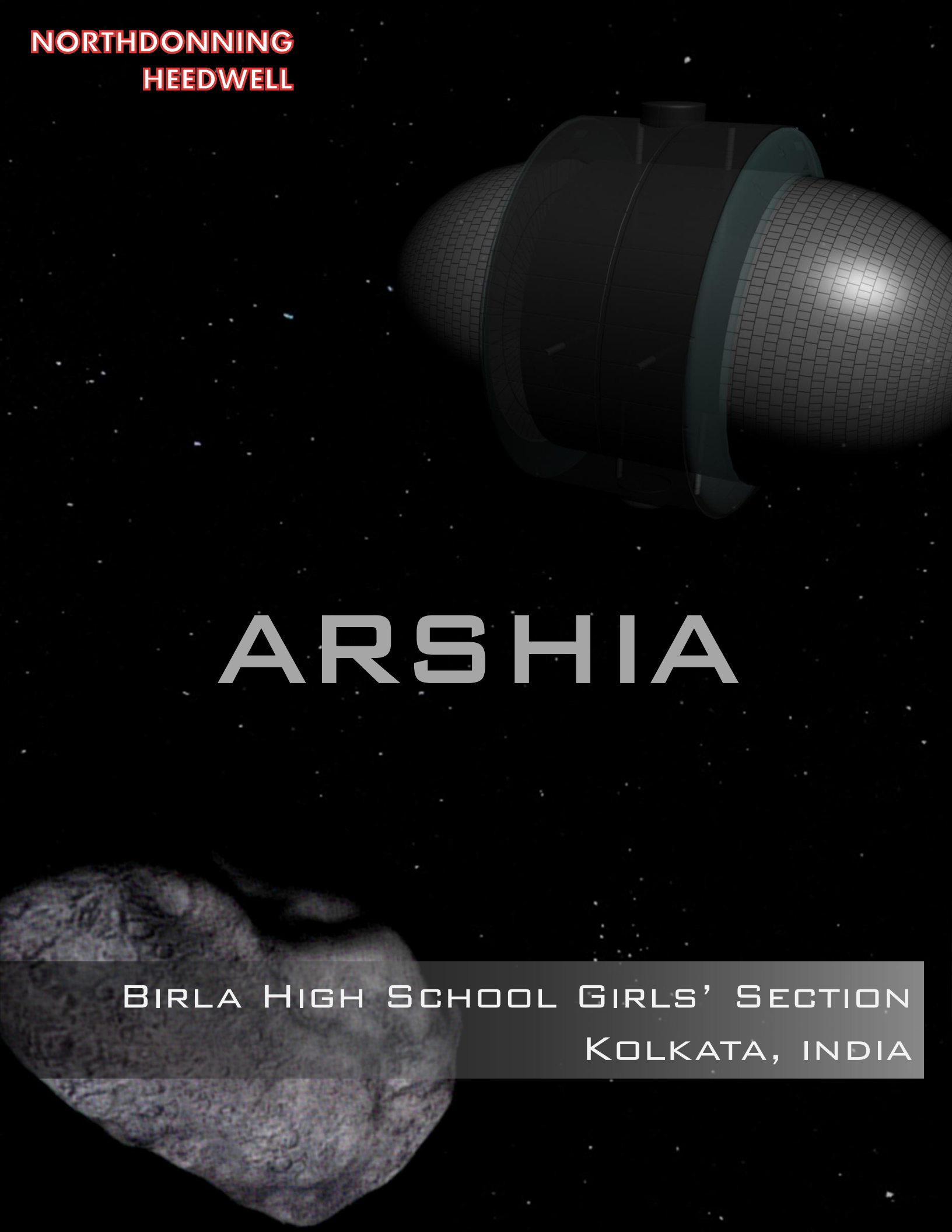
NORTHDONNING
HEEDWELL



ARSHIA

Birla High School Girls' Section
Kolkata, India

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

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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)\

Neha Jain	[11] (17)	Pragya Daga	[11] (16)
Pallavi Goenka	[11] (17)	Ahana Mustafi	[11] (17)
R. Kavya Iyer	[11] (17)	Archita Prahladka	[11] (17)
Kritika Jain	[11] (17)	Sanjana Maniar	[11] (17)
Pragya Sancheti	[11] (17)	Shagun Sheth	[11] (17)
Disha Agarwal	[11] (16)	Damini Agarwal	[12] (18)

Names of two adult advisors currently expecting to attend the Finalist Competition:
Mrs. Ratna Biswas Mrs. Meeta Shailendra

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.

Ratna Biswas 08.03.2011

Responsible Teacher / Advisor Signature Date

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY

"We want to explore. We're curious people. Look back over history, people have put their lives at stake to go out and explore. We believe in what we're doing. Now it's time to go."

We, at Northdonning Heedwell believe that the time has truly come – the time to explore. 'Arshia', which means heavenly in Sanskrit, is an embodiment of our commitment towards our goal, our belief.

Proposed for completion in 19 years, Arshia will be located in the Asteroid belt, which provides myriad lucrative mining opportunities. Northdonning Heedwell chooses the S-type asteroid **6-Hebe** as its mining target, which shall provide valuable minerals, required not only for construction but also for manufacture of other goods and commodities. Northdonning Heedwell keeps the following objectives in mind, to ensure the Foundation Society's enduring success:

To design the structure keeping in mind that along with the advantages of remaining in orbit, the settlement also faces a multitude of risks from high velocity dust particles as well as meteorite and asteroid collisions. The entire structure has therefore been shaped accordingly to provide minimum drag.

To create Differential Gravity Zones to maximize efficiency and utilize every bit of available volume. Space allotment has been done in such a way that agricultural and industrial sectors never prove to be visual nuisances to the citizens of Arshia, while providing them natural views of space at every given point of time.

To automate most operations on the settlement to reduce manual labor and to provide facilities for entertainment, recreation and employment to all citizens.

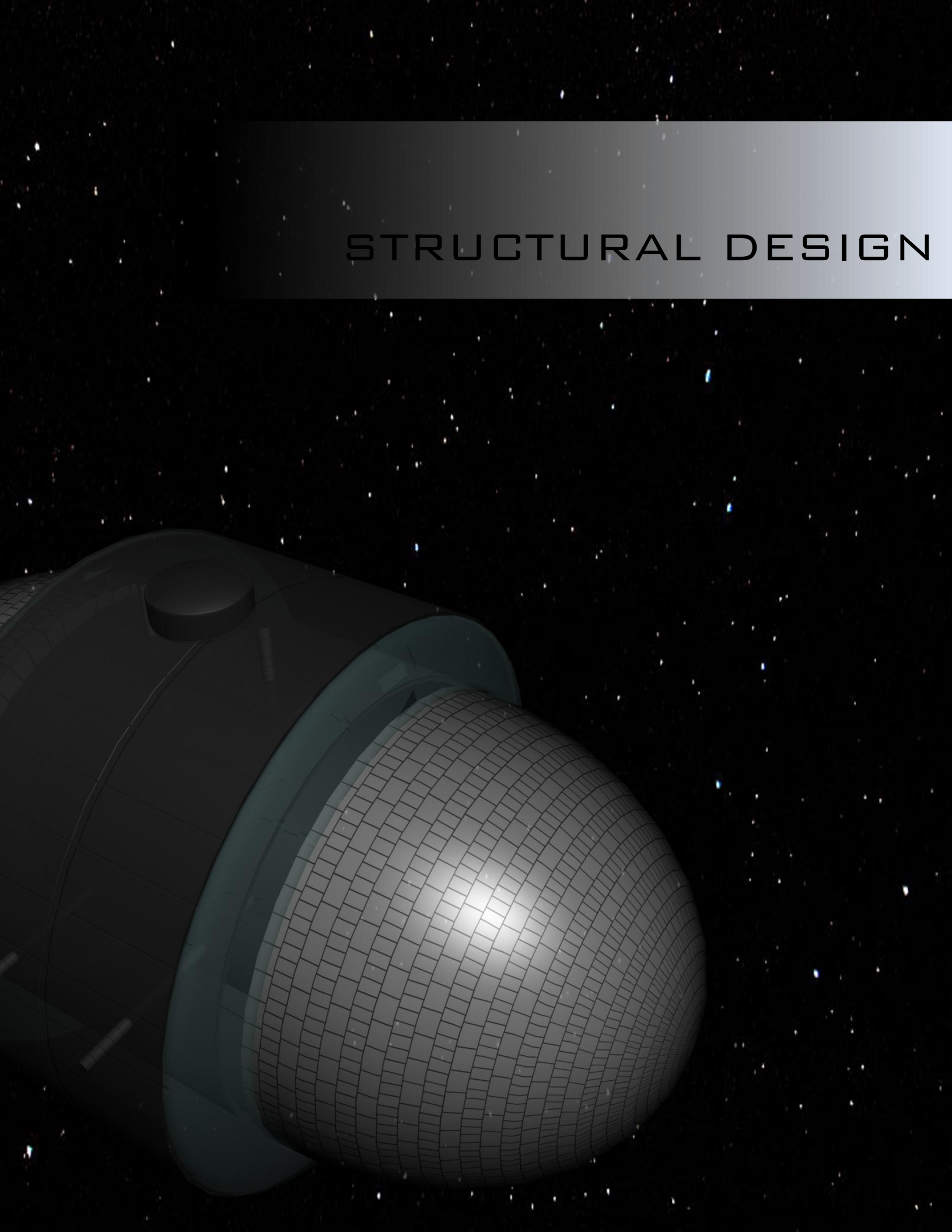
To make Arshia a self-sustaining, mine-to-manufacture unit that generates its own resources such as food and consumer goods required by the citizens, by means of aeroponic agriculture and industries.

To secure Arshia's position as a pioneer in mining, shipping and an economic gains hub in the Asteroid Belt, to achieve our ambition of exploring the unexplored.

Innovation, practicality, profit and comfort are characteristic attributes of all Northdonning Heedwell models, and Arshia shall be no exception.

Northdonning Heedwell welcomes you to Arshia, a "Home Away from Home".

STRUCTURAL DESIGN



2.0 STRUCTURAL DESIGN

Arshia is a one of its kind space settlement whose structure provides a break from the much propagated toroidal structure. Northdonning Heedwell introduces the concept of 5 different gravity zones due to the unique structure comprising of concentric cylinders. The structure of Arshia draws inspiration from the streamlined shape of an airplane fuselage, to minimize the drag associated with cosmic dust, hence the ends of the cylindrical structure have hemispherical nozzles.

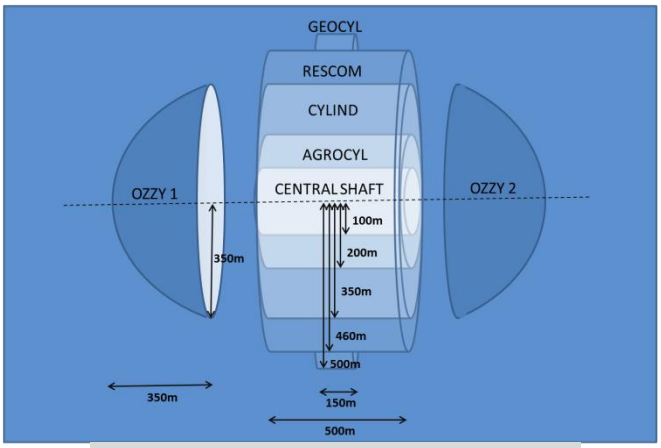


Fig. 2.1 Dimensions of main components

2.1 EXTERNAL DESIGN

2.1.1 EXTERNAL DIMENSIONS AND FUNCTIONS

COMPONENT	2 Nozzles (Ozzy 1 & Ozzy 2)	Central Shaft	Agricultural (AgroCyl)	Industrial (CylInd)	Residential & Commercial (ResCom)	2 Special 1g Areas (Geocyl)
SHAPE	Hemispherical nose	Cylinder	Cylinder	Cylinder	Cylinder	Cylinder
RADIUS (m)	350	100	200	350	450	75
LENGTH (m)	350 each	500	500	500	500	50
VERTICAL CLEARANCE (m)	Variable	200	90	140	90	140
BASE SURFACE AREA (m^2)	769,300 each	314,000	628,000	1,099,000	1,409,075	35,325
VOLUME (m^3)	89,751,666 each	15,700,000	43,803,000	123,088,000	128,740,000	1,766,250
GRAVITY	0g	0g	0.4g	0.7g	0.9g	1g
RATE OF ROTATION	-	-	1.33rpm	1.33rpm	1.33rpm	1.33rpm
PRESSURISATION	Partially pressurised	-	13.47 psi	-	13.2 psi	13.2 psi
FUNCTION	▪Attached to the two ends of the central shaft to minimize drag while in orbit, and in the process, minimize wear and tear ▪Main ports and docking stations ▪Detachable volumes in case of emergencies	▪Main stationary component that supports a nozzle at each of its two ends ▪Primary Control Unit ▪Power Station ▪Transportati-on between various facilities	Houses all agricultural activities (aeroponic chambers, processing units and food storage)	Houses all refineries for mineral processing as well as storage.	▪Housing ▪Offices & Shops ▪Administrative centers ▪Public spaces & Recreational activities	▪Observatories ▪Education center ▪Communication antenna ▪Recreational snow park

Table 2.1 Dimensions and Functions of Main Components

2.1.2 CONSTRUCTION MATERIALS

Arshia makes skillful use of the materials required in its construction, which are acquired from the moon, Mars and 6-Hebe itself. This saves the expense of carrying material from Earth against high gravity.
The entire structure can be divided into three main parts in terms of the construction material - Transparent glass parts, non-transparent hull components and the Pneumatic Chamber Shield (PCS) (Fig 2.2).

The hull components are all fabricated in the form of the **interlace,** a structural innovation whereby the hull is made capable of enduring maximum stress. This is done in the form of two layers of tubings, one of NI-Fe alloy and the other of Titanium alloy, spiraling in opposite directions, hence creating a mesh, radically increasing the structural integrity of Arshia.

Natural views of space are provided from the two ends of the cylinder, where electrochromic glass is used to provide the day and night cycle. These large transparent, well shielded structures serve as windows to the outside world.

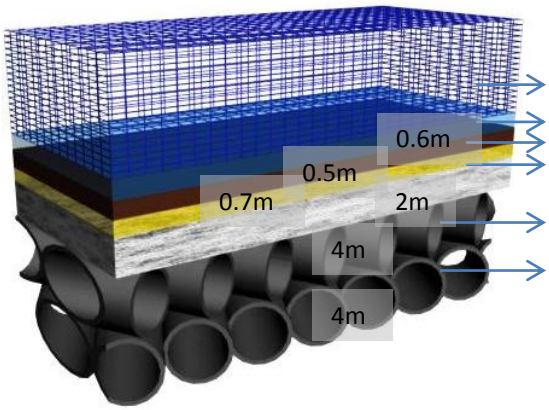


Fig. 2.2(a) Construction Materials of Hull Components

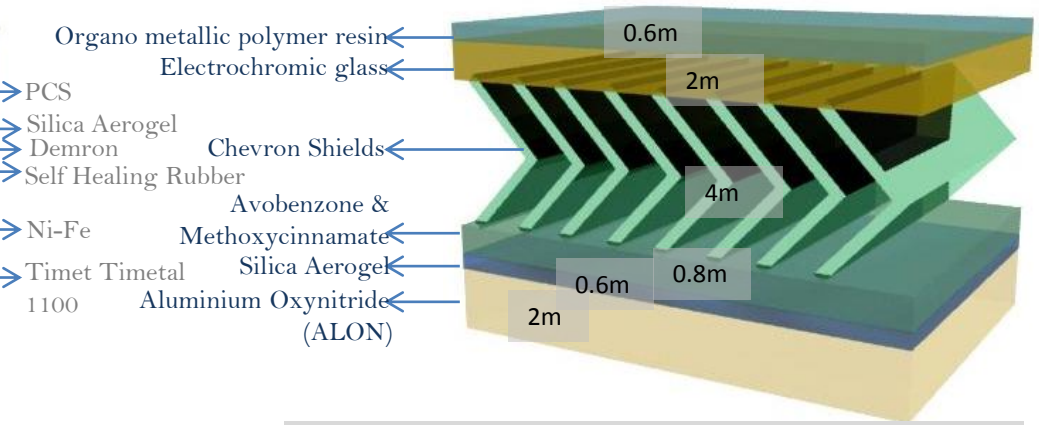


Fig. 2.2(b) Construction Materials of Transparent Components

Material	Use
Ni-Fe	Structural Integrity
Timet Timetal 1100 Alloy	Strength, fracture toughness, creep resistance, thermal resistance
RXF1	Radiation shielding
Self healing rubber	Shock absorber, healing cracks
Demron	Radiation shielding
Silica Aerogel	Thermal insulation, absorbs infrared radiation

Table 2.2(a) Construction Materials of Hull Components

Material	Use
Aluminium Oxynitride	Durability, optical transparency, scratch resistance
Silica Aerogel	Thermal insulation, absorbs infrared radiation
Avobenzone & Octyl Methoxycinnamate	Absorbs UV radiation
Chevron Shields	Radiation shielding
Electrochromic glass	Glass with variable transparency/opacity depending on passed electric current
Organo metallic polymer resin	Makes glass nuclear blast proof

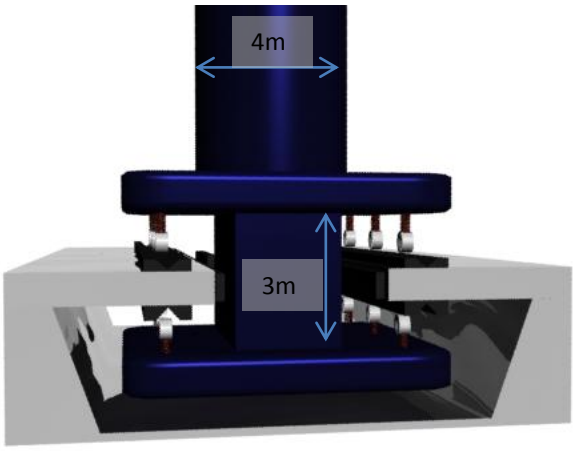
Table 2.2(b) Construction Materials of Transparent Components

2.1.3 RATIONALE FOR SELECTED ROTATION RATE AND ARTIFICIAL GRAVITY

Different magnitudes of Artificial Gravity are provided in different parts of the settlement (Refer to Table 2.1) . This is done to ensure that the optimum gravity requirements are provided to every operation. Since research proves that adults prefer gravity slightly lower than 1g and children must be exposed to 1g gravity for atleast 3 hours a day, Northdonning Heedwell's pioneering design caters to such needs. The vertical clearance in the ResCom cylinder experiences 0.9g gravity. The GeoCyl, where the educational centre is located, has 1g conditions, therefore fulfilling the needs of children. Since agricultural output is maximized in areas of lower gravity, 0.4g has been chosen as the ideal gravity condition for the agricultural cylinder (AgroCyl).
Gravity is generated by means of rotation of the cylindrical sections around the stationary central shaft, all in the same speed. The variation in radii generates different magnitudes of gravity.

Keeping in mind this variation in gravity and the area required for habitation and economic activities, a rotation rate of 1.33 rpm has been selected, since the Coriolis Force does not drastically affect humans at a rate less that 2 rpm

2.1.4 INTERFACE BETWEEN ROTATING AND NON-ROTATING COMPONENTS



The structural interface between the rotating and non-rotating sections is in the form of Superconducting Electromagnetic Levitation. This ensures no loss due to friction as the two systems do not have any physical contact and provides the required 1.33rpm.
Eight solid cylinders of 2m radius, each passing through all the hull layers, are distributed in two rings of four. They interface at the central shaft, where a setup (as shown in Fig. 2.3) locks the cylinders and the strips of Superconducting magnets cause the levitation.
In case of power failure, wheels suspended by springs are lowered onto the magnetic tracks and glycerine is released by the storage area to reduce friction and reduce loss of angular velocity.

Fig. 2.3 Interface between Rotating and Non-Rotating Components

2.2 UTILIZATION OF INTERIOR SURFACES

Arshia has a cylinder within cylinder structure to maximize area and volume for utilization, without effectively increasing the exposed surface area. The vertical clearance and volume of each section can be found in Table 2.1.

2.2.1 CENTRAL SHAFT

It is divided into two halves, each of vertical clearance 100m, to provide maximum utilization of the volume
One of the enclosed volumes within the shaft is used for providing transportation between
o The two nozzles
o The other cylindrical volumes and the nozzles
The other volume houses the
o Primary Control Unit and Main Data Bank (Master Brain)
o Principal power station that supplies energy for all other operations in the settlement.

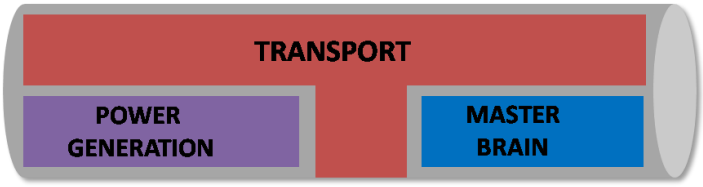


Fig. 2.4 Interior Utilization of Central Shaft

2.2.2 AGRICULTURAL CYLINDER (*AgroCyl*)

It is the innermost rotating cylinder after the central shaft and houses all the agricultural activities along with water and waste management. All the food produced here fulfils the requirements of the
Arshians and enough of surplus is produced to provide backup in case of emergencies. A detailed explanation of agricultural procedures has been given in Section 3.2.2.

2.2.3 INDUSTRIAL CYLINDER (*Cylind*)

The industrial cylinder houses all the refineries for mineral processing as well as storage. This cylinder houses a large volume, all of which may not be entirely utilized. This has been done keeping in mind that:
•Arshia would provide the first access to the outer solar system and should be flexible enough to accommodate any future demands.
•The mining program might be open to expansion in the future.
•The volume will be used during an emergency evacuation.

2.2.4 RESIDENTIAL CYLINDER (*ResCom and GeoCyl*)

The ResCom houses all the residents of the settlement. It has residential homes, offices, shops, administrative centres, public spaces and recreational areas. The GeoCyl which is an extended part of the Rescom has the educational centre, observatories and the recreational theme parks. (Refer to section 4.1)

2.2.5 NOZZLES

The 2 hemispherical nozzles, Ozzy 1 and Ozzy 2, are attached to the two ends of the central shaft.
Each is divided internally into sub-sections to maximize utility of the large volume.
The main function is to serve as the ports and the docking stations. The ports- Entarshia and Extarshia- are situated both in Ozzy 1 & 2, for incoming and outgoing vehicles (**Refer to *3.5***).
Apart from serving as the main ports and docking stations, the two nozzles also serve as the detachable volumes in case of emergencies. The nozzles also contain

- an emergency food storage
- a fuelling station and a backup fuel tank
- thrusters
- retractable wings for maneuvering

2.3 CONSTRUCTION SEQUENCE

The construction of Arshia is a fully automated procedure. It will commence on the moon in Alaskol. The nozzles will be constructed on the moon itself. Crabbot E-8s (the main exterior construction robots), the primary control unit, the positioning sensor and exterior construction material will all be placed in Ozzy 1 which will be the first vehicle to be launched from the moon for the construction of Arshia.

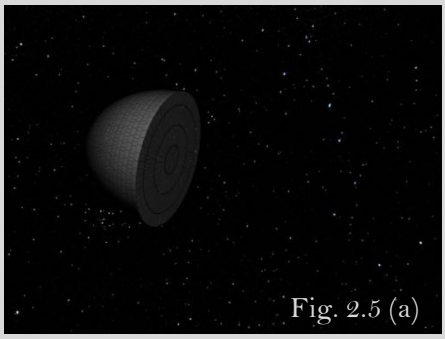


Fig. 2.5 (a)

Positioning sensors will direct Ozzy 1 to position itself in orbit near 6-Hebe.

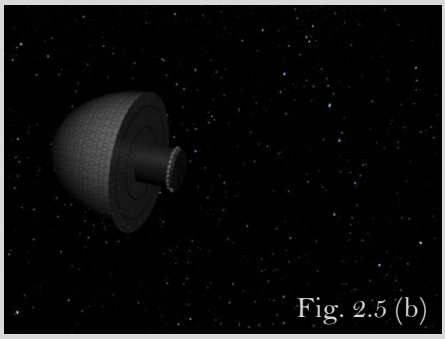


Fig. 2.5 (b)

Ozzy 1 releases Crabbot E-8s to start the exterior construction. The central shaft will be made and the control unit will be shifted to the shaft.

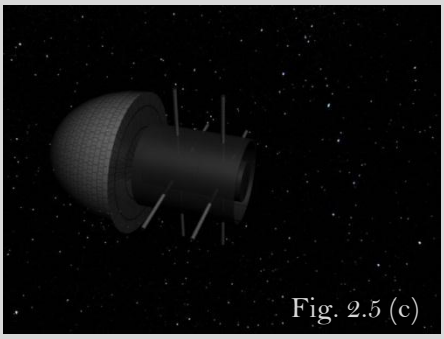


Fig. 2.5 (c)

The cylinders will be constructed, starting with the AgroCyl. The spokes joining the rotating and non-rotating structures are also constructed.

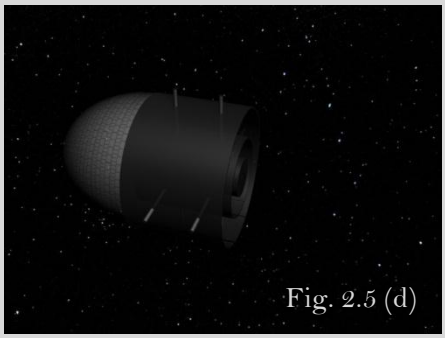


Fig. 2.5 (d)

The Cylind is constructed in a manner similar to the other cylinders.

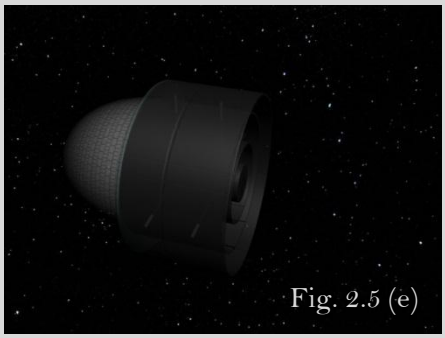


Fig. 2.5 (e)

ResCom and 2 GeoCyls are constructed with edges made of electrochromic glass. Ozzy 2 will then be launched from the moon.

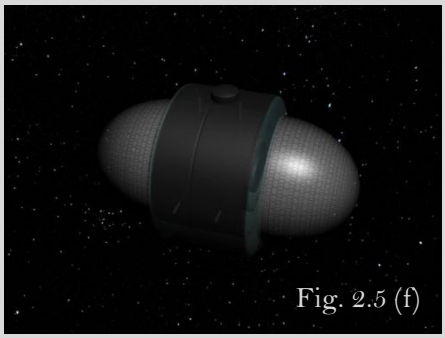


Fig. 2.5 (f)

Ozzy 2 is finally attached to the structure, completing external construction

Ozzy 2 will contain another CU and the main data bank, materials required for interior construction and Movits (for transportation of construction material). After attachment of Ozzy 2 to the structure, Crabbot E-8s are modified by the CU of Ozzy 2 to form Crabbot I-8s which carry out interior construction and finishing for 4 years (Refer to section 5.1).

Interior finishing of all cylinders is carried out by Crabbot I-8s. For all movement of material for interior construction, Movits will be used. In approximately 19 years, the construction will be over, and it will be safe to send the residents and all other required machines and supplies to occupy Arshia.

2.4 DEBRIS DAMAGE PREVENTION

2.4.1 SMALL DEBRIS SHIELDING

Arshia's exterior is provided with a Pneumatic Chamber Shield (PCS). The PCS follows a sandwich model where stable non-reactive Nitrogen gas is bound by two outer layers of considerably elastic materials. Any small particles colliding with the PCS will rebound back due to the elasticity of the material. Inside the chamber, the gas will be pushed away from the stress spot and relocate to another part of the chamber, where it . will cause a temporary deformation. The gas molecules will then relocate to uniformity and the elastic structure will be restored to its original form. At a distance of every 25 m, elastic bands of reinforced Kevlar will be present, joining the two layers to each other for structural integrity by preventing the sliding of one layer over the other.

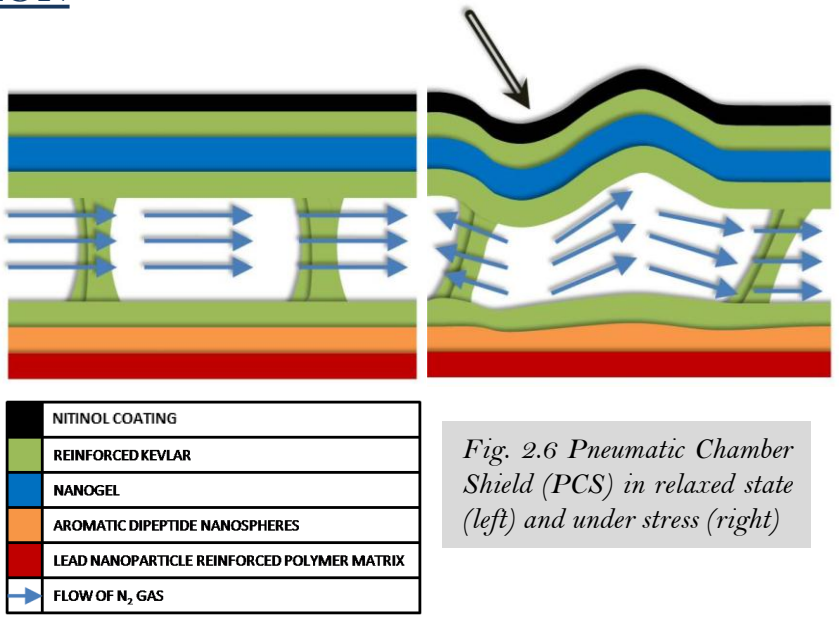


Fig. 2.6 Pneumatic Chamber Shield (PCS) in relaxed state (left) and under stress (right)

2.4.2 LARGE BODY COLLISION SHIELDING

In the event of a collision with a small asteroid or any other mid-size body that poses a threat to Arshia, automated rail guns attached at each nozzle will eject a ball of compacted debris towards the approaching body and divert its path to avert any damage that the body could have inflicted upon Arshia. In the case of a large asteroid collision, the entire settlement will be maneuvered away from the path of the asteroid, for which thrusters have been provided in both the nozzles. The parabolic nose cone will reduce the amount of drag that the settlement experiences in the case of such an event.

2.4.1 DAMAGE REPAIR

Cattepede is a robot which repairs the damage to outer coverings of the settlement due to activities like bombardment with particles, collision with asteroids, solar flares etc. It is able to work in solar flare activity as well (Refer to Section 5.2.1).

2.5 MINING CAMP

Arshia is built with the motive of mining 6-Hebe, an S-type asteroid. The mining on 6-Hebe will be controlled by two mobile mining camps, Hebetat I and Hebetat II. The mining base is a section of cylinder which will rotate at 3.2 rpm, which is feasible for humans to stay safely in for short periods of time. The gravity generated in the living areas will be 0.7 g using G3s or gravity generating gears. Pressurized areas include the living quarters of miners, Hebe Control Unit (HCU) and Hebedock.

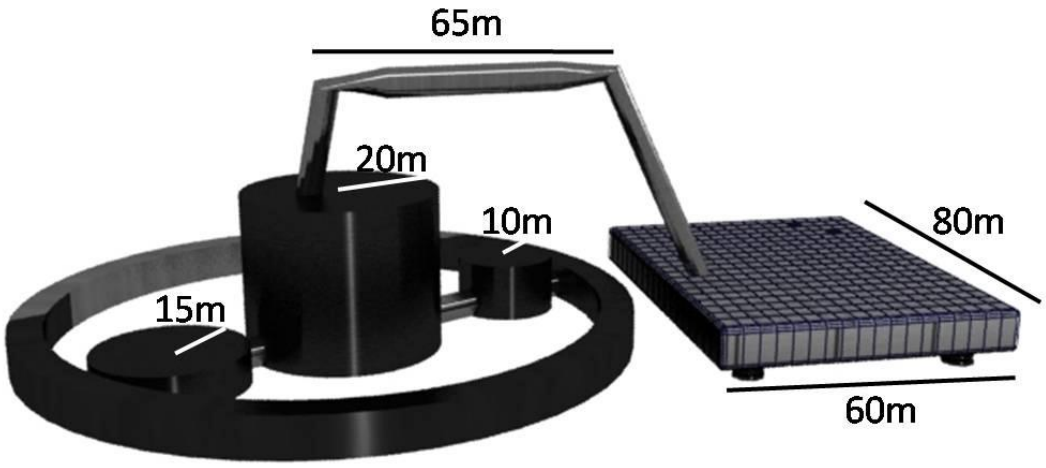


Fig. 2.7 Mining camp on 6-Hebe

Built using super adobe, the various sections of Hebetat will be connected via Hebe Connector – a transport system to ferry people and materials. Part of the processing of minerals is done in the Processing and Refining Unit to facilitate the refining of raw materials during the construction process. All the activities of the Hebedigs and Hebedrills (ref to section 5.4) shall be operated by the HCU. The mining base also consists of Hebedock, a launch pad which facilitates launching of spaceships.

OPERATIONS & INFRASTRUCTURE

3.0 OPERATIONS AND INFRASTRUCTURE

Northdonning Heedwell shall provide a highly secure and comfortable lifestyle to the people living in Arshia. The infrastructural design for Arshia shall cater to all the requirements of the people so that they can work in a healthy and conducive environment.

3.1 ORBITAL LOCATION AND CONSTRUCTION MATERIALS

3.1.1 ORBITAL LOCATION

Fig. 3.1 6-Hebe

Arshia is located in the orbit of 6-Hebe (an S-type asteroid). The orbital location is such that our settlement is kept close to Mars so that transportation costs are minimal. 6-Hebe is a large asteroid (205x185x170 km^3) with a mass of 1.28x1019 kg. It has a composition of nickel-iron metal and silicate chondritic rocks. Metals comprise 40%of the immediate surface of Hebe at present thus facilitating mining. Besides, other C-type and S-type asteroids viable for mining are also found in its vicinity. *(For transportation of materials to Arshia refer to section 5.5)*

PERIHEION DISTANCE	1.937 AU
APHELION DISTANCE	2.914 AU
ECCENTRICITY	0.202
AVERAGE ORBITAL SPEED	18.93 Km/s
EQUATORIAL SURFACE GRAVITY	0.087m/s^2

Table 3.1.1- Orbital Characteristics

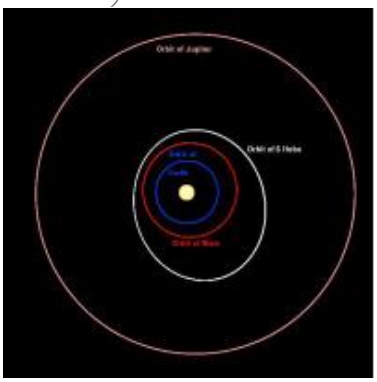


Fig. 3.1.2 Orbit of 6-Hebe

3.1.2 CONSTRUCTION MATERIALS

Name of Material	Source	Amount (in kg)	Use
Kevlar reinforced with Carbon nanotubes	Bellevistat	78063175931	Structural Frame
Timet Timetal 1100 Alloy	Moon	337334291708	Structural Frame
Nickel Iron Composites	6 Hebe	273240776315	Structural Frame
Aromatic dipeptide nanospheres	6 Hebe, Bellevistat	196522903739	Structural Frame
Nitinol (Memory alloy)	6 Hebe, Moon	213544750058	Flexible layer for PCS
RXF1	Alexandriat and Bellevistat	495454084700	Radiation Shielding
Demron	Alexandriat and Bellevistat	155572582678	Radiation Shielding
Chevron Shields	Alexandriat	21468461381	Radiation Sheilding
Silica Aerogel	Alexandriat	14001963267	Thermal Insulation
Apnano IF Nanoparticles	Bellevistat and Alexandriat	1793676709	Shock Absorbing
Aluminum Oxynitride(ALON)	6 Hebe and Aresam	3070487948	Transparent material required
Avobenzone and octylmethoxy animate	6 Hebe and Bellevistat	2486489579	Transparent Radiation Shielding
Organometallic polymer resin	6 Hebe and Alexandriat	3069454393	Transparent material required
RTV adhesive	Alaskol	13853578459	Joining Different Layers
Aluminum	6 Hebe	683759392858	Robots and Interior Construction
Self-healing rubber	Bellevistat	34858855858	Sealing Cracks, Insulation
Calcium Silicate	6 Hebe	198545586707	Building Material
Bamboo	Grown in the Settlement	73564958	Flooring Material
Cenosphere	Bellevistat and 6 Hebe	22693000	Shielding of Robots

Table 3.1.2- Construction Materials

3.2 ELEMENTS OF BASIC INFRASTRUCTURE

3.2.1 ATMOSPHERIC CONDITIONS

GASES	ResCom and GeoCyl		Agrocyl	
	% by volume	Partial pressure (in psi)	% by volume	Partial pressure (in psi)
Nitrogen	74	9.78148	74.6%	10.0466
Oxygen	22	2.90803	24%	3.23209
Carbon dioxide	0.4	0.05273	1%	0.13456
Argon	3.35	0.44275	NA	NA
Water Vapour	0.05	0.00646	0.4 %	0.05376
Other Trace Gases	0.2	0.00249	NA	NA
Total pressure		13.1945		13.4670

Table 3.2.1 Atmospheric Composition

GASES	SOURCE
Oxygen	Moon(Ilmenite),Earth,6 Hebe
Carbon Dioxide	Mars ,Phobos ,Deimos
Nitrogen	Mars(Icecaps),Earth
Water Vapour	Phobos, Deimos, Earth, Moon
Hydrogen	Electrolysis of water, ISS
Argon	Mars

Table 3.2.2 Gases and their Sources

Factor	Regulation
Heat	Nitinol shape memory alloys are used as thermal sensors to monitor the thermal conditions of the atmosphere.
Carbondioxide and Methane level	Infrared sensors detect the increase in the level of carbon dioxide and methane.Excess of ammonia is removed by activated charcoal.Excess of carbon dioxide is separated by the CO_2 membrane technology.The CO_2 is removed by passing it through a zirconia electrolytic cell.
Humidity	The humidity level is constantly monitored via a solid state humidity sensor and regulated according to the seasonal requirements. This is achieved via automated humidity control devices.
Rain and snow	Artificial rain is created via a sequentially aligned network of sprinklers and water tanks. Artificial ice can be created by mixing the water in the tanks with ice-nucleation active proteins.Besides,dry CO_2 blasting shall also be employed to form snow.

Table 3.2.3 Regulation of Atmosphere

3.2.2 FOOD PRODUCTION

GROWTH	The total volume available for food cultivation is 1571500m^3. Arshia's food sustainability will be dependent on aeroponics method of cultivation. In this, a hydro-atomized spray method is employed using small amounts of water. The nutrient medium contains Na, K, P, Ca, Mg, S as macronutrients and Fe, Mn, Zn as micronutrients. The nutrients required by the plants will be chemically produced, using the nitrogenous compounds which will be extracted from human wastes (faeces). Other nutrients will be taken from Earth, Mars and Moon. An array of metal halide lamps, mercury lamps and sodium lamps is used to provide artificial light corresponding towavelengths 400nm- 700 nm. Production of in-vitro meat to meet the protein requirements of the people is undertaken.
HARVESTING	Crops are harvested mechanically using **Agrobots**(refer toSection 5.3). Crops grown are healthy and nutritious. Also **back up hydroponic** systems are located in certain divisions.
PROCESSING	Food processing and packaging is highly mechanized. Spirulina and Chlorella powder is added to cereals as a protein supplement. Spirulina and Chlorella are cultivated in water farms with suitable alkanity, salinity and temperature.
PACKAGING	The food processed will be packed in airtight zipped storage bags made from aluminized BoPET. Also, PolyLactide (PLA) packaging is employed.
STORAGE	The total volume available for food storage is 785700m^3.The processed food is stored in the food storage tank called The Ambrosia after irradiation which kills the pathogens. Storage is vacuumed to maintain shelf life. Emergency food provisions are made for a maximum of 10 months. The emergency food is stored in the nozzles. The following table gives the storage conditions of some important crops.
RESEARCH	Research work on genetic engineering to upgrade the quality of food is undertaken.
DELIVERY AND SELLING	The packaged food is delivered to the grocery shops via the Double Helical Avenue from where Arshians can purchase their requirements.The transportation of food from the groceries to the residential units is done via the **Interlace**(refer to section 2.1.3) implementing the suction technology.

Table 3.3.1 Food Production

CROP	REQUIRED GRAMS PER PERSON PER DAY	STORAGE CONDITIONS
Rice	125	Humidity: 12.5% Temperature: 4.44°C
Wheat	225	Humidity: 14% Temperature: 4.44°C
Corn	50	Humidity: 20% Temperature: 4.44°C
Potato	450	Humidity: 85% Temperature: 10°C
Soyabean	470	Humidity: 13% Temperature: 4.44°C
Onion	250	Humidity: 65% Temperature: 0°C
Lettuce	150	Humidity: 90% Temperature: 0°C
Tomato	225	Humidity: 85% Temperature: 15°C
Strawberry	325	Humidity: 90% Temperature: 0°C
Spirulina and Chlorella	0.1	Powdered and stored in food grade Aluminium bags flushed with N_2, heat sealed and converted into tablets. Humidity: 10% Temperature: 12°C

Table 3.3.2 List of Crops and their Storage

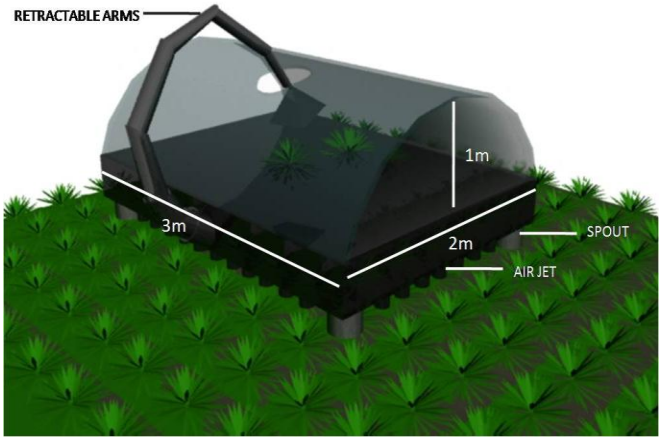


Fig. 3.2 Agrobot

3.2.3 ELECTRIC POWER SOURCE

3.2.3.1 POWER GENERATION

Industrial Area	50730 kW
Agricultural Area	3450 kW
Residential Area	25050 kW
Total Power	79230 kW

Table 3.4 Daily Power Requirements

A Nuclear Breeder Reactor set up in the central shaft generates power for Arshia. The nuclear reactor is a Liquid Fluoride Thorium Reactor (LFTR). The LFTRuses inexpensive thorium as a fuel, transforming it to uranium-233 which on undergoing fission produces heat and electric power. The thorium and uranium are dissolved in molten salt, simplifying fuelling and waste removal.1 kg of thorium produces 1 MW of energy .Thus,90kgs of thorium meet the daily power requirements of Arshia.

3.2.3.2 POWER DISTRIBUTION

Power is distributed via a 3 phase power distribution system. There is an interconnected power distribution network. This includes the transmission over power lines, through electrical substations and pole-mounted transformers. The advantages being that the power generated is uniform. Further if one phase stopped working then alternative is there as a 2nd or 3rd phase, load on transformer is less, distribution is easy, finding an error in the blockage of power supply is easy.

3.2.3.3 POWER STORAGE

Ultra-capacitors will be used for storage of electric power. Their efficiency is not affected by cold temperature, they are easily rechargeable, can be used for long periods and have high turnaround efficiencies (percentage of charge energy that can be reversed is more than 90%). Besides, they are not made of any hazardous material. A combination of ultra-capacitors and hydrogen fuel cells will serve as a great power source with excellent power density and energy density.
Power Generated: 90000 kW
Surplus Power: 10770 kW

3.2.4 WATER MANAGEMENT

- The total down area allotted for water treatment is 157150 m^2.
- The daily water requirement of Arshia is 575000 liters.
- Moon, Earth, Phobos and Deimos will serve as the prime sources of water for Arshia.
- The water storage unit of Arshia has a storage capacity of 1,61,00,000 liters to meet the emergency requirements for a minimum of 4 weeks.

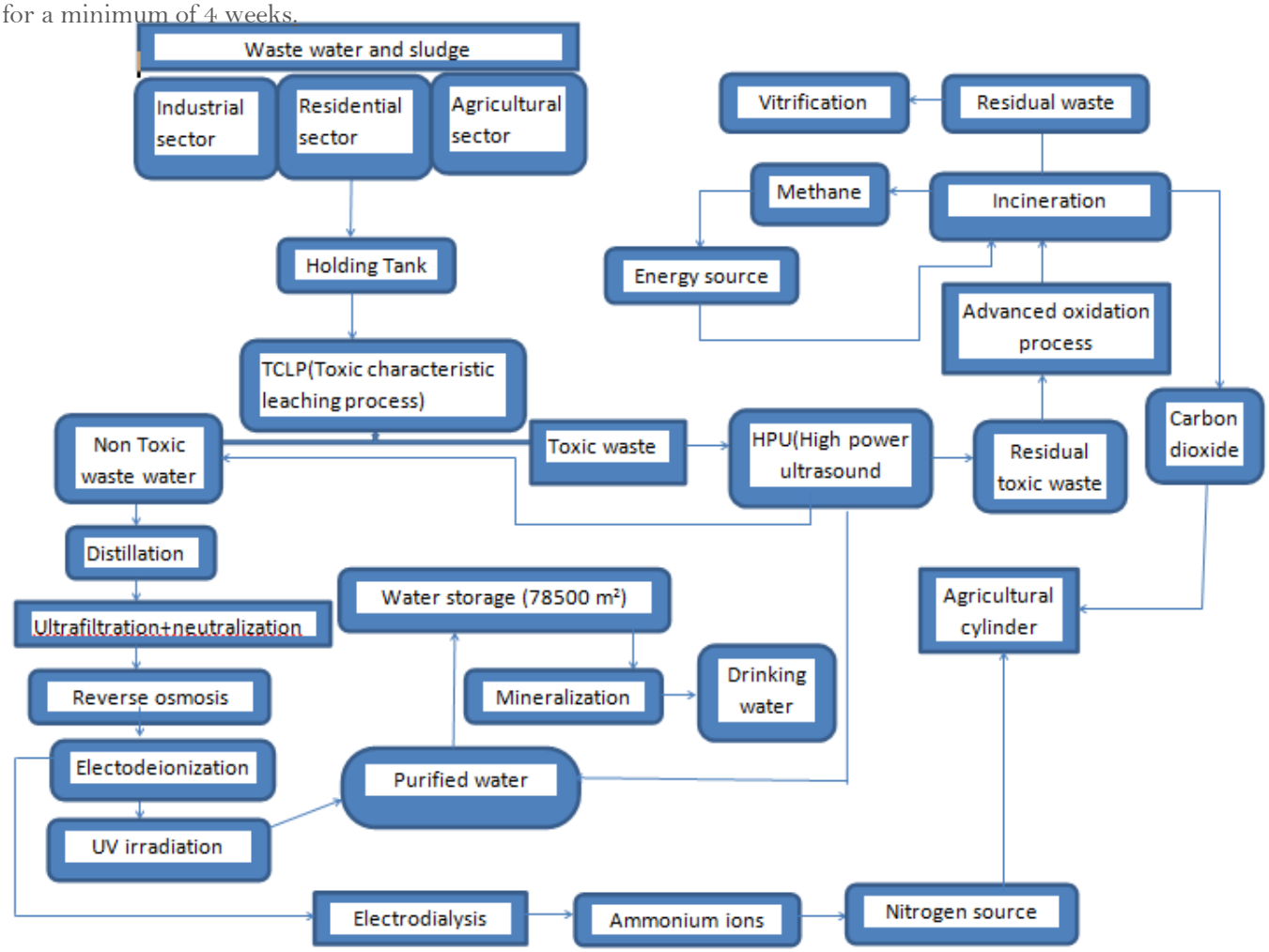


Fig. 3.3 Water Management

3.2.5 INDUSTRIAL AND HOUSEHOLD WASTE MANAGEMENT

3.2.5.1 INDUSTRIAL WASTE MANAGEMENT

Industrial waste comprises of **Titanium, Cenosphere, Steel, Aluminium** and other metals. The following table describes the disposal, recycling and usage of these metals.The scrap metals are melted, recast and used for various purposes. The toxic metals are ejected into space.

Type of Waste	Disposal/ Recycling
Fly Ash	Cenosphere is extracted from fly ash waste
Aluminium	Waste or scrap Aluminium is cut into small even pieces and melted in a furnace at temperatures of 750°C-850°C. The molten Aluminium can then be used as desired. It does not require disposal because it can be recycled and used indefinitely.
Titanium	• Large quantities can be chlorinated to a usable product • Vacuum arc reduction or cold hearth melting are used for recycling
Other metals	Recycled through re-moulding

Table 3.5 Industrial Waste Disposal/Recycling

3.2.5.1 HOUSEHOLD WASTE MANAGEMENT

The prime sources of waste are the kitchen waste and human waste(urea and feces).

Kitchen waste will be dumped into the**ScariCan,**made of 0.55 mm thick Hypalon laminated with Neoprene and reinforced with nylon. The transportation of wastes from the residential units to the ScariCan is done via the **Interlace** (refer to section 2.1.3). This air-tight tank transforms the organic waste into methane producing renewable energy that can be used for heating, electricity, and many other operations that use any variation of an internal combustion engine. The carbon dioxide emitted from the biogas plant is converted to dry Carbon dioxide to form snow(atmosphere regulation).Human waste(urea and feces) are the only sources of nitrogen in Arshia.Chemical toilets are installed in each residential unit. The waste is rich in nitrogenous and organic compounds. Glutaraldehyde is used as a disinfectant and deodorizer. After the hydrolysis of urea, ammonia and hydrogen peroxide are formed. Both of these have individual industrial uses and react with each other synthesizing hydrazine which is used as an energy source.

3.2.6 EXTERNAL AND INTERNAL COMMUNICATION

3.2.6.1 EXTERNAL COMMUNICATION

The communication between Arshia and Earth is enabled employing a bi-directional LASER network through satellites. The data signals incorporated in the form of MASERS are sent from earth terminal to the nearest orbiting satellite AEC-1 .The signals received by the electro-optic microwave signal receiver at AEC-1 are converted to laser signals. The LASER signals reach the terminal at Arshia via point to point links between 6 satellites .Each satellite has an Optical Transceiver System of its own. The Optical Transceiver System comprises of an Optical Receiver, Optical Duplexer, Fine Pointing assembly, an Optical Booster Amplifier and Transmitter. The laser signals from Arshia are also relayed to AEC-1 via the same process. The optical microwave converter converts the received laser signals to MASERS and relays the signals to the earth terminal. Communication between Arshiaand **Aresam, Alaskol, Balderol, Columbiat and Bellevistat**is also enabled via LASERS.

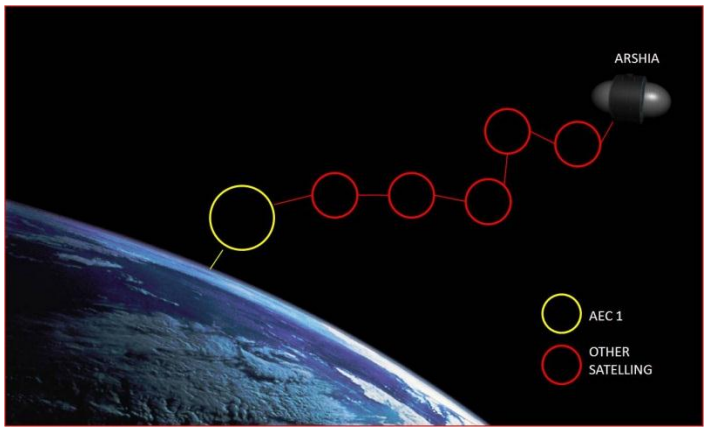


Fig. 3.4 Relay Signals from Earth to Arshia

EQUIPMENTS	NUMBER	DESCRIPTION
MICROWAVE TRANSMITTER	1	A Phased Array with a Phase and Amplitude Controlled Magnetron(PACM) implements the transmitter functions.
MICROWAVE RECEIVER	1	Implementation of receiver functions through an array based on silicon bipolar devices and thin-film polysilicon resistors with low parasitic capacitance and excellent matching.
OPTICAL TRANSCEIVER	12	Laser source with internal modulation, optical receiver using grapheme based photodetectors and silicon optical amplifiers.

Table 3.6.1 Number and Description of Equipment required for External Communication

3.2.6.1 INTERNAL COMMUNICATION

- Communication between humans and robots: Communication between humans and robots is facilitated through an infrared remote control Transmitter. This is enabled via the infrared receivers embedded in the robots .
- Communications between robots: The robots communicate between themselves using a pair of radio transmitter and receiver board. The radio boards have a communication range of about 20 feet .Robots develop ASRL (Adaptable Synthetic Robot Languages)which help in one to one mapping of signals.
- Communication among the people: The Pinnserts are connected via the LTE++(Long Term Evolution Super Advanced) network. Orthogonal Frequency-Division Multiplexing Access (OFDM) modulation combined with MIMO(Multiple Input Multiple Output) and multiple antenna system is employed.

Data download rate	2Tbps
Frequency	80 GHz-100GHz
Wavelength	3mm-3.75mm
Band	E BAND
Distance range	30km-55km

Table 3.6.2 Long Term Evolution Super Advanced Network (LTE++)

	LASERS	MASERS
Data Transfer Rate	100 GBps	5 GBps
Frequency	0.1916 PHz-0.1960 PHz	33 GHz-50 GHz
Wavelength	1530 nm-1565 nm	6 mm-9 mm
Band	C-Band	Q-Band

Table 3.6.3 Specifications of External Communication

3.2.7 INTERNAL TRANSPORTATION

The DNA shaped Double Helical Avenue (DHA) runs throughout the length of the cylinder. This is an airtight transportation tube cutting through the various cylinders, providing a system of transport between them. It contains two lanes:

- Auto-walks equipped with handrails and seatbelts for people
- Conveyor belts equipped with security belts and superior grip for transportation of cargo

Mode of Transportation	Transportation of	Transportation Area	Description
Autowalk	People and Objects	Within ResCom; Also used for transportation of people in the DHA	Moving belt made of steel with handrails and seatbelts to prevent people from hurting themselves.
Conveyor Belts	Cargo	From docking areas to required areas in AgroCyl, Cylind or Central Shaft; Used in the DHA	Moving belt made of a steel mesh for greater grip.
Gecko-like Tape Shoes	People (individually)	IntraResCom, intra Cylind and intra AgroCyl or in the Central Shaft;	The soles are provided with tiny hairs which allow the wearer with greater grip and prevent them from slipping or falling.Piezo-electrics is the source of power.
Elevators	People	Between the ResCom and the GeoCyl.	These elevators are used for daily travel of children from the Rescom to the GeoCyl and back.
Private Cars	People and Objects	Within ResCom	The cars are provided with sensory brakes and advanced tyre grip. The cars run on hydrogen fuel cells. There are mainly two cars: • Torix • Exorus

Table 3.7 Transportation

3.2.8 DAY AND NIGHT CYCLE

A soft LED(Light Emitting Diode)curtain screen covers the down surface of the industrial cylinder which has a total surface area of 1257150m^2 .The screen forms the sky for the people living in the residential cylinder. The screen is powered by hi-tech computers that control the video display on the screen by varying the colour combinations. The display is such that the people experience a 12 hour day and a 12 hour night cycle including all the phase transitions between day and night.

Daily power consumption	19 MW
Resolution	1920*1080 pixels
Brightness	2000 cd/m^2

Table 3.8 LED Screen Specifications

3.2.9 STORAGE FACILITIES

All daily life commodities and other items that are not readily used after production are stored in Ozzy1 and Ozzy2. 10000m^{3}is allocated for storage. (For food storage refer to section 3.2.2)

3.3 CONSTRUCTION MACHINERY AND SEQUENCE

3.3.1 EXTERNAL CONSTRUCTION

Crabbot E-8s are the external construction robots for Arshia. Ozzy1 contains Crabbots along with the materials for construction. Ozzy1 is launched into space and locates itself in orbit. The Crabbots and the construction materials are released. Initially, a few Crabbots are released. They form a circular ring and begin with the construction of the central shaft .The CSU(Control and sensing unit)of each Crabbot is monitored by Ozzy1.After the construction of the central shaft the Ozzy1 releases more Crabbots, for construction of the AgroCyl. Similarly the external construction of Cylind, ResCom and GeoCyl is undertaken. After the construction is over, the Crabbots are distributed in the cylinders and modified for internal construction.

3.3.2 INTERNAL CONSTRUCTION

Then Ozzy2 is launched and it attaches itself to the completed cylindrical structure after releasing the materials that are to be used for internal construction via the transport robots (Movits).The control unit of Ozzy2 modifies the Crabbots E-8s.The modified Crabbots I-8 then carry out the internal construction of Arshia.

3.3.3 CRABBOT E-8 AND CRABBOT I-8

Aretes E-8 and Aretes I-8 are the four long foldable arms extending from the center of the external construction robots, Crabbots E-8s and the internal construction robots, Crabbots I-8s respectively. These are highly specialized structures that have been designed to perform all the construction activities like drilling, air compressing, brick making, crushing, floor laying, tiling, pipe laying, painting, rolling, cutting, craning, pneumatic layer compacting, dredging, vibration, compacting, etcetera.
(For details on construction materials refer to section 3.1)
(For details on construction robots refer to section 5.1)

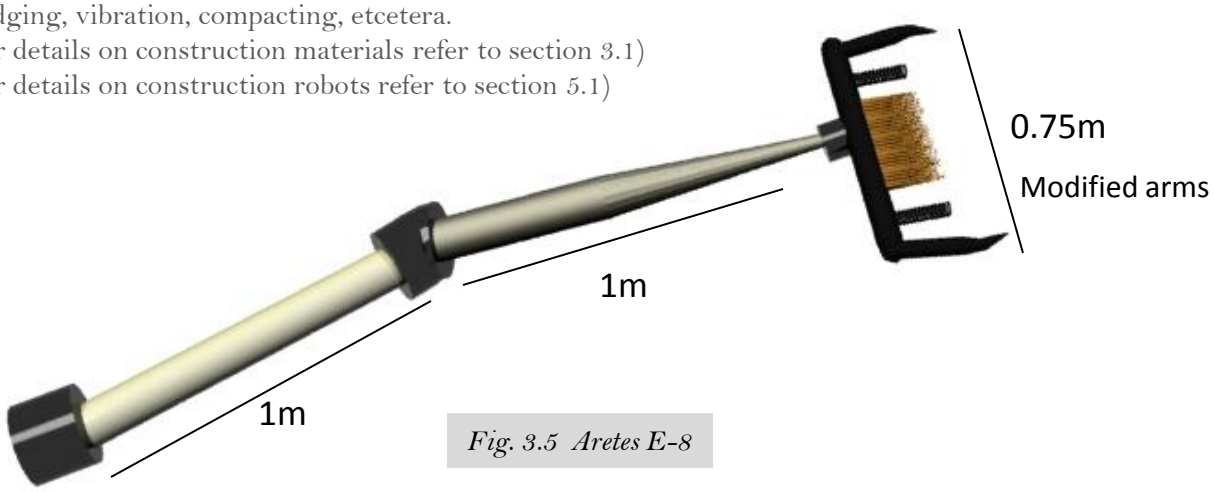


Fig. 3.5 Aretes E-8

3.4 PROPULSION SYSTEM

VASIMR (Variable Specific Impulse Magneto-plasma Rocket)engines are used to propel the settlement to evade an asteroid collision or collision with some other objects. VASIMR is a plasma-based propulsion system. An electric power source is used to ionize the fuel into plasma. Electric fields heat and accelerate the plasma while the magnetic fields direct the plasma in the proper direction as it is ejected from the engine, creating thrust for the spacecraft. The engine can even vary the amount of thrust generated, allowing it to increase or decrease its acceleration. Argon is used as the fuel for the engines. Two VASIMR engines are embedded at the ends of both the nozzles Ozzy1 and Ozzy2.The engines are powered by Molten Salt Fission Reactors. During chances of collision, two VASIMR engines of a nozzle are fired such that the acceleration is in a direction opposite to the linear velocity of Arshia. After the collision has been evaded Arshia is brought back to its orbit by firing the two VASIMR engines of the other nozzle.

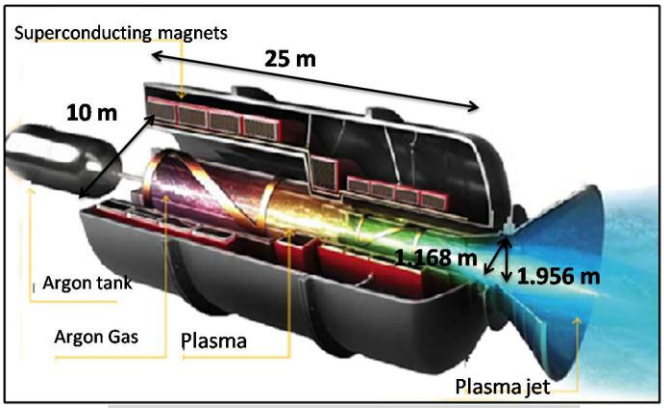


Fig. 3.6 VASIMR Propulsion Engine

Acceleration	0.43 m/s^2
Operation Time	1 day
Required Thrust	37 Giga-Newtons
Specific Impulse	320 x 10^{11} m/s
Required Power	856 MW
Required Fuel	100 kg

Table 3.9.1 Requirements for Maneuvering Arshia through A Distance of 2 Kilometers

Height	25 m
Diameter	10 m
Weight	760000 kg
Nozzle length	1.956 m
Nozzle Diameter	1.168 m

Table 3.9.2 Specification of each VASIMR Engine

3.5 PORT FACILITIES AND ORE HANDLING

3.5.1 ACCEPTING RAW ORE FROM OTHER LOCATIONS

6-Hebe is the primary mining site. However, in case of availability of useful minerals, asteroids in the vicinity of 6-Hebe may also be mined. Arshia shall accept raw ore from the C-type asteroid, 253Mathilde, the M-type asteroid 21 Lutetia and the S-type asteroids 8 Flora and 9 Metis. RADAR technology shall be implemented to detect asteroids which may prove to be viable for mining. Arshia shall deploy Hebexy-S10 spaceships (refer to section 7.1.3) to mine them as well. After the mining process is complete, they shall return to Arshia and unload the collected material at Hebezone, similar to the process of unloading materials collected from 6-Hebe.

Mining Location	Mined Ore
6 Hebe	Iron and nickel ores, Calcium Aluminium silicate, Potassium Aluminium silicate, Magnesium, Iron silicate, Sodium Aluminium silicate, olivine, pyroxene
21 Lutetia	Iron ores, Nickel ores, Graphite, Gold, Platinum, Iridium , Platinum.
253 Mathilde	Carbonaceous chondrites, oxides, sulphides, olivine.
8 flora	Silicates, Iron, Sulphides, Oxides.
9 Metis	Silicates, Iron, Sulphides, Oxides.

Table 3.10 Requirements for Maneuvering Arshia through A Distance of 2 Kilometers

3.5.2 ORE HANDLING PROCESSES

The entire ore-handling process in Arshia is automated using the Ore Receiving Enrichment system (refer to section 5.5.). Once the ore is transferred to Cylind, the following refining processes are carried out to manufacture finished materials:

The ores are transported to the ore processing industries, **Scribd.**

The ores are segregated and the silicate, carbonaceousand Fe-Ni ores are separated and processed differently.

Crushing,Grinding and Pulverization of the ores is done by the Indobots.

Ore dressing is done in Simulated Ore Dressing Plants .Acoustic technology is implemented for the dressing of ores with gold and quartz sands.

The carbonaceous chondrites and other ores with volatile impurities are calcined and the sulphide ores are roasted to convert them into their respective oxides.

Direct reduction of iron ores to Hot Briquetted Iron(HBI) ans smelt reduction of iron ore is undertaken. Recuction of other ores is done in a carbon monooxide(generated via Zirconia Electrolysis) rich environment.

Crucible type medium frequency induction method is employed for the refining of Iron alloys. Pyrolysis is undertaken to isolate noble metaliferous elements.

The refined minerals are then sent to the manufacturing industries , **Metoph** and the unused minerals are sent to the **storage area of Arshia**.

3.5.3 PORT FACILITIES

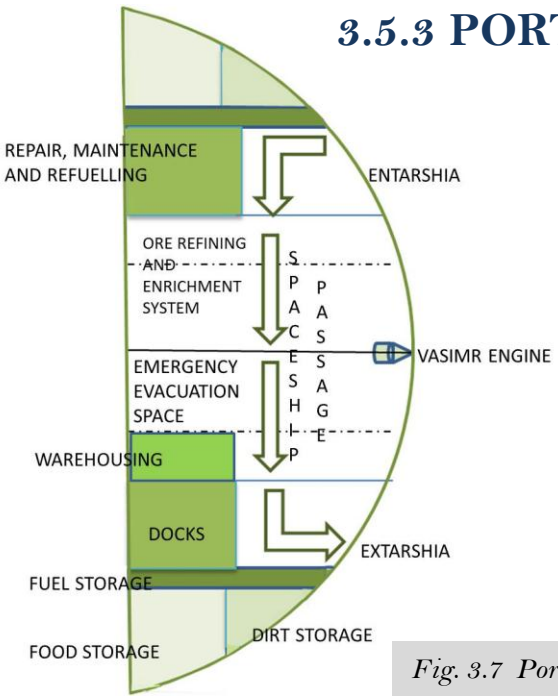
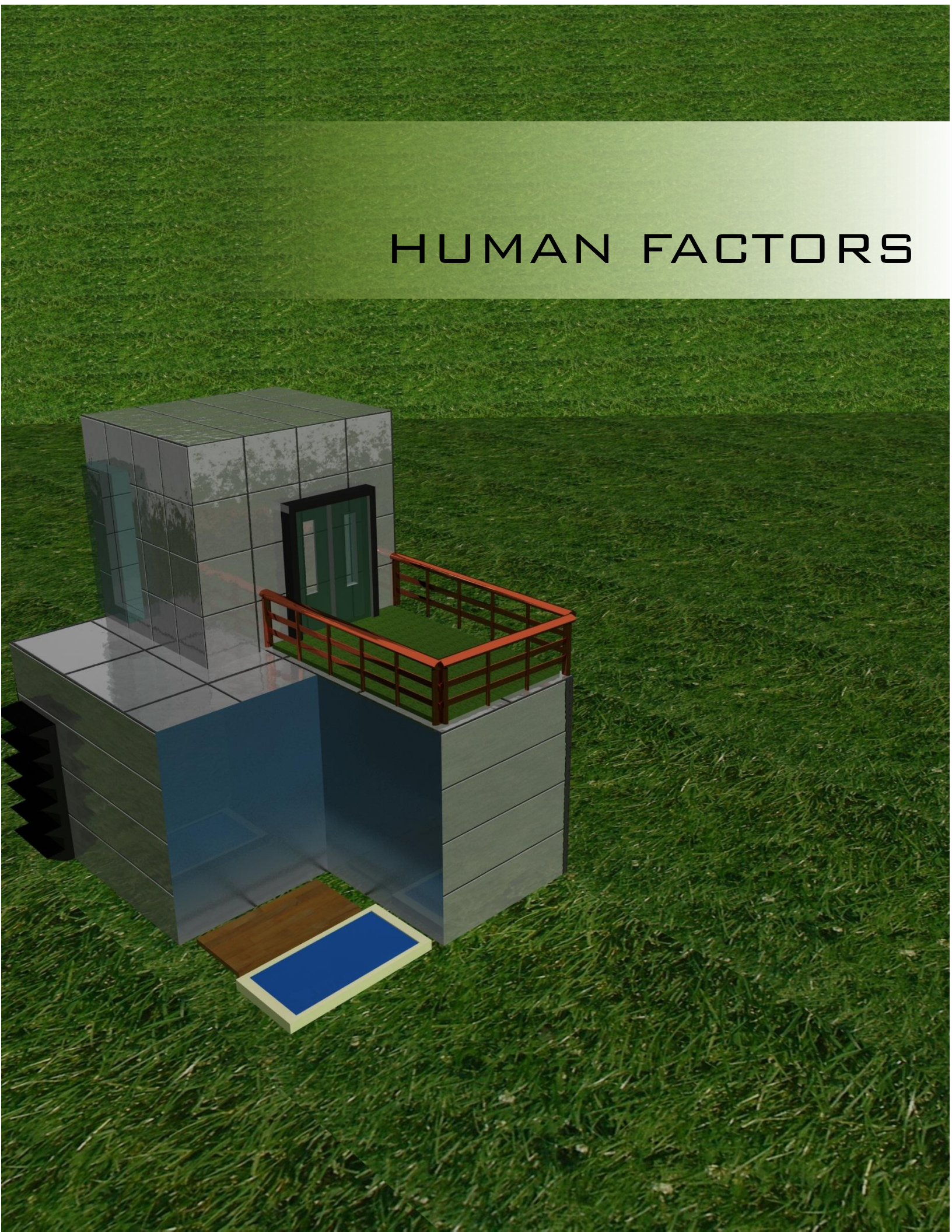


Fig. 3.7 Port facilities in the nozzle

The nozzles Ozzy1 and Ozzy2 have areas for docking, fuel storage, dirt storage and storage area for surplus agricultural production. Arshia possesses 5 large spaceships called Hebexy-L5 and 10 small spaceships called Hebexy-S10. These enter the settlement through Entarshia. The spaceships are then sent to the RZone for repair, maintenance and refuelling. The ore collected by these spaceships is transferred to the O.R.E system for further refinement. The spaceships pass through the passage and go through Extarshia to carry out further mining operations. The Hebexy-S10s are stored in the docks which are used during emergencies and for other export and import operations.

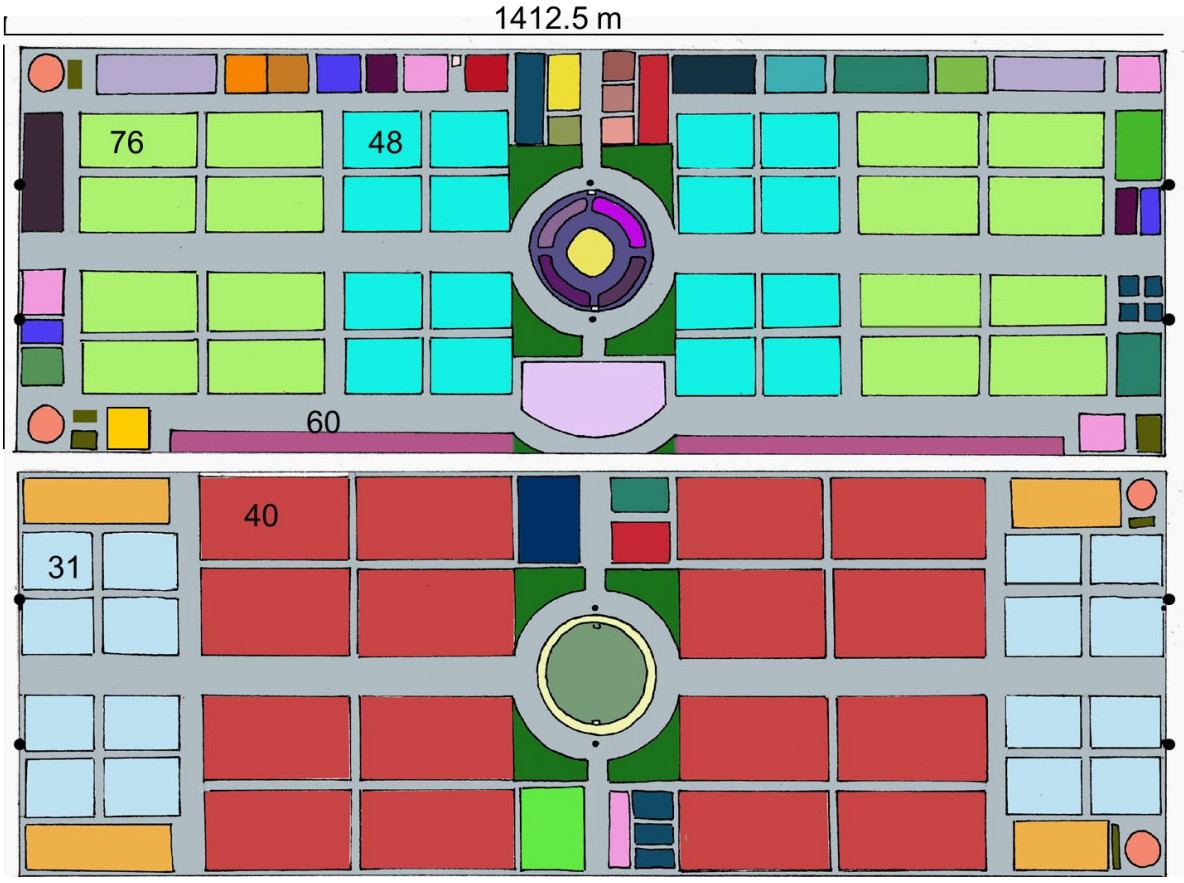
HUMAN FACTORS



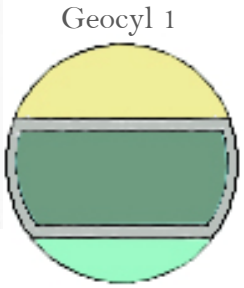
4.0 HUMAN FACTORS

Providing a comfortable and enjoyable living environment for all residents of Arshia, is the topmost priority of NorthdonningHeedwell. Keeping in mind the various psychological and physiological concerns of people living in an isolated environment for a long period of time, Arshia has been designed with striking features to provide a wholesome living for all Arshians.

4.1 COMMUNITY DESIGN



Figures in the community design indicate the number of homes present in each block. Roads and pathways take up about 28.57% area of the community. Geocyl 1 will be located 50 m below the control room, so as to facilitate easier access children, staying in the vicinity, to the educational centre.



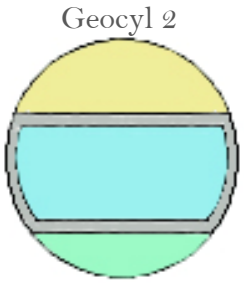


Fig 4.1 Community Design of the Residential Cylinder and the Geocyls

4.1.1 AMENITIES AND FACILITIES

a) Natural sunlight and views of space outside: Arshians enjoy natural views of the Sun, Mars, Asteroids and other celestial bodies through the electro-chromic glass surrounding the ResCom and the GeoCyl. (Refer 2.1.3)

b) Houses: Residents are provided with comfortable homes in safe localities, with easy access to various amenities. (Refer to Fig 4.1.1)

c) Recreation and entertainment: There are numerous facilities for recreation and entertainment to provide the residents with diverse choices

Malls and shopping outlets with high-end brands. **4-D theatres**, virtual laser gaming arcades.	**Libraries, museums, art galleries** which are not only history-based but also with information on life on earth and other settlements.	**Amusement parks** with rock climbing, roller coaster rides, car racing. Also snow park **Pluto**, where one can feel the chills of snowy Alaska.	**Water world** with beautiful water bodies and various water-rides providing water lovers an earthly recreation.
Clubs and pubs providing an interesting nightlife and leisure time.	**Cultural centres, media house** for integration and harmony of various cultures.	Sports complex housing variety of outdoor sports and **0-g super world simulation** in the central shaft.	**Goodlife** - A centre for wine, chocolate and cheese connoisseurs.
Restaurants and hotels for vacations and short holidays.	**Religious and spiritual centre** for peace and connection with oneself.	**Space observatories** for public use, especially children.	Parks and **open spaces** for children; green walks.

Table 4.1 Amenities and facilities

d) Health and grooming centre: Hospitals will be provided with rehab facilities, medical personnel and medobots (refer 5.2.2.A). These will have optimum facilities for diagnosis and prevention of all kinds of diseases. Gyms, spas and saloons are provided to pamper the residents.

e) Transport and communication: For transportation and communication within the ResCom the DHA system will be used. (Refer 3.2.6 & 3.2.7)

f) Education and research: The **Sky High School** will cater to the educational requirements of the children (600-700.) Courses are designed for **self-education.** Teachers and EDU-R9 guide students to self-education. Huge data pools are kept at the disposal of the students. This system caters to the **preschool, middle school, primary school, and secondary school**. Courses for graduation and beyond are made available through distant learning schemes with the help of u niversities on Earth and Alexandriat. Each student has a personal **Pinnsert** (For functions refer to 5.3.1.A) to facilitate learning. The school will have extra-curricular activity clubs for the all round development of the children through various enjoyable activities like: sports, performing arts, interactive sessions, etc. The edu-research centre will be dedicated to space research and mining technology and development of newer technology.

Fig 4.2 An EDU-R9 in School

g) Security and safety: Police/security, law and order and emergency/disaster response units will provide the residents a safe and secure life.

h) Banks, offices, commercial buildings and hotels: The Arshite hotel would have the facilities to cater to the rich as well as the middle class. It will be capable of accommodating 800 people on its sprawling premises. Offices and commercial buildings will cater to the **administration** (**Foundation Society**) and control. Entrepreneurs may lease offices.

4.1.2 PSYCHOLOGICAL AND PHYSIOLOGICAL CONCERNS

PSYCHOLOGICAL PROMBLEM	CAUSES	DESCRIPTION	PREVENTION / CURE
Isolation/ home sickness and general adaptation syndrome.	Remoteness of the settlement and distance from earth; artificial environment.	Neglect and isolation; inability to adapt surroundings and new pattern; longing for earth.	Integrated community; communication with earth; clubs; facilities like those on earth and earth like community design along with innovative features.
Claustrophobia	Cramped living and public spaces.	Panic attacks in small and confined spaces.	Long line of sight: front view 177m (approx) and a side view 76m (approx); spacious homes and open spaces in the community.
Interrupted sleep cycle (Hatzfeldt syndrome)	Un-earthlike day-night cycles; erratic work schedules.	Interrupts natural sleep schedule; irritability.	Proper sleep, rest and medical help in order to adapt the body to a new clock.
Solipsism syndrome	Artificial man-made environment.	Feeling of illusion and detachment from reality.	Recreation facilities; long line of sight; parks with trees and plants.
Multi-cultural issues and social conflict.	Inter- cultural population; clash of cultures.	Social tension; inability to accept new norms and integrate in the settlement's culture.	Clubs for residents to interact; museums and libraries for knowledge about other cultures; cultural centres.

Table 4.2.1 Psychological Concerns

PHYSIOLOGICAL PROBLEM	CAUSE	DESCRIPTION	PREVENTION / CURE
Dysbarism	Formation of bubbles of dissolved gases in the blood due to exposure reduced pressure areas	Joint pain; paralysis or even death.	Artificial gravity in the residential cylinder; use of space suits with pressure control and safety equipment in 0-g area.
Discomfort during motion (coriolis effect)	Coriolis force; More than 2 r.p.m.	Dizziness, loss of balance, disorientation.	Proper design of transport to ensure minimum head movement; settlement rotates at less than 2 r.p.m.
Decreased production of RBCs (anemia)	Prolonged exposure to micro-g environment	Dyspnea; fatigue	Proper diet; intake of iron supplements, vitamin B-12, vitamin C, epoetinalfa
Osteoporosis (de-calcification of bones)	Continued exposure to micro-g environment.	Weak and brittle bones.	Artificial gravity; proper physical exercise.
Space Adaptation syndrome	Weightlessness; micro-gravity.	Dizziness; nausea; lack of balance and disorientation.	0.9g gravity is provided; proper head movement exercise; pneumatic boots.

Table 4.2.2 Physiological Concerns

4.1.3 CONSUMABLES

CATEGORY	PRODUCT/ DESCRIPTION	AMOUNT REQUIRED	SOURCE	DISTRIBUTION SYSTEM
Food	Refer to table 4.3.2	5,238,590 kg/yr	AgroCyl.	• All consumables except space-suits and Pinnserts are transported to the RESCOM through the 'DHA'. Distributed to the residents through shopping malls, stores and the Interlace System. • Space-suits and Pinnserts will be distributed to the residents on Alaskol
Medicines	Vitamins, vaccine, suspension, pills and tablets.	3,274 kg/yr	Cylind	
Clothes	Formals and casuals (stain and crease resistant)	13,000 units/month	Cylind	
Space-suits and Pinnsert.	Dust and pathogen resistant; radiation shielding.	11500 units(initially)	Cylind	
Stationery	Paper, pen/ pencil, etc.	700,000 kg/yr	Cylind	
Toiletries and personal grooming products	Body wash, cosmetics, tissues, toilet-paper, detergents, dental care products, etc.	96,600 kg/yr.	Cylind	
Sports products	Micro-g gears, basket-ball, pool table, racquets, etc.	10,113 kg/yr	Cylind	
Gadgets	Gaming/ networking systems, communication system, etc.	700,000 units/ 5yr	Cylind	
Furniture & appliances	Refer to table 4.2.1.			

Table 4.3.1 List of Consumables

VARIETY OF FOOD GOODS	QUANTITY OF FOOD GOODS/ PER PERSON PER YEAR (kg)
Milk (and its products)	162.5
Breads and cereals	114
Meat	32.5
Beverages	180
Fruits and vegetables	162.5
Oils and fats	14
Spices, sugar and other products	55

Table 4.3.1 List of Food

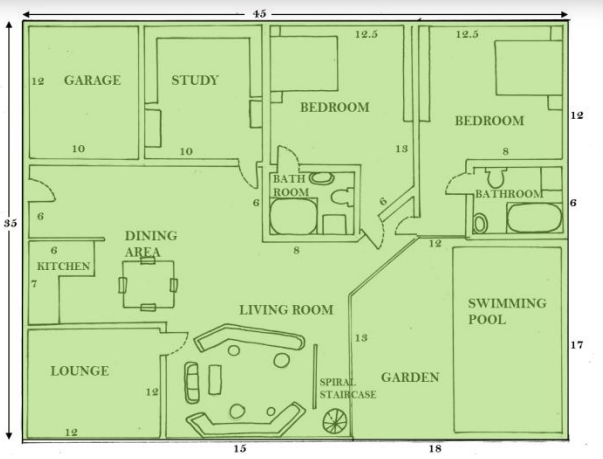
4.2 RESIDENCES

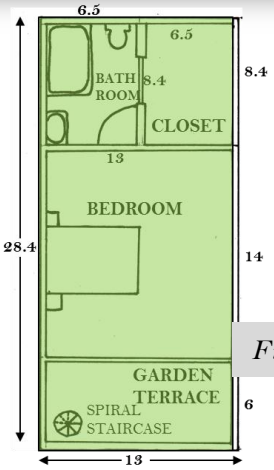
Residents will be offered four home types. Each of these are designed keeping in mind the requirements and demographic division of the population. The four home plans along with the exterior models:

FEATURES	HOME DESIGN #1	HOME DESIGN #2	HOME DESIGN #3	HOME DESIGN #4
Area/ Home	1,944 sq. ft.	1,902 sq. ft.	1,450 sq. ft.	2,000 sq. ft.
No. of Units	502	733	2,558	120
No. of Storeys	G+1	G+1	G+ 1	G
No. of Occupants	3-4 (Couple + children)	2 (couple)	2 (2 singles)	3-4 (high income class)
Interesting Features	• All glass doors and sliding doors are made of electro-chromic glass. • Foldable light weight furniture 4.2.2. • Bamboo flooring and foldable bamboo furniture.			

Table 4.4 Residences

4.2.1 HOME DESIGNS





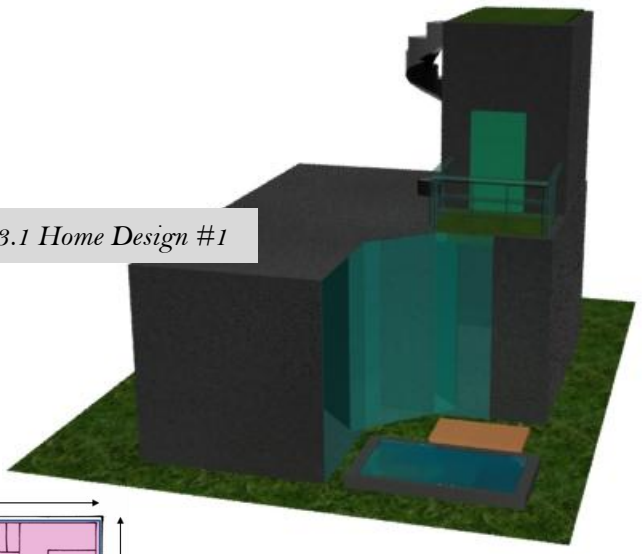
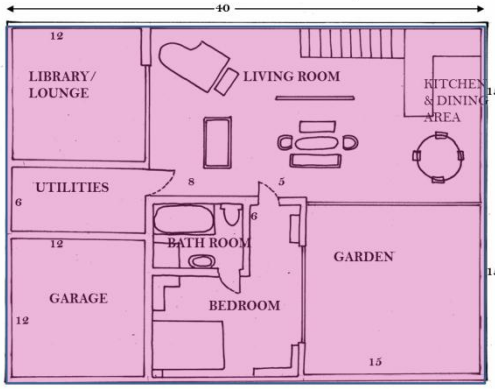
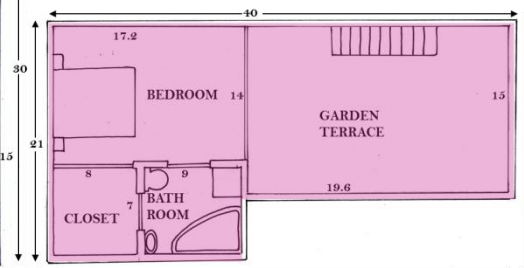
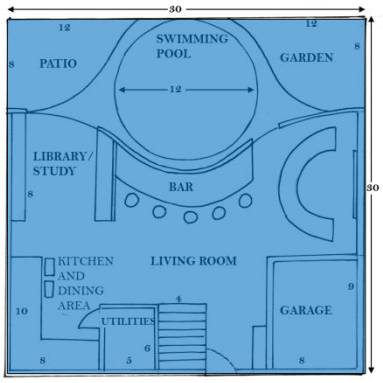


Fig 4.3.1 Home Design #1

Fig 4.3.2 Home Design #2







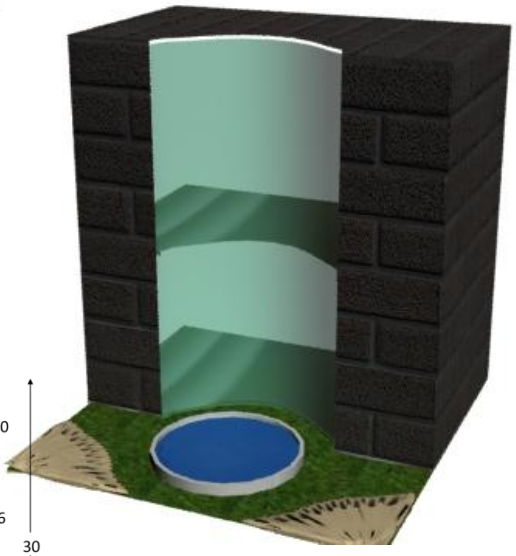
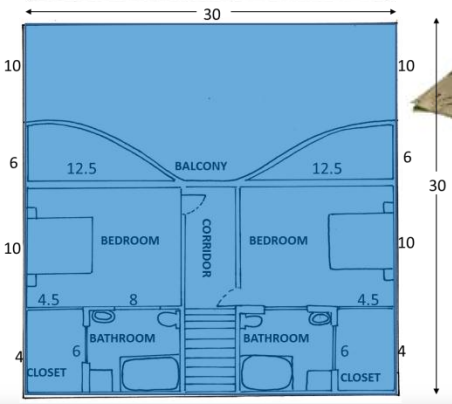


Fig 4.3.3 Home Design #3



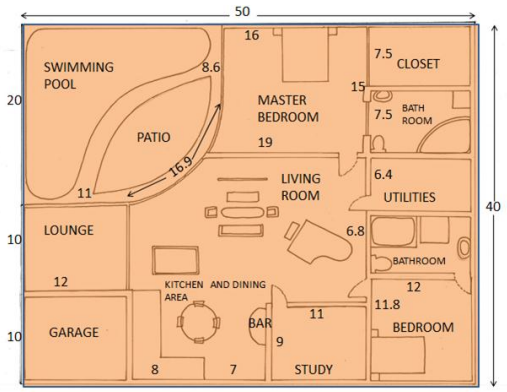


Fig 4.3.4 Home Design #4

4.2.2 FURNITURE AND APPLIANCES

Arshia will provide inhabitants with unique furniture made out of bamboo grown in the AgroCyl. This ensures that the **furniture is light weight, hardy, flexible and cheap**. Sofas, beds, couches, etc. are made with corrugated sheets (made out of bamboo) having accordion like folds. These can be **folded to a desired size**, and **help optimise space** in homes and offices. Cabinets, chairs, desks, cupboards will be made out of bamboo ply-wood. These are both durable and cheap. And they can be **folded innovatively** to suit the whims of the residents and can be used to give homes new looks. Offices and homes will be provided with state-of-art appliances and gadgets.

HOME / OFFICE FITTINGS	PRODUCT	QUANTITY / 5 YEARS	SOURCE / MANUFACTURE	DISTRIBUTION
Furniture	Beds, sofas, chairs, desks, couches, cabinets, cupboard etc.	700,000 units	Industries in the settlement. Bamboo produced is processed in industries.	Transported to the RESCOM through the DHA and the interlace. Distributed to the residents through shopping malls and stores.
Appliances (including kitchen-ware and bath-ware)	Home theatre, mood lighting system, music systems and temperature control system and Robots.	1,178,500 units	Manufactured in industrial cylinder.	

Table 4.5 Sources, Quantity and Distribution of Furniture and Appliances

4.3 SPACESUIT DESIGNS

The space suit subsystems are conceived to allow the explorer, the same ease of use as ordinary clothing; eventually the entire system is envisioned to give a 'second skin' capability to the wearer. The suit is based on the principle of mechanical counter pressure. A unique feature of our space suit is that, instead of giving a hard torso which although supports the PLSS, SOP, radio, battery and 'Floydon', but also restricts movement; it just has a hard module which supports all of the above. This space suit provides 'gecko tape boots' for easy grip in micro gravity and 0 gravity areas. The tool pocket provides tools, tethers, as well as gun type tether for easy access to long distances.

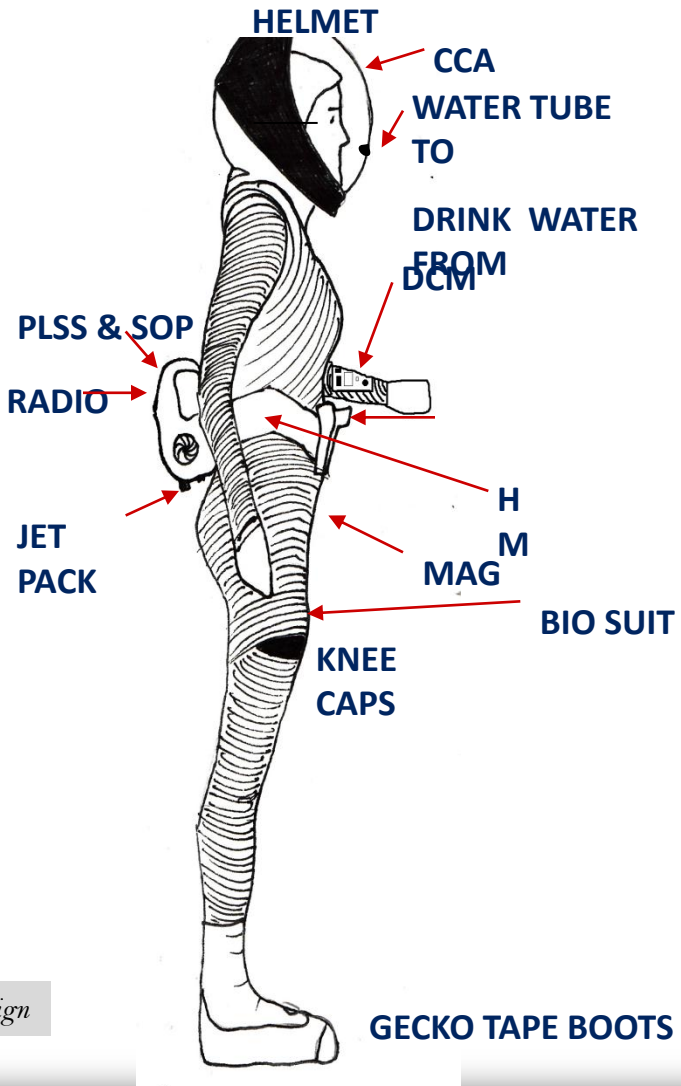


Fig 4.4 Spacesuit Design

COMPONENT	FUNCTION/DESCRIPTION	MATERIAL	ADVANTAGES
Maximum Absorbency Garment (MAG)	It absorbs urine and feces.	1. MicroFiber 2. Sodium Poly-acrylate	**Sodium Poly-acrylate can absorb around one thousand times its weight in water.**
Liquid Cooling &Ventilation Garment (LCVG)	It incorporates a network of fine tubing through which water is circulated. Controls body temperature along with the bio suit and computerized temperature control system.	1. Spandex 2. Nylon Tricot	**1. Highly elastic and flexible.** **2. Comfortable**
Electric insulation	Provides insulation against the electro-spinlacing of the bio suit.	BOPET film or Mylar	**1. Di-electric strength.** **2. Physical toughness**
Bio Suit	Electro-spinlacing provides seamless Mechanical Counter Pressure layer. 5 mm thick ribbed bladder providing 55 kPa pressure (214 mm of hg /8.0 psi). Small pads are placed on various concavities of the body to keep them in contact with the space suit.	1. Kevlar fibers. 2. Neopropene rubber. 3. Piezo-electric materials like lead zirconiatetitanate (PZT). 4. Smart memory alloys. 5. Spray on urethane inner layer.	**1. Lighter, skin fit.** **2. Easy to don and doff.** **3. Pressure of 55 kPa eliminates need for pre breathe.** **4. Porous material allows wearer to sweat out; reduces work of thermal control system.** **5. Piezo Energy Generator (PEG) Module converts mechanical strain into electric charge and vice versa. Moreover it allows to control pressure.**
Thermal Micrometeoroid Garment (TMG)	1. Abrasion resistance 2. Radiation shielding 3. Protective restraint layer 4. Supports MAG and LCVG	1.Dacron 2. RXF1 3. Inner layer of nylon rubber	**Dacron-** **1. Light weight** **2.High tensile strength** **3. Can survive low temperatures.** **RXF1-** **1.Strong and light** **Nylon rubber-** **1. Good insulator**
Hard Module (HM)-replacing the Hard Upper Torso (HUT)	1. Supports PLSS and SOP	Fiberglass	**1.Strong** **2. Heat insulator**
Helmet	**1. Pressurized.** **2. Provides clear view** **3. Fan to move away the perspiration from the face, and prevent fogging up the helmet.**	**1. Clear Polycarbonate plastic.** **2. Avobenzone and Octyl Methoxycinnamate**	**Polycarbonate plastic-** **1. Unbeatable strength** **2. Light weight** **Avobenzone and Octyl Methoxycinnamate:** **1. Transparent shielding** **2. light weight**

Table 4.6.1 Spacesuit Components

COMPONENT	FUNCTION	FEATURE
Primary Life Support System (PLSS)	Controls all life supporting functions- 1. Providing oxygen 2. Scrubbing carbon dioxide 3. Maintaining pressure 4.Water for LCVG It includes radio, battery, Pinssert and the positioning system.	1. Provides almost 1.2 lb / 0.54 kg (at 518 atm tank pressure) oxygen 2. Provides almost 10 lb / 4.6 kg total water 3. Scrubs almost 240 litres of carbon dioxide 4. Pinssert positioning system 5. It is a "micro" PLSS, where all the equipments have been compressed, so as to reduce their size and weight on the wearer's body.
In-suit Drinking Bag (IDB)	Provides drinking water to wearer. Mounted inside HM in a pouch. Consists of a tube and straw. Contains about 1.9 litres of water.	There is also a slot in the helmet for a rice-paper-covered fruit and cereal bar that the astronaut can eat if he or she gets hungry during the spacewalk. The bar is designed so that the astronaut can take a bite and pull the remainder up. The entire bar must be eaten at once to prevent crumbs from floating within the helmet
Secondary Oxygen Pack (SOP)	Fits below the PLSS on the backpack frame.	Contains 2.6 lb (1.2 kg) of oxygen which will suffice for two hours which is enough to get back to the settlement. This oxygen supply automatically turns on when the oxygen pressure in the suit drops below 0.23 atm.
Communications Carrier Assembly (CCA)	It contains microphones and speakers for use with the radio.	It allows hands-free radio communications within the suit.
Display and Control Module (DCM)	It is mounted on the inside of the left arm and is used to control the working of the PLSS or any other component.	It contains all of the switches, gauges, valves and LCD displays necessary to operate the PLSS. The DCM, with the help of the Pinssert will give holographic views, assisted with audio facility for easy access and operation.
EMU Electrical Harness (EEH)	This is a set of communication wires and bio-instruments that is worn by the astronaut inside the suit. It provides connections to the radio and bio-instruments in the suit's backpack.	It allows for communication and for monitoring of the astronaut's vital signs (respiration rate, heart rate, temperature, etc.) and keeps the control room in the settlement.
Extravehicular Visor Assembly (EVA)	The EVA fits over the helmet. It helps in communication, operation and safety.	It contains: • A metallic-gold-covered visor to filter sunlight • A clear, impact resistant cover for thermal and impact protection • Adjustable blinders to block sunlight • Four head lamps • A TV camera

Table 4.6.2 Important Spacesuit Components

Airlocks will be accompanied with mechanical helpers (Mech R-9) (Refer to *5.3.3*) who will assist in the donning and doffing process.

4.3.1.1 DONNING

1. The MAG is put on and airlock is entered and atmospheric pressure is gradually reduced to 0.7 atm. Pre-breathe of 100 percent oxygen for 30 minutes to remove nitrogen from their blood and tissues. This allows the space-walking astronauts to pre-breathe oxygen for only 30 minutes before they enter their space suits- The purpose of this is to eliminate any dissolved nitrogen in the body that may come out when they put on their Space suits. **2.** The LCVG is then put on. And the Bio suit is zipped up, before which urethane is sprayed on. Subsequently, the TMG is also zipped.
3. The PLSS is then mounted onto the hard module which is donned next and coupled to the hip. The DCM will then be mounted on the inside of the left arm. **4.** The helmet is rubbed with an anti-fog compound. CCA is checked for proper functioning and is put on after which the helmet is donned. Then the gloves and boots are put on. **5. Airlock** pressure drops to 0.3 atm. Mechanical helper checks suit for leaks. The astronaut is now prepared to leave.

4.3.1.2 DOFFING

1. On entering the airlock, the Pressure is dropped to 0.7 atm. **2.** Helmet is removed. Hard module is subsequently removed along with all the attachments. **3.** The two layers of bio suit and TMG are unzipped and removed. **4.** Suitable clothes are worn. Subsequently atmospheric pressure is increased to 1 atm. Then the door to Arshia is opened.

4.3.2 AIRLOCKS

Spacesuits will enable movement between pressurized and unpressurized or low pressurized zones. Airlocks have been adequately designed to carry out the essential function of allowing people to move between areas of different pressures, minimizing the change in pressure and loss of air from the initial pressurized area. It will be a chamber with two air tight doors at the end. It provides a proper breathing environment for the person. The person enters the airlock and the pressure is gradually reduced to 0.7 atm and reduces further. This air is pumped using specialized pipes.

Fig 4.5 Airlock

When the occupant has stayed the stipulated time to prevent decompression sickness, the second door is opened leading to the area with different pressure. The gradual change in pressure reduces air temperature fluctuations, reduces stress on air seals and more importantly prevents decompression sickness. It is then closed.
For re- entry, a glass wall comes down; mechanical helpers enter and help in dust mitigation. Afterwards, the same procedure is followed with pressure being adjusted gradually according to the difference in pressure in the environment outside and inside with the specialized pipes providing the compressed air again. The occupant is again made to spend the stipulated time and then allowed to re-enter.
For entry into unpressurized zones, the airlocks will follow the same procedure and reduce it to the suitable pressure in the environment outside, Airlocks will be positioned on the entrance to the DHA, which will connect the three cylinders as well as help in transport to the ports. Moreover airlocks will be automated to perform the above functions

4.3.3 SYSTEMS AND DEVICES

Systems and devices have been adequately designed to help movement in low g and unpressurized areas.

The Pinnsert will be equipped with a positioning system and the person in the above mentioned areas will be tracked by the control room. The spacesuit will be equipped with a control panel, radio and communications carrier assembly to facilitate communication with the control room.

The spacesuit will also be accompanied with tethers and gun type tethers for easy access. The exterior structure of the settlement will have hooks all around for attachment onto the settlement. Moreover hooks will be present all along the DHA and low g areas for support and easy access. These tethers will be built using silicon carbide, as it is chemically inert, strong, has high elastic modulus, tensile and low in density and survives temperature extremes.

Handrails will be provided throughout DHA to provide grip and to prevent people from floating away. The spacesuits will also have gecko-like tape boots. (Refer to 3.2.7)

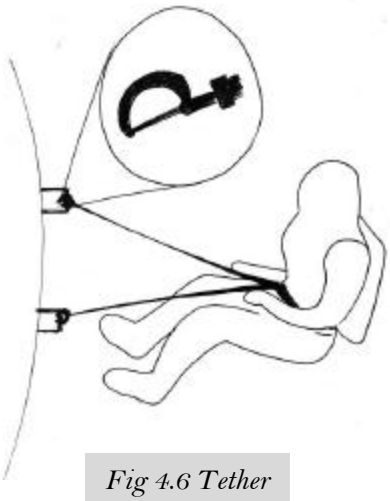
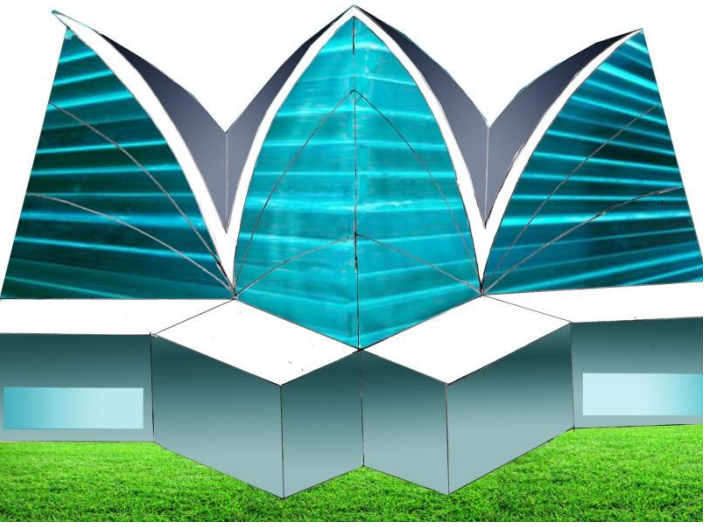


Fig 4.6 Tether

4.4 MEANS FOR CHILDREN TO SPEND TIME IN 1g



Special care has been taken to ensure that children are exposed to 1g for at least 4-5 hours daily. This is made possible by constructing the school in the Geo-Cyl which has 1g (For location and space usage by schools in the GeoCyl, refer to Fig 4.1).

During vacations it is advised that children come for the extra-curricular activities club for at least 3 hours/ day.

The option of an Observatory in the 1g area has also been provided to the children to enhance their curiosity.

Pluto- the Snow Park has been offered as well for the enjoyment of the children while they are in 1g areas.

Fig 4.7 A School in the 1g area (GeoCyl)

4.5 INSTANT MOVE-IN HOMES

Arshia endeavours to create a warm home-like environment for its semi-term residents. They will be offered with instant move in homes of various sizes (according to their requirements- 1800/ 1200/ 900 sq. ft). These homes will be fully furnished and stocked with daily consumables and essentials. **Northdonning Heedwell** proposes to construct **1,217 instant move-in homes.** Semi-term occupants can integrate into the society by joining clubs and interacting with fellow residents.

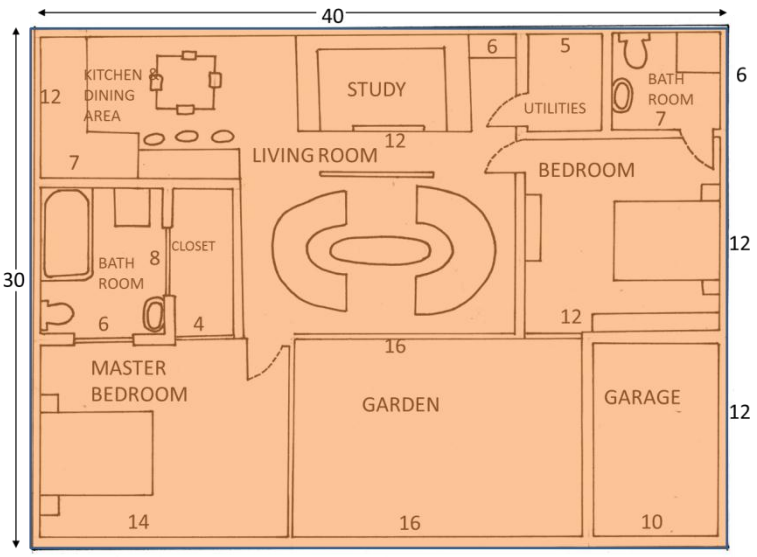
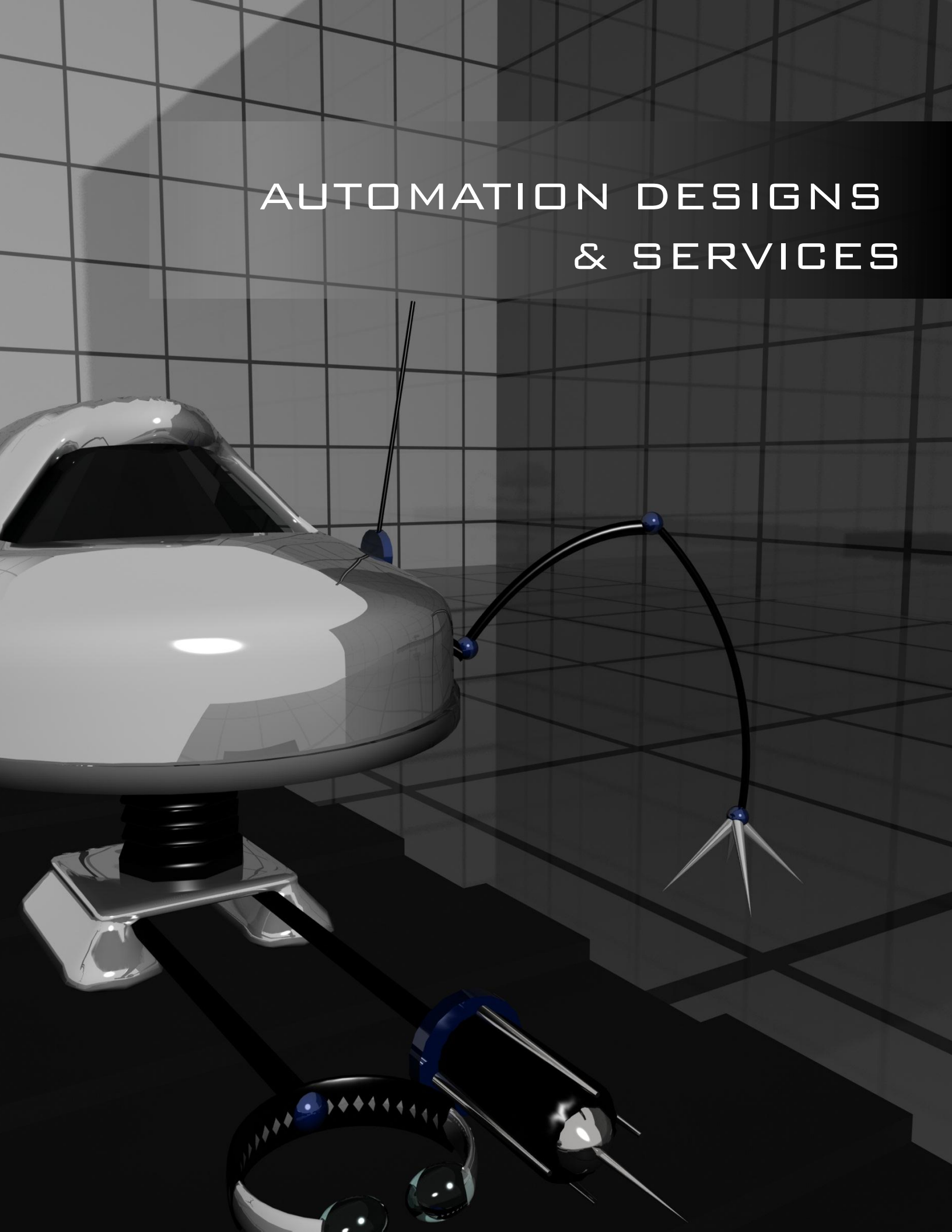


Fig 4.8 Floor Plan of a 1200 sq. ft Instant Move-In Home



AUTOMATION DESIGNS & SERVICES

5.0 AUTOMATION DESIGNS AND SERVICES

Northdonning Heedwell has designed the entire Automation Services of Arshia such that human effort is minimized. The residents of the settlement are provided with all facilities for better adaptation and to make their lives very comfortable. Construction of the settlement is carried out in steps by the use of advanced machines for construction in space. Cloud computing and Pervasive Network Communication help in extremely fast communication and ensure high security. Moreover, security of all kinds of data is ensured by various identification systems. This section also elaborates on the machinery used by Arshia for mining 6-Hebe.

5.1 AUTOMATION FOR CONSTRUCTION

Northdonning Heedwell shall provide efficient and high-tech robots for expedient and detailed construction of Arshia. The materials extracted from 6-hebe, Mars, Bellevistat, Alexandriat and the Moon shall be used proficiently. In this way, the exterior and interior construction of Arshia shall be completed in a cost-efficient, swift and meticulous manner to build a solid structure to support the entire settlement.

NAME	FUNCTION	DESCRIPTION	QTY
Crabbot E-8	Carries out the main exterior construction process of the entire settlement. Forms Crabbot I-8 when this task is completed.	Made of titanium and steel. Coated with cenosphere to protect from solar flares. Has four long foldable arms extending from centre. The ends of the arms have clamps with tools required for the construction. Has storage volume for storing construction material. Each E-8 has a Control and Sensing Unit (CSU) passing through its centre, monitored by Ozzy 1. Several E-8s join together to form a circular ring according to the size of the circumference of the cylinder which is being constructed at that time.	900
Crabbot I-8	Interior building, finishing, tiling, pipe laying and construction of roadways, parks, etcetera is done by the Crabbot I-8	A modified Crabbot E-8 with a similar CSU monitored by the Ozzy 2. I-8s join together to construct and finish buildings and other community infrastructure. The tools on its clamp include drillers, screws, and brushes for complete construction.	900
Movits	For movement of all machines, cargos, construction material around the settlement.	T-shaped robots. Made of aluminium and titanium. The top is an adjustable clamp and the bottom has an inbuilt control and memory storage system. The retractable clamps adjust themselves in such a way that the T-bots can fit together in one system monitored by a main board.	100

Table 5.1 Automation for Construction

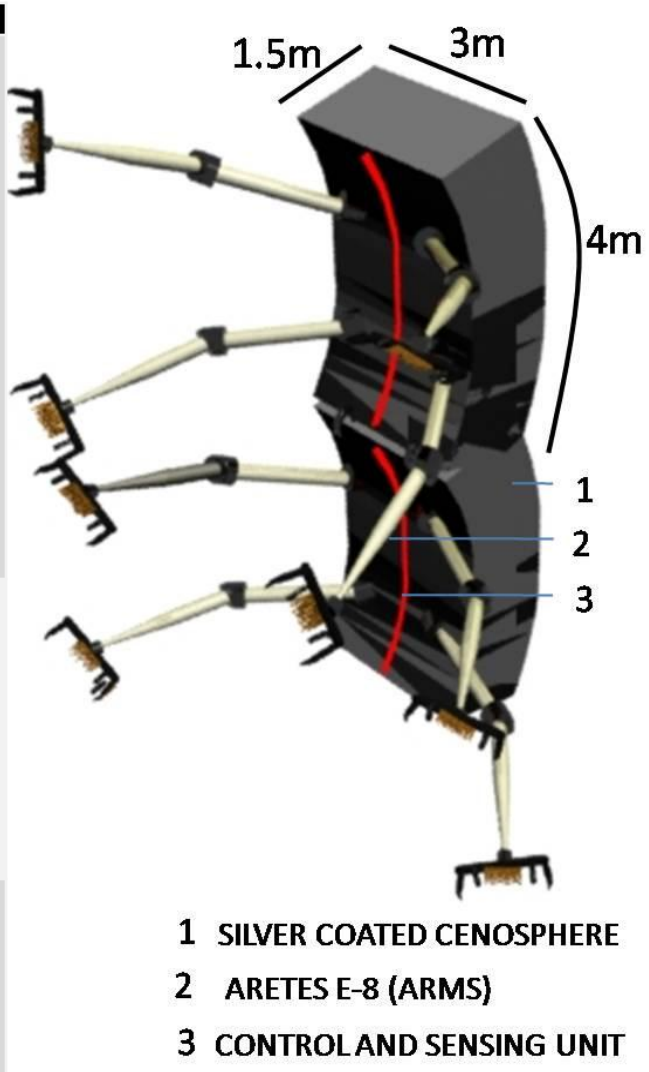


Fig. 5.1.1 2 Crabbots linked together

For the initial exterior construction of the settlement, the nozzles, Ozzy 1 and Ozzy 2 will be assembled in Alaskol on the moon and launched from there. Ozzy 1 will contain the main construction robots called Crabbot E-8s and the material required for exterior construction and shielding. Ozzy 2 will contain the materials for construction of the interiors and interior finishing. Both the nozzles have positioning monitors and control units. Each Crabbot has a sensor which is instructed by the control unit.

First Ozzy 1 is launched and it places itself in the required orbit (Refer to section 2.3).The Crabbots are then released to start the construction process. Once each cylinder has been built, Ozzy 2 is launched. Ozzy 2 releases the materials required for all the interior constructions with the help of transportation robots called Movits and attaches itself to the other end of the cylinders, thereby completing the exterior structure. The control unit of Ozzy 2 then instructs the Crabbot E-8s to be modified to Crabbot I-8s which carry out the interior construction.

5.2 AUTOMATION FOR REPAIR, MAINTENANCE AND SAFETY

The state-of-the-art technology used by Northdonning Heedwell shall provide efficient repair and maintenance facilities. It shall inspect and repair both internal and external loopholes at all times to ensure the smooth running of Arshia. Networked robotic devices in smart environments, called "Ubiquitous Robotics", shall provide a radically new way to build intelligent robot systems in the service of people.

NAME	FUNCTION	DESCRIPTION	SIZE	QTY
Cattepede	External maintenance and repair. Various tasks such as painting, tightening screws, welding and drilling.	Coated with silver-coated cenosphere for protection from solar flares. Several body compartments with multi-tasking hands.	8m x 1.5m x 3m	40
Crabbot mr-8	Internal maintenance and repair- renovation of buildings, cleaning public spaces, disposal of garbage, repair of glitches in other automation systems.	Re-modified Crabbot I-8s	4m x 3m x 1.5m	700
Medobots	First-aid and transportation of patients to hospitals	Storage unit for keeping various medical paraphernalia. Two medobots join together to form a stretcher.	1.65m x 0.5m x 0.5m	1000
Polarshia	Security and public safety	Police like robot with antennas to sense frantic movements or screams for help. Arms with stun guns, tranquilizer guns and handcuffs. Pinnsert of the criminal shall be de-activated as soon as a polarshia attacks, to block services provided in Arshia.	1m x 1m x 1.5m	320

Table 5.2 Automation for Repair, Maintenance and Safety

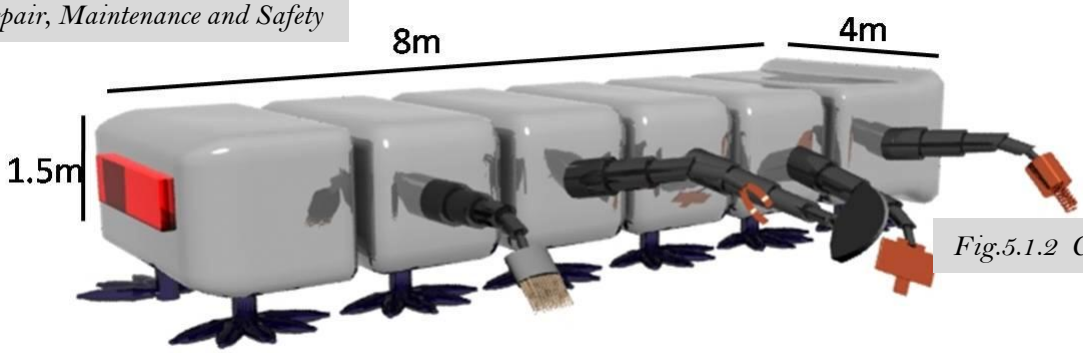


Fig.5.1.2 Cattepede

5.2.1 AUTOMATION FOR REPAIR AND MAINTENANCE

Repair and maintenance of Arshia shall be carried out by a variety of robots which shall be re-modified so that Northdonning Heedwell can save the Foundation Society a lot of money by not having to build new robots. The Crabbots are re-programmed to carry out internal maintenance tasks. The robots are dispatched to the concerned area in case of any damage which is blocked temporarily till the problem is revamped. The robots have a storage unit with numerous tools and paraphernalia which are used as per the requirement. **The Cattepedes or exterior maintenance robots are coated with silver-coated cenospheres for protection from solar flares. Immediately after a solar flare, the robots are assessed for any kind of damage and immediately repaired.**

5.2.2 AUTOMATION FOR SAFETY

Northdonning Heedwell takes full responsibility in ensuring a safe and healthy environment for all Arshians.

5.2.2.A MEDICAL SAFETY

Level 1: **Stay-fit Pills** consumed by all residents each month monitor the health-conditions of all users and provide reports regarding the user's health, along with monitoring of diet and exercise

Level 2: In case of emergencies, **Medobot** sensors are activated on receiving a call for help through Pinnsert. They will provide first aid to the affected person, till the time they transport him/her to the nearest hospital. Two medobots can together form a stretcher to carry the patient. They shall contain specialized tools in their storage unit such as CPR kit, ECG scanner, blood-pressure monitor, sterilized gloves, injections, etcetera.

Level 3: Patients in a critical state are provided excellent medical facilities at the **hospital** and are treated by qualified doctors, assisted by robots.

5.2.2.B PUBLIC SAFETY

The Polidofense system consists of emergency posts in the entire settlement at a distance of 150 m each. These consist of movement and voice recognition systems designed to identify frantic actions or distressed screams. As soon as the sensors are activated, Polarshias with transponder devices are dispatched to the concerned area. The robot can use either a stun gun or tranquilizer gun to immobilize the criminal.

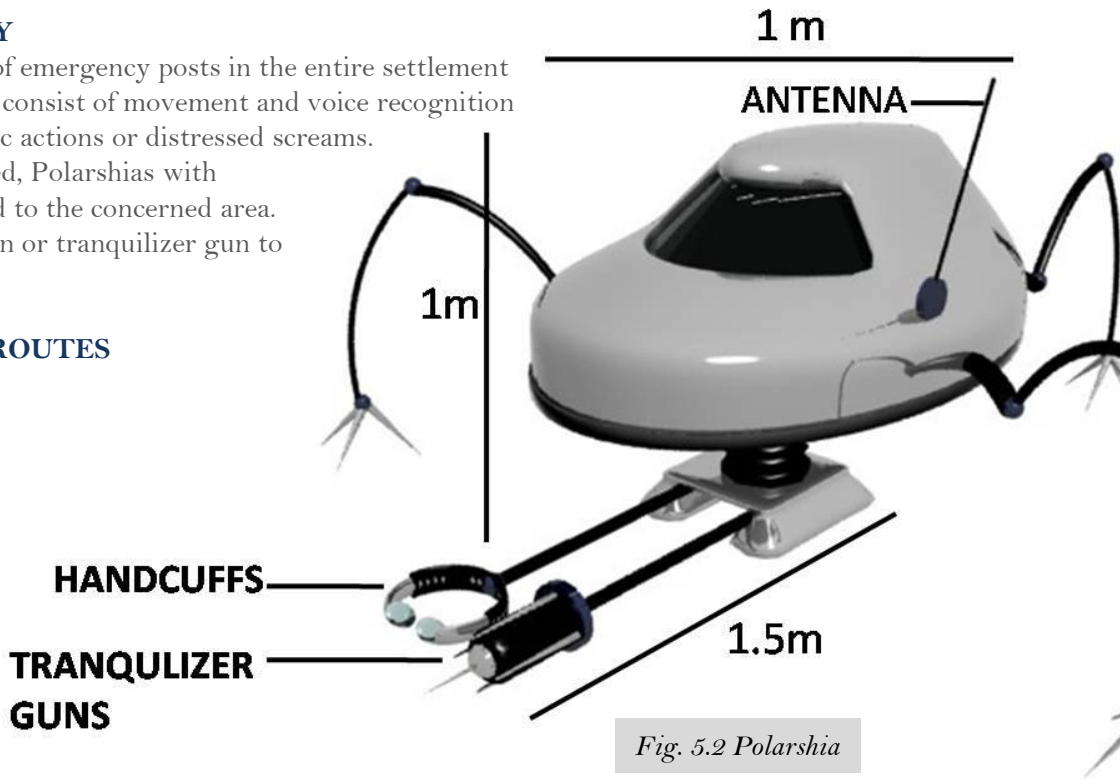


Fig. 5.2 Polarshia

5.2.2.C EVACUATION ROUTES

Arshia has two evacuation plans in case of emergencies:

- In case of a minor hull breech due to collision, entry to the affected section is restricted. The residents of that area are temporarily shifted to the **Cylind** (Industrial Cylinder), where instant move-in houses can be constructed by the 200 extra Crabbot I-8s to accommodate the people.
- In case of a large scale emergency, all residents will immediately don their spacesuits and be transferred to the nozzles. The nozzles and the central shaft will then detach themselves from the rest of the settlement. Since the nozzles contain additional food, fuel and water, it can sustain people up to 20 days, by which time repair work shall be carried out.

5.2.2.D BACK UP SYSTEM/CONTINGENCY PLAN

POSSIBLE PROBLEMS	POINT OF OCCURRENCE	BACK UP/CONTINGENCY PLAN	RESPONSE TIME
FIRE		Alert all residents immediately.	45 seconds
- Class A	Residence and Agriculture areas	Water-based extinguisher	
- Class B	Propulsion system and fuel storage areas	Foam-fire extinguishers	
- Class C	Electrical wires and equipment	Dry-powdered extinguishers	
- Class D	Equipment made with combustible materials	Dry-powdered extinguishers	
- Class K	Kitchens	Wet Chemical extinguisher	
DEBRIS COLLISION	Exterior of the entire settlement	Refer to section 2.4	15 seconds
FOOD / WATER SHORTAGE	Residential areas	Back-up storage food in nozzles for 10 months	N/A
EXPLOSIONS	Mining base, industries	Type A, B, C, D and K extinguishers used to put out fire. Damage repaired by robots. Medobots deployed to treat people.	1 minute
TRANSPORT-RELATED ACCIDENTS	Transport system – internal and external	Vehicles repaired or replaced.	2 minutes
TREMORS	Entire settlement	Presence of shock-absorbant materials in protective outer layer (Refer to section 2.1.2)	Protecting at all times
NETWORK FAILURE	External and internal communication systems	Immediate identification of problem and rectification	5 minutes

Table 5.3 Backup Sustem/ Contingency Plan

5.2.3 ACCESS TO CRITICAL DATA BY AUTHORIZED PERSONNEL

LEVEL I : RESIDENCES AND OFFICES			
METHOD OF AUTHENTICATION	FUNCTIONING	PEOPLE GIVEN ACCESS	RELIABILITY
Passwords, fingerprint recognition, DNA testing through salivary swab	Only after the user passes all 3 tests can he/she enter his home.	Residents, workers, short-term and semi-term occupants	60%
LEVEL II: AGRICULTURAL AREAS			
Passwords, fingerprint recognition, Jaw scan	It allows access to a minimum of 3 individuals at a time to the designated areas. No individual can enter alone. All 3 individuals have to pass all 3 scans to enable access.	Agriculturalists	80%
LEVEL III: INDUSTRIAL AREAS			
Passwords, fingerprint recognition, micro-expression	Industrialists are allowed 4 at a time. All 4 individuals have to pass the 3 scans to gain access.	Industrialists	90%
LEVEL IV: CONTROL ROOM AND DOCKING PORTS			
Passwords, fingerprint recognition, retina scan, jaw scan, DNA test through blood prick	Allows access to a minimum of 5 individuals at a time. No individual can enter alone. All 5 individuals have to pass all tests to enable access.	Authorized personnel and technicians	98%

Table 5.4 Access to Critical Data by Authorized Personnel

Any access to unauthorized activity as detected by the control parameters of the computer will lead to immediate disabling of all access permits.

5.3 AUTOMATION TO ENHANCE LIVABILITY

NorthdonningHeedwell shall provide a vast array of automated devices and tools, which shall augment not only the business activities but shall also, provide a conducive environment for Arshians to live in, thus accelerating the Foundation Society's goals for Arshia.

5.3.1 LIVABILITY AT COMMUNITY LEVEL

5.3.1.A PINNSERT

The most essential automation device, which shall be embedded in the earlobe of all Arshians is called Pinnsert, based on voice recognition system. It is a multifunctional gadget which when in use shall project a holographic monitor, with a menu to perform any of the following functions:

- Serve as the owner's personal computer with high-speed internet facilities and information processing storing large amount of data based on nano storage. (This refers to usage of metallofullerenes or carbon "cages" with embedded metallic compounds as materials for miniature data storage devices. Metallofullerenes are capable of forming ordered super molecular structures with different orientations. By specifically manipulating these orientations, data will be stored and subsequently accessed.)
- Control and monitor Resobots
- E-banking and shopping including purchase of grocery requirements, food, clothes, etc. On placement of order, the commodity shall be sent via the DHA to the residential cylinder from where goods are delivered to the door-step using the interlace system.

Fig. 5.3 Pinnsert

- Serve as information and news portals to all the residents of Arshia.
- To activate a Medobot to approach in case of any medical problem.

Pinnsert shall work on the principle of *PERVASIVE NETWORK COMMUNICATION (PNC)*. Those wearing spacesuits in outer space can also enjoy the functions of pinnsert. Incase of any problem, the control unit can be intimidated back on Arshia for help using this device.

5.3.1.B REDUCTION OF MANUAL LABOUR

- Internal maintenance robots shall regularly clean streets, parks and roads.
- Resobots, pinnserts, specoview also help in reducing manual labour.

5.3.2 PRODUCTIVITY IN WORK ENVIRONMENTS

5.3.2.A SPECO VIEW :

3-D glasses called SpecoView are worn during work hours with following functions:
1) It reads the user's brain and thought processes. It can be monitored and edited by the individual only.
2) Worn during the working hours, it keeps track of the activities of the employees.
3) It is the virtual computer of the worker. It has additional features such as that of a camera, and a microphone.

5.3.2.B SPECONETWORK

All workers are connected via speco-network. The work-related information posted by various people is available on this portal and can be accessed by other workers, thus creating a link between different working sectors.

5.3.3 MAINTENANCE AND ROUTINE TASKS

NAME	FUNCTION	DESCRIPTION	QTY
AGROBOT	Sprays minerals in the aeroponic chambers. Harvests the plants as per required i.e. Seed, leaf, root, etc. Also maintains the inclination of the plant and regulates temperature and sunlight for faster plant growth.	1. Made of aluminium. 2. Spouts at the base spray minerals 3. Has air-jets to move around in the aeroponic chambers. 4. Retractable arms to collect ripened crops and place in storage unit to take to Agrocyl.	380
INDOBOT	Operates the machinery as and when commanded to do so. Reports snags in manufacturing processes and performs quality checks	1. Made of aluminium. 2. Has inbuilt electro magnetic radiators. 3. Has retractable arms with various tools for machine repair.	400
RESOBOTS	Performs routine household tasks like cleaning utensils, Vacuuming, Baby sitting, Laying the table, Making the beds, Watering the plants, Assisting in offices, Maintaining the diary and address book. In addition, it also repairs household or office equipment and repaints walls. Works on both auto pilot mode and manually controlled mode.	Modeled on the present day ASIMO robot with several more features. It consists of one main body with a storage unit of various paraphernalia. The bottom half has air jets at the base to provide movement with minimum friction. The head has an inbuilt camera, memory storage and a transponder.	7000
A) EDU-R9	They shall also assist teachers in the classrooms to promote interactive learning for children.	Re-programmed resobots	40
B) MEC-R9	They shall act as mechanical helpers to assist in the donning and doffing process. They also help removing dust from airlocks.	Re-programmed resobots	35

Table 5.5 Maintenance and Routine Tasks

5.3.4 PRIVACY OF PERSONAL DATA AND CONTROL OF SYSTEMS IN PRIVATE SPACES

Northdonning Heedwell strives to protect the privacy of all Arshians. Privacy of personal data in one's computer is guaranteed as information stored by an individual on his computer can only be accessed through his Pinsert. Pinsert only responds to its owner, thereby safeguarding the owner's information.

5.3.5 DEVICES FOR COMMUNICATION AND ENTERTAINMENT SERVICES:

For E-communication and video conferencing, Pinsert-controlled holographic screens will be used. Home theatre systems with adjustable screens are used for the purpose of entertainment viewing. Excellent music systems, mood-lighting and temperature-control facilities are provided. Robot resources and entertainment systems are controlled at home using Pinnsert.

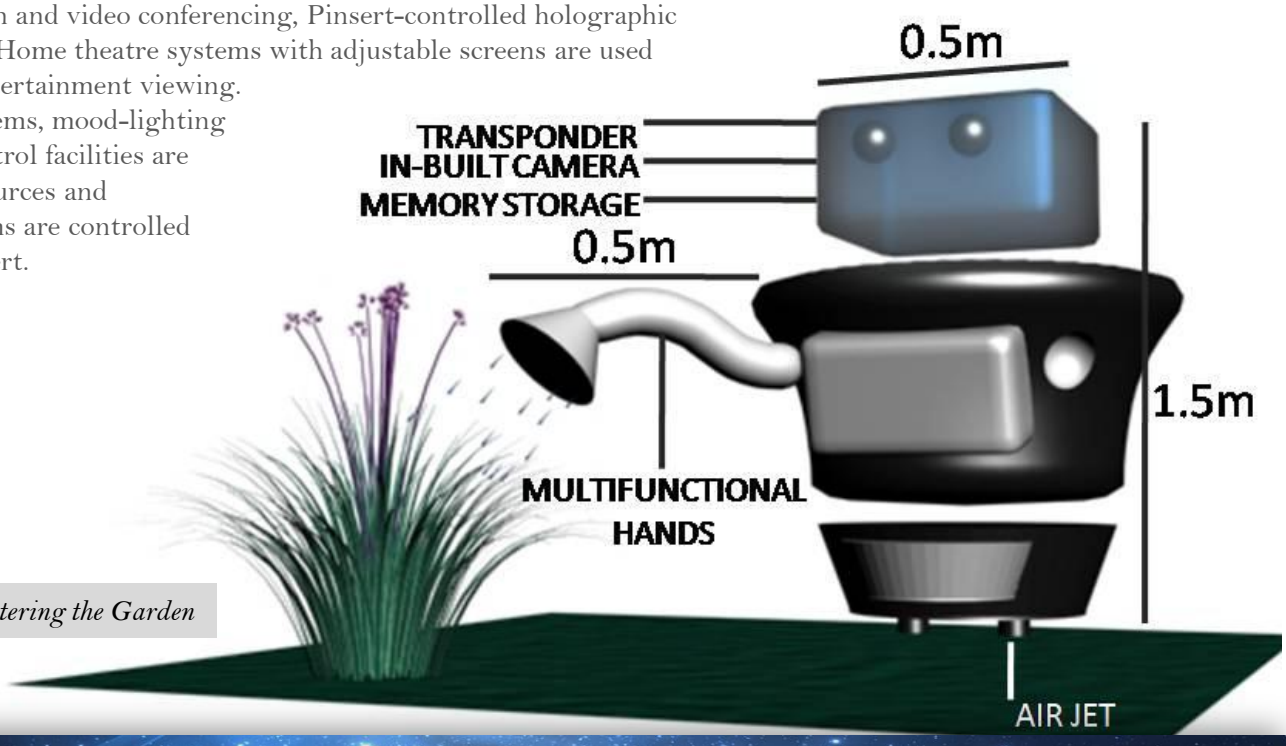


Fig. 5.4 Resobot watering the Garden

5.3.4 NETWORKING AND BANDWIDTH REQUIREMENTS

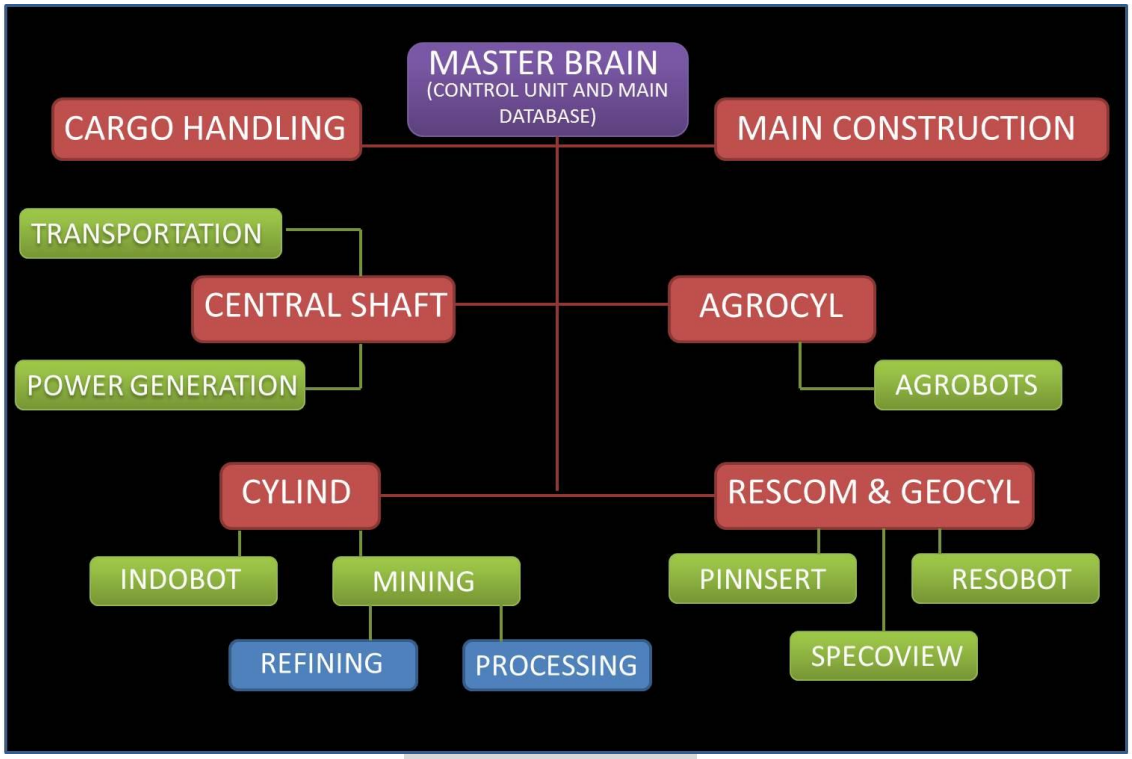


Fig. 5.5.1 Networking

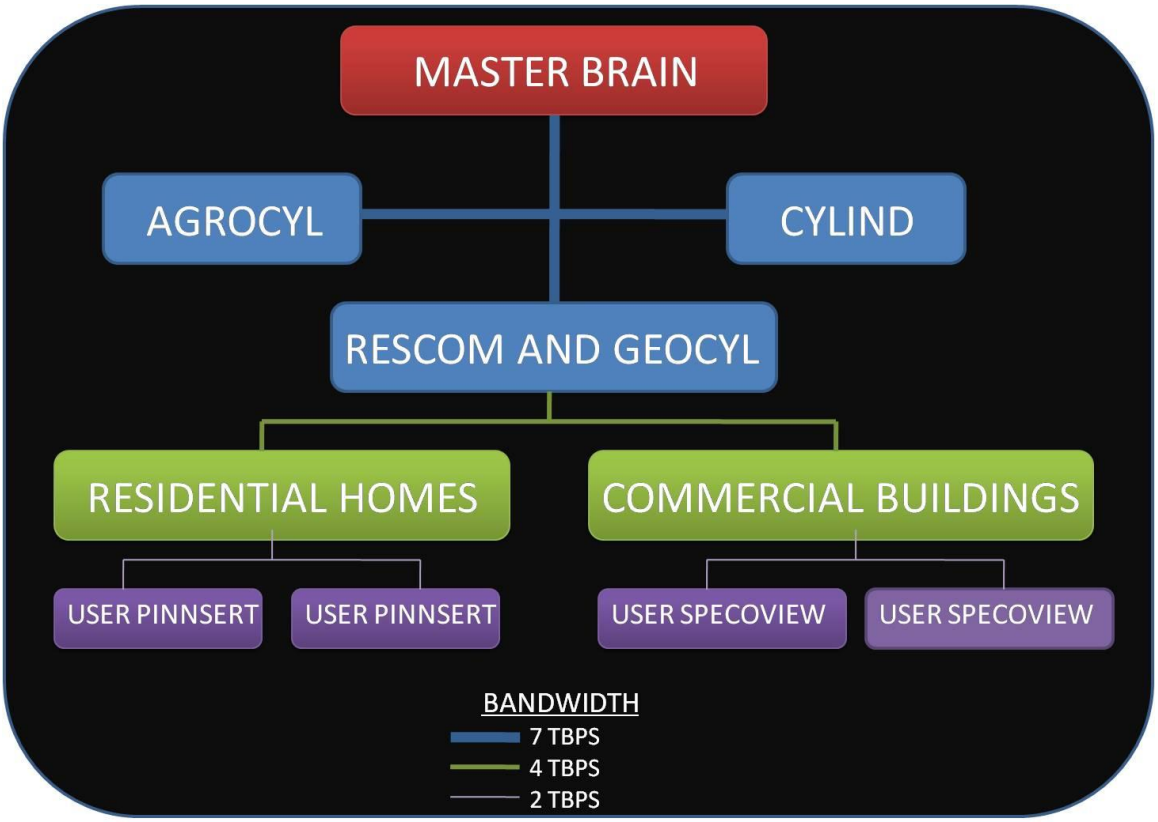


Fig. 5.5.2 Bandwidth Requirements

5.4 AUTOMATION FOR MINING

Keeping in mind the importance of mined materials for business and construction related purposes, Northdonning Heedwell has designed capable, highly productive and dexterous robots for quick and efficient mining.

5.4.1 LOCATION OF MINING SPOT

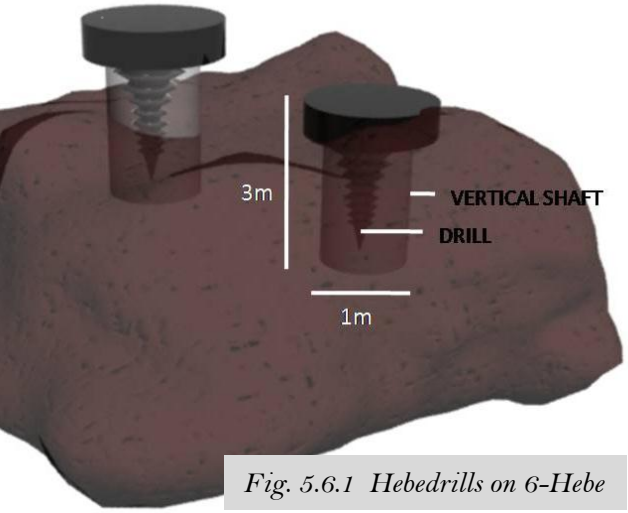


Fig. 5.6.1 Hebedrills on 6-Hebe

6-Hebe shall first be scanned thoroughly using 'space weathering phenomenon' and RADAR. Once the radio waves are sent, they react differently to different materials thus showing which portions have maximum amount of minerals. The robots are then deployed from Hebetat (Refer to section 2.5) to begin the mining process. The robots shall be made of titanium and shall be coated with a tough graphite-epoxy coating, to prevent wear and tear.

5.4.2 ROBOT DESIGNS

All major mining operations on 6-hebe shall be carried out by Hebedig and Hebedrill. They shall both have CSUs (control and sensor units) and transponder beacons to be instructed by the mining officials at Hebetat.
Once a certain section has been mined, Hebedrill and Hebedig are programmed to return back to the mining camp for recharging

NAME	FUNCTION	DESCRIPTION	SIZE	QTY
Hebedrill	Outlines the chosen mining location along a circular track and loosens and disintegrates rocks to accelerate mining. Excavated regolith travels up the cylinder and is collected within the removable storage unit.	Contains a solid, cylindrical vertical shaft. Projects out – pneumatic drill, laser drill, angle drill, rotary drill, hammer drill or ultra-sonic drill depending on type of terrain.	Radius : 0.5m, Drill length: 3m	10
Hebedig	Performs shoveling and loading of mined materials and also stores and transports minerals back to the mining base for refining.	They travel on treads. The large mining wheels are attached to both sides of the body, perform shoveling functions. The collected material is stored in the main body.	2m x 3m x 4m	100

Table 5.6 Mining Robots

Once a certain section has been mined, Hebedrill and Hebedig are programmed to return back to the mining camp for recharging.

5.4.3 ROBOT ADAPTATIONS FOR NEARLY NON-EXISTENT GRAVITY

To cope with 6-hebe's nearly non-existent gravity of 0.087 g, the cylindrical shaft possesses anchor-like clamps to fasten on to the surrounding soil and perform the drilling operation. The Hebedig has a central harpoon-like system which ejects out anchors to attach firmly to the ground.

5.4.4 ADAPTATION FOR DUST BUILD-UP

5.4.4.A Mining activities may produce a lot of dust from which mining robots have to be protected. Nano-tech based coating not only prevents dust build-up but is also heat and erosion resistant. The joints of the robots shall also be at a higher pressure, such that the dust cannot affect them.

5.4.4.B The Hebedigs have a mesh like filter system within them to separate the ore from the dust and other unwanted materials. These materials are also transferred to Hebetat where they are refined.

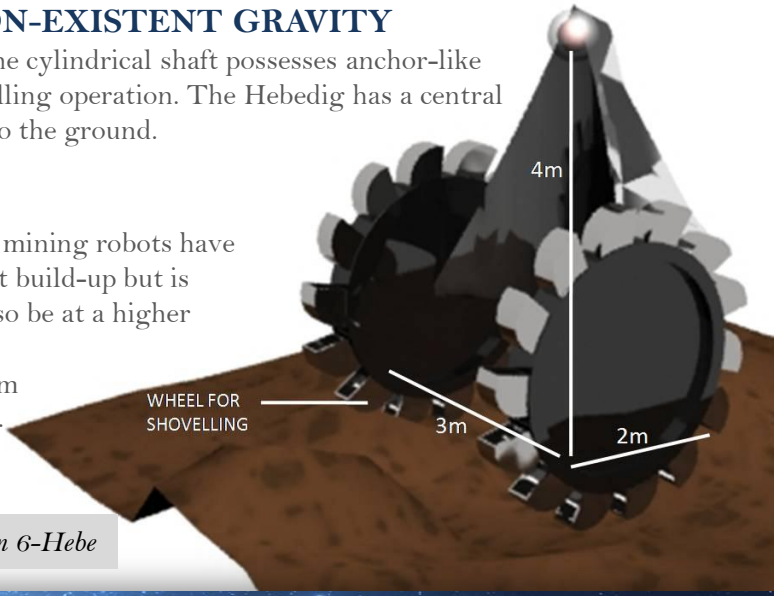


Fig. 5.6.2 Hebedig on 6-Hebe

5.5 ORE UNLOADING PROCESSES

5.5.1 AUTOMATION DESIGNS

NAME	FUNCTION	DESCRIPTION	SIZE	QTY
Process-A72	Examines and detects presence of harmful particles in the ore. Removes unwanted particles.	Large rectangular frame-shaped structure with in-built sensors and retractable hands attached to interior section of the frame.	6m x 3.5m x 3m	4
Conveyor Belt system	Ore Belt transfers ores to the DHA whereas the Dirt Belt carries dirt and sediments to the storage area in the nozzles.	The conveyor belt is a two-way system: 1. The ore conveyor belt (OCbelt) 2. The dirt conveyor belt (DCbelt)	250 m x 4m each belt	N/A
Collection Units (CUs)	Collects materials brought in by the Hebedigs.	Cube-shaped collection components fixed firmly on both conveyor belt systems	2.5m x 1.5m x 1 m	100 on each belt

Table 5.7 Automation for Ore Unloading

5.5.2 ORE RECEIVING AND ENRICHMENT SYSTEM (ORE SYSTEM)

Ore from other locations shall be accepted in containers .The automated Ore Receiving and Enrichment system (ORE system) facilitates a complete cycle of transfer of ore from the ports to Cylind, for further enrichment. The Hebezone chamber is used for unloading of all mined material collected on 6-Hebe. The spaceship, Hebexy enters Ozzy 1, where the Crabbot I-8s remove all dirt and dust from the spaceship to prevent dust build-up. The containers containing mined material are brought from 6-Hebe by Hebedigs. The containers function as CUs on the OCbelt – where magnetic ores and non-magnetic ores are taken in separate CUs and regolith and dirt are taken on CUs on the DCbelt. The OCbelt connects to the DHA on which it is transferred to the Cylind for further processing. The DCbelt transfers the stored dirt to the storage area in the nozzles for future use.

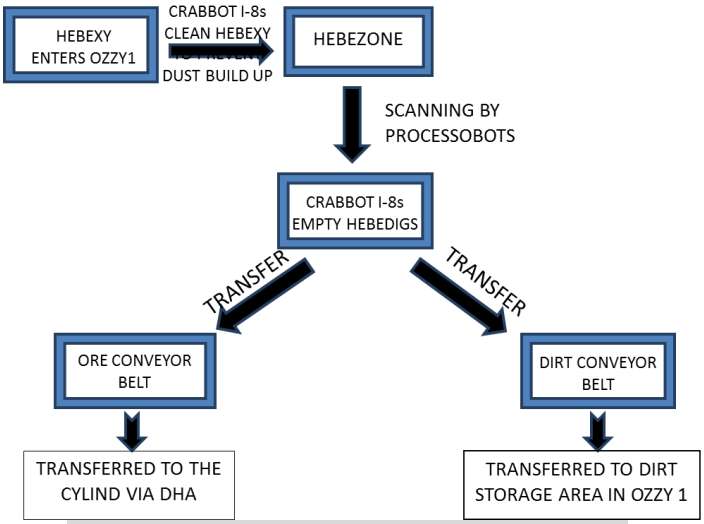


Fig. 5.7 Transfer of Ore from Port to Refinery

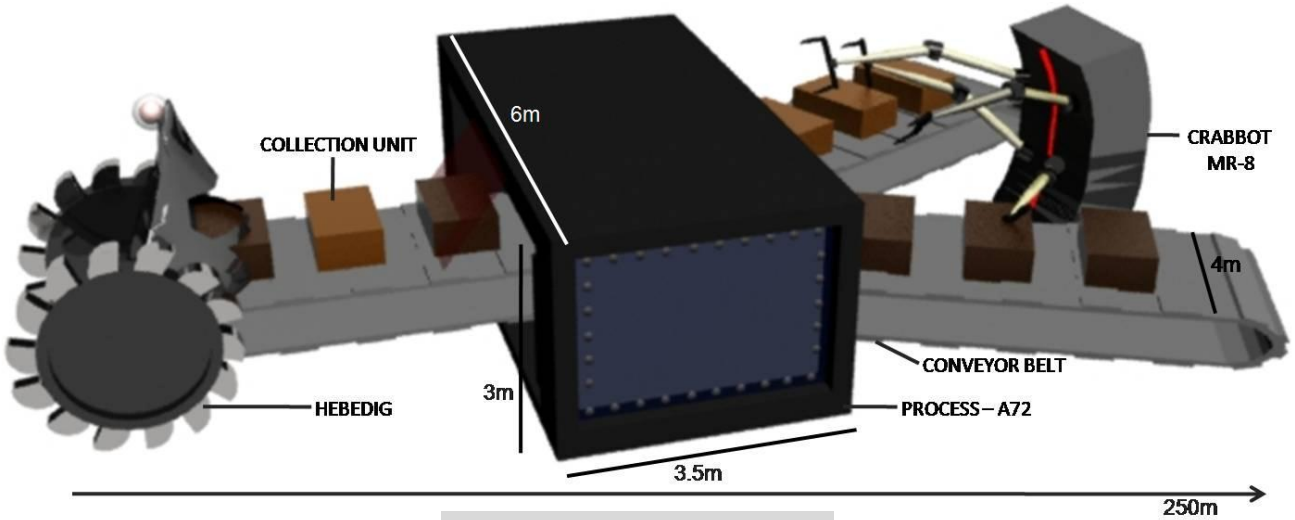
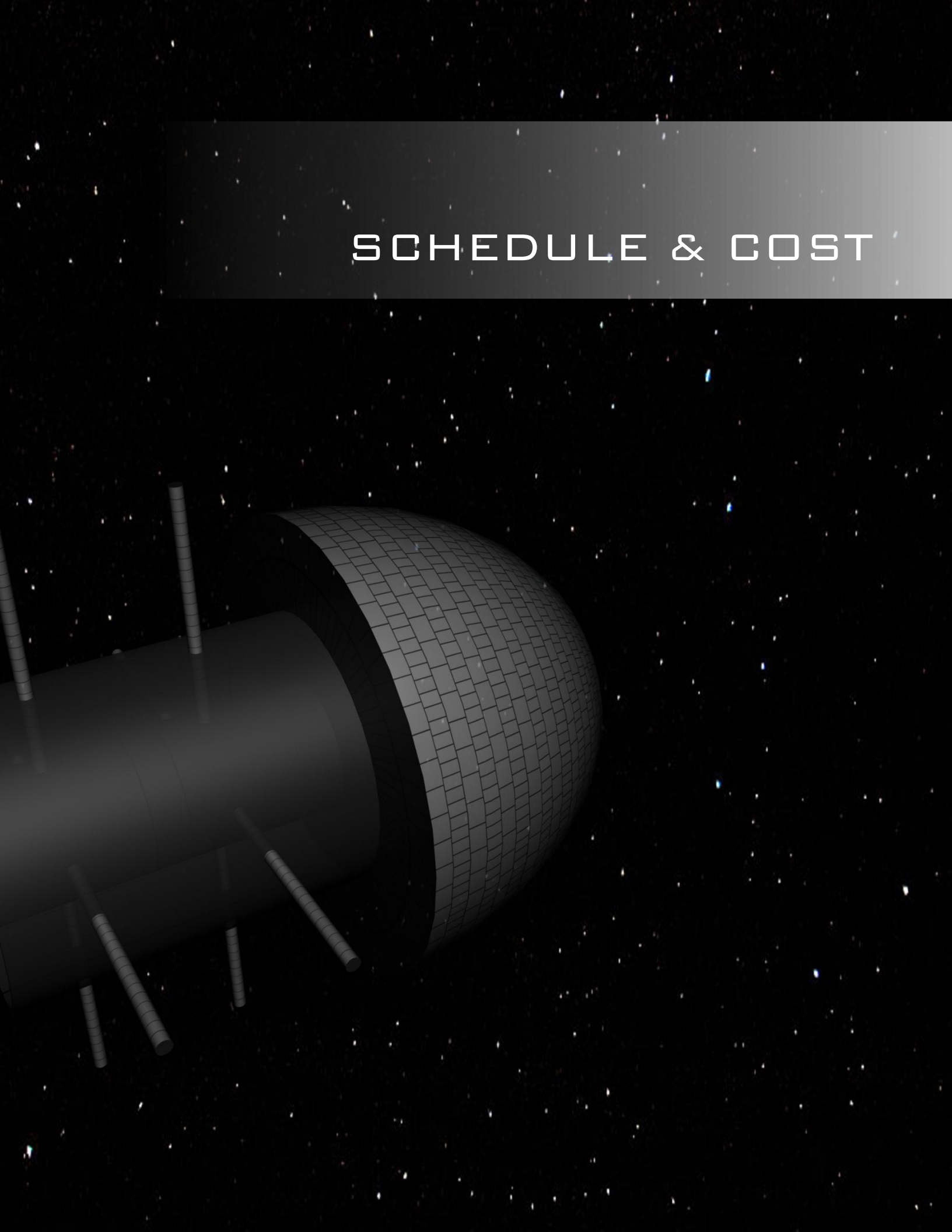


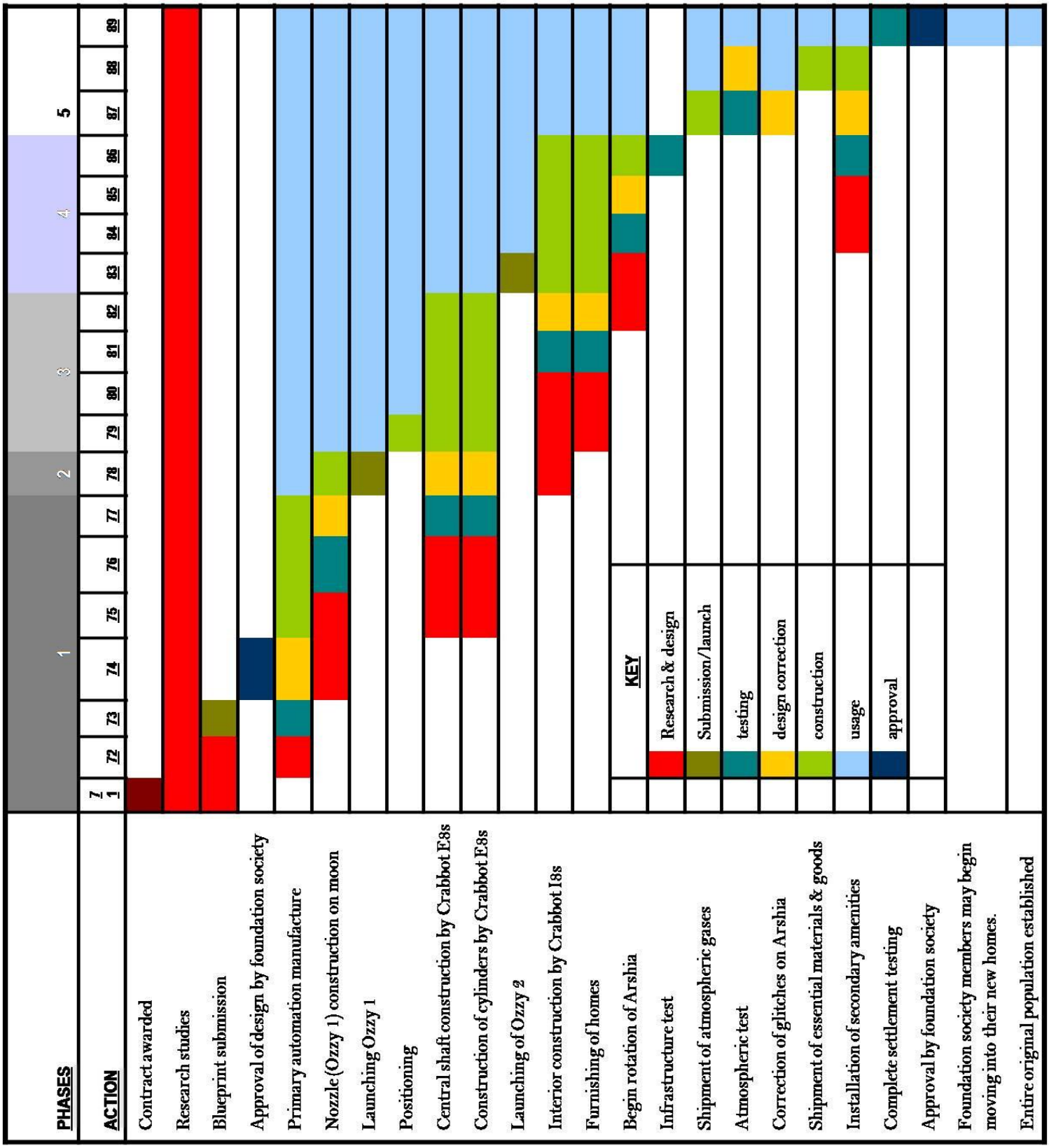
Fig. 5.8 Ore Handling in Ports

SCHEDULE & COST



6.0 COST AND SCHEDULE

7.1 SCHEDULE



7.2 COST

MATERIALS	QUANTITY(in Kg)	COST PER UNIT (in $)	TOTAL COST (in $)
Nickel	56,960,000,000	0.13	7,404,800,000.00
Titanium	2,912,000,000	6.5	18,928,000,000.00
Nanogel	847,500	5	4,237,500.00
Kevlar	16,272,000	9.95	1,619,064,000.00
Rxf1	22,600,000	105	2,373,000,000.00
Demron	35,482,000	120	4,257,840,000.00
Silica Aerogel	33,900	1.6	54,240.00
Alon	27,459,000	2.9	79,631,100.00
Shape Memory Alloys	73,450,000	4.9	65,901,600.00
Benzene Oxpyl Methoxy Cinnamte	12,560,000	1.5	18,840,000.00
Chevron Shield	NA	NA	5,743,798.00
Self Heeling Rubber	17,270,000	10.2	176,154,000.00
Superadobe	NA	NA	304,985,040.00
TOTAL			**35,238,251,278.00**

EQUIPMENT	QUANTITY	COST PER UNIT (in $)	TOTAL COST (in $)
Operational Super Computer	1	6,500,000	6,500,000
Spacesuits	12,000	2,800	33,600,000
Satellites	6	40,000,000	240,000,000
Automation Robots(medium)	9,175	15,000	137,625,000
Automation Robots(large)	1,140	55,000	62,700,000
Computers	1,200	700	840,000
Transportation For People	NA	NA	200,000
Transportation For Materials	NA	NA	295,482,980
Coatings(graphite-epoxy and Nano-tech)	NA	NA	35,500
Sensors	11,770	110	1,294,700
TOTAL			**778,278,180**

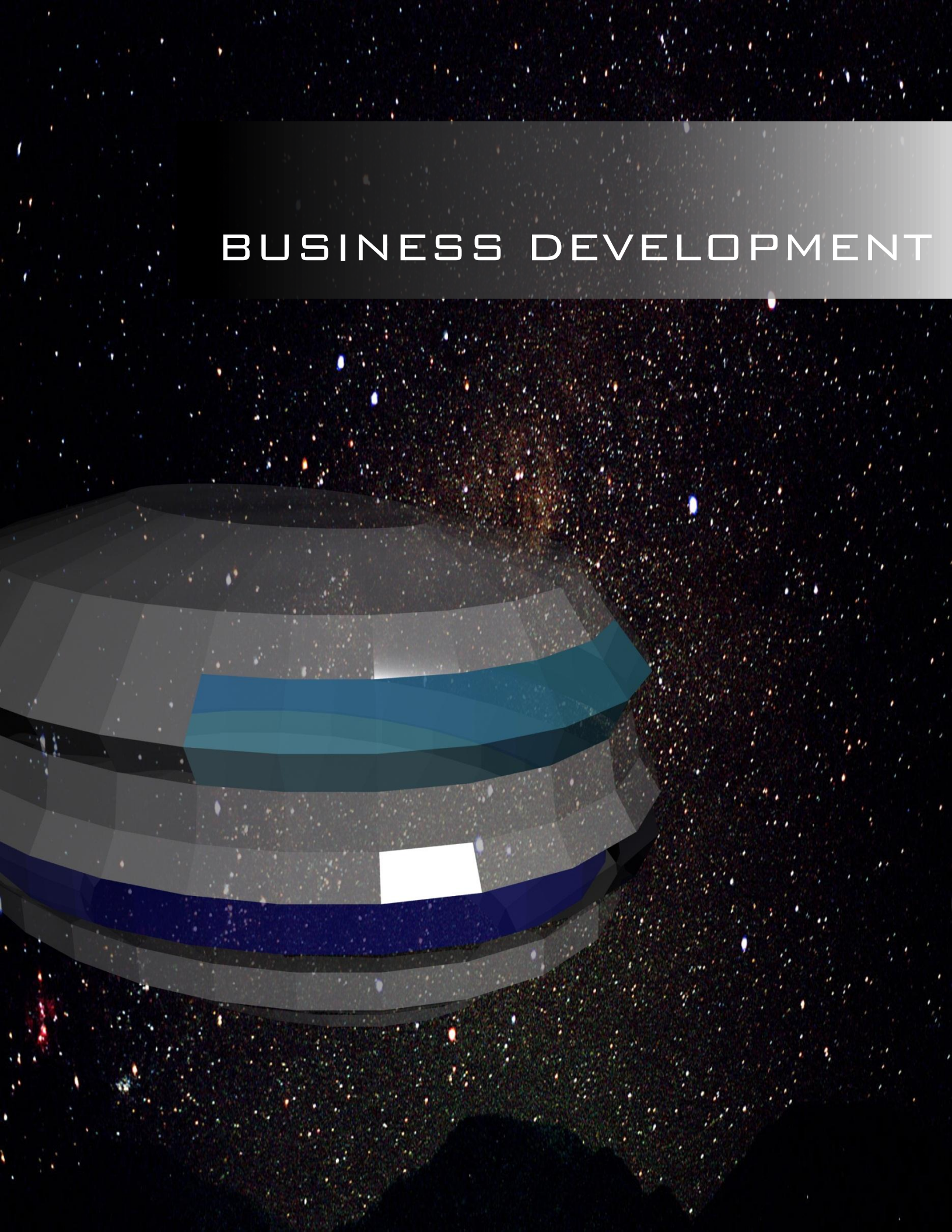
PHASE	TIME PERIOD (IN YEARS)	EMPLOYEES (NUMBER)	COST (IN $)
1st PHASE	6	RESEARCHERS(50)	2,500,000
		ARCHITECTS(30)	1,350,000
		CONSTRUCTION ENGINEER(60)	2,400,000
2nd PHASE	1	RESEARCHERS(20)	1,000,000
		ARCHITECTS(25)	1,125,000
		CONSTRUCTION ENGINEER(15)	600,000
3rd PHASE	4	RESEARCHERS(40)	2,000,000
		ARCHITECTS(30)	1,350,000
		CONSTRUCTION ENGINEER(35)	1,400,000
4th PHASE	4	RESEARCHERS(45)	2,250,000
		ARCHITECTS(35)	1,575,000
		CONSTRUCTION ENGINEER(30)	1,200,000
5th PHASE	3	RESEARCHERS(35)	1,750,000
		ARCHITECTS(20)	900,000
		CONSTRUCTION ENGINEER(15)	600,000

Total cost billed to the foundation society is 36,039,000,000 $.
Northdonning Heedwell ensures Arshia's economic sustainability and productivity on account of the following annual revenue pattern.

COST RECOVERY	
SOURCES	AMOUNT (IN $)
MUSEUM	105,068,599.00
ART GALLERY	82,657,623.00
LIBRARY	5,050,000.00
AMUSEMENT PARK	9,657,000.00
PLUTO SNOW PARK	9,854,900.00
SPORTS COMPLEX	75,000,000.00
SHOPPING MALL	8,500,000.00
GAMING CASCADE	76,500,000.00
PUB AND CASINO	102,000,000.00
RESTAURANTS	91,000,000.00
HOTELS	220,644,058.00
CLUB	57,000,000.00
WINE TASTING CENTER	39,000,000.00
INDUSTRIAL DEVELOPMENT	450.740,096.00
TOTAL YEARLY REVENUE	1,332,672,276.00

Contract awarded on 8th may 2071. Foundation society members may begin moving into their new homes from 1st april 2089. Entire original population will be established in the community on 31st october 2089.

BUSINESS DEVELOPMENT



7.0 BUSINESS DEVELOPMENT

Northdonning Heedwell shall provide all facilities for Astoria to host a variety of commercial and industrial ventures. The system shall be flexible such that other business types can be added with little configuration, to cater to the needs of the residents. The financial future of Arshia shall be solidified on a flourishing mining and manufacturing industry, which shall secure Arshia's economy. Thus, Northdonning Heedwell shall not only ensure a thriving business economy but also make sure that Arshians are comfortable in the settlement.

7.1 INFRASTRUCTURE FOR CONDUCTING MINING OPERATIONS

7.1.1 INFRASTRUCTURE FOR ASTEROID MINING AND HARVESTING OPERATIONS

Arshia shall be located in close proximity to 6-Hebe. The initial construction of mining robots shall take place in ARESAM and then be shipped to 6-hebe, to accelerate the construction process. The construction of Arshia shall be carried out simultaneously. The mined materials shall be used for initial construction phases. Once the construction of Arshia is fully complete, it shall posses all the technology to build more mining equipment.

MINERALS	USES
Nickel	Construction purposes
Iron	Construction purposes, Manufacturing steel
Manganese	Manufacturing steel
Aluminium	Making alloys, Construction purposes
Silicon	Solar cells, Glass and ceramics
Oxygen	Liquid fuel, For air
Calcium Aluminium Silicate	Extracted aluminium, used in construction of buildings

Table 7.1.1- Mineral Usage

7.1.2 METHODS FOR SELF-SUFFICIENCY AND TRADE

Minerals extracted from 6-hebe shall be used to the fullest potential for lucrative ventures as well as construction processes. Though most materials needed for maintenance and assembly of the settlement are available on 6-Hebe, materials needed for initial construction are imported from other installations. Refining and processing of minerals take place in the CylInd. These are then used to manufacture various finished goods. Thus Arshia shall be a self-sustaining, independent, mine-to-manufacture settlement that shall support all its activities and reduce the need for expensive imports, thus making immense profits.

7.1.3 PORT FACILITIES AND WAREHOUSING AND SHIPPING OF COMMODITIES

Arshia has efficient port facilities for handling all cargo that is being brought in, with temporary warehousing and storage facilities. These functions are carried out by the Crabbot I-8s. The two nozzles, Ozzy1 and Ozzy2 have entry (Entarshia) and exit (Extarshia) points. The conveyor belt system supports transfer of cargo, raw materials and other goods and commodities to and fro from the ports. The Hebexy S-10s ferry goods and services to and from Arshia whereas the larger Hebexy spaceships are used to transport mining equipment. The ports and docking areas shall be pressurized. (For further details refer to section 3.5.3)

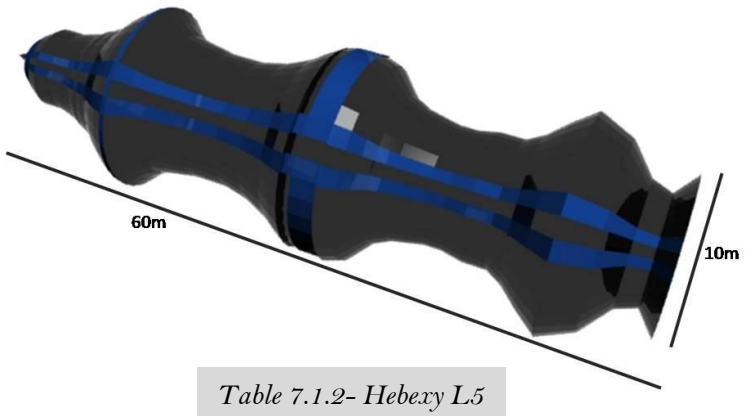


Table 7.1.2- Hebexy L5

7.1.4 PREVENTION OF DUST

The entire settlement has a pneumatic chamber whereas the robots are given a nano-particle coating for prevention of dust build-up. Nano-particle coating helps to prevent abrasion and accumulation of dust in joints, thus ensuring efficient function of robots at all times. When the space-vehicles enter the settlement, the Crabbot MR-8s dust off all the dirt gathered on the vehicles using highly pressurized air along with various dusting-cleaning paraphernalia.
[Further adaptations given in section 5.4.3]

7.2 SERVICES FOR REMOTE ASTEROID MINING OPERATIONS AND OUTER PLANET EXPEDITIONS

7.2.1 EXCESS AGRICULTURAL PRODUCTION

Cultivation of crops on Arshia takes place on a large area covering 157142 m ^{2}. Thus, the amount of crops produced (1571420 cubic metre of crops) is not only sufficient for all the residents but also for visiting tourists. The surplus food is stored in the agricultural cylinder itself, in the storage area, with 785710 m^3 amount of excess food, which can support visitors as well as the settlement during any impediment in food production. A part of the food supply is also stored in the nozzles at all times to support residents during evacuation.

7.2.2 REST AND RECREATION FACILITIES FOR VISITORS

Northdonning Heedwell has taken full responsibility for providing rest and recreation facilities for visiting spacecraft crews. The semi-term occupants will be housed in instant move-in homes (refer to section 4.5.1) whereas the short-term visitors shall be accommodated in luxurious hotels. Arshia also boasts of several clubs, spas, health centers, spiritual centers, a water-amusement park and a museum for recreation purposes. The observatories in the residential area as well as those on the GeoCyl shall provide facilities for having closer and better views of space.

7.2.3 REPAIR DEPOT FOR SPACE VESSELS

The space vessels traveling around the settlement shall need constant checking for any glitches. Hence, in case of need for any renovation, the space vessels place themselves in the maintenance zone near the docking ports, which consists of all necessary equipment such as highly pressurized air, drillers, nano-coating, and cenosphere etcetera. Here the maintenance and repair robots also perform lubricating and cleaning functions. Trained staff and port officials are also present for consultation and help regarding replacement of major parts or major repairs.

7.2.4 REFUELLING, FUEL PRODUCTION AND STORAGE FACILITIES

Arshia shall be using LOX, LH2 and argon for fuelling purposes. Arshia has the capability to produce 1132.4 m^3 of LOX and 3114.1 m^3 of LH2 which shall be replenished monthly. Re-fuelling of spacecrafts can take place at the nozzles, which shall be handled by the Crabbot MR-8 robots and port workers. Hydrogen and oxygen are produced using electrolysis of water and subsequent liquefaction using fractional distillation. Moreover, photo catalytic cells that split water to produce hydrogen and oxygen using sunlight and the power of nanostructured catalysts (such as titanium dioxide, tungsten oxide and iron oxide in compacted nanostructures with superior opto-electronic properties) will be used. The nozzles shall provide storage area of 4246.5 m^3 for storage of LOX and LH2 in separate tanks at all times which can be used during emergencies.

7.2.5. SPACE TUGS

Space tug facilities shall be readily available to assist or drag back non-functional or disabled space vessels. The space tug shall have propellant tanks, thrusters and avionics bays and a life span of 15 years.
The space tugs after being launched, shall detach themselves from the launch rocket. They shall have claw-like grappling devices to attach to the disabled space vessel and either put it back on orbit or drag it to the settlement for maintenance operations. In case of bigger ships, 2 space tows may be deployed which can grapple the vessel from both ends.

7.2.6. RESCUE OPERATIONS

Arshia shall have 5 rescue spaceships, that shall be ready at all times at the docks to perform rescue operations. The ship shall contain provisions to feed about 100 miners for a period of 10 months, also having sufficient fuel to sustain for 10 months. The ship shall also contain medobots, Cattepedes Crabbot MR-8s for any kind of medical or repair emergency. The provisions shall be replenished regularly so that even within 24 hours of notice, the ship can be deployed to perform rescue operations, thus ensuring safety and security of stranded personnel.

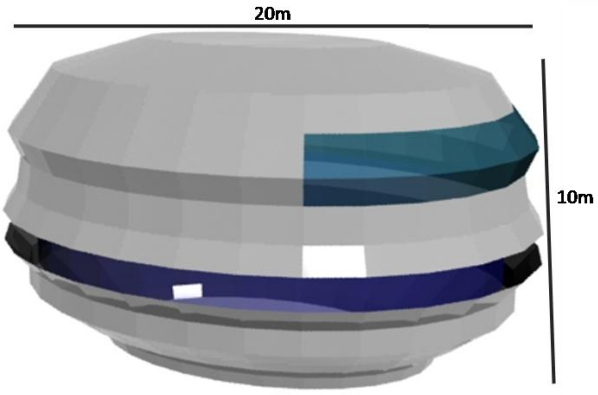


Table 7.2.1- Hebexy S10

7.3 SENSING AND IMAGING RESEARCH

7.3.1 RADIO TELESCOPES

The telescope uses the technology of Large Adaptive Reflector (LAR) which is a Canadian design concept for building large radio telescopes at extremely low cost per square meter of aperture. The LAR concept incorporates a large-diameter (D>150 m), large focal-ratio (f/D»2.5, giving f>375 m) reflector. Instead of using a conventional single mount point, the LAR design supports the near-flat reflector over its entire surface, and relies on actuators to adjust the surface shape and the pointing direction. An airborne phased-array feed is positioned at the focus, and provides multiple beams to image a patch of sky simultaneously.

7.3.2 OPTICAL TELESCOPE

7.3.2.A DESCRIPTION

Membrane mirror optical telescopes will be used in Arshia. The optical telescope in Arshia will use large membrane mirrors as their optical surfaces. Membrane mirrors are lightweight; they can be compactly stored, and they have the potential to provide high-quality optical imaging. Current work concentrates on making optically flat mirrors using stretched membranes. Very lightweight mirrors can be made that only require a rigid support at the perimeter of the membrane. Contact with the membrane need not be continuous, only discrete attachment points are required to tension the material. Electroformed nickel is appealing as a membrane material because of its strength and stability.

7.3.2.B POSITION

Two radio telescopes and optical telescopes will be placed at the diametrically opposite observatories placed in the GEO-CYLS. Signals can be intercepted coming from all sides of Arshia as the telescopes will have a 360 degrees range. Along with the above mentioned telescopes, communication antenna will also be placed in the GEO-CYLS.

7.3.3 STRUCTURAL ISOLATION

Since most of the vibration causing activities i.e. industrial processes, power generation, etc, will be located around the inner shaft of Arshia (Refer to Fig 2.1), these sensing and imaging instruments will not be affected as they will be situated on the periphery of Arshia.

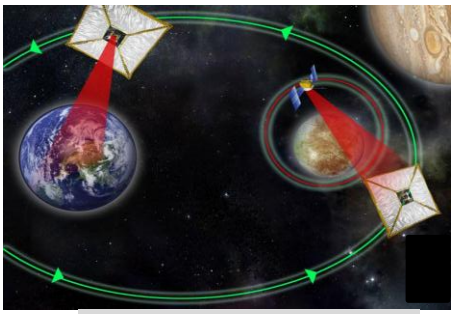


Table 7.3.1- Data Clippers

7.3.4 RETURNING DATA TO EARTH IN REAL TIME

In order to return data to the Earth in real time, Arshia will employ fleets of 'data-clippers' which are maneuverable spacecraft equipped with solar sails, to ship vast quantities of scientific data back to the Earth. Their concept is for a clipper to fly close to a planetary orbiter, upload its data and fly by Earth, at which point terabytes of data could be downloaded to the ground station. A fleet of data clippers cruising around the Solar System could provide support for an entire suite of planetary missions.

8. A OPERATIONAL SCENARIO

As the image of the sun appeared on the screen, indicating the beginning of a new day, the family Resobot, Titania pulled off the bedcovers of two children peacefully sleeping on their retractable bunk beds. "Time for school! Time for school!" said a friendly voice as Mrs. Arshon swept into the room, tying her hair. "Good morning Ryan! Morning Rachel! You heard Titania. Get up now!"

As the children were helped by Titania to get ready for school, Anne Arshon instructed the family's second Resobot, Steffi, to prepare breakfast for everyone. "Cornflakes with milk for the children, bread toast and omelet for Charlie and me. Prepare some coffee for us too." Seeing that there was no milk in the fridge, Steffi immediately placed an order for a carton of milk, which was delivered at the residence via the Interlace system. As Steffi laid down the breakfast table, Ryan and Rachel came running down the stairs of their Luxury Condo, while Charlie came out of his room, with some research papers in hand. "Morning everyone!" he smiled. "I shall present my research on the asteroid 16-psyche today at office. It is going to be an important day for me."

"Oh yes Charlie! I hope others shall be convinced about its lucrative mining opportunities as well."

"All the best daddy!" said 4-year old Rachel. "Oh! And can we go to Water World today evening?" she asked, as the family had their breakfast.

"Sure love! Now off to school. Take your bags. Titania, take them via the elevator to the GeoCyl. Take care!"

"Bye mommy! Bye daddy!" said both children as they made their way out.

As Anne prepared to leave, she kissed Charlie good-bye. Charlie then got ready to go to the Research Centre, where he worked. The presentation would be a defining moment in his life…

Within 6 minutes, the elevator came to a halt in front of the massive structure of the Sky High School on the GeoCyl. As Ryan and Rachel got off, they waved to Titania. The school campus consisted of playgrounds, sports centers and art complexes. Young Ryan and Rachel walked to their respective classrooms. Ryan who studied in Level IV had chosen the 'solar system' as his main subject. As the class settled down, the Edu-R9 robots started the lessons for the day:

"Good Morning class. Today we shall learn about the collision which occurred between Neptune and Uranus in 2055. Refer to your pinnserts. Your homework shall be to get interesting clippings about this event and share it with the class tomorrow!"

During recess, the students also have the facility to visit the observatories for views of space. Ryan, who was interested in the subject, took his friend, Joe along. Looking out at space and pointing to a distant star, he said," Maybe one day we will explore that far!"

Charlie used his Gecko-like tape shoes to reach his workplace in 8 minutes. Being the assistant head of the research center, he was greeted pleasantly by all other staff members. Straightening his coat and tie, he walked into the Executives Meeting Hall. All important analysts and officials were present. Arshian researchers and analysts were exploring the surrounding asteroids for future materials harvesting opportunities. As the meeting commenced, various analysts presented their research through SpecoViews, where all the information was collected on SpecoNetwork. When it was Charlie's turn, using his Specoview holographic screen, he went into a detailed explanation on the benefits of mining 16-psyche.

Anne travelled on the AutoWalk to reach her destination – the repair and maintenance (Rzone) in the nozzles. To stay in zero-g conditions, Anne donned her spacesuit. Anne had been working as Head of the Repair Unit for Robots for the past 3 years. Following the usual routine, she went around scrutinizing the work of all those under her. The monitor in her chamber also gave her constant updates regarding the repair work going on in the entire zone. After a round of examination, as Anne returned to her private office, the alarm system suddenly beeped, "Help needed".

Meanwhile, Titania and Steffi together cleaned and swept the house. A leak found in the taps was also fixed by them at once. When Ryan and Rachel came back, lunch was served to them, after which they went to take a dip in their personal swimming pool. Ryan then sat down to complete his assignments whereas Rachel ran off to play in the community park.

As Charlie finished speaking, everyone applauded him for the thorough research and analysis that he had done. The next day, the Supervisors would choose the asteroid for further mining ventures based on various researchers' presentations.

Anne rushed down to the RZone to troubleshoot the problem. One of the Hebedigs had a faulty configuration due to which the shoveling wheels were not moving in the required manner. Being a technical expert in the field, Anne soon figured out the glitch and instructed one of the Crabbot MR-8s to fix the fault.

After a full day of hard work, Anne and Charlie finally returned home to spend some quality family time. As a routine, the family sat down to watch the daily news on their size-adjustable home theatre system. On Astnet TV, a reporter was saying, "The polarshia-K8 robot stuns a criminal with its tranquillizer gun, thus preventing robbery of the Arshian Bank ."

"Daddy, you promised to take us to Water World today! Please let us go!" requested Rachel. And so, the family set off in their car, Torix. The evening was spent in enjoying the water-rides and other recreation facilities. But unfortunately, Rachel caught a cold. The stay-fit pills indicated the kind of medicine she would need. "Oh love! This is so unfortunate. Let us go to the supermarket to buy you your medicine."

After buying the medicine, Anne purchased a pair of shoes for herself and Charlie bought a book – 'Space Exploration in 2211'. When the family finally went back home at night, the beds were made by their resobots. A special day awaited Ryan.

***

"Surprise! Happy birthday!" Anne, Charlie and Rachel exclaimed. Lying at the Arshon's commodity receiving terminal, was a well wrapped gift, which had been ordered sometime back. As Ryan excitedly unwrapped the gift, there inside lay the Encyclopaedia he had been dying to have!

"Thank you so much! This is my best birthday gift ever!" Ryan exclaimed, as he hugged each of them.

Just then, Charlie received an alert on his pinnsert from the Chief Head: 'Congratulations, Mr. Arshon! Your presentation yesterday is worthy of praise. Future mining operations on 16-psyche shall be considered. Meet me at my office, today at 1:30 p.m.'

Charlie's happiness knew no bounds. His hard work had paid off. Living on Arshia, had proven to be like a dream come true.

8. B BIBLIOGRAPHY/ REFERENCES

STRUCTURES

1. Beauchamp, G. T.: Adverse Affects Due To Space Vehicle Rotation, Astronautical Sciences Review, Volume 3
2. Haviland, RP : Influence Of Coriolis Forces On Some Design Choices In Rotating Spacecraft, AIAAA And Aerospace Medical Association Weightlessness And Artificial Gravity
3. Glaeser, Ludwig: Architectural studies for space habitat, Princeton University Conference Meeting
4. Chapman, CR: The Natureof asteroids, Scientific American, Volume 232
5. McCord TB, Chapman CR: Asteroids: Spectral Reflectrance and Color Characteristics, Astrophysics Journal, vol 197, 1975
6. Martin, A., Harbison, S.A.: An Introduction to Radiation Protection, Chapman and Hall, London(England)
7. Clarke, A.C.: Islands in the Sky, John C. Winston\
8. Settlement.arc.nasa.gov

OPERATIONS AND INFRASTRUCTURE

1. http://www.sidleach.com/6_Hebe.htm
2. http://cat.inist.fr/?aModele=afficheN&c
3. http://www.docstoc.com/docs/45157672/Osmotic-Concentration-Apparatus-And-Method-For-Direct-Osmotic-Concentration-Of-Fruit-Juices---Patent-5281430
4. http://www.sciencedirect.com/science?_
5. http://www.popsci.com/technology/article/2010-10/123000-mph-plasma-engine-could-finally-take-astronauts-mars?page=2psidt=16855248
6. http://onlinelibrary.wiley.com/doi/10.1002/mop.10490/pdf
7. www.ursi.org/Proceedings/ProcGA02/papers/p1552.pdf
8. www.cisco.com/en/US/prod/collateral/video/.../7012168.pdf - United States
9. http://www.coretk.com/CataLog/cata_img/FILE/1524076778/SEI/57/72/57_72_1061788574.pdf
10. http://www.techrepublic.com
11. http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=896351
12. http://www.eoportal.org/directory/pres_OICETSOpticalInterorbitCommunicationsEngineeringTestSatellite.html
13. http://www.nasa.gov/home/hqnews/2003/nov/HQ_03377_ion_engine.html
14. http://www.aip.org/tip/INPHFA/vol-6/iss-5/p16.pdf
15. http://alfven.princeton.edu/papers/choueiriJPP04a.pdf
16. http://gltrs.grc.nasa.gov/reports/2001/TM-2001-210676.pdf
17. http://gltrs.grc.nasa.gov/reports/2003/CR-2003-212714.pdf
18. http://www-pub.iaea.org/mtcd/publications/pdf/te_1544_web.pdf
19. http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file39197.pdf
20. http://dma.ing.uniroma1.it/users/bruno/Petro.prn.pdf
21. http://www.ijcaonline.org/journal/number18/pxc387583.pdf
22. http://www.artechhouse.com/GetBlob.aspx?strName=Aviv_028_CH01.pdf
23. http://whatis.techtarget.com/definition/0,,sid9_gci1249890,00.html

24. http://www.wordiq.com/definition/Spacecraft_propulsion
25. Larry C.Andrews, Ronald .L.Phillips, *Laser Beam Propagation through random media.*2nd ed
26. National Academy of Engineering, *Lasers Invention to Application*
27. Hugo Weichel, *Laser beam propagation in the atmosphere*

HUMAN FACTORS

1. http://www.marsdrive.com/Libraries/Downloads/Physiological_Issues_in_Human_Spaceflight_-_Review_and_Proposed_Countermeasures.sflb.ashx
http://www.worldlingo.com/ma/enwiki/en/Solipsism_syndrome
http://www.bookrags.com
2. http://spacewardbound.nasa.gov/australia2009/docs/Waldie%202005%20MCP-Paper.pdf
3. http://mvl.mit.edu/eva/biosuit/reports/BioSuitDJN_May05.pdf
4. http://dspace.mit.edu/bitstream/handle/1721.1/35564/73828770.pdf?sequence=1
5. http://www.nasa.gov/vision/space/travelinginspace/25aug_plasticspaceships.html
6. http://www.google.com/url?sa=t&source=web&cd=7&ved=0CFMQFjAG&url=http%3A%2F%2Fwww.iitk.ac.in%2Fdirections%2Fdirnet7%2FP~S
7. Kamle~F.pdf&rct=j&q=piezoelectric%20materials&ei=ahZ1Te_dI4XQcd3f4PgC&usg=AFQjCNGCNQzKf2Dq9QFwtKfEhbRlpYFdXg&cad=rja
8. http://www.ceradyne.com/uploads/Silicon%20Carbide.pdf
9. http://science.howstuffworks.com/spacesuit.htm/printable?referer=www.clickfind.com.au

AUTOMATION DESIGN AND SERVICES

1. http://asimo.honda.com/
2. http://cenotechnologies.com/silver_coated_cenospheres.php
3. http://www.sciencedaily.com/releases/2010/09/100919182645.htm
4. http://www.skatelescope.org/PDF/memos/72_Johnston.pdf
5. http://pdf.aiaa.org/jaPreview/AIAAJ/2009/PVJA31166.pdf
6. http://www.nanodaten.de/index2.php?pID=42&nID=113
7. http://searchnetworking.techtarget.com/definition/pervasive-computing
8. Judith Hurwitz, Robin Bloor, Marcia Kaufman, Fern Halper, Cloud Computing For Dummie,111 River Street, Hoboken NJ: Wiley Publishing Inc., 2010

BUSINESS DEVELOPMENT

1. http://www.skatelescope.org/PDF/memos/72_Johnston.pdf
2. http://pdf.aiaa.org/jaPreview/AIAAJ/2009/PVJA31166.pdf
3. http://www.sciencedaily.com/releases/2010/09/100919182645.htm
4. http://news.softpedia.com/news/Artificial-Fuel-Cell-Produces-Hydrogen-from-Water-with-Sunlight-Just-Like-Plants-53953.shtml
5. http://www.computescotland.com/solar-sail-powered-data-clippers-3672.php

8. C COMPLIANCE MATRIX

REQUIREMENT	SECTION	PAGE NUMBER
SECTION 1 : EXECUTIVE SUMMARY		
Contractor will describe the design, development, construction of settlement operations/maintenance planning for the space settlement in the asteroid belt.	1.0	2
SECTION 2 : STRUCTURAL DESIGN		
Provide a safe and pleasant living and working environment for a community of 6,000 long-term residents, 5000 semi-term occupants, and up to 500 short-term visitors.	2.0	4
Provision of natural views of space.	2.1.2	5
Attributes and uses of large enclosed volumes.	2.1.1	4
Dimensions and construction materials of major hull components and design features	2.1.2	5
Volumes where artificial gravity will be supplied	2.1.1	4
structural interface(s) between rotating and non-rotating sections	2.1.4	6
Rationale for selected rotation rate and artificial gravity magnitude(s)	2.1.3	6
Rationale for selected rotation rate and artificial gravity magnitude(s)	2.1.3	6
Means of protecting from radiation and debris penetration.	2.1.2	5
Capability to isolate at minimum any two separate volumes in case of emergency.	2.2.5	7
Minimum Requirement : overall exterior view of settlement, with major visible features showing rotating and non-rotating sections, pressurized and non-pressurized sections, and indicating functions inside each volume	Fig 2.1, 2.2	4,5
Percentage allocation and dimensions of interior "down surfaces", with drawings labeled to show residential, industrial, commercial, agricultural, and other uses	2.2	5
Orientation of "down surfaces" with respect to overall settlement design, and vertical clearance in each area.	2.1.1	4
Minimum requirement: overall map or layout of interior land areas, showing usage of those areas.	2.1, fig 2.4, fig 3.7, fig 4.1	4,6
Description of process required to construct the settlement, by showing the sequence in which major components will be assembled.	2.3	7
Specification of when artificial gravity will be applied.	2.1.1	4
Description of a construction technique for interior structures making use of materials from asteroids.	2.3, 3.1.2, 3.3	6
Minimum requirement: drawing(s) showing at least five intermediate steps of settlement assembly, and method of initiating rotation for artificial gravity.	2.3	7
Details of shielding and damage repair methods for frequent impact by small particles	2.4.1	8

Means for reducing damage due to larger items that can only be detected hours in advance.	2.4.2	8
Minimum requirement: illustrations of shielding and damage repair systems.	Fig 2.6	8
"Mining camp" infrastructure on the target asteroid, based on selected Astoria design	2.5	9
Minimum requirement: drawing(s) of human habitation at asteroid mining location.	2.5	9
SECTION 3 : OPERATIONS AND INFRASTRUCTURE		
Choice of orbital location (e.g., distance from sun) for Astoria and the reasons for its selection.	3.1.1	11
Sources of materials and equipment to be used in construction, then in settlement operations after construction is complete (using as much material as possible from asteroids)	3.1.2	111
Means for transporting those materials to the Astoria location.	3.1	11
Specification of the mining target either a known large asteroid, or preferred small asteroid size, shape, and orbit.	3.1	11
Minimum requirement: table identifying types, amounts, and sources of construction materials.	Table 3.1.2	11
Elements of basic infrastructure required for the activities of the settlement's residents: • atmosphere/climate/weather control (identification air composition, pressure, and quantity),	3.2.1	12
• food production (including growing, harvesting, storing, packaging, delivering, selling),	3.2.2	12
• electrical power generation (in kilowatts), distribution, and allocation for specific uses,	3.2.3	13
• water management (required water quantity and storage facilities),	3.2.4	14
• household and industrial solid waste management (recycling and/or disposal),	3.2.5	14
• internal and external communication systems (devices and central equipment),	3.2.6	15
• internal transportation systems (routes and vehicles, with dimensions)	3.2.7	16
• day/night cycle provisions (schedule and mechanisms).	3.2.8	17
Storage facilities required to protect against interruption in production of food or commodities needed for daily life where supply lines may be interrupted for 10 months	3.2.9	17
Minimum requirement: chart(s) or table(s) specifying quantities required of air, food, power, water, waste handling, communications devices, and internal transport vehicles.	**3.2**	
Conceptual designs of primary machines and equipment employed for and assembling exterior hull and interior buildings / structures	3.3	17
Materials, components, and/or subassemblies delivered to the machines, and how the machines convert delivered supplies into completed settlement structures	3.1.2, 3.3	17

<u>Minimum requirement:</u> primary construction machinery, showing how it shapes and/or manipulates raw materials or structural components into finished form.	3.3, Fig 3.5	17
Requirements for a propulsion system to move Astoria when threatened with impact of a large object.	3.4	18
<u>Minimum requirement:</u> drawing showing location(s) and approximate dimensions of propulsion system(s), with descriptions of thrust, acceleration, and fuel requirements.	3.4, fig 3.6, table 3.9.1, table 3.9.2, fig 3.7	18
An option for accepting raw ore to refine from other locations	3.5.	19
<u>Minimum requirement:</u> illustration of port facilities and ore handling processes.	3.5, fig 3.7	19
SECTION 4 : HUMAN FACTORS		
Provision of natural sunlight and views of space outside for residents.	4.1.1	21-24
Features in design of community facilities (e.g., roads and paths) and residences, enabling mobility and access with a practical minimum of motion to counter coriolis effect	4.1	21-24
Provision of services that residents expect in comfortable modern communities (e.g., housing, entertainment, medical, parks and recreation)	4.1.1a,b,c,d,e,f	21-24
Variety and quantity of major consumer goods	4.1.3	21-24
Public areas designed with long lines of sight	Fig 4.1, 4.1.2	21-24
Means of distributing consumables (including food) to residents.	4.1.1	21-24
<u>Minimum requirement:</u> map(s) and/or illustration(s) depicting community design and locations of amenities, with a distance scale; percentage of land area allocated to roads and paths	Fig 4.1, 4.1	21-24
Designs of typical residences, clearly showing room sizes	4.2.1	25
Identification of source(s) and/or manufacture of furniture items and appliances	4.2.2	26
<u>Minimum requirement:</u> external drawing and interior floor plan of at least four home designs, the area and the number required of each design.	Fig 4.3.1, fig 4.3.2, fig 4.3.3, fig 4.3.4	25-26
Spacesuit designs, with stowage and donning/doffing procedures, and airlock designs for exiting/entering the settlement from unpressurized volumes.	4.3, fig 4.4, table 4.6.1, table 4.6.2, 4.3.2	26-29
<u>Minimum requirement:</u> drawing(s) showing examples of handrails, tethers, cages, and/or other systems enabling safe human access to any location on or in low-g settlement areas.	**4.3**	26-29
<u>Minimum requirement:</u> drawing(s) of means for children to spend time in 1g.	**4.4**	30
Methods of integration of semi-term occupants into society.	4.5	30
<u>Minimum requirement:</u> drawing(s) of "instant move-in" home designs.	Fig 4.8	30
SECTION 5 : AUTOMATION DESIGNS AND SERVICES		
Robot designs, clearly indicating their dimensions and illustrating how they perform their tasks	Fig 5.1.1	32
Automation for construction, transportation and Delivery of materials and equipment, assembly of the settlement, and interior finishing.	Table 5.1	32

Costs billed per year of Astoria design through construction in U.S. dollars	6.2	43-44
Estimate numbers of employees working during each phase of design and construction in the justification for contract costs to design and build the settlement.	6.2	43-44
Minimum requirement: chart(s) or table(s) listing separate costs associated with different phases of construction, and clearly showing total costs that will be billed to the Foundation Society.	6.2	43-44
SECTION 7 : BUSINESS DEVELOPMENT		
Infrastructure for conducting major asteroid materials harvesting and processing operations:	7.1	46
Build, or import and then deploy, equipment required to conduct asteroid harvesting operations	7.1.1	46
Capability for refining or otherwise processing asteroid Materials to enable as much self-sufficiency as possible, and create commodities and products for export and trade	7.1.2, 7.1.3	46
Port facilities must enable receiving incoming raw materials, warehousing import and export products, and shipping of commodities and other products	7.1.3	46
Method(s) for preventing dust from entering enclosed areas in Astoria	7.1.4	47
Services for remote asteroid mining operations and outer planet expeditions:		
Excess agricultural production, storage, and processing capability (beyond the needs of settlement residents) will service provisioning needs of visiting spacecraft	7.2.1	47
Provide suitable facilities for visiting spacecraft crews "rest & recreation" (R & R)	7.2.2	47
Provide a full-service repair depot for major maintenance and repair of space vessels	7.2.3	47
Provide fueling services for spacecraft traffic using port facilities; show fuel production and storage facilities for at least 40,000 cubic feet of LOX and 110,000 cubic feet of LH2, replenished monthly	7.2.4	47
-"Space Tug" services will be available to assist disabled vessels	7.2.5	47
-Capability to send rescue operations for asteroid miners requires at least one ship fully provisioned for a mission up to ten months long, ready to leave in 24 hours	7.2.6	48
Sensing and imaging research appropriate to Astoria's outer solar system location:		48
-Radio telescope with dish diameter of at least 500 feet (150 meters)	7.3.1	48
-Optical telescope with mirror diameter of at least 20 feet (6 meters)	7.3.2	48
-Structural isolation from vibration-causing activities on Astoria	7.3.3	48
-Data processing and communications capability to return data to Earth in real time	7.3.4	48