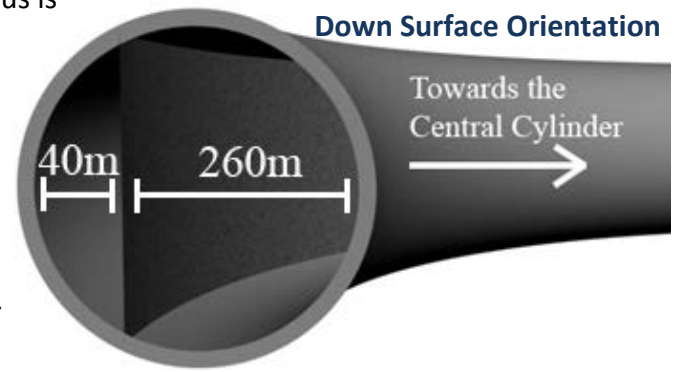
The internal organization of the settlement determines the social arrangements of the inhabitants. It is of great significance as internal organization also extends into and influences the design of the commercial, public utility and industrial areas.

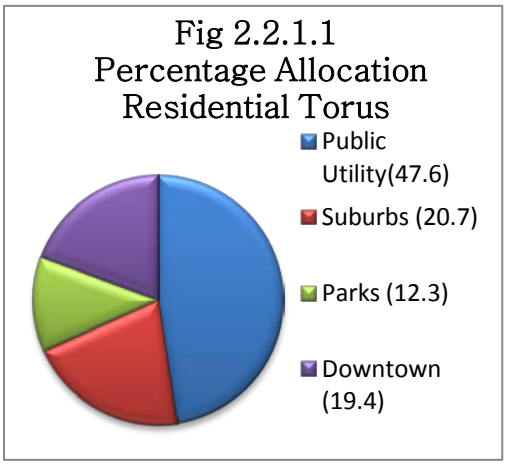
2.2.1 The Residential Torus

The Residential Torus' internal arrangement is the heart of the Auroria, as it is the centre of commercialisation, socialisation and recreation; making it is important to have thoughtful internal arrangement for the Torus.

The vertical clearance for the Residential Torus is 260m, with the "down surface" 110m below the center of the cross section of the torus. The width of the down surface is 203.96m. The volume below the down surface is used for water, storage, food delivery, waste disposal and robotic transportation systems. The residential down surface consists of four identical communities – "Bronx", "Kings", "Queens" and "Richmond - each with unique recreational areas. Each community consists of a commercial center, the highrise, in the middle of the downtown core. The "Downtown Core" consists of small apartments and small houses. Right next to the "Downtown Core" is the "Suburb" section, which has large apartments and large houses. The Suburb is joined with the Public Utility area, which facilitates different commercial, recreational and infrastructural facilities, depending on the community. The residents are able to view natural views of space outside from time to time, facilitated by making the electromagnetic glass transparent and disabling the OLEDs.

Image 2.2.1.1
Down Surface Orientation



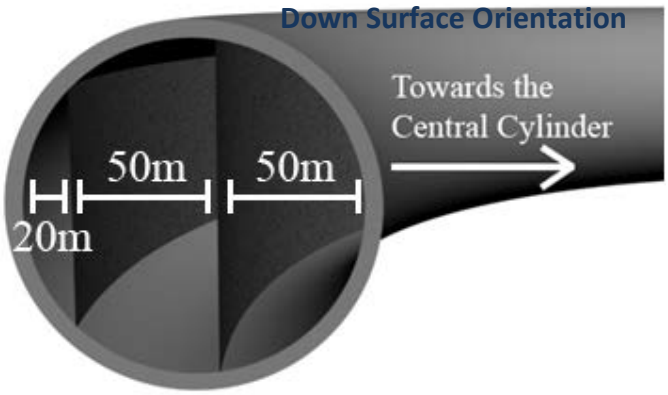


Most of the residential torus is dedicated to commercial use, which includes recycling industries, warehouses, lakes, stadium, etc. The downtown area, consisting of small apartments and cottages, covers almost 21% of the down surface area. The suburbs cover 19.4% of the total surface area. The parks, covering 12.3% of the area, are integrated into the downtown core and the suburbs. The public utility area covers 47.6% of the total down surface area.

2.2.2 The Agricultural Torus

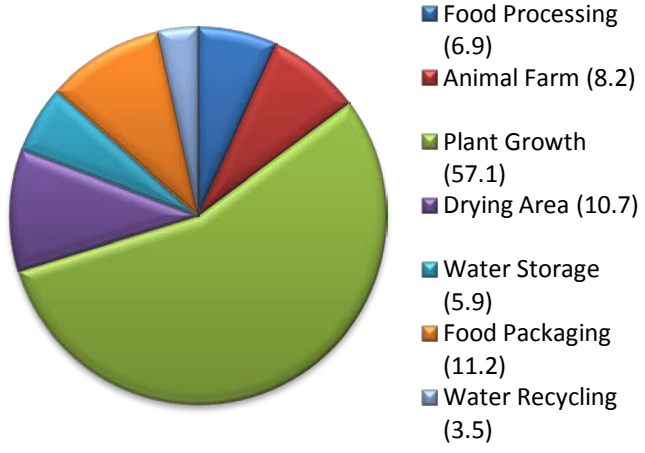
The internal arrangement of the agricultural torus is of great significance to agricultural efficiency. Proper arrangement ensures maximum agricultural yield.

Image 2.2.2.1



The vertical clearance for each down surface is 50m, with 20m distance below the first down surface. The second surface is 50m above the first one, thus making its distance from the bottom 70m. The two down surfaces, the bottom one 89.44m and the top one 118.32m in width, ensure the availability of maximum agricultural area while maintaining the ideal gravity suitable for plant growth.

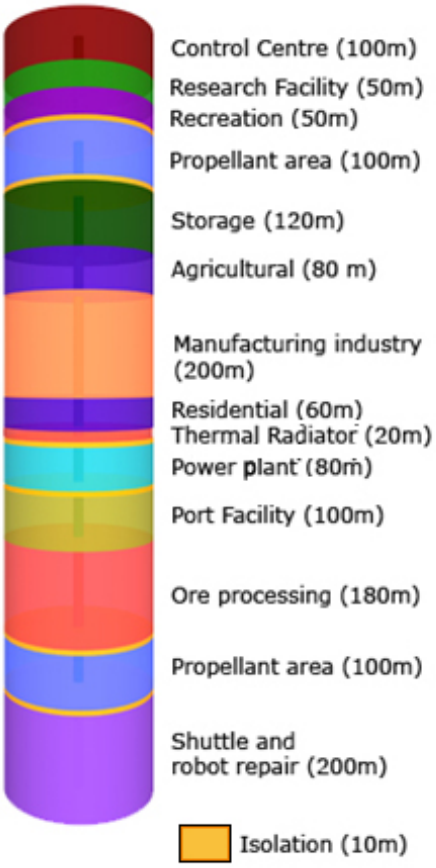
Fig 2.2.2.1
Agricultural Torus



The two down surfaces allow for a total down surface area of 915,773m^2. About 66% of this area is used for agriculture, where plants are grown and harvested through robots. After plants have been harvested, they are dried on the drying area, covering about 10% of the area. The food is then sent to the food processing industry where it is cleaned and preserved. About 5% of the area is dedicated to the food processing industry. The food is then forwarded to food packaging industry where it is packaged. The food packaging industry covers 7.3% of the area. The food is then sent to the residential torus' warehouses via the central cylinder. The vital Water Recycling unit covers about 3.5% of the total down surface area. The complete recycling process is carried out in here. The Water Storage, which takes up to 5.9% of the area is able to sustain the settlement for an year even if the recycling unit shuts down.

2.2.3 The Central Cylinder

Image 2.2.3.1
Central Cylinder Allocation



The internal arrangement for the central cylinder is of great significance to the functioning of Auroria, as it has vital industries located on it. The micro pseudo gravity makes it an ideal location for facilities which require zero gravity.

The central elevator, 20m in radius, runs throughout the cylinder and provides easy transportation of, both residents and cargo.

The central cylinder has four port facilities, two at the bottom, adjoining the shuttle and robot repair, and other two on the sides of the cylinder 545m from the bottom edge of the cylinder. The two ports located adjacent to the Ore Processing, partially pressurized, section provide easy import and export.

The Control Center of Auroria is located at the top of the cylinder, located near the top antenna, controls every aspect of the settlement. The Control Center is equipped with a super computer, which maintains external scan data and gives commands to various robots, depending on the settlement's conditions.

There are two Propellant Areas for fuel storage, which is highly pressurized, located right behind the Thrusters. The Isolation Area, which is unpressurized, is equipped with leakage detection system and cooling system on either side of the Propellant Area localizes fuel storage and reduces the risk of explosions.

The Central Cylinder also had a Manufacturing Industry for producing as much as possible of the things the residents need. This pressurized industry manufactures equipment for asteroid mining.

The Power Plant, equipped with Thorium-based engine, meets the energy requirements of Auroria residents. The electricity produced is also stored in Lithium-Ion batteries for backup. The Power Plant section is partially pressurized.

There is also a Recreation facility, which provides for micro-g recreational activities, stated in *Section 4.1.1 – Recreation/Entertainment.* The scientific research on Auroria takes place in the Research Facility located above the Recreation Section.

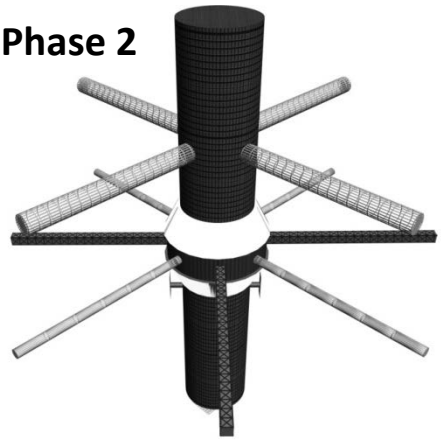
The Thermal Radiator is used to expel the accumulated extra heat from Auroria, into the free space.

2.3 Construction Sequence

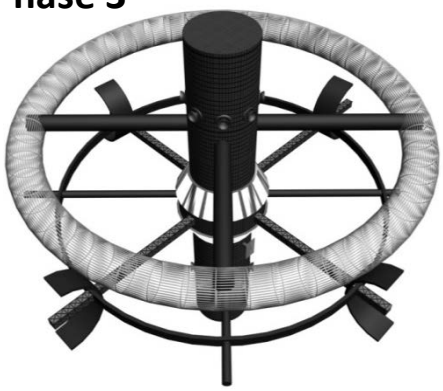
Following are the steps for the construction sequence of Auroria:

PHASE 1

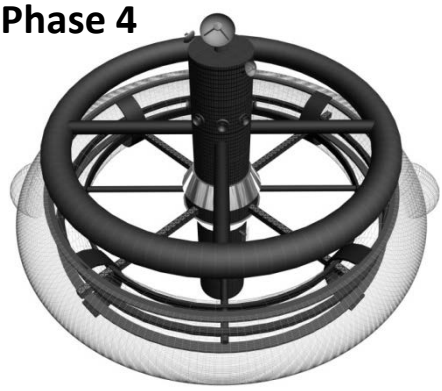
Phase 2



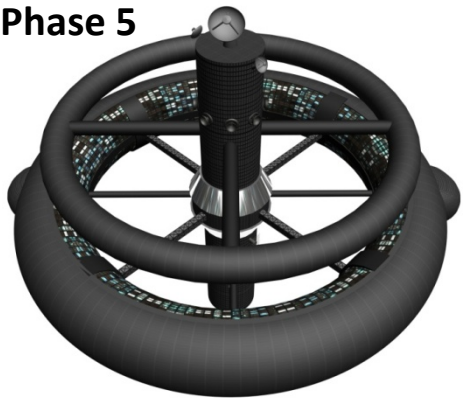
Phase 3



Phase 4



Phase 5



The Psuedo-Gravity generation starts after Phase 4, once the Agricultural Torus has been completed. The thrusters - located at the top and bottom of the Central Cylinder - would fire off, each at an angle to 45, to start the rotation.

Once Auroria is completed, Phase 5, the Engineers live in the Residential Torus temporarily until the inner construction is completed.

2.4 Shielding and Damage Repair

2.4.1 Large Asteroids

LIDS (Laser-based Intrusion Detection System), based on the LADAR concept, is used to detect asteroid impact 2 days in advance. The system detects asteroids by shooting out lasers into free space and detecting the reflected beams. The system then sends this information into the mainframe computer located in the central cylinder.
The settlement can then be moved out of the pathway by firing thrusters (Section 3.4).

2.4.2 Small Asteroids

The settlement is able to take in the impact by debris which is smaller than 0.25m in radius. The structural integrity of the high tensile strength construction materials contributes to this. These materials also serve as a shield.
The Nextel 610 high tensile strength aids in primary protection against debris. The Kevlar 49 is located underneath the Nextel 610 layer to intake any debris particles which breach through the Nextel layer. Another steel layer beneath the Kevlar layer takes any residual shock and prevents any loss of pressure due to breaches.
The following table specifies each material, its thickness, properties and function.

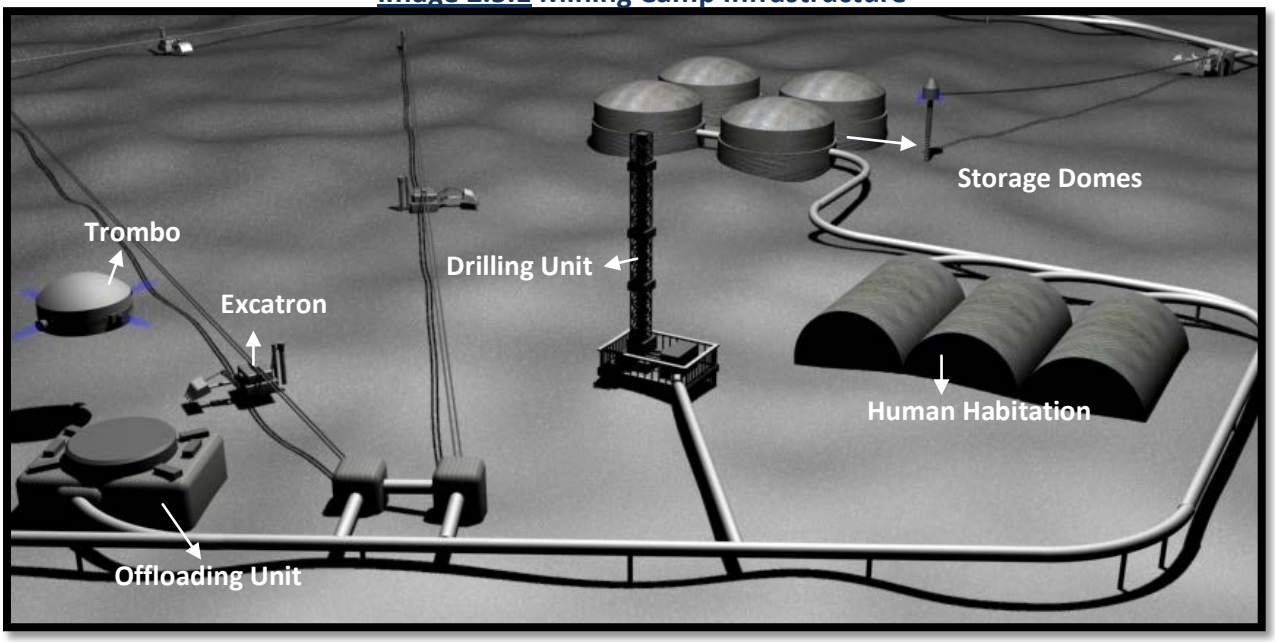
Table 2.4.2.1 Shielding Materials

Construction Material	Width	Properties	Function
Nextel 610	2.0m	Excellent tensile strength Good elastic modulus	Structural Support and Debris Protection
Kevlar 49	1.5m	Can take minor impacts giving more time for the repair to arrive High tensile strength	Protection against Debris Penetration
Steel	0.5m	High tensile strength Excellent Durability	Structural Support and secondary Debris Protection
Titanium	0.2m	Excellent Specific strength	Structural support during initial phases of construction

Any breach in the primary Nextel layer is detected by the "Sensory Net" covering the Kevlar 49 layer. The message is sent to the Control Center in the Central Cylinder, which sends AU-303 (Section 3.3.2) to repair the damaged Nextel blocks. The AU-303 replaces the breached layers. Any layer suffering more than 50% damage will be replaced by AU-303. Each block has a radioactively imprinted identification number. Monthly scans are performed to ensure the functionality of each Nextel block.

2.5 Mining Camp

Image 2.5.1 Mining Camp Infrastructure



The above image shows mining camp installation on the surface of the selected asteroid. Asteroid mining is the backbone of Auroria's economy. To start off with, pre-fabricated mining installations are first placed on the asteroid and anchored deeply into the ground. Mining installations included Storage Domes, Human Habitation, Drilling Machinery (for extracting materials from deep down the asteroid's surface), Tether fixations, Offloading units for Transportation (section 3.3.3), Power distribution systems and communication systems. After the initial setup is done, all the robots are placed on the asteroid.

Before the mining begins, a rotating canopy made up of Kevlar is placed right above the mining installations. Once all the units are powered up, the dust generated is collected on the sides of canopy due to centrifugal force. The volatile materials are stored in the storage domes, where they are then shipped to Auroria. Once the mining is finished, the whole machinery is moved to another location on the asteroid and the canopy is tied up and transferred to Auroria. *Image 2.5.2* shows the canopy attached to the asteroid.

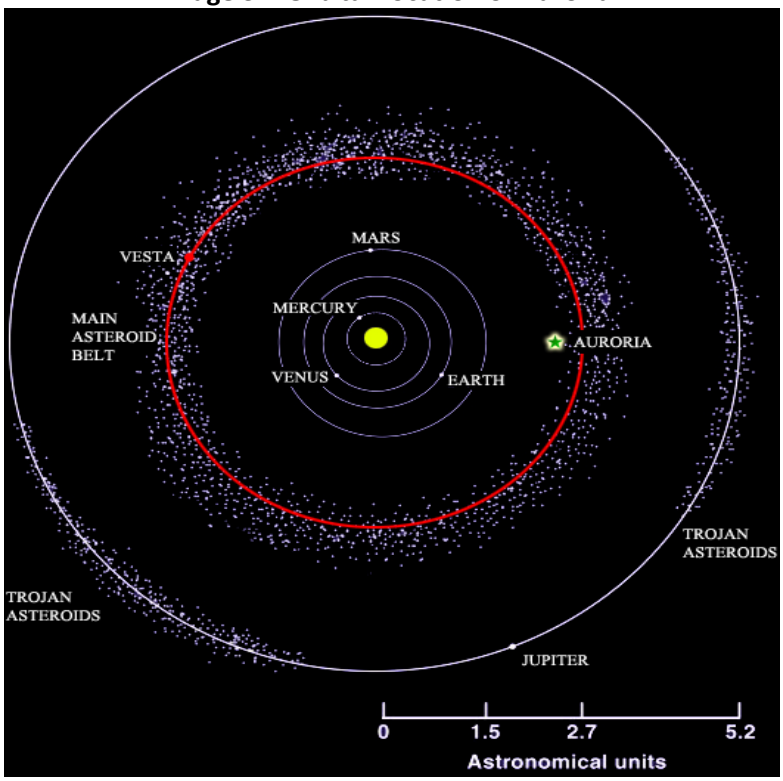
3.0 OPERATIONS AND INFRASTRUCTURE

PM AEROSPACE

Auroria will provide all the facilities and infrastructures for communities to sustain life, as well as meet the manufacturing and mechanical needs.

3.1 Orbital Location

Image 3.1 Orbital Location of Auroria



The orbital location of Auroria will be at the inner edge of the asteroid belt at about a distance of **1.893 AU** from Sun i.e. around 5.52 x 10^7 km from Mars. The main reason for the selection of this location is that it is prior to the denser regions of the main asteroid belt hence reducing the chances of asteroid collisions. Auroria from this location will have easy access to the main asteroid belt for asteroid mining and is also reasonably close to Mars for various materials and equipments. Auroria will carry its major mining operations on **4 Vesta**. Orbital inclination of as low as 7.14 degrees allows easy entry and exit to its orbit. Also similar geographic pattern as that of earth makes mining operations easy to execute.

3.2.1 Atmosphere Control

An efficient atmosphere is extremely important for the residents of Auroria. The Air

Table 3.1 Types, amount and sources of construction materials

Material	Composition	Source	Transportation
Steel	Fe, Al	Moon	Aediles
Kevlar 49	C, N, H	Moon, Asteroid	Aediles, Antenor
Nextel 610	Al, Si	Moon	Aediles
Titanium	Ti	Moon	Aediles
Super Adobe	Asteroid Soil	Moon/Mars/Asteroid	Aediles, Antenor
Silicon	Si	Mars	Aediles
Polyethylene Layers	C, H	Asteroid	Antenor
RTV Adhesive	C, H, O, Si	Asteroid	Antenor
S-Glass	Si, Al, Mg, O	Asteroid	Antenor
Lead Glass	Si, Pb, O	Moon	Aediles
Electrochromic Glass	Ni, Mg, Si, O	Asteroid	Antenor
Water	H, O	Ceres	Antenor
Construction shack			

Revitalisation System plays a crucial role in maintaining the right atmospheric conditions. The atmosphere would consist of 21% oxygen, 78% Nitrogen and 1% other gases at 14lbs per square inch.

Oxygen Generation System

The water recovered from the Water Recovery System is supplied to electrolytic cells to produce oxygen. The electrolysis is carried out by the Elektron Electrolysis System.

Carbon Dioxide Reduction System

Atmospheric airborne chemicals, oils and odours, would be filtered using activated carbon beds, while the CO2 would be removed using Lithium Hydroxide based filtration system.

Water Recovery System

This system would recycle the waste water using the WRS and the purified water would then be rechanneled into the Water Supply System and Oxygen Generation System.

Temperature and Humidity Control

The Temperature Control Units maintain the temperature according to the seasons. Hygrometer will be used to check any change in humidity which will be then maintained via humidifiers and dehumidifiers. Humidity level will be 40-50% in summer and 30-40% in winter.

Table 3.2.1 Season Cycle of Auroria

Season	Temperature (^{0}C)	Period (Months)
Summer	18/29	3
Spring	12/21	5
Autumn	8/16	2
Winter	-2/+8	2

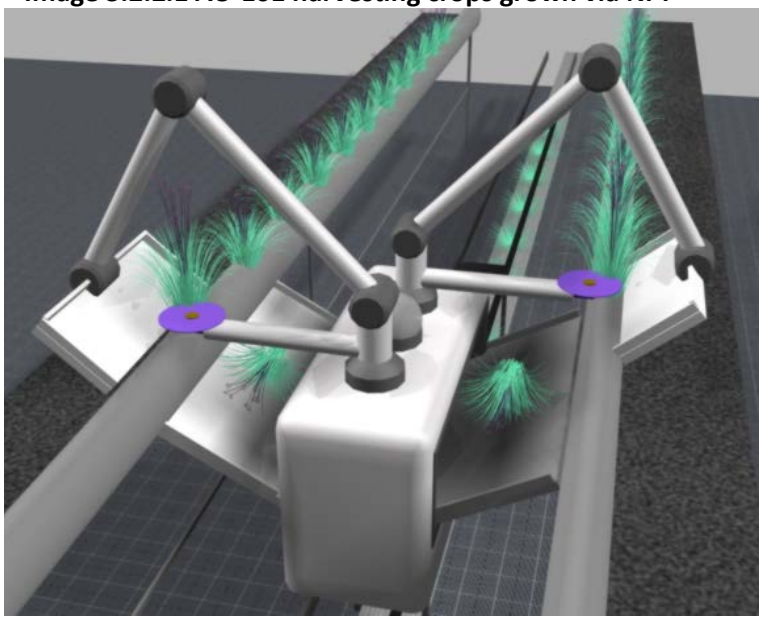
Table 3.2.2 Composition of Air at Auroria

Gas	Parts per million (by volume)	Partial Pressure (mBar)
Nitrogen	780805 (78.08%)	781.8
Oxygen	209450 (20.95%)	209.7
Argon	9340 (0.93%)	9.34
Carbon Dioxide	380 (0.038%)	3.3×10^{-1}
Neon	18.21 (00018%)	1.82×10^{-2}
Helium	5.24 (0.0005%)	5.23×10^{-3}
Krypton	1.14 (0.0001%)	1.15×10^{-3}
Hydrogen	0.50 (0.00005%)	4.94×10^{-3}
Xenon	0.087 (8.7×10^{-16} %)	8.7×10^{-3}

3.2.2 Food Production

Food production will be carried out in the agricultural torus with a total growing area of 523,250 m^2. For growing plants Nutrient Film Technique (NFT) will be used in which plants are grown in a thin film of water filled with nutrients. A small pump will be used to maintain the flow of nutrient water and a nutrient monitoring device will be used to keep track of the nutrient level of the solution. The constant flow of water eliminates the need of supplying oxygen at regular intervals. As the plants absorb the minerals, the pH level tends to change which is monitored by a pH monitoring device. If the solution becomes alkaline then H2SO4 is added and if the solution becomes more acidic then KOH and NaOH are used to keep it neutral. The temperature is kept between 50F-75F where at least 8-10 hours of light is given to the plants via OLED's.

Image 3.2.2.1 AU-101 harvesting crops grown via NFT



Food Harvesting

When harvesting for food, the nutrient supply is stopped for a period of 3-7 days prior to the harvest. Then after that required wait, AU-101 (image 3.2.2.1) is used which cuts the main stem above the root and the harvested plant is hanged upside down for drying.

Storage

A total area of 63,250 m^2 of the agricultural torus is allocated for storage. For short term, storage freezing is used. No additional preservatives are added which ensures that food is preserved in its natural flavour. For long term food storage Food Irradiation Technique is used where food is exposed to ionizing radiation. The radiation breaks apart the genetic material of micro organisms present on the surface of food while the nutritive value of food remains intact.

Packaging

Vacuum packaging will be used for food packaging in which air is vacuumed out of the packaging bag hence reducing the atmospheric oxygen which prevents the food from spoiling. Since the growth of bacteria and fungi will be stunted, the food will be able to be preserved for long term packaging.

Delivery and selling

After the food is packed in the agricultural torus, it is transported to the ware-houses in the residential area through cargo elevators. Consumers can buy food in two ways - by ordering from their SmartScreens at home where the food is delivered by AU-151, or by shopping in one of the malls in four highrises.

Image 3.2.2.2 SmartScreens of Auroria

3.2.3 Electrical Power Generation

The expected electrical power allocation for Auroria is as follows:

Table 3.2.3 Electric Power Requirements

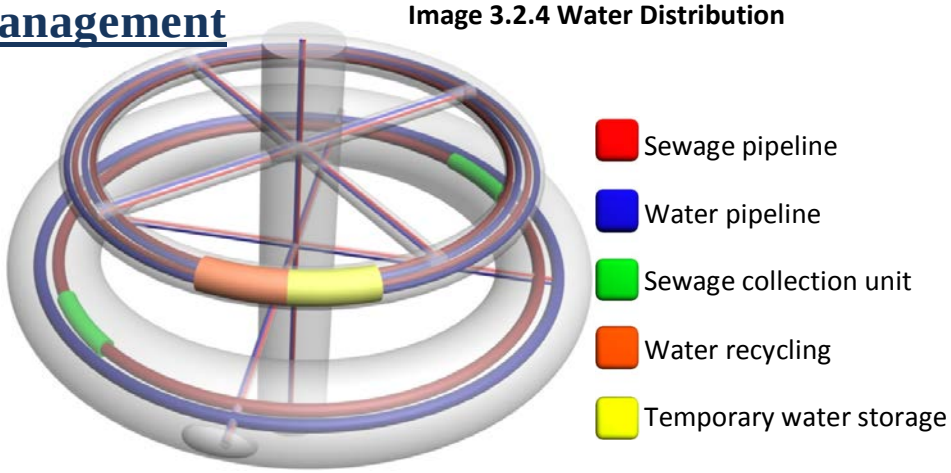
Per person requirement per day	5 kW
Residential torus	60 x 10^3 KW
Agricultural torus	37 x 10^3 KW
Central cylinder	152 x 10^3 KW
Mining camp	9 x 10^3 KW
Total power consumption	**258 x 10^3 KW**

Electricity at Auroria will be generated via Thorium based Gas Turbine Modular Helium Reactor (GT-MHR) with Helium as its coolant. The reactor can produce up to 300 x 10^3 KW of electric energy. The excess energy is stored in Lithium Ion batteries. Thorium and Helium are available on both moon and mars. Gamma Scout Radiation Detector is used to detect any leakage. Also there is a 10 meter isolation on both sides of the reactor to prevent any further damage in case of emergency. No stress corrosion or carbon emissions occur with GTMHR making it a much safer and efficient production unit. Electricity will be transferred to the mining camp via Microwaves and any lag in power will be covered using lithium ion batteries.

3.2.4 Water Management

Image 3.2.4 Water Distribution

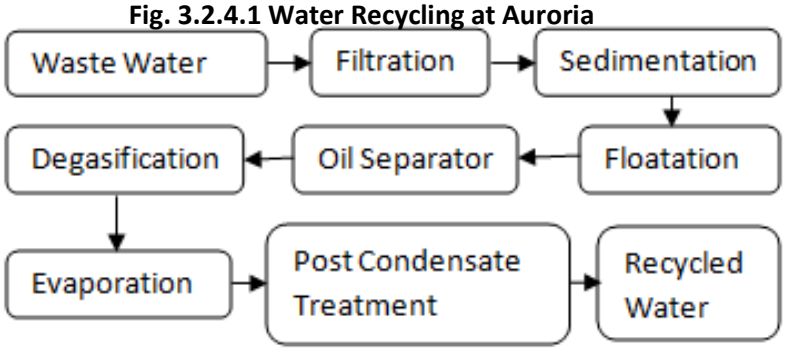
Frozen water would be procured from Ceres and treated at the water treatment plant located in the agricultural cylinder. The water would be liquefied and



processed to meet the daily requirement of **15,551 m^3**. **5,676,124 m^3** is allocated for water storage in the storage area of the central cylinder which can meet the requirement of Auroria for one year even without recycling. Water is distributed throughout the settlement through pipelines.

3.2.4.1 Water Recycling

Fig. 3.2.4.1 Water Recycling at Auroria

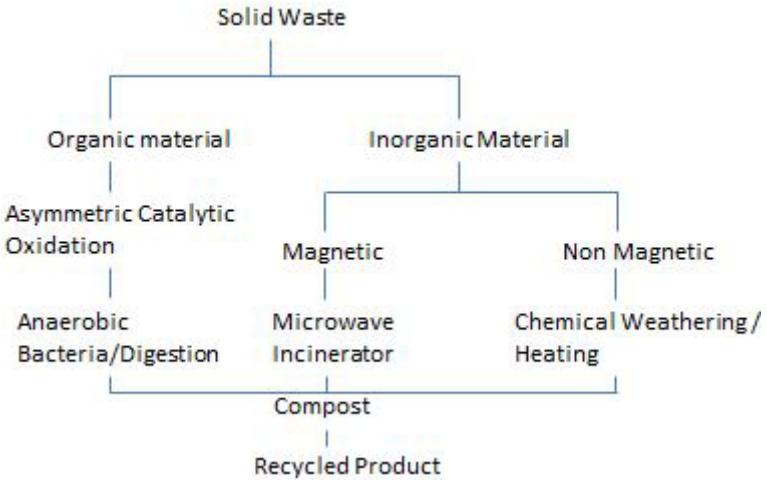


Water recycling will take place inside the agricultural torus. Upon reaching the water recycling plant, the waste water first undergoes filtration and sedimentation to remove any debris and un-dissolved particles. Then, the suspended matter is removed by using the process of floatation in which impurities attach with air bubbles and rise to the surface in form of froth, which is then removed by a skimmer. Immiscible liquids are removed from water during oil separation process, while any dissolved gases are then removed by the process of degasification. Multi-stage evaporation then leaves the water free of gaseous impurities. Water vapour is then subjected to post condensate treatment in form of neutralization, Ph adjustment, Aeration and Oxidation, before it is finally resupplied to residential area giving a 100% recycling.

3.2.5 Household/Industrial Solid Waste Management

The expected total waste of Auroria is 7,657 m^3. For waste management, firstly the solid waste will be treated in organic separator to separate out organic and inorganic wastes. Organic waste will undergo catalytic wet oxidation, anaerobic digestor and compositing respectively. Parallel to it, the inorganic waste is first treated with electro-magnetic separator, which segregates the non-magnetic waste which undergoes heating before being fed to the hopper. During this proces the magnetic waste is sent to the microwave incinerator. This system is expected to provide 80-85% efficiency and the rest of the waste is disposed on Vesta.

Fig. 3.2.5 Solid waste recycling at Auroria



3.2.6.1 External Communication

Auroria will use Deep Space Laser Network (DSLN) System for external communication which uses laser beams for data transmission, as they accumulate lower frequency dispensing low signal-to-noise ratio. Laser beams with K_U Band frequency, would provide transmission rates of up to 1.5GB/sec and a transmission time of 6 minutes when it is closest to Earth and 23.68 minutes when it is farthest from Earth. A 70-feet antenna will be located on the Central Cylinder transmitting signals to the 230-feet antenna located on Earth via the amplifiers located at LEO. The transmission would be controlled by an automated system installed in the Signal Processing Unit (SPU), located inside the cylinder. The SPU also controls telemetry and command systems, digital signal processing, and spacecraft navigation data.

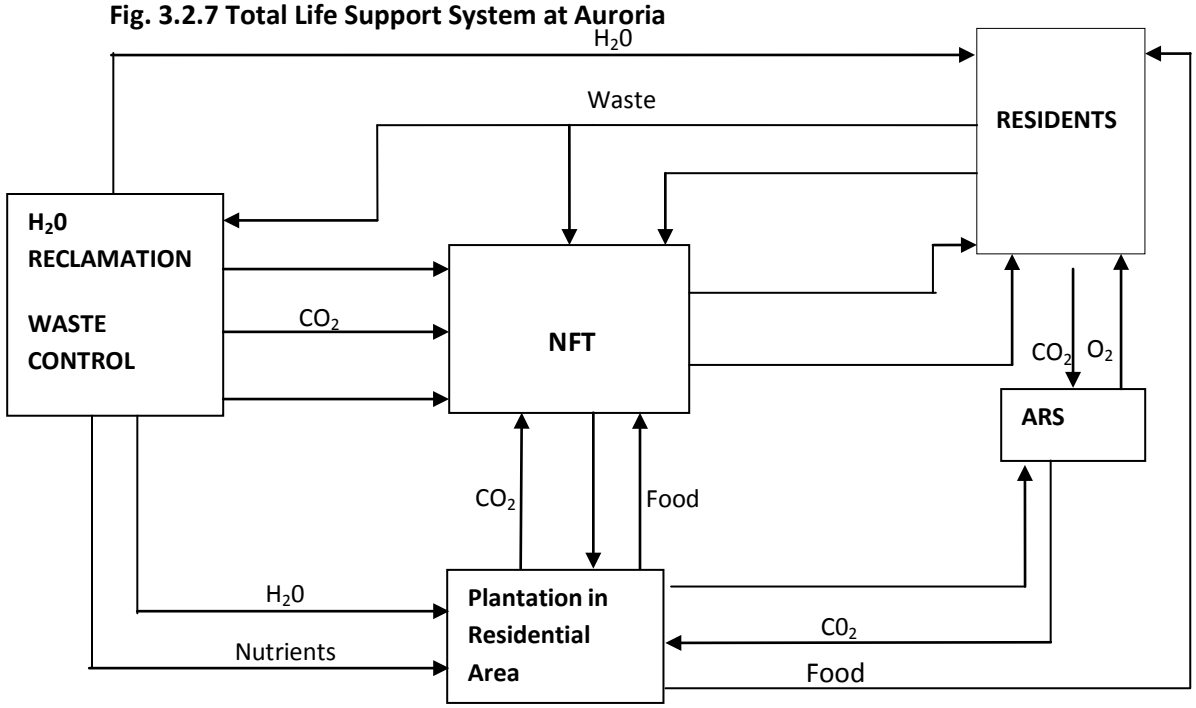
3.2.6.2 Internal Communication

Internal communication will be carried out through wifiber technology which uses digital millimetre waves of frequency 70-85 GHz to carry out communication. Availability of multi-encryption levels ensures high security along with almost no practical limits to the number of wifiber links that can be installed within Auroria. Four 1.52 m long antennas (2 in residential torus, 1 in agricultural torus and 1 in central cylinder) will be installed to ensure negligible error loss. Auri will be used to carry out internal communications.

Image 3.2.6 Auri

3.2.7 Life Support System

Fig. 3.2.7 Total Life Support System at Auroria



3.2.8 Internal Transportation Systems

Auroria uses Setro internal transportation which consists of a constantly moving main train and top-boarding shuttles. Passengers aboard the shuttle at the station and the shuttle doors close one minute before the arrival of the train. The train scoops up the shuttle while passing the station and passengers descend into the main train. The passengers wanting to get down at the next station enter the shuttle which is automatically deposited onto the next station and another shuttle is scooped up. The speed of Setro is 2.25m/s and the maximum distance itcovers is 2714.33m in 20min. There are 8 stations and it takes about 5 minutes to get between the stations. The elevators are used to move from the residential torus to the central cylinder and within the central cylinder itself. The maximum distance the elevator covers is 1600m in 6.8 minutes. Though more emphasis is laid for public transit Byk and Vroom are also available for individual transportation.This system runs efficiently saving power and total transit time. Though more emphasis is laid for public transit Byk and Vroom are also available for individual transportation

Image 3.2.8.1 Byk

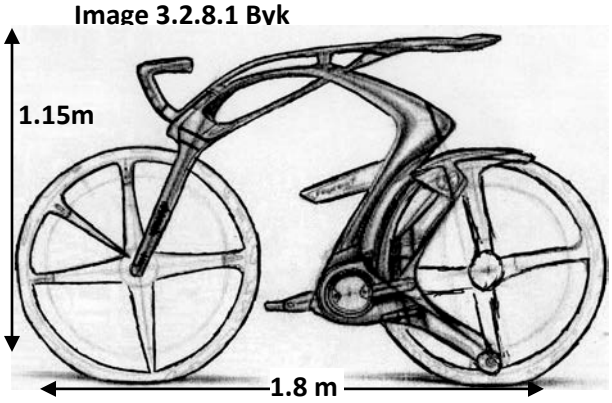


Image 3.2.8.2 Vroom

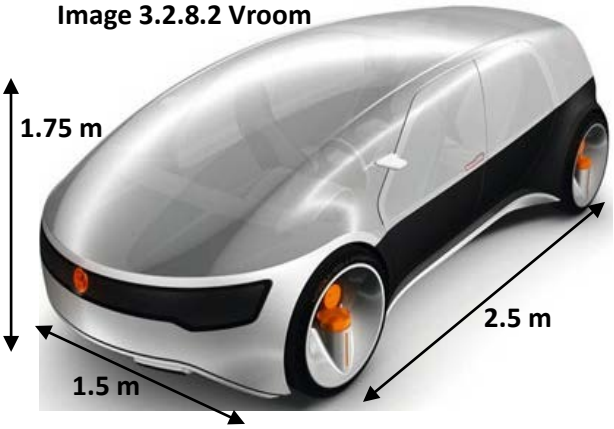


Image 3.2.8.3 Setro

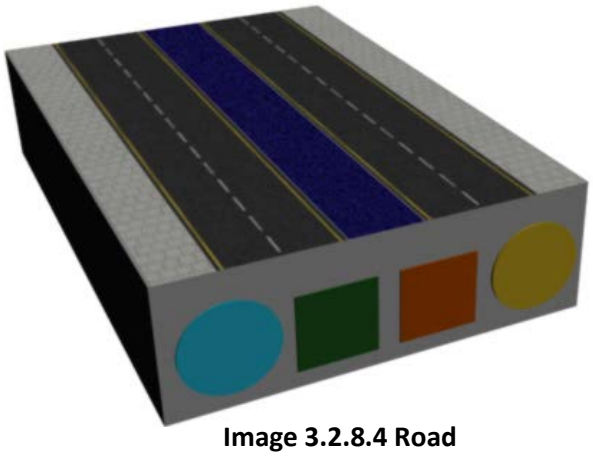


Image 3.2.8.4 Road

3.2.9 Day/Night Cycle Provisions

A 14 hour day and a 12 hour night will be maintained at Auroria. Reflectors at the central cylinder are continuously adjusted at different angles to provide the illusion from dawn to dusk. Any lag in intensity will be covered using artificial OLED's. At night the intensity of sunlight will be reduced using the electro chromic smart glass.

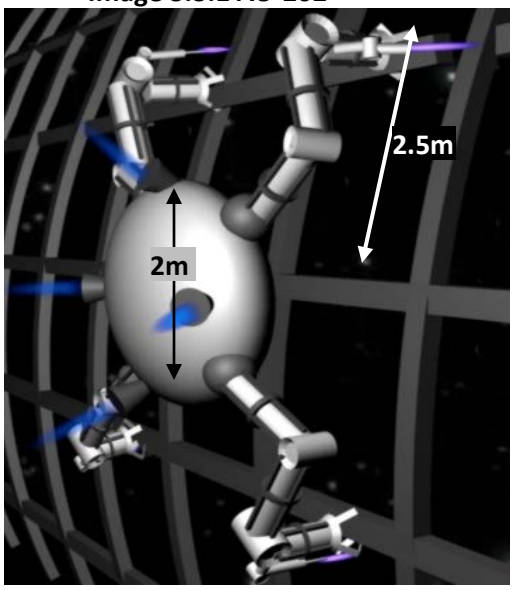
3.3 Exterior Construction

Construction of Auroria will be done directly at its orbital location. First, a construction shack is transported to the site and a mass catcher is deployed to collect the processed materials from Mars and Moon. Then, the whole area is mapped using 3D positioning system and data is fed into AU-202 on the grid and secure pre-manufactured tiles in the grid. The whole construction process is supported by Transporter which transports material from the Construction Shack to the robots.

3.3.1 AU-202

AU-202 is responsible for the construction of the outer grid of the settlement. Using its small and efficient design, AU-202 helps build the outer grid within minimum amount of time. The four arms placed strategically enable it to crawl on the grid, while the thrusters on the back allow it to manoeuvre unfinished sections of the frame. Grippers placed on each arm places the segments of frame while welders attached to the gripper weld it to the spot.

Image 3.3.1 AU-202



3.3.2 AU-303

AU-303 is used for laying tiles of construction material into the framework. The whole system consists of 2 storage units, along with the tethered AU-303 in the middle. The system of tethers allows it to lay 9 tiles in a few seconds while staying at one place. The tiles in storage units are replaced using Trombo (section 3.3.3). Image 3.3.2.1 shows the tiling process.

Image 3.3.2.1 Tiling on Auroria

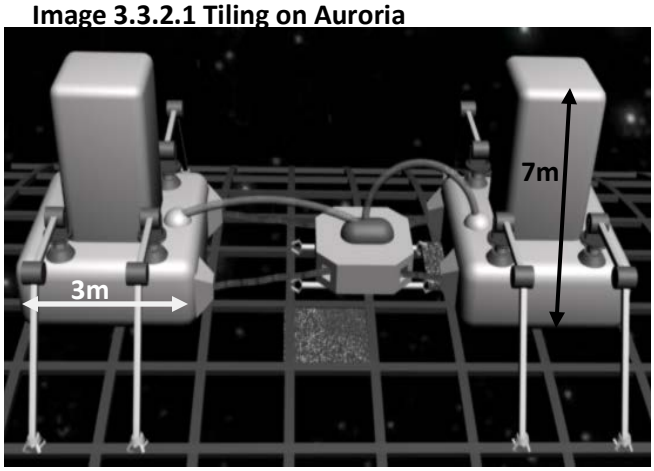
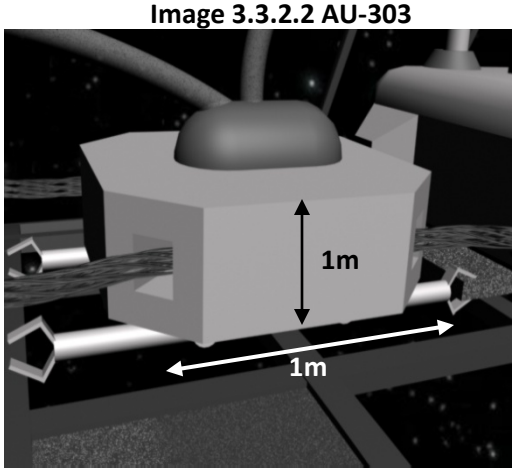


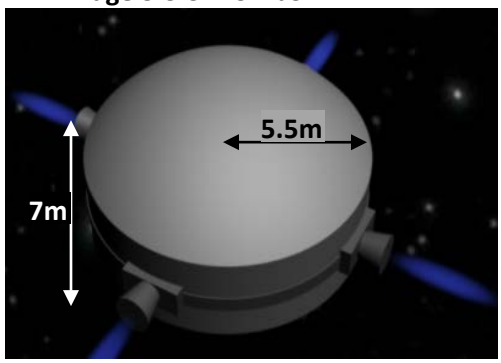
Image 3.3.2.2 AU-303



3.3.3 Trombo

Trombo will be used for transporting materials from the Construction Shack to the robots present at the construction site.

Image 3.3.3 Trombo



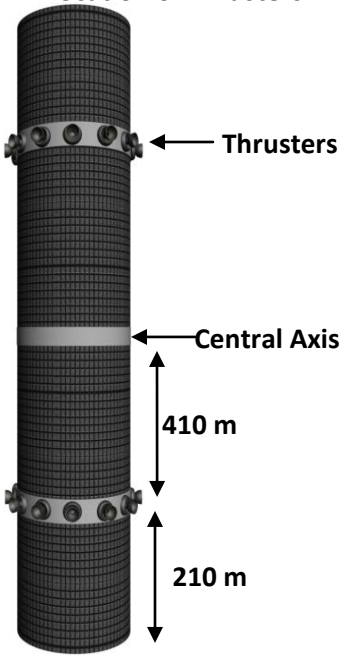
3.4 Propulsion Systems

Auroria will use Bi-propellant propulsion system to move it from its orbital location in case of a threat of an impact by a large object. This engine gives very high Specific-Impulse with light weight fuel which is one of the key requirements for producing high thrust in space. The basic requirements of this propulsion system are as follows:

- Thrusters and engines placed equidistant at both ends of central cylinder to maintain balance
- Storage area for fuel (LH2)
- Oxidizer (LOX)

- Temperature regulators
- High pressure carbon fibre wound helium pressurant vessels

Image 3.4.1 Location of Thrusters



A propulsion section of radius 150m and height 100m is allocated on both sides of central cylinder which consists of all the propulsion provisions mentioned above. The volume of the propulsion section, excluding the transportation elevator area, is 6,942,919m^3 on each side. An isolation of 10 m is present on either side of the propellant section to ensure safety in case of emergency.

Each propellant section will consist of 12 thrusters producing up to 200,000 N of thrust. With the engine's exhaust velocity of 5000 m/s, the expected change in velocity of Auroria is 0.014814 m/s. With this velocity it will take Auroria about 30 hours to move a distance of 1600m. The overall expected mass of the engine is 0.95 tons. Since the calculated mass ratio i.e. propellant per unit mass of payload comes out to be 1.000003292, the expected mass of the entire system with the fuel is 0.190000312 tons. Due to easy availability of the required fuel, once used, it can be easily acquired within a short duration of time.

Image 3.4.2 Bi-Propellant Engine

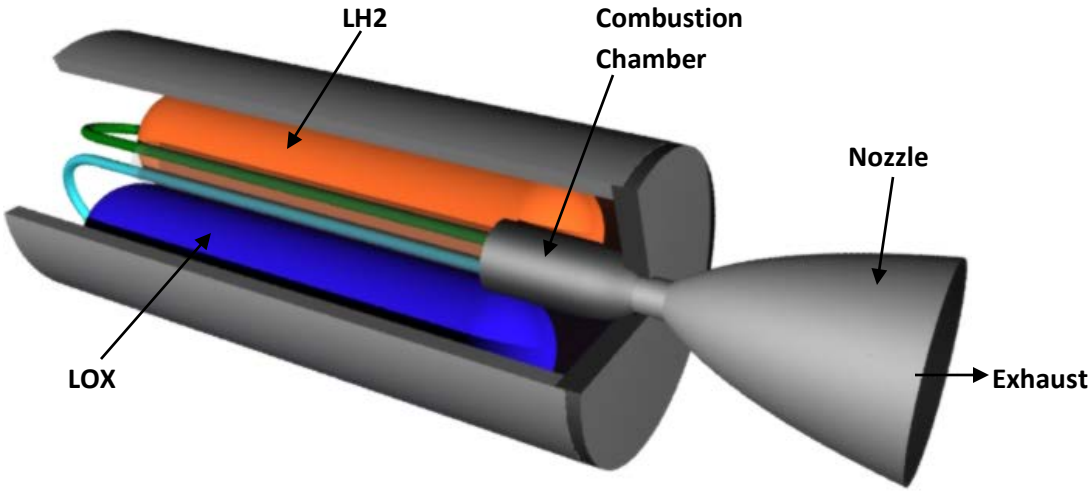


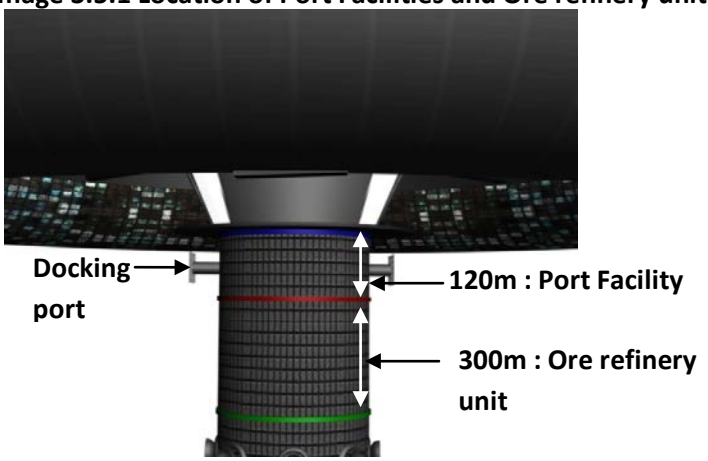
Table 3.4.1 Specifications of the Propulsion Engine

Engine	Bi propellant
Fuel / Oxidizer	LH2 / LOX
Exhaust Velocity (m/s)	5000
Thrust (N)	200,000
Mass Engine (tons)	0.95
Mass Engine with fuel (tons)	1.000003292
Engine idle Power Production (MW)	0.192697768

3.5 Port Facilities and Ore Handling Process

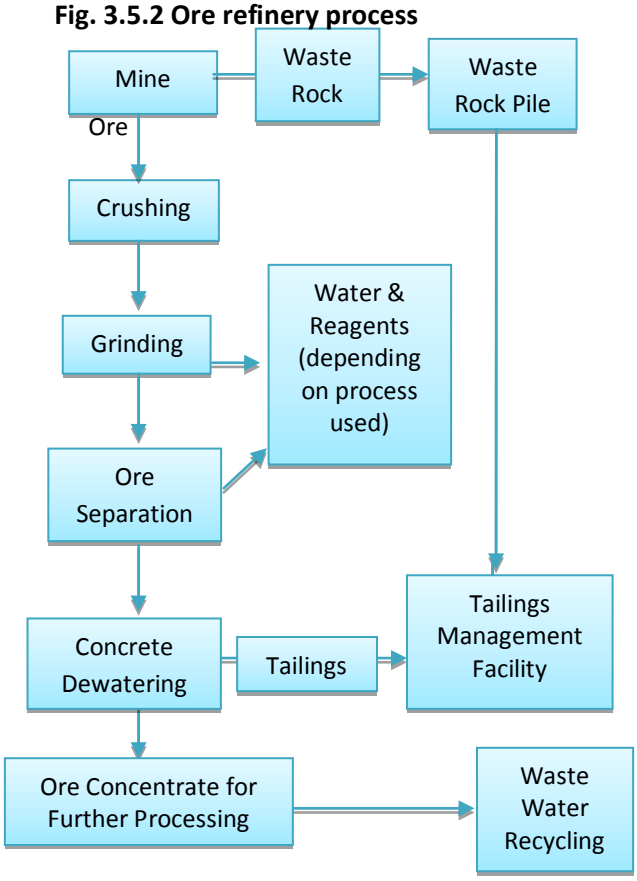
The Port Facility section has a radius of 150m and a height of 100m. The main transportation elevator section is in the middle with a radius of 20m. The volume of the port facility section, excluding the transportation elevator area, is 6,942,919m^3. Two docking ports are present in this area which allows the incoming and outgoing of the materials. Air locks with donning and doffing facilities (4.3.4) along with refuelling facilities and cargo handling equipment are also present within this section. Right next to the port facilities is the ore refinery section which has a radius of 150m and a height of 180m along with the main transportation elevator (radius 20m). The volume of the ore refinery section, excluding the transportation elevator area, is 12,497,255m^3.

Image 3.5.1 Location of Port Facilities and Ore refinery unit



Raw ore coming from other locations can be transported through cargo spaceships which dock to the ports present at the port facility section. Materials are received and then fed into the ore processing industry via Electro-magnetic crane (refer to 5.5). Once the ore reaches the ore processing industry, it is first fed into a series of crushers and grinding mills to reduce its size. Following this, the magnetic separation takes place depending upon the ore. After that, fine bubbles are introduced into the mixture of ground ore in water to form slurry through the process of Flotation Separation. Then depending upon the type of ore, the respective leaching operations are carried out, involving the addition of a dilute cyanide solution. Following that, the removal of the excess water takes place i.e. dewatering. Tailings, the left over materials after separation, are extracted and transferred to the Tailings Management Facility. The resultant ore is preserved for further processing if necessary.

Fig. 3.5.2 Ore refinery process



4.0 HUMAN FACTORS

4.1 COMMUNITY DESIGN

The length of the down surface of residential torus is **6031.86 m^2**. The residential down surface is divided into four communities; Bronx, Kings, Queens and Richmond, all centred around the transportation spoke. Each community is further divided into the Downtown area, Countryside area, Public Utilities area, and a high-rise in the middle built around the transportation spoke to give residents a feel of the city. Utilising the space available in the torus without disrupting line of sight as the view of high-rise gets immersed with that of spoke.

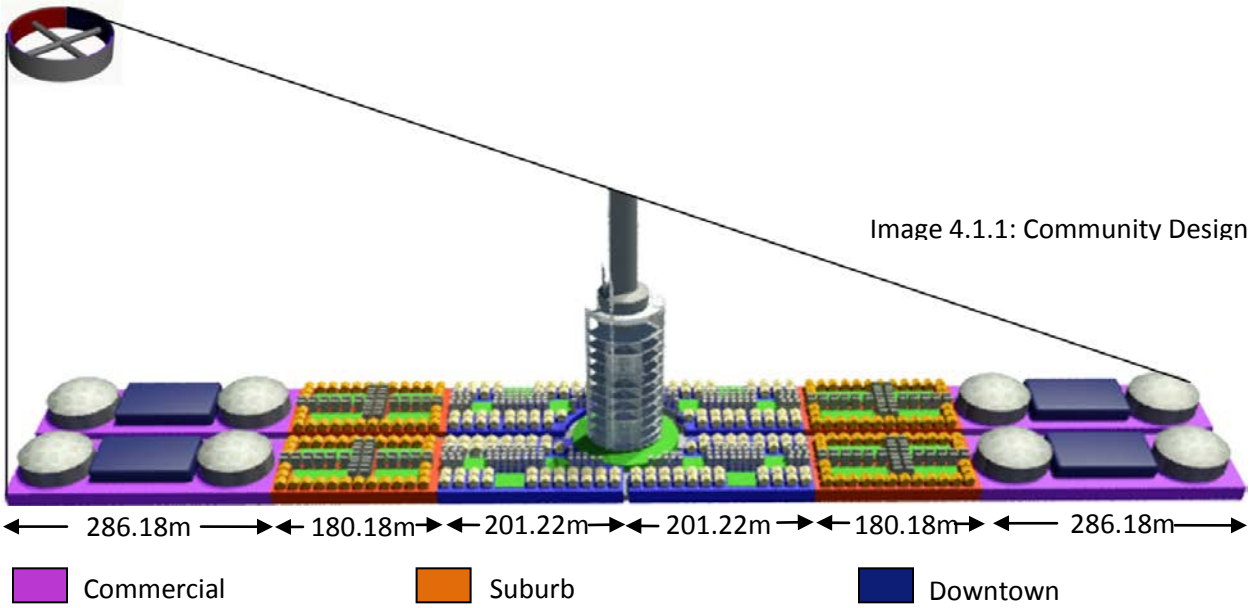


Image 4.1.1: Community Design

The radius of high-rise is xx m, and the width of the park is xxm

4.1.1 Features

Auroria provides a high standard of living for both workers and residents. It welcomes every one with an earth like feeling. Auroria is an incorporation of a comfortable suburban with a hi-tech environment which includes education, housing, medical facilities, recreational activities and entertainment sources.

Houses - Each community has two kinds of residential areas; Downtown and Suburban area. The Downtown area has smaller houses and apartments to accommodate more people near the transportation spoke. The Suburban area includes larger houses and vast open spaces for the people who like countryside living. Floor plans for residences are given in section 4.2.

Recreation/Entertainment - The four communities in Auroria have their unique recreational areas. “Bronx” has a stadium where most of the outdoor sports activities and competitions take place. The “Queens” and “Richmond” communities each have a Cineplex. There is a lake located in “Kings”. The central cylinder facilitates micro-g recreation. It has facilities like zero-g clubs, hockey arenas, yoga classes and swimming.

Healthcare - There are two hospitals, one in the “Queens” and the other in the “Kings”. Robots help in the treatment and taking care of the patients in the hospitals. Regular check-ups of all the residents are conducted semi-annually to keep the environment in Auroria healthy and disease-free.

High-rise - A high-rise is built around the transportation spoke to give residents a feel of the city along with utilising the space available in the torus without disrupting the line of sight. It will be 100m high, and has 20 stories. The bottom 8 storeys of the high-rise will contain the mall and the remaining will contain offices. A park around the highrise will act as a separation from the rest of the community and would provide some open space in the dense Downtown area.

Education-Education will be given utmost importance in Auroria. The first mini-torus contains the schools and playgrounds. University, which is in the second mini-torus offers different vocational courses related to tasks required for the functioning of Auroria, and various research facilities for those who want to work for the betterment of science. All the educational facilities are in a calm and serene environment, away from any distractions.

Natural views of space - Half of the total surface area of the torus above the down surface of the residential torus is made up of glass, which provides residents with natural views of space. This ensures that there is no psychological feeling of isolation among the residents.

4.1.3 Consumables and Supplies

The following is a list of consumables that are available to the residents of Auroria.

Table 4.1.3 Consumables and Supplies

Consumables	Quantity required per month	Manufacturing and Distribution
Food	625830 kg	Food is produced in the agricultural torus where it is processed and packed before being supplied to the warehouses in the residential torus.
Water	258750 kg	After the water is acquired from Ceres, it is recycled and stored in the Agricultural Torus. It is then transported to various locations in Auroria using water pipelines.
Clothing and footwear.	36000 items	Clothes are manufactured in the manufacturing industries in the central cylinder, and then stored in warehouses in the residential torus. The footwear will be made by processing the skin of animals. On demand manufacturing of clothes and footwear is also available.
Household Supplies	172500 items	Household supplies, including toiletries and cosmetics are manufactured in industries, and stored in warehouses in residential torus before they are delivered to houses and shops in high rises.
Medicines	55000 units	Most of the medicines are organic and manufactured from medicinal plants grown in agricultural area. They are available to the consumers only from the pharmacy in the hospitals.

Open Spaces – There would be a total of 166,377m^2 of open spaces in form of lake, parks, golf courses to give an earth-like feeling to the residents and also, it provides a scope for expansion of the settlement.

Area allocated to the roads : 127,175m^2

4.2 HOUSE DESIGNS

People have different tastes and therefore Auroria will be providing four different types of residences. These houses will be comfortable, spacious and innovative. Interior decoration will be upon the owner's discretion. Table 4.2.1 shows the number required for each house design.

Table 4.2.1 House

POPULATION TYPE	NO. OF PEOPLE	TYPE OF RESIDENCE	NO. OF RESIDENCE(in units)	Dimension (in feet) lxw	Area (in $feet^2$)
Married adults	3300	Small Houses	900 units	25x32	1600'
		Big Houses	750 units	25x35.9	1795'
Single adults	7040	Small Apartments	5040 units/ 1260 blocks	38.5x26	1001'
		Large Apartments	2000 units/ 500 blocks	40x35	1400'
Children	660	Houses	Along with married adults		

Image 4.2.1 Large Apartment Plan

Image 4.2.2 Large Apartment Exterior

Image 4.2.3 Small Apartment Exterior

Image 4.2.4 Small Apartment Plan

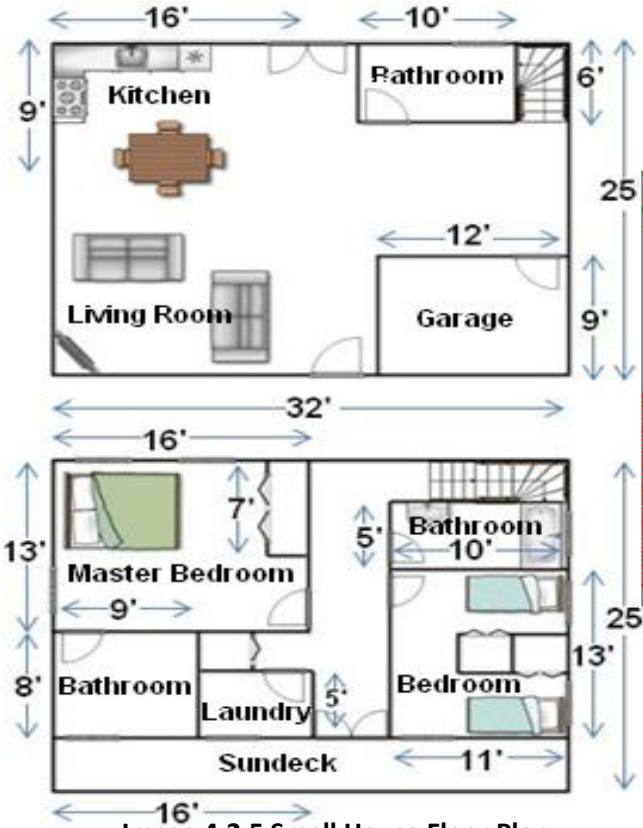


Image 4.2.5 Small House Floor Plan

Image 4.2.6 Small House Exterior

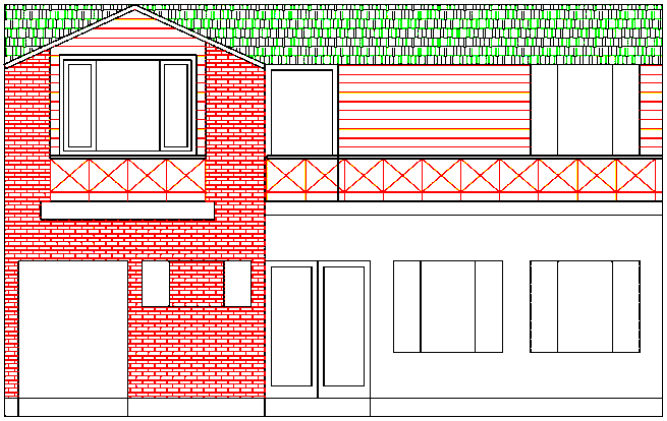


Image 4.2.6 Large House

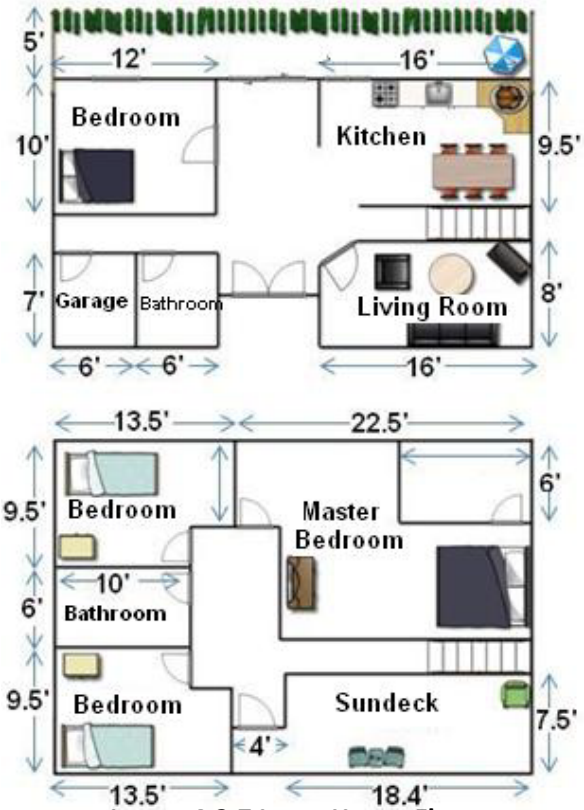


Image 4.2.7 Large House Floor

4.3 Designs of Systems, Devices and Vehicles

4.3.1 Systems

Table 4.3.1 depicts the various systems that are used for safety outside the artificial gravity area.

	System	Location	Purpose
1	Pressure Check System	Mining Base and Auroria	Detects leaks in pressure in enclosed gravity, and notifies the control centre in case of any leaks.
2	Air Revitalization System (ARS)	Mining Base and Auroria	Responsible for maintaining the air supply and the composition of air.
3	Deep Space Tracking System	Control room in Auroria	Designed to track the location of miners and space craft's for their safety.
4	Emergency Evacuation System	Central Cylinder	Designed to rescue miners working in the mining camp in case of an emergency.

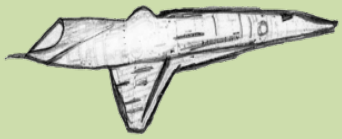
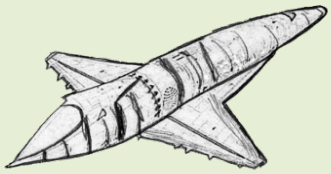
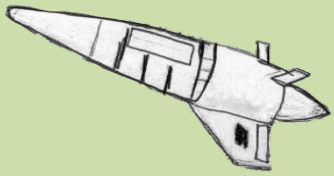
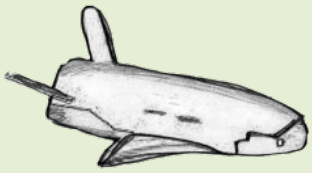
4.3.2 Devices

Table 4.3.2 shows various devices used outside of the artificial gravity area.

	Device	Location used	Purpose
1	Tethers	Central Cylinder and outside Auroria	For bonding humans with a surface while floating in microgravity.
2	Handrails	Central Cylinder and mining base	Provide support for commuting in microgravity.
3	Cages	Central Cylinder	Horizontal elevators for moving around the industrial section.
4	Safety Helmets	Central Cylinder	Lightweight helmets for protection against head injuries.
5	Tracking Chips	Outside enclosed volumes	For tracking the location of miners and vehicles near Astoria.
6	SOS Button	Central cylinder and mining base	To make a distress call. Location will be tracked using tracking chips and a rescue mission will be sent immediately.

4.3.3 Space Vehicles

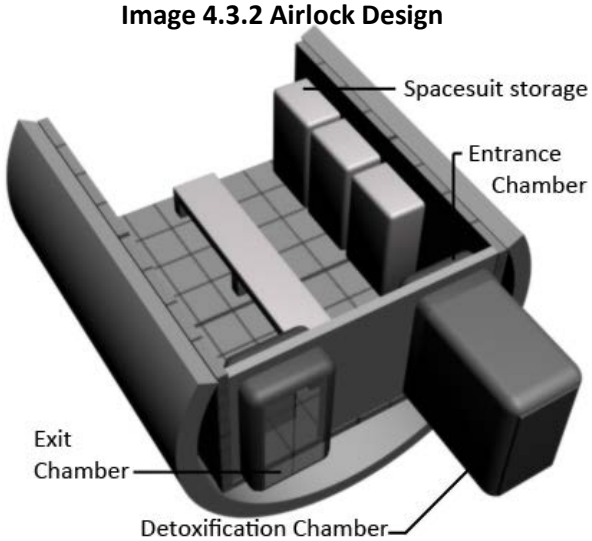
Table 4.3.3 shows different vehicles used for transportation in space

	Vehicle	Number	Purpose	Capacity	Dimensions (in meters)
1	**Aediles** 	10	Transportation to mars and LEO.	Payload: 75 tones Passengers: 400 Cargo: 40tones	28 x 10 x 12
2	**Aeneas** 	08	Transportation of products/people to Earth.	Payload: 50 tones Passengers: 450 Cargo: 16 tones	24 x 9 x 11
3	**Angu** 	04	Used for space research and studies.	Payload: 100 tones Passengers: 100 Cargo: 32 tones	30x 15 x 14
4	**Antenor** 	10	Transportation of mined materials form the mining colony to the settlement	Payload: 120 tones Passengers: 100 Cargo: 80 tones	32 x 16 x 1

4.3.4 Donning and Doffing procedures

Before the donning procedure takes place one has to breathe 100% oxygen for 30 minutes, and then they enter the airlock (figure x.x.x) and don the space suit, along with helmet, the comfort gloves, the boots, and the LSB (life support backpack). A leak check is conducted on the spacesuit. Finally when vacuum is created in the chamber, the person enters the exit chamber and the door slides back down to

Image 4.3.2 Airlock Design



through the

entering chamber into the airlock. The pressure of airlock is slowly increased and when it reaches the normal pressure, the person removes the space suit and is then ready to leave the airlock.

4.3.5 A-suit

The A-suit (figure 4.3.5) will allow settlement workers and miners to conduct space walks with all the required amenities. It is a lightweight, compact suit which includes a first aid kit, tool pocket and a chip attached to it so that the exact location of the miners can be tracked from the control centre. Circulation of cooled and purified oxygen will be controlled by the Life Support Backpack.

seal the chamber. The opposite door will slide up and the person will then step into outer space. On coming back to the airlock, the person will first enter a detoxification room in which they will be sprayed with pressurized air in order to remove any dust that may have been on their space suit. The detoxification room will be sucked of all dust. Then the person will pass

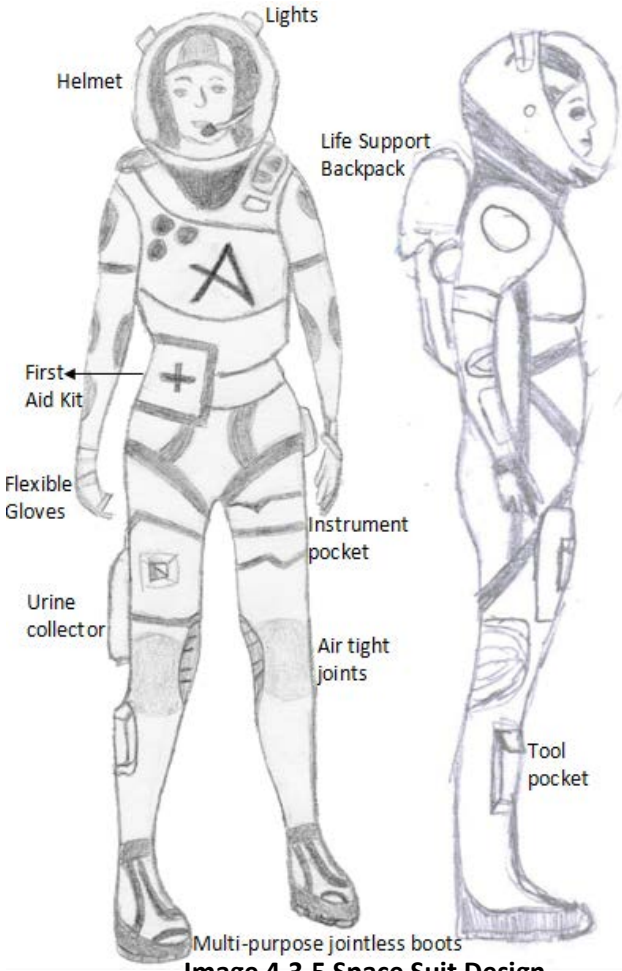


Image 4.3.5 Space Suit Design

4.4 Means for child growth in 1 g

The residential torus of Auroria provides 0.86g which is not sufficient for development of children. From the existing space settlements of the Foundation society, it has been shown that children need to spend at least three hours per day in 1g environment for their proper physical and mental growth. Table 4.4.1 shows various deformations that happen to children raised in low gravity.

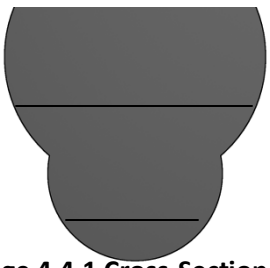


Image 4.4.1 Cross-Section of School sub-torus

Table 4.4.1 Effects of Low Gravity on Humans

Effects	Body Effects
Musculoskeletal Atrophy	➢ Inability to perform tasks due to loss of skeletal muscle mass, strength, and endurance. ➢ Brittle and weak bone. ➢ Renel stone formation.
Cardiovascular Alterations	➢ Under-developed cardiac muscles ➢ Manifestation of serious cardiac dysrhythmias and latent disease. ➢ Impaired cardiovascular response to orthostatic stress.
Neurovestibular Alterations	➢ Disorientation ➢ Impaired coordination ➢ Impaired cognition

To counter this issue, Auroria will have two sub-tori below the down surface area of the residential torus. One sub-torus will house a university, while the other sub-torus will house the playschool, high school, daycare centre and playgrounds. This will ensure that all the children spend enough time in 1g to grow up without any deformities.

4.5 Instant Move-in Homes

To accommodate the nomadic nature of humans, Auroria will provide instant move in homes. Short term houses will be available for temporary visitors. There will be 4 different styles of houses, and people can choose according to their own taste. These houses are designed to accommodate two to three people. Instant move in homes are built in a luxurious fashion and it is an outstanding offering from Auroria to its visitors.

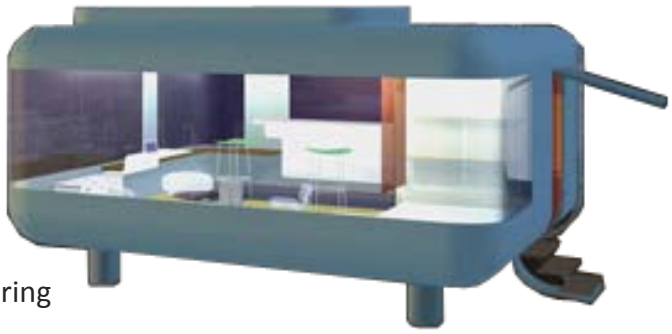


Image 4.5.1 Instant Move in Home

5.0 AUTOMATION DESIGN AND SERVICES

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5.0 AUTOMATION DESIGN AND SERVICES

Auroria's state of the art technology allows it to sustain a large population efficiently. In order to function properly and avoid human errors, all the activities are automated and coordinated by super computers. Robots are used to perform maintenance tasks which provide efficiency and ease in carrying out settlement operations.

Table 5.0.1 shows various information processing devices used by Auroria residents.

Device	Processor	Memory	Storage	Number
Auri (Handheld)	4 Ghz	64 Gb	4 Tb	10740
Personal Computers	128 Ghz	512 Gb	128 Tb	9190
Business Machines	512 Ghz	2 Tb	2 Pb	6000

Table 5.0.2 shows the servers that are used in Auroria.

Server	Location	Processor	Memory	Storage	Number
Auroria Main Server	Central Cylinder	512 PFLOPS	4 Pb	200 Pb	1
Residential Server	Residential Torus	64 PFLOPS	2 Pb	60 Pb	1
Agricultural Server	Agricultural Torus	32 PFLOPS	2 Pb	20 Pb	1
Industrial Server	Central Cylinder	64 PFLOPS	2 Pb	40 Pb	1
Mining Server	Mining Base	8 PFLOPS	1 Pb	20 Pb	1

* Auroria Main Server also acts as a backup server to all the other servers listed above.

Table 5.0.3 shows the network devices that will be used in Auroria.

Device	Location	Purpose
Signal Processing Unit	Central Cylinder	Controls all the data transmission.
70 m Antenna	Outer surface of central cylinder	Communication between Auroria and other settlements.
1.52 m Antenna	2 in Residential Torus 1 in Agricultural Torus 1 Central Cylinder	Provide networking in Auroria

Data Storage - 3D Volume Optical Storage Technology will be used to store data which has a data density of more than 200 Terabits/sq.inch. Residents will have access to portable memory storage devices that range from 10 to 80 TB. Hard drive capacities of different computers and servers are listed above in table 5.0.1 and 5.0.2.

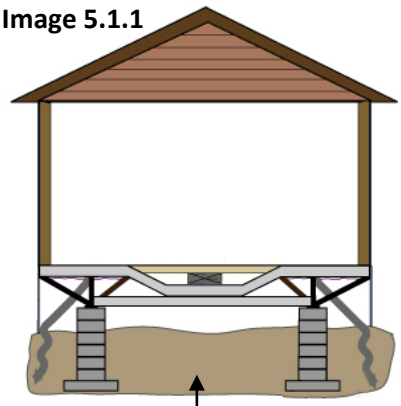
Data Security - Firewalls and antivirus software will be used to provide data protection from malicious software. Impact-resistant aluminum devices will be used to provide protection from physical damage; even in harsh conditions of outer space.

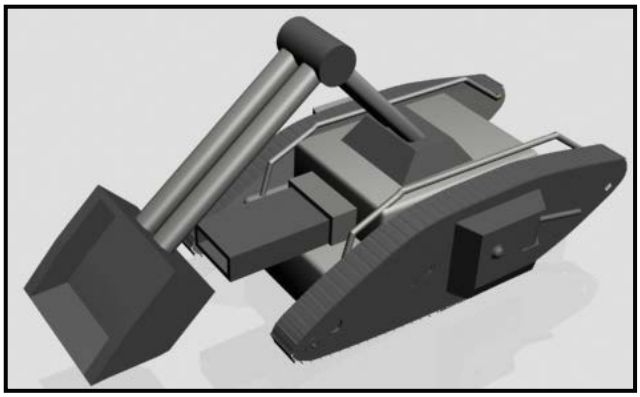
User Access To Computer Networks - All the residents will be able to access the network by using a combination of retina and fingerprint scan. Once logged on, the user's location on the network will be stored to prevent a possible security breach from each of the electronic devices. However, only administrators will have access to critical system data after clearing multiple security procedures. (section 5.2.5)

5.1 Automation for Construction

Interior construction of houses is done in manufacturing industry in residential torus. Houses are fabricated in industries set up in the commercial area of the residential torus. All the materials are transported to one site, which makes handling of materials easier and reduces wastage. The finished buildings are then towed to the site of construction where they are placed carefully over the wet concrete base, which dries up to secure the house permanently to the ground. Anchors are provided for additional support, and skirting is used to hide the base of the house. Using this method of construction, we can save Foundation Society millions of dollars in construction costs. (Image 5.1.1)

Image 5.1.1





AU-099 is used to make the concrete bases for the houses. It digs up a hole for the base, and concrete is poured in to the base using concrete pouring vent.

For external construction Au-202, AU 303, and Trombo are used. (Section 3.3)

5.2 Automation for Settlement Maintenance

5.2.1 Automation for External Repair

External repair is carried out by robots reconstructed from the AU-202. After the construction of the settlement is finished, the construction robots will be refitted in the robotics repair facility in the central cylinder. This will save the Foundation Society time and money. Any breach in the primary Nextel layer is detected by the "sensory net" covering the Kevlar 49 layer,

which sends the message to the mainframe system to dispatch the TiloBot. (Refer 2.4.3 for the repair details)

Safety during Solar Flares: All parts of the robots will be made up of Aluminum, which helps combat solar flare activity. Thin layer of RXF1 will provide extra shielding.

5.2.2 Automation for Settlement Maintenance and Safety

Name	Purpose	Numbers
AU-121	Maintenance of roads and parks	4
AU-131	For maintaining the security	8
AU-141	For providing emergency healthcare	8
AU-151	Delivery of groceries	150
AU-161	Cleaning of drains and pipes	4

5.2.3 Backup Systems

- All robots will have at least one extra unit for providing backup.
- All the major processes regarding functioning of the settlement will be done on the four local servers, while Auroria Main Server will coordinate their activities and act as a backup for all the data.
- Electric power will be stored in Lithium Ion batteries for backup.

5.2.4 Contingency Plans

To counter the life threatening emergencies, structural isolation of different volumes is provided. Residents will be shifted to other areas and the affected areas will be sealed off. Extra food and water will be stored in the central cylinder to provide backup for up to six months. To rescue the miners in case of an emergency, the Angu model II shuttle will always be docked in the docking port, located at the bottom of central cylinder.

5.2.4 Authorised Access

Fingerprint scan will be used in all areas that require security. However in areas of high security, a combination of fingerprint, vein pattern and retinal scan will be used. Three chances are given at each test; if a person passes all three tests, access to the area is granted. All the activities that require high security clearance are monitored and logged. Areas of high security are under video surveillance. If someone tries to break in, the security alarm is tripped and the area will be locked until the security robot arrives.

5.3 Automation for Liveability in Community, Productivity in Work Environment, and Convenience in Residences

5.3.1 Automation for Liveability in Community

Various automated devices will be used to maintain a clean and healthy environment in Auroria. Health information of all the individuals will be stored in Auroria Main Server, and individuals will be reminded of the next routine checkup through Auroria SmartMail. SMARTSCREENS (Image 3.2.2.2) in homes will allow residents to do their grocery shopping over the Auroria Network along with the option for window shopping that can be done in one of the four high rises. Each resident will be issued Auroria Resident Card (ARC)

5.3.1.a Auroria Resident Card

- This card can be used as an access card for almost all the operations on Auroria that the resident has been granted permission.
- This includes a finger print reader, which activates the card, allowing the user to operate the buttons to switch between identities for different departments. A unique, encrypted barcode will be displayed on the screen every time by Auroria Main Server which can be scanned by special code readers to grant access to different operations.
- All the information is accessed from the Auroria Main Server over a secured network, which eliminates the risk of data tampering.

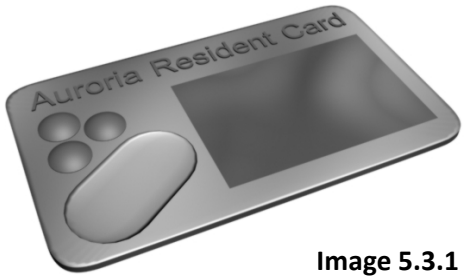


Image 5.3.1

5.3.2 Automation for Productivity in Work Environment

Use of automation at work places will be done to enhance productivity. Separate handheld devices, palmers, are given to employees working in the industrial sector. The palmers of all the employees will connect with each other, check with the agenda for other employees and organise the employee's meetings activities and tasks for the day accordingly. All the officials holding high posts will have an AU-22 with them which will act as a personal assistant.

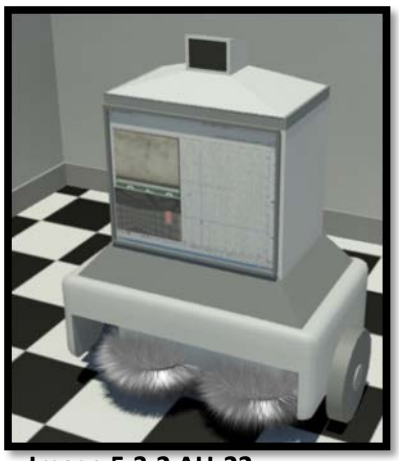


Image 5.3.2 AU-22

5.3.2.a AU-22

- Daily task organising in coordination with palmer.
- A High Definition projector for use in presentations.
- Touch screen display for remotely accessing files from office computer.

- Controlled by voice commands for easy use.
- A vacuum cleaner for cleaning office floors.

5.3.3 Automation for Convenience in Residence

All houses will be fully equipped with up to date technology for enhanced convenience and liveability. A combination of face and voice recognition technology will be used to prevent any unauthorised access to homes. All the appliances and gadgets will be used through voice recognition to provide easy use. There will be automatic temperature and humidity control, and remote monitoring of the house is also possible by using Auri.

5.3.3.a Eve

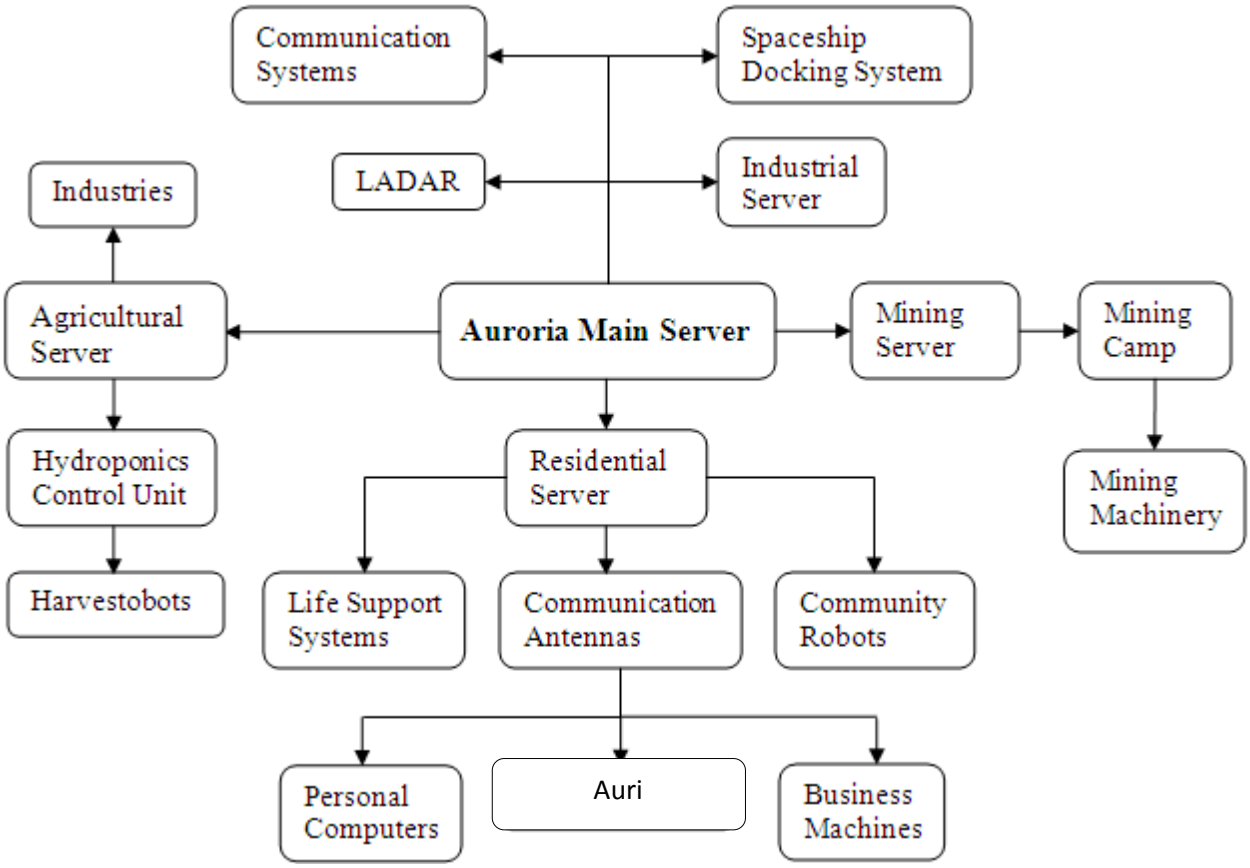
At 1.5m tall, Eve is the pride of every single Aurorian residence. Equipped smart voice recognition system, it is able to take commands through the voice of the master and is also able to distinguish between different sounds. The cameras in the head provide 150 degree vision at any instant, while the 360 degree rotational head ensures that no sight remains unseen by Eve's "eyes". A vacuum cleaner at the bottom helps it to keep the floor clean. Three joints in each arm allow the robot to have similar flexibility as a human arm. It also comes with a tray that can be used to transfer utensils. Programmed to be cheerful and playful, the sleek and slim Eve will be a "man's next best friend".

Image 5.3.3 Eva

Privacy of personal data: Software encryption will be used for protecting personal data along with use of firewalls and antivirus system. However, for the data that requires more security, quantum cryptography will be used.

Network Bandwidth diagram

The bandwidth provided over the Auroria Network to the residents will be 100 Gbps. However, a faster and more secure communication network of 800 Gbps will link the servers with different infrastructural and automated facilities. The bandwidth link between the servers would be 2 Tbps.



5.4 Mining Robot

Mining on the chosen asteroid will be done with Excatron(Image 5.4.1). Excatron will be sent along with other equipment to the asteroid camp before the humans arrive. Once the mining camp is completely established, all the units are powered up and the mining begins. Excatron moves with the help of tethers, thus resolving the problem of non-existent gravity found on the asteroids. Most of the dust that is generated during mining is collected by the rotating canopy. To protect the robotic joints from the remaining dust present on the surface of asteroids, the joints are sealed with pressurised, flexible covers which keep the dust out. However, the robots are subjected to scheduled maintenance in the robotic care facility to keep the dust off.

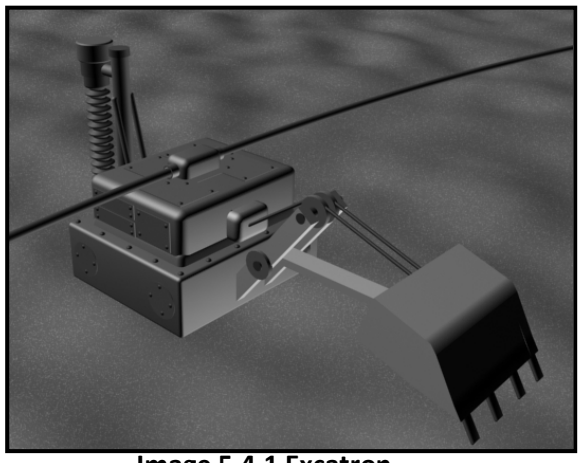


Image 5.4.1 Excatron

The Excatron is equipped with a shovel for mining a surface and a drilling component to extract volatiles deep beneath the surface. This loosens the surface dust which is then collected in

canopy, while the drilled volatiles are directly collected by trombo(section 3.3.3) which will be re-commissioned at the mining base, once the final construction of structure is done. The transport unloads the materials at the collection point which are then transported to the storage domes through pipelines.

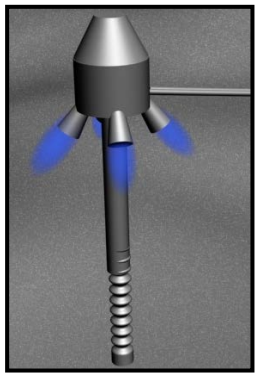


Image 5.4.2 Astro

The fixing of tethers is done by Astro, which grasps the tether poles and drills them at other feasible locations. Before moving the tether poles, the excatron attaches itself to the fixed wall on the other side of tether to provide ease for the movement of tethers. (Image 5.4.2)

Once the mining on a particular location is finished, the canopy is transported to Auroria and a ship collects the materials from the storage dome, and transports them to Auroria. Once all the profitable materials are extracted from that location, the equipment is shifted to another location.

5.5 automated systems for unloading ore delivered by ships from other mining installations.

Auroria will also include infrastructure to accept mined materials from mining installations other than the one at 4 Vesta. The ore will be accepted in containers with dimensions 10m x 10m x 5m. The cargo ship docks at the docking bay in the port facility where the cargo is unloaded and transported to the refinery in the ore processing area, which is located right below the port facility in the central cylinder. To unload the containers from the ship, an electro-magnetic crane is used. The crane is fixed to one end of the wall near the unloading bay. Once the cargo is ready to unload, the crane moves near the containers (made of iron), and supplies EMF to power the electro-magnet. The electro-magnet attaches itself to the container, and the crane rotates to transport the container to the elevators located on the opposite side. Once the crane detaches itself from the container, the elevator takes the container to the ore processing area. A similar procedure is used to transfer the container from the elevator to the refinery using the electromagnetic crane. Empty containers are transported back to the ship using the same procedure.

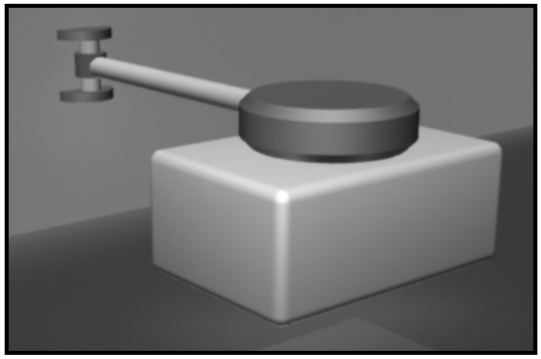


Image 5.4.2 Electro-magnetic Crane

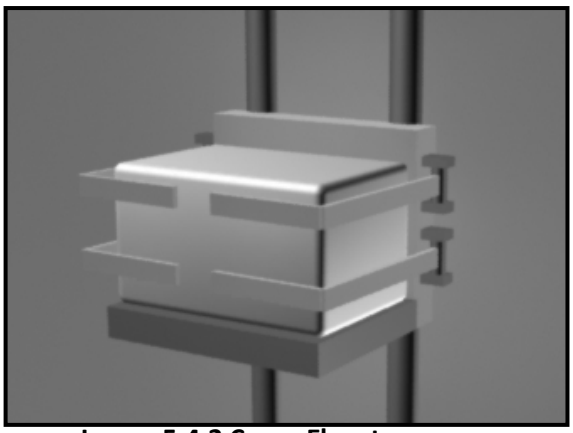


Image 5.4.2 Cargo Elevators

6.0 SCHEDULE AND COST

6.0 SCHEDULE AND COST

6.1 SCHEDULE

The planning regarding the construction of Auroria will start on May 9, 2071 i.e. the very next day of award of Contract. Using multi-tasking, Auroria will be ready for human habitation within seventeen years(2088). Then, after four months of testing all the infrastructure, it will be opened to members of Foundation Society in 2088 and transfer of population will be completed by 2089. The following chart shows different phases of the construction process, and time taken to complete them. (years are in form of 20xx)

Award of Contract	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89
Initial Planning																			
Hiring Workers																			
R & D																			
Crew Training																			
Subcontracts																			
Robots & Machinery																			
Mass drivers																			
Construction Shack																			
Location mapping																			
Mining Camp																			
Transfer of Crew																			
Outer Construction																			
Phase 1																			
Phase 2																			
Phase 3																			
Phase 4																			
Phase 5																			
Testing																			
Human Habitation																			

6.2 COST

Phase (No. Of Employees)	Description	Total Cost
Initial Planning (80)	Done at Columbiat	3.5 M
R&D (800)	Done at Bellevistat/Aresam	2500 M
Crew Training (500)	Done at Aresam	300 M
Robots and Machinery (1250)	Manufactured in Bellevistat	15000 M
Mass Drivers (150)		15000 M
Construction Shack (400)	Building Construction Shack	6500 M
Mining Camp (550)	Installed on Asteroid	25000 M
Crew Transportation (1500)	To Construction Shack	6000 M
Outer Construction (800)	Central Cylinder	7000 M
	Agricutural Torus	7500 M
	Residential Torus	18000 M
	Spokes	2000 M
	Docking Ports	3700 M
	Propulsion System	1600 M
	Antennae	125 M
Interior Infrastructure (650)	Central Cylinder	35000 M
	Agricultural Torus	18000 M
	Residential Torus	29000 M
	Transportation Systems	5000 M
Human Habitation	Transportation of Humans	15000 M

Total Cost to Foundation Society : $212.2285 Billions

6.1.1 Cost to Foundation Society Per Year

Year	Tasks	Total Cost
2071	Initial Planning, R&D, Awarding Subcontracts	503.5 M
2072	R&D, Crew training, Mass Driver, Construction Shack	10250 M
2073	R&D, Crew Training, Mass Driver, Construction Shack	10150 M
2074	R&D, Construction Shack, Mining Camp, Crew Transfer	21100 M
2075	R&D, Machineries, Mining Camp 1	13900 M
2076	R&D, Machineries, Outer Construction1	4900 M
2077	Machineries, Outer Construction1	4500 M
2078	Machineries, Outer Construction, Interior Finishing1	13750 M
2079	Machineries, Outer Construction, Interior Finishing 2	14750 M
2080	Machineries, Outer Construction, Interior Finishing2	23000 M
2081	Machineries, Outer Construction, Interior Finishing1	21000 M
2082	Machineries, Outer Construction, Interior Finishing1	20425 M
2083	Machineries, Interior Finishing2	8000 M
2084	Machineries, Interior Finishing1	7000 M
2085	Machineries, Interior Finishing2	9000 M
2086	Interior Finishing	6000 M
2087	Interior Finishing	9000 M
2088-89	Testing, Human Habitation	15000 M

7.0 BUSINESS DEVELOPMENT

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7.0 Business Development:

"Business, more than any other occupation, is a continual dealing with the future; it is a continual calculation, an instinctive exercise in foresight. " To make a colony prosper, a good business infrastructure is required which will be provided in Auroria to maximize Foundation Society's profits.

- Astoria's economy will be mostly depended on mining. Mining on asteroids will start before the construction of settlement begins. Therefore, initial mining equipment will be manufactured in Bellevistat and transported to Vesta to mine the materials which are required in construction of the settlement.
- All the mined materials will be transported to Auroria where processing and manufacturing industries convert it to final product. A total of 13,885,839.53m^3 of industries ensures the constant supply of trade commodities.
- Most of the manufactured goods will be exported to Earth and other space settlements. In order for that, Astoria is equipped with 2 docking ports which also help in avoiding traffic of shipments. In each port, there are separate bays for import and exports of trade commodities.
- Once a ship enters the docking bay, it first has to go through airlock which in which all the surface dust is removed using pressurised gases. Then the ship's surface is brushed to remove any remaining dust. Special gas blowers are used to clean the moving part of the ship.
- Food is produced in excess to accommodate the needs of visiting spacecraft crews. After processing and packing of food, it is stored in storage area in Central Cylinder. At any single time, enough food is stored to provision a spacecraft with a 10-person crew for a six month flight.
- Auroria will offer a sophisticated life style to all the visiting space craft crews. Along with providing comfortable houses for living (Section 4.5), visitors will be issued a temporary Auroria Resident Card so that they can access all the recreational facilities available to residents of Auroria. There will be guided tours of Auroria and the mining camp for the visitors.
- Auroria will act as a service station for space vessels. Aroria's A-station is built in such a way that it can do the maintenance of multiple space vessels at the same time. Shuttles will be repaired in repair facility located at the very bottom of the central cylinder with a total volume of 14142857.14 $m^{3,}$ out of which 9,900,000 m^3 is dedicated for shuttle repair.

- Since the thrusters use the same fuel as space crafts, the storage for spacecraft fuel is shared with the storage for thruster fuel which is present on two locations in central cylinder near the thrusters. The fuel is transported to port facility via separate elevators.
- The propulsion section of Auroria has a volume of 6,942919m^3 out of which 5000m^3 is allocated for fuel storage. For fuel production h2 and oh are acquired by electrolysis of water which are then liquefied using a compressor.
- Tug ship will be there to assist the disabled vehicles. It hooks up to the disabled ship using tethers and transports it to Auroria where it is repaired in Shuttle repair facility.
- Auroria's Angu model II space ship can be used as an emergency vehicle. It has a pay load of 200 tonnes which can carry up to 500 passengers. It will be equipped with a hospital which consists of 3 operation units and 5 Intensive Care Unit.
- A radio telescope will be installed on the centre of top surface of the central cylinder with a dish diameter of 150m. Its position on Central Cylinder ensures that it is relatively stationary with respect to the settlement. The radio telescope will be used to map the location and composition of different asteroids to search for possible mining locations.

- An optical telescope will be provided in the Research facility in central cylinder, with a dish diameter of 8 meters. This telescope will help researchers to study the phenomenon of space, and carry out further research using the images gathered from telescope.

8.0
APPENDICES

Appendices

A. Operational Scenario

A typical resident family of four in Auroria consists of 38-year old man, John, 35-year old woman, Martha, 10-year old boy, Max, and 4-year old girl, Lily.
The family lives in a large house in the community 'Bronx" in the "Suburb" section A typical day begins with a simulated sunrise at 7:00AM, using the OLEDs. Martha and John wake up at 8:00AM and are served with coffee and breakfast in bed by Eve, the "maid" robot. The breakfast is consumed while watching the Morning News on a Smartscreen in the bedroom.

By 9:00AM, Martha, the mother, gets Max and Lily ready for school and daycare respectively. The whole family leaves the house at 9:30AM, and take the Setro towards the highrise in the "Downtown Core". They arrive there in 10 minutes, and take the elevator down into the School Sub-Torus. At 9:55AM, the kids are dropped off at School and Daycare located in the Sub-Torus.
Martha and John then take the elevator towards the Central Cylinder and arrive there at 10:00AM. After arriving at the Central Cylinder, they part as John takes the elevator up towards the Research Unit and Martha down towards Shuttle and Robot Repair Section. The workers check into their workspace using their ARC (Auroria Resident Card), which only enables with a fingerprint scan. John and Martha work till 6:00PM, after which they proceed back towards the School Sub-Torus to collect their kids.
Lily and Max are dispatched from the daycare and elementary school at 2:00 PM after which they go to the "Play Land" and enjoy their time there till 6:00PM under teacher supervision. They are then picked up from there by their parents at 6:15PM and reach home via the Setro.

After arriving home, Martha and John rest for half an hour and decide to go out for the evening. They make a dinner reservation using "Auri" – the cellphone. The kids rest in their rooms for a while, and then start getting ready for dinner. At 7:15PM, the family travels to the Public Utility Area using their "VROOM", their personal automobile. They then park at the Mall and go shopping for house utilities, apparel, toys for children, medicine and other necessary groceries.
After shopping for about 45 minutes, they proceed to the restaurant at 8:00PM where they enjoy a nice dinner for about an hour. Then the family proceeds back to their home in the suburban section. After arriving home at 9:15PM, the children get ready for bed while the parents watch the evening news. Then the parents program Eve for next day and head off to bed.

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Asteroids - Their Nature and Utilization (Second Edition).
Materials Handbook (Eleventh Edition)

C. Compliance Matrix

Sections	Description	Page No.
Section 1.0	**Executive Summary**	
Section-2.0 Structural Design		
2.1.1 Basic Structure	Various components of structure are shown, along with their description and uses. Table 2.1.1.1.1 shows the different dimensions of the volumes and shows different functions of each component Means of isolating two volumes.	2
2.1.2 Functions	Uses of various components are discussed.	3
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