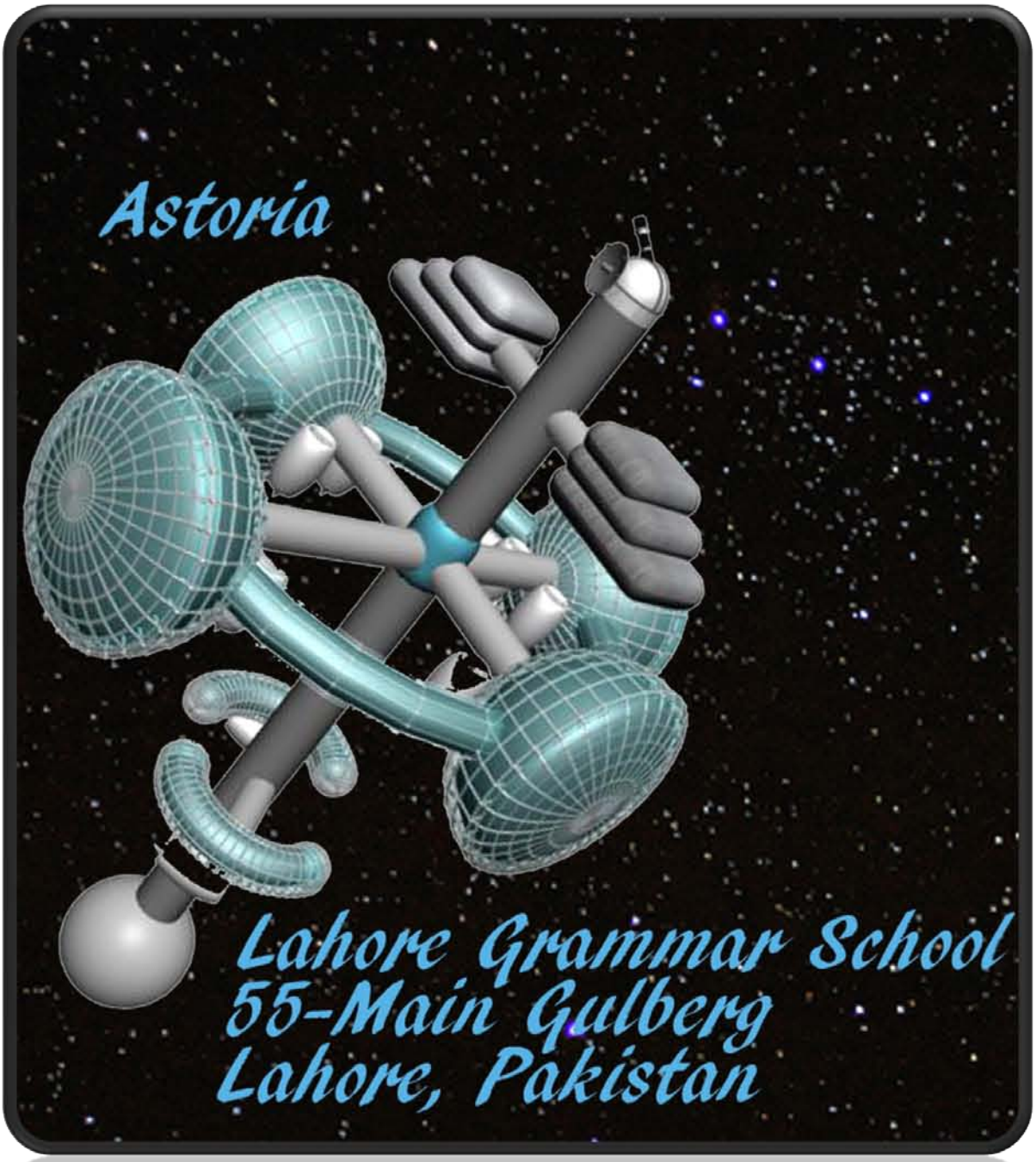

Astoria
Lahore Grammar School
55-Main Gulberg
Lahore, Pakistan

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

Name of responsible teacher/advisor: Mr. Nadeem Anwar
School (or other Group Name): Lahore Grammar School
School Address: 55-Main Gulberg
School City, State, Zip or Postal Code: Lahore 54660 Punjab
Country: Pakistan
Daytime Telephone at School: 0092 42 35712566
Message Telephone: 00923008441784 (anees)/ 00923364564946 (Fatima)
Fax: 0092 42 35871792
e-mail address: anees.ansari@lgs.edu.pk/fatimajamalkhan@gmail.com
Last day of school in Spring 2011: _____

Contact information for responsible teacher/advisor when school is not in session:
Name if different from above: Mr. Anees Ansari
Address: Lahore Grammar School 55-Main Gulberg
City, State, Zip or Postal Code: Lahore 54660 Punjab
Country: Pakistan
Telephone (also evenings / weekends): 00923008441784
e-mail address: anees.ansari@lgs.edu.pk

Information for alternate contact person (may be a student): Fatima Jamal Khan
Telephone ___day ___eve ___weekend: 00923364564946
e-mail address: fatimajamalkhan@gmail.com

Names, [grade levels], and (ages) of 12 students currently expecting to attend the Finalist Competition:
(we request that participants be at least 15 years old, and not older than 19)

Fatima Javaid	[A/L](___)	Faiqa Khan Niazi	[A/L](___)
Imbisat Fizza	[A/L](___)	Fatima Jamal Khan	[A/L](___)
Fatima Najam	[A/L](___)	Sana Farrukh	[A/L](___)
Itrah Israr	[A/L](___)	Zarnab Khalid	[A/L](___)
Zeinab Jamal Khan	[A/L](___)	Neha Ansari	[A/L](___)
Meher Habib	[A/L](___)	Kinza Rizvi	[A.L](___)
Aneeqa Pervaiz (Reserve)		Zoya Luqman (Reserve)	

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

Nadeem Anwar Sanaa Nusrat

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.

_____ 9th March 2011

Responsible Teacher / Advisor Signature Date

1.0 Executive Summary

Nestled among the asteroid belt, with the aim of researching and then redefining the limits of human knowledge of space, Astoria stands as a pioneer. Thus, we, at Northdonning Heedwell not only feel humbled to represent this venture, but would also like to encapsulate this same dynamic spirit in all our designs. We are confident that the request for proposal sent to us has been followed in a creative and intelligent way. Therefore, we hope this will be met with the approval of the Foundation Society.

Total Down Surface Area:	
Total Cost:	$92,000,000,000
Payback Period:	12 years

Below, we have listed some of the features of Astoria which display the ingenuity of our design, and showcase our deep belief in thinking of and ***for*** the future.

- Our structure contains 4 hemispheres encased in larger hemispheres. The area between the two is filled with water. Not only does it provide appropriate storage area for water but also acts as a radiation protection shield. Finally this provides a scenic view for residents.
- We are using interesting materials such as RXF1 polyethylene ad arimid fiber. These are not only cost-efficient but also protect from radiation and water leaks respectively.
- Our water purification system takes the shape of numerous mechanical “fish” that also emit a glow in the dark. These provide clean water as well as being entertaining to watch.
- Transport vehicles which travel between the spokes are well designed for luxurious travel.
- Special VIP rooms have been made for those guests who wish to make use of the most luxurious facilities
- Butterfly babysitters oversee the children on Astoria. These mechanical creatures are made using carbon nano-tubes; the latest technology
- Our security systems, tangible and procedural make Astoria the safest living space imaginable
- Our payback period is only 12 years, after which we will be making increasing profits in a variety of ways.

In conclusion, our vision of Astoria not only meets the RFP requirements but is bound to exceed Foundation Society’s expectations. Our links between elaborate and simple operational systems provide not only a safe haven for people looking to explore, but also a productive mining base that is as feasible as imaginable.

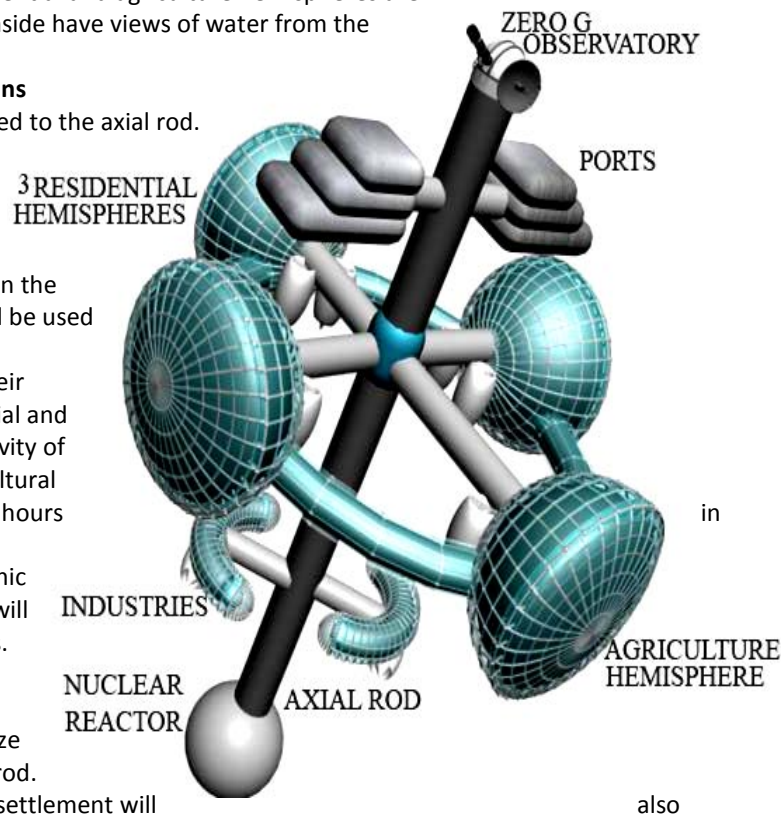
2.0 Structure

2.1 Description of the settlement

Astoria will have a highly durable, secure and efficient structure. The structure has been designed with a large storage area to serve its main purpose of harvesting and processing materials extracted from the asteroid. The main visible features include ports, three hemispheres for residential, commercial and storage purposes, one agricultural hemisphere, two quart tori for industrial purposes, telescopes, thrusters, a sphere consisting of nuclear power plant for power generation and an observatory for views of space.

No of residents at Astoria	
Permanent residents	6000
Short term residents	5000
Visitors	500
Total	11,500

Astoria's structure is one of a kind since its residential and agriculture hemispheres are shielded by water. Due to this the community inside have views of water from the inside.



2.1.1 Description of volumes and area allocations

Astoria comprises of two docking ports connected to the axial rod. Soon after the space craft's dock the cargo will be unloaded and sent for either processing, storage or usage. People will travel through the pressurized passage and will be taken to the settlement via the transportation corridors in the axial rod. Three out of the four hemispheres will be used for residential and commercial purposes. These hemispheres will have gravity less than 0.9g. Their main use will be commercial, business, residential and recreation. The fourth hemisphere will have gravity of magnitude 1g and will mainly be used for agricultural purposes and a school for children to spend 8-9 hours in curricular and extra-curricular activities. The agricultural hemisphere will be used for aeroponic food processing and storage. The hemispheres will be interconnected with transportation corridors. These spokes would also contain pipelines for transportation of food and water. 1g will be provided in this hemisphere by increasing the size of the spoke that is connecting it with the axial rod. The control unit and the research center of the settlement will also reside in the hemisphere allocated mainly for agriculture. The underground area (below the down surfaces) will be used for storage purposes and pipelines for electricity and water. Zero g recreation will be provided in the observatory (this has been further explained in Human Factors). Below the living area, two quad tori have been constructed for the set up of industries. A sphere attached at one end of the axial rod will be used for setting up the nuclear power plant (Refer to Operations and Infrastructure for details on nuclear reactor) to generate electricity for the whole settlement. If something goes wrong with the power plant, electricity will be immediately switched to solar satellites to provide electricity as a backup system and the nuclear reactor will be detached and taken away with the help of thrusters. A collision forecast station will be installed to detect asteroids approaching Astoria, in advance and to diverge small asteroids approaching Astoria from their path using lasers. For details refer to Operations and Infrastructure section.

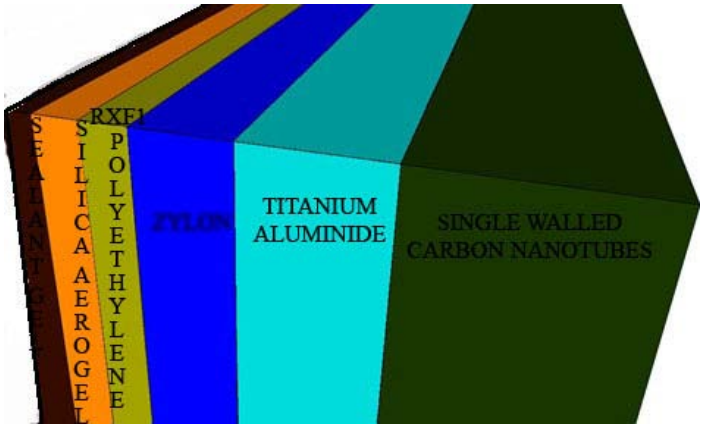
2.1.2 Provision of sunlight and natural views

Residents will be provided views of space using periscopes which will be installed on the curved surface of the residential hemispheres. These periscopes will project the views on LED screen covering the axial rod. The residents will have natural views of space outside in the observatory located on top of the axial rod. A telescope will be placed in the observatory which can fold in and out to provide magnified view of the space.

2.1.3 Dimensions and materials

Materials	Thickness (m)	Density g/cm^3	Properties	Usage
Single Walled Carbon Nanotubes	1.5	1.35	➢ Can resist a wide range of temperatures ➢ High tensile strength and Young's Modulus	➢ Provide strength to structure
Titanium Aluminide	1.0	4.0	➢ Strong ➢ Corrosion resistant ➢ Temperature resistant ➢ Low density ➢ High elastic modulus ➢ Fatigue crack growth resistance.	➢ Structural frame
Zylon	0.7	1.54	➢ Can be converted into fabric ➢ Light weight ➢ Strongest manmade fibre ➢ Young's modulus of 270 GPa	➢ Structural strength
RXF1 Polyethylene	0.5	0.935	➢ Absorbs cosmic rays ➢ High resistance to solar flares ➢ Tough impact resistant as high hydrogen content ➢ Strong ➢ Light weight	➢ Radiation protection ➢ Structural strength
Silica Aerogel	0.6	0.0019	➢ Absorbs infra-red radiations ➢ Absorbs shock vibrations ➢ Low density	➢ Used for thermal insulation ➢ To act as shock absorber
Silicone Sealant Gel	0.2	2.8	➢ Prevents cracks and air bubbles in silica aerogel	➢ Filling up impact affected areas
PMMA (Acrylic Glass)	0.9	1.18	➢ Shatter resistant ➢ Light weight	➢ To provide strength for windows
Aluminum oxynitride glass	0.6	3.7	➢ 3 times harder and stronger than other glass	➢ Make windows
Lead Crystal Glass	0.5	2.5	➢ Absorbs gamma radiations ➢ x-rays and other radiations	➢ Radiation protection

TABLE 2.1.2 Materials used for the construction of the structure



Component	Radius (m)	Length (m)	Width (m)	Height (m)	Total Area (m^2)	Area used (m^2)	Volume (m^3)
Observatory	9	-	-	6	508.9	254.47	1526.81
Ports	-	120	100	90	63600	36000	54000 (approx.)
Axial Rod	9	1200	-	-	67858.4	-	305362.8
Spokes (shorter x3)	6	561.81	-	-	21179.74	-	63539.21
Spokes (longer x1)	6	591.81	-	-	22310.71	-	66932.13
Interconnecting spokes (shorter x2)	6	780.26	-	-	23509.4	-	70528.19
Interconnecting spokes (longer x2)	6	874.51	-	-	24397.66	-	73192.9
Hemispheres (x4)	238.19	476.38	-	238.19	356473.23	178239.695	28302785.95
Industry quad tori (x2)	12.14	-	-	-	143750	-	218186.75
Spokes (industry x2)	6	300	-	-	11309.7	-	33929.2
Nuclear Reactor	20	-	-	-	5026.5	-	33510.3

TABLE 2.1.3 Dimensions, areas and volumes of major structural components

2.1.4 Magnitude of artificial gravity

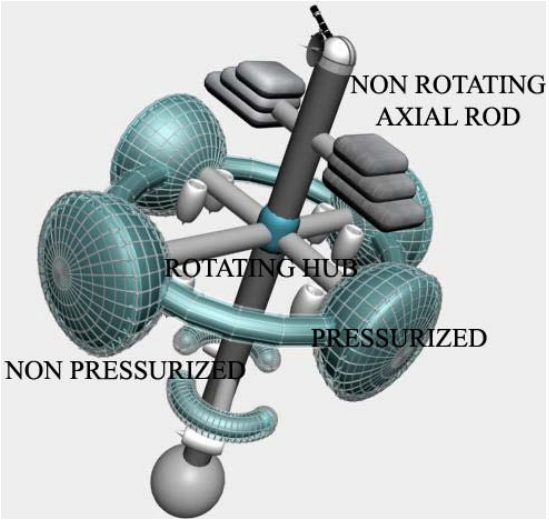
At Astoria, three hemispheres will be used for residential and commercial businesses and will have gravity of magnitude 0.89g. The fourth hemisphere will be used for agricultural and educational purposes and will have gravity of magnitude 1g.

Gravity	Residential hemispheres/ Agricultural hemisphere
Magnitude	0.89g/ 1g
Rotation rate	1 rotation/min
Tangent velocity	83.77m/s

TABLE 2.1.4 Magnitude of artificial gravity

2.1.5 Means of debris and radiation protection

Astoria is protected from the debris impact and radiations by the best materials available. RXF1polyethylene, silica aerogel and lead glass will be used for radiation protection. Properties are mentioned in table 2.1.2. Outermost layer of silica aerogel will trap the dust particles. This layer can later be scraped off and replaced by the external repair robot. Water covering the curved surface area of the hemispheres will provide maximum radiation protection since the hydrogen in it absorbs the incoming radiations.



2.1.6 Rotating and non-rotating interfaces and pressurized and non-pressurized sections

Pressurized and non-pressurized sections: The axial rod will have two transportation corridors, pressurized for humans and non-pressurized for cargo transportation. Other pressurized areas include the residential and agriculture hemispheres, the interconnecting transportation spokes and the observatory. Non- pressurized areas includes spokes, nuclear reactor, ports and industrial sector.

Rotating and non-rotating interfaces: Four hemispheres are linked to a hub attached to the axial rod by spokes. The hub rotates causing only the cylinders to rotate while the axial rod remains stationary. Cylindrical Roller thrust

bearings will be used here, as they have the capability to support heavy loads and are relatively insensitive to shock loads. Their long service life can be increased by using a dry lubricant such as graphite. Anti-foaming additives will be added as they prevent foaming which can lessen the load carrying capability of the lubricant being used. Automated control systems manipulate the amount of lubricant being added for repair and maintenance of bearings. In case of worn-out bearings, replacements will be put in before the old machinery breaks down ensuring smooth functioning in Astoria.

2.1.7 Transport from rotating to non-rotating hubs

Cable cars will be used to transport residents. There will be a rotating belt around the axial rod with clamps. The cable car will attach itself to the clamps and the belt will rotate and face the respective spoke. In this way, the cable car can easily enter the spoke and residents can make their way into Astoria.

2.2 Layout of interior

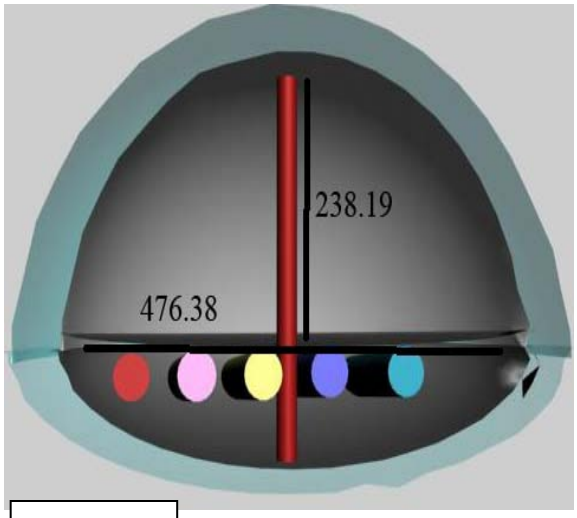


Fig 2.2.1

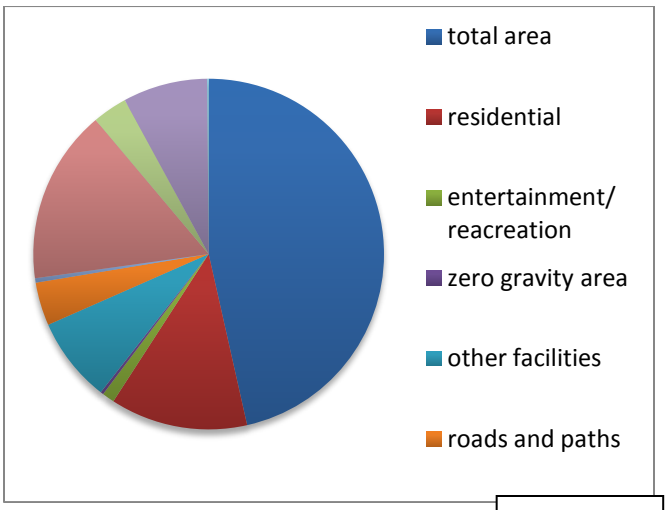


Fig 2.2.2

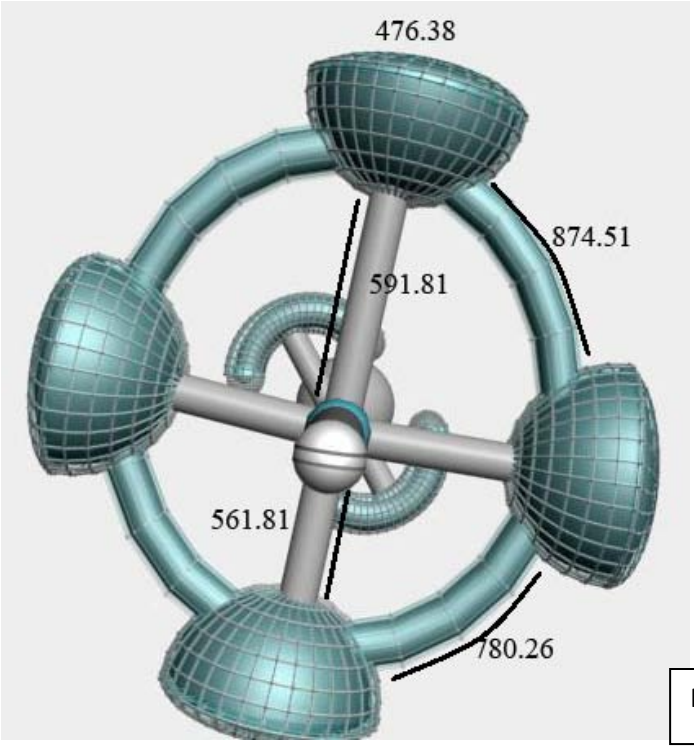
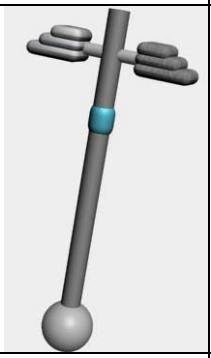
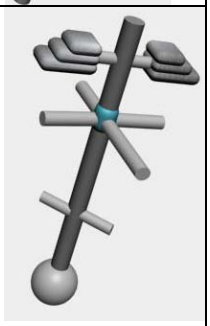
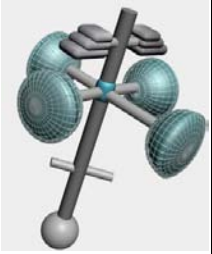
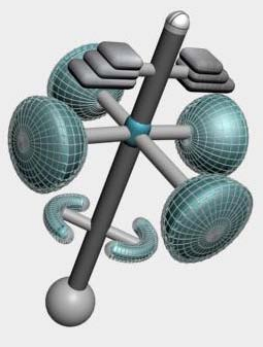
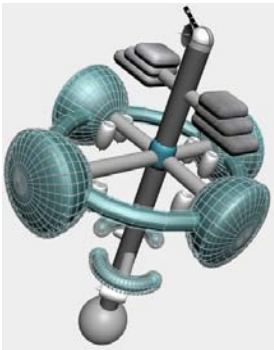


Fig 2.2.3

2.3 Construction process

2.3.1 Sequence of construction

Phase 1 A mining base is setup on 250 Bettina where extraction of materials is initiated. The construction and manufacture of the components of the settlement takes place using Netpar 3.0 for exterior mesh construction and Park 6.0 for exterior finishing. These components are then transported to the construction site to begin assembling. The modular method of construction is used.	Phase 2 The axial rod is constructed with the rotating and non-rotating interfaces. Engines are set up inside the hub (rotating sections) 
Phase 3 The nuclear reactor and ports are constructed simultaneously to maintain balance of the settlement. 	Phase 4 Four spokes are constructed simultaneously on the rotating hub and two spokes are constructed below the rotating hub for industrial tori. 
Phase 5 Four hemispheres are constructed simultaneously to avoid the structure from toppling. 	Phase 6 Two quad tori are constructed. At the same time, the zero g observatory is also placed on top of the axial rod. 
Phase 7 Interconnecting transportation corridors are placed. Antenna, telescope and thrusters are installed on the structure. 	Phase 8 Engines are started to initiate rotation to provide gravity for interior construction. The interior construction is completed by Ibex 3.0 for interior mesh construction and Cide 3.0 for interior finishing. Residents start to move in and the settlement starts functioning.

2.3.2 Construction of interior; Interior construction will be carried out by robots. This has been further explained in Operations and Infrastructure. Refer to (3.3)

2.3.3 Method of initiating rotation

Engines will rotate the settlement to provide a stable magnitude of gravity at all times. These engines will be placed inside the rotating hub and will have censors and speedometers to monitor and manipulate rotation speed. The engines will rotate slowly and gain speed. Censors will be used to decide when speed is high enough for the engines to shut down and will be used again to restart the engines when an increase in speed is required. In this way, continuous gravity is ensured.

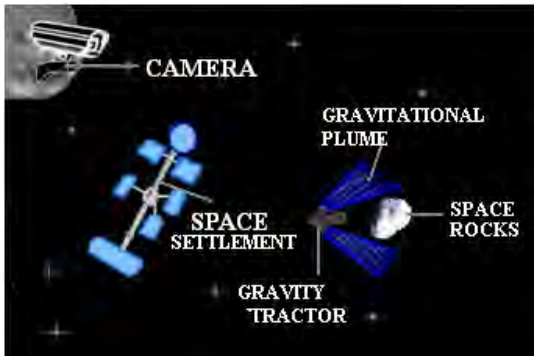
2.3.4 Future expansion

For future expansion four hemispheres will be added to the four existing hemispheres, resulting in four complete spherical structures. The newly added hemispheres will have a curved down surface area. Their dimensions will be identical to the old hemispheres. In addition to the existing ports, two new ports will be added on the axial rod so that four will eventually encircle it. Two quad tori will be added to provide area for industries. These will combine to form a complete torus for the set up and storage of industries.

2.4 Shielding and damage repair systems

As Astoria is in the asteroid belt, we need more than mere shielding for protection. Therefore we at Northdonning Heedwell are using several methods to protect our settlement from impact by particles.

2.4.1 Shielding and protection system



- Remote sensors (made of acrylate-based resins, which can survive in very cold conditions) have been placed on the asteroids orbiting near Astoria to detect incoming particles.
- The gravitational tractor will use its gravitational pull to slowly drag the asteroid off its orbit and secure our settlement.
- Nanocomputers have been integrated in the main structure to act as smart computers. These are responsible for receiving signals from nearby remote sensors as well as transmitting those signals to the control unit.
- Lasers have been installed on the ports to ablate smaller asteroids and debris particles so that their impact on the shield can be lessened.
- Charged coupled device cameras have been installed on prominent asteroids near Astoria to monitor movement of other large asteroids, which may head towards the settlement.
- If the approaching asteroid is too large then the settlement will be moved away from its trajectory and will be taken to a safer position by the help of thrusters.

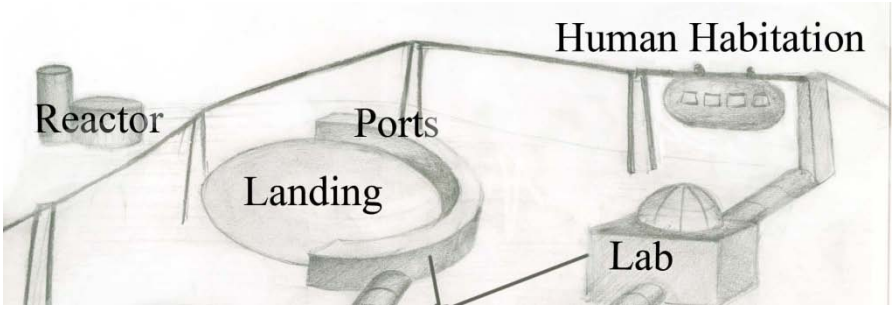
2.4.2 Damage repair system

- External Repair Robot will remove the outermost layer of debris trapped in silica aerogel and replace it with a new one.
- External Repair Robot will heat polymer and fix any damage to Astoria due to debris,
- General repair and maintenance will continue without human involvement, as Astoria's elaborate computing systems will continually monitor the structure of the settlement. Furthermore, all actuators (repair robots) are only monitored by humans, and no direct intervention is required.

2.5 Mining base

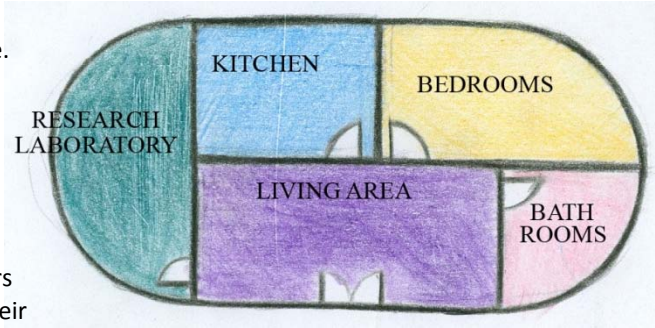
2.5.1 Mining camp

To construct the mining base on the asteroid, strong, solid materials that are resistant to harmful radiations and debris will be used. The same materials will also be used for the construction of the settlement. The idea is to construct a cart-like vessel that orbits the asteroid and operates on electricity, within which would lie the Command Control Centre The vessel will

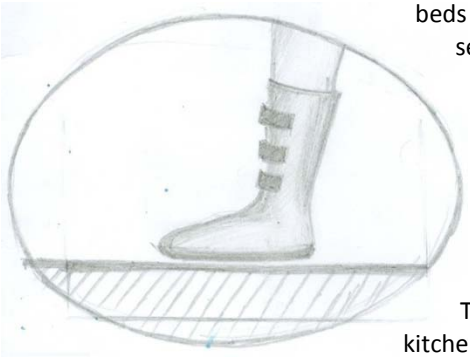


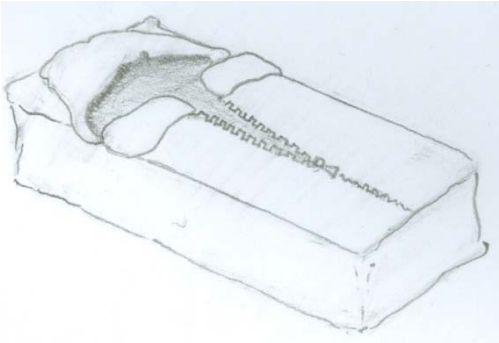
be able to provide livability for eight humans, who monitor the mining activities carried out by robots from within the same centre. Glass windows will be installed at each end of the vessel to provide views of space outside Sensors placed on the vessel will detect approaching asteroids and transmit signals to the control system. Therefore the vessel will be taken underground to avoid any damages due to large debris impact. Once the surface mining is complete the capsule will permanently shift underground to monitor the underground mining activity. Clamps will protrude out of the vessel and it will be anchored to asteroid regolith. Views of space outside will then be projected on the LCD screen with the help of a periscope. The structure of the human habitation will have vacuum walls to prevent any sound to reach there from the mining location while it is underground. (Refer to 3.**)**, for the location on the mining base on the asteroid.

2.5.2 Human habitation



We at Northdonning Heedwell recognize that bone degradation must be accounted for on our mining base. To meet this need, the mining base will include iron walkways and floors. The workers will have shoes with magnetic soles, and the force of attraction between the surfaces will keep them upright and stable. The residential area will include bedrooms, bathrooms and a kitchen unit. The bedrooms will hold beds with zippers sewn into their covers to keep the workers rooted. The bathrooms will utilize pressurized pipes and valves, and all human waste will be disposed off into landfills in lead containers. We also recognize the importance of constant supplies of food for the individuals on the base. Therefore the kitchen unit will store enough food and water for a two month stay to avoid any shortages. Purpose-built robots will perform all mining tasks such as drilling, digging, shoveling and more. Humans will only be overseeing the process through the command control center within the mining base.





2.5.3 Rescue plan:

In case of emergency, Space tug will rescue all the people from the mining base and take them to Astoria.

3.0. Operations & Infrastructure

Operations & Infrastructure will make human habitation possible on Astoria by harvesting a number of asteroids and producing as much as possible of the necessities of human sustenance. These products will also be available for customers in Mars orbit and beyond.

3.1. Location & Materials Sources

3.1.1: Settlement Location

Characteristics	Ceres orbit		24 Themis orbit	
Fulfilling the purpose	Approach to outer solar system is hindered by many asteroids	5	Approach to outer solar system is relatively easier being on the outer edge of the belt	8
In emergency situations	Escape would be relatively difficult due to high concentration of asteroids	4	Quicker escape into outer solar system or in the Kirkwood gap	8
Availability of materials	Less variety of asteroids present	5	Near variety of asteroids having different materials	9
Water Availability	Plenty water!	10	Plenty water!	10
Total (40)	24			35

Table 3.1.1: Trade Study showing reasons for selection

Chosen Location: 24 Themis
Distance from Sun: 479 Million km from the Sun

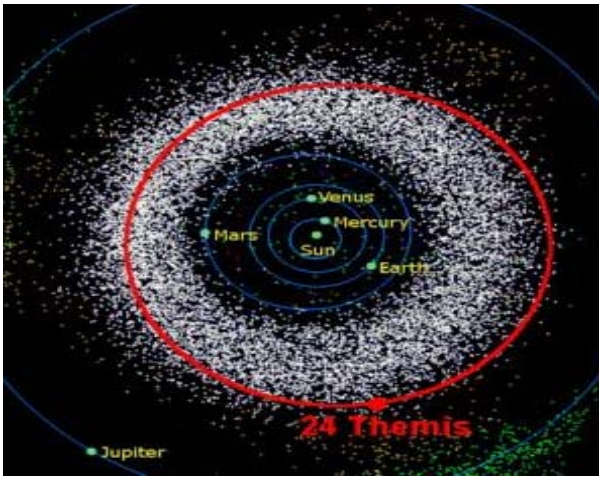


Fig: Orbit of 24 Themis

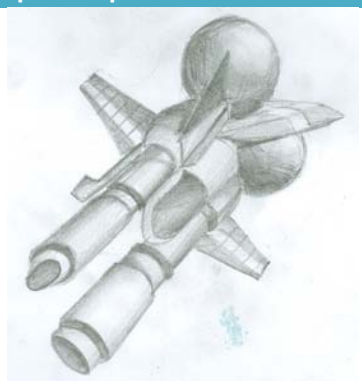
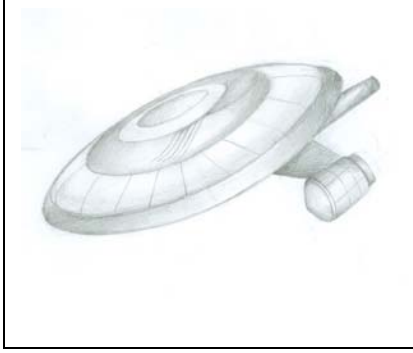
3.1.2: Materials

Mining base and Manufacturing Unit will be set up on 250 Bettina. Mining Robots will bring materials harvested from other asteroids (10 Hygiea, 24 Themis, 451 Patentia) to the Bettina manufacturing unit(BMU), where materials will be brought to finished form. Nitrogen will be provided to this Unit in compressed form to enable production of nitrogen-containing Materials.

Material	Composition	Source
Polystyrene	C, H	Bettina Manufacturing Unit
Polyester	C, H, O	Bettina Manufacturing Unit
Polyurethane	N, C, O	Bettina Manufacturing Unit
Polyurethene	N, C, O	Bettina Manufacturing Unit
Synethetic Fibres	C, H ,O	Bettina Manufacturing Unit
Urethane-coated Nylon	C, H ,O, N	Bettina Manufacturing Unit
Iron	Fe	Bettina Manufacturing Unit
Aluminium Alloy	Al, Fe	Earth
Steel	Fe	Bettina Manufacturing Unit
Silicon	Si	Earth
Plaster Board	CaS, Al	Earth
Fiberglass	C, H ,O	Bettina Manufacturing Unit
Freon	C, H, F, I	Earth

Single-walled carbon nanotubes	C	Bettina Manufacturing Unit
Aluminium Oxynitride Glass	Al, O_2, N	Earth
Poly-Methylcrylate (PMMA)	C, H ,O	Bettina Manufacturing Unit
Sealant Gel	Si	Earth
Lead Glass	PbO	Bettina Manufacturing Unit
RXF1 Polyethylene	C, H	Bettina Manufacturing Unit
Silica Aerogel	Si, 0_2	Earth
Titanium Aluminide	Al, Ti	Earth
Zylon	C, H, O, N	Bettina Manufacturing Unit

Table 3.1.2: Material Sources

Spaceships	No.	Fuel	Purpose
	30	Hydrogen fuel cells	Transfer of cargo and passengers to and from areas of atmosphere and gravity such as earth.
	30	Hydrogen fuel cells	Transfer of cargo and passengers to and from areas without atmosphere and gravity such as settlements in orbit around Earth. .....

For amounts of construction materials Refer to 6.2 Cost

3.1.3: Mining Base

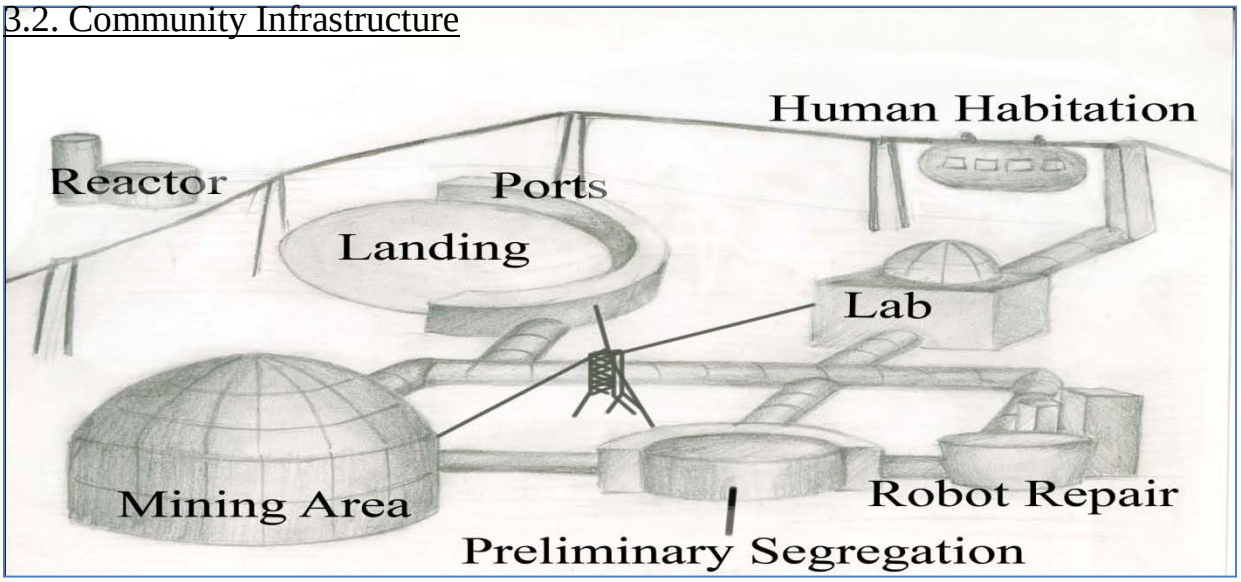
Northdonning Heedwell recognises the need to be self-sustaining and will therefore focus on harvesting asteroids to keep imports at a minimum. Our shuttles will bring harvested material from mining robots at work on other asteroids to our docking port for refining and further processing.

Two 8-member mining teams will alternate every 3 months, and as they alternate, drinking water food and other commodities will also be transported to replace the diminished ones.

Fig: Mining Base on 250 Bettina

Mining Base Location: on 250 Bettina

3.2. Community Infrastructure



3.2.1: Atmosphere

The human body undergoes oxygen deprivation when oxygen is 19.5% of air. As Nitrogen is inert and does not support combustion, it will form the bulk of the air volume, while oxygen will be kept at 25% of the total air volume.

Gas	%age Composition	Source
Nitrogen	73%	Earth (initially obtained in compressed form)
Oxygen	25%	Splitting of H_20 (in Reactor Sphere)
Carbon dioxide	1%	Mining Base(Carbonaceous Compounds processing)
Trace Gases	1%	Earth (initially obtained in compressed form)
Atmospheric Pressure	93. 08 kPa	

Backup: Nitrogen, Trace gases, Oxygen, and Carbon dioxide will be stored in cylinders in all 3residential areas in case of emergency

Sectors	Volume
Observatory	1526.81 m^3
Residential x 3	28302785.95m^3 x 3
Agriculture	28302785.95 m^3
Total Volume:	**367932670.6 m^3**

Table: Air Volume

Regulation: Each sector will have its own Atmosphere Control & Management Unit (ACM), which will be equipped with sensor and control mechanisms that will help it regulate the composition of air and also temperature & humidity levels according to the values fixed. Here, air will be passed through activated carbon filters and air ionisers so that it can be filtered. HEPA Air filters (soaked in germicidal solution) will also be present, that are capable of filtering radioactive materials from the air. A clean supply of air will once again be made available to Astoria's residents.

Season	Temperature
Summer	25-30°C
Winter	17-19°C
Autumn	19-21°C
Spring	21-24°C

Weather: Weather parks will be created to simulate Earth-like experiences of living under different weather conditions. The difference however is that on Astoria, residents will be able to choose between different weather conditions as a variety of parks will be available.

The Mechanism overseeing every park will be programmed with comfortable temperature-humidity levels, and temperature will be varied between 17-30°C (e.g. Season: Winter, Condition: Snowfall, Temperature: 17°C, Relative Humidity: 35%)

Artificial precipitation will also be available (powder-like snow blown downwards, and rain showered via porous pipes). Holographic Screens will depict the perfect scene respectively.

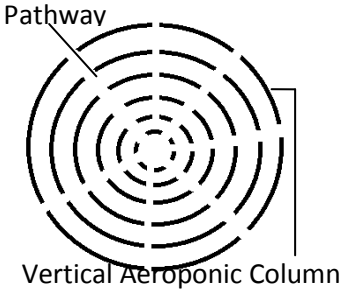
3.2.2: Food Production

Food Production Processes will be carried out in the Agricultural Sector, while processing and packaging will be done in the Industrial Area.

3.2.2.1: Growing

Meat Production:
Hi-tech labs will make use of biotechnology and grow batches of loose muscle cells into meat portions in Bioreactors (Sponge-like matrix perfused with growth medium). Artificially produced growth hormones, proteins, & antibiotics will be added to ensure healthy, timely production. In vitro process can decrease exposure of meat to bacteria & disease.

This meat will be healthier than conventional meat as we will control nutrients and fat contents. This helps diminish health-risks related to obesity. Omega-3 fatty acids will be added artificially to fulfil bodily requirements as fish will not be produced.



Types of Food Produced
- Starchy Tubers
- Carrots
- Onions
- Garlic
- Ginger
- Radish
- Beetroot
- Turnip
- Mushrooms
- Cocoa Beans
- Soy Beans
- Oil Crops
- Meat

Fruit & Vegetable Production:
Vertical Aeroponics will be carried out on a large scale. Water, Minerals, Dissolved oxygen, and Organically-Derived Collodials(ODC) will make up the nutrient solution, which will be sprayed on plant roots via Hydro-atomising spray jets which allow efficient absorption. ODC will enhance plant protection and growth. For Easier uptake, plants roots will be kept at low pressure.
Different crop varieties will b grown categorically, with the nutrient solution adjusted slightly to the plant's requirements

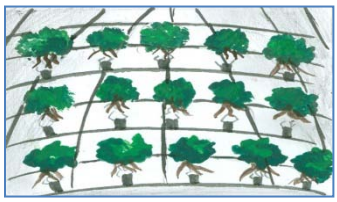


Fig: Aeroponic Column

Milk Production: Soy milk will be produced from soy beans

3.2.2.2: Harvesting

Astoria's harvesting system will be automated. Different crop varieties will b grown separately, and harvesting too, will be carried out relative to a crop's growing period. Our robots will be programmed with this information and will collect the harvested crops in containers that will be sent to the food processing industry.
Meat batches will be continually grown and harvested by the experts working in the lab.

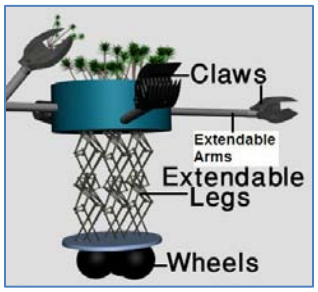


Fig.1.: Agrus 3.0

3.2.2.3: Storing

Food, both packaged and unpackaged, will be temporarily stored in aseptic containers which will be sent to residential areas and then stored in perfect condition depending on food type. Bottled liquids will be sent separately in refrigerated conditions. Packaged food with larger shelf lives will be sent for storage in each of the residential sectors, to be used in case of supply interruption.

3.2.2.4: Packaging

Short Term packaging for consumption within few months: Astoria's food products will be vacuum sealed, and kept sterile until it has been consumed. Milk will be bottled and kept refrigerated at all times.

Food Requirement= 2.3 kg per person per day	
Consumption	26450 kg/day
Storage	8199500 kg
Supply to mining base	20kg every 3 months
Total Production per year	17,853,830 kg
We will have a surplus production capacity of upto , which will add to our total production. Refer to BD	

Long Term packaging for Backup Storage: Meat will be canned (shelf life 2-5 years), but must be refrigerated once the can is opened and consumed from 3 to 5 days. Milk will be dehydrated and stored in packaged form. Canned fruits & vegetables will have a shelf life of over 1 year.
Cans of different products will be wrapped in plastic bags (Ultimate VCI Protection Bags) lined with non-toxic corrosion inhibitors.
Food that is to be used for immediate consumption will be sent in containers to the residential areas via the transportation corridor in the axial rod. Here it will be picked up and taken for delivery.
For Delivering & Selling of Food Refer to HF

3.2.3: Electrical Power Generation

Electrical Power will be generated by Nuclear Fission. Our Lead-Cooled-Fast-Reactor (LFR) will use Thorium (from mars) as fuel. Due to actinide recycling, the reactor's efficiency is increased i.e. the reactor uses fuel in numerous cycles. Hence LFR will have a lengthened fuel cycle. Fuel imports will be done every 15 years.
Another advantage of using LFR is that due to extremely high temperatures, the reactor splits water into Hydrogen and Oxygen, which will be compressed and stored as rocket fuel (LOX and LH2)

Backup: Proton Exchange Membrane fuel cells will use the stored LOX and LH2 to produce electricity.

Power Allocation	
Sector	**kW/day**
Domestic	130,000
Lighting	10,000
Industrial	580,000
Agricultural	2,000
Automated Systems	15,500
Recreational	49,000
Settlement Operations	3,250
Transportation	250
Total Consumption	790,000
Total Production	800,000

Batteries:
Electricity produced will be stored in Highly Afferent Super Efficient Lithium Ion Batteries (HASELI Batteries) that can store up to 1MW/kg. Batteries will be used to provide temporary backup for electricity and will also be used to provide electricity for various systems.

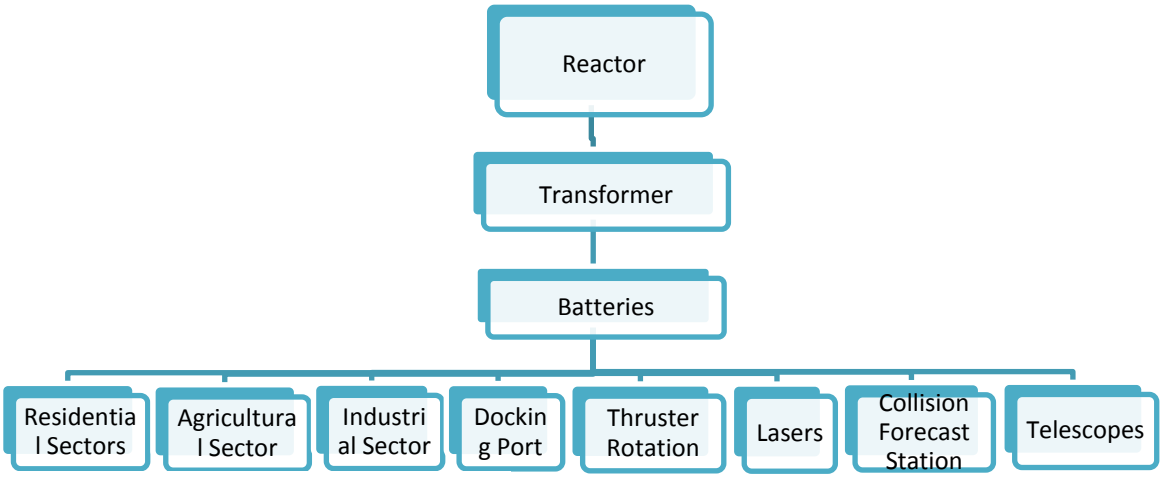


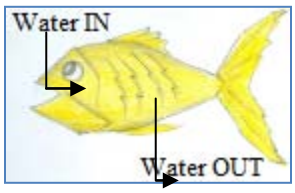
Fig: Power Distribution

3.2.4: Water Management

Source: Water Plant on 24 Themis.
The water plant will provide initial water as well as make-up water for our water regulation as well as for our reactor. This water will be transported by our vehicle.

Water from all the residential hemispheres will be treated by their own Water Purification Units (WPU), where wastewater will be treated and dissolved materials separated. At WPU's final stage, the composition and temperature of water will be controlled to as to meet human requirements,

Water will pass from the space between the two hemispheres making up 1 residential sector to the residents via pipelines. Used water along with wastewater from waste separation will then be sent to WPU. Clean Purified water will be sent through the gap between hemispheres once again. In the industrial sector however, where there is 0g, water will be continually pumped.



Water in the gap between hemispheres will still be passed through micro filters and its levels monitored-by our robots, which will also maintain a neutral pH. To add beauty these robots will be fish, Nemo 3.0, moving through the wall gaps.

Wastewater Treatment: Metals and harmful substances will be removed by Rapid mix tank, sedimentation, and filtration processes. Following this, water will be disinfected via UV lamps. Finally, salts and organics are separated from this water to form a concentrate stream (sent to agricultural sector for nutrient solution formation) and a clean-water stream (sent to final stage purification)

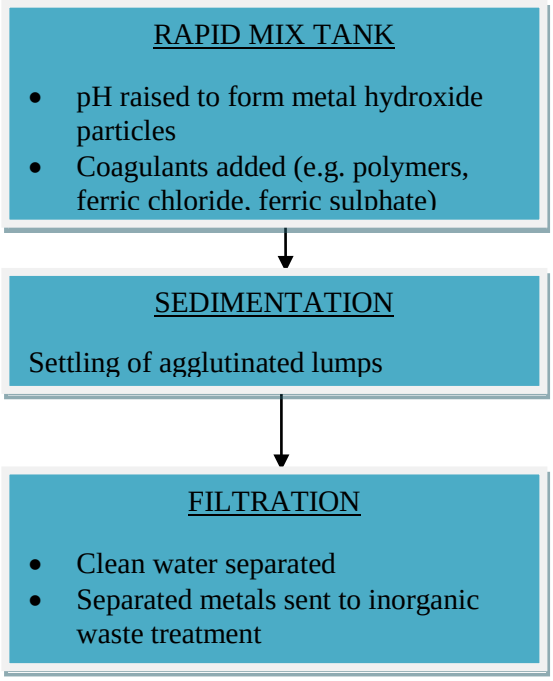


Fig: Heavy metal removal in wastewater treatment

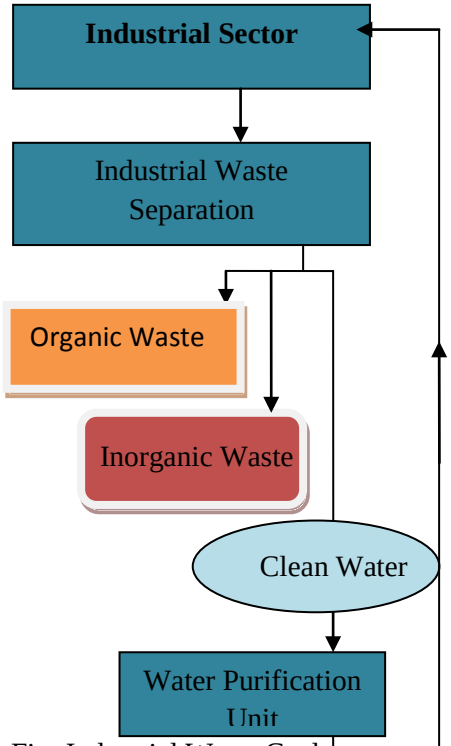


Fig: Industrial Water Cycle

Makeup water will be released into the system every month to account for water losses.

Purpose	Value
Consumption	128500 l/day
Storage	3983500l
Mining Base	650l every 3 months

Table: Water Requirements

Storage Tanks:
Height: 4m
Diameter: 8m
Volume: 201m3
Total number of tanks: 20
Total volume of tanks: 4021m3
1 cubic meter = 1000 liters
4,021 m3 = 4,021,000 liters

3.2.5: Household and Industrial Solid Waste Management

Waste will be collected by robots throughout the settlement

The system:

Though each of the residential, agricultural, and industrial sectors will have WPUs, the Solid Waste Treatment Plant will reside in the industrial sector. Hence waste treatment processes will be carried out away from food-producing and agricultural areas.

In the Industrial Sector, waste arriving in containers will be grouped together in terms of organic and inorganic. These will join the industrial waste (refer to Fig3.2.5) and sent for treatment.

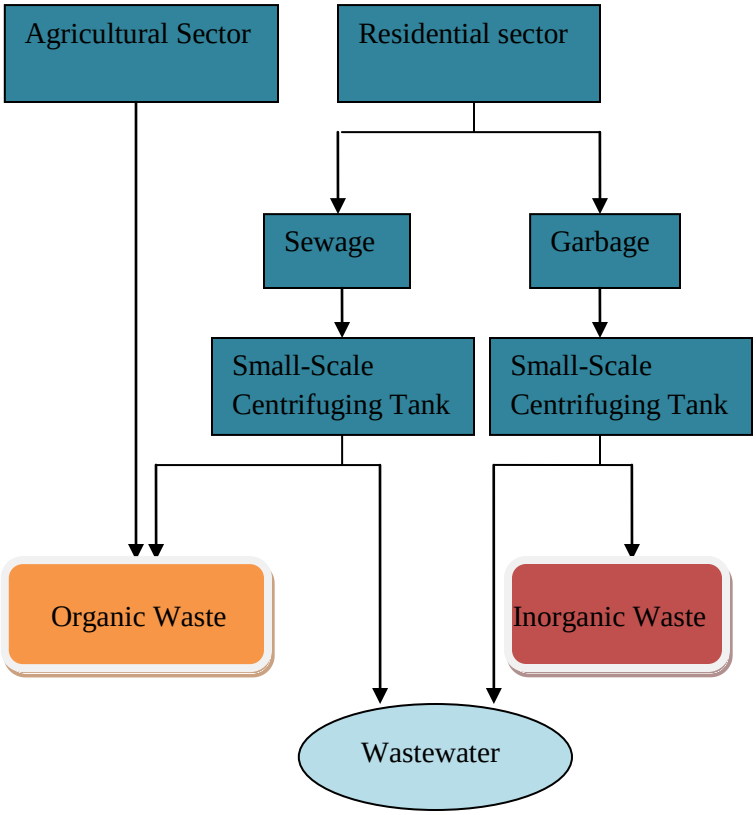
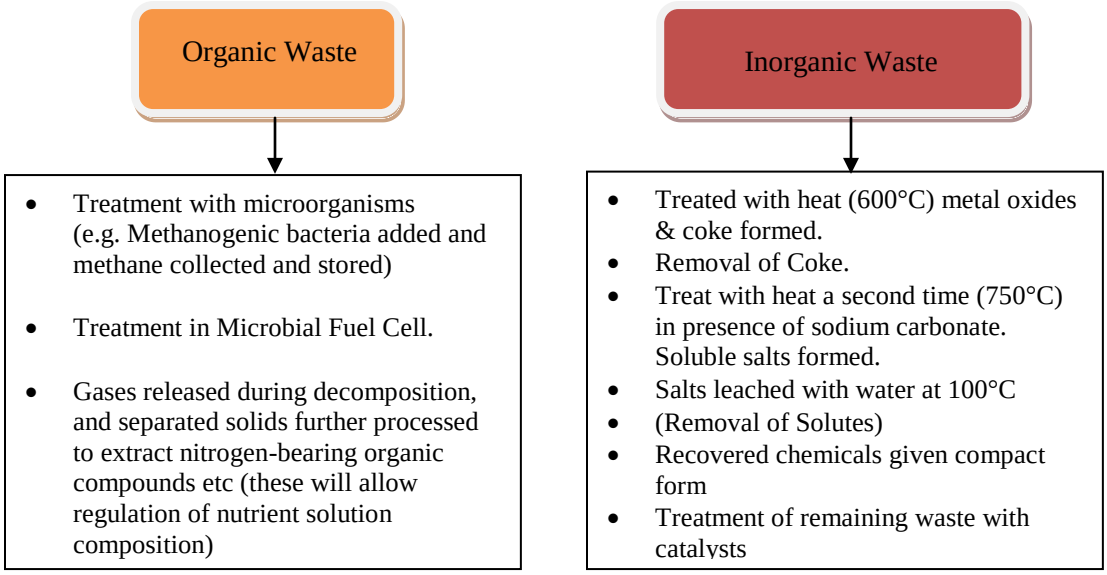
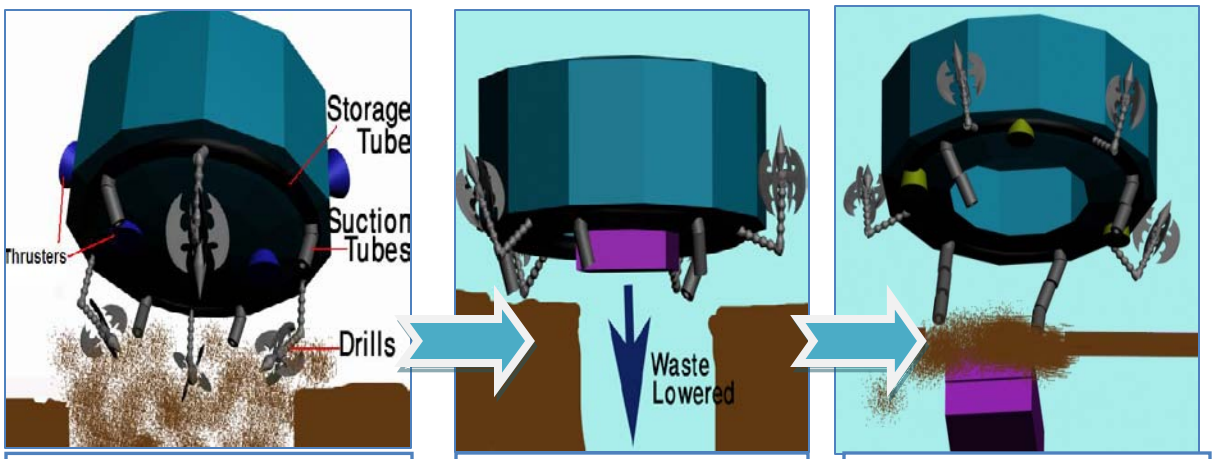


Fig.3.2.5.: Waste Collection and Separation

Treatment:



Disposal:



Stage 1	Stage 2	Stage 3
• Drills displace top layers of asteroid surface • Suction pumps suck these layers into the storage tube • Central Thrusters are off at this point	• Drills fold upwards when not required, • Waste from waste compartment dropped into landfill	• All waste deposited, & storage emptied onto waste by suction tubes. • High pressure replacement of asteroid surface compresses the landfill • Central thruster moves the robot upwards and away

Fig: Waste Disposal by Nala 3.0

Waste that cannot be further processed, and nuclear waste will be taken to our landfill site on 451 Patientia by Nala 3.0. This robot will take waste aboard the shuttle sent for retrieval

of ores, landfill, and return on that shuttle with the ores instead of waste, and stand by for the next time waste needs to be disposed. Transport costs will be reduced as our robot will be travelling en route.

3.2.6: Internal & External Communication

Astoria will launch 3 satellites, and subcontract the rest of the satellites with Earth, Aresam, Argonom, and Columbiat. There will be 3 communication satellites around Earth, 1 around the Moon and 3 around Mars, 2 in obit of Ceres, 1 in orbit of 24 Themis.

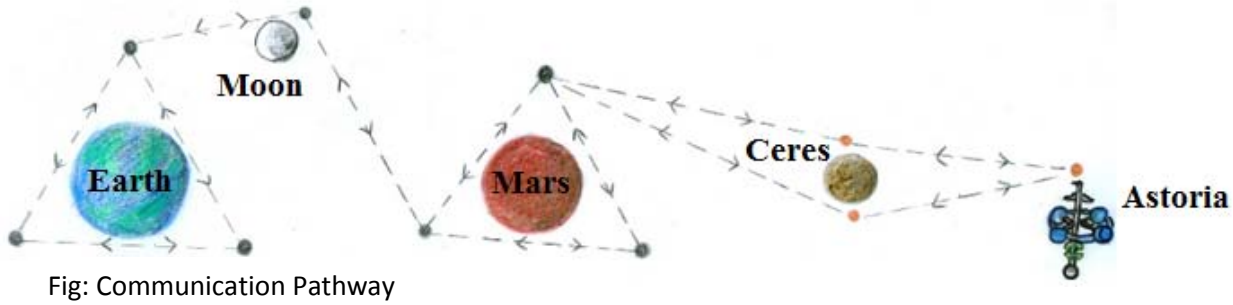


Fig: Communication Pathway

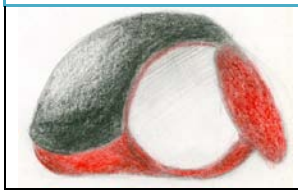
Transmissions from Earth will use satellites to relay the signals to the settlement and this system works in reverse too. Part of the relay system may 'drop packets' due to static or transmission errors. Those dropped packets are retransmitted, so no data is lost. Also, stored data and real-time data can be transmitted at the same time, each with their different time stamps. Astoria will have a series of internal and external video cameras to see inside and outside. All of this information is fed to the control unit, and is stored in the backup server on the settlement.

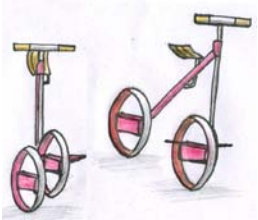
Table 3.2.6	Communication System	Equipment	Specifications	Devices
External Systems	Regular System	6M antenna and focusing dishes	X-KA Band Freq. (15-80GHz) Max Speed:50Gbps	Control servers
	Emergency System	5 smaller gain antennas	KA-band (80 GHz)	Backup server
Internal Systems	Regular System	Wimax towers placed at strategic points	30 Tbps	RVail
	Emergency System	Intercom	----------	Speakers with backup power

3.2.7: Internal Transportation System

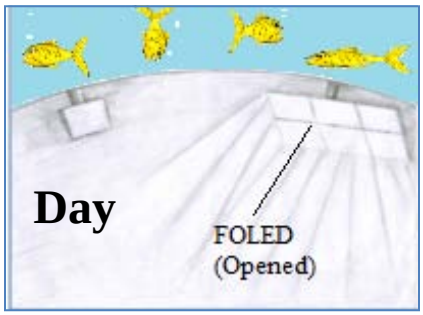
Vehicle	Dimensions	Fuel	No.	Materials
	Length: 2.5m Width: 1.5m Height:1m	Hydrogen fuel cells	2772	• Aluminium alloys • Polyethene plastics • Rubber
	Length: 1.5m Width: 0.5m Height:1m	Hydrogen fuel cells	2772	• Aluminium alloys • Polyethene plastics • Rubber

Table 3.2.7 VIP Vehicles

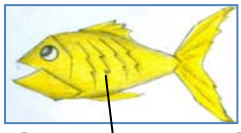
Vehicle	Dimensions	Fuel	No.	Materials
 **4-seater car**	Length: 2.25m Width: 1.5m Height:1.25m	Hydrogen fuel cells	72	• Aluminium alloys • Polyethene plastics • Rubber
	Length: 2.1m Width: 1. 5m Height: 1.75m	Hydrogen fuel cells	72	• Aluminium alloys • Polyethene plastics

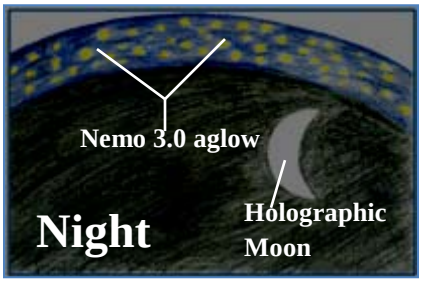
4-seater car				
 **2-seater car with air thrusters for transport between interconnecting spokes**	Length: 2m Width: 1.5m Height:1m	Hydrogen fuel cells	1824	• Aluminium alloys • Polyethene plastics • Iron
 **Foldable Bicycles for kids**	Length: 1m Width: 0.25m Height: 1m	None	360	• Recyclable plastic
 **Wheelchairs for hospitals**	Length: 1.5m Width: 0.75m Height: 1.5m	Hydrogen fuel cells	50	• Aluminium alloys • Polyethene plastics

3.2.8: Day/ Night Cycle Provisions



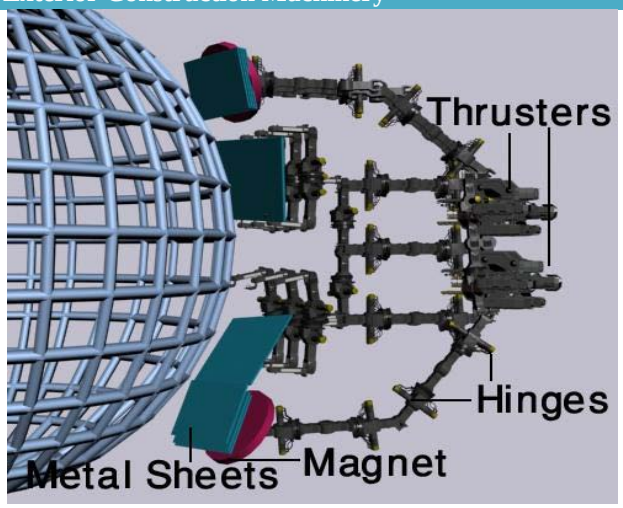
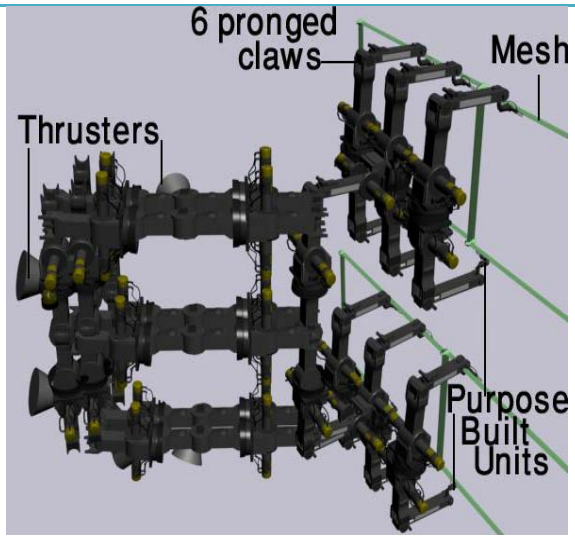
As the intensity of sunlight reaching Astoria is almost negligible, our day night system will wholly depend on efficient FOLED screens. On the upper structure of the dome there will be a number of FOLED screens throughout the settlement to provide daylight for 12 hours. The intensity of light emitted by the FOLEDS will be automated and varied accordingly. Its intensity would be greatest at afternoon hours and thereon it will be decreased to give a natural effect.



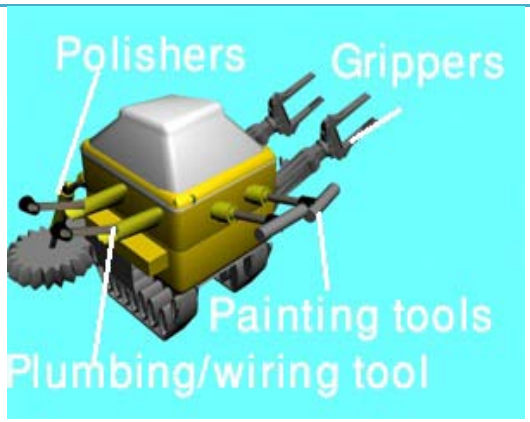


By the time FOLEDS are switched off, the slow moving robots (Nemo3.0) in the water above will glow due to their coating of fluorescent material. They will serve as artificial stars, and also align themselves in constellations to enhance the beauty and mystique of the night environment. In addition to the artificial stars, a holographic moon will complete the night sky making them feel like home.

3.3. Construction Machinery

Exterior Construction Machinery	Name	Features
 **Exterior Finishing Robot**	Parks 6.0	• Multiple hinges for fluid movement while maintaining control over heavy materials • 6 pronged claws are equipped with lasers for welding/cutting along with bolters/rivet guns. • Central hinges of 6 pronged claws are magnetic. In this way the claws draw the materials to themselves one sheet at a time for assembly. Magnetic fields are also automatically determined by a fully computerized process.
 **Exterior Mesh Construction**	Netpar 3.0	• Purpose built units on 6 pronged claws have lasers for cutting/welding and rivet guns/bolters • Thrusters for movement • They pick up raw material (pieces of mesh) from a magnetic platform (magnetic: to hold materials in place) supported by thrusters that floats nearby.

Interior Construction Machinery	Name
	Ibex 3.0

Interior Mesh Construction	
 **Interior Finishing Robot**	Cide 3.0

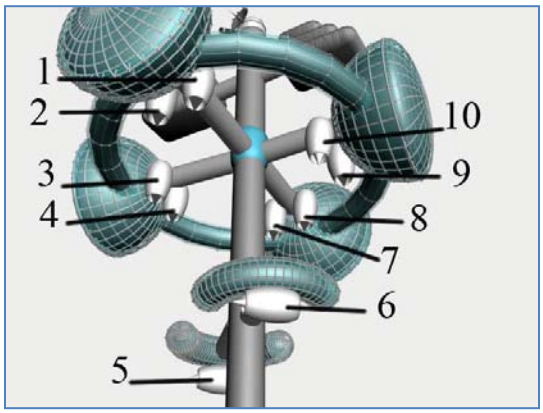
3.4. Propulsion System

Astoria will use bipropellant rocket propulsion system to propel the settlement prior to an impact or in any emergency situation. The propulsion rockets will be rotatable, electricity for which will be provided. LH2 and LOX will be used as propellants. Special care would be taken to avoid hydrogen leakage as it is explosive.

Liquid oxygen will act as oxidizer. Both the propellants are pumped in the combustion chamber where they are burned to produce exhaust gases which will be used to propel Astoria.

Thruster Dimensions

Length: 3.4m
Diameter: 1.8m

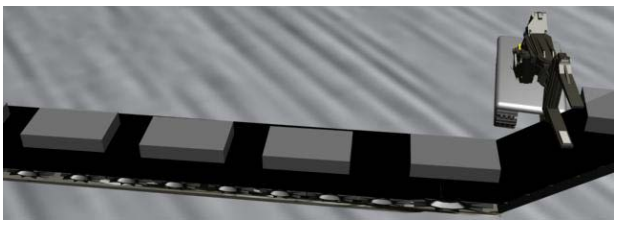


In zero-g areas liquid propellants tend to self-ignite the rocket. In order to prevent this from happening we will use Ullage motors. Ullage motors are minor rockets which will accelerate the rocket before the major ignition. Guidance system for the rockets will be set up. This system will provide navigation, guidance and control facilities to our propulsion system. Liquid rocket engine's ability to be reused several times, overpowers its disadvantages.

Maximum Thrust	**66896447 N**
Acceleration	0.0000786 m/s^2

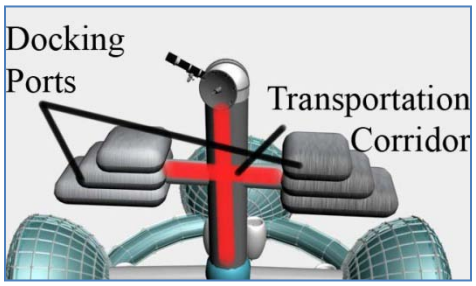
200 liters of fuel will be available for use in case of any emergency. This fuel is enough to move the settlement miles away from the point of impact.

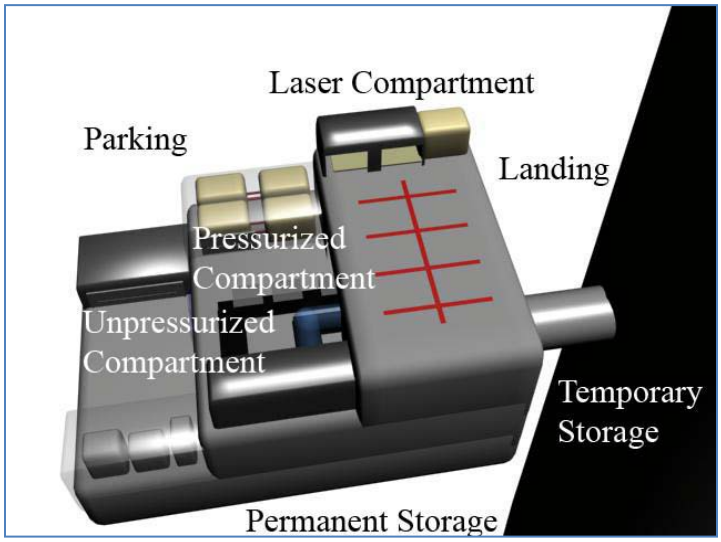
3.5. Port Facilities



Docking port of Astoria will be highly functional with the latest machinery and equipments available for loading and unloading. Raw ores from asteroids will

be transported to Astoria in sealed containers; this packaging of ores will be done at the mining base. Containers will be unloaded from transport ships by robots and and will be loaded to conveyor belts which will carry them to a





temporary storage area. In the storage area all the computers will process the data of all incoming ores and classify them. Labeled packages will then be transported through conveyor belts to the industries that require them

4.0 HUMAN FACTORS

Astoria is designed to suit the requirements of its residents as closely as possible, and thus have been provided with many opportunities of recreation as well as a satisfying way of life. They would be able to experience everything available in the developed areas of Earth, along with the thrill of outer space.

4.0.1 Natural Views Of Space

4.0.2 Provision of Sunlight

4.0.3 Psychological Factors

Problems caused by the CORIOLIS effect	SOLUTIONS
• Vertigo syndromes/Dizziness • Physical discomfort • Loss of drive and concentration • Pressure in the upper abdomen • Tiredness and pains	Experiments have shown that rates of rotation, lower than 2rpm reduce the Coriolis force and its effects. These can further be reduced by: • Multi-vision spectacles and Ear-pieces will be provided to the residents of Astoria with maximum comfort and to give them views of front and rear. • Mirrors in homes and public places to minimize head-turning.

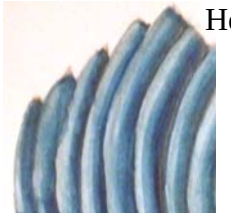
4.1.1 Basic Facilities Provided

Hospitals

The residents and visitors of Astoria will be provided with all the basic facilities as those provided on earth. Astoria will have 5 hospitals so as to be within easy reach of everyone at all times. All minor and first aid operations would be under robot care. However, all robots will operate under human supervision.

Schools

For education, a school has been located in a 1g area within easy access of all children.The children will be using multipurpose touch pads, to serve as a table as well as the child's books. However, we understand the need for limited automation and requirement of children to have teachers who they can relate to, and so, teaching will remain manual.



Hotels

Seven star Hotels will be used for tourists to reside in throughout their stay.

Further Education

After graduating from the school, the students who want to pursue further studies will be assisted in doing so at the university in Alexandriat.

Malls

Holographic browsing will assist people in selection of the item that they want, and transactions will take place with the help of the personal device, RVail.

Restaurants and Bars

Astoria has provided the best restaurants to its residents. The customers will be served by state-of-the-art robotic waiters.

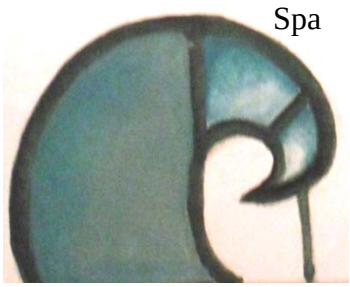
Glow-in-the-Dark Trees

The glow-in-the-dark trees, in parks will laminate as the sunlight fades. These glow-in-the-dark trees will be placed along roadsides as well, to serve as streetlights.

Entertainment and Recreation Opportunities

Astoria will provide its residents and visitors with a variety of entertainment and recreational opportunities.Following is a list of facilities provided aboard the settlement.

- **Zero Gravity Pool.** Experience a sensational feeling of swimming in complete weightlessness.
- **Zero Gravity Observatory.** Natural views of space accompanied by a feeling of weightlessness (Fig. 4.0.1)
- **Craft Centre**: the residents can explore their inner creativity, by shaping pots and crafts out of natural clay
- **Museums** for information on past explorations and events in history on earth
- **Casinos**
- **Multi storey weather parks**, which will enable visitors to experience different topographies and climates on different levels of the park.
- **3D and 4D cinemas**
- **Virtual Gaming Arcade** ultimate experience of gaming, as a person's movements will be reflected in the virtual world.
- **Interactive libraries** for the book-lovers of Astoria
- **Parabolic Football** will be a major sport in Astoria with annual tournaments will take place every year in 0g area.
- **Souvenir shops**, for the tourists.
- **Spa** for giving the hard-workers a well-deserved break
- **Dance Parties** an excellent way of socializing with other Astorians
- **Rooftop Gardens** for those who love gardening. The residents will have an option of maintaining rooftop gardens themselves, or by means of a helping robot..

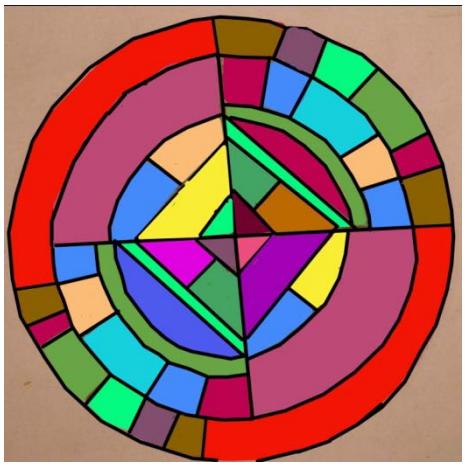


Spa

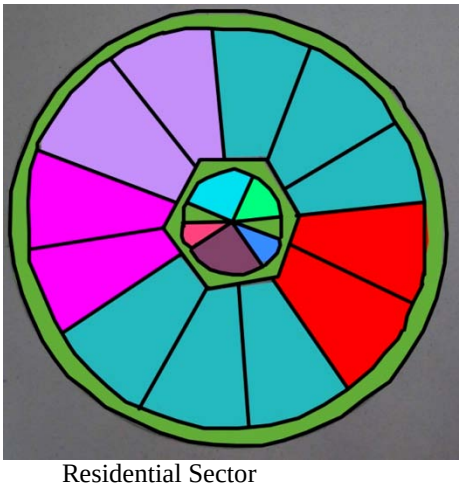
Casino

4.1.2 Community Plan

One dome of down surfaces will be focused mainly to be commercial, whereas two will be residential sectors and will have a similar community plan



Commercial Sector



Residential Sector

Key

	Malls
	Restaurants
	Casinos
	Hospitals
	Library
	Gyms
	Craft Centre
	Museum
	Sports Complex

Area allocated to roads and paths: 4%

Distance Scale: 1cm to 92m

	Spa
	Virtual Gaming Arcade
	Offices
	Police Station
	Parks/ Areas for Future Expansion

	Hotels
	Semi term Occupants
	Single/Couples
	Families
	VIP Singles/Couples
	VIP Families

4.1.3Variety and Quantity of Consumables and means of Distribution

Consumables	Quantity per person per annum/kg	Means of Distribution
School and Office Stationary	7	Malls
Medical Equipment	18	Hospitals/Malls
Electrical Equipment	2	Malls
Garments	12	Malls
Food	840	Malls/Restaurants
Toiletries and Cosmetics	3	Malls
Miscellaneous	6	Malls

4.1.4 Public Areas

In order to prevent people from feeling claustrophobic, Astoria will have large public areas with long lines of sight. The line of sight will be 238m.

4.2 Home Designs

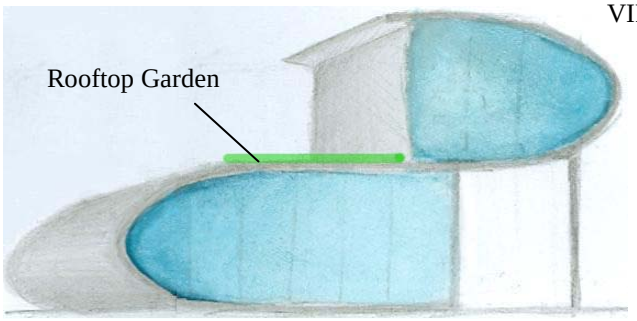
Here at Astoria, we realize that even though tourists from earth who spend a limited time in an outer space settlement, have high expectations from the technology used in entertainment facilities as well as in everyday life, the permanent residents would on the other hand require an earth like environment, so as to prevent feeling home sick.

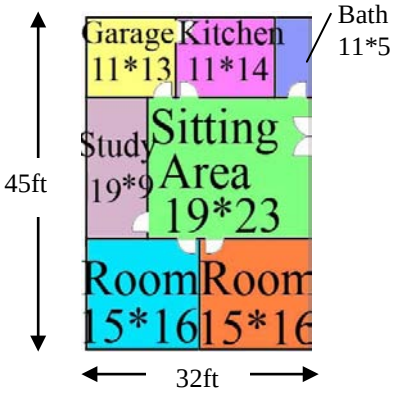
4.2.1 Demographics

	Singles/Couples	VIP Singles/Couples	Families	VIP Families
Area of 1 apartment	900	1334	930	1440
Residents in 1 apartment	1 or 2	1 or 2	4	4
Total no. of Residents	2112	3168	576	144
No. of apartments	1824	2736	144	36
Total Area	547,200	3,649,824	44,640	51,840

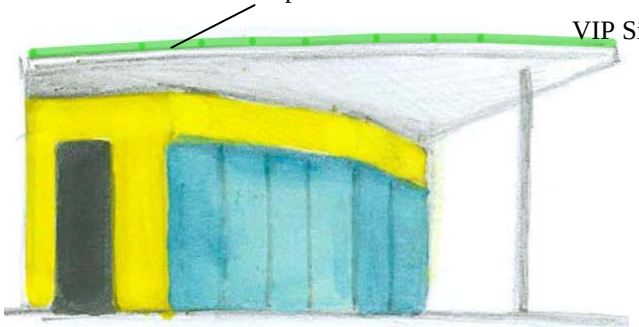
4.2.2 Exteriors and Floor Plans

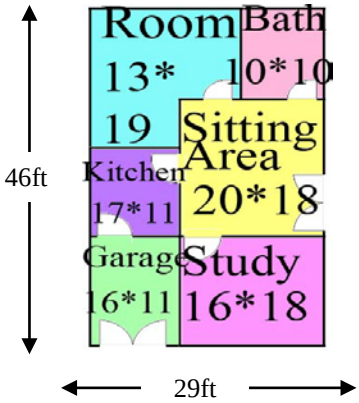
VIP Families

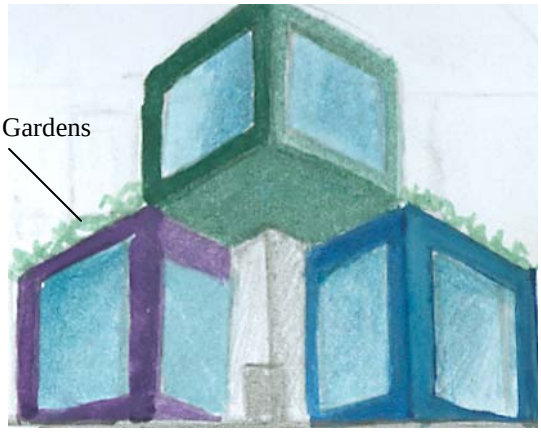


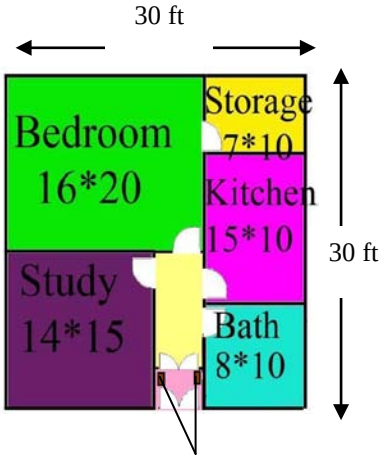


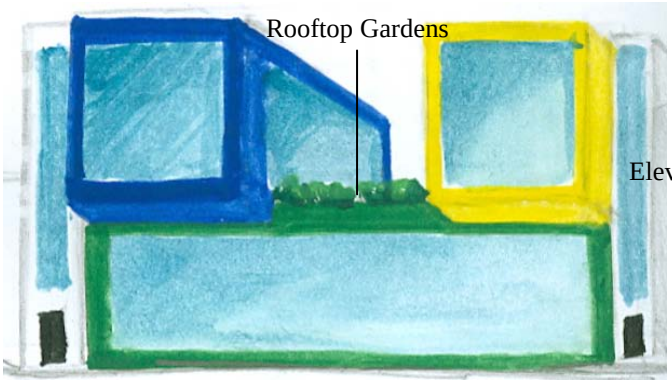
VIP Singles

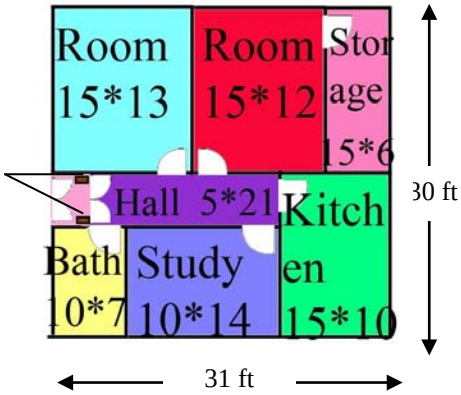










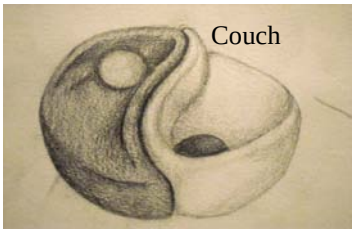


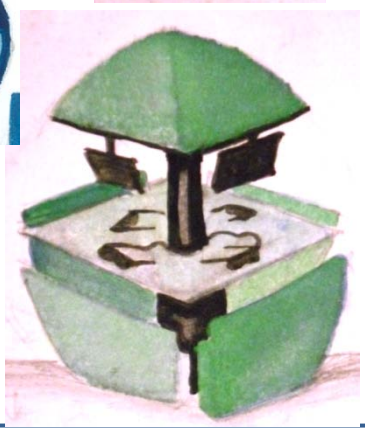
4.2.4 Examples of Furniture Items

Holographs used for a realistic experience

Resting Couch

Virtual Gaming Unit





4.2.4. Sources and Manufacture of Furniture and Appliances

Initially Furniture and Appliances will be brought from Earth. However with time materials will be imported and Astoria will begin to manufacture its own appliances and furniture; making it independent.

4.2.5 Materials

Furniture	Appliances
1. Aluminum	1. Polythene
2. Iron	2. Silicon
3. Polystyrene	3. Metal
4. Synthetic Fibers	4. Freon
5. Polyester	5. Fiber glass
6. Polyurethane	6. Plastics

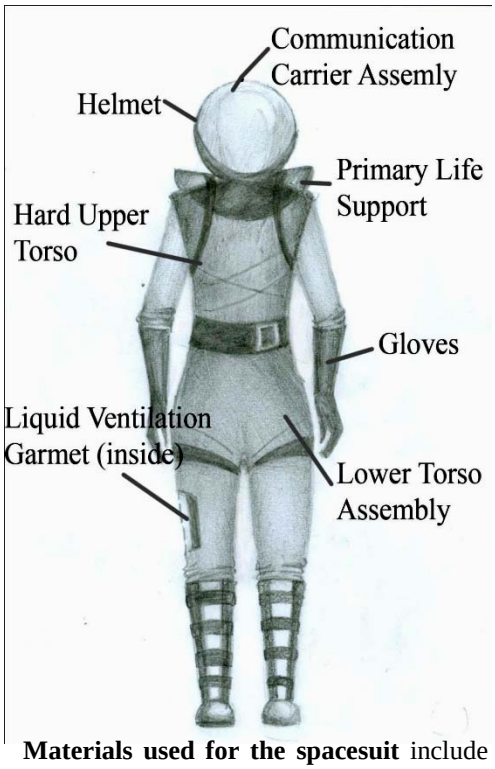
4.3.1 Safety Measures in Low g areas

The low g areas will be those of the zero gravity swimming pool, the observatory and the parabolic football area. All these areas will require them to wear biosuits and will be monitored by surveillance cameras at all times.

In the Zero Gravity Swimming Pool, swimmers will be required to wear emergency oxygen masks for their safety.

The observatory will have tethers and walls will be somewhat padded so as to avoid serious injuries in case of collisions.

4.3.2 Spacesuit Designs



Materials used for the spacesuit include Kevlar, Nylon tricot, Mylar, Spandex, Nomex, Urethane-coated Nylon, Neoprene-coated Nylon, , Goretex, Dacron

Device	Specifications
Communications Carrier Assembly	•Skull cap, made from Teflon and nylon fabrics, will be in contact with the Electrical Harness Assembly • Earphones and microphones for communication
Helmet	• For clear and wide field vision • Vent assembly will be connected to the rear inside of the shell to spread the incoming gas inside the helmet
Hard Upper Torso(HUT)	• Vest-like shell made of rigid fiberglass will have provisions for helmet, arm and lower torso assembly attachment • Water line and vent tube will be secured to the shell interior and connected to the LCVG and life support system • Water and oxygen storage and circulation provisions will hang on the back and life support system controls will be attached to the front
Primary Life Support Subsystem(PLSS)	• Oxygen tanks, carbon dioxide scrubbers/filters, cooling water, radio, electrical power, ventilating fans and warning system all placed inside the backpack
Gloves Assembly	• Hot pads to protect hands from extreme extra-vehicular temperature • Controllable fingertip heaters
Lower Torso Assembly	• Features conjoined body seal closure, waist, waist bearing, leg, thigh, knee and ankle joints as well as boots • Surrounds the entire of the lower body and will be connected to the HUT

4.3.3 Stowage

The spacesuits will be stored in the airlock after they are sanitized.

4.3.4 Donning/Doffing

Donning and Doffing will take place with the assistance of robotic arms. It will be carried out in the following order:

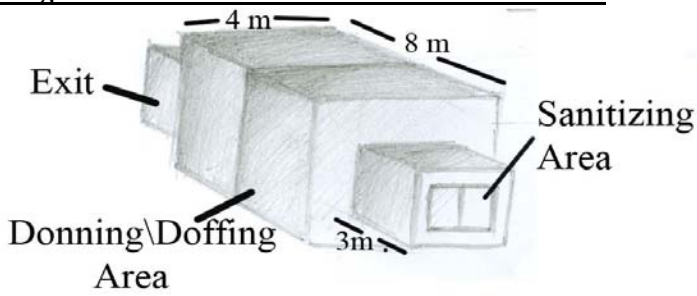
1. Wear Lower Torso Assembly
2. Wear Hard Upper Torso
3. Wear Boots
4. Wear Gloves.
5. Wear Primary Life Support
6. Wear Helmet

4.3.5 Airlocks

The airlock will serve as the entrance to Astoria and will automatically remove germs and dust from the incoming ships as well as people.

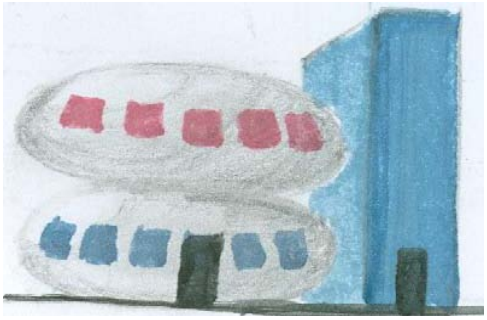
The airlock will also serve as an exit. It will consist of two chambers both serving the same purpose, in case of failure of either. The pressure will initially be the same as that of inside the settlement. It will gradually decrease to acclimatize the astronaut's body with the conditions of outer space.

4.5.1 Integration of Semi Permanent Residents into Astoria



4.4.1 1g Area

In order to allow for the normal physical development of children on account of low gravity, educationn will be provided in a 1g area, where they will be required to spend between 4 to 6 hours every day. Children will also be encouraged to take up extra curricular activities.



Semi Permanent Residents will be encouraged to mingle with Astoria residents and to take part in social activities so as to interact with the other residents. At Astoria, we will take the following steps to ensure that the semi permanent residents do not feel alien to this new world.

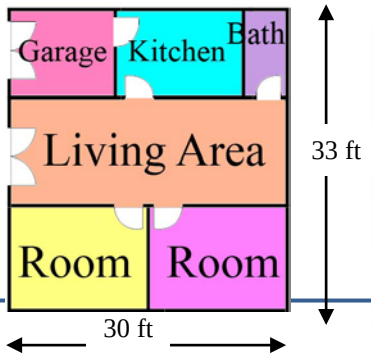
- The first activity that the semi permanent residents will engage in will be to take a tour of the settlement. All important venues and areas will be highlighted for them as well as short cuts to popular destinations.
- The instant move-in houses, for the semi permanent residents will be located in or near the permanent neighborhoods to encourage socialization.
- These residents will be encouraged to attend social events like dance parties, go to restaurants and bars, and volunteer for activities like sports and pottery making.

4.5.3 Instant Move-in Homes

The instant move in homes may be custom made for the semi permanent residents. New instant move in units will have the ability to be stacked on or next to the previous units. Similarly, old units can be removed without much

4.5.2 Employment Opportunities

- Research Work
- Mining Invigilation
- Invigilation of Industry work
- Supervision of Medical Robots
- Surgeons for major operation
- Robot Repair
- Teaching
- Control Unit



5.0 Automation Design and Services

5.0.1

Software	Use
Hiphazat	This program has been especially designed to provide automated protection for Astoria's residents. An elaborate system of sensors is installed on every compartment that needs to be sealed/isolated in case of contamination, leaks, or fire emergency, as well as the outer hull in case of hull breach. Sensors alert actuators (including our repair robots), to remedy issues that could arise on Astoria swiftly and automatically. Hiphazat deals with operational difficulties.
Florus – specialised component of Hiphazat	Florus is a software embedded within all Agrus 3.0 units. The claw of a harvester will use moisture of the cut stem/root to judge the quality of the crop. This standardisation provides high quality food without fail to Astoria's residents.
Phacoplex	State of the art treatments and procedures are downloaded onto all automated medical facilities on Astoria. The software is impenetrable to viruses or hacking, with multiple layers of data security and self-deactivation in case any information is lost or tampered with.
Trench	Trench keeps track of reserves discovered on nearby asteroids and directs future exploitation and expansion by deriving optimal production reports. These guide Astoria to maximising efficiency in mining and processing, while keeping track of it's new reserves and amounts of material mined.
Recreate	This software is present on the 500 units of Astoria's Personal Device (refer to 5.3) that the 500 tourists will possess. The software observes the recreational facilities individuals order and engage in using their devices to derive demand statistics for each provision. Most importantly, the software allows only limited access to residents who should not be accessing personnel-only data.
Derive	Derive is to be installed on the PDs of Astoria's employees. It determines the identity of the holder of the device using DNA Body Oil Scans and subsequently provides them with their given level of access.
Assimilate	This software is automatically downloaded into childrens' Rvail units. Programs are specially design to aid their education process in the most interactive way possible.
Pro 71	This software may be added for all those who wish to engage in multi party conference calls and internal and external video communication. This is most suited for those involved in the business community.
Table 5.1	

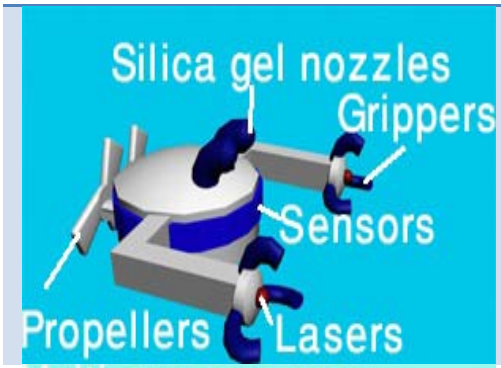
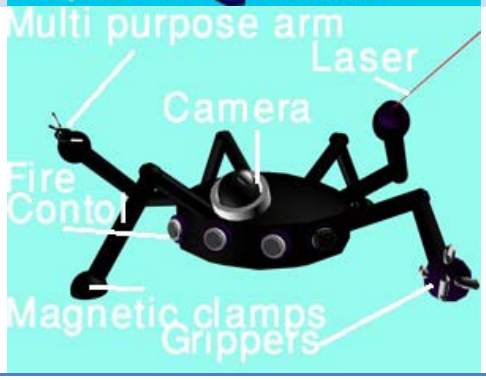
5.0.2. Multi-function Electronic Tools

Electronic Tool	Use
Jeeves	A hovering spherical robot acts as a butler, an encyclopaedia and can use it's white gloved dexterous hands to perform menial tasks like brushing your teeth if you so wish. A real gentlemen's gentleman.
Diamond	Shaped like a Swiss army knife lipstick, it contains 6 lip-stains, a mechanical nail polish applicator, a self massager, a hidden perfume, a digital clothing catalogue, mp4 and e-books. It can access fashion websites and give you the latest style advice in audio.

5.1. Automated Construction

This entirely automated process is described in great detail in Operations and Infrastructure 3.3.

5.2.1. Repair and Maintenance of Settlement

Robot	Specifications	Use
	• Units not required to function underwater will have thrusters instead of propellers and will not be covered aramid fibre • Lasers are centrally placed for greater efficiency • Nozzles replenish silica gel after scraping off the old layer, as it will capture much dust.	**External Repair** Dimensions: Height including gel nozzles: 0.7 m Entire Length: 1.4 m Diameter of full hand-span: 0.5m #200
	• Magnetic clamps for climbing on walls, other structures • Multiple arms capable of performing a wide range of functions.	**Internal Repair** Dimensions: Tallest Height: 0.5m Length of limbs: 1.0m #250

5.2.2. Automated Safety Functions

Automated System	Usage
Automated Shutters	To seal off contaminated areas and for structural isolation.
Depressurisation	To stop fires from spreading, to recreate environment in damaged areas.
Switch to back-up/alternate systems	To ensure steady supply of electricity, to ensure constant filtration of air and water.

The hardware and software utilised in Astoria is able to detect threats and come up with well calculated contingency plans for the future. This kind of precision ensures automated safety measures on the settlement, making it entirely reliable.

5.2.3. Contingency Plans

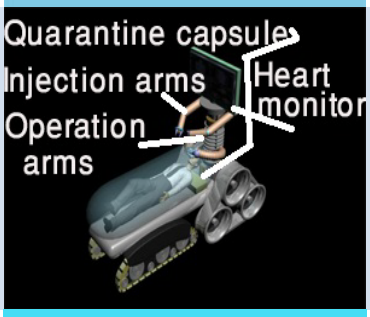
Settlement failure	Short term response	Long term solution
Hull Breach	Capsules of silicone sealant gel within layer of silica aero gel erupt, immediately sealing hole.	External Repair robot (actuator) dispatched as soon as Hiphazat reports breach.
Solar Flare	RxF1 polythylene perpetually protects from solar flare.	Thrusters help Astoria to hide behind asteroid. External Repair Robot repairs any damage.
Server Malfunction	Back-up storage can be accessed due to presence of data redundancies.	Internal Repair Robot repairs servers.
Emergency Evacuation	All unaffected residential hemispheres disconnect from structure. If 3 hemispheres are compromised, the fourth can transport all 11,500 residents to safety.	If only agricultural hemisphere remains, space tugs and cargo vehicles will aid in transportation of people to safety. Temporary residence on nearby settlements will be provided till re-establishment of a safe Astoria.
Atmospheric Contamination	Multiple air purification units alternate work to compensate if one fails. Hiphazat determines what unit begins	Internal Repair Robot repairs problem(s) with air filtrations systems. Once systems are re-established, Hiphazat senses desired

	work. In extreme cases, the area is evacuated and shutters fall to prevent spread.	air configuration and gives clearance for repopulation of area.
Electromechanical Failure	Internal Repair Robot dispatched to affected area. If malfunction lies in tools in the home, for example the PD or the massager, Household Robot will remedy problem.	Any defective parts will be replaced.
Power Failure	Hiphazat senses flaw in fission reactor, switches to back-up power from rocket fuel via proton exchange membrane fuel cells. Refer to Operational Engineering 3.2.3.	After Hiphazat determines whether fission reactor has stopped due to external or internal problems, External Repair Robot or Internal Repair robot will be deployed to re-establish control over fission, and power will once again be derived from reactor. Internal Repair robot will specially be radiation protected using silica aerogel, RXF1 and zylon fibre.
Water Supply Failure	Back-up water drawn from storage area. Water stored for other uses, besides agriculture, will be directed towards human use.	If problem persists, shuttles will bring additionally mined water from plant on asteroid.
Personal Assault	Security Robot subdues and isolates perpetrator.	Perpetrator sent to detention centre. Home country of individual alerted.
Fire	Evacuation/ cutting off of air supply/ depressurising area.	Internal Repair Robot assesses damage and repairs. Once conditions restored, the area can be re-established.
Refinery Mishap	Trench senses trouble at refinery, alerts settlement maintenance, deploys repair robots.	Internal/ External Repair Robots remedy issues. New units of any required machinery issued to retain quality and efficiency of work.
Cargo Handling Mishap	Temporary re-routing of arriving vehicles to other dock.	External Repair Robots repair damage.
Epidemic	Perpetual health scans prevent such happenings within the settlement.	In case of any illness, medical robots quarantine and treat patients until the virus has been eliminated from the population.
Agricultural Contamination	ODC protects vegetation from harm. According to Astoria's standard operating procedures, Florus keeps a perpetual check on crop quality.	Agrus 3.0 removes affected plants after receiving instructions from Hiphazat. Sanitises tools used to perform removal.

5.3.1- Enhancing Liveability

H: Height A: Arms length extended B: Breadth

Robot	Use	Description	Dimensions
	**Massager Robot**	• Spa tool and scent diffusers use aroma therapy to relax all users	**H: 1m** **A:0.5m** **#50**

	Security Robot Dimensions: Height: 0.7 m Arm Length(extended): 0.5 m	• Stun Gun/Handcuffs for subduing wrongdoers • Distress sensor that also synchs with DistrX (5.3.3)	H:0.7m A:0.5m #50
	Medical Robot	• Hands for injections/operations • Multi-function screen	H:0.5m B: 2.5m #40
	Dancing Robot	• In-built processor for various dance moves • Human like for best teaching approach	H:1.2m #30
	Butterfly Babysitter	• Small with integrated processor to keep track of childrens' location at all times without distressing them.	#360
	Power Shower	• Industrious process is enjoyable as well as water efficient • Reduces manual labour completely	H:2m B:0.75m #1890

5.3.2- Enhancing Work Productivity

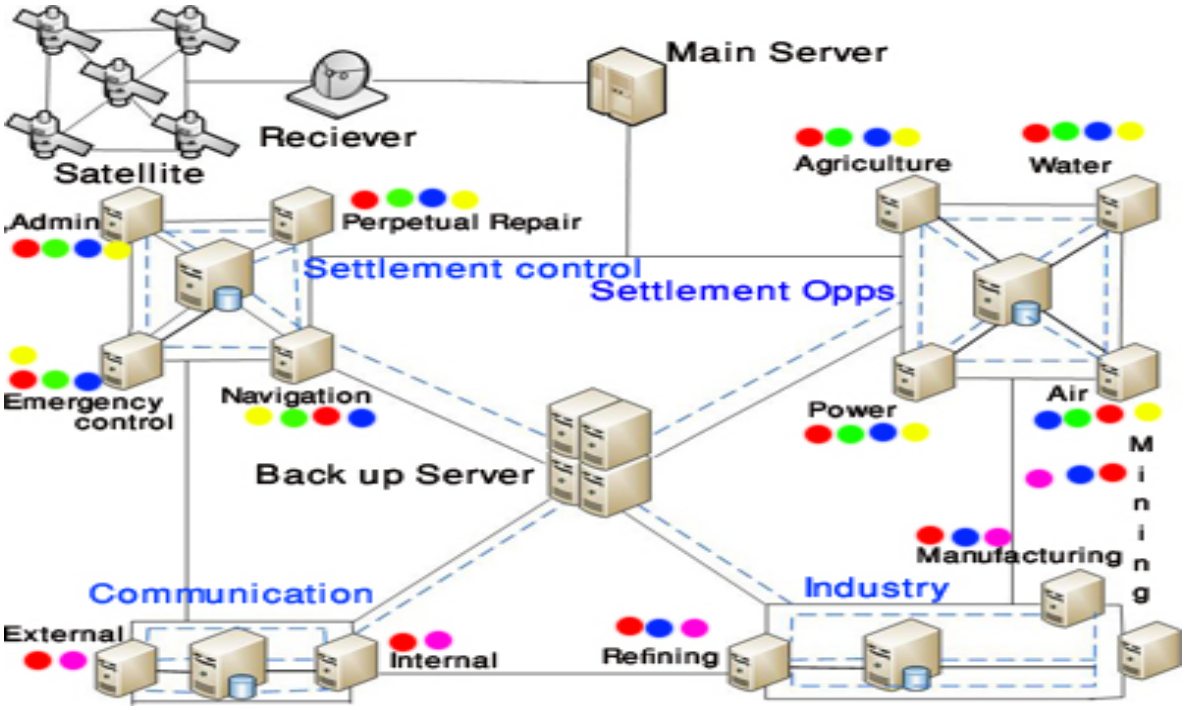
Feature	Use
RVail Pro-71	**Allows multi-user video calls and conferencing. Includes word processors, spreadsheets, excel cell sofwares.**
Synch Walls	**Allows you to synch you Rvail Pro to larger mediums for presentations and convert most wall surfaces to touchpads.**

5.3.3- Automation for security

Feature	Use
CamView	A webcam on the outside of each entrance door allows residents to see who exactly is outside from a screen on the inside of the doors.
Security Swipe	One must swipe one's RVail into the slot to gain access to the authorized room. The Astoria I.D details are displayed on the inside door screen (see above). In case of
DistreX	Peripheral camera's allow constant footage of halls and corridors. Built in distress alarms notify Security robot in case of violence, angry voices etc.
Smart Door	The entrance door frame has a built in weapon detector. If one is detected the door is automatically closed and locked and the Security robot is notified.

5.3.4 Communication, Connectivity and Data Security

The network plan uses a tri-hybrid plan with data redundancies (dotted blue lines) and layered data security to ensure the safest, most reliable and most cost effective communication for the residents of Astoria.



Key	Data Secuirty Measure
	Voice Resonance Test
	High Strength passwords
	Vascular Pattern Recognition
	Iris Recoginition Test
	Body Oil Scan

	Primary Servers
	Secondary Nodes

5.3.5 Computing Devices and Storage Mediums

Server	Type of Computer	RAM(TB)	Number	Storage Capacity(TB)	Processor(Core*Ghz)
Main	Quantum	250	1	125	168
Back-up	Super	175	4	175	100
Primary	Mainframe	100	4	100	80
Secondary	Hybrid	150	13	125	60

Storage Medium	Storage Capacity	Used in	Number Required
Protein Coated Discs	50TB	Main, Back-up and Primary servers	15
Holographic Versatile Disc	6TB	Secondary servers	25

5.3.6 Personal Device for Entertainment, Communication and Computing

The personal device provided to each resident at Astoria, the RVail, will be distinctly designed to cater to their specific needs. However, all RVail sets will use holographic and flexible displays, allowing comfortable internal and external communicative access. The Rvail is a three piece device. An ear piece and a bionic lens set for maximum 3-D experience. The third piece is a hand-width strip worn around your four fingers. The four finger "ring" designs, allows it to remain on one's person, making it perfect for identification purposes through perpetual body oil scanning. Business people will have different sets which will enable in-house conference calls, multi-media file sharing, business recording etcetera. The transient residents' RVail will be more geared towards what Astoria has to offer. Specific software is included for children, who will be able to be involved in virtual reality educational exercises. Entertainment possibilities included virtual surf gaming, intellectually stimulating quizzes and more.

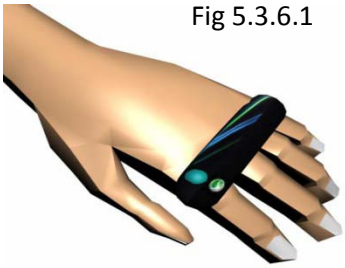


Fig 5.3.6.1

Fig 5.3.6.2

The RVail also synchs to all automated facilities on the settlement allowing for increased comfort levels for all residents. The facilities you receive then will be the ones you have set out. This also reduces time-consuming security measures at each and every step.

5.4.1–Robot Designs Conducive to Asteroid Conditions

Northdonning Heedwell recognises the need for special construction materials for the manufacturing of robots working on the outside of Astoria and those working on the asteroid belt. To protect our robots from the threats they are likely to face, such as solar flare and dust, we have in place certain barriers. To ensure that our robots are unaffected by dust which may clog parts and reduce efficiency, an electrodynamics dust shield will use copper in the electrodes of an electric curtain to mitigate dust. These robots will also have a lotus-like nanostructure coating

of Silica and Zinc Oxide. The success of our robot protection stems from the carefully chosen substances used to produce our robots. These include;

Material	Where	Purpose
Aero Gel	Joints and seams	Absorbs dust, can withstand compressive forces 200 times its own weight. Debris protection.
Aluminium Alloys	Limbs	Light but sturdy for fluid movement
Vectran	Power cabling	Melting point of 330 degrees celcius and moisture resistant.
Silicon	Microprocessors	Radiation hardened
UHWMPE	Exploration Robots' Arms	Self-lubricating, dust resistant, resistance to water, resistance to abraision
Titanium 6 Al/4V	Robots bodies	Robust and durable
Carbon	Graphene used for ram processors	Radiation hardened and efficient
Aramid Fibre	Coating on Robots working underwater	Water resistant material, enables robots to work underwater

5.4.2. Mining robots and vehicles

Once Astoria's construction is complete, the exterior mesh construction robots are converted into mining robots as the former will no longer be required. If 100 units of the external mesh robots are converted, 100 cargo-carrying vehicles are produced, and 200 units of mining robots are produced.

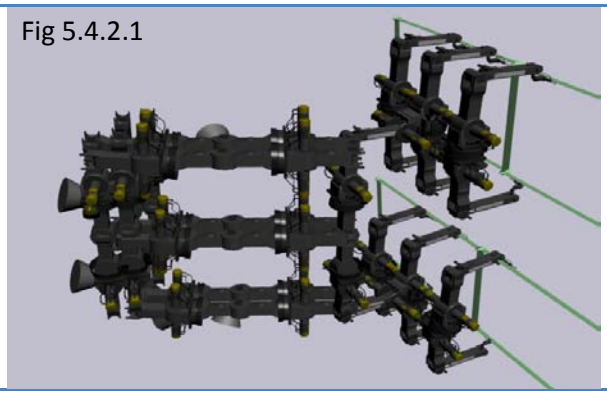


Fig 5.4.2.1

Step One

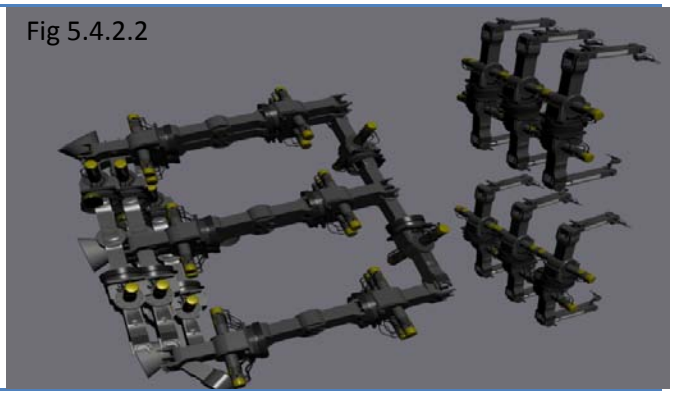


Fig 5.4.2.2

Step Two

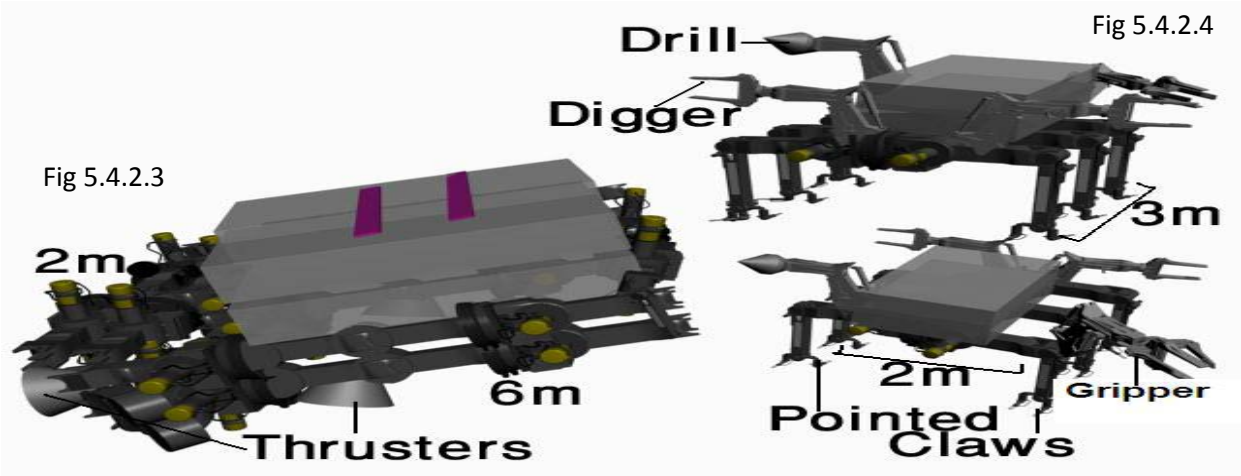
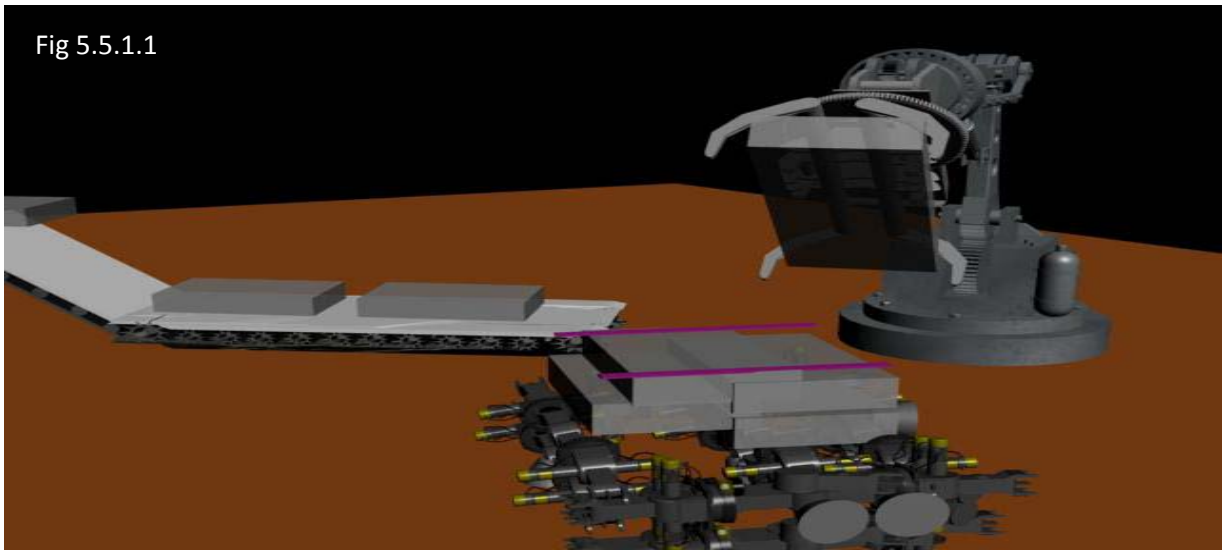


Fig 5.4.2.3

Fig 5.4.2.4

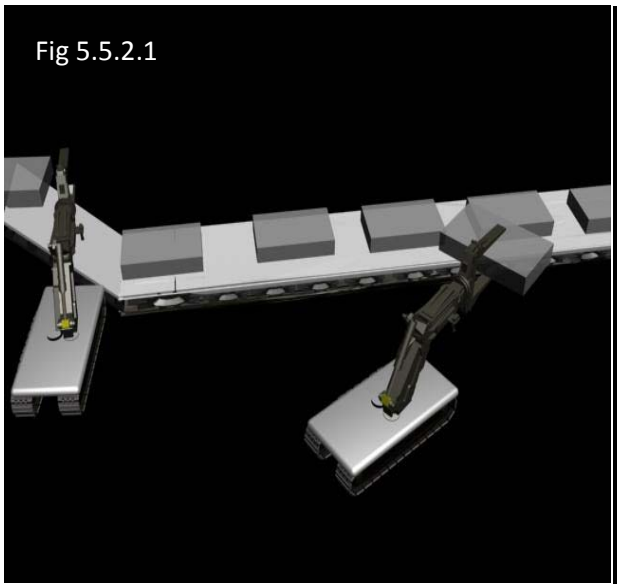
Step Three showing two mining robots that are able to drill, use their diggers to remove asteroid pieces, and grippers that are good for loading. Also depicted is a cargo vehicle that holds containers in place using magnetic straps as well as a magnetic base.

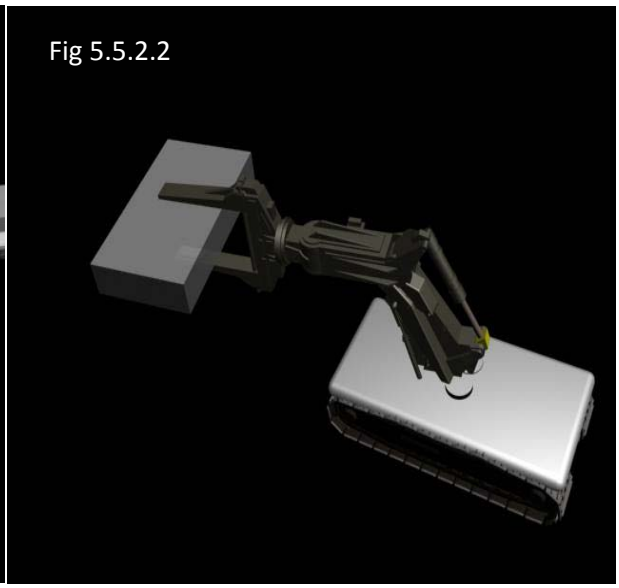
5.5.1 Loading Cargo



Fixed arm takes the conatiners from the transport vehicle. The containers are loaded onto the conveyer belt which leads them to transportation vehicles.

5.5.2





Mobile arms for loading cargo.

Multi-hinged sturdy structure with caterpillar wheels.

6.0 Schedule & Cost. (Table 6.1 Action)	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Contract Award															
Research & Design															
Manufacturing of Robots															
Construction of mining base															
Extraction of mineral ore															
Transportation of materials and equipment															
Manufacturing of materials on Aresam															
Assembling major components at Sun Mars L4															
Construction of axial rod															
Construction of rotating and non rotating surfaces															
Construction of Docking Port															
Construction of a nuclear reactor															
Construction of six spokes															
Construction of hemispherical component															
Construction of Quadtori and observatory															
Construction of interconnecting transportation corridors															
Attach propellers and antennas															
Start rotation of the settlement															
Setting up an electricity mechanism															
Setting up back up satellites															
Installation of external communication system															
Setting up a day and night cycle															
Generation of atmosphere															
Setting up agricultural mechanism															
Setting up an emergency service															
Installation of a waste management system															
Wiring, plumbing and piping															
Installation of Internal communication system															
Interior Finishing															
Installation of reflectors															
Testing															
Approval by the Foundation Society															

Astoria's construction will be completed in 15 years and it will be handed over to the Foundation Society on 8th May, 2071. Its payback time is approximately 12 years. Total cost of the settlement is US $ 92b_____

Key	
Contract Award	
Research &Design	
Construction	
Usage	

Construction Phases	
Phase 1	
Phase 2	
Phase 3	
Phase 4	
Phase 5	

Time Duration	
Phase 1	1st May, 2056 – 1st May, 2061
Phase 2	2nd May, 2061 – 2nd May, 2063
Phase 3	3rd May 2063, - 3rd May, 2066
Phase 4	4th May, 2066 – 4th May, 2069
Phase 5	5th May, 2069 – 5th May, 2071
Handed over to the Foundation Society on 8th May, 2071.	

6.2: Schedule

Table 6.2.1 cost of materials phase 2 & 3			
NAME	**QUANTITY**	**RATE/kg($)**	**COST($)**
Pre-construction preparations			
Research and Feasibility studies	Varied	Varied	3b
Initial Designing and planning	Varied	varied	1b
External Materials			
Titanium Aluminide	232,000,000,	4	928m
Poly-Methylcrylate (PMMA)	68500,000	6	4b
Aluminium Oxynitride Glass	21500,000	5	107m
Sealant gel	162,000,000	36	6b
Carbon nanotubes	78300,000	95	8b
Lead crystal Glass	145,000,000	50	8b
Silica aero gel	110,000,000	34	4b
RXF1 polyethylene	54300,000,0	5	3b
Zylon	89400,000,	50	5b
Internal Materials			
Silica	10,000,000,000	2	20b
Polyurethane	20,000,000	1.55	31m
Polyester	35,000,000	1.12	40m
Polystyrene	10,000,000	4	40m
Ceramic	50,000,000	30	2b
Stainless Steel	5,000,000,000	32	1b
Aluminium	90,000,000	3	270m
Iron	100,000,000	5	5b
Total Cost: 71b			

6.2.2 phase 4	
Research and design	10m
Aeroponics	15m
Day and night cycle	4m
Waste management system	4m
Communication satellites	22m
Internal transportation	6m
Thrusters	5b
Water extraction	1b
Electrical power generation	85m
Total cost	8b

Table 6.2.3 Phase 5		
Process/Material	**Quantity**	**Total Cost ($)**
Apartments	4740	1.5b
Sports complex	1	8m
Hotels	33	200m
Hospitals	7	52.5m
Schools	1	1m
Research Centre	1	1m
Library	3	2m
Cinemas	3	45m
Police Stations	1	1m
Casinos	3	10m
Offices	20	2b
Restaurants	30	60m
Markets	10	35m
Gym	15	15m
Parks	4	67m
Malls	2	16m
Museum	1	2m
Crafts center	1	3m
Observatory	1	4m
Total Cost		**9b**

Table 6.2.4 Revenue per year	
Tourism	17 b
Import/ export	2 b
Transportation taxes	380 m
Business taxes	250 m
Entry taxes	270 m
Property rights	400 m
Industrial taxes	300
Recreation facility	2 b
Advertising rights	200 m
Occupying seat in stock exchange	37.5 m
passenger fees	24 m
Cargo shipping fees	10 m
Marketing to passengers	12 m
Total revenue	**78.68 b**

Table 6.2.5 Maintenance Cost	
Residential sector	30 m
Agricultural sector	8 m
Commercial sector	10 m
Docking port	500 m
Industrial sector	90 m
Automated devices	50 m
Operational sector	30 m
Cargo system	60 m
Transportation system	60 m
Communication	60 m
Automated devices	80 m
salaries	82m
Total cost of maintenance	**1 b**

Table 6.2.5 Maintenance Cost	
Residential sector	30 m
Agricultural sector	8 m
Commercial sector	10 m
Docking port	500 m
Industrial sector	90 m
Automated devices	50 m
Operational sector	30 m
Cargo system	60 m
Transportation system	60 m
Communication	60 m
Automated devices	80 m
salaries	82m
Total cost of maintenance	**1 b**

Table 6.2.7 Payback Period
Net profit per annum (Revenue- maintenance) 78.7 b- 1 b=77.7 b
Payback period is 12 years

7.0 Business Requirements

Astoria will primarily serve as a harvesting and processing center for asteroid resources. It will be sufficiently flexible to host various commercial and industrial ventures. Hence, businesses will thrive, with little configuration change taking place.

7.1 Asteroid material harvesting and processing infrastructure

7.1.1 Asteroid Harvesting

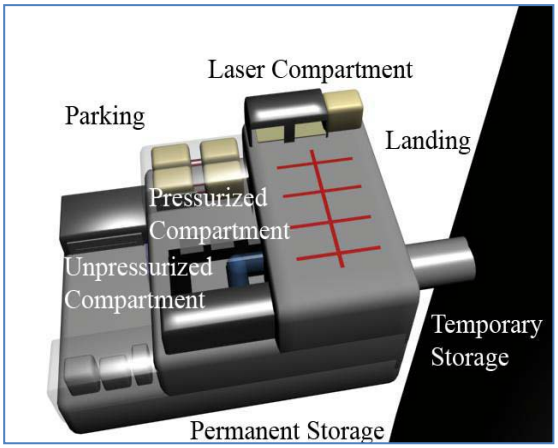
Initially, Astoria will contract out the mining and construction robots from Aresam. During this time Astoria's own construction robots will be produced. This will not only speed up the construction process but will also readily provide raw materials extracted using Aresam's robots, that will later be processed by Astoria's robots. Once Astoria has been completed the construction robots will be moulded into mining robots, this way the cost of producing additional mining robots is reduced.

7.1.2 Processing of the ore

Table 3.2.1 (operations) shows the materials that will be extracted from mineral ore (250 Bettina, 10 Hygea, 450 Patientia, 24 themis) .These materials will be processed at Bettina Manufacturing Unit near the mining base. Once Astoria has been completed the manufacturing unit will be transferred inside the Industrial Unit. Materials such as RXF1 usually remain in high demand by other settlements; therefore these materials will be extracted and manufactured in excessive amounts to be exported to other settlements.

7.1.3 Port Facilities

Astoria will have two docking stations located on axial rod beneath the zero-g observatory. Goods received at the port will first be stored in the temporary storage unit to remove any dust particles. Following that they will be directed through the transportation corridors to either the industrial unit for further processing or to the settlement for direct usage. Visitors will **save by receiving a refund of the Astoria Sales Tax paid on purchases in Astoria while leaving; this will encourage them to shop, enabling Astoria's commercial sector to thrive.**



7.1.4 Dust Entry Prevention

Elaborate dawning and doffing procedures at Astoria will ensure that no dust is brought into the settlement due to visiting spacecrafts (refer to 4.3.2).Visitors will go through dust mitigation procedures twice, once at the port and then before entering the residential unit, so as to ensure maximum safety. Astoria's spaceships will have a coating of silica aerogel to prevent dust accumulation on the exterior.

7.2 Services offered by Astoria

7.2.1 Agriculture

Food for miners working on nearby asteroids will be produced using Aeroponics (refer to 3.2.2). Food will be produced in surplus to cater the needs of the visitors. Packaged food will be sold to the nearby settlements. The production will be increased even further by practicing vertical farming (refer to 3.2.2).

7.2.2 Facilities for Visiting Spacecraft

Table 7.2.1 shows the facilities that Astoria will provide for visiting spacecrafts:

Table 7.2.1 FACILITIES OFFERED

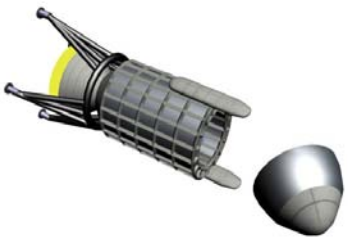
Residential Area	Zero g Area
Sports Complex	Space Arena
Casinos	Dance Studios
Malls	Gymnastics Clubs
Cinemas	Parabolic football
Multi-storey park	Micro-Gravity Pools
Weather zone	Observatory

7.2.3 Major maintenance and repair of vessels

A maintenance and repair system will be set up at the docking port where disabled vessels will be docked for rectifying their technical errors. Internal and External robots will help make the process efficient.

7.2.4 Fuelling Services

LOX and LH2 will be produced on the settlement in our reactor sphere and will then be transported to the port through the transportation corridor. Spaceships on their inter-planetary expeditions can dock for refuelling. Hence, generating revenue.



7.2.5 Space Tug Services

A maximum of two spaceships will be prepared to assist the damaged or disabled vessels. Medical facilities with a group of trained personnel will be aboard this rescue ship to assist the passengers of the damaged or disabled spacecraft. Food will also be provided aboard the rescue ship. These spaceships will be towed to the docking port for repair and maintenance.

7.2.6 Rescue operations for asteroid miners

The ship will contain 3 people, 3 robots, a water and waste treatment system, food for the patients and the 3 people, medicines, furniture and fuel. The ship will have foldable beds. These beds will be set up vertically on a conveyer belt. Also, multipurpose furniture would be used to use the internal space efficiently. Packaged food will sustain the people on the ship. A layer of silica aerogel will protect the ship from dust and radiation.

7.3 Sensing and imaging research for Astoria's outer Solar System Location

7.3.1 Radio Telescope

A radio telescope with a dish diameter of 500 feet will be placed above right above the observatory. The dish will have an area of about 60 acres and will make use of a single Gregorian reflector. The telescope will be used to identify and detect the asteroids in close proximity to Astoria. Asteroids are identified using their Albedo readings and spectroscopic images, thus using these features the asteroids to be mined will be identified and their potential will be calculated.

7.3.2 Optical Telescope

Astoria will have an optical telescope located above the observatory. The telescope will help Astoria study various celestial phenomena as well as planetary bodies in the outer solar system.

7.3.3 Structural Isolation

In the construction of Astoria, shutters are installed in every hull of the settlement, which will fall down each enclosed section. Each hull is detachable therefore in case of emergency the affected hull will be detached and taken away from the settlement by the help of the thrusters.

7.3.4 Data Processing

Fig. 7.3.1 shows how data will be circulated between Astoria's servers and the Earth's servers. This will aid the communication between Earth and Astoria in an efficient manner.

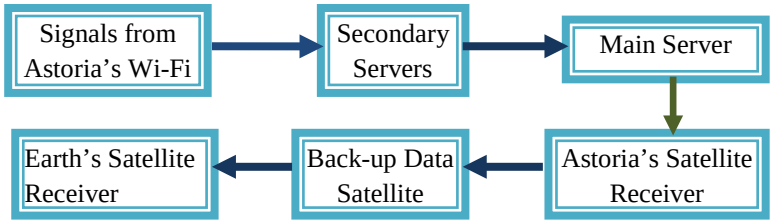


Fig 7.3.1

8.0 APPENDICES

8. A: Operational Scenario

Lilly rose from her luxurious bed, still smiling from the restful slumber and wonderful dreams her home processor had enabled. Singing the birthday song at the top of her lungs, she skipped into her brother's room while her parents followed with huge grins on their faces. As Lily pushed the curtains aside, the sun's rays filled the room with its warmth and light while Tom moaned in his bed as a sign of discontent over the fact that his peaceful sleep and dream had come to an end.

As he raised himself from the silky sheets of his bed, his mother quickly wished him before she rushed over to the kitchen to prepare the breakfast, while Lily and her father John returned to their rooms to get dressed for the day ahead. While Lily looked through her wardrobe, her mother came in to help dress her up. Once ready, they returned to the breakfast table where they were joined by John and Tom for a filling breakfast, made exactly to their liking by the household robot, while John used his RVail to go through today's news.

John kissed his wife Anne goodbye as he got into his smart car and left for his lab, swiftly dropping off Tom to school on his way. Anne had an hour before she was due at the maintenance department; a robot used for mining had malfunctioned and was going to take some time to be transported to Astoria. While she got dressed, Lily brought out her stuffed toys from her room to play with them while watching 4-D cartoons. Her babysitter butterfly fluttered around her head, and Anne knew that even if her daughter got home before her, in Astoria, she did not have to worry about her well-being.

Ready for work, Anne locked the house and left for her lab before dropping Lily off to her kindergarten class. Today in class, lily was going to learn her ABCs and was excited about using the special children software on her RVail for the first time while Tom was learning history of the Earth in virtual reality. During lunch break, both of them went to the playground where they had pasta which the household robot had prepared for them. It was a treat, because the food was always fine-tuned until the most minute details were perfect according to their individual tastes. After lunch, they then played in the playground for half an hour with their friends before going back to their classes.

Meanwhile, John had arrived in his lab only to find fresh reports to go through as well as new samples of different asteroids that came along with them. With the help of his lab equipment, he had been able to quickly dissect the pieces of asteroids and classified them according to the minerals they contained. Anne had arrived at the maintenance department within 10 minutes of dropping Lily and as she prepared the tools and equipments for the incoming robot, she booked their usual four seats at the cinema for the premiere show of Tom's favorite movie through her RVail. Once the robot was brought in, she quickly used her lab robot to diagnose the problem before using her RVail to link up to the repair robot she intended to work through.

After sending as many samples with the reviewed reports as he could, John decided to call it a day, satisfied with his work. He had spent the day utilizing the observatory's retractable telescope. He also had access to the CCD cameras placed on large Asteroids within the plentiful cluster they resided in.

He left his wife a message through the RVail that he was going to pick the kids up while Anne decided to join them at the mall later. Once at the mall, John decided to make a small stop at the pharmacy before picking up his favorite book from the bookstore which he had earlier ordered through his RVail. The diagnostic robot at the pharmacy diagnosed Lily with a sore throat and quickly gave her syrup she was to have for the next two days. Anne left for the mall after working on the mining robot the entire day; she met up with the rest of the family at the toy shop where Tom was trying out different games before he finally selected the latest gaming software as his birthday present. They checked out the gaming console with the advertiser-robot at the counter who gave Tom the code to needed to unlock the full gaming version on his RVail. On their way to the cinema, Anne stopped at the shoes store, where she tried on a new pair of shoes that a massager robot helped her into, relieving the stress in

her feet. She immediately bought the shoes, crediting the amount to her RVail bank account while John returned with the milk from the grocery store.
Once everyone had bought everything they needed, they proceeded to the theatre, a block away from the mall. They decided to walk to the 4-D theatre, enjoying the glowing trees as the sky got darker.
They returned home on their cars, and came home to the household robot having made spaghetti for dinner. The table was always set with such care. The household robot knew each member of the family as if it were a part of it himself. The family enjoyed a hearty meal, after which John spent some time watching sports while Anne helped Tom with his homework after putting Lily to bed.

8. B: Bibliography

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8. C: Compliance Matrix

Chapter	Requirement	Fulfillment	Page numbers
1.0 Basic Requirements	•	•	
2.0 Structural Design	• Provide safe, pleasant living and working environment for the whole community.	• 6000 long term residents • 5000 semi term occupants • Up to 500 short term visitors • Natural views of space outside have been provided to the residents through observatory	
2.1 Exterior Design	• Identification of attributes and uses of large enclosed volumes • Construction materials of major hull components and design features • Specification of volumes with artificial gravity and the selected rotation rate and rotating/non rotating and pressurized/non pressurized sections • Means of protection from debris and radiation • Overall exterior view of settlement • Capability to isolate any two separate volumes in case of emergency	• Table 2.1.1 • Table 2.1.2 • Magnitude of artificial gravity and rotating and non rotating sections • Prevention of debris penetration and Radiation protection as well as water leaks • Drawing showing major visible features. • Isolation of settlement in case of emergency as well as detachment of hemispheres	
2.2 Layout of Interior	• Percentage allocation of areas for various uses • Dimensions of interior down surfaces	• Pie chart showing percentage allocation of down surfaces Fig 2.2.3 • Dimensions table Table 2.1.3	
2.3 Construction Process	• Construction of the settlement • Specify when and how artificial gravity will be applied • Interior construction technique	• Construction sequence table • Method of initiating rotation • Construction of interior	
2.4 Shielding and Damage Repair System	• Details of shielding damage repair methods	• Shielding and protection system • Materials table • Illustration of prevention	
2.5 Human Habitation on Mining base	• Mining camp infrastructure on target asteroid	• Human habitation structure • Layout of the interiors Fig 2.2.5 • Drawing of human habitation at asteroid mining location	
3.0 Operations	• Description and facilities	• Facilities and infrastructure	

and infrastructure	for Astoria	essential for operating the community are described in this section in detail	
3.1 Location; source of materials and transport	• Recommendation of orbital location along with its reasons. • Source of construction material and equipment • Specify mining target	• 3.1.1: Orbital location; trade study giving reasons for location selection • 3.1.2: Table 3.1.2a and 3.1.2b shows the source of material and transportation vehicles • 3.1.3: Sources of construction material • 3.1.4: Drawing showing an overview of Astoria's mining base • Description of mining base	
3.2 Basic infrastructure	• Show elements of basic infrastructure required for the residents' activities in Astoria • Storage facilities for emergency situations	• 3.2.1: Atmosphere • 3.2.2: Food availability and storage facilities • 3.2.3: Electrical power generation • Storage and back up source • 3.2.4: Water management • Recycling of liquid waste • 3.2.5: Solid waste management • 3.2.6: Internal and external communication systems • 3.2.7: Internal transport system • 3.2.8: Day and night cycle	
3.3 Systems	• Primary construction machinery and how it processes the structural components into finished form	• 3.3.1: Details of primary construction machinery (3.3)	
3.4 Propulsion system	• Requirements for the propulsion system	• 3.4.1: Propulsion system being able to move Astoria when necessary.	
3.5 Port facilities	• Port facilities • Ore handling process on Astoria	• 3.5.1: Drawings showing the facilities	
4.0 Human Factors	• Provision of natural sunlight, views of space outside • Details of Coriolis effect and how to overcome it	• 4.0.1:Provision of sunlight through concave reflectors • 4.0.2: Problems Caused by Coriolis effect and their solutions • 4.0.3: Views of space outside using holographic screens.	
4.1 Community Design, amenities and facilities	• Services provided to the residents of Astoria • Consumables variety and distribution	• 4.1.1: List of Entertainment and Recreation facilities. • 4.1.2: Description and illustrations of basic facilities like health, education and recreation.	

		• 4.1.3: Consumable variety • 4.1.4: Means of distribution of consumables • 4.1.5: Minimum line of sight • 4.1.6: Diagram and key for community planning	
4.2 Demographics and Residential Design	• Interior floor plans and exterior drawings of houses • Demographics graph	• 4.2.1: Description of housing • 4.2.2: Demographics graph • 4.2.3: Floor plans and exterior of housing for VIPs, singles and families. • 4.2.4: Description and drawings of flexible furniture	
4.3 Safe Access	• Designs of systems and devices used in areas of 0.9g or less. • Spacesuit designs • Airlock designs	• 4.3.1: Illustration and description of Spacesuit design • 4.3.2: Diagram and instruction for donning and doffing • 4.3.3: Illustration and procedure of airlocks • 4.3.4: Devices and systems for human help • 4.3.5: Safety measures in low g areas	
4.4 Access to 1g area	• School for children in 1g area	• 4.4.1: Location, illustration and description of children in 1g areas	
4.5 Instant Move in Housing	• Drawings of semi-term occupants' housing	• 4.5.1: Drawings of exteriors of housing for semi-term occupants	
5.0 Automation Design and Services	• Specify number and detail of all automated services being provided • Illustrate all computing capacities, security detail, networking and use	• Providing latest technology to enhance livability and productivity in each chapter • Specified software and multi function tools	
5.1 Construction Automation	• Consider automated external and internal construction and finishing of settlement • Use automated design for transportation of materials.	• Supervised, separate robots for internal external construction and finishing • Transport vehicles for efficient delivery (Opps 3.1.3)	
5.2 Automation for settlement operation and control	• Specify robot for all operative tasks • Describe contingency plans • Show data security measures	• All robots for settlement control shown, e.g Medical robot • All back-up plans with immediate and long term solutions shown • Robots shown for external and internal repair and/or maintenance	
5.3 Automation	• Illustrate automated	Designs for enhancing livability in	

for livability	designs to enhance livability and productivity in the workplace • Show device for personal communication and entertainment • Show data privacy maintenance	settlement shown • Personal device for all residents shown for person communication, entertainment and business • Network plan with security measures shown • Types and numbers of computers being used specified • Mediums of data storage specified • Internal and external communication described	
5.4 Automated mining	• Display robots for mining withstanding zero-g situation	• Shown robots with descriptions for automated mining • Displayed use of specific material to withstand harsh conditions	
5.5 Automated docking facility	• Display automated unloading port • Specify whether ore will be delivered in bulk or containers	• Displayed efficient docking mechanism with separate pressurized and non pressurized loading areas	
6.0 Schedule and cost	• Schedule for completion • Costs for design	• Tables of schedule and cost are given in this section with relevant details	
6.1 Schedule	• Details of schedule including specific dates	• Table(6.1) gives the detailed schedule of construction of Astoria • Construction to be completed in 15 years	
6.2 Cost	• Specify costs for each phase of Astoria design through construction • Estimate number of employees working during each phase of schedule	• Tables 6.2.1, 6.2.2, 6.2.3, 6.2.4 give details of cost in all the phases • Table 6.2.5 gives the revenue details • Maintenance cost is given in table 6.2.6 • Details of professionals for Astoria fabrication are given in table 6.2.7	
Business Development	• Infrastructure for major asteroid harvesting and processing operations	• **Port facilities with a temporary storage unit** • Contracting out Astoria's own	•

	• Services for remote mining operations and outer planet expeditions • Sensing and Imaging appropriate to Astoria's outer solar system	construction machinery after Astoria has been completed • Selling profitable minerals that have been extracted and are found in abundance on Astoria. • Provision of expanded capabilities and repair and maintenance units for generation of revenue by charging incoming foreign ships in return for offered services. • Gaining profit by providing suitable facilities for visiting spacecraft • Research centers and laboratories present for experimentation on resources.	