NORTHDONNING HEEDWELL

PRESENTS

LAHORE GRAMMAR SCHOOL DEFENCE

PAKISTAN

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

Name of responsible teacher/advisor: Mr MAJEED AHMED BASHIR
School (or other Group Name): LAHORE GRAMMAR SCHOOL DEFENCE
School Address: 136-E PHASE1 DHA LAHORE
School City, State, Zip or Postal Code: 54000
Country: PAKISTAN
Daytime Telephone at School: 0092 423 5894306
Message Telephone: -
Fax: -
e-mail address: lgs@wol.net / aliakazi_@hotmail.com
Last day of school in Spring 2011: 22nd March 2011

Contact information for responsible teacher/advisor when school is not in session:
Name if different from above: -
Address: 541-L ; phase V ; DHA
City, State, Zip or Postal Code: 54000
Country: PAKISTAN
Telephone (also evenings / weekends): 0092 333 4237350
e-mail address: majeedbashir@hotmail.com

Information for alternate contact person (may be a student): ALIA YAQUB KAZI.
Telephone ✓day ✓eve ✓weekend: 0092 321 8830306
e-mail address: aliakazi_@hotmail.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)

ALIA YAQUB KAZI	[13](18)	MARIUM AHMED UQAILI	[13](18)
MAHAM MASOOD SADIQ	[13](18)	MISHA NASIR JAMY	[12](17)
NIDA-E-HAQUE MAHMUD	[12](17)	MAHAM MALIK	[12](17)
EHAAB IQBAL	[12](17)	UMAIRA SAJJAD	[12](17)
ALI HUSSAIN	[12](17)	MEHRU-UN-NISA FARHAN	[13](19)
NUMRA ABDUL ALEEM	[13](18)	SHAROON ADIL	[13](18)

Names of two adult advisors currently expecting to attend the Finalist Competition:
MAJEED AHMED BASHIR FAREEDA CHUGHTAI

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.

Majid Al — 9 MARCH 2011

~~Responsible~~ Teacher / Advisor Signature — Date

TABLE OF CONTENTS

Executive Summary

1.0 EXECUTIVE SUMMARY

In response to the Foundation Society's request for a proposal dated 1st January 2071, Northdonning Heedwell is proud to present Astoria; the first large space settlement community in the Solar orbit, within the asteroid belt between Mars and Jupiter. Since, in the long run, every planetary civilization will be endangered by impacts from space, every surviving civilization is obliged to become spacefaring--not because of exploratory or romantic zeal, but for the most practical reason imaginable: staying alive. If our long-term survival is at stake, we have a basic responsibility to our species to venture to other worlds.

The spherical design of Astoria as embedded in an asteroid will give it implausible protection against potential threats. Providing variable gravity, the unique design would enable populations to live at environments best-suited to them. The industrial area has been completely separated from other sectors saving the cost of filling up the extra atmosphere as well as reducing the risk of contamination by the release of harmful substances in the residential areas. The structure is capable of isolating its components in such a way that they are not lost and can easily be repaired once the emergency crisis has been overcome. Embedded in an asteroid and fully justifying its name Astoria, the asteroid belt settlement by Nothdonning Heedwell has all the needs required by a prospering community. Automated food production and supply system along with efficient means of internal transport such as capsules enable a fast moving and easy way of life for the inhabitants of the settlement. An earth-like day and night cycle along with controlled weather fluctuations ensures that the residents shall feel no difference between the Earth and the environment provided by the space settlement. The asteroid itself provides shielding and protection from the hostile conditions of the distant asteroid belt whereas facilities for multiple ore processing make it an efficient and self-reliant asteroid mining settlement.

Astoria is a community which offers all the attributes to its citizens that a small city in a developed country would. Not only does it provide long lines of sight along with views of outer space, but it also offers a variety of different house designs that people can choose according to their tastes. The human factors department at Northdonning Heedwell provides a great deal of leisure activities which shall enable people to relax and reduce their tension after a long, tiring day at work. Along with providing facilities to adults, a 1g area has been provided so that children in the settlement can nurture properly. Keeping in mind the safety aspects, a space suit has been designed to meet all imaginable requirements. Apart from that, the contractor also provides safety devices such as tethers and handrails in areas where outside gravity isn't provided. To accommodate semi-term occupants, hotels and flats have been constructed. The fully automated lifestyle in Astoria surpasses all the comfort that the previous settlements have provided. Astoria provides swift networking along with a competent security system. Domestic and office robots make work stress-free and comfortable. Enthralling technology and effectual automated machines, (escape pod, sixth sense, frogtile just to name a few) exploit productivity and population satisfaction.

The settlement will take **25 years** to be built and will cost **$1,520,830,954,000**. Designed to provide all the living, working and entertainment needs of an initial population of 11,500 people, and all the infrastructural requirements for the exploration and eventual development and habitation of Mars, Astoria promises to be the successful realization of the most ambitious project ever undertaken by the Foundation Society. Northdonning Heedwell contractors can confidently guarantee that Astoria will be a settlement where the comfort and luxury of its citizens is put on the highest pedestal.

As the science fiction writer Larry Niven shrewdly observed:*"The dinosaurs became extinct because they didn't have a space program. And if we become extinct because we don't have a space program, it'll serve us right!"*


2.0 STRUCTURAL DESIGN

2.0 STRUCTURAL DESIGN

2.1 – Exterior Configuration:

Astoria is designed to be built inside the asteroid 951 Gaspra. Such a design will give it incredible protection against potential collision threats as well as other reasons described in **section 3.1**. It has an outer spherical structure with another sphere-cylinder complex inside it as seen in **Fig. 2.1**. The only visible parts of the settlement outside the asteroid will be the docking ports and space observatories, as shown in **Fig. 2.3**. The space observatories will also provide natural views of space outside for the residents of Astoria.

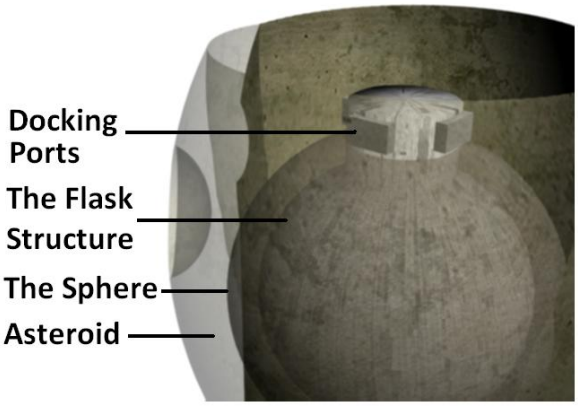


Fig 2.1

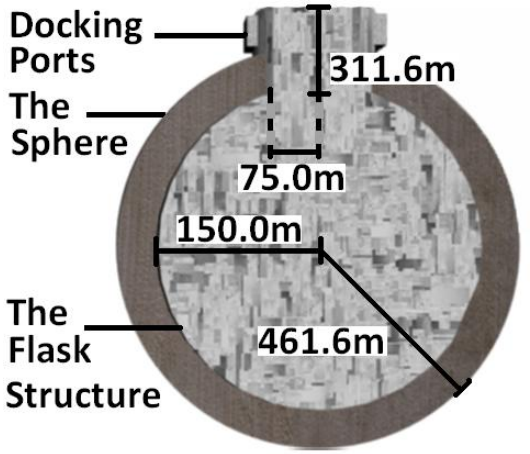


Fig.2.2

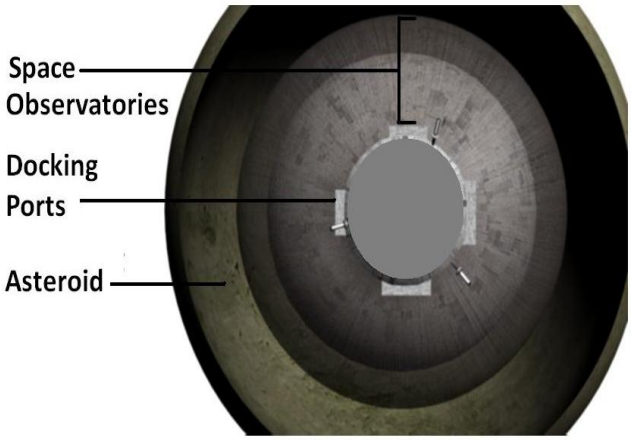


Fig.2.3

2.1.1. Dimensions

Table 2.1

Hull Component		Radius /m	Height /m	Surface Area/m^2	Volume/m^3	Rotating (Y/N)	Artificial gravity /ms^{-2}	Pressurized (Y/N)
The Sphere		461.6	-	2.68×10^6	0.412×10^9	Yes	Variable	Yes
The Flask Structure	**The Cylindrical Part**	75.0	311.6	0.15×10^6	5.506×10^6	No	-	No
	The Spherical Part	150.0	-	0.28×10^6	14.14×10^6	No	-	No

2.1.2. Uses of Large Enclosed Volumes

The Sphere: The outer structure has the largest volume and is designed as a sphere that has the capability to accommodate a population of 11500 at a time. With a curved down surface, it has the capability to provide variable g. It is connected to the rest of the settlement through the docking ports.

The Flask Structure: The inner structure is a combination of a cylinder and a smaller sphere. It will house all the industrial processes as well as regulation and control units. The docking ports are present at the top of this structure.

The reasons why a spherical design was chosen are:-

- Due to the Flask structure, lesser volume would have to be filled with atmosphere, hence lesser cost.
- There is variable g at the down surface. Residential area extends from regions of 0.5g to 1g (refer to **Fig.2.6**). Since most of the surface has less than 0.9g, structural maintenance costs are significantly reduced.
- Since only the outer sphere is rotating, less fuel is used to generate gravity.

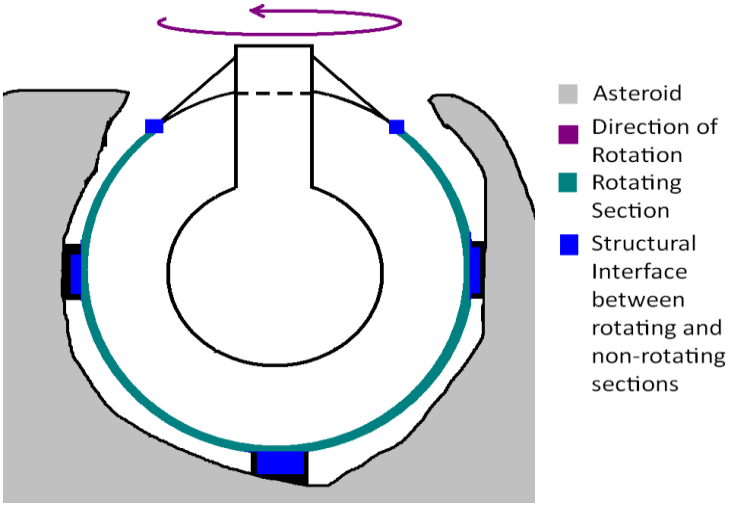


Fig 2.4

2.1.3. Structural Interfaces

The **Fig. 2.4** shows all the locations which are the interfaces between the rotating and non-rotating section. These interfaces are used by attaching di-magnets on the Sphere, which effectively repel and attract the other surface such that there is no contact between the two. At the same time, it is kept from drifting away.

2.1.4. Artificial Gravity

The Sphere is rotated at an rpm of 1.39 so that it can generate an acceleration of 1g at the equator. The rest of the surface will have gravity lower than that. Hence school requirements are fulfilled (**section 4.4**), while maintaining low costs. The rotation is caused by using **ion thrusters** attached to the Sphere.

2.1.5. Construction Materials

Table 2.2: Framework Construction Materials		
Materials	**Properties and use**	**Source**
Aluminium-Titanium Alloy	Resistant to oxidation and corrosion	Asteroids
Graphite-Epoxy	Forms a tough coating	Asteroids
Carbon composite	Durable; resistant to high temperatures;	C-type asteroids
Aluminium	Used in the outer shell; Low density but high tensile strength; use in Friction Stir Welding (**refer tosection 2.4.2**)	Asteroids
Aluminium Silicate	Low density; high thermal shock resistance as it has a high melting point; transparent material	Asteroids
Lead glass (Windows)	Transparent material; adds strength to the layers.	Asteroids
Polycarbonate (Windows)	Thermoplastic Polymer; Strong and able to withstand high temperature; undergoes large plastic deformation without cracking or breaking; Highly transparent and is an excellent light transmitter	Bellevistat
Aerogel (Windows)	Thermal insulation; insulation from infrared radiation; protection from high-velocity particles; low density; transparent	Bellevistat

2.1.6 Protection

Table 2.3: Debris and Radiation Protection		
Materials	**Properties and use**	**Source**
Regolith	Radiation protection; used in the outer shell	Asteroids and Mars
Lead	Radiation protection; and acts as a backbone for regolith	Asteroids
Nextel-Kevlar composite	High tensile strength, and thus provides protection against space debris; flexible; fireproof; resistant to high temperatures	Brought from Aresam, which will mine it from Phobos and Deimos
Liquid Hydrogen	Radiation protection and shock absorber	Asteroids

2.1.7. Isolation Technique

Isolation facilities will be provided to cope with emergencies. The Sphere can be isolated into 5 sections whereas the Flask Structure can be isolated into three sections. The **Fig.2.5** shows some of the points where isolation can take place. In case of an emergency, 'Escape Pods', manufactured especially for the purpose of evacuation, will be sent to the area immediately (**refer to section 5.2.4)**. Residents will be effectively evacuated through emergency exit doors to safety.

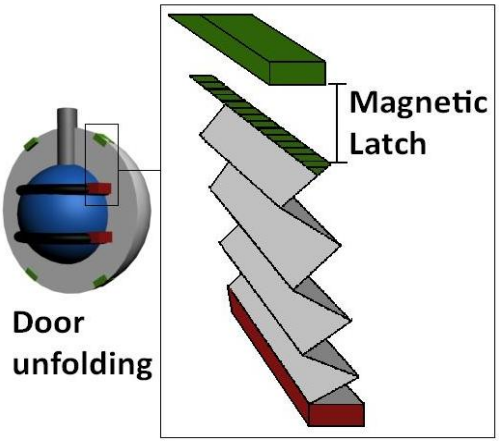


Fig. 2.5

Following evacuation, the area would be immediately isolated by airlock doors. These are special doors, made of titanium metal, and folded into the walls of the settlement during construction. They will be connected wirelessly to the main computer system of the settlement. For isolation, signals would be sent to the doors, which would immediately unfold, and expand to enclose the area. This would be followed by creation of a vacuum inside the area, achieved by using the airlock pumps.

2.2 – Interior Arrangement:

2.2.1 Percentage Allocation

Refer to human factors **4.1.1**

2.2.2 Dimensions of Interior Down Surface Area

Table 2.4		
A	End of Residential Area	Gravity = 0.5g Distance from the axis of rotation = 230.8m
B	Center of Residential Area	Gravity = 1g Distance from the axis of rotation = 461.6m
C	Down Surface	Length C= 967 m Total area = 892000 m^2
D	Filling to reduce curvature	Length= 6m

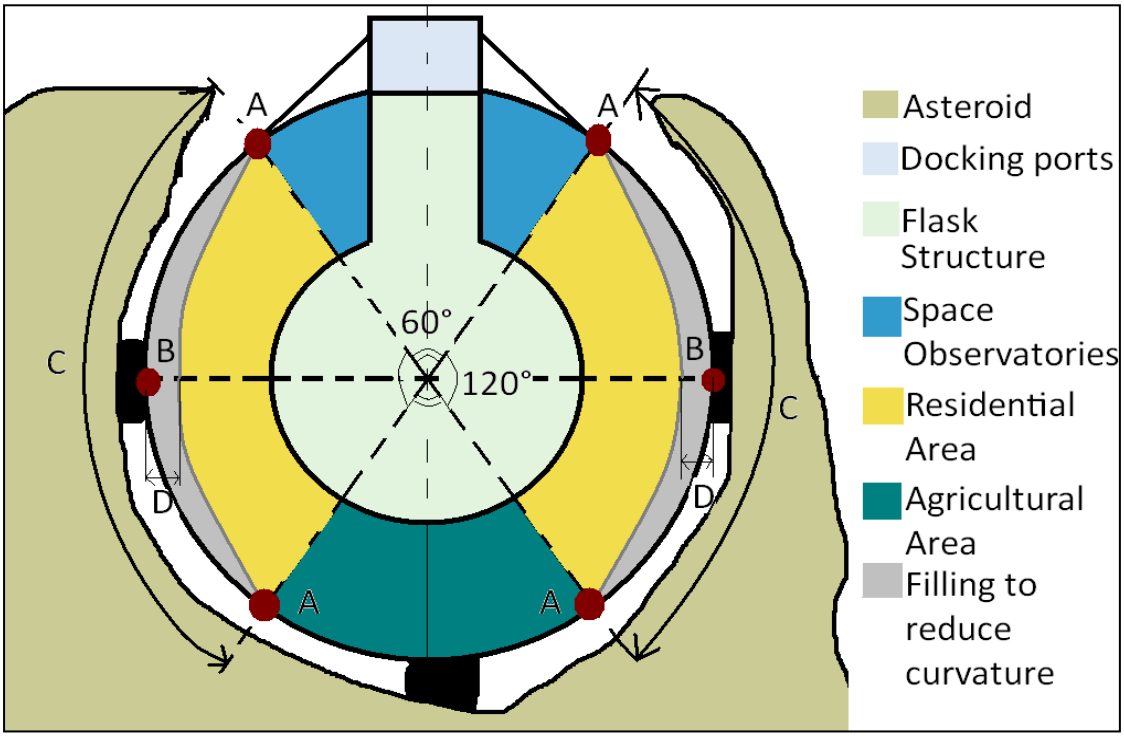


Fig 2.6

2.2.3 Drawing Illustrating Uses

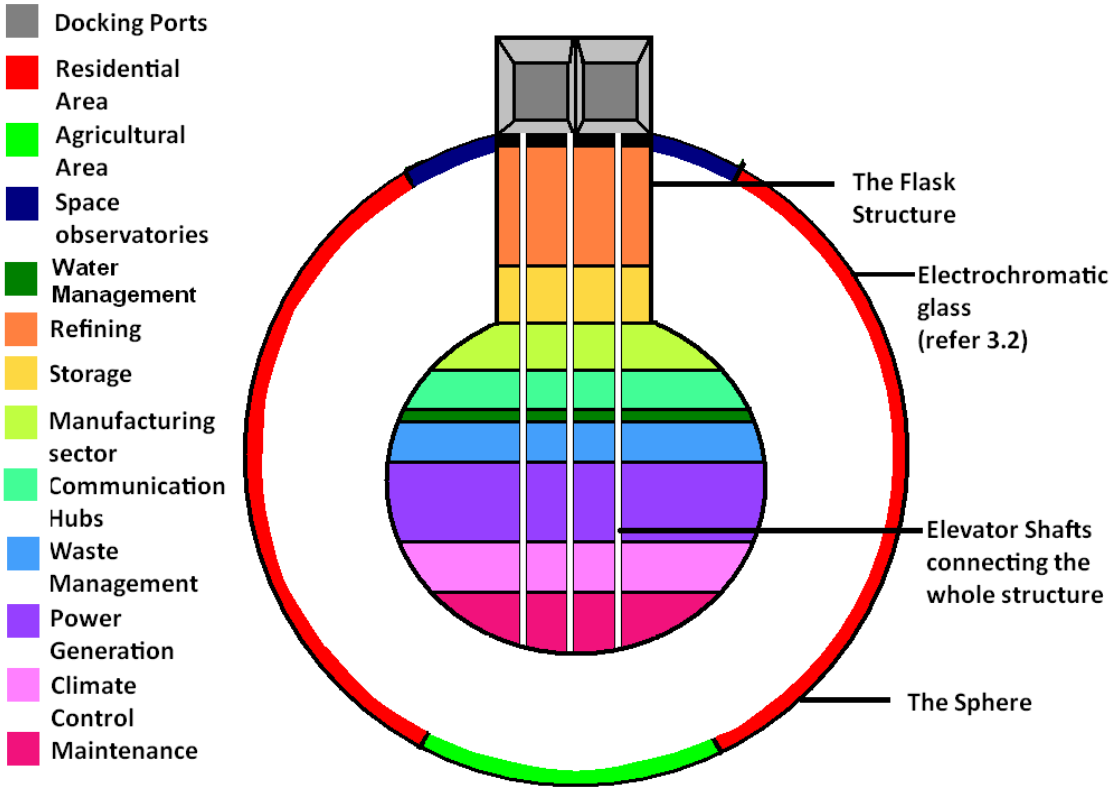


Fig.2.7

2.2.4 Orientation of Down Surface (Fig.2.8)

The line of sight is significantly reduced at the equator due to a smaller structure. To avoid the resulting psychological problems, there are mirrors placed at each end of the residential area which reflect scenes from other parts of the settlement.

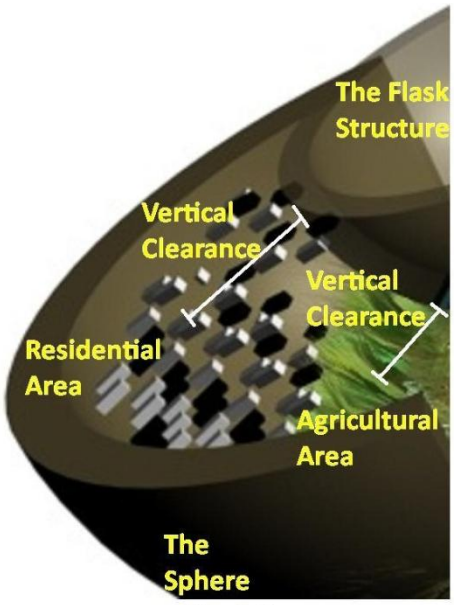


Fig. 2.8

2.3 – Construction Sequence:

2.3.1. Process for Exterior Configuration

The construction is carried out using Super Adobe Construction Technique. The regolith obtained from excavating the asteroid in the first phase is compacted into long tubes of flexible material. Robots are programmed to fill the tubing and stack in layers. Once the structure is complete, some additional shielding is provided by piling loose regolith on top of it, and it is sealed to be air-tight with the glaze on the interiors. The additional regolith also provides shielding as shown in **Table 2.3**. The construction materials are then added to this basic structure, layer after layer. The method is extremely cost-effective and provides great stability to the settlement.

2.3.2. Construction Sequence

Table 2.5

Phase	Process	Illustration
Phase 1	The construction begins with the transport of construction machinery to the Gaspra 951 where the excavation begins	
Phase 2	The construction of the Flask structure takes place first, using the regolith obtained while excavation using the technique explained in **2.3.1.**	
Phase 3	Completion of the Flask Structure. The Flask structure houses the refining and manufacturing sectors which produce materials necessary for making interior structures as per requirement of the next steps.	
Phase 4	Building of the docking ports. This will ease the transportation of mining equipment and machinery. At the same time, excavation continues for the next step.	

Phase 5	The Sphere is built and the agricultural areas are developed for the sustenance of the future population	
Phase 6	The Sphere is complete and it is made to spin about its axis for the creation of gravity. The atmosphere is released and the influx of human population begins.	

2.3.3 Construction of Interior Using Asteroid Materials

The construction of interior structures is done using Contour Crafting Technique. **Refer to section 3.3**

2.4 – Damage Repair:

2.4.1. Damage Repair for Frequent Impacts

Damage due to frequent impacts is significantly reduced due to construction of Astoria inside the asteroid.

An additional method to prevent damage, especially during the construction of Astoria as well as on the surface of the docking ports which will be exposed all the time, is the use of Grubb's Catalyst. Tiny capsules containing liquid epoxy polymer composite will be placed in the walls of Astoria. The wall also includes Grubbs' Catalyst. When there is an impact and the target hits the walls containing the capsules, the capsules would rupture and would mix with the Grubb's catalyst, causing it to solidify. This way, any cracks formed would be filled by this material, preventing any further damage and potential atmosphere leakage.

2.4.2. Damage Repair for Larger Collisions

For repairing large damaged areas, Friction Stir Welding is used. The metals need not to be melted during the process. A dowel is rotated between 180 to 300 revolutions per minute, depending on the thickness of the material (mainly Aluminium). The pin tip of the dowel is forced into the material while rotating and moving forward. As the pin rotates, friction heats the surrounding material and rapidly produces a softened "plasticized" area around the pin. As the pin travels forward, the material behind the pin is forged under pressure from the dowel and consolidates to form a bond. Unlike fusion welding, no actual melting occurs in this process and the weld is left in the same fine-grained condition as the parent metal.

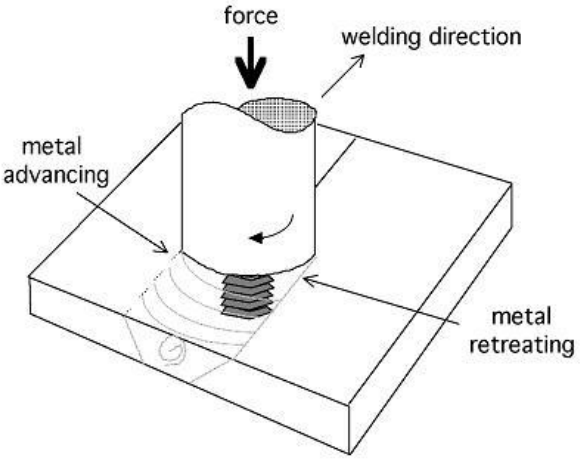


Fig. 2.9

2.5 – Mining base:

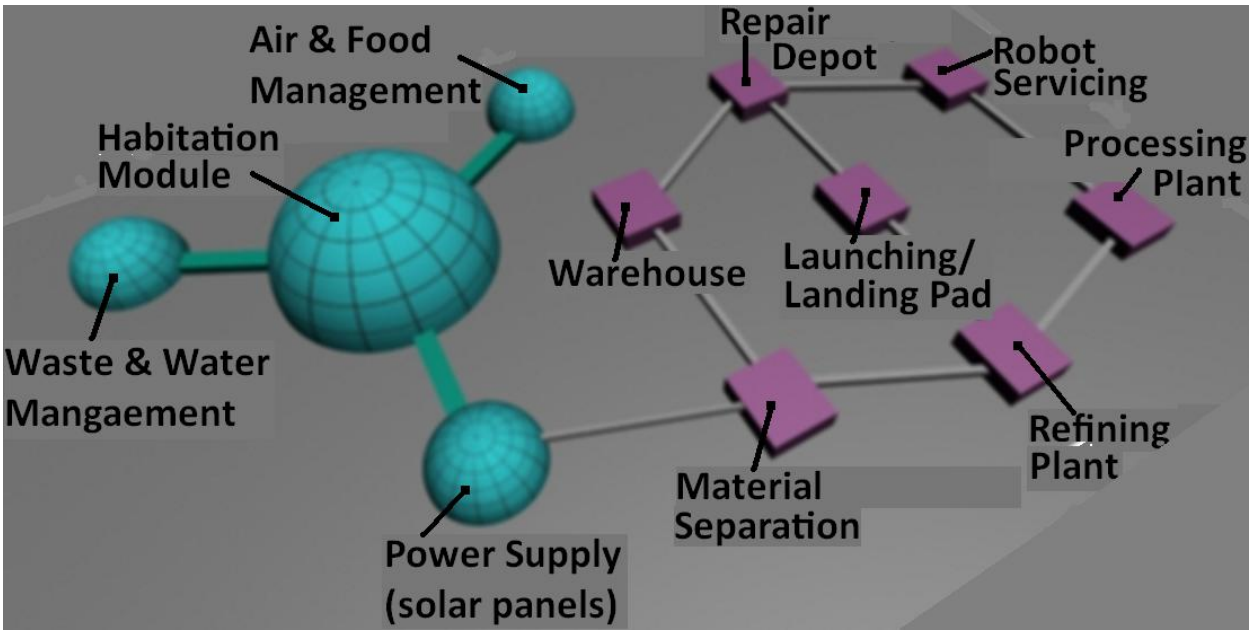


Fig. 2.10

3.0 OPERATIONS AND INFRASTRUCTURE

3.0 OPERATIONS AND INFRASTRUCTURE

3.1 – Location and Materials Sources

951 Gaspra is an S-type asteroid that orbits very close to the inner edge of the main asteroid belt which would allow us to extract a majority of construction materials.

951 GASPRA as a location for the asteroid embedded settlement.

Apart from a multitude of small craters, 951 Gaspra has half a dozen large flat areas and concavities which would facilitate mining.

Mean radius: 6.1 km Mass: 2-3 $\times 10^{16}$ kg
Mean density of ~2.7 g/cm^3 Surface gravity ~0.002 m/s
Orbital period: 1199 days Orbital speed: 19.88 days
Its small mass would enable easy propulsion.

.

Another mining target would be Ceres, which has a radius of 487.3 km, an average orbital speed of 17.88km/s and a period of 1680.5 days. It is a spherical asteroid coated with dark carbon rich compounds and can be useful for providing carbonates apart from water which is our primary requirement for various uses as it contain more than 200 million cubic g of water. The main transport of materials would be done by heavy-lift launch vehicles from Earth, and by mass drivers and ion thrusters from settlements and asteroids.

MATERIALS	USES	SOURCE	Volume /m^3
Aluminium silicate	High thermal shock resistance	951 Gaspra	5.38 x 10^6
Graphite	Forms a tough coating	Obtained from M type asteroids	4.03 x 10^6
Regolith	Radiation protection	951 Gaspra	5.38 x 10^6
Aerogel	Thermal insulation	Bellevistat	4.03 x 10^6
Liquid Hydrogen	Shock absorbers	Asteroids	6.73 x 10^6
Lead glass	Making windows	Asteroids	5.38 x 10^6
Carbon composite	Durable	C type asteroids	8 x 10^6
Water	Domestic, agricultural and industrial uses	Ceres	1560000
Carbon nanotubes	High tensile strength used for construction	Earth	5.08 x 10^7
Super adobe	Radiation Protection	Earth	6.02 x 10^6
Iron and Nickel	Primary Construction Material	Asteroids	3.62 x 10^6
Titanium	Structural support, robots, infrastructure.	Asteroids	4.03 x 10^6

EQUIPMENT	SOURCE	EQUIPMENT	SOURCE
Hall electric propulsion system	Earth	**Mixers**	Bellevistat
Heavy lift launch vehicle	Bellevistat	**Refueling units**	Columbiat
Spacesuits	Bellevistat	**Ion thrusters' rockets**	Bellevistat
Computers	Earth	**Cranes**	Earth
Automated sensors	Earth	**Assembly robots**	Bellevistat
Dozers	Bellevistat	**Harvesting robots**	Bellevistat

3.2 – Community Infrastructure

3.2.1. Air temperature/climate/weather control

Pressure Maintained: 93 kPa		Nitrogen	Oxygen	Carbon dioxide
Percentage By Volume	Agricultural	80 %	15-18%	3%
	Other	78 %	21 %	0.01%
Quantity (m^3) Total: $4.12\times10^8 m^3$	Agricultural	3.3×10^8	6.6×10^7	1.2×10^7
	Other	3.2×10^8	8.7×10^7	4.12×10^4
Partial Pressures	Agricultural	74.4 x 10^3Pa	15.8 x 10^3 Pa	2.79 x 10^3 Pa
	Other	72.5 x 10^3 Pa	19.5 x 10^3 Pa	93Pa
Sources of Production The gases obtained will be used to maintain the Air composition and shall be introduced in the ACTU where sensors monitor the concentration of gases. No atmosphere provided in Industrial Sector.		• Obtained From asteroids. Stored in cylinders connected to ACTU. The %age of nitrogen in the settlement shall overall remain the same.	• Reduction Of oxides in S-Type Asteroids (36% O_2). • Electrolysis of water from asteroids • Photosynthesis	• Extracted from Martian Atmosphere using ZIF crystals (made of Cobalt zinc compounds) • Respiratory CO_2 extracted • Excess CO_2 transferred to Agricultural Sector

MaintainingAir Temperature and Humidity:

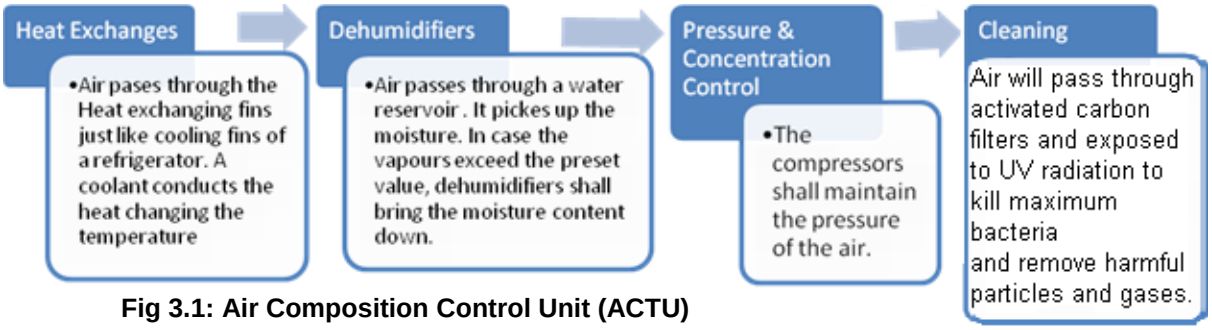


Fig 3.1: Air Composition Control Unit (ACTU)

Weather And Climate Control		
Summer	**Winters**	Weather Parks For residents to enjoy their "first rain of the summer" or the "snowing in Christmas"
Temperature(^{0}C)	Temperature(^{0}C)	Artificial Snow machines installed
<35	<15	Sprinklers with atomizing nozzles to produce light drizzle to heavy showers.
Humidity (%)	Humidity	
60	20	

3.2.2 Food Production

GROWING: Crops are grown using stack farming method using the mud we dig from Ceres or Themis 24 using digging robots. Martian regolith will be mixed with asteroidal mud to make crops grow better and increase chances of a successful harvest.

HARVESTING: A Harvesting robot with multiple hands is to be used whose length increases along each storey. It then stretches its hands to harvest the crops and also has drawers which open at each level to store the food harvested.

PACKAGING: Meat: in plastic film containing nanoparticles of clay which block oxygen, carbon dioxide and moisture from reaching the meat inside keeping it fresh. Biopolymers will be used as bags.

FOOD PRODUCTION

DELIVERING: Food Machines will be installed in houses. The food will just be a button press away. Then the food will be transported through underground channels from warehouses to homes via robots.

SELLING: To prevent boredom, and keeping in view the psychology of shopping, shops will also be present near the residential area, giving an option to people who may choose to buy food from supermarkets rather than using food machines.

STORING: Fruits and vegetables: cold storage, temperature maintained at 5 degrees C. There will be a warehouse next to the growing tower to reduce transport costs. Meat: Frozen at -4 degrees Celsius.

Food requirement of approximately 1250kg of crops every day is fulfilled by the method stated above the surplus is to be stored in warehouses next to the agricultural unit to ensure a continuous supply. Bamboo will also be grown as a source of wood for house construction.

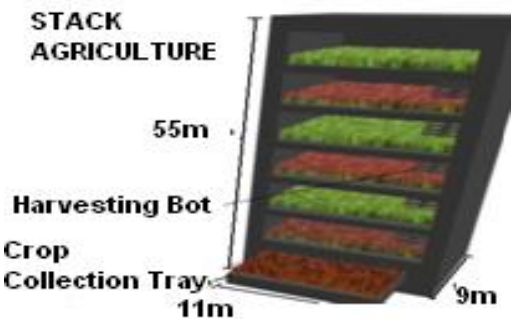


Fig 3.2

3.2.3 Power Generation

Production, Allocation and Distribution

SPS

- Power Production For Astoria Shall be primarily by Solar Power Satellite. Since Astoria shall be in Solar orbit the location of the satellite and its orientation shall have to constantly changed.

Production

- The intensity of Radiant energy in space is 1400W/m^2.
- . Large reflecting mirrors focus light onto the PV panels. Assuming they have an area of $1x10^6$ m^2 and an energy conversion efficency of 45 %, the power produced is close to $6.5x10^5$ KW.

Conversion

- Solar generated DC power would be converted to microwaves and sent via large transmission antennas at a frequency close to 2.5 GHz
- Rectennas convert the microwaves back to electricity and transmit them to Superconducting Magnetic Energy Storage devices for storage.

POWER ALLOCATION power required		
Sector	Power (KWh)	%age Allocation
Industrial	220,000	45
Agricultural	40,000	10
Residential	100,000	25
Commercial	60,000	15
Other	20,000	5
Total required	**440,000**	
Production	**650,000**	

Backup and Additional Sources:
Fuel Cells shall remain as a backup in case of power breakdown or maintenance.
Piezoelectricity will fulfill electricity requirements for street lights.

3.2.4 Water Management

Required Water Quantities and Allocation

Sector	Water usage per day (liters)
Domestic	418 000
Industrial	836 000
Agricultural	250 800
Other	167 200
Total	**1672000**

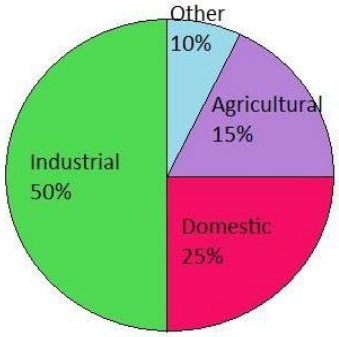
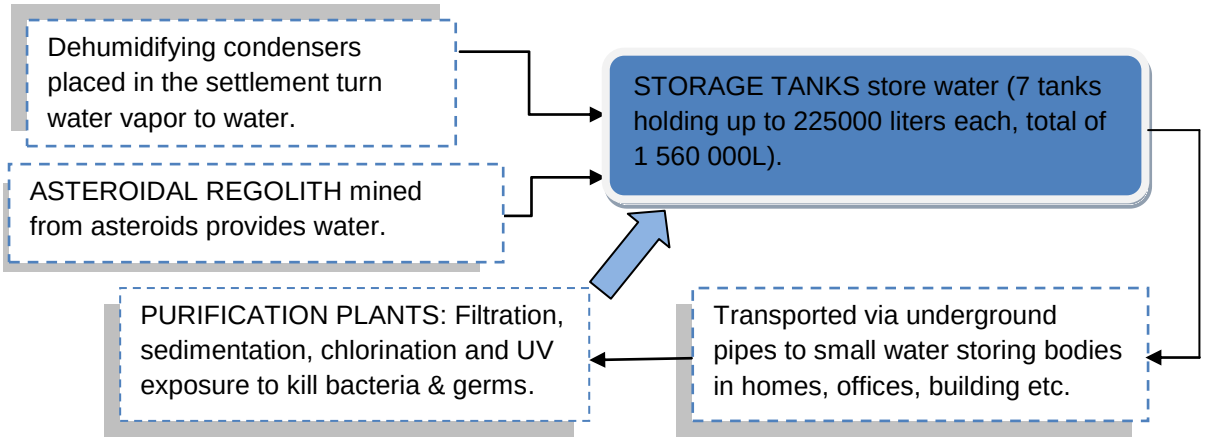


Fig 3.3



3.2.5 Waste Management

Waste	Type	Method for Handling
Domestic (Household)	Organic	Super Critical Water Oxidation is used to remove all solid dissolved effluents in water. This method is 99% efficient.
	Inorganic	It is either incinerated or dumped. That which is re-usable is recycled in plants. Inorganic waste gases, e.g. Carbon dioxide are removed through the Sabatier reaction.
Industrial	Toxic/non-recyclable	It is either dumped in shafts or dumping sites on an asteroid, or it is treated using High Power Ultrasonics method, removing toxic contaminants in water.
	Re-usable waste	Glass, metals and plastics are treated, recycled and re-used on the settlement.

The settlement will have 4 Industrial waste processing units and 2 Domestic waste processing units located at the Operations Core.

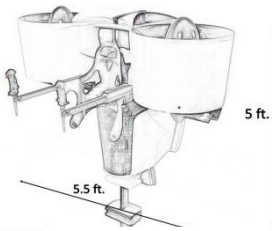
3.2.6 Internal and External Communication

	DEVICE	DETAILS	CENTRAL EQUIPMENT	QUANTITY USED
INTERNAL	FIBER OPTIC NETWORK	Fiber Optic Networks provide high speed transfers and are space efficient. On Astoria, we will use optic amplifiers to increase the speeds up to 14 Tb/sec. Fiber optic networks are also very secure.	Optic fibers	Optical fibers, 2 with l= 4050m and 1 with l=974.9m
	WLAN	Wireless Local area network available to all areas of the settlement. High internet speeds. One Person Computers connect to the LAN and enable personal use for all residents.	Routers	10
	STATION WIDE INTERCOM SYSTEM	The intercom will be used for station wide announcements and can be accessed by residents as well. The intercom can be used to communicate with the entire station or with certain segments. It maybe accessed from another control centre.	Intercom	3
EXT	RADIO WAVES	Radio transmission between earth and Astoria for communication as radio technology is less cost-effective and is easier to intercept.	Satellites	10

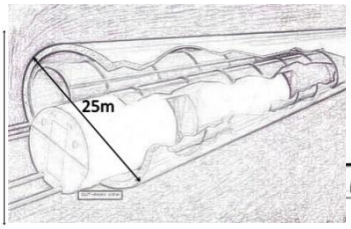
BACKUP: A system of 6 satellites will be used for communication between earth and Astoria. This system consists of two fully functioning satellites which will redirect laser signals from earth to Astoria and another which handles incoming traffic from Astoria and redirects it to Earth. In case of a malfunction in this system, we have two other satellites as well as a back up.

3.2.7 Internal Transport

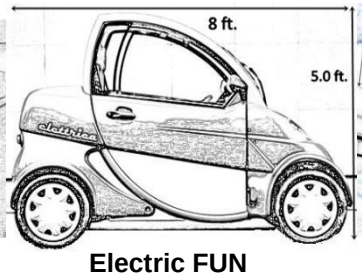
Transport and use	Jet Packs- Transport	Whizz Rails- Public Transport	Electric FUN BUGs- Personal transport	Fast Track Capsules- Transport of goods
Description	Fuel Operated Twin Ducted fans Jet pack that can produce sufficient lift for vertical takeoff, landing and Sustained Flight for up to 30 minutes.	Single Beam Balanced Electrically Driven Rail system that occupies very little down surface area. Important and efficient means of mass transit.	Electrically charged vehicles that can run approximately 200 miles per charge. No emissions Plug it in any power source, charge it and drive it.	Pneumatic Tubes where containers can be loaded inside and compressed air is used to propel the containers via underground tubes.
Quantity	**750**	**200 carriages**	**4000**	



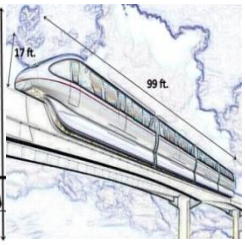
Fuel Operated Jet packs



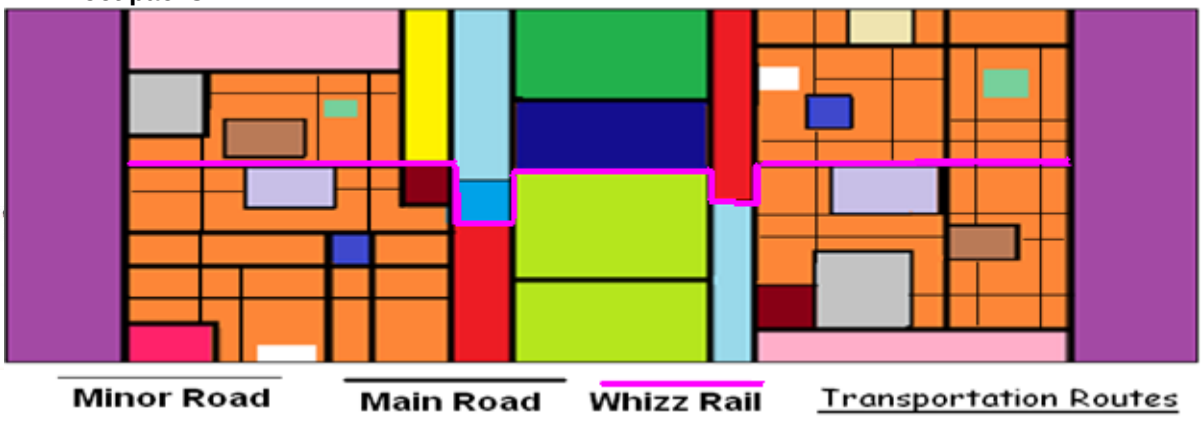
Fast Track Capsules



Electric FUN



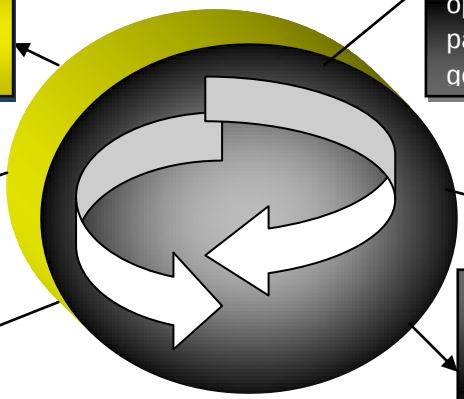
WHIZZ Rail



3.2. DAY AND NIGHT CYCLE PROVISION

Astoria utilizes sunlight abundantly available for creating a day-time effect.

Electro-chromatic glass present in the hull turns opaque when a current is passed through it, generating artificial night.



14 hours of day

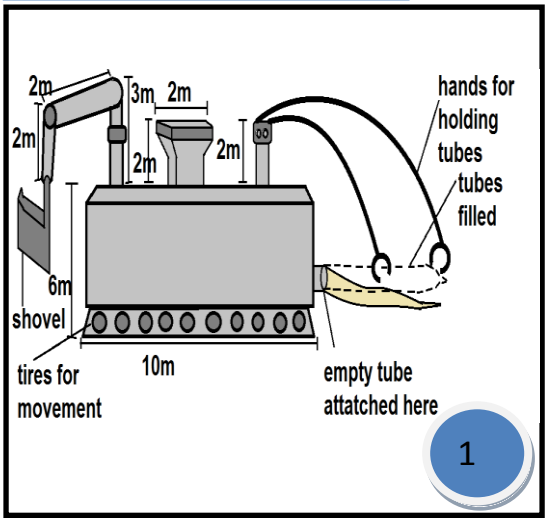
10 hours of night

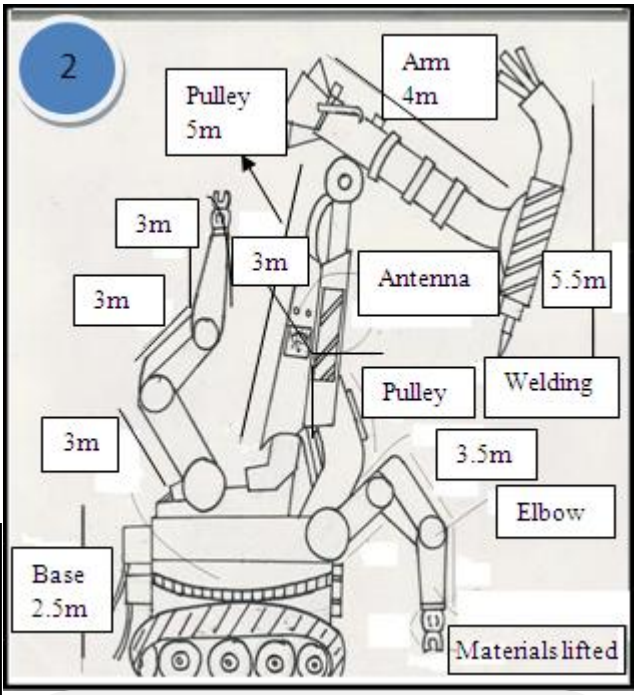
Incase sunlight is not present, depending on the location of the settlement, optical fibers present in the hull of the settlement create artificial light.

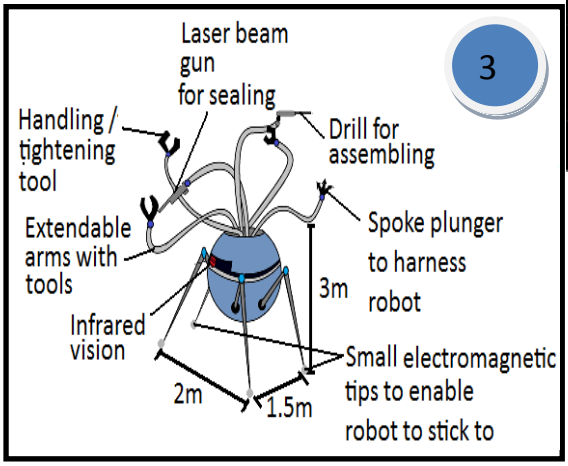
Fiber optic cables and electro chromatic glass combined turned on and off are used to create the illusion of a sunset and sunrise across the hull.

3.3. Construction Machinery and Equipment

Exterior Hull Construction



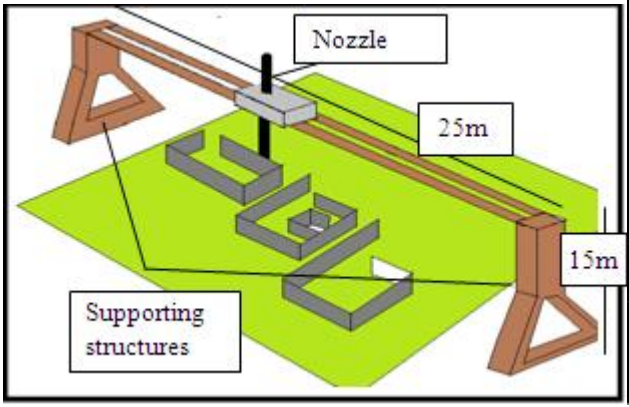


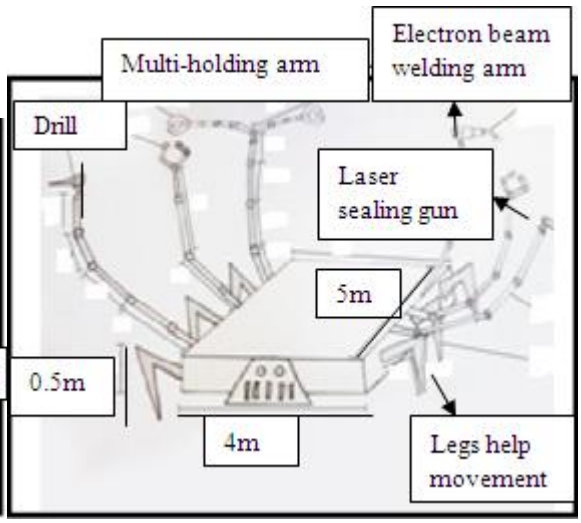


Super adobe technique is used by the first equipment to stack tubes. The second machine welds materials using acetylene flames. The third machine is used for the final stage of exterior hull construction by assembling all parts. All these work in the presence of Assembler Mx 10 (refer to section 5.1).

Construction of Interior Structures

Contour crafting equipment is shown for the construction of houses. For the construction of other interior structures, a machine welds, seals or drills materials according to the requirement. The robot, Astorian constructor will also be used (refer to section 5.1).





3.4 – Collision Evasion

Nuclear pulsed Propulsion

The settlement embedded structure is a massive body with a mass in the order of 10^{16}. Thrust in ten millions is required to move the settlement in the given timeframe of 48 hours. In order to provide such a high thrust for long duration we shall use Nuclear Pulse Propulsion.
Nuclear pulsed Propulsion involves a series of timed nuclear explosions. A propellant magazine ejects small thermonuclear explosives out of the rear of a vehicle covered in a propellant e.g. water or wax. Upon detonation the massive amount of energy released and the high temperature converts the propellant into high energy plasma, which bounces off a pusher plate and produces thrust.
Since the reaction is not confined, larger explosives can be used to produce large amounts of thrust.

Acceleration to be provided: 6.09 x 10^{-8} m/s**Thrust providing Period:**45 hrs.
Total Thrust Required:300 000 000N

Attachment to the asteroid:

Each thruster will be mounted on a rotatable platform and the whole legs of the support shall be embedded into the asteroid. Considering the settlement a complete sphere we shall attach 5 thrusters each at the farthest ends of the asteroid as shown in **Fig.3.4** (the blue spots show the attachment areas).
Each thruster shall provide a thrust of 15 million Newton making up a total of 30 million Newton, making the asteroid cover the 2000 meters in 45 hrs.

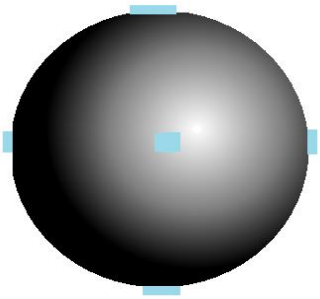


Fig 3.4

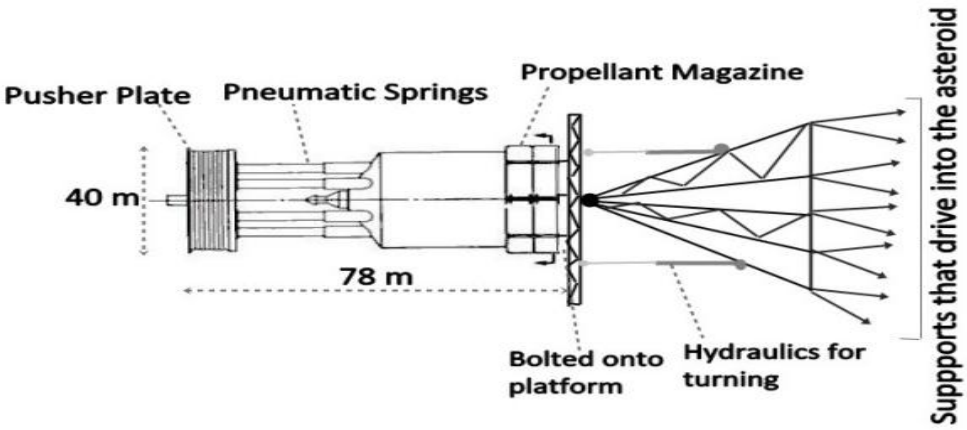


Fig 3.5: Nuclear Pulse Thruster

Total fuel Required	Reaction Mass or Fuel required per Thruster
777514 Kg	38875 Kg

3.5 – Docking Port Facilities and Ore Handling Processes

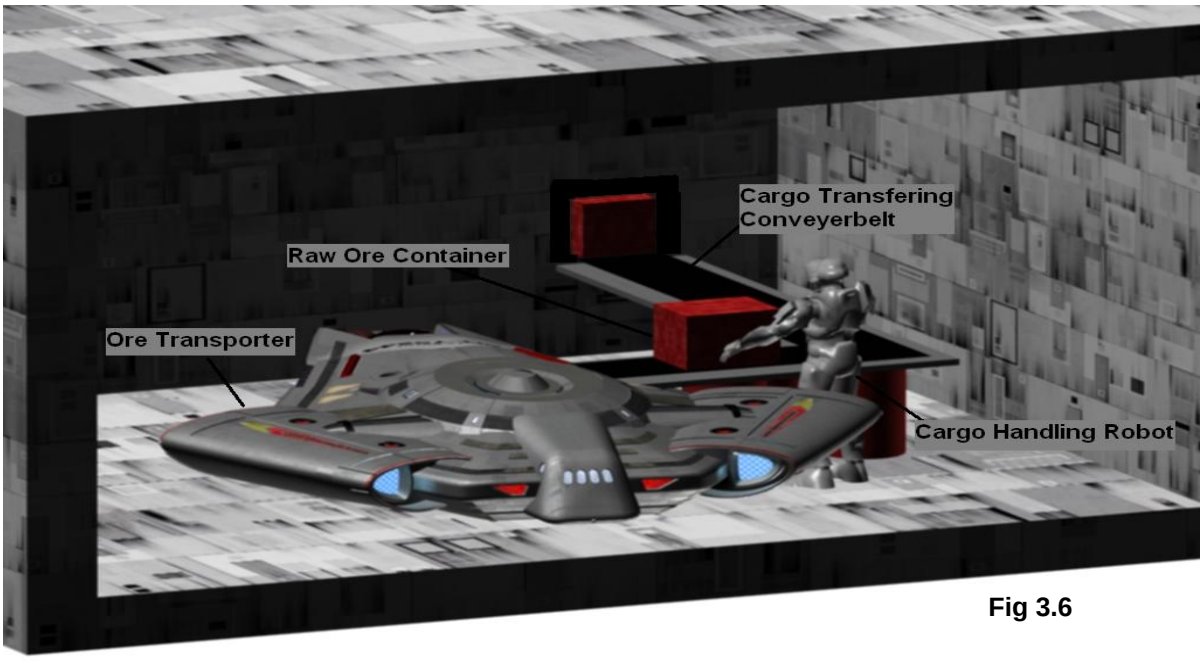
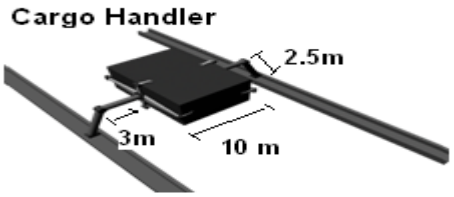


Fig 3.6

These robots are designed like retractable hands whichfacilitate the transportation of cargo in zero-g conditions. They transport the cargo materials from the dock to the storage area , residential torus or kept at the dock to send it to further destinations.



Ore will be collected and transported to the Astoria refinery at Docking Ports 2 and 4. After the ore transporter has docked, the ore handling robot will transfer the cargo containers to a conveyer belt which will take the ore to the elevators which will directly transport it to the refinery. The raw will then undergo various refining processes depending on the type of ore. Blast furnace, reactors and reaction chambers will be used in the processes of heating, cooling and electrolyzing each kind of metal ore to produce metal and waste products such as carbon dioxide, contaminated water, slag and toxic waste chemicals. The metals will be purified and used immediately for purposes such as robot repairing and manufacture of communication devices. All unused metals will be stored as sheets or slabs in the Operations Core storage area.

Ore Handling Processes

Some important features of an ore handling system are:

- Removal of harmful materials
- Refining
- Ore transportation
- Ore storage

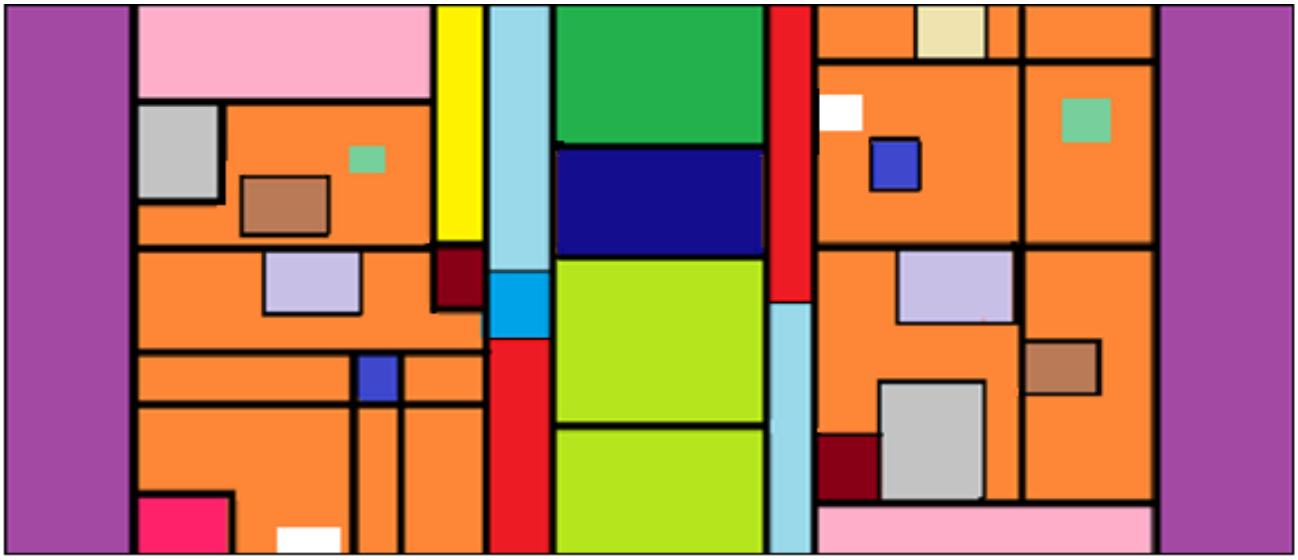

4.0 HUMAN FACTORS

4.0 HUMAN FACTORS

4.1 – Community design:

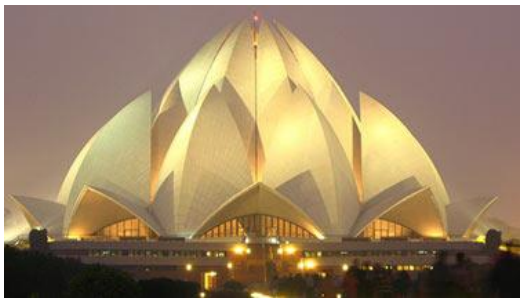
Astoria will offer its residents all the facilities that a small city in a developed country does. It will provide a safe environment and Earth-like attributes to prevent any psychological or physiological and health related problems. The settlement has been planned in such a way to provide long lines of sight, natural sunlight and views of space outside for residents. Atmosphere and climate will also be kept into account. Community will provide a blend of space-related facilities and an atmosphere just like that of Earth.

4.1.1. Layout



Distance scale: 1cm represents 17262m on the x-axis

	Component	Percentage (%)	Area (meters square)
	Houses	35	624750
	Hotels	10	178500
	Flats	13	232050
	Warehouse	3	535500
	Restaurants, discos etc	1	17850
	Parks	2	35700
	Sports stadium and miscellaneous	1	178500
	Hospitals	2.5	44625
	Clinics and other medical facilities	2.5	44625
	Religious places	1	178500
	Offices and banks	3	535500
	Water recycling plant	2	35700
	Water for agriculture	6	107100
	Administration centers	1	17850
	Education	5	89250
	Shopping Areas, convenience stores etc.	2	35700
	Roads and pathways	10	178500
	Space observatory	100	466000
	Plant harvesting area	60	267600
	Animal breeding	20	89200
	Food processing	20	89200



4.1.2. Entertainment: Astoria will provide a variety of quality entertainment for all its residents. There will be grand annual competitions including sports championship, zero-gravity games, spaceship racing and thrilling competitions for children. The community club will be a hub of social activities and will thus bind the community together. Bars, casinos and discos will light up the night life. The 4-D cinemas and restaurants with a variety of cuisine will provide an opportunity for families and friends to spend quality time together. Virtual reality games will be part of every house hold, systems will be centrally linked so that settlers can play amongst themselves without leaving their houses. Using software, residents will be able to make a personalized homographic friend that will entertain them in their houses whenever they want.

A major attraction will be the theme park called **Earth.** In it earth's alluring natural beauty will be recreated. Waterfalls, lakes, lush green gardens, artificial rain, holographic animals all will make people feel at earth. A museum will give illustrations of a brief history of mankind. Also a special star gazing center will allow people a peek into the mysterious universe.

4.1.3. Medical: Health care of every resident is of primary importance. To incorporate a healthy lifestyle in the community there will be various health care centers around the settlement. Residents will go there for monthly checkups. They will also have gyms, spas, and therapy centers offering color and aroma therapy. They will also include a rehabilitation center to cater to the needs of those who have certain psychological problems or who underwent any kind of trauma.

Every resident will have the Smart Shirts that will record heart and respiration rates, body temperature and calories burned. All this Information will be relayed wirelessly to the healthcare center and will be stored there as the person's history along with all other information of the person's health.

There will be ambulances with mini operation theatres and robotic medical staff that will be patrolling the settlement. The house robot will send signals to these ambulances in case of any medical emergency.

A main hospital will be present at the center of the community. It will be equipped will all modern technology and highly sophisticated medical facilities. All the staff will be robotic including nurses and assistant doctors; however the major operations will be done by the professional human doctors.

There will a proper medical scanning and vaccination of anyone entering the settlement.

4.1.4. Housing: There will be 3 categories of residential designs which include houses, flats and hotels. Proper utilization of space and comfort of residents will be achieved through the state-of-art architecture of the houses.

4.1.5. Industry: Industries are located in the inner sphere. The Flask structure contains not only industries but also a refining area, the communication hub, waste management plant, power generation plant etc. For more details, refer to **section 2.2.3**.

4.1.6. Consumables and consumer goods

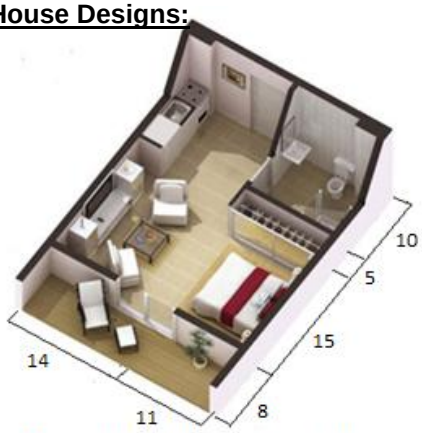
Major Consumer products			
Category	**Goods**	**Sources**	**Quantity /year/person**
Clothing and shoes	Clothes, shoes, accessories	Textile industry	20-30 pieces
Consumer Care/Everyday essentials	Toilet paper, Toothpaste, Shampoo, Soap etc	Chemical industry	60-80 pieces
	Perfumes, Cosmetics etc		30 pieces
Health and Fitness	Pharmaceuticals, first aid kits etc	Chemical industry	100 items
Home ware	Furniture, house accessories	Refer to Section 4.2.2	15-30 items/house
	Kitchen utensils, crockery	Manufacturing unit	35 pieces
Electronics and technology	Electrical appliances	Automation unit	10-15 pieces
	Personal gadgets, computers	Automations unit	5 pieces
Distribution: Special robots will provide residents with all consumer goods and consumables at their door step. Whenever anything will be short the house robot will send signals to the commercial area and robots from there will deliver that item. Financial transactions will be made between the robots. However some items will be bought from the shopping centers.			

Daily Dietary requirements			
	Adults	Children	Sources
Water	2.8 liters	2.8 liters	-
Carbohydrates	130g	130g	Fruits, dairy products, honey, sugar, bread, beans
Proteins	24g	28g	Meat, eggs, milk
Fats	48g	54g	Dairy products, Green leafy vegetables, fish oils
Fiber	25g	25g	Fruit, vegetables, nuts, seeds, pulses
Calcium	1000mg	1200mg	Milk, cheese, yogurt
Iron	15mg	18mg	meats, chicken,
Iodine	125 µg	125 µg	milk, iodized salt, sea food
Sodium	1000mg	1000mg	salt
Vitamin C	3g	3g	Citrus fruit
Vitamin D	400 µg	600 µg	Butter, eggs, milk
Vitamin A	9000IU	9000IU	Carrots, spinach, tomatoes, peaches, eggs, milk
Vitamin E	15mg	11mg	Walnuts, peanut, whole grain, beans
Daily diet will include meat, cereals vegetables, vitamins, minerals, fruits, dairy products			

4.2 – Residential Design:

All the residents will be provided with comfortable living environment with special emphasis on their security and privacy. The houses will have large self-cleaning windows with automatic adjustability to light, centrally controlled temperature, and proper sewage systems. A house robot will be responsible for all house hold chores from cleaning to cooking; also it will be programmed to handle emergency situations like a medical emergency or any security threat. There will be some sliding inner walls in the houses which can be operated through computers. The residents can modify the inner house designs according to their own desire.

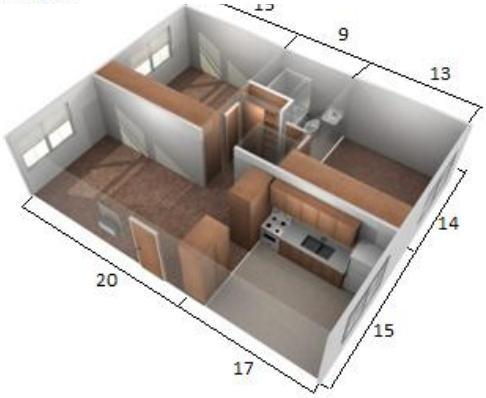
4.2.1. House Designs:



1- 2000 comfortable houses for singles
Total area 950 sq. ft.

2. 1000 luxurious houses for singles/couples
Total area 1008 sq. ft.

3. 1000 modern houses for families
Total area 1184 sq. ft.



4. 1000 comtemporary houses for families
Total area 1073 sq. ft.

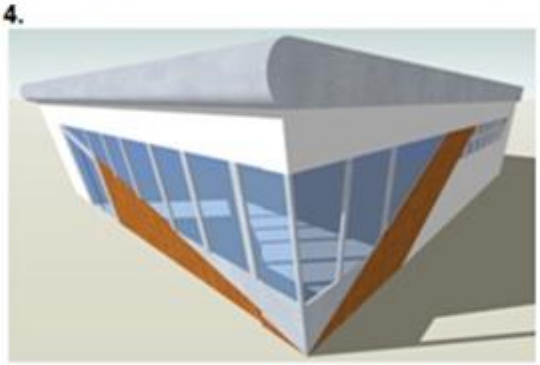
4.2.2. Exteriors

1.

2.

3.

4.



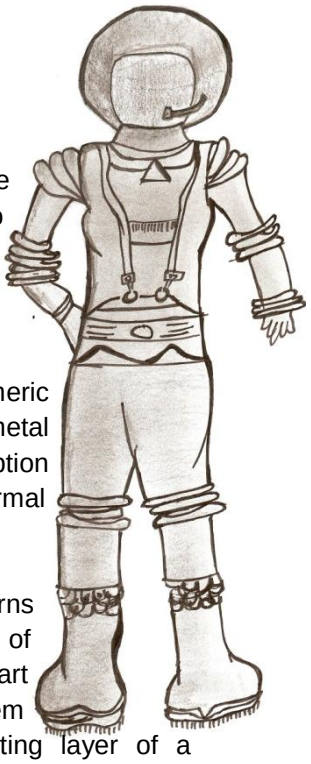
4.2.3. Furniture items and their sources:

Materials	Qualities	Sources
Carbon fiber	Strong, versatile, lightweight	Industrial unit
Aluminum Stainless steel	Strong and durable	Industrial unit
Wood	Strong, traditional	Agriculture land

Furniture item	House design	Minimum Quantity
Bed	For singles For families	1 1-4
Sofas/chairs	For singles For Families	4 6-10
Tables	For singles For Families	2 2-4

4.3 – Safe Access:

4.3.1. Space suit design



The first layer will be of bio suit. The Bio-Suit System would provide life support through mechanical counter-pressure where pressure is applied to the entire body through a tight-fitting suit with a helmet for the head. Wearable technologies will be embedded in the Bio-Suit layers and the outer layer will be recyclable.

A middle section includes a succession of thermal insulating layers of polymeric thermoplastic or thermoforming material, each of which is coated with a metal deposit of high infra-red emissivity and low solar radiation absorption characteristics and separated from adjacent insulating layers by a low thermal conductance material.

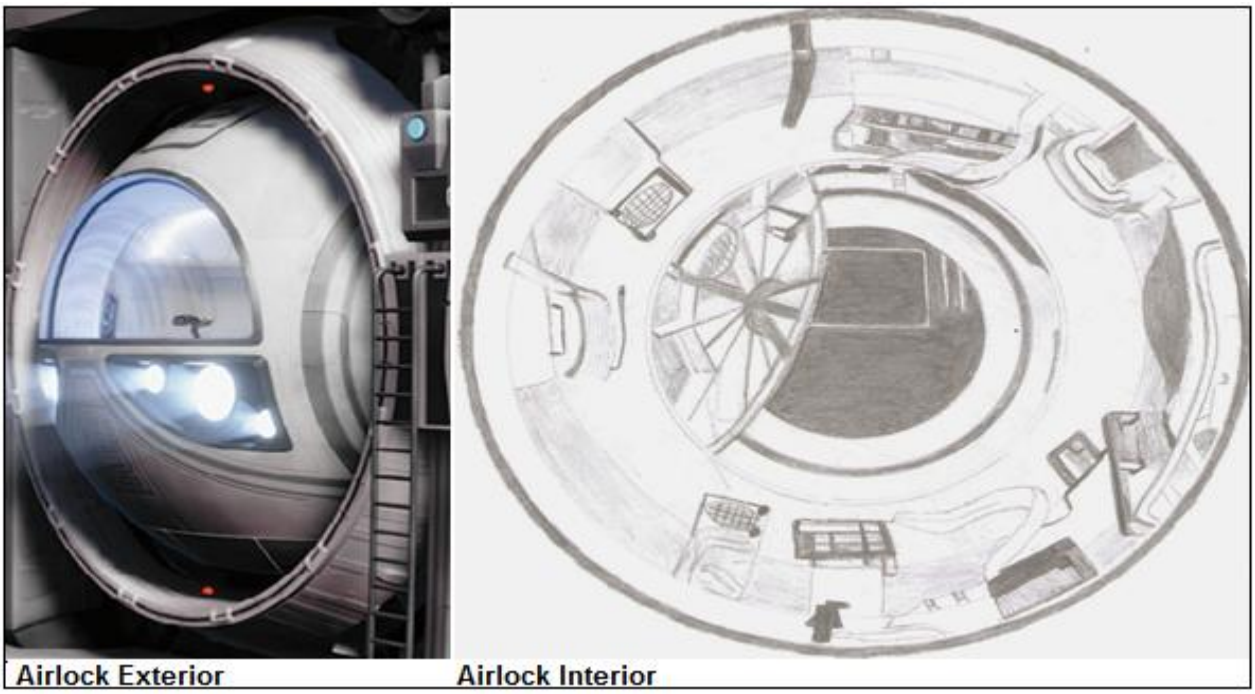
It will have an outermost lamina of woven expanded tetrafluoroethylene yarns (Gore-Tex) for protecting against abrasion and tearing, an underlying weave of meta-aramid yarns (Nomex) and para-aramid yarns (Kevlar) for particle impart protection, an electrostatic charge dissipation and control system incorporated therein. The covering further includes a radiation attenuating layer of a tungsten-loaded polymeric elastomer binder for protecting against "bremsstrahlung" radiation and an inner layer of "rip-stop" polyester material for abrasion protection. A chloroprene coating may be supplied to the polyester-material for added micrometeroid protection. Another material used is d3o which responds to a sudden impact by locking instantly into a solid form - absorbing huge amounts of energyharmlessly.The space suit will be able to function for a total of 8 hours. Its pressure at all times would be 32.4 KPa. The cooling center has 4 kg of water and the temperature inside the spacesuit is 25 degrees at all times. The space suit has a variety of valves to get rid of the built up pressure or heat that would raise the internal temperature

Parts	Features
Helmet	double walled with anti-shattering material
Gloves	Equipped with muscle wires and have rubber grips at the tips
Boots	Have nylon socks with in-built soft cushioning and arch support.
Primary Support System	contains oxygen tanks, carbon dioxide scrubbers/filters, cooling water, radio, electrical power, ventilating fans and warning systems
Communication carrier assembly	Contains earphones and microphone
Maximum absorption garment	Large diaper that absorbs urine and feces
Secondary support system	Provides emergency oxygen supply

4.3.2. Donning/doffing and stowage

Before donning, the clothing and respiratory equipment must be examined. The legs are to be placed in the inner garments. Then the sleeves of the garment are put over the arms and shoulders.
Then the hard torso, respirator and face piece are worn and adjusted to be secure. The person's breathing is checked. Lastly the boots and gloves are put on. The inner garment of the space suit is custom fitted to each person using laser scanning. For doffing, the person is disengaged from the extravehicular mobility units. Then all the above steps are repeated in the opposite way. Donning and doffing will take place in stowage area where all the space suits will be stored.

4.3.3. Airlock designs and stowage area



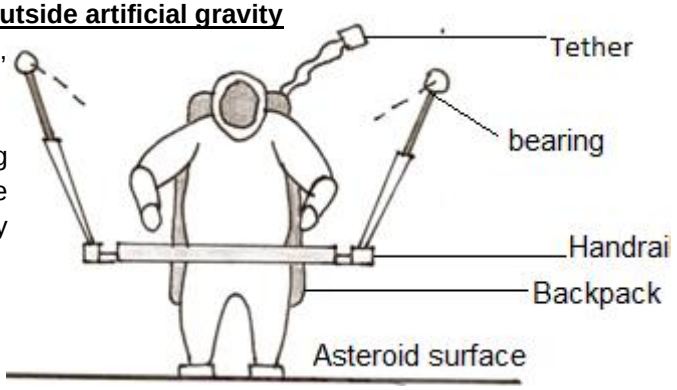
Airlock Exterior Airlock Interior

In an airlock, before opening either door, the air pressure between the two doors is gradually equalized with that of the environment beyond the door that is to open. The airlock will also serve as a place for cleaning the space suit when the astronaut comes. The cleaning of the space suit before the wearer enters the settlement will happen in three stages. The airlock contains a vaccuming system that removes all the dust from the space suit as it enters. Then all the minute particles left on the space suit are charged negatively with the use of plates. Once charged, positively charged plates attract all the minute particles and the space suit is cleaned. Also there are waste receptacles that carry out a detailed examination of the space suit testing it for the presence of any kind of different waste materials.

4.3.4. Systems, Devices, Vehicles used outside artificial gravity

1. Head Restraints, seat belts, air bags, autonomous cruise control in vehicles.

2. Elastic bands worn to compress leg bones and reduce osteopenia, muscle stimulatordevice to prevent muscle atrophy to prevent physiological problems.



3. In areas outside artificial gravity or in manufacturing area, a backpack will be provided with primary and secondary life support system and a containment control center.

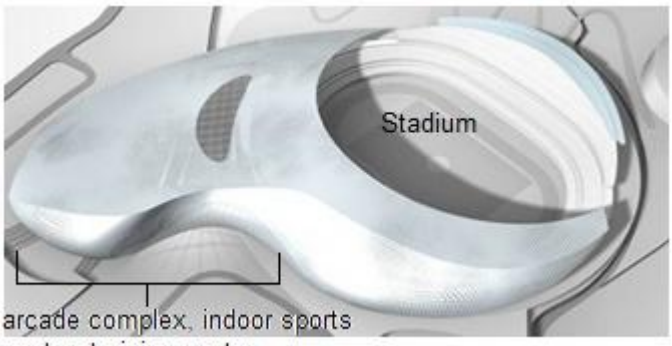
4. To aid safe movement outside the artificial gravity, there will be usage of handrails and tethers. The tether can be attached to the space suit and the hook can be placed on the handrail.

4.4 – 1g Area:

The adults of Astoria prefer living in an environment with less than 1g. Such is not the case for children. An area of 1g is allocated for children to ensure their stable and natural growth. Such infrastructure – where children must spend 3 hours or more – requires it be both entertaining and yield productivity in the youth of Astoria. The 1-g area will lie along the equator, and will include:

Education

- **Schools**,which will provide quality education to the residents. Experienced and qualified teachers will be teaching till the primary level so that children can be groomed and educated at the same time. For secondary level there will be interactive video conferences with earth and other settlements so that students remain updated, and can develop better thinking and reasoning skills.
- **Day care centers** for toddlers.
- **A library** will be set up with storytelling facilities where children can spend an hour daily or on alternate days. Also it will stock books on diverse subjects.
- **After-school clubs** will be arranged for music, dance, art, taekwondo classes etc.
- **A sports complex**with multiple zones including:
- An arcade complex which is guaranteed to hold the attention span for more than three hours.
- A training centre with an exciting schedule of energetic, creative and highly satisfying activities for children aged 5-15 years. All the games and excitement will be planned to provide optimum levels of entertainment and fun while nurturing each child's inquisitive and creative mind.



- An indoor games club providing all board games with monthly competitions
- **Parks** will be designed in such a way so as to provide aesthetic beauty along with peace and relaxation to adults, along with entertainment to the children. It will have a hilly landscape with streams of water running all over its length, the walking paths and swings for kids. The children can go hiking and enjoy the beauty around them. It will also have kid-friendly art areas which will include a variety of activities for them related to nature.

4.5 – Instant move-in designs:

Astoria will provide the semi-term occupants with a perfect living environment in which they will get a chance to interact with the permanent residents and will get all types of facilities for maintaining high quality lifestyle. There will be 3 types of residential divisions which depend upon the period of stay of the semi term occupants.

- **Hotel:**

The people visiting Astoria for up to six months of time will be accommodated in the Hotel. It will offer a variety of room designs ranging from personalized suites to comfortable 1 bed rooms. The hotel will offer extensive facilities and unparalleled service to all its guests. There will be a grand lobby on the ground floor. Shopping malls, food court, bar and a fitness zone including gyms, swimming pool, saloon and spas will be on the second floor.

The facilities and services provided will include efficient room service, WLAN, and transportation. The guests can also rent the House bots for doing their personal chores.

- **Flats:**

The flats will have furnished studio apartments and a few apartments for families which will include two bedrooms with attached bath, kitchen, and living room. Transportation facilities will also be provided.

- **Houses:**

Some people who have a long stay can also rent houses that are present in the residential area (refer to section 4.2). They can become paying guests or two three people can live in a house and share expenditure. This will help the people to integrate into the community and live a healthy social life.


5.0 AUTOMATION DESIGN AND SERVICES
graphic by stephen turner

5.0 AUTOMATION DESIGN AND SERVICES

Servers and Sub servers

The main server is a very fast computer, with the following specifications:

Numbers	Description	Configuration
2 (one is working and the other as a backup)	Located in the control centre in the Flask structure The backup is in the industrial sector	100 Core Processor, 42PFLOPS processing speed, 659Tb Ram, 1.2ExaByte Storage

Sub Servers		
No.	**Purpose**	**Configuration**
12	Residential Connectivity	32PFLOPS,550Pb,250Tb Ram
10	Industrial Connectivity	29PFLOPS,510Pb,280Tb Ram
8	Commercial	22PFLOPS,450Pb,250Tb Ram
8	Communication	22PFLOPS,430Pb,170Tb Ram
7	Transport	25PFLOPS,300Pb,200Tb Ram
5	Agricultural	21PFLOPS,250Pb,160Tb Ram
14	Robots	28PFLOPS,420Pb,300Tb Ram
8	Maintenance and Security	24PFLOPS,350Pb,250Tb Ram

5.0.1 COMMUNITY COMPUTERS

No.	Place	Description	Configuration
12000	Homes	Every resident above 10 will have his or her own computer	45 core processor, 4.8 GHz speed, 12Tb Ram, 400Tb
4400	Settlement Terminals	Computers with basic user functions will be placed in Internet Cafes at every 150 square meters, providing high speed internet facilities	35 Core Processor, 3.8 GHz speed,8Tb Ram, 280Tb

5.0.2 NETWORKING DEVICES

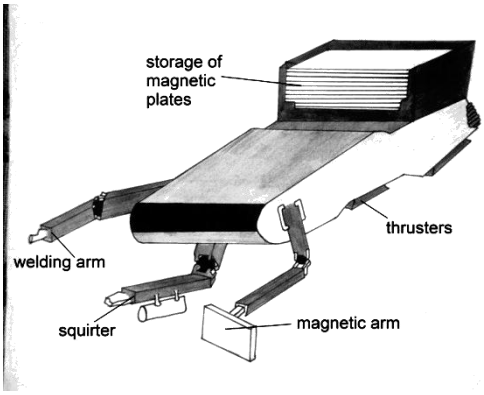
Xperto SV-8	A wireless transmitter device which not only provides High-bandwidth Digital Content Protection but allows multi-gigabit wireless connectivity between the computers.
Router	Routers link two or more networks together: they receive packets and select the optimum path to forward the packets across the network
Network interface cards	They provide the physical connection between network cable and the workstation.

For data storage, USB flash drives equipped with powerful firewalls and holographic hard disks will be used.

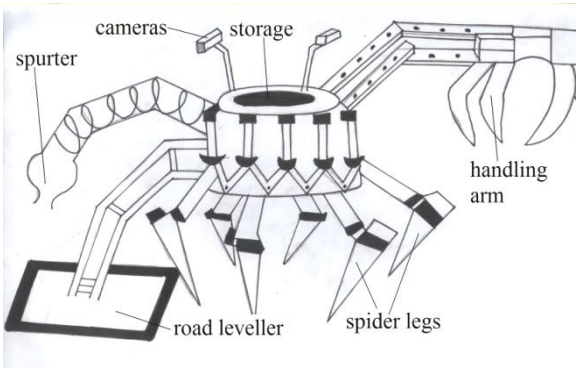
5.1 Automation For Construction:

Robots and their Features			
Name	**Purpose/Function**	**Features**	**Dimensions(m)**
Assembler Mx 10	Assembly of the settlement	Magnetic arm and gripping claw, Rotating thrusters Inbuilt motion sensors and thermal sensors, coated with a layer of Kevlar	20x10x15
Astorian constructor	Construction of buildings	Brick and cement container with a movable arm and a nozzle for ejection of cement	8x6x5
Tyrobot	Efficient and quick construction of roads within Astoria	Six legged robot, Asphalt pump and store, handling arm, smoothening arm, dimension and thickness control system	5x6x4

Assembler Mx 10: The spacecraft can hover, as well as fly at high speeds in different directions due to its rotatable thrusters. It can grip the metallic sheets tightly due to its magnetic arm, and then weld them in place. Also, it can hold on to multiple metallic plates by its magnetic arm and it can be used to position different sheets correctly at different places. Its motion and heat sensing capabilities are vital for an efficient assembly procedure. Once the construction is complete, Assembler MX-10 can be modified to Robot Cam 32 (see section 5.2).



Astorian constructor: Its mechanical arm can collect bricks and place them in a line, by the movement of the wire as well as the arm. The wire can move sideways so that the arm can place the bricks outside of the robot, onto the ground. After they are placed, cement is placed on top of them, and then a new layer of bricks is added. This way, walls and layers of different materials can be laid. Also the control box and engine can allow modification of the robot if a building of a new type is to be constructed.



Tyrobot: TYROBOT is designed for the time-effective construction of roads for the settlement. It has spider legs which allow it to move quickly and also has a handling arm which allows the robot to carry construction loads. The arm used to smooth the road surface has sensors placed at the bottom which help to determine the thickness of the material used to construct the road. The body of the robot is used as a store for the construction material (asphalt) and is connected to a pump. Pre installed cameras are used for motion and image sensing.

5.2 – Facility of the Settlement

5.2.1 MAINTENANCE AND REPAIR OF THE SETTLEMENT		
Name	**Features**	**Dimensions (m)**
Robot CAM 32	Magnetic plate to hold the metal plates, which are welded by the welding arm Crack filling material is used for small cracks Rotating brush and sprinkler	6x5x3

This robot is a hybrid, used for both maintenance and damage repair. For minor repairs, it can fill in cracks by the crack filling arm. For major damage, it can seal off the cracks by first applying heat to the area by the welding arm, then applying heat to one of the metal plates it has by

holding it with the magnetic arm. When both the surfaces are heated, they are melded together to clear the crack. Also, the rotating brush and sprinkler is used for cleaning up the roads and arena while this robot patrols the area.

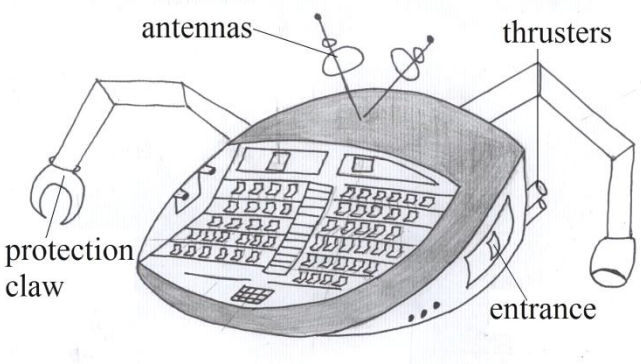
5.2.2 SAFETY OF THE SETTLEMENT		
Name	**Features**	**Dimensions (m)**
Spylert 2.0	Six rotors, GPS facility, Handheld flight controller, High damage tolerance, Electronic Flight Stability, Thermal Infrared and HD digital video Camera	2x1.5x1.5

Continuously on the petrol around the whole settlement, Spylert 2.0 combines intelligent cameras with advanced database analysis software. These intelligent surveillance cameras automate and streamline security tasks. Smart cameras track targets and also make decisions on which targets to watch. These security cameras can focus on individuals and recognize faces; and objects the person is carrying. Data is stored and cross referenced with police databases, hotel registrations, or any other data to determine the threat level of any given person. Using behavioral analysis algorithms(patterns), the system can notify security monitoring personnel of any suspicious activity. These robots are small in size and hence extremely difficult to detect. Also they have an ability to change the color of their body according to their background, giving themeven greater stealth ability.

5.2.3 BACKUP SYSTEMS AND CONTINGENCY PLANS			
Risk to the Settlement	**Pre installed safety measures**	**Back up plans**	**Time of action**
Fire	**Active fire protection**: includes automatic fire detection and fire suppression. In case of a fire, the thermal sensor sends signals to the container installed in the ceiling of the houses, which automatically releases nitrogen gas to suppress the fire	**Passive fire protection**: the overall buildings are compartmentalized through the use of fire-resistance rated walls and floors. Organization into smaller sections, consisting of one or more rooms or floors, prevents or slows the spread of fire from the room of fire origin to other building spaces, limiting building damage and providing more time to the building occupants for emergency evacuation.	Within 1 minute
Atmospheric imbalance	Computer systems analyze and manage the supply and demand of air composition in each section of Astoria, preventing it from misbalancing.	In case of extreme imbalance, the residents of the area are evacuated via escape pods, and the area is then temporarily isolated till the atmospheric conditions are brought back to normal.	Immediately
Solar Flares	Layers of Kevlar, Graphite-epoxy, aerogel, carbon composite and regolith in the outer walls protect the settlement from solar flares.	External Repair robot will go to the site where the flare hit the settlement, and repair the damage done	As soon as flair occurs
Asteroid and Meteorite Collisions	The settlement will be propelled using thrusters.	Robot Cam 32 will repair the damage caused in case of collision.	Within 2 minutes
Human violence	The administration ensures that no residents of Astoria have weapons without license. In case of violation, the security bot of the sector immediately responds.	In case of extreme violation, a team of robots, comprising both fighting bots and security bots, will reach the site of violence to bring matters under control. Violators will be punished by law.	As soon as the cameras alert the security stations

5.2.4 Escape Pod:

The escape pod is designed to accommodate more than 70 people in case of emergency. The entrance is located at the side of the escape pod and leads directly to the seating area. At the base of the escape pod there is a medical facility, sanitation

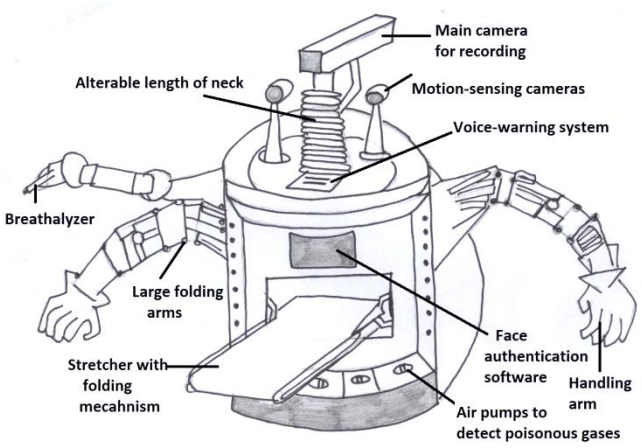


facility as well as a food store. The windows are made up of strong, thermal resistant material for protection from fire and explosions. The body of the escape pod is made up of a Ti/Al alloy and thrusters are placed at opposite ends in order to make the escape pod move. Antennas are used for communication with the main server which sends control signals to the autopilot and directs the escape pod to its destination.

5.2.5 ROBOTS FOR WORKING IN COMBUSTIBLE ATMOSPHERE		
Name	**Features**	**Dimensions (m)**
Orbitron	Colored CCD cameras, Brushless DC motors, Onboard tank of compressed air,Electro mechanical and electronic components, Pressure transducers and Sensors	1.5x2x3
Robocop	Motion sensing cameras, mobile robot, atmospheric control, stretcher, alterable length of neck, first aid facility	2x1.5x2

Orbitron: The robot includes non-sparking and non-arcing electro-mechanical and electronic components designed to preclude igniting the combustible atmosphereand positively pressurized enclosures that house the electro-mechanical and electronic components of the robot and prevent intrusion of the combustible atmosphere into the enclosures. The enclosures are interconnected such that a pressurized gas injected into any one of the enclosures is routed to all the other enclosures through the interconnections. Pressure transducers for detecting if the pressure within the enclosures falls below a pre-determined level are included. The robot also has a sensing device for determining the types of combustible substances in the surrounding atmosphere, as well as the concentrations of each type of substance relative to a pre-determined lower explosive limit (LEL). In addition, the sensing device can determine the percentage level of oxygen present in the surrounding atmosphere.

Robocop:A patrolling robot with dual functions i.e. measuring atmospheric levels and carrying the injured ones to the hospitals in minimum time. Robocop inhales a sample of air after every 10 minutes and measures the concentration of all the gases and then compares with the pre set values. In case there is a serious variation in concentration of any gas, it alerts the emergency computers which then take the prescribed action.



Robocop can also take the injured ones to the hospitals. It has a built in road map of the settlement, due to which it can automatically decide which hospital is closest and which route has least traffic flow. On its way, it can provide first aid services to the injured ones as well, as it has a complete stock of important medicines, drips, bandages and other medical equipments.

5.2.6 SECURITY OF BUILDINGS AND OFFICES	
Biometric technique	**Description**
Skin Texture Analysis	This technique turns the unique lines, patterns, and spots apparent in a person's skin into a mathematical space.
Infrared Face Thermography	The scanners clearly see the deep ear temperature (timpanic), the carotid artery, the face thermal distribution and even see hair texture. Each of these features is different for every human being. It is a non-destructive test method as hackers won't be able to obtain the face of the personnel to enter as temperature readings are taken in. Lower temperature readings will be seen if the hacker tries to use an axed head to get inside.

5.3 – Habitability and Community Automation

5.3.1 CONVENIENCE IN LIVABILITY			
Name	**Purpose**	**Feature**	**Dimensions (m)**
Robo-cleaner	Cleaning the house	Cameras, Pressure sensors,Room positioning system, Laser range finder, Sonar or ultrasonic sensors	1.5x2x1.
SMART robot	For convenience in households	Smart thermostat,Wireless signal generator, Camera, Bluetooth technology, Lidar or infrared light sensors	Not required
Assisto	Performs kitchen tasks	Speech recognition system, Image sensing cameras, Flexible upper body, Storage area, Ion craft propulsion system underneath the robot, Touch screen, Thumb attachments	1.25x2x2

Robo-cleaner: Cameras inside the robot's eyes enable it to see and adapt to its surroundings.The robot has sensors all over its body. These sensors help it to respond if too much force is being applied to its body.The robot preps the floor by vacuuming loose debris from hardwood floors as well as carpets; it squirts clean solution, scrubs the floor, and then sucks up the dirty solution leaving a nearly dry floor behind. The robot uses a Room Positioning System. It will travel in straight paths with minimum of overlap, with the help of a laser range finder and an algorithm which allows it to map the room being vacuumed while it is completing its task. The robot is able to locate its charger and charge itself when running out of energy, and has sensors which prevent it from falling off stairs.

Robo-cleaner can also steam press clothes. It consists of an expandable metal plate on top which heats up when a temperature is set. There are a few holes in this plate which release steam. The robot also has an arm whose length varies as it is expandable. This arm has a suction pump at the end which helps to clean curtains.

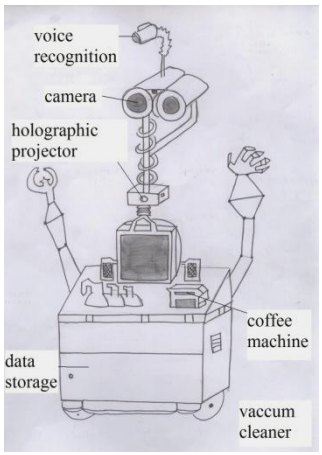
SMART robot: This robot is linked into the home's own technology and wireless internet service. Voice commands to the robot are translated into wireless signals to turn on the washing machine, change the TV channel, dim the lights or change the music. The robot can also be programmed to wake you up in the morning with a song or tour the house during the night to provide security. It is a great surveillance tool for the home.

This robot features Bluetooth technology which means it can be controlled by a mobile phone, and voice activation technology. The lidar or infrared light sensors prevent it from bumping into objects or people.

Assisto: The antennas are used to receive signals which can help to activate the robot while the cameras on its face ensure the double recognition of the real owner of the kitchenbot as it has already stored the image of the person in its data. The cameras also allow it to see where it is going and avoid obstacles.

The flexible upper body of the kitchen bot allows the body to flex upward and downward so that it can look for the things in the storage area. Also the ion propulsion system helps the robot to hover so that it can be placed anywhere without difficulty of lifting it. The thumb attachments can be used as a clamp to grab things.

5.3.2. PRODUCTIVITY AT THE WORKPLACE		
Name	**Features**	**Dimensions (m)**
ZT- OFF- 23	Camera to navigate its way around Voice recognition Scanner, printer and fax Storage and transfer of data Holographic projector Coffee and tea machine Vacuum cleaner and garbage disposal	1x1x1.25
SIXTH SENSE 	'SixthSense' is a wearable gestural interface that augments the physical world around us with digital information and lets us use natural hand gestures to interact with that information. It visually augments the officebot or any other robot we are interacting with. It projects information onto surfaces, walls, and physical objects around the person, and lets him or her interact with the projected information through natural hand gestures, arm movements, or our interaction with the object itself.	Not required



For maintenance and repair of the settlement refer to section 5.2.1

5.3.3 ENTERTAINMENT		
Name	**Features**	**Dimensions (m)**
Frogtile	4-legged robot, Five Scanning Sequences, Edge Detection, 72 Preprogrammed functions, 40 programmable moves, demo feature.	2x0.75x1.5

Frogtile: With its light, sound and IR sensors, Frogtile is pre-programmed to simulate reactions to external stimuli and acts accordingly. Its demo features a dance routine. Frogtile can send and receive MP3s and messages that are read out loud as well as perform the following services (by either speaking the information out loud or using indicative lights): weather forecast, stock market report, news headlines, alarm clock, e-mail alerts, RSS-Feeds, MP3-Streams and others. Not only this but on the command of the user it can also sing and dance.

5.3.4. Security of Personal Data:

Techno-fundamental Security is a composite tool which will be used for providing security to personal data of the residents. The system will have to be installed in the computers and laptops. It will safeguard the personal data of the residents against any sort of interference and fraud, providing protection to files, folders, communication, messages, faxes, and all types of stored or online data.

The following programs in the system will ensure safety of all personal applications:

PSD(Personal Secure Drive)	A personal electric safe providing protection to digital files and folders
CS Security	Will provide protection by encrypting conversations and files transferred through instant messenger
Web mail Security	Provides on- the- fly text and attachment encryption of web mail messages
Desktop Search Tool	Will prevent encrypted file from being cached and indexed by desktop search tools
Lock Code	The Lock Code is a password protected utility. The passwords will have to be setup first before using the utility

Moreover the system will contain modes for providing web security. It will provide isolation of untrusted Internet resources, so that every user is reassured that his digital environment is clean. He will stay safe and secure while surfing the Web. The “Surf Secure” mode will scan each Internet connection and will automatically block access to Web sites containing malicious links and codes. Doubtful applications, with possible threats of viruses will be eliminated- viruses from USBs will be instantly recognized, and the power will automatically shut down, with unsaved, secure data automatically saved, to block the virus from entering. “Safe Search” for Web sites mode will allow the users to run Web sites in a safe virtual browser while suspicious applications and Web sites will both be launched in a “Test” to be checked for safety. Both modes will provide for security of personal data.

The system also contains a “Parental Control” module to restrict a child‘s access to social networking sites, instant messaging (ICQ, MSN) and specific programs on the computer. It will enable parents to control the downloading of files and the transfer of personal data by their children, and so keep an eye on them to create a healthy child environment in the settlement.

5.3.5. Internal Communication

Digital communication via RF(Radio Frequency) and IR(Infra red): this technique would be used for speedy delivery of data between the computers and other connecting devices of the settlement. The data can be transferred wirelessly from one sector to the other e.g. from the residential sector to the industrial sector. Routers would be installed at different locations providing a path for data sending and receiving.
Voice controlled IR/UV remote Controls: these remote controls will primarily be used to control the household robots and other electronic devices. The remote controls will beinstalled in the houses and will have voice sensors in them. When a command is given they receive voice signals and, through an analogue to digital converter,they convert those signals into commands that are readable by the robots and electronic devices. These remote controls are also used to locate the robot through a tracker system installed in it.
Radio-frequency identification (RFID): this technique would be used for communication between the robots, people and computers. Communication sent via electromagnetic waves to exchange data between a terminal and an object is also used for the purpose of identification and tracking.
RFID installed in Astoria contains at least two parts. One is an integrated circuit for storing and processing information, modulating and demodulating a radio-frequency (RF) signal, and other specialized functions. The other is an antenna for receiving and transmitting the signal.

5.3.6. External Communications

Between Earth and Settlement:
Problems: The speed of light (3×10^8 ms^{-1}) puts a massive constraint on the data transfer between the planets. There will be a minimum delay between a signal being sent from Earth to be received by settlement of ten minutes (when the planets are at their closest) and a maximum delay of twenty minutes when the planets are in conjunction.

What would be done to overcome this problem:Therefore, we will Cache (store) as much of the terrestrial Internet as possible on the settlement servers, regularly uploading new information depending on demand. The Interplanetary Internet would update (or synchronize) at regular intervals, perhaps during periods of low electronic traffic. Once the mission-critical websites are uploaded, there would be a steady flow of low priority updates trickling through the network. This would be in the form of the peer-to-peer file-sharing model; small packets are downloaded and assembled by the client. Should the connection fail, it simply picks up where it left off as if nothing had happened.

- A single computer and a radio transmitter brought from Earth to settlement
- On Earth there is a corresponding radio transmitter, or network of global transmitters, and a buffered interface to Earth's Internet. The buffer on Earth side should have some additional functionality:
- Collect all files (e.g. pictures) that are related to a requested HTML page and send them together with the HTML page.
- Reduce resolution of pictures if appropriate.
- Compress data stream.
- Add redundancy to the signal to allow data reconstruction for lost parts

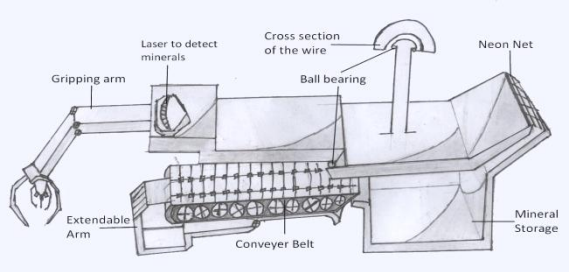
Between Mining Robots and Settlement:
Radio waves connect the robots to the settlement. The instructions sent in the form of radio waves are generated from special antennas located on the docking ports. The mining robots are programmed such that they receive the waves, and interpret the information sent to them.

5.3.7. ACCESS TO COMMUNITY COMPUTING AND ROBOT RESOURCES FROM INDIVIDUAL'S HOMES AND WORK PLACES	
Query	**Solution**
How to access robots in houses	The owner of the house will wear a band which sends signals to the robots and activates them. Remote controlled robots will be used which send infra-red or ultraviolet radiation to activate the robots.(refer to 5.3.5) The robots can also be activated by sending ultrasound signals to them if the robots have sensors to detect ultrasound. Humanoid robots can also be used which will have skin, underneath which they will have flexible pressure sensors so when pressure is applied in those sensors the robots will be activated. For further details refer to section 5.3.5
How to access computers in houses	The computer will be fitted with voice sensors and when the owner has to access the computer, it will recognize the voice and allow the entry. The heart beat sensors and retinal sensor will also be used for enhancing security. Both of these robots will allow the owners only of the computers to access them.
How to access household robots when not in home	If the person is away from house he will communicate with his household robots with the help of holographic image. Once the holographic robot is in front of the person, he will communicate with it as the robot will recognize the voice. We also use the concept of telephone as when the person dials a specific number of the robot and speaks; the robot will recognize its voice due to voice detectors and will communicate with the person.
How to send signals to office bot from far away	Telerobotics will be used to send signals to the office bots with the help of Wi-Fi, Bluetooth, and the Deep Space Network Radio signals will also be used to send the signals to the robots.

5.4 – Robot DesignAdaptations for Difficult Mining Conditions

A spacecraft consisting of iron rods, an add on iron wire coil of "U" shaped cross section, extendable hollow pipes with conveyer belt running through it, mining robot, ore carrying trolleys and ore carrying containers sets off to establish a mining base in the asteroid.

5.4.1 Mining on zero g surfaces:

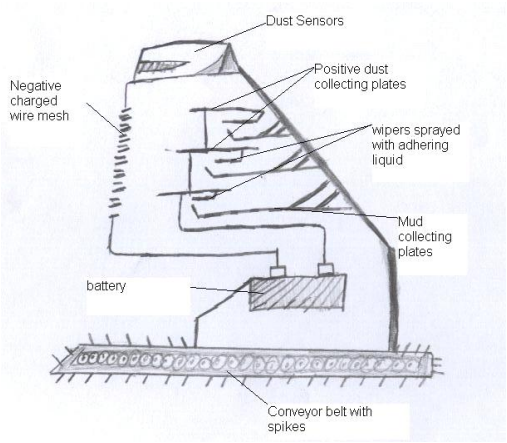


The space craft locates the mine and 6 iron rods are fired off from the spacecraft towards the asteroid around the mine and another one in centre of mine so that rods anchor into the ground.The top of these rods isfitted with a coil of U shaped iron wire and a pulley helps in the extension of these wires.These wires are used to connect all the poles together so that a Structure as shown in the figureon the right is achieved. The figure shows the path along which a robot can move.

A robot connected to extendable hollow pipes enables movement horizontally while suspended from the wires.The long powerful robotic arms reach to the ground, drill the ore, excavate it andplace it on the conveyor belt running in the hollow pipe. The conveyor belt transports the ore to a temporary storage on the suspended robot. The robot's horizontal movement is supported by the use of ball bearings.

Name: X-Cavator		
Function	**Method**	**Feature**
Drilling	Sharp diamonds forming a chainsaw-like structure which enables quick and smooth cutting. The action of roll with the cutters in the ore enables an easy uniform cutting of ore. Cooling liquid sprinklers to cool the cutters to prevent overheating due to friction.	A laser detects the presence of ore and guides the robot's arms to it.
Shovelling	Jaws to grip ore and excavate it.	Electrostatic dust remover around the jaws prevents tiny particles formed during drilling from flying off and polluting the mining area.
Loading	Jaws to load mined ore onto a conveyor belt running through the robot	Long arms with joints enable pitch, yaw and roll
Transporting	Conveyor belts to transport the ore to a temporary storage space covered with nylon net.	Due to pressure sensors installed in the conveyer belts they automatically start when the load on them is greater than a specified quantity

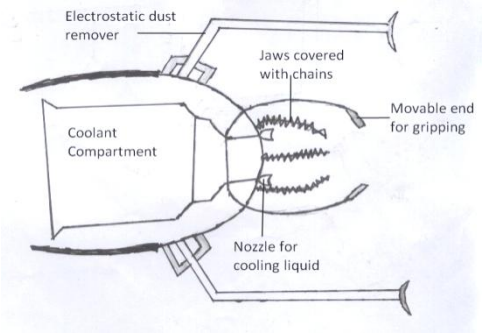
5.4.2 Mining in Deep Layers of Dust:



Problem: While mining in a dusty environment i.e. on the surface of an asteroid, a lot of dust would prevail in the atmosphere due to which the efficiency of robots will be reduced as dust accumulates on the moving parts, data receivers, data sending (as most of the robots would be using laser signals) and sensors. Due to this not only will the mining process be hindered but also a large sum of money would be required to replace the parts that stop functioning due to dust plus the construction process of the settlement will slow down.

Solution: Dust will be removed using an electrostatic dust remover. Dust particles of all sizes will be negatively charged. Positively charged plates will then be used to collect these particles. On the asteroids there is no air, so dust particles do not flow with the motion of air particles and thus are light masses moving in different directions. For this a robot, Thrittler (shown in the figure above), with thrusters and caterpillar tracks, is used to move around and gather dust. The front of this robot consists of a narrow net made of iron with small holes to let the dust pass. This net is negatively charged so that the dust which now enters the robot is also negatively charged. This dust is then collected using positively charged plates. The dust can be removed without stopping the operation of the robot. This requires a blade sprayed with a liquid which, when absorbed by dust, forms a clay-like structure. The blade is then swept over the plates to clean them. This method can be used to free a mine covered in suspended dust.

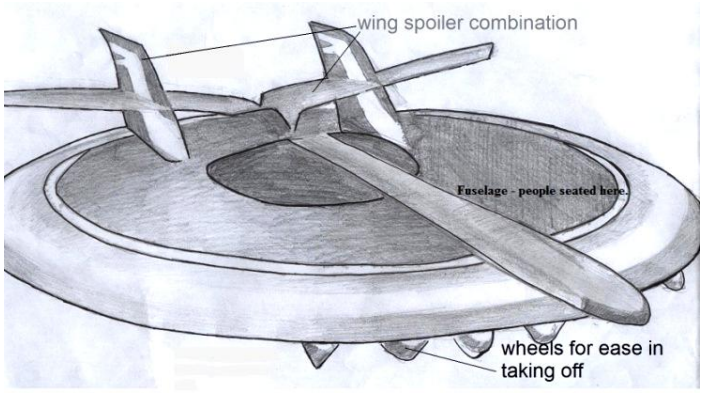
Similarly the robots cutting the ores will have a cylindrical arm which has a very similar electrostatic dust remover so that any dust emitted will be collected instead of flying off and polluting the asteroid(see figure on the right).



5.5 – Transportationof Mining Materials:

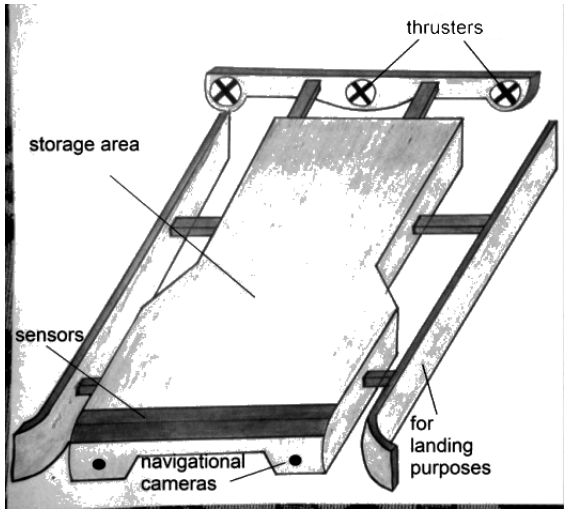
5.5.1 Transportation of Materials from Astoria to the Mining Location:

GX-360 is a large robot which not only carries the materials required for building the mining base but also the X-Cavator robot (refer to section 5.4.1.). The large disc-like shape and the wing spoiler combination at its rear gives it extra stability. The managerial crew will control the mining operations while seated inside GX-360's cockpit. The inner circular plate of the GX-360 contains robots and other electronic devices while the larger outer circle is loaded with mechanical machinery. It is also coated with a sheet of regolith to prevent any damage to it from radiations and collisions. It is able to interact with the settlement servers and provide them with important feedbacks. The tyres are used for easier take off and landing of GX-360 and also help in moving on ground. It has a hydrogen fuel tank which provides energy for its thrust.



5.5.2 Transportation of Mined Ores from the Asteroid to the Settlement:

Once the ores are mined by X-Cavator, they are unloaded in the storage area of Skater(shown in the figure on the right**)** in the form of piles. The storage area of skater is sub divided into further parts, allowing it to carry a variety of materials in one go. It is ionically thrusted, thus it can carry large amount of loads to its prescribed destination in short time intervals. The navigational system allows it to steer smoothly without any collision with the space debris and the robots working in the outer atmosphere. It has a storage capacity of 40 tonnes and is made of Al/Ti alloy with a coating layer of Kevlar to not only keep it lightweight but also to protect it from solar radiation. The skate-like bases at the sides help in smooth landing of the robot.



6.0 SCHEDULE AND COST

6.0 Schedule and Cost

6.1 –Design and Construction Schedule:

Action	Time period (one block represents a year)
Phase 1	8 May 2071-8 May 2072
Research	
Feasibility	
Phase 2	8 May 2072-8 May 2075
Building crew quarters	
Transport of crew	
Transport of construction material	
Building of construction robots	
Phase3	8 May 2075-8 May 2086
Excavation	
Processing and refining	
Building sub-assemblies of structure	
Flask structure	
Docking ports and elevators	
Refining and automation industries	
Establish mining base	
The Sphere	
Connecting inner and outer structures	
Phase4	8 May 2086-8 May 2091
Propulsion system	
Power system	
Airlocks	
Pressurization	
Water and waste plants	
Food production	
Food storage	
Construction of robots	
Phase5	8 May 2091-8 May 2095
Wiring, piping and communication	
Roads and pathways	
Houses and entertainment	
Emergency systems	
Testing and customization	
Inauguration	

6.2 – Cost:

Phase 1:

Work Description	Number of Employees	Employee salary per year ($)	Total Salary per year ($)	Total Salary ($)
Research	60	55,000	3,300,000	75,900,000

Total cost during phase 1: $75,900,000

Phase 2:

Material	Density (kg/m^3)	Volume used per year (m^3)	Mass used per year (kg)	Cost per kg ($)	Cost of material per year ($)
Liquid H_2	67.8	2.24×10^6	1.5×10^8	5.5	825,000,000
Liquid O_2	1141	1.05×10^6	1.2×10^9	0.15	180,000,000
Iron	7700	90	6.93×10^5	355	246,015,000

Cost of materials per year $ 1,251,015,000 Total cost of materials: $3,753,045,000

Work Description	Number of Employees	Employee salary per year ($)	Total Salary per year ($)	Total Salary ($)
Building of construction robots	40	85,000	3,400,000	10,200,000

Total cost of employees: $10,200,000 **Total cost during phase 2: $3,763,245,000**

Phase 3:

Construction Materials	Density (kg/m^3)	Volume per year (m^3)	Mass per year (kg)	Cost per kg ($)	Total cost per year ($)
Al/Ti Alloys	4350	3.66×10^5	1.59×10^9	2.24	3,561,600,000
Graphite-epoxy	1550	3.66×10^5	5.64×10^8	81.1	45,740,400,000
Carbon Composites	158	1.2×10^5	1.9×10^7	55.0	1,045,000,000
Lead glass	3204	4.9×10^5	1.56×10^9	5.6	8,736,000,000
Aluminium Silicate	500	4.9×10^5	2.44×10^8	4.8	1,171,200,000
Regolith	2700	4.9×10^5	1.32×10^9	0.02	26,400,000
Lead	2243	2.44×10^5	5.46×10^8	2.48	1,354,080,000
Aerogel	1.9	3.66×10^5	6.96×10^5	380	264,480,000
Nextel-Kevlar Composite	1356	4.9×10^5	6.64×10^8	67.8	45,019,200,000
Liquid Hydrogen	67.8	6.12×10^5	4.18×10^7	5.5	229,900,000
Polycarbonate	1200	2.44×10^5	2.93×10^8	102	29,886,000,000

Cost of materials per year: $137,034,260,000 Total cost of materials: 150,737,686,000,000

Work Description	Number of Employees	Employee salary per year ($)	Total Salary per year ($)	Total Salary ($)
Construction management	20	65,000	1,300,000	14,300,000

Total cost of employees: $14,300,000 **Total cost during phase 3: $1,507,391,160,000**

Phase 4:

Material/Process	Cost per unit ($)	Quantity required	Cost per year ($)	Total cost ($)
Livestock embroys	5	100,000	500,000	1000,000
Seeds	1	100,000	100,000	200,000
Dimagnets to fix settlement	213	30	6390	6390
Robots	750	8,650	6,487,500	64,875,000
Propulsion system	9,500,000	1	9,500,000	9,500,000
Storage warehouse	500,00	1	500,00	500,00

Total cost of materials per year: $22,481,390. Total cost of water management plants = $7,888,034. Total cost of waste management plants = $8,500,000.

Work description	No. of employees	Salary per employ per year ($)	Total salary per year ($)	Total salary ($)
Installation of Infrastructure	110	60,000	9,600,000	33,000,000
Construction of robots	80	90,000	7,200,000	72,000,000
Installation of propulsion system	10	45,000	450,000	450,000

Total cost of labour during phase 4: $75,750,000 **Total cost during phase 4: $114,619,424**

Phase 5:

Cost of 1 router = $40. Cost of optical fibers = $1,855. Cost of launching 1 satellite = $8,000.

Equipment	Total cost ($)
Internal communication devices	2,255
External communication devices	80,000

Total cost of equipment during phase 5: $82,255. Total cost of construction materials of roads and path ways: $26,400,000.

Material	Density (kg/m^3)	Volume (m^3)	Mass (kg)	Cost per kg ($)	Cost per year ($)
Polycarbonates	1200	1220	1464000	102	149,328,000
Epoxy adhesives	550	970	533500	316	168,586,000
Iron	7,700	1050	8085000	350	2,829,750,000

Cost of housing per year: $3,147,664,000 Total cost of housing: $6,295,328,000

Work description	No. of employees	Salary per employee per year ($)	Total salary per year ($)	Total salary ($)
Installation of infrastructure	105	45,000	4,725,000	14,175,000
Emergency system	17	35,000	595,000	2,380,000

Total cost of labour during phase 5: $16,555,000 **Total cost during phase 5: $9,486,029,255**

Total Cost Billed to the Foundation Society: $1,520,830,954,000

7.0 BUSINESS DEVELOPMENT

7.0 BUSINESS DEVELOPMENT

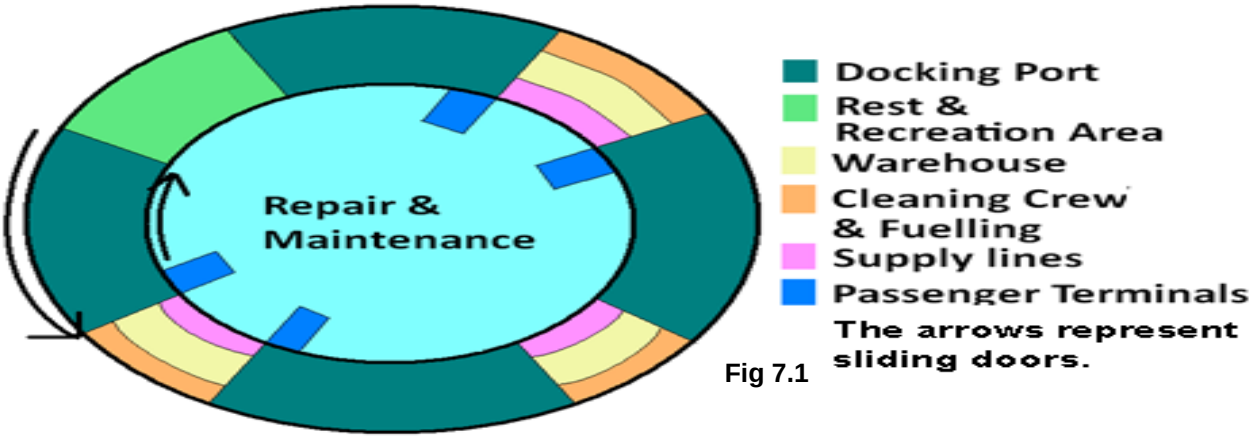


Fig 7.1

7.1. – Infrastructure for Conducting Major Asteroid Materials Operations

A major source of revenue for Astoria is through incoming ships from Earth and other settlements. Another source is the export of valuable materials that are mined. These materials are first harvested, brought to the settlement, processed in the refinery below the docking ports and then sent to other places via ships. The supply lines shown in **Fig 7.1** allow the transportation of these materials to and from the settlement. The incoming ships are first cleaned. Equipment supporting electrostatic precipitation is brought in as soon as a ship lands.

7.2 – Services for Remote Asteroid Mining Operations and Outer Planet Expeditions

For catering the needs of people at remote asteroids, the agricultural area has the capacity to produce extra food. Since vertical stacking is used, more floors can be laid any time and new crops can be grown. The method is cost-effective. For the engineers that frequently shuttle to and from Astoria, Rest & Recreation area has been provided. A Repair & Maintenance depot is frequently used to fix not only damaged ships but also the ports that are under continuous wear and tear.

To ensure that no vehicle is stranded in space, space tug facilities will be provided for disabled spacecrafts. Any damaged vessel will automatically send SOS signals to Astoria. A rescue vehicle will then be deployed which will attach the damaged vessel to itself and pull it back to the settlement, where it will be repaired.

The ships will be designed in such a way so as to provide all facilities for a mission up to ten months. It will provide food which will be available because of the capability of the agricultural area to provide extra food. It will be equipped with the robot X-Cavator to help in operations for asteroid miners. These rescue operation ships will be able to leave in 24 hours. This business will be very efficient and cost effective as the entire product will be ready before hand. It will generate profits for Astoria and will give a boost to the economy in the long run.

7.3 – Sensing and Imaging Research Appropriate to Astoria's Outer Solar System Location

Radio telescopes:

A radio telescope having a diameter of 305 m (1,001 ft) will be placed near the settlement on the unused asteroid area. The telescope has three radar transmitters and is a spherical reflector. It also consists of a parabolic mirror which would induce a varying astigmatism when the receiver is in various positions of the focal point. . The receiver is located on a 900-ton platform which is suspended 150 m (500 ft) in space above the dish by 18 cables running from three reinforced concrete towers. The radio telescope is made up of aluminum panels which are supported by a mesh of steel cables.

Many astronomical objects are not only observable in visible light but also emit radiation at radio wavelengths. Besides observing energetic objects such as pulsars and quasars, radio telescopes are able to "image" most astronomical objects such as galaxies, nebulae, and even radio emissions from planets. This will help us identify asteroids in close proximity to the settlement.

Optical telescopes:

Latitude	**49.2881 deg**	**Diameter of corrected field**	**24 arcmin**
Longitude	122.5731 deg	Detector	Thinned 2048 x 2048 pixel CCD
Altitude	395 m	Image scale	0.495 arcsec/pixel
Median seeing	0.9 arcsec	TDI integration time	103.6 sec
Telescope diameter	6.00 m	Detector width	16.9 arcmin
Primary mirror focal ratio	f/1.50	Broadband limiting magnitude	25.4 (R)
Effective focal length	10.000 m	Medium band limiting magnitude	R = 24.4 (750 nm)
Corrector lens	4-element refracting		

This optical telescope will be placed near the radio telescope. It will help us measure spectral energy distributions and red shifts of over 100,000 galaxies and quasars, and to detect distant supernovae. These observations will allow us to study cosmology, the large-scale structure of the universe, and the evolution of galaxies. It will also help us make Astoria a mining station.

Structural isolation

The use of flexible connectors physically reduces the vibration transmission. Anti vibration mounts and spring hangers are the devices that also help in reducing vibration. Apart from this, titanium-matrix composite and carbon nanotubes will absorb most of the vibration from asteroids.

Data processing and communication

The expected data rate varies depending on Mars's position in its orbit, the weather and atmospheric conditions on Earth, and whether reception is occurring in the daytime or night time. When Mars is at its farthest point from Earth and the reception is occurring during daytime, the team expects to receive data at a rate of a million bits per second, but when Mars is at its closest approach and reception is at night, the rate could be thirty times higher. Today, the maximum data rate transmitted to Earth by spacecraft at Mars is about 128,000 bits per second.

The radio frequencies traditionally used for deep space can pass through clouds, while laser (optical frequencies) can be partially to completely blocked by them. The communication delay between Mars and Earth is approximately 3 to 22 minutes. The use of optical smooth surface satellites in the orbits is expected to reduce the time delay.

Utilization of Construction Machinery

Keeping in view the high amount of money spent on construction, Northdonning Heedwell aims to utilize the construction machinery illustrated in Section 3.3 for settlement operations. Once the construction is complete, the machinery shown in the first 3 steps will be used for the refining and finishing of materials mined from asteroids while the interior construction machinery will be utilized in the repairing of settlement buildings. By making use of every dollar invested by the foundations society in this project, our company ensures the full use of your resources and promises a successful venture!

"This is the goal: To make available for life every place where life is possible. To make inhabitable all worlds as yet uninhabitable, and all life purposeful."


APPENDICES

APPENDIX A

The father's work requires him to go on outer space trips to investigate the asteroids. Using the X-Cavator to mine and the Skater to transport the mined material, he comes back to the settlement. After collecting samples and data he will work in the research labs. In the research labs, he can take help from ZT - OFF - 23, the office robot, which assists in office work and acts like an actual assistant. The father can make use of SixthSense, the modern technique, for ease and comfort. His wife on the other hand will be working in the industrial zone. The children will go to the 1-g area while their parents are gone for work.

The family members will leave for their respective places at 8 in the morning after having proper breakfast made by Assisto, the kitchen bot. The father will use an air board while the mother will make use of cable cars to get to her work and the children will be using solar bicycles to go to and get back from school. The parents will be working till 5, after which they will go to the gyms for their daily exercise sessions.

The children however will attend school till 2 and after that will go to the sports complex, training center or library according to their will. However they will have to attend 1 hour of daily fitness sessions.

The family will come home by 6. After that they can relax and watch TV. Or they can go out for an exciting family evening. The family will be using cable cars to get to the commercial areas and shopping complexes where they will be served by the robots in the shops that will get them everything that they want. Also, if they're seeking entertainment, they can turn Frogtile, the entertainment robot, on to keep themselves happily occupied. They complete all the work by 10 and then go to sleep.

Family activities on the day

The meal will be prepared by Assisto, which will be programmed to prepare a variety of meals. For the sink repair, the Robot CAM 32 will be activated to take immediate action. In case the Robot CAM 32 is busy, the Immaculator will act as a backup robot and readily repair the leak. The bill will be added to the account of the family by the repairing robot and money will directly be deducted from there.

The 3D Television with voice recognition system will be connected to the broadcasting center of the community. From there it can assess daily news and other shows, movies etc. On demand it will show the daily news. Frogtile can also send and receive MP3s and messages that are read out loud as well as perform the following services (by either speaking the information out loud or using indicative lights): weather forecast, stock market report, news headlines, alarm clock, e-mail alerts, RSS-Feeds, MP3-Streams and others.

For a fun evening the family can go watch 4D movies, or visit the theme park Earth to enjoy and spend quality time with each other. From there they will go to the mega shopping mall which offers variety and quality of consumer goods. Book will be bought from the book shop that stocks works of authors from Earth and other settlements. For example the books can be bought from a machine similar to the ATM where only the name of the author will have to be typed along with the name of the book and it will be available at their service in no time. The computer screen will list down all the results along with the ratings of the books.

In the shoe store the fashion robots will inform the buyer of latest trends and will help find the best pair of shoes for the lady.

The gift shop will also have robots that will provide guidelines on the toys and their features and will present items according to the demands of the customers.

For the medicine the family will go to the healthcare center and after a quick checkup medicines will be given to the little girl. In case of emergency, the Robo Cop is always there to serve the family. There will be no need to go to the hospital as it has a complete stock of important medicines, drips, bandages and other medical equipments. This will make the procedure faster and more efficient.

Milk can be bought from the grocery shop. But in case of emergency, or according to the level of requirement, Assisto, the kitchen bot, can be made aware of the situation so that the robot can get the milk or any other grocery in the fastest way possible.

APPENDIX B

- http://ssi.org/assets/images/slide01.jpg
- http://www.drct.com/dss/Lead_glass/lead_glass.htm
- http://www.marshield.com/page/2/53/
- http://www.aerogel.org
- http://isru.msfc.nasa.gov/
- http://curator.jsc.nasa.gov/lunar/letss/Regolith
- http://jap.aip.org/resource/1/japiau/v55/i6/p2608_s1?isAuthorized=no
- http://chemistry.about.com/od/demonstrationsexperiments/ss/liquidmagnet.htm
- http://www.lifeboat.com/ex/ark_i
- http://space.mike-combs.com/spacsetl.htm
- http://www.nss.org/settlement/nasa/basics_how.html
- http://settlement.arc.nasa.gov/75SummerStudy/Chapt4.html#Shielding
- http://www.spacedaily.com/
- http://www.astronautix.com/craft/traodule.htm
- http://www.personal.reading.ac.uk/~scsharip/tubes.htm
- http://www.sbir.nasa.gov/SBIR/abstracts/04/sbir/phase2/SBIR-04-2-X3.01-7964.html
- http://www.weldingengineer.com/1%20Electron%20Beam.htm
- http://www.wisegeek.com/what-is-ultrasonic-welding.htm
- http://www.googleimages.com
- http://www.contourcrafting.org/
- http://www.clean-energy-ideas.com/articles/how_do_you_produce_electricity_from_solar_energy.html
- http://www.trnmag.com/Stories/2004/100604/Sound_makes_electricity_for_space_Brief_100604.html
- http://www.novaspace.com/METEOR/Find.html
- http://chview.nova.org/station/sps.htm
- http://www.energy2020today.com/windmills/Windmill-Electricity.php
- http://www.climatecontrol.com/
- http://www.ibiblio.org/lunar/minecarb.html
- http://www.freepatentsonline.com/6129841.html
- http://www.solstation.com/stars/asteroid.htm
- http://www.nrel.gov/csp/troughnet/thermal_energy_storage.html
- http://www.nasa.gov/
- http://www.nasa.gov/centers
- http://www.thespacereview.com
- http://www.settlement.arc.nasa.gov
- http://www.astrobiology.com

- http://www.solarviews.com/eng/ceres.htm
- http://www.wordiq.com/definition/15_Eunomia
- http://nineplanets.org/gaspra.html
- http://www.observatorynano.eu/project/filesystem/files/Food%20Packaging%20Report%202010%20DKR%20Robinson.pdf
- National Geographic Magazine
- 1975 Stanford Space Settlement Study
- Lahore Grammar School Defence, ISSDC Proposal 2010
- http://www.pkstudiosblog.com/2009/11/future-clubhouse-design/
- http://www.bellabrava.nl/bellaapart.html#floor
- http://best..homepic.info/2010/06/amazing-futuristic-house-design-from.html
- http://g-ecx.images-amazon.com/images/G/01/dvd/disney/walle/walle_spaceship_large.jpg
- http://www.destination360.com/north-america/canada/butchart-gardens
- http://www.archicentral.com/hwaseong-sports-complex-by-drds-25050/
- http://exquisite-design.com/hotels/category/modern-hotel-design/
- http://pcmgonline.com/2010/08/30/studio-apartment-tips-finding-the-right-furniture/
- http://images.paraorkut.com/img/wallpapers/1280x1024/u/us_dollars-6916.jpg
- http://files.arkedia-international.webnode.com/200000063-4bb0b4da4f/000012184709.jpg
- http://www.pathnet.org/sp.asp?id=7542
- http://www.squidoo.com/latestinventions
- http://www.pranavmistry.com/projects/sixthsense/
- http://www.brighthub.com/computing/smb-security/articles/62968.aspx

APPENDIX C – COMPLIANCE MATRIX

Requirement	Fulfillment	Page no.
STRUCTURAL DESIGN		
2.1		
6,000 long-term residents, 5000 semi-term occupants, and up to 500 short-term visitors	Accommodated in the Sphere	3
natural views of space outside	Starting paragraph	2
exterior design drawing	Drawings given and clearly labeled	2
identify attributes and uses of large enclosed volumes	2.1.2 paragraphs describing the role of each part of the settlement	3
dimensions	2.1.1 table given	2
construction materials of major hull components	2.1.5 table given	4
design features	Drawings given and labeled, along with description in paragraph form	2
Specify volumes where artificial gravity will be supplied	Values of g in various sections given	3
Specify structural interface(s)	2.1.3 Diagram and explanation given	3
artificial gravity magnitude(s)	Values given	3
means of protecting from radiation and debris penetration	2.1.6 table given	4
show capability to isolate at minimum any two separate volumes	2.1.7 paragraph explaining isolation technique	4
showing rotating and non-rotating sections	Diagram given	3
pressurized and non-pressurized sections	Given in Table 2.1	2
2.2		
Specify percentage allocation of interior “down surfaces”	4.1.1 Diagram of community layout with distance scale and land allocation table	18
dimensions of interior “down surfaces”	2.2.2 table and diagram given	5
Drawings labeled to show residential, industrial, commercial, agricultural, and other uses	Figure 2.7	6
orientation of “down surfaces”	2.2.4 paragraph and diagram given	6
vertical clearance in each area	Shown in Figure 2.8	6
2.3		
process required to construct the settlement	2.3.1 construction technique explained	6
sequence in which major components will be assembled	2.3.2 table showing main steps	7,8
Specify when artificial gravity will be applied	Mentioned in Table 2.5	8
construction technique for interior structures	3.3 Technique explained	15
construction technique making use of materials from asteroids	3.1 Table showing materials and their sources	10
method of initiating rotation for artificial gravity	2.1.4 paragraph specifying method	3
2.4		
details of shielding and damage repair methods	2.4.1 repair method explained	8
means for reducing damage due to larger items	2.4.2 repair method explained, diagram given	9
2.5		
“mining camp” infrastructure	Figure 2.10	9
drawing(s) of human habitation	Figure 2.10	9
3.0 OPERATIONS AND INFRASTRUCTURE		
3.1		
Location	Embedded in 951 Gaspra	10
Reasons for Selection	Most of the construction materials present	10

Sources of Materials Used in Construction	Given in table	10
Sources of Equipment Used in Construction	Given in table	10
Sources of Materials for Settlement Operations	Given in table	10
Sources of Equipment for Settlement Operations	Given in table	10
Means of Transportation of Materials	Heavy-lift launch vehicles, mass drivers, ion thrusters	10
Specification of Mining Target Asteroid	Ceres	10
	3.2	
Atmosphere: Air Composition	Given in table	11
Air Pressure	Given in table	11
Air Quantity	Given in table	11
Climate	Winter and summer	11
Weather Control	Given in table	11
Food Production: Method of Growing	Stack farming using asteroidal regolith	11
Quantity of Food Grown	1250 kg per day	12
Crop Harvesting	Harvesting robot	11
Food Packaging	Plastic film and biopolymers	11
Food Delivering	Food machines	11
Selling of Food	Shops near residential area	11
Storage facilities	Cold storage	11
Backup of 10 months for everyday commodities	Stored in warehouses	11, 12
Electrical Power Generation	Solar powered satellite	12
Kilowatt-hours of Power Required	440,000	12
Distribution of Power	Distribution through superconducting magnetic energy storage	12
Allocation of Power for Specific Uses	Given in table	12
Water Management: Source	Asteroidal regolith	13
Storage facilities	Storage tanks	13
Required Water Quantity	1672000 litres per day	12
Recycling of Household and Industrial Waste	Given in table	13
Disposal of Waste	Given in table	13
Quantities of Waste handling Devices	6	13
Devices and Central Equipment for External Communication	Given in table	13
Devices and Central Equipment for Internal Communication	Given in table	13
Quantities of Communication Devices	23	13
Routes for Internal Transport	Shown on community plan	14
Internal Transportation Vehicles with Dimensions	Drawings shown	14
Quantities of Vehicles	Given in table	14
Day and Night Cycle Mechanism	Electrochromatic glass used	14
Day and Night Schedule	14 hours of day and 10 hours of night	14
	3.3	
Designs of Machines Employed for Construction of Exterior Hull	Drawings shows	15
Designs of Equipment Employed for Construction of Exterior Hull	Drawing shown	15
Designs of Machines Employed for Construction of Interior Buildings	Drawing shown	15
Designs of Equipment Employed for Construction of Interior Buildings	Drawing shown	15
Description of Materials Delivered to Machines	Given with the drawings	15
Description of Components and	Given with the drawings	15

other systems for safety	space use	
- Space suit design	4.3.1 gives details of space suit design along with its drawing and a table listing its features	22
with stowage donning and doffing	4.3.2 paragraph on donning and doffing	23
- airlock designs	4.3.3 shows airlock interior and exterior along with its details	23
4.4		
-drawings of 1g area for children to spend at least three hours	4.4 Pictures of 1-g area and list of activities arranged for children to spend 3 or more hours in the area	24
4.5		
-instant move-in designs	4.5 gives 3 designs along with pictures, for the semi-term occupants	25
5.0 AUTOMATION DESIGN AND SERVICES		
5.0		
No. and types of servers	Server Virtualization	26
Data Storage	USB flash devices and Holographic hard discs	26
Networking Devices	Wireless transmitter device and routers	26
Community Computers	Tables showing numbers of computers and their configuration	26
5.1		
Assembly of the Settlement	Assembler Mx 10	27
Construction of buildings	Astorian constructor	27
Construction of roads	Tyrobot	27
Transportation	Refer to Operations	14
5.2		
Maintenance and Repair	Robot CAM 32	27
Safety of the Settlement	Spylert 2.0	28
Backup Systems and Contingency	Shown in the table	28
Emergency Escape	Escape Pod	28, 29
Working in Combustible Atmosphere	Orbitron Robo cop	29
Authorization	Table specifying different methods of accessing systems	29
5.3		
Livability in Community	SMART robot	30
Productivity in Work	ZT - OFF - 23	30, 31
Convenience in Residence	SixthSense Robo-cleaner Assisto	30
Privacy of Personal Data	Encryption software, Adware and Spyware removal program, Anti-virus and Anti-spy protection, Passwords, Etc.	31, 32
Devices for internal communication, external communication, entertainment, obtaining information and computing, and accessing robot resources	Digital communication via RF and IR Voice controlled IR/UV remote controls RFID A single computer and radio transmitter for external communication Frogtile for entertainment Telerobotics, Holographic robots, Voice sensors, Humanoid robots. Solutions described in Table 5.3.8.	31, 32
5.4		

Mining on Zero-G surfaces	X-Cavator	33, 34
Mining in Deep Layers of Dust	Thrittler	34
	5.5	
Transportation of materials from Astoria to the Mining location	GX-360	35
Transportation of mined ores from the Asteroid to the Settlement	Skater	35
SCHEDULE AND COST		
	6.1	
Schedule from the time of contract till the settlement is operational: - Duration and completion dates of major design - Duration and completion dates of major construction - Duration and completion dates of occupation tasks	Detailed chart with dates provided - Phase 1 - Phase 2 and Phase 3 - Phase 4 and Phase 5	36
Date when Foundation Society moves in	May 2095	36
Date when the entire population moves in	After May 2095	36
	6.2	
Costs billed per year	Given in tables of each phase	37, 38
Number of employees working during each phase	Tables provided of each phase	37, 38
Separate costs of each phase of construction	Given below the tables of each phase	37, 38
Total cost	$1,520,830,954,000	38
7.0 BUSINESS DEVELOPMENT		
	7.1	
Equipment required to conduct asteroid harvesting operations	Robots designed	33, 34, 35
Capability for refining and processing asteroid materials, and creating commodities for trade	Paragraph describing processing of harvested materials, along with diagram	39
Port facilities enabling receiving incoming raw materials, warehousing and shipping	Figure 7.1	39
Dust prevention	Electrostatic precipitation	39
	7.2	
Excess agricultural production for needs of visiting spacecrafts	Vertical stacking is used	39
Crew R & R	Shown in Figure 7.1	39
Repair depot for space vessels	Repair and maintenance depot provided	39
Fueling services	Shown in Figure 7.1	39
Space tug services	Paragraph explaining space tug services	39
Capability to send rescue operations for asteroid miners	Paragraph given	39
	7.3	
Radio telescope	Specifications given	39, 40
Optical telescope	Specifications given	40
Structural isolation	Flexible connectors, anti vibration mounts and spring hangers	40
Data processing and communication	Paragraph given	40