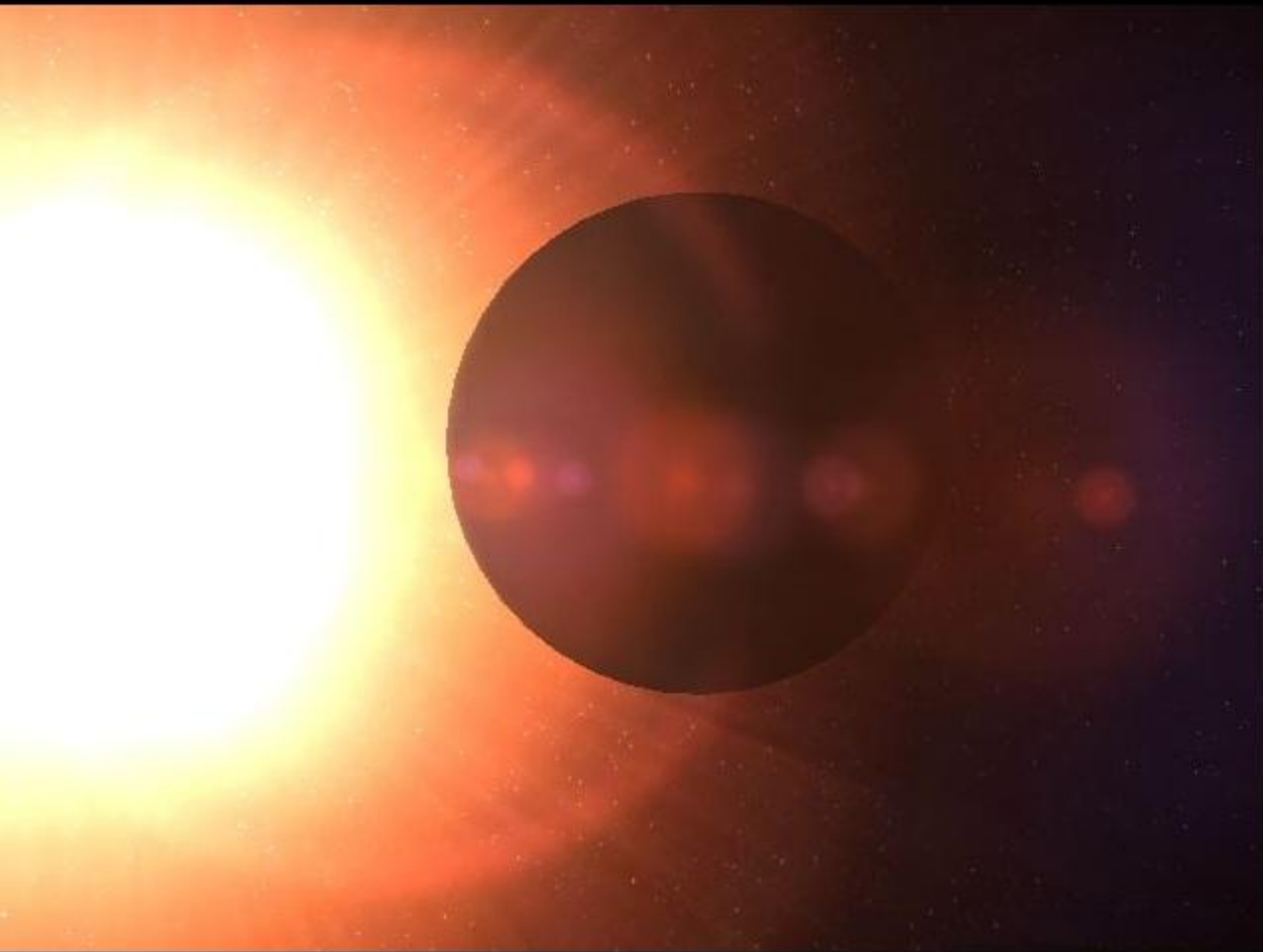


AYNAH



Lahore Grammar School Defence
Lahore, Pakistan

19th Annual International Space Settlement Design Competition Proposing Team Data 2012

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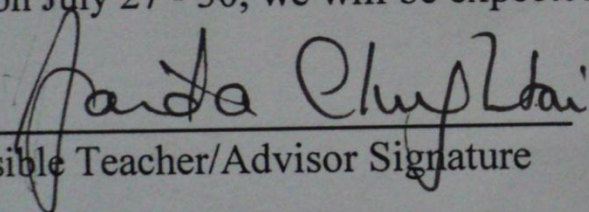
Names, [grade levels], and (ages) of 12 students currently expecting to attend the Finalist Competition (we request that participants be at least 15 years old, and not older than 19)

<u>Aaida Rao</u> [12] (19)	<u>Misha Nasir Jammy</u> [12] (18)
<u>Alizeh Maqbool</u> [11] (17)	<u>Rasham Warraich</u> [11] (17)
<u>Farzad Effan</u> [12] (18)	<u>Saad bin Arshad</u> [12] (18)
<u>Mahira Ahmed Tiwana</u> [12] (17)	<u>Salaar bin Shehzad</u> [10] (17)
<u>Mahnoor Faisal Khan</u> [11] (19)	<u>Sara Tahir</u> [11] (17)
<u>Maria Javaid</u> [12] (18)	<u>Zara Khalid Sheikh</u> [11] (17)

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

Farida Chughtai Majeed Ahmed Bashir

I understand that if our Team qualifies for the International Space Settlement Design Finalist Competition July 27 - 30, we will be expected to finance our own travel to/from Nassau Bay,


Responsible Teacher/Advisor Signature

22nd March 2012
Date

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In response to the Foundation Society's request for proposal, the design, development, construction and operations planning of the first space settlement in polar orbit of Mercury, Aynah, has been proposed by the engineers of our company. Aynah has been given a remarkably simple and functional structure, keeping in mind the physics and scientific aspects involved in the creation of the most comfortable living environment in the realm of Mercury.

Our location in sun facing polar orbit is ideal for surveillance, electrical power generation and mining of Reardonium. A large “cup” of solar panels attached to the top of our structure provides the massive amount of solar energy reardonium production requires.



Fig 1.1

We have provided extensive automation and computerization to facilitate reardonium production and the smooth uninterrupted running of settlement procedure. Solar energy would provide power, while water and waste would be strictly conserved with efficient recycling methods.

Settlers are provided with every facility imaginable in order to make their experience on Aynah as Earth-like as possible, while adding that extra spin of innovation that adds to our settlement's appeal and increases the residents' sense of enjoyment while at the same time eliminating any possible feelings of homesickness that could arise. Housing and Culinary facilities along with entertainment provide the entire population with an experience of a lifetime, where they not only live as luxuriously in space as they would on Earth, but in fact their living conditions are far improved in every single way.

Total Cost of Settlement = \$ 185 billion

Structural Design of Aynah

The cup of solar panels has been removed to allow a closer view at the structure, which consists of a residential torus, an industrial sphere, a non-rotating axle and four docking ports as shown below. Solar panels also cover the top half of the sphere, and are arranged in a disc as well. These together provide energy for the running of the settlement.

Sphere
The sphere will house the industrial sector. The upper hemisphere will contain the regular industries required to run the settlement (e.g. Communication Hubs, Power Generation, Climate Control, Water Management, Waste Management, etc.), while the lower hemisphere will contain the industries for the manufacture of reardonium. Thus they will be closer to the docking ports, allowing faster transport.

Torus
The torus has two sections; the side facing the sun will be the agricultural area and the side away from it will be the residential area. The cross-section of the torus is flattened so as to reduce wastage of space. There will be extensions on the torus, to provide high-g areas for children and recreation.

Spokes
Four symmetrically-placed spokes connect and provide support to the settlement. They are used for transport of passengers and cargo. Reardonium passes directly from the axle to the industrial sphere, so does not need to pass through the spokes at all, making the process faster and more efficient.

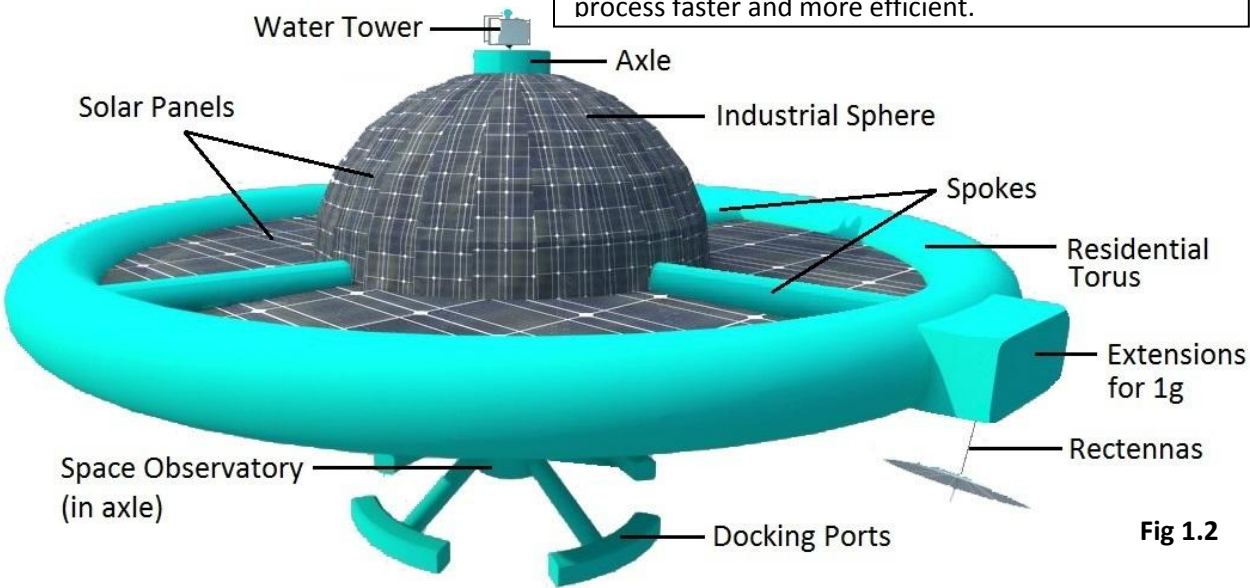


Fig 1.2

Docks
The segmented torus serves as an efficient docking port, as it gives a lot of space and can easily be compartmentalized for specialization. The edges of the segments are chamfered to prevent accumulation of pressure, especially in case of a collision.

Axle
The axle is the non-rotating part of the settlement. It will house 0g activities and industries and be used for storage. Docking ports are attached at the lower end of the axle, protruding from the structure and so being easily accessible. Separate elevators for passengers and cargo run all the way through, also connecting to the sphere and torus through the spokes. The axle also houses the space observatory.

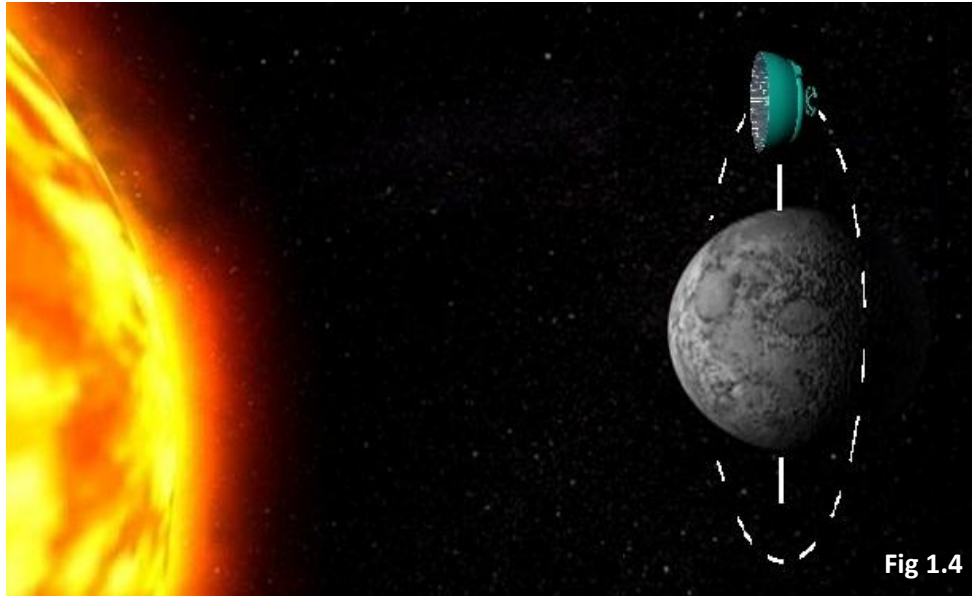
Each property was rated relatively on a scale of 1 (smallest) to 5 (largest).

The entire structure is symmetrical and so is highly stable.



Location of Aynah

Aynah revolves around Mercury in a polar orbit, **5790 km** above the terminator, giving it an orbital velocity of **2700 m/s**. It is positioned with the solar panels permanently facing the sun, as shown below.



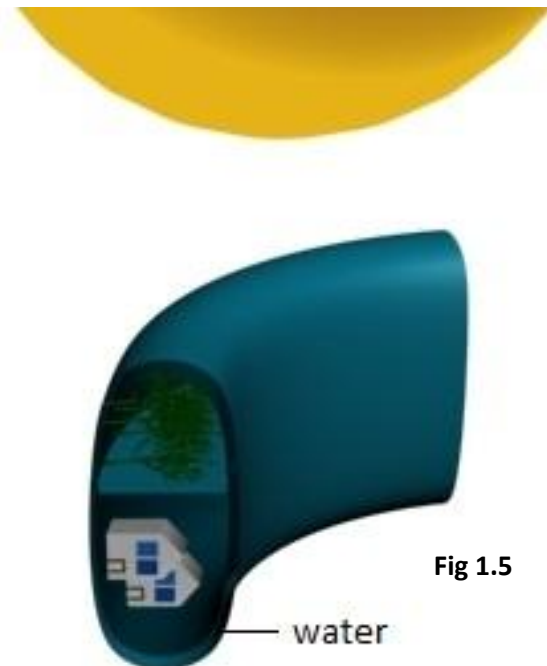
Reasons for selection of altitude:

- The transport distance from Mercury, and hence, costs are kept minimal
- Easy accessibility of reardonium, and other materials on the surface of Mercury, is also assured
- The poles of Mercury, which show evidence of ice, are at 90 degrees to the orbital plane so the Sun is at the same angle above the horizon at all times. If the settlement is too far away, the Sun's light will be blocked so the settlement must be at this particular altitude to prevent this from happening.

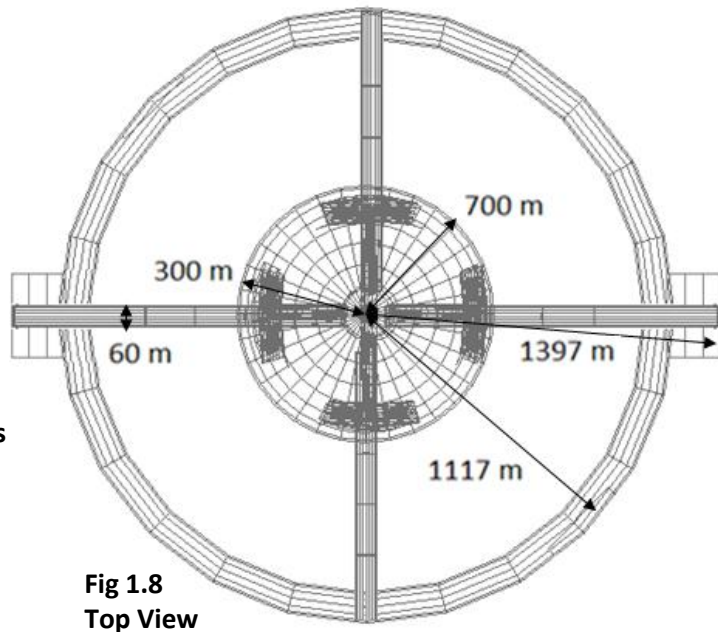
The orientation allows the residential areas to be on the opposite side of the torus from the sun.

As required, the torus is surrounded by a 0.5m layer of water, held between two reardonium walls.

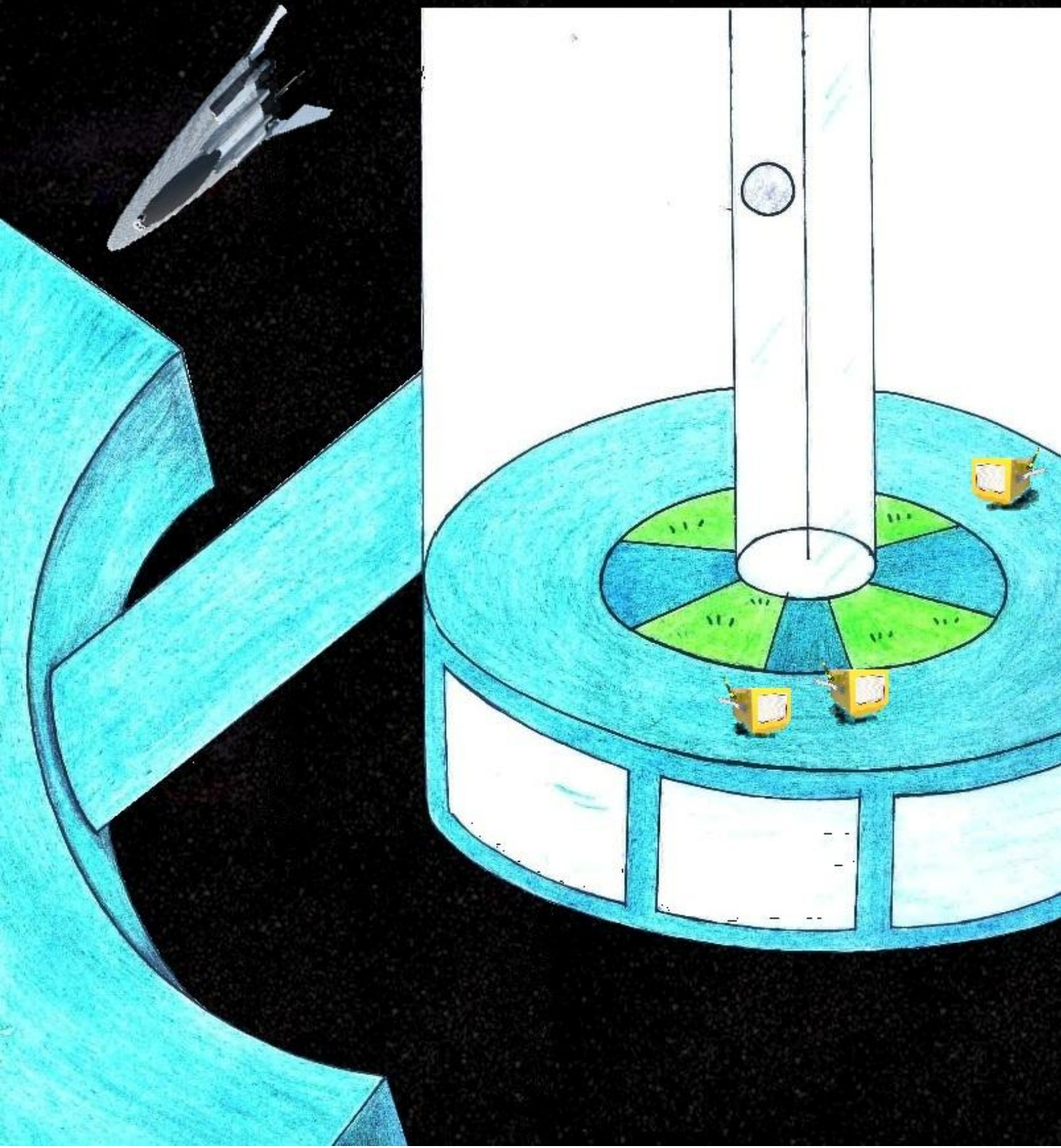
The plants in the agricultural area can also absorb any sunlight that gets past the solar panels and protective reardonium and water layers, ensuring maximum protection of the residents.

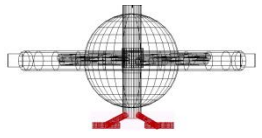


Hull component	Radius/ m	Height/ m	Surface area/m²	Volume/m³	Rotating	Artificial gravity/ g	Pressurized
Torus	1117	-	5,077,000	109,780,000	Yes	0.8	Yes
Extensions (2)	1397	280	264,000	5,600,000	Yes	1.0	Yes
Sphere	700	-	6,158,000	1,323,185,000	Yes	Variable (max 0.5)	Variable
Axle	150	1500	1,555,000	106,029,000	No	0	Only parts occupied by humans
Spokes (2+2)	30	967 1247	364,000 470,000	5,472,000 7,054,000	Yes	Variable	Only elevators
Docks	300	100	419,000	10,472,000	No	0	Partly

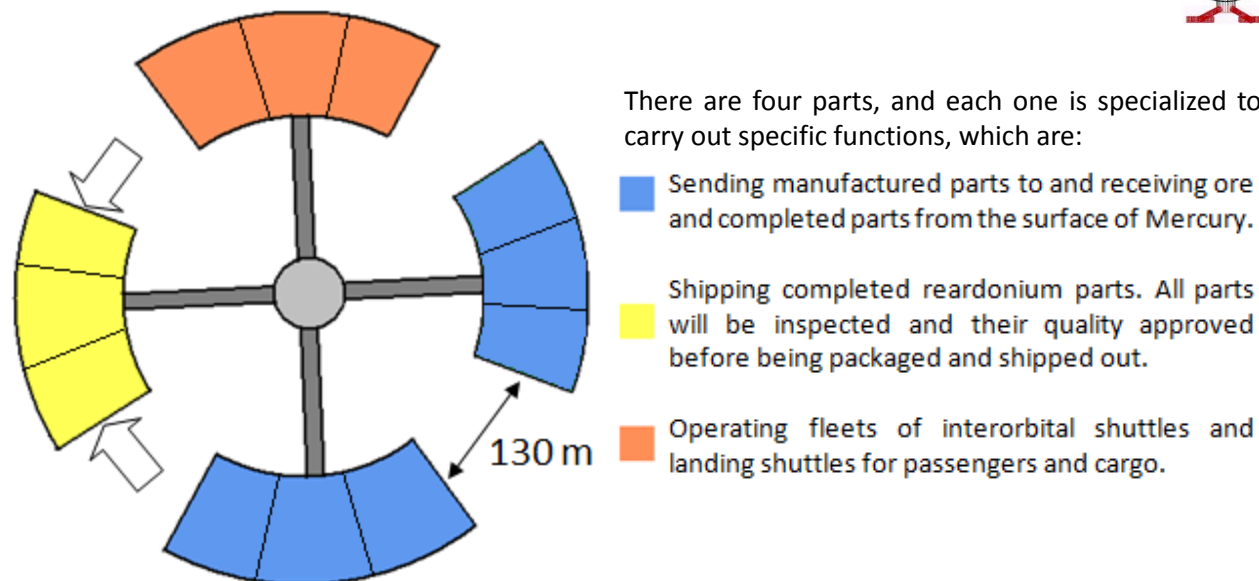


Enter: The Settlement





The first part of Aynah a person will experience is the docking port.



Each segment is divided into three parts: two terminal sections and the middle section. A ship can enter from either terminal section (see arrows on diagram). The doors and available runways are lit so incoming ships can land easily. When the ship has landed, the door will close and the ship will be cleaned to remove dust and grit. A tube will be connected to the ship which will transport the passengers and cargo to the middle section, which is pressurized. From there they move into the foyer at the bottom of the axle (see cover page). Refueling and repair facilities are available at the docks.

Warehouses and storage areas run all along the length of the axle, as shown in **Fig 1.3**. Cargo awaiting other ships or needing to go through customs will be stored in the lowest part of the axle, from where it can easily be taken into the respective dock. Cargo which needs to be stored for a longer time will be taken higher up the axle.

Although the docks are sufficiently large for accommodating various businesses, a second segmented torus can be added above this one if there is a need for expansion.

Dust Mitigation

Centrifugal bowl concentrators are used for concentrating metal in its ore. We will use different magnitudes of driving force for the separation of particles and grit from the space vehicle. This can be classified into multi-g and single-g processes. Multi-g processes allow the separation of fine particles which are in the range of 10 to 50 microns. The single G will process particles that are greater than 80 microns in diameter.

Next, magnetic separation will be used in which non-magnetic particles are separated using strong magnets. These include high gradient magnetic separation (HGMS), high intensity magnetic separation (HIMS) and low intensity magnetic separation (LIMS).

After that automated sorting is done by optical sensors, which coupled with electrical conductivity, control the mechanical separation of ore.

Airlocks

Between the middle and terminal sections there are airlocks to prevent loss of atmosphere. The basic design of airlocks for humans is given below.

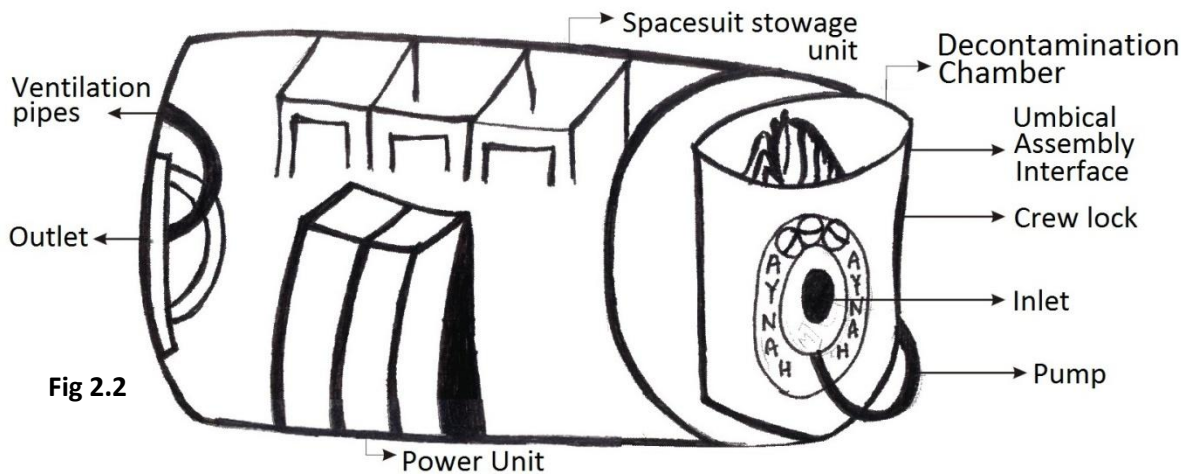
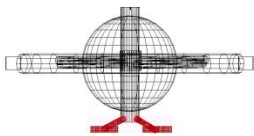


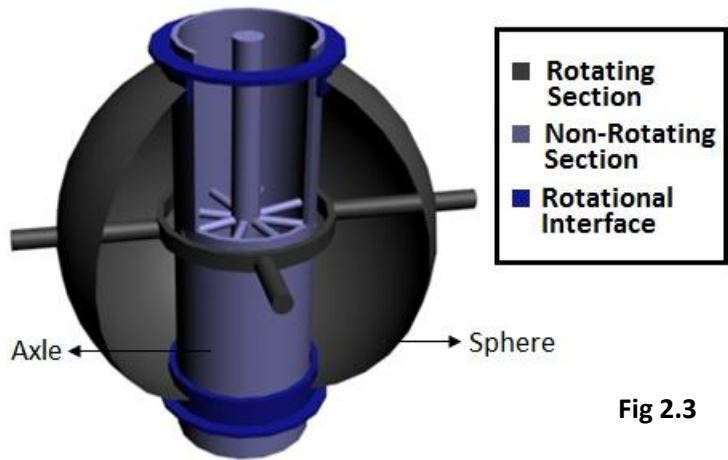
Fig 2.2

Overhead grab bars are installed in the airlocks. **Tethers** will also be used during donning/doffing. Before the process of donning starts, the wearer is made to breath in high oxygen partial pressure for better adjustment to the space suit environment.

There are 80 main airlocks, present in the docking ports. Airlocks are also present throughout the rest of the settlement, between areas of varying air pressures and content. However, these do not have decontamination chambers as they are not needed.

To the Torus

Most people arriving at Aynah will go directly to the residential area in the torus. The torus is rotating and held away from the axle. The interfaces between rotating and non-rotating structures are located at the top and bottom of the sphere, as shown:

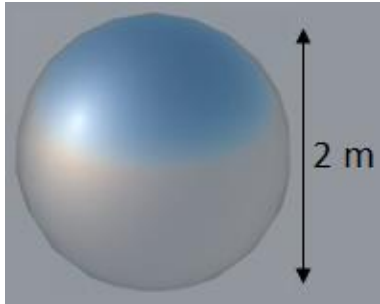


- Magnetic levitation will be used. The sphere is repelled from both ends, causing it to levitate in the middle. The rotating and non-rotating sections do not touch at any point.
- As all the industries are in the rotating section, there is no hassle of moving pipes or wires over the interface.

Fig 2.3

(Figure not drawn to scale)

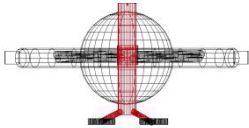
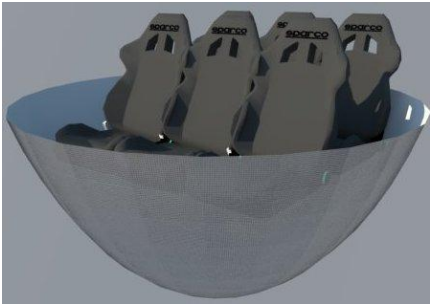
People can move across the interface via the spokes at the centre. To enter the torus, a person arriving at the docks will first be seated in spherical “elevators” called Pinballs (Fig 2.4), which will run through the axle and reach the rotational interface. The rotating section will have grooves in the wall where the Pinball can fit in. As it rotates, it will “catch” the Pinball and lock it in place. The Pinball will then be moved through the spokes and into the torus. The entire system is computerized to ensure efficiency.



← Exterior

Fig 2.4

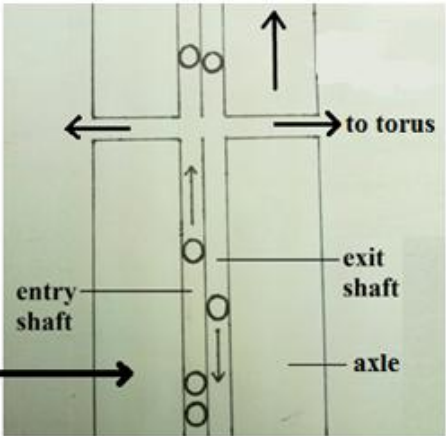
Interior →



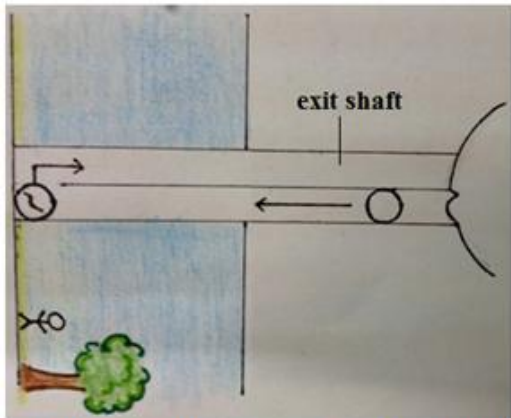
1. Person is seated and strapped into Pinball.



2. Pinball rotates 90°.



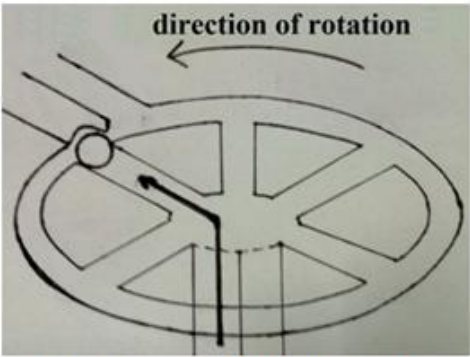
3. Pinballs run through shafts in the centre of the axle.



7. Person enters settlement upright.

6. Pinball moves through spoke.

8. Pinball moves back through exit shafts.



4. The computer sends the Pinball into the next available tube that one of the spokes is about to approach.

5. The groove "catches" the Pinball.

This is only a diagrammatic representation. There will be 20 tubes and 4 spokes.

Rotation Rate = 0.8 rpm

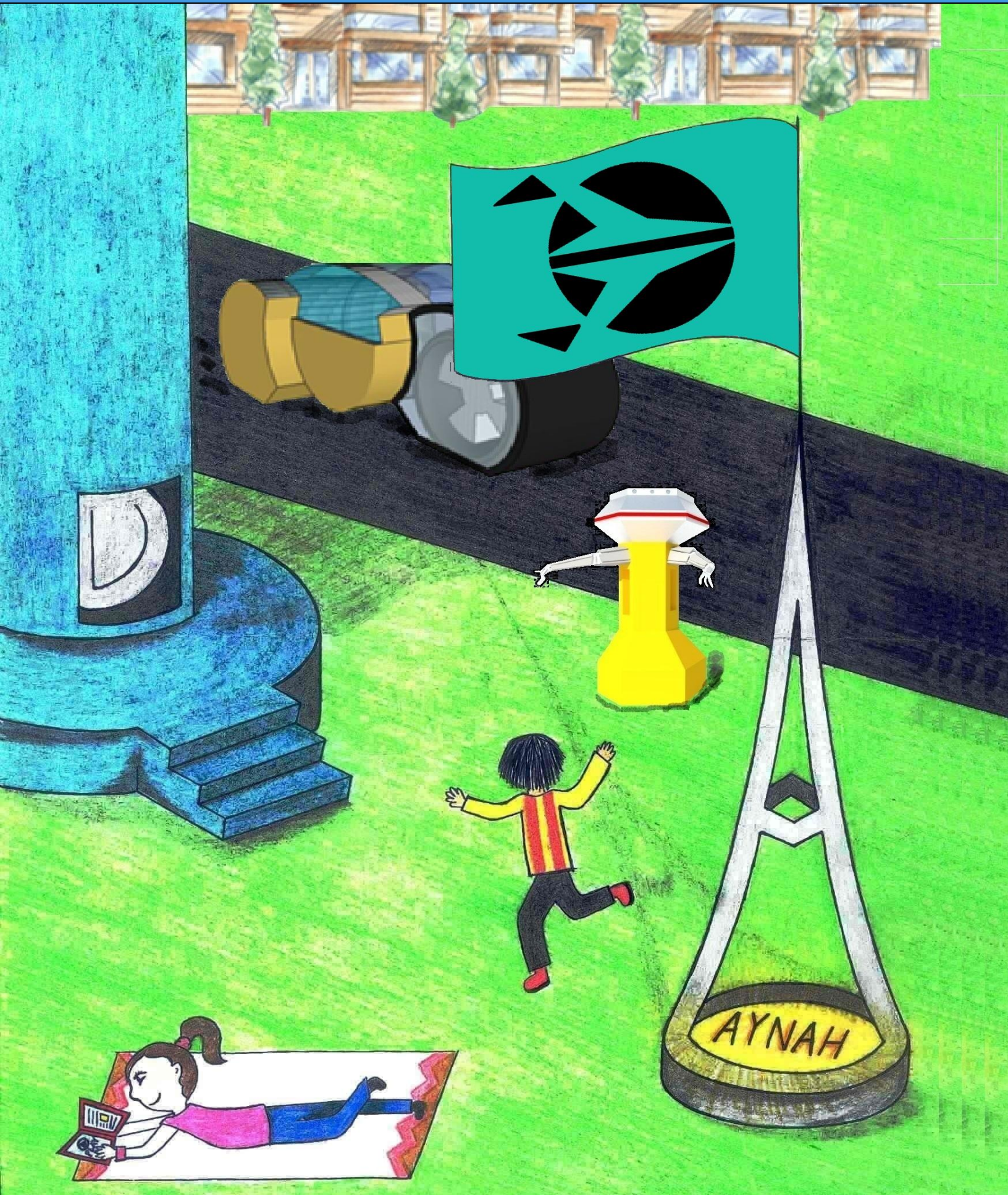
⇒ Time taken for one complete rotation = $60/0.8 = 75$ s

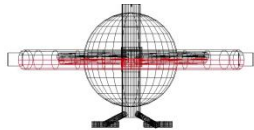
⇒ $75/20 = 3.75$, so each spoke loads one Pinball every 3.75 s

⇒ There are four spokes, so four Pinballs can be loaded simultaneously.

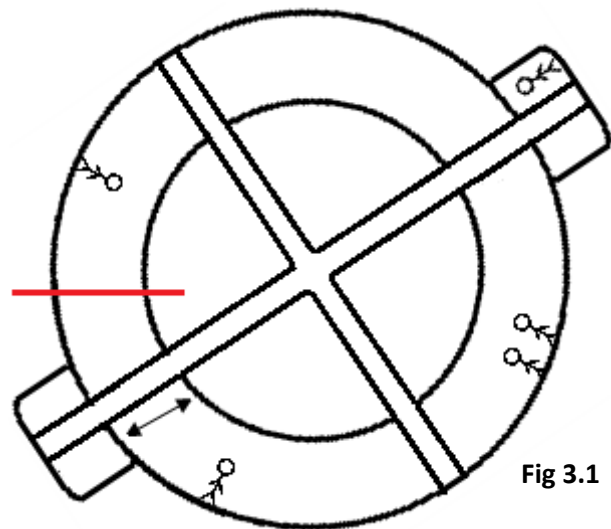
⇒ So Pinballs can move across the interface in no time.

Aynah's Community





Aynah is not only a residence, but a home. We want our residents to have a feeling of patriotism, and to be part of a large, healthy community. For this reason, Aynah has its own unique culture and heritage. Our flag has been proudly displayed on the cover page.

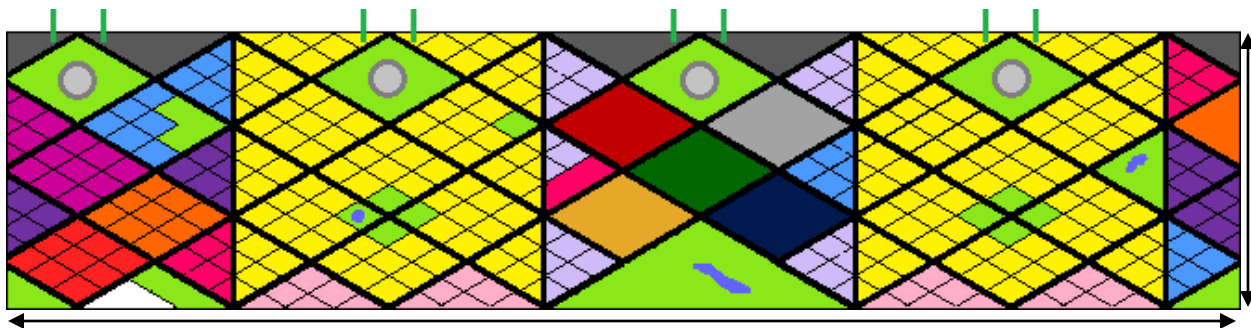


To the left is a Top View of the residential part of the torus, showing the orientation of down surfaces.

The arrow denotes the Vertical Clearance, which is = 50 m.

The torus has been cut at the point shown in red and the residential down surface stretched out to give the community layout below, showing major roads and distribution of areas.

Fig 3.1



The length and breadth (denoted by arrows) are 6860m and 190m respectively.

Fig 3.2

Community center and town hall	Entertainment
Residence	Cemetery
Apartments	Multi-Purpose complex
Library, lab and research center	Religious places
Restaurants	Banks and offices
Health care services	Markets and malls
Aynah administration and control	Museum
Parks, Greenery and recreation	Hotels
Warehousing and Storage	Water Bodies
Airlocks to Agricultural Sector	Entrance points (spokes)

In designing the community, the comfort of the residents has been our main priority.

- The residential areas are directly above the extensions, so children can easily go there for their daily 1g exposure.
- Lots of parks and green areas are scattered around the settlement (not shown on map, as only large parks are shown). Green belts run alongside all the major roads.
- The community is quite open. Long lines of sight prevent adverse psychological effects.
- An area of 1m height has been given underground to lay wires and pipes. They will come from the spokes and will run in the same pattern as the roads. The water pipes will be above the sewage pipes.
- Due to the high percentage of married couples, we expect a relatively large increase in the population in the near future. Therefore a lot of space has been provided for expansion. In case there is a drastic increase, another torus can be constructed below the current one to accommodate the extra population.

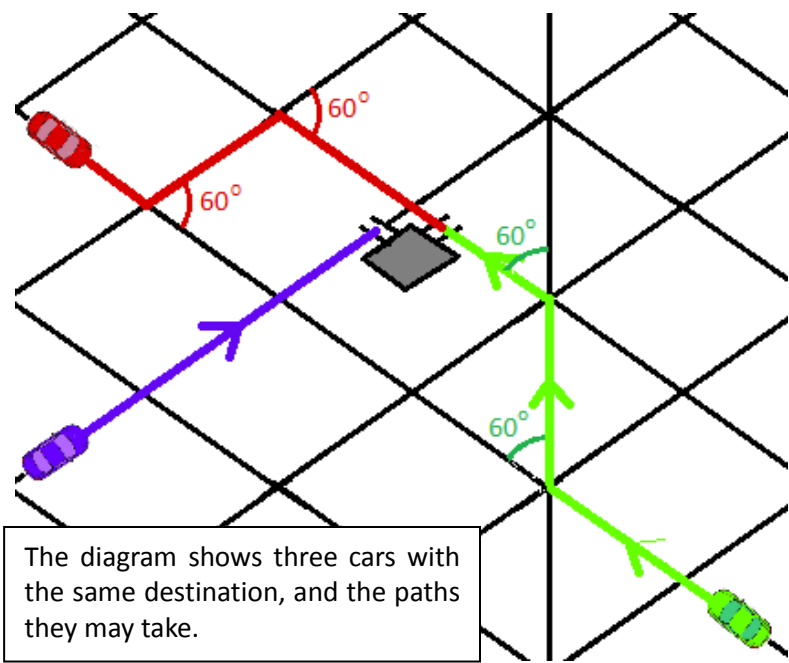
The percentage allocation of the down surface area of the torus is as follows:

Type	Allocation (%)	Area (m ²)
Residence	33.2	730,000
Offices	1.0	20,000
Markets	1.5	33,000
Agriculture	40.6	892,000
Semipublic (Hospitals, Halls, etc.)	1.4	30,000
Public open space	6.4	141,000
Storage and Warehouses	3.5	77,000
Miscellaneous Infrastructure	4.5	99,000
Transportation (Roads)	7.9	174,000
Total Area		2,196,000

Fig 3.3

As required, the roads have been laid out in a diamond grid pattern to minimize head turning. The straight roads crossing the diamond grid also reduce the need of rounding acute corners, or taking long paths.

The acute angle of the roads is 60°, which is the optimum, as decreasing this angle further would cause the obtuse angle to increase. Major buildings such as hospitals, banks and main offices will be placed on the corners of the diamonds. They will also have two entrances, reducing the need to turn acute corners. All cars will have navigation systems that automatically pick out the best route for you.



Vehicles for Internal Transport

Allegatus: a fuel cell family car which can seat upto 6 people.

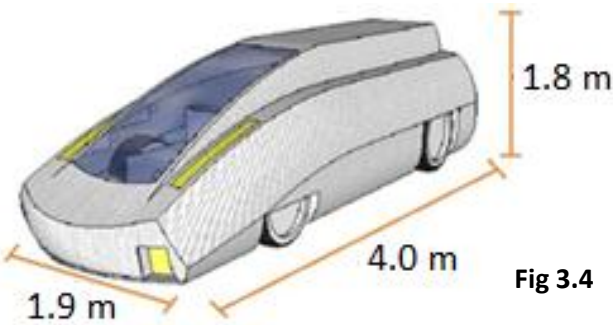


Fig 3.4

Vasculum: a two-seater smart car designed for individual use.

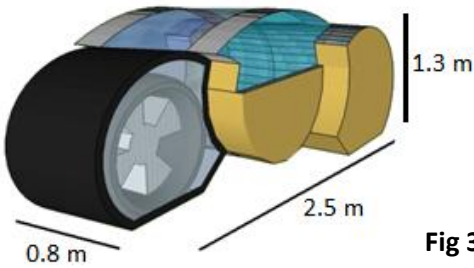


Fig 3.5

Tron: A spokeless, magnetic dome bike

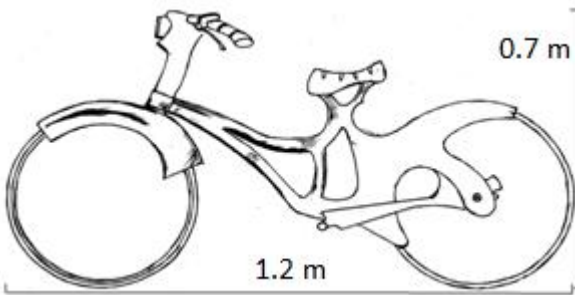


Fig 3.6

Residential Design

We want our residents to feel completely at home. Our houses have walls which can be moved around at will, so each individual or family can design their own residence, and change it at will if they need to expand or simply want a change.

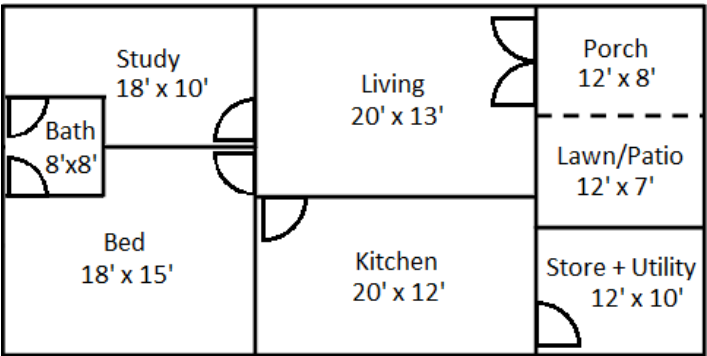
However, we have designed standard houses for those who think it a hassle. To allow maximum flexibility we have provided simple, rectangular houses. Four basic townhouse models have been designed keeping in mind the diverse preferences the residents may have. Their exteriors and floor plans are shown below.

Single's House:

Area: 1250 sq. ft. (50'x25')

Quantity: 1100

Fig 3.7



Simple Family House (double story):

Area: 1500 sq. ft.(50'x30')

Quantity: 3000

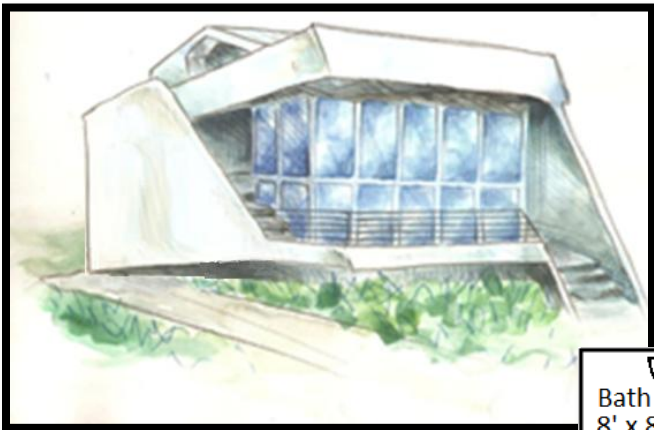
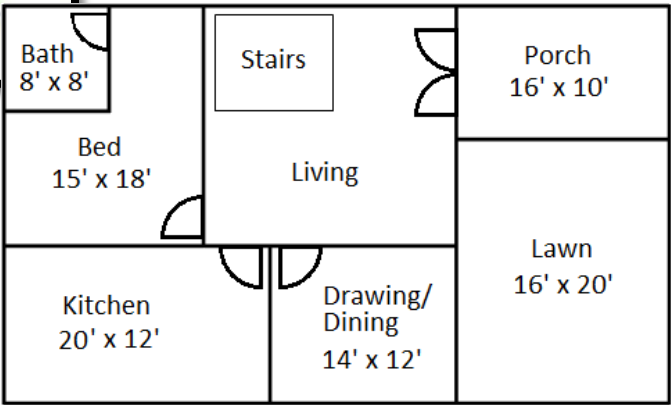
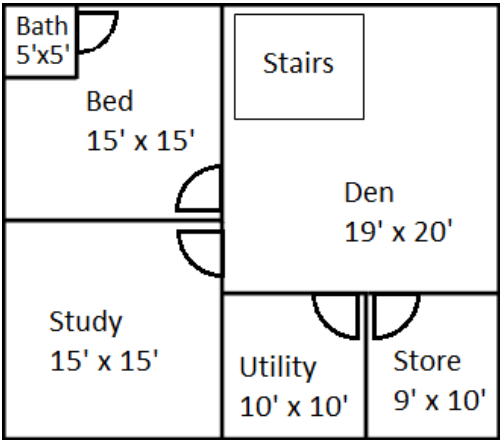


Fig 3.8



Shared Housing (double story):

Area: 1800 sq. ft. (60'x30')

Quantity: 700 buildings, housing 4 people per building.

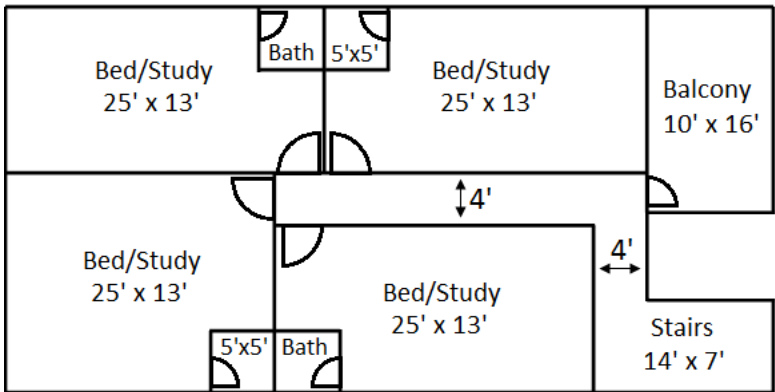
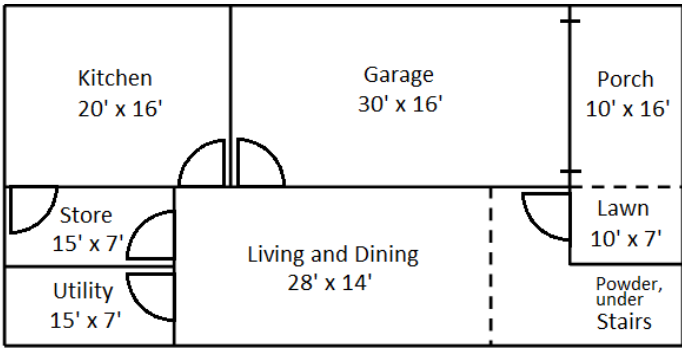
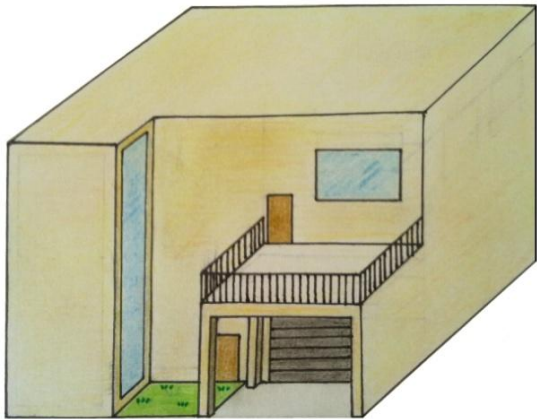


Fig 3.9

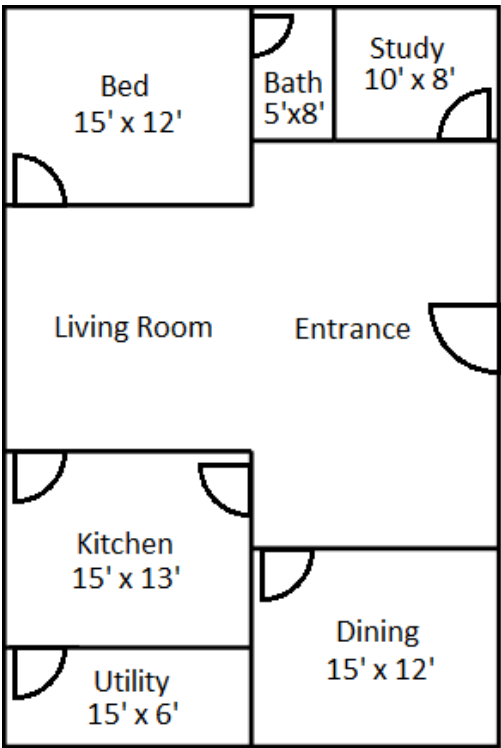
Apartment (five stories):

Area: 1350 sq. ft.(30'x 45') (per flat)

Quantity: 50 buildings, with 50 rooms per building.



Fig 3.10



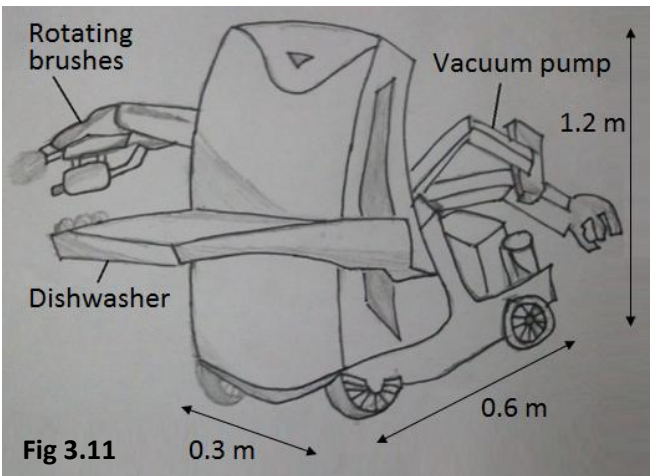
Tall ceiling heights and spacious houses add to a high standard of living. The utmost comfort and security has been provided to the residents, including:

- Remote controlled windows which change colors and transparency as desired.
- Smart mirrors are your personal style guides, from mixing and matching your wardrobe and fitting it to your body for a virtual try on to letting you know if anything is amiss, these mirrors are available in every house hold.
- Nano glass cleaners
- Electronic wallpapers which show picturesque scenes of the Earth
- Retina and finger print scans for security
- Smart electronics in the house, profile each inhabitant on the basis of their different tastes and lifestyle and manage their routines.

Dio, the Domestic Robot

Features include:

- Rotating brushes.
- Vacuum pumps
- Robotic arms with multi tool first aid kit
- Modifiable hands, which can be adjusted for mopping, dusting, scrubbing, etc.
- Arms can also perform functions of a pram or a cradle or even a digital blackboard as per the requirement.



Its functions include washing dishes, ironing clothes, cleaning the floor, baby sitting, setting the table, making beds, maintaining plants, and repairing taps and pipes. It is powered by rechargeable batteries.

Automated Kitchen	
System Includes:	Functions
Motion sensor	Detects motion commands from Dio. Cabinets and doors slide and open by the mere movement of Dio's hand.
Wireless touch screen	Through which commands can be given.
Preloaded recipes	Time will be fed in of when the food needs to be cooked and served.
Biometric system	Only permits house members over the age of 21 to gain access to the liquor cabinet.
Grocery outlet	Keeps an accurate record of the groceries in stock. Has direct connectivity to the supermarket computers. Touch screen enables grocery orders to be placed from the house.
Stove and Oven	Auto temperature control. Pans and ingredients are placed by Dio.
Exhaust	Automatically turns on and off according to need.
Refrigerator	Robotic arms automatically place food items requiring refrigeration in the refrigerator. It also functions as a water purifier. Immediately provides water to the user at the required temperature.
Baby sensors	Floor slides moving the baby away from sharp corners and dangerous areas. Sensors also inform the residents of the presence of the baby in the kitchen.

Automated living room		
System Includes:	Functions	Unfolded/Folded
Holographic Screen	Provides a 3-D experience. Also has numerous buttons.	Unfolded
Camera	High definition 3D camera, with excellent picture quality, captures picture of anything, anywhere, when given command.	Folded
Mood sensor	Plays music in accordance to your mood. Also plays music on command.	Unfolded
Virtual Sports	The holographic effect lets you experience sports like cliff diving or skiing. A touch of Earth in Space.	Unfolded
Alarm Clock	Sets the alarm itself according to the routine of the user.	Folded
Dancing	Transforms into a humanly shape and can perform different types of dances with you.	Unfolded
News	Gives headlines, weather forecasts and news about business world. Can also record and repeat news.	Folded
Video Conferencing	Type the name of the person you want to call and he'll appear, in and out of the settlement.	Folded
Games	The screen allows the user to play multiple games. Other people having this device or the same network can connect in too. The holographic screen makes the two feel like they are together.	Unfolded
Smell-e-vision	If there is a cooking show on the screen the aroma of the food will be felt outside.	Unfolded
Motion Sensors	Lights of the house turn off when there is no movement for a certain time, to conserve energy.	Unfolded

VIS – Your All-in-One Key

The **Visual Interface Screen (VIS)** is a wrist band worn by the residents which can create, extend and work by using a visual screen. It serves both the purpose of a personal device and also enables people to control operations from remote areas. You can personalize it and change its color to match your attire. It has a miniature motherboard and about 10TB of flash storage.

The VIS uses **SixthSense** technology. The map application lets the user navigate a map displayed on a nearby surface using hand gestures, similar to gestures supported by Multi-Touch based systems, letting the user zoom in, zoom out or pan using intuitive hand movements. The drawing application lets the user draw on any surface by tracking the fingertip movements of the user's index finger. SixthSense also recognizes users' freehand gestures. For example, the SixthSense system implements a gestural camera that takes photos of the scene the user is looking at by detecting the 'framing' gesture. The user can stop by any surface or wall and flick through the photos he/she has taken. SixthSense also lets the user draw icons or symbols in the air using the movement of the index finger and recognizes those symbols as instructions.

VIS is also useful in situations dealing with complex automated machinery and to assign them various tasks corresponding to their function. Multiple screens can be drawn out and machines can be controlled from remote areas. It acts as a skeleton key which allows communication with all the computers and devices of the settlement the wearer is authorized to use.

The **VIS** will also contain the entire user's identification information (such as home address, age, blood group, email I.D., tax details, ID number etc) helping the recognition of a person and eliminating the hassle of carrying ID cards and certificates etc. Fingerprint scanning will ensure that no one but the owner can wear the VIS, hence preventing identity theft.

Security of Personal Data

Central security unit has MAC addresses and can track usage of users to check for unusual activity (This is optional for residents).

Proxy servers and fixed ports for the secure transmission of data. Data sent through mail is first encrypted. It can be decoded only by the VIS of the person to whom it is sent.

Biometric signatures can be used. The computer asks the user for their signature which is drawn with the operator's finger tips on a touch screen. The finger prints as well as the signature are then examined.

- Data on wireless routers is encrypted and secured by WPA2
- Key logger and activity monitor on each computer for tracking all activity.
- Spam Filter
- Virus protection framework, whereby the power will automatically shut down with secure data automatically saved in order to block a deadly virus from entering.
- All systems also contain a "Parental Control" module.

Entertainment and Recreation

We realize that Aynah will be not only a centre of reardonium production, but the home of thousands, and possibly more in the future. Life at Aynah is comfortable and lively, thanks in part to a few of these:

Parks and open areas big and small have been provided throughout the settlement. In one special feature park, part of the wall and floor is made of borosilicate glass, revealing the swirling water underneath. Colored pool lights have been installed, giving a marvelous effect at night.

The Multiplex is a triple-story recreational complex which includes:

- 4D Immersion Cinema and Theatre
- An Ice land with an artificial mountain, skiing, and ice skating
- The Terra Casa Nature Reserve, an indoor jungle which features realistic 3D holograms of animals of the Earth, of both the present and the past, going about their daily lives.
- A Couples-only Night Club
- A Play Place to leave the kids at, which is supervised by Dio bots.
- A Mega Mall large enough to get lost in.

The Millenia Museum is the storehouse of knowledge on space exploration. Special items found on Mercury and in space will be displayed here. It will be an interactive learning experience.

The extensive library will also encourage learning. The books will be made of e-paper and will interact with the VIS, allowing searching, copy-pasting and saving of specific material. The library computer allows efficient checking in/out of books and will indicate **the exact location of any book** whose name is typed in. Interactive holograms enhance learning. There is one section dedicated to Earth, so that residents can learn the history and culture of their forefathers.

Scattered around Aynah are replicas of famous landmarks on Earth, with modern twists. Granted, Aynah's Pyramids won't be as tall as Earth's, but they will have a fully computerized interior, digital hieroglyphs, and a moving labyrinth.

The extensions of the torus each have three floors. Two of these are for children's areas. The other four are each dedicated to different activities:

- On one side, we have the Christensen Gym, a large fitness centre with state-of-the-art machinery. The high g of the extensions will make exercise more effective.
- Directly above that is the Sports Complex and Stadium. The annual Aynah Olympics will be held here. Once every five years we will also host an Inter-Stellar Olympiad here.
- On the other side is the Aynah Autodrome – the largest in the Solar System.
- Below which is **AVIRA** – The **Aynah V**irtual **R**eality **A**rcade. This is the place to let your imagination run wild – you think it, it appears!
 - The main feature is the **Avatar**, which in essence is a standard chair with virtual headset and controls. It will create a simulated environment for users to play games (or e.g. for scientific experimentation), where the person will feel as if they are inside the game's fantasy land. All avatars are connected allowing multiplayer gaming.
 - Sports which cannot be provided in reality, like fishing and horse riding, will also be provided here.

Zero-g Rec Room - the name says it all. This arena will appeal to adults and children alike. Lighten your load and let go of yourself - in every sense!

Markets

Other than the Mega Mall there are markets, shops and convenience stores located in accessible areas of the community, where residents can easily purchase goods. **Smart vending machines** allow residents to scroll through choices and make a selection using touch screen. It has a massive 65-inch transparent HD display to create animations.

The vending machine also uses a face recognition strategy. When someone approaches the machine, a camera measures the person’s physical features and makes a guess as to the person’s sex and age, then displays advertisements targeted to those demographics. In times of emergency it goes into “public safety mode” and displays information such as alert updates and evacuation routes.

Residents can also send Dio robots to do their shopping for them. Perishable items like vegetables and fruits will be freshly distributed to the markets from the agriculture sector. Other consumer goods will be manufactured in the residential area. The goods and equipment brought from the earth will be stored in the axle.

The major consumer goods are:

Category	Products	Amount required/year
Toiletries	Personal hygiene, cosmetics, soaps, tissues	160400 kg
Stationary/office supplies	e-paper, pens, staplers and other items	32000 kg, 33,000 pieces
Cloth	Clothing, footwear and linen	420000 m
Furniture items	Chairs, tables, beds, fixtures and fittings etc	216000 pieces
Electronics and hardware	Wires, gadgets, fridges, ovens etc	650000 units
Garden equipment and tools	-	19,000 pieces
Pet items	Pet foods and medicines	9000 kg
Medicines	Drugs and injections	21000 kg

Medical Services

The VIS device that colonists wear has an integrated health monitoring system, which will track each person’s vital signs periodically. If it detects something abnormal, VIS will notify the colonist and search the medical database to determine the cause.

The MedBot is equipped for taking care of ill residents. It has:

- 4 hands to perform various functions
- ECG scanner, Blood pressure monitor, and other diagnostic tools
- Stretcher
- Sensors for navigation
- Tends to patients’ needs till they have been transported to the hospital



Fig 3.14

Human doctors and other medical staff will also be available at hospitals in cases of importance where human involvement is required, such as for sensitive operations or psychological support.

Offices

At work, **Sandler’94** is your helping hand.

- Inbuilt computing capabilities
- Can print, scan and photocopy e-paper, and interact with it.
- Storage for stationary and paper.
- Multi lingual communicator.
- Maintains log books of office workers.
- Coffee machine.
- Powered by chargeable battery.

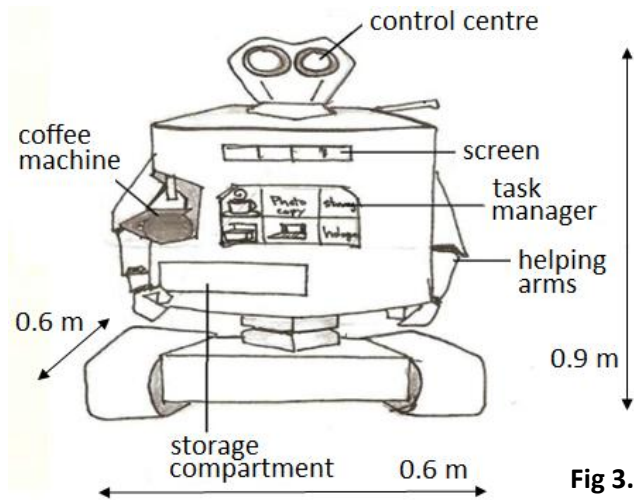
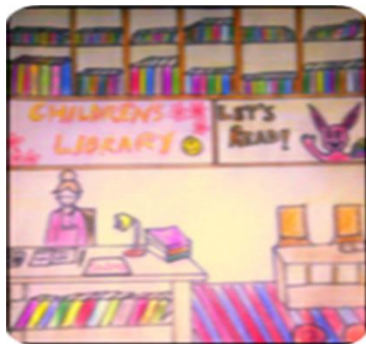


Fig 3.15

Artificial Gravity

The settlement is rotated about the axle at an angular velocity of 0.8 rpm, which is low enough to prevent the dreaded Coriolis Effect, as well as other psychological factors. This generates a gravity of 0.8g in the residential torus, which is ideal for human habitation, and a maximum gravity of 0.5g in the sphere, as required. The extensions on the torus will have 1g, which is beneficial for children.

The 1g areas can be accessed through the spokes. The exotic and colorful environment of the 1g areas is well suited to the liking of children.



- * To cater to not only the physical but also the mental growth and development of the children Aynah Grammar School (AGS) provides perfect automated education.
- * The children's library is located close to the school, and encourages thought in children.

- *A day care centre ensures that even infants get the essential exposure to 1g.
- *The mini theatre shall air movies for these children.



- *The indoor Play area is a constructive way for young people to spend time; it provides fun activities ranging from chess to dressing up.
- * Also, various sports can be played in the 1 g area ranging from football to table.

* The children's camping ground nourishes the body and provides healthy exercise. The clubs will encourage leadership, creativity and activity.



Education

- At young ages, human interaction and attention is important for children, therefore the Aynah Grammar Schools will have actual teachers. Higher education will be carried out primarily through a holographic teaching avatar. It will be projected from holographic projectors mounted on a robotic base unit or an individual student's desks. E-lectures will also be given.
- Students will use Multi-Functional Flexible e-pads, which work like any other ecopad but look like e-paper. The difference is that they can store large amount of information in a single page and information can be manipulated and edited simply by the stroke of your finger. This negates the use of bulks of paper as hardcopy.
(These e-pads will also be used throughout the settlement instead of paper.)
- The two branches of AGS (one in each extension) have a healthy rivalry and there are many inter-school competitions between the two.

The **LightScythe** is a device which allows you to draw, manipulate and capture pictures of colorful text and images frozen in midair. It works with a wireless link, whereby image data is sent to the scythe at specified times, making it possible to visualize the invisible network data into some awesome light paintings.



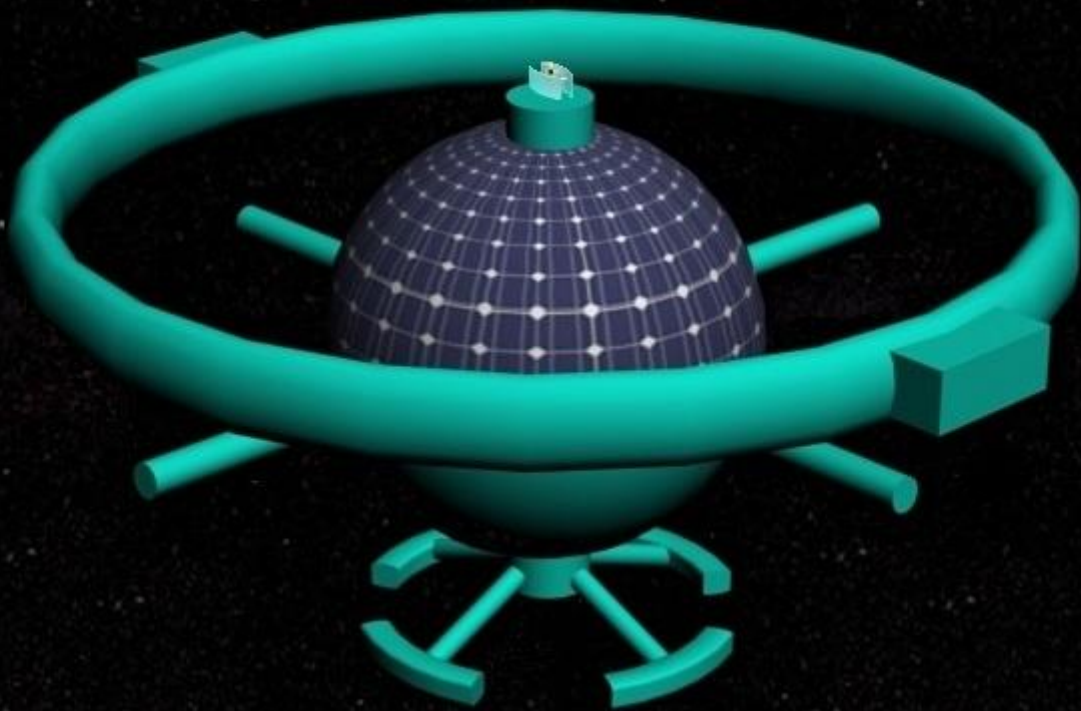
Space Observatory

Aynah's zero-gravity space observatory is located in the axle as rotation may be a nuisance to people looking outside. It is at the side farthest from the sun, both for protection and to provide a better view. The windows are made of borosilicate glass. As an added measure, reardonium shutters can close over the windows if needed.

The observatory is luxuriously equipped with stationary telescopes and seating areas with belts and straps so that the residents of Aynah can enjoy views of outer space and carry out research work in a peaceful and calm ambiance.



Construction of the Settlement



Construction Sequence



Fig 4.1

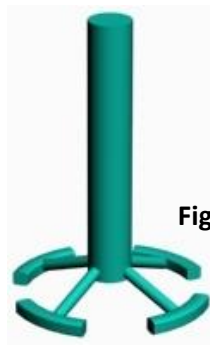


Fig 4.2

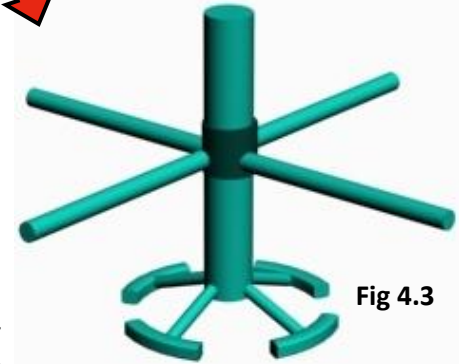


Fig 4.3

Stage 1 - Construction of the axle will take place to provide a base for the rest of the settlement.

Stage 2 - The docking ports will be constructed so that materials can be brought in easily.

Stage 3 - The spokes will be constructed outwards from the axle. All four will be constructed simultaneously so that the weight is balanced.

Stage 4 - Construction of the industrial sphere will occur. After completion rotation will be initiated and industries will start working to generate revenue and produce material for further construction. Solar panels on the sphere provide enough energy to initiate reardonium production.

Stage 5 - While the rest of the settlement is rotating, the residential torus will be constructed separately.

Stage 6 - Rotation will be stopped. The torus will be attached onto the rest of the settlement, the disc and cup of solar panels will be attached, and rotation will be initiated again.

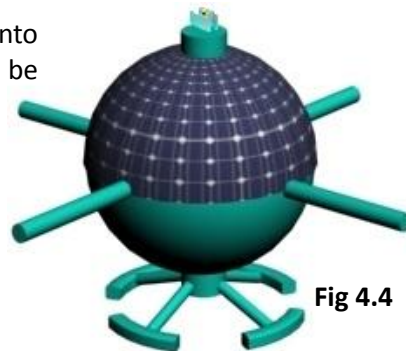


Fig 4.4

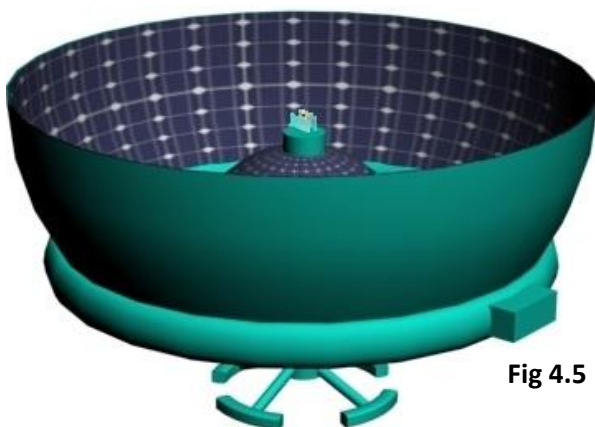


Fig 4.5

Fusion rockets will be used to initiate rotation. Helium-3 will be used as fuel, which is readily available on Mercury. In Stage 4 two rockets will be placed on diametrically opposite points of the sphere. In Stage 6 they will be detached and reattached along with two others, symmetrically, onto the torus. These thrusters can also be used to maintain the speed of the settlement in case it slows down or to reposition it if required.

Transport of Equipment for Construction:

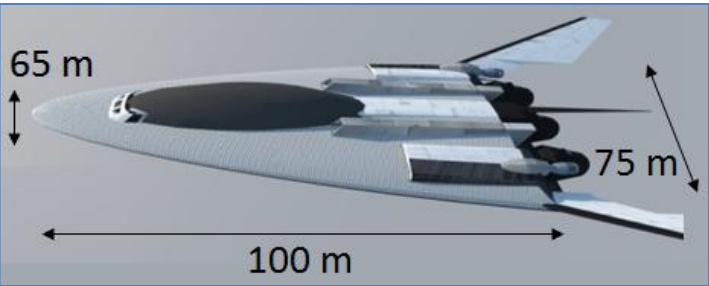


Fig 4.6

The AynRyder (Fig 4.6) is best for intra-orbital journeys. It has a large capacity, and is equipped for handling pieces as well as raw ores. It can be used to carry commercial cargo and can also act as a passenger airliner.

Quantity: 20

Exterior Construction

Magnetic pulse welding (MPW) will be used to construct the settlement. It is a welding process that uses magnetic forces to drive two work-pieces together at high velocities. The impact produces a solid state weld.

This method is suitable because it does not require the metal to be melted, which would be highly impractical considering the high melting point of reardonium. It can be carried out in vacuum and has no adverse effects on the metals being welded. Small pieces of reardonium can be joined without cracks or holes, and once joined will seem to be a single piece.

The EMP-bot (Fig 4.7) will be used. One of the arms contains thousands of capacitors that will supply the current to induce the magnetic field, and the other arm is for gripping the two materials together while welding. Take note that these arms themselves are insulated, so as to not interfere with the welding.

Quantity: 50

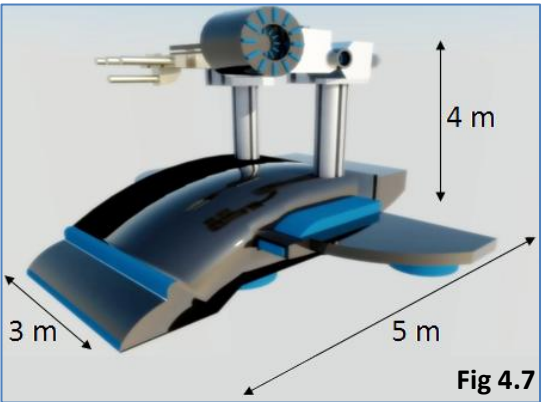


Fig 4.7

Automation for Assembly

Ringo66 is a ring shaped robot with assembly tools lining its inner surface. To aid the construction process there are various sensors installed in Ringo66 e.g. temperature and pressure sensors etc. It has various end effectors and each tool has the ability to extend, rotate to 360 degrees and also bend in directions to make construction easier (All the tools work along three axes). Ringo66 has been made from reardonium, which is solar flare resistant. The size of the assembly robot is varied depending upon the nature of the task; for instance the radius of the robot used for external assembly of the settlement can be extended from 500 to 800 metres.

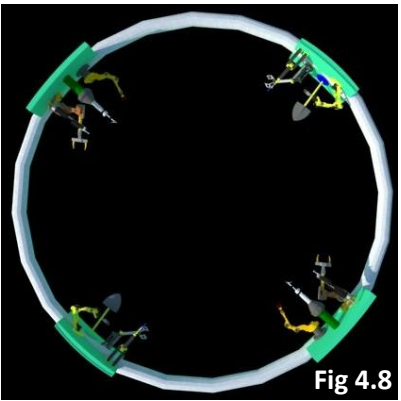


Fig 4.8

After construction, these robots will be used for maintenance and repair. They will also accompany humans working on or in the immediate vicinity of the settlement, and shield them if danger arises. Some of them will work in the reardonium industries.

Interior Construction

Selective Laser Sintering (SLS) will be applied to construct interior structures. It is an additive manufacturing technique that uses a high power laser to fuse small particles of plastic, metal, ceramic, or glass powders into a mass that has a desired 3-dimensional shape. The powder to be used will be purified soil from Mercury, which will greatly reduce the cost of shipping material to the settlement.

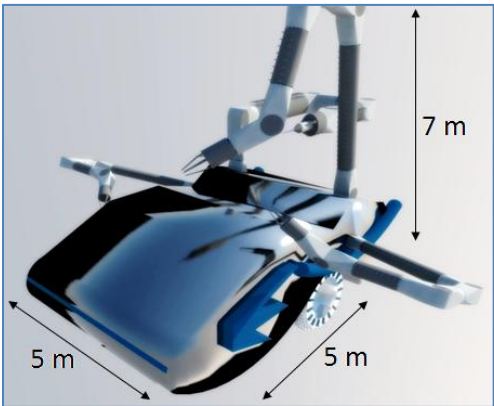


Fig 4.9

The SLS-bot (Fig 4.9) uses a CO₂ laser. A thin layer of mercury soil is laid down and the laser “draws” on the layer, sintering together the particles hit by the laser. The layer is then lowered a small amount and a new layer of powder is placed on top. This process is repeated one layer at a time until the part is complete. By using thermal and area capacity scanners, the SLS-bot will design quality houses and buildings. Its efficiency is unmatched; within minutes, it can prepare even the toughest of designs, providing the best quality there is.

Quantity: 200

Interior Finishing

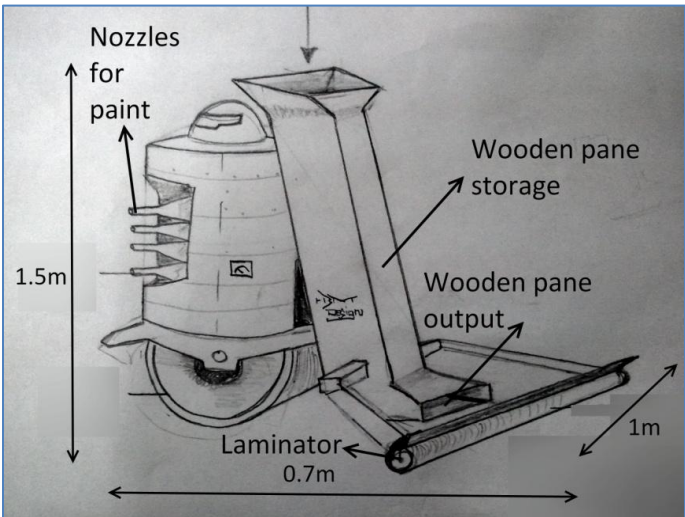


Fig 4.10

The Decrobot (Fig 4.10) can spray paint through a tiny nozzle, so as to concentrate it into a beam and create sophisticated designs according to the user's wish. It can also paint in bulk, finishing a wall in 10 seconds. It simultaneously adds wooden floor pieces and assembles, levels, and laminates them. The rover-type wheel is utilized to ensure that the floor is leveled perfectly. It has 3D holographic imagery that allows the user to manipulate the robot and make any desirable changes that need to be done in the design.

Quantity: 200

Aynah’s roads will be built by BituBot’07 (Fig 4.11). It basically operates by commands given on its computer touch screen. It has an adjustable main arm with various 360 degree rotatable end effector modules to do various tasks. It has a gravel shower that can also be used for other liquids. Next to the gravel shower is the electromagnetic plate extending out of the robot’s body which collects all metallic trash. The other metal arm extending from the robot’s body has a laser cutter/driller attached to its end.

Prepared asphalt is unloaded into its rear ‘drum’ by Ringo66. While the rear drum revolves to ensure the uniformity of the mixture, the nozzles attached on the front roller spread out the material. Simultaneously, the hot and heavy roller presses over and hardens the road material. Sensors are installed on it to ensure the uniformity and spread of material.

Quantity: 25

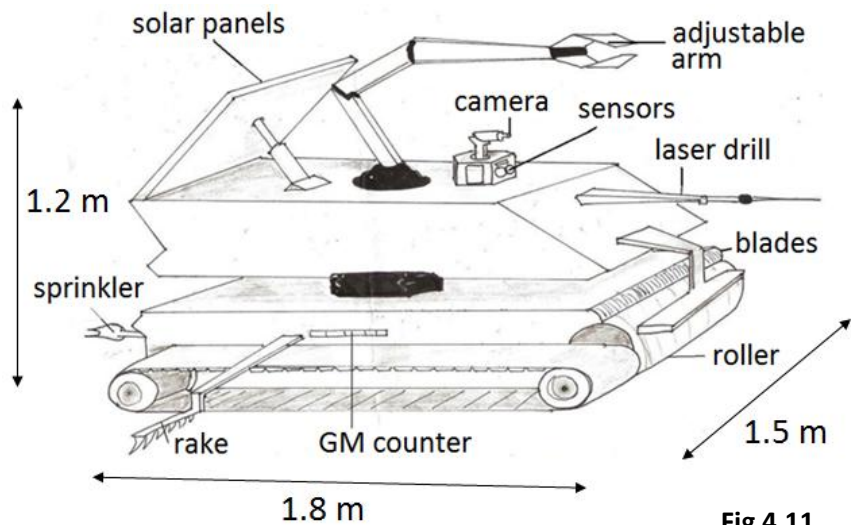
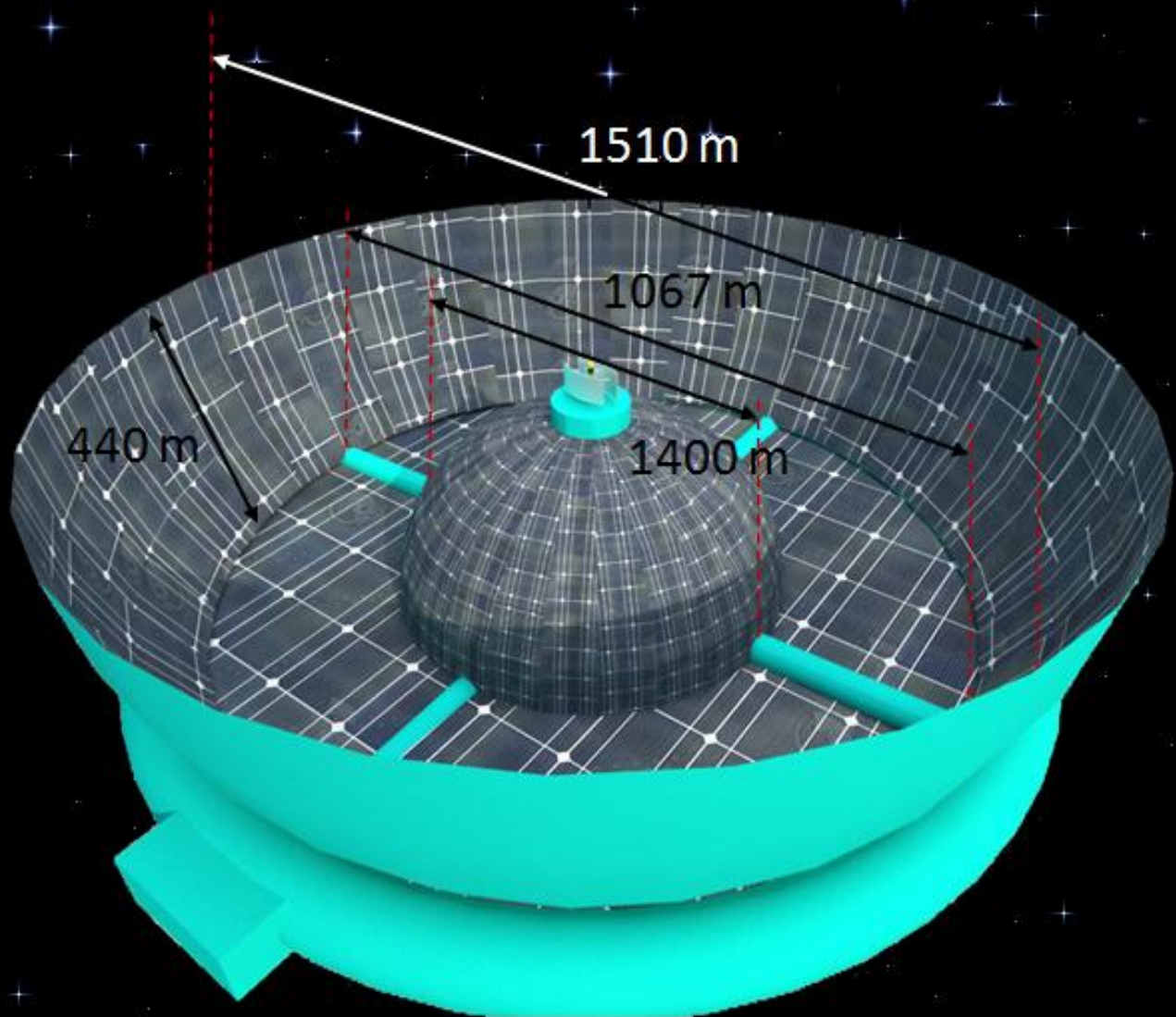


Fig 4.11

Materials Required for Construction and Operations, other than Reardonium

Material/Equipment	Amount	Sources
Launch vehicles	400 units	Bellevistat
Construction robots	250 units	Bellevistat
Assembly robots	10 units	Bellevistat
Mining robots	270 units	Bellevistat
Computers	15,000	Aresam
Spacesuits	710 units	Aresam
Helium-3	As required periodically	Mercury
Borosilicate glass	50,000 m ³	Mercury
Mercurial regolith	10,200,000 m ³	Mercury

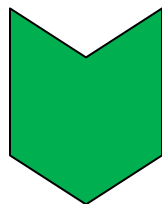
Running the Settlement



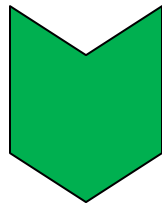


Agriculture and Food Production

The torus also contains the agricultural area. It is compartmentalized so that each crop can be grown in the temperature, atmosphere and humidity conditions best suited to it. Airlocks separate the residential and agricultural areas (shown on the community map), and are also used between the agricultural compartments as needed.

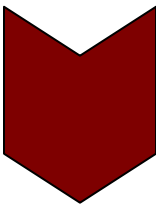


All essential crops will be grown using an air-dynaponics system, an enhanced version of the antiquated aeroponics system. The crops will be exposed and regularly misted with nutrient rich spray through a small air pump with a narrowing tube which ensures that air flows through at a high pressure and hence requires less force thereby reducing energy requirements.



At the time of harvest, the Agrobot (see below) will collect all the produce. It will then plant new seeds and the cycle will be repeated. Food will first be irradiated and then packaged, using Modified Atmospheric Packaging and Equilibrium Modified Packaging, and stored in the axle until needed. 1,000,000 m³ of volume has been dedicated to food storage only.

All kinds of meat will be grown using meat printing where muscle and other flesh cells are grown on a biopolymer scaffold which copies the extracellular matrix of the cells and then prints it using a 3-D printing device.



Food will be sent to houses via underground suction pipes when ordered by the Automated Kitchen. They will originate from the agricultural area and move underground alongside the water pipes. It can also be purchased at conveniently located retail stores.

Trade Study for Food Production				
Rated 1 (worst) to 5 (best)				
System	Feasibility	Efficiency	Cost	Total
Zeoponics	1	2	3	6
Hydroponics	3	2	1	6
Aeroponics	3	4	4	12
Dynaponics	4	5	5	14

Major Consumables Grown/Produced on Aynah

Type of Food	Quantity per person per year/kg
Meat	25.8
Fish	8.5
Chicken	32
Milk, eggs and cheese	120
Fruits and vegetables	132
Bread and cereals	82
Oils and fats	8
Sugar and honey	28
Spices and sauces	8.5
Total quantity per person	444.8
Total quantity	6,449,600

Essential Nutrients	Sources
Carbohydrates	Honey, sugar, bread, fruits
Fats	Nuts, seeds, cream, meat
Proteins	Meat, egg, milk, pulses
Fiber	Grains, seeds, vegetables
Calcium	Milk and milk products
Vitamins (A, B,C, D)	Carrots, Spinach, tomatoes, citrus fruits, nuts, eggs, milk
Vitamin C	Citrus fruits
Vitamin D	Butter, eggs, milk
Vitamin E	Nuts, beans
Magnesium	Green vegetables, legumes , nuts and seeds
Phosphorus	Cheese, soy products, fish, whole grain
Iodine	Iodized salt, seafood
Iron	Liver, fish, lentils, beans
Zinc	Oysters, beef, wheat, germ, seeds, chocolate, nuts

Crops for industrial uses will also be grown, such as cotton for making cloth, and bamboo for making furniture. Bamboo is used as it is not only cheap, but also easy to grow and grows fast.

The Agrobot

Features

- Pneumatic Nozzles on the front to sow seeds with Air Pressure.
- These Nozzles are also used to spray water
- Contains a roller to flatten the land for sowing and cultivation
- Blades come over from the roller for harvesting the crops.

Quantity: 10

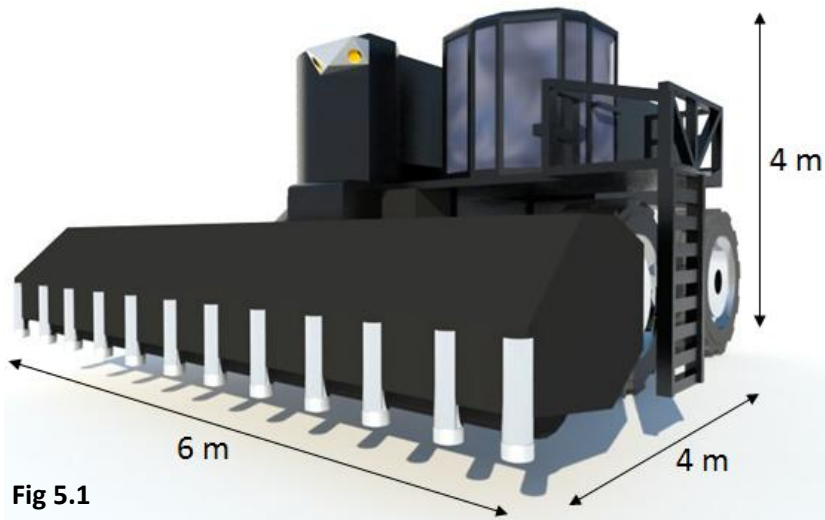


Fig 5.1

Day and Night Cycle



Micro-blinds, composed of thin metal blinds on glass, can control the amount of light passing through in response to the applied voltage. They will form the “ceiling”, or “sky”, of the residential area, to provide an Earth-like day and night cycle.

A thin insulator is deposited between the rolled metal layer and the TCO (transparent conductive oxide) layer. With no applied voltage, the micro-blinds let light pass through but when there is a p.d. between the rolled metal layer and the TCO, it causes the micro-blinds to stretch. The dimness of the lights shall vary in order to make provision for sunset and pitch darkness.

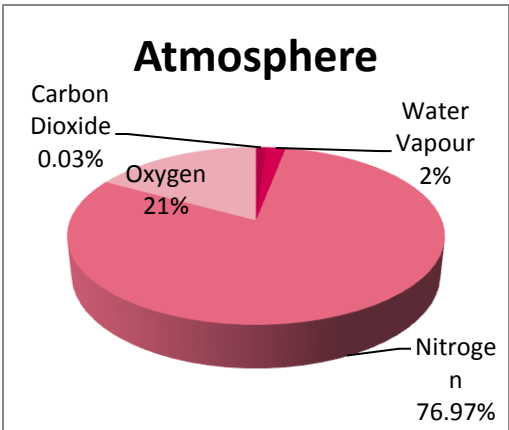
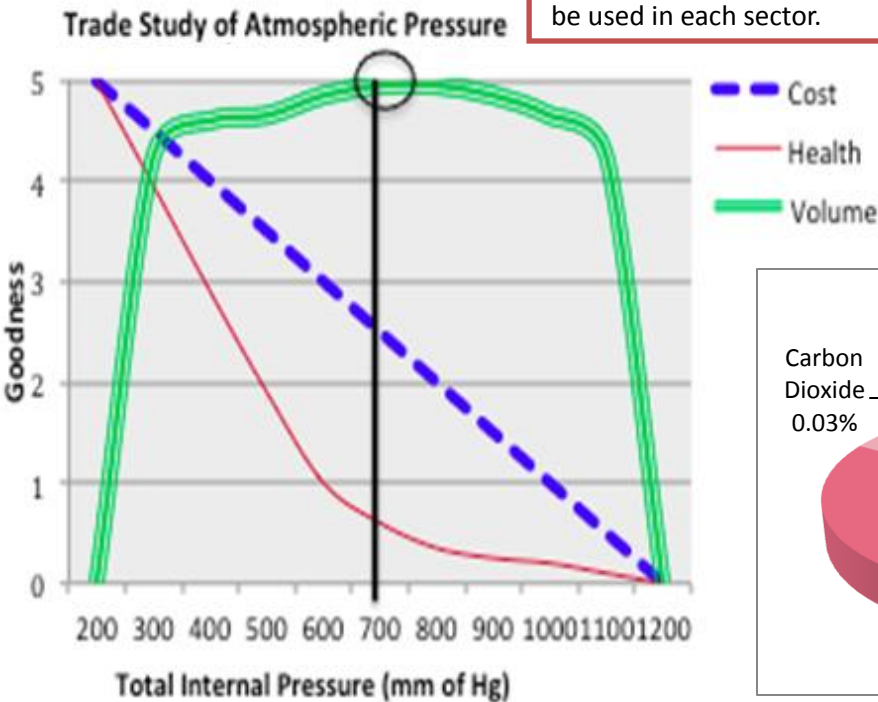
At sunset, cameras attached to the axle will capture views of Mercury which will be projected onto the ceiling, as the lights gradually get dimmer. This completes the 24-hour cycle.

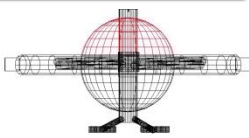
Atmosphere/Climate/Weather control

Gas	Total amount Required in the settlement (m³)
Nitrogen	602,000,000
Oxygen	164,000,000
Carbon Dioxide	300,000
Water Vapor	16,000,000
Total	782,300,000

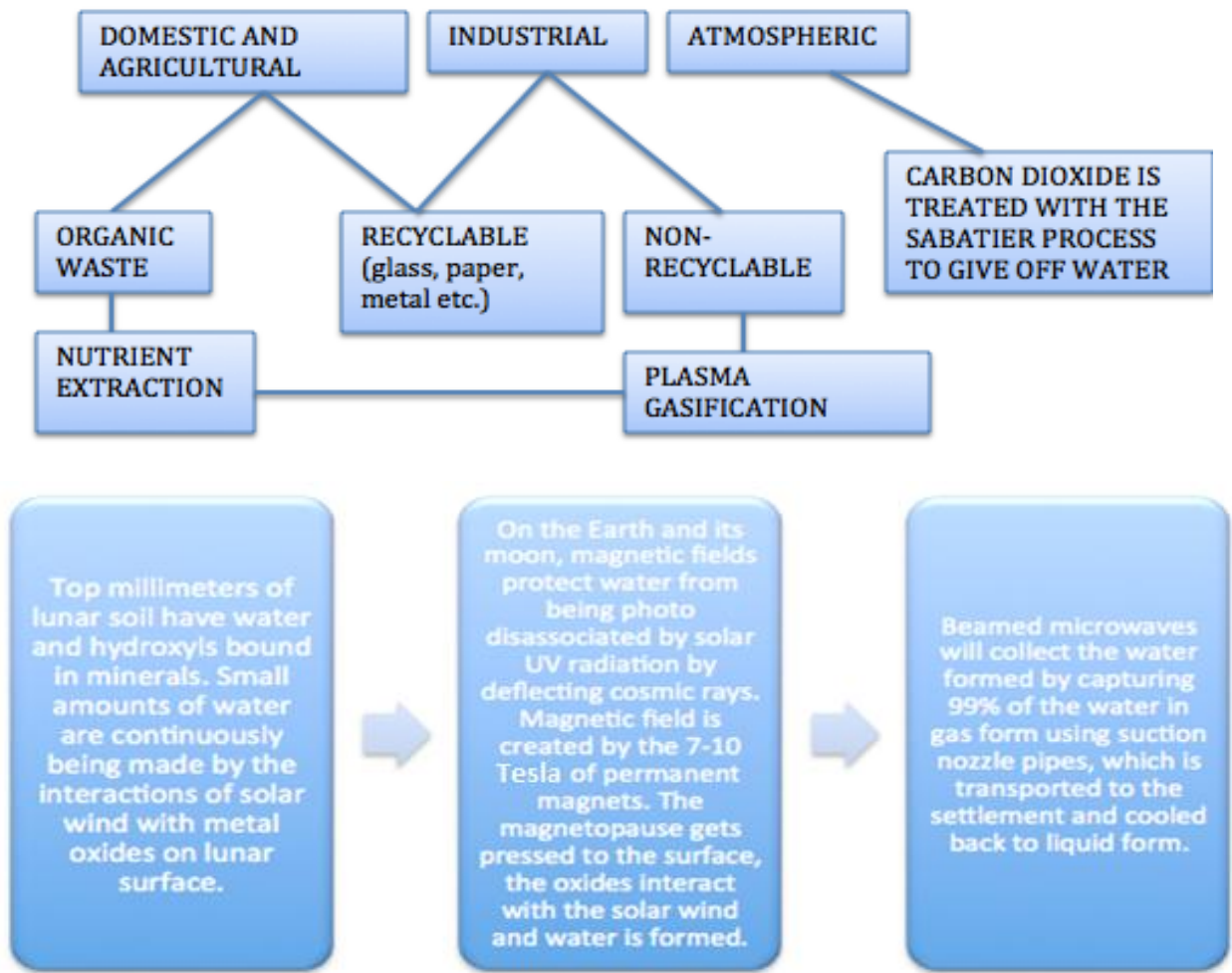
Temperatures of between 2 and 30 °C will be maintained in the settlement, and the seasons provided will imitate Earth seasons; Artificial Rain and Snow will be provided using sprinklers and snow guns, while the water vapor content shall be maintained with the help of humidistats. Air will also be filtered to remove dust and grit.

We have given the composition of air for the residential areas. The agricultural areas will have more CO₂, while the industrial areas will be pressurized according to the requirements of reardonium. Atmospheric stabilizers will be used in each sector.





Water and Waste Management



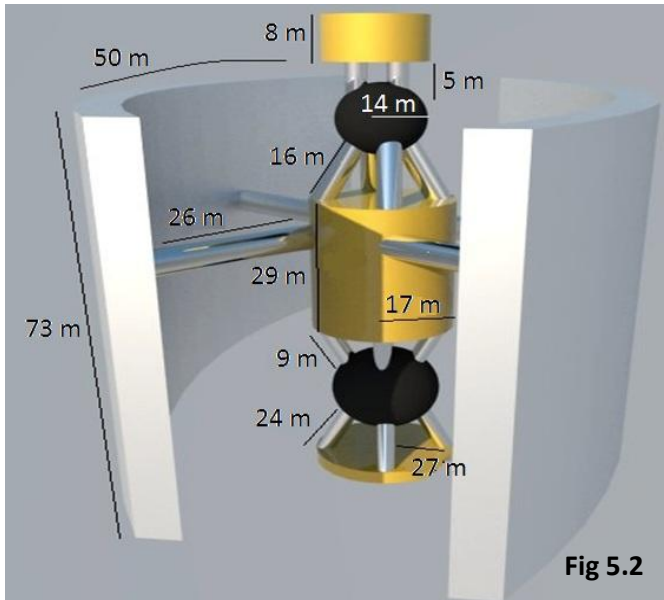
Top millimeters of lunar soil have water and hydroxyls bound in minerals. Small amounts of water are continuously being made by the interactions of solar wind with metal oxides on lunar surface.



On the Earth and its moon, magnetic fields protect water from being photo disassociated by solar UV radiation by deflecting cosmic rays. Magnetic field is created by the 7-10 Tesla of permanent magnets. The magnetopause gets pressed to the surface, the oxides interact with the solar wind and water is formed.



Beamed microwaves will collect the water formed by capturing 99% of the water in gas form using suction nozzle pipes, which is transported to the settlement and cooled back to liquid form.



WATER MANAGEMENT

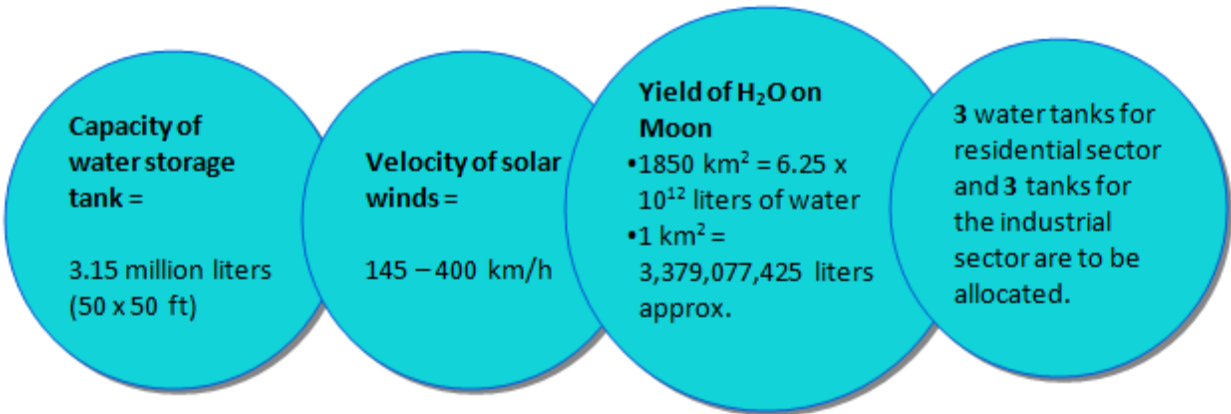
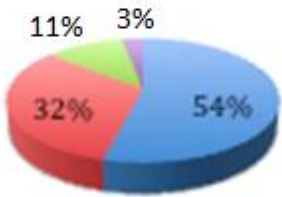
1. Screening to remove solid waste (Recyclable materials taken to recycling sites)
2. Grease skimming of water
3. Membrane filtration using nanofiltration
4. Flocculation using PolyDADMAC
5. Wet oxidation
6. Addition of compounds depending on needs



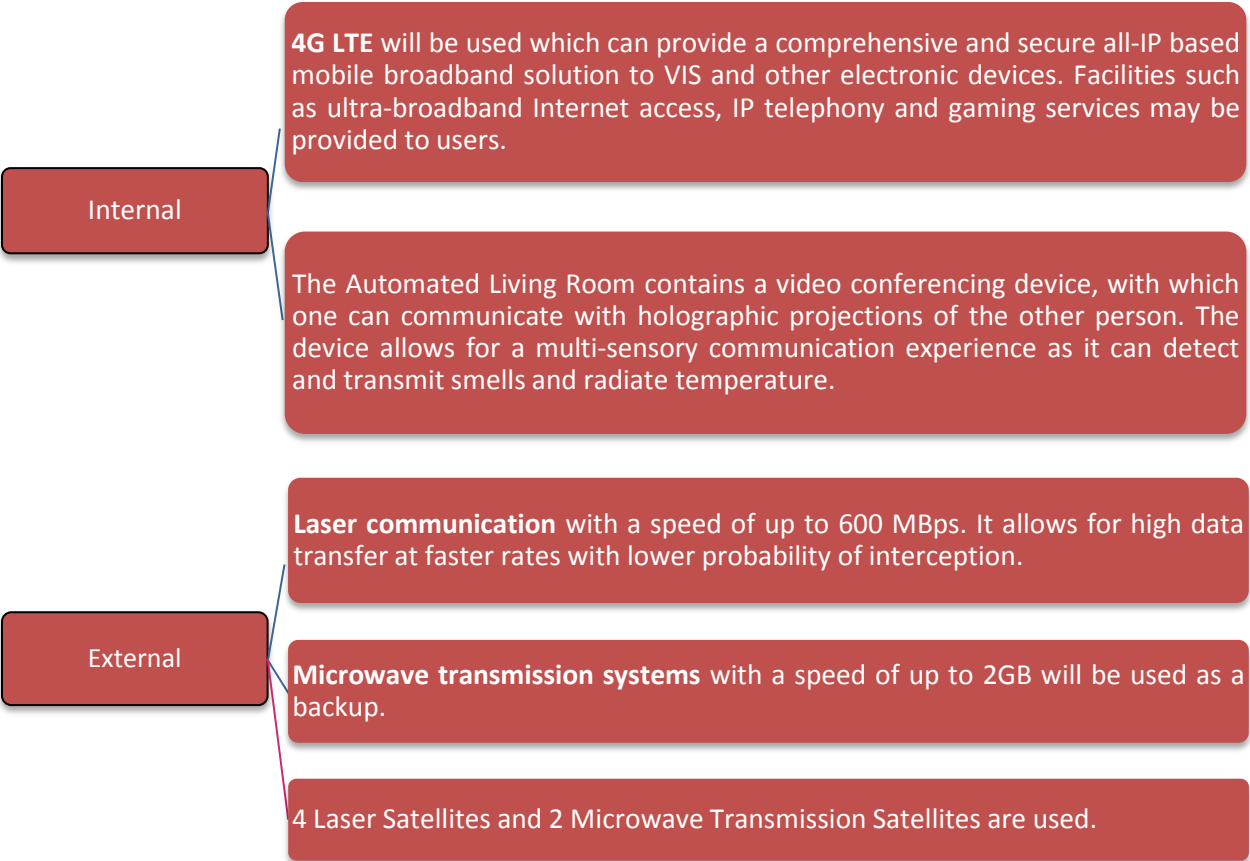
Daily water usage per person	450 liters
Daily usage of population	6,300,000 liters
Yearly need	2,299,500,000 liters
Water for shielding	2,670,000,000 liters

Water Distribution

■ Domestic ■ Industrial ■ Agricultural ■ Other



Communication





Servers

The entire settlement will be controlled and run by a central unit which will direct various other sub-servers to carry out their respective functions. This complex computer will have 1256 core processor technology, 65 PFLOPS processing speed, 1150TB RAM and 2.0 Exabyte storage space.

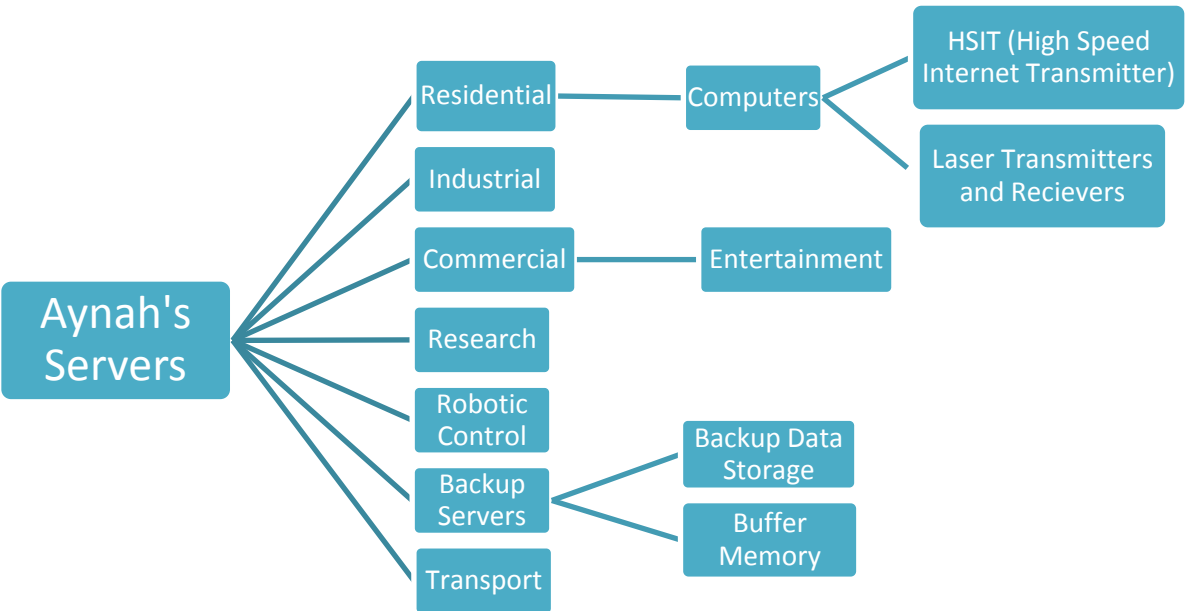
The purposes for which this will control the sub-servers include:

Quantity	Aynah's Sub-servers Purpose	Specifications
17	Residential	18 PFLOPS, 865 TB
15	Commercial	30 PFLOPS, 1020 TB
13	Industrial	27 PFLOPS, 1.3 PB
14	Research	23 PFLOPS, 950 TB
12	Robotic Control	29 PFLOPS, 975 TB
21	Backup Servers	30 PFLOPS, 1050 TB
8	Transport	25 PFLOPS, 350 TB

There will be two machines working on the hull of the settlement whereas two others will play the part of detectors checking for any dangers such as approaching asteroids, etc. Guidance robots will direct the rest of the robots to do their jobs.

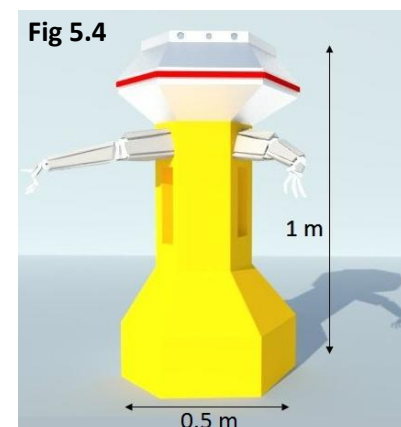
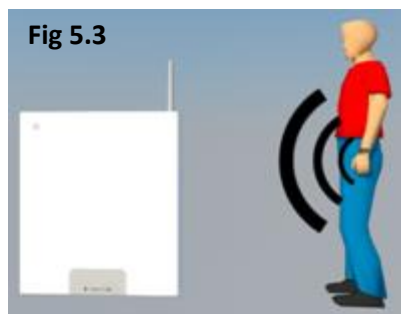
Network Devices	Functionality
HSIT (High Speed Internet Transmitter)	This router will emit 7GS internet which will spread across the entire radius of the settlement, being utilized at homes, industries, and research facilities. The speed ranges from 4/4.5 GBPS
Laser Transmitters and Receivers	Used for the traveling of data. This has proven to be one of the most efficient data traveling mediums, as the high transmission speed is unmatched.

Data Storage Devices	Specifications
Backup Data storage for the settlement (Dedicated to different sectors, i.e. Industrial, Residential, and Research.)	1.2 ExaByte for each sector.
Buffer Memory	350 TB



Security of Aynah

- **Virtual Turnstile (VT)** will be employed in major buildings and offices. It is an access control solution which uses **Radio Frequency Identification (RFID)** to identify people and objects using CCTV cameras equipped with intelligent video analytics. It negates the need for obtrusive physical barriers such as traditional turnstiles by creating an invisible radio field around the entrance. Used in conjunction with the VIS, it enables a computer to monitor the passage of every individual entering and leaving a facility. Once inside the building, the system can be used to locate and track people and can assist in safe evacuation during an emergency. An added dimension to the system is its usefulness in monitoring time and attendance.
- Surveillance cameras fitted in the F.L.Y. bots (Fig 7.1) would keep a check on all the activities in public places. Any unusual activity would be reported immediately to the control centre. Thermal and x-ray scanners detect any potentially dangerous weaponry. Security robots with artificial intelligence (Fig 5.4) patrol the settlement to control any criminal activity. They are programmed to detain troublemakers, but not to harm them in any way.
- Cameras in the docks record anyone entering/exiting the settlement.
- If a person is leaving the settlement to work, they will first check out through ID-readers attached to all exit points in Aynah, which identify data installed in the VIS. These machines read the code through LASER and will save all the information regarding the person on the security computer, including time of exit. If the person is gone for too long the appropriate security team will be notified and the person contacted to see if they are in any trouble.



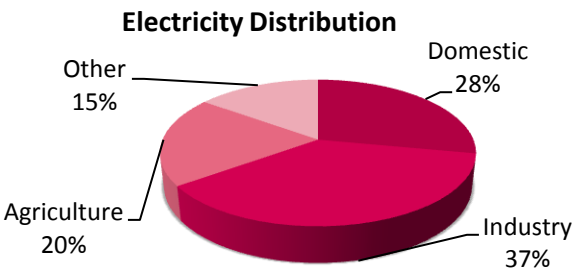
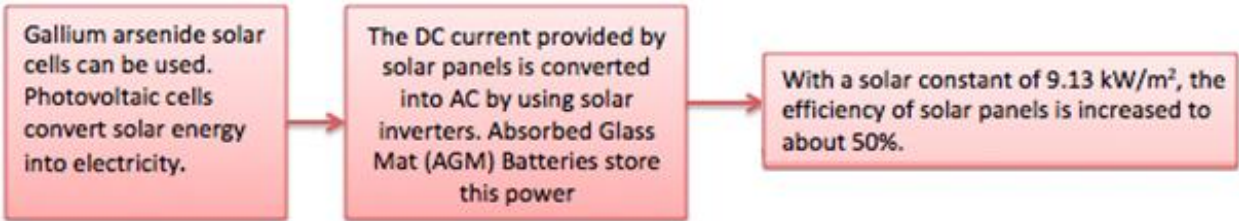
High Level Security, for Industrial Sector, Important Information, and Main Computer Systems

- Complete Face Recognition is used to identify the person accessing the settlement's computer systems.
- Plasma shielding outside important data libraries to prevent any unauthorized transfer of data.
- Automatic Biometric Authentication (ABA) scans both, a mixture of genes as well as the brain pattern scanning of specific regions of the brain involved in cognitive processing and analysis (e.g. the hippocampus). Both of these factors for authentication give varying results among individuals and a very minute probability of an error. A computer processes the blood sample from the person (extracted by pricking one's finger with a needle). The needle is laminated and discarded so as to prevent the transmission of diseases. The DNA sequence from the blood sample is matched with the computer's database of different people's genomic sequence and the encrypted information is accessed according to one's respective designation. Forgery of one's blood sample is unlikely since the RNA of blood cells are destroyed when extracted from the human body for a prolonged period of time. The information in the computer is encrypted and is only made available when the brain scanning as well as the genetic code of the user matches that of the enlisted authoritative members stored in the computer.
- The main computers allow authorized personnel control to a certain limit. To make a drastic change to settlement operations, the computer will require 3 highly ranked officials to approve the change. (An exception to this is if the settlement has gone into lockdown in a case of emergency.)



Power Requirements

The cover page shows the placement of solar panels on the structure and their dimensions, adding up to a total of 15,000,000 m² (5.8 sq. miles) in area.



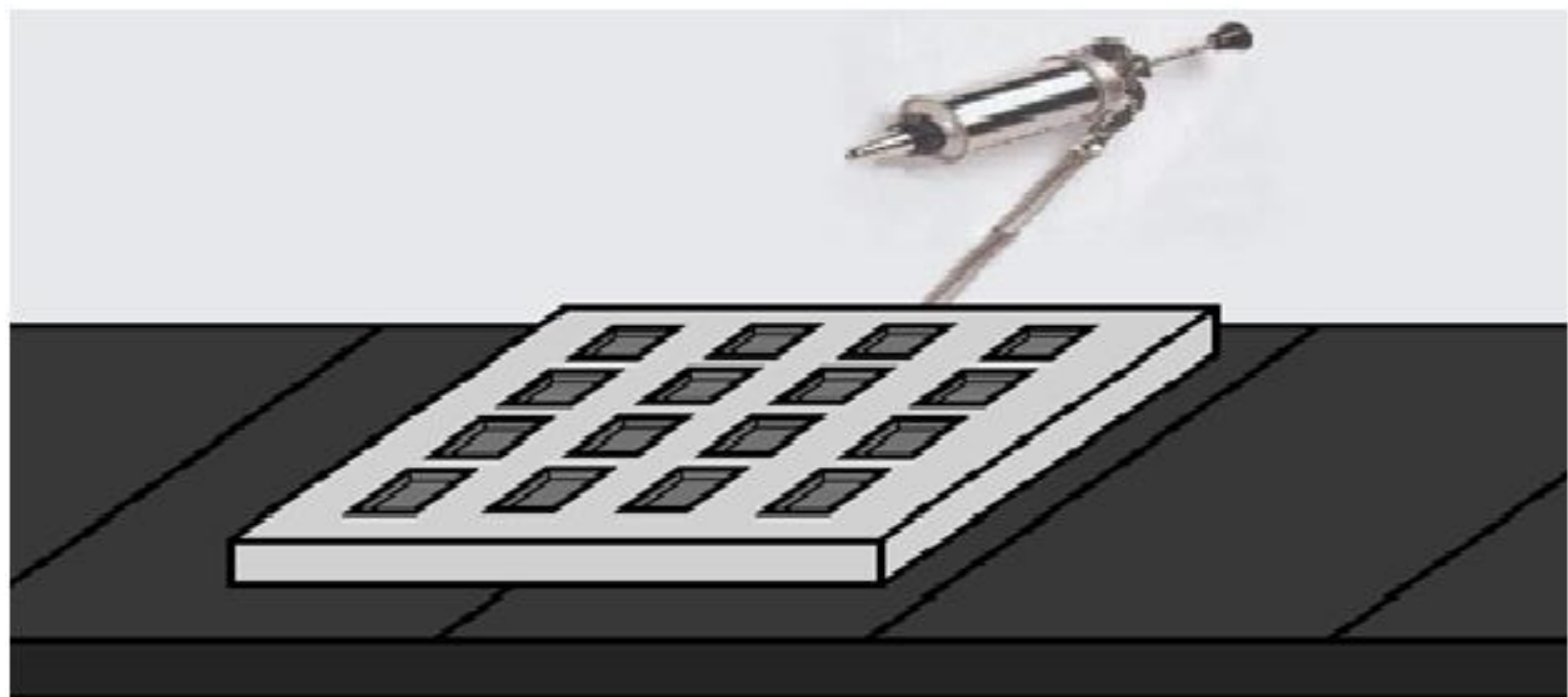
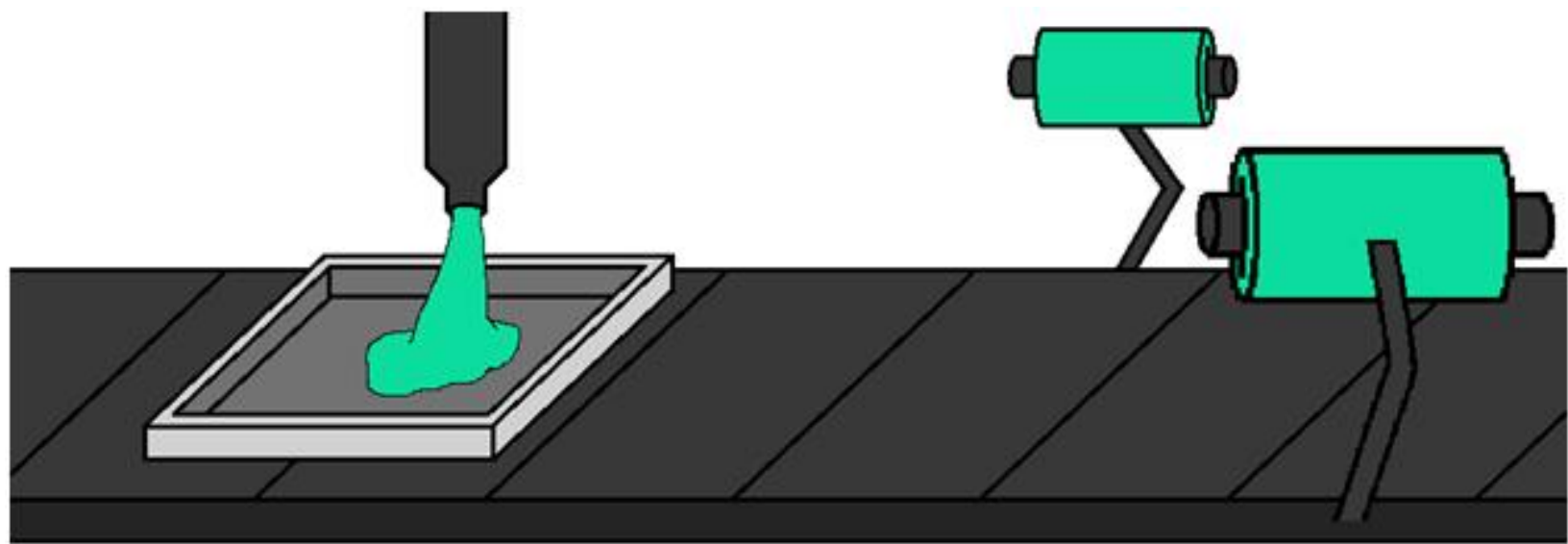
A travelling wave reactor shall be used as a back-up. It uses a modicum of enriched uranium initially but then the nuclear reactor runs on the waste product and can make and consume its own fuel. It doesn't have to be refueled or have its waste removed until the end of life of the reactor, thereby providing an infinite supply of power.

Trade Study for Power

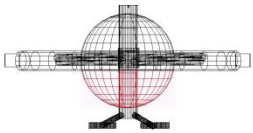
System	Feasibility	Efficiency	Cost	Total
Solar Panels	5	4	4	13
Solar Power Satellites	4	3	2	9
Solar Paints	5	1	4	10
Travelling Wave Reactor	5	4	2	11

Sectors	Power Requirement (KWh)
Industrial	222,000
Domestic	168,000
Agricultural	120,000
Other	90,000
Total	600,000

Manufacture of Reardonium



The industries for the refining and manufacturing of reardonium will be located in the lower half of the sphere, enabling them to be close to the docking ports for easy transport.



The advantage of having a spherical structure is that we naturally have variable gravity. With the chosen rotation rate and radius, the maximum gravity in the sphere will be 0.5g, at the equator, as required. 0g industries will be located in the axle.

The sphere will be compartmentalized radially and each section pressurized separately, according to its requirement, with the help of vacuum pumps. In case new properties of reardonium are later discovered which require different pressures, more radial walls can easily be added.

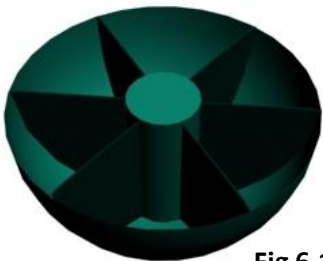


Fig 6.1

With this arrangement every possible combination of gravity and pressure required can be achieved.

The vertical clearance is variable, going up to a maximum of 550 m. The areas will provide sufficient ceiling height for the production of reardonium. We have also given plenty of space for the setting up of more industries once more of the miracle metal is being mined.

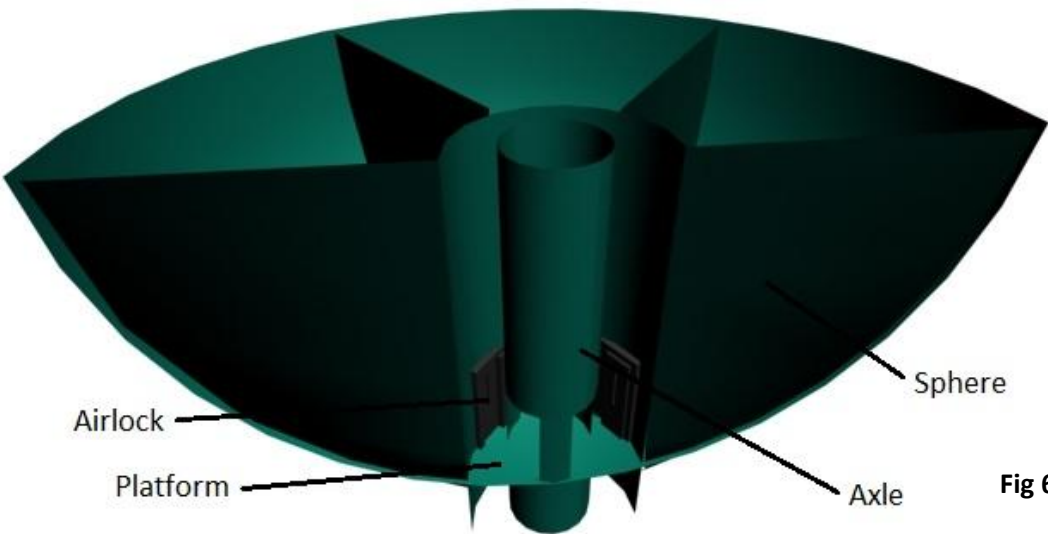
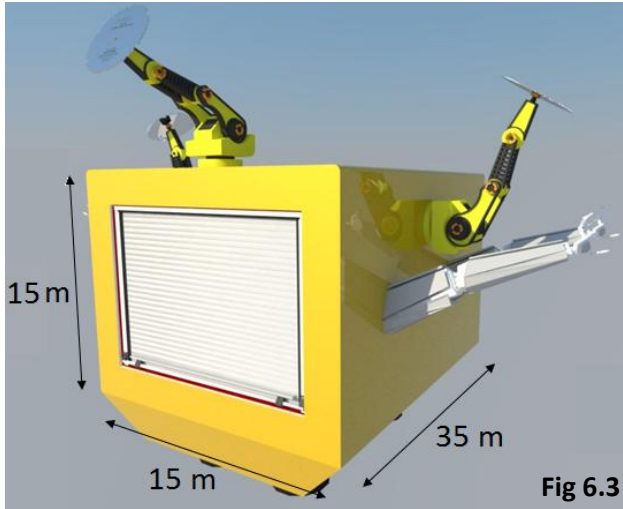


Fig 6.2

Between the axle and the sphere is a platform of radius 200m, where robots move between rotating and non-rotating sections. From here, they can enter into any of the variably pressurized sectors. All movement of reardonium will take place across this platform. As it is in the center, the distance moved is minimum. Airlocks in each sector maintain the pressure.



Anconioh works in the docking ports and industrial sector. It has 4 robotic arms for handling and 3 additional blades/cutting arms. It has a shutter tank to store reardonium, of size 15x15x35m. This is large enough to comfortably hold the largest reardonium piece that can be produced. It has an air reservoir and can pressurize and depressurize its tank, therefore the reardonium can be kept at a specific pressure while being transported from one section to another. It can magnetize itself to attach to the floor, allowing it to work in low and 0 g.

Quantity: 200

The industrial sector is completely automated to minimize human involvement. Ore is taken to the refining area by Anconioh, after which it is moved through standard processes via conveyer belts with various arms and tools for shaping, e.g. rollers and spraying nozzles. After the basic shaping is done, Anconioh helps with transport, further shaping and detailing.

Additionally, the robots used in construction of the settlement (already being specialized to handle reardonium) will later be used in the manufacture of parts. This will reduce costs.

Humans in Low g Areas

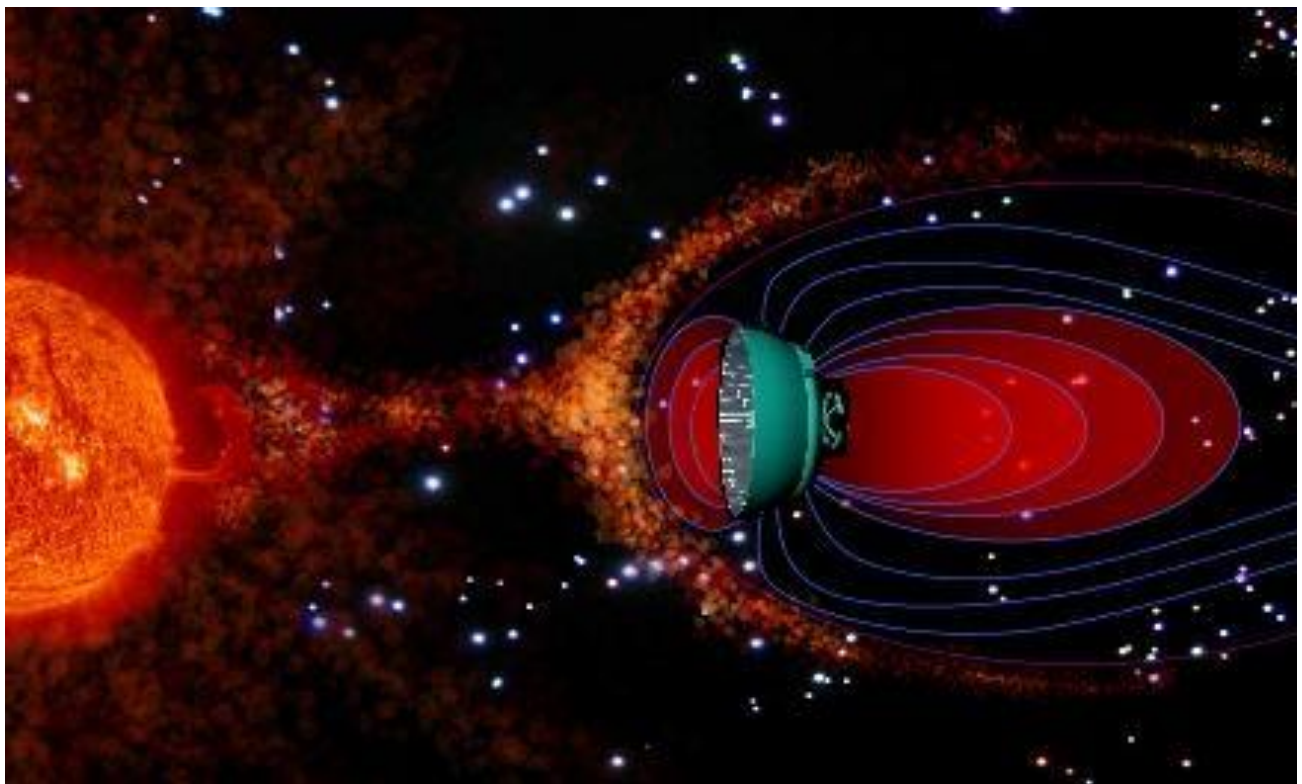
Despite automation, there will be humans involved in the production of reardonium, and many of them may need to go into the industrial area for detailing or inspections. For this they will wear a bio suit, which is like the space suit but lighter. It does not need protective layers, but it will have a PLSS so that the humans can go into the areas of variable air pressure.

There will be cages installed in entrances to low g areas, where people may get accustomed to or prepare for the low gravity. Mobile cages, which move along the floor, will take the worker through the industrial area. To avoid accidents, there are paths allocated for these cages where no robot goes. If a person needs to veer off the course, they may tether themselves to the cage.



Humans going into low g areas will also wear special magnetized boots. The wearer can control the level of magnetization but there is a minimum limit to prevent floating away. Therefore many methods are used for redundancy, to ensure the safety of the residents.

Maintenance and Repair



Plasma shield protection given to Aynah, in the face of solar flare activity.

Structural maintenance and repair will be done by the construction and assembly robots. The F.L.Y. will handle minor repairs.

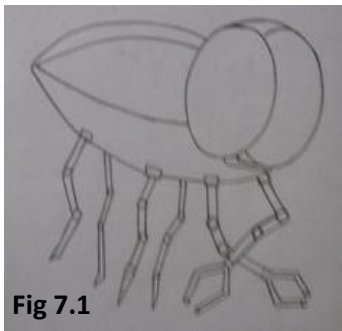


Fig 7.1

Quantity: 1000/section

A compact and robust nano robot (size 10^{-9} m), called F.L.Y. is programmed to scan for small electric as well as structural failures in mega structures, robots and other electrical appliances. Its very small size allows it to enter through small spaces and complicated networks of wires and fix the targeted problem without disassembling the entire machinery. It has embedded audio/visual as well as heat sensors and x-ray vision so it can scan for repairs in any structure. It has a laser beam to cut or dislocate wires and other small components. Its front two legs allow it to grab small components, while the other two are for screwing and welding. In case of complicated tasks, the user can monitor the F.L.Y's operation through a computer and can even control its actions if necessary.

All robots will also undergo regular checks, maintenance and repair. A repair centre will be set up at the mining base as well, for robots working on the surface of Mercury.

Contingency Plans and Emergency Procedures		
Problem	Fixation	Time
Power failure	Switch to back up power source (travelling wave reactor). If limited power supply, first priority is given to the maintenance of atmosphere.	10 s
Solar Flare activity	The settlement is made of Reardonium, which protects the community from solar flares. Robots working outside the settlement (e.g. construction and maintenance robots) are also made of reardonium, and have solar refractors. In case any part of the settlement is exposed, a plasma shield is generated at the affected area, while the construction robots repair the damage.	Less than 2 min
Cyber-security breach (Malware)	Restore and destroy original files. Backup information is already stored.	15 s
Cyber-security breach (Hacking)	Quantum cryptography will be used that keeps out the intruder by changing the encryption key. Original files will be restored. The intruder will be located and appropriate action will be taken.	15 s
Explosion	Parts of the settlement which are prone to explosions e.g. nuclear or fusion cell compartments are sealed with silicon ceramic based covering. Any nuclear contamination can spread in an instant; therefore extra precautionary measures are taken to safeguard the inhabitants. In more severe cases, residents can even be evacuated.	Already in place
Biohazard	Infected areas and infected people will be quarantined. Evacuation plans will be executed if needed. In case of a biohazard, the infected are isolated from the rest of the population and sent to an automated intensive care. They are diagnosed and operated through specialized robots controlled by the medical staff. If required, the patient(s) can be sent to Earth in one of the escape pods.	As soon as illness is detected

Fire	UV and infrared sensors are used for detection of fires. Nitrogen from lunar imported lunar material as well as mineral retardants are used to put out fires. In case of a large fire shutter doors isolate the area and the atmosphere is drawn out using vacuum pumps, thereby dousing the fire.	45 s
Asteroids and meteorite attack	Small mass drivers powered by photovoltaics are installed on the structure. The momentum of ejecting pieces of the object would change its course in the opposite direction. Ion beam shepherd is used to destroy small remains after the mass driver has completely destroyed an object.	Within 30 min after detection
Violent activity	24 hour security surveillance. Weapons are manufactured with encoded chips thus making it possible for the security bots to jam them whenever required. Computers for social monitoring have artificial intelligence. Development of security robot force for each sector of the settlement. Force dived into armed and un armed robots.	At once after detection
Atmospheric imbalance	Atmospheric stabilizers will be used in each sector of the settlement. In case of major disruption the maintenance robot supplies appropriate constituents. In case of a serious imbalance the sector can be sealed off and people can evacuate and move into another part of the settlement. The extensions may be particularly useful for this as they are atmospherically isolated from the torus.	Approx. 15 min
Magnetic Levitation failure	Nylon bushing has been placed around the rotational interfaces, so that if any of the magnets should stop working, the settlement is kept from floating away and continues rotating with minimum friction until repairs can be made.	Already in place
Break in Outer Wall of Settlement	The double layer of walls prevents atmosphere from being lost, so in this case the residents are not affected. The major problem is the rapid loss of shielding water. Maintenance robots will immediately put pressure on the damaged area, and Magnetic Pulse Welding will be used to seal it.	5 min

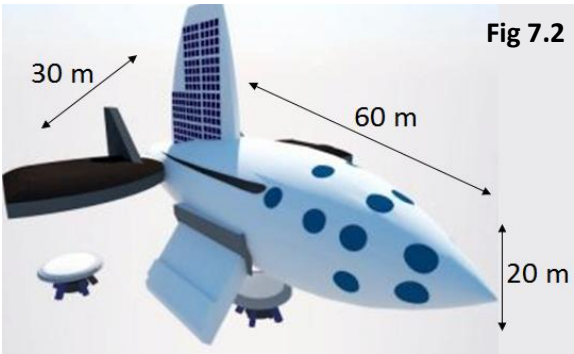
In case of a serious emergency (such as a large break in the inner wall, or drastic atmospheric imbalance), the residents will be evacuated and the entire sector will be sealed off. Reardonium roller shutters will be attached to the ceiling at 10 specified points, and can be pulled down by the computer. The bottom half of the industrial sector is already compartmentalized. The upper half can be isolated radially as well.

If evacuation becomes necessary, pods in the **Transporto** designated to checkpoints within the residential torus provide quick escape from the settlement.

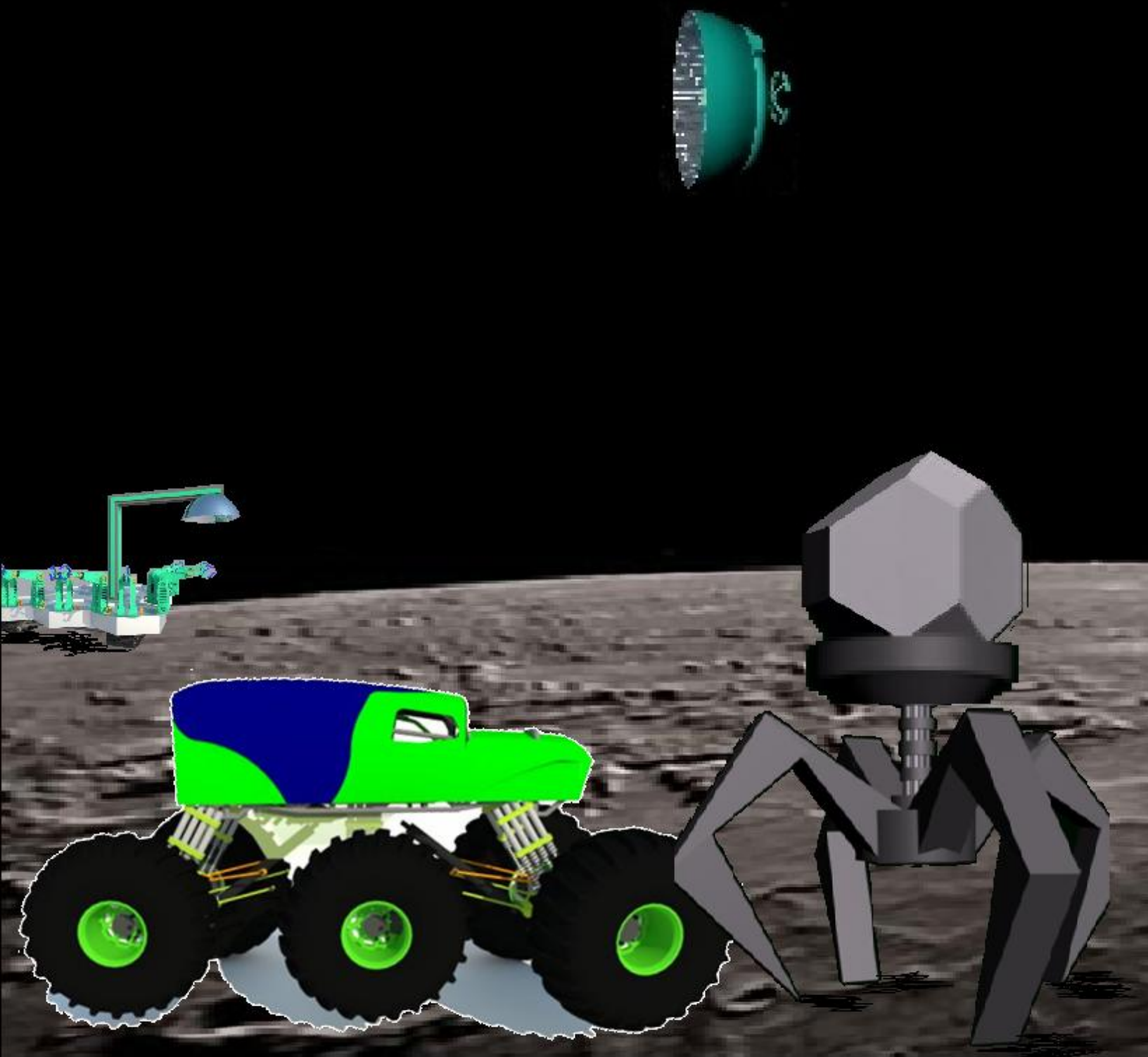
The ‘Transporto’ (Fig 7.2) is a luxury space vehicle which also serves a double purpose for carrying escape pods inside it to safety. Enough food and water is stored in the Transporto to sustain the passengers for up to 1 month.

Quantity: 4

There are 16 escape pods, each with a capacity of 1000 people, so a total of 16,000 people can be evacuated.



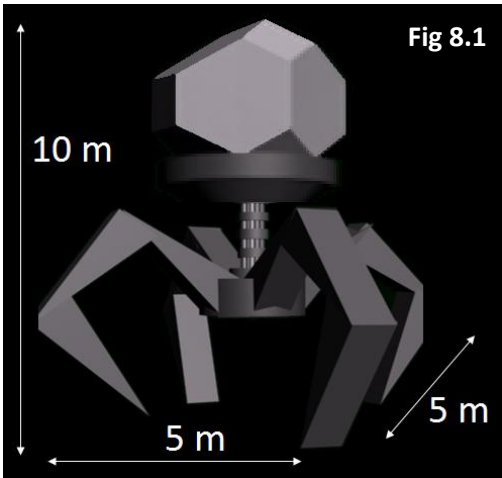
On the Surface of Mercury



Macrophage

The Macrophage serves two purposes:

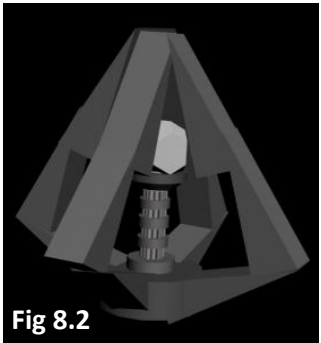
- mining and extraction of ores from Mercury, and
- loading ore and parts onto larger robots (Hexatrons) and ships (AynRyders).



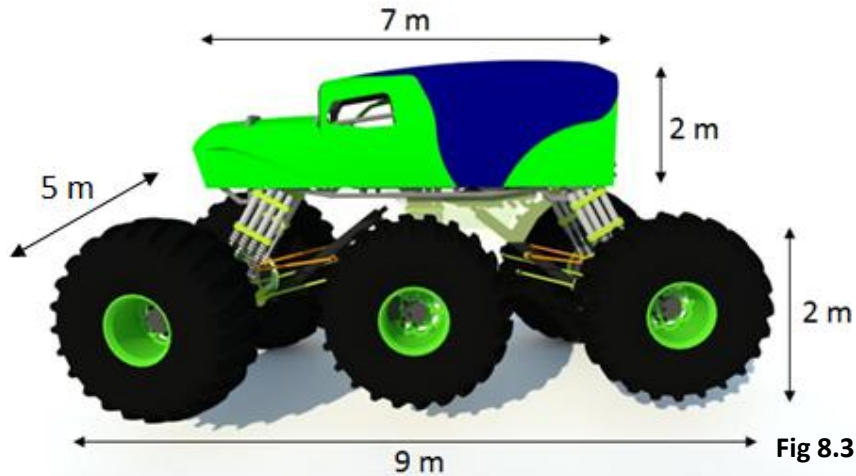
Its shape and structure is similar to a microphage pathogen. Its head is a storage unit with a large capacity, followed by a cylindrical torso which bears the extraction pumps used for drilling in to the surface and loading the ores. The cylindrical torso also has lasers that separate the required mineral from the ore. The Macrophage uses extraction pumps to dig for the materials, separates the ores through laser and preserves them in its storage unit. The extraction pipes are retractable mechanical pipes with circular drilling rings (pressure sensors installed) at their heads, analogous to round worms.

The spider-like legs allow it to crawl on difficult terrains. Stabilizers are used to increase efficiency. It is also able to shake dust off of itself. The robot will be powered by solar paint. Black paint is used to absorb maximum energy.

In case of Solar flares, the legs of the Macrophage fold into the body, which compresses, and Plasma Shield Generators are activated to deflect solar flares. If damaged, the Macrophage can also bury itself underground.



Hellion



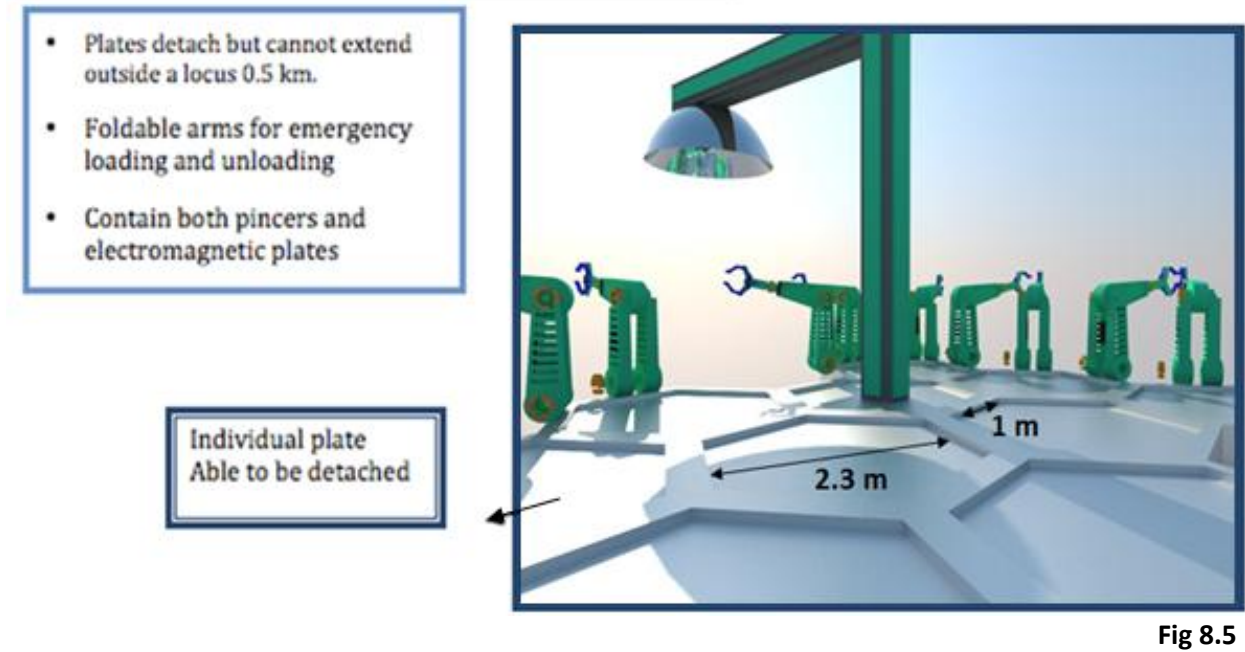
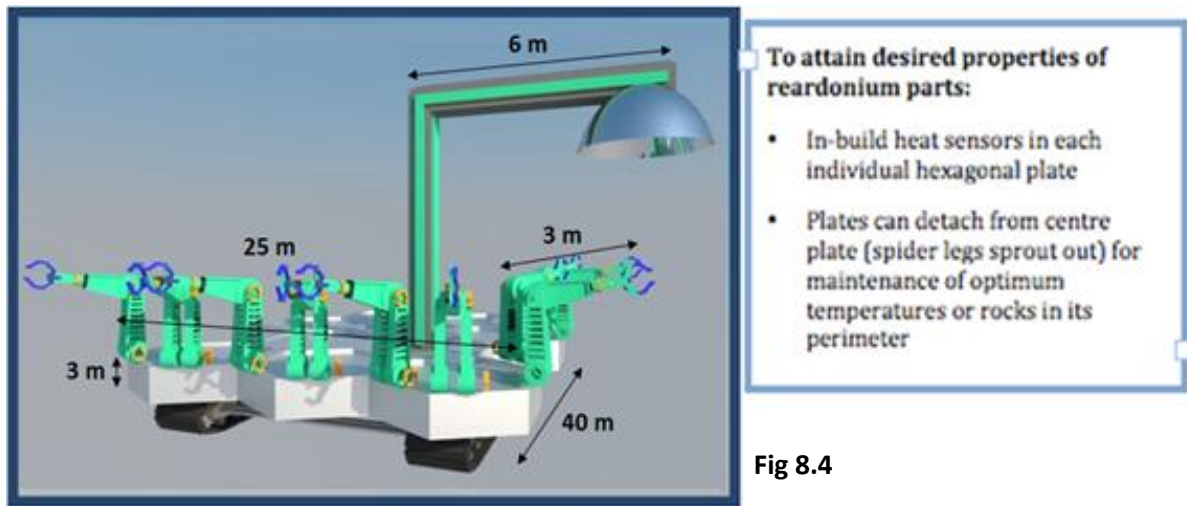
Whenever humans need to go beyond the terminator, they will use Hellion.

Hellion is large enough to comfortably house a group of scientists or workers. Its facilities include a mini-lab, communications hub, and first aid kit, among others. All of the life-support systems and power storage systems are inside the body of the vehicle.

- It has 6 solid rubber tires, as air-filled ones carry the risk of explosion.
- It has Magneto rheological suspension, with springs as a backup.
- Each wheel is independently driven by electric motors.
- The windows are made of smart glass and can be tinted and illuminated during day and night.
- It is large and made with brightly colored blue-green reardonium and so can easily be seen by a human on the surface of Mercury. Blinkers have also been installed in this regard.

Hexatron

The Hexatron is used to store, move and turn over pieces of metal sent to Mercury for curing. It has many detachable plates so that it can work on multiple pieces at a time.



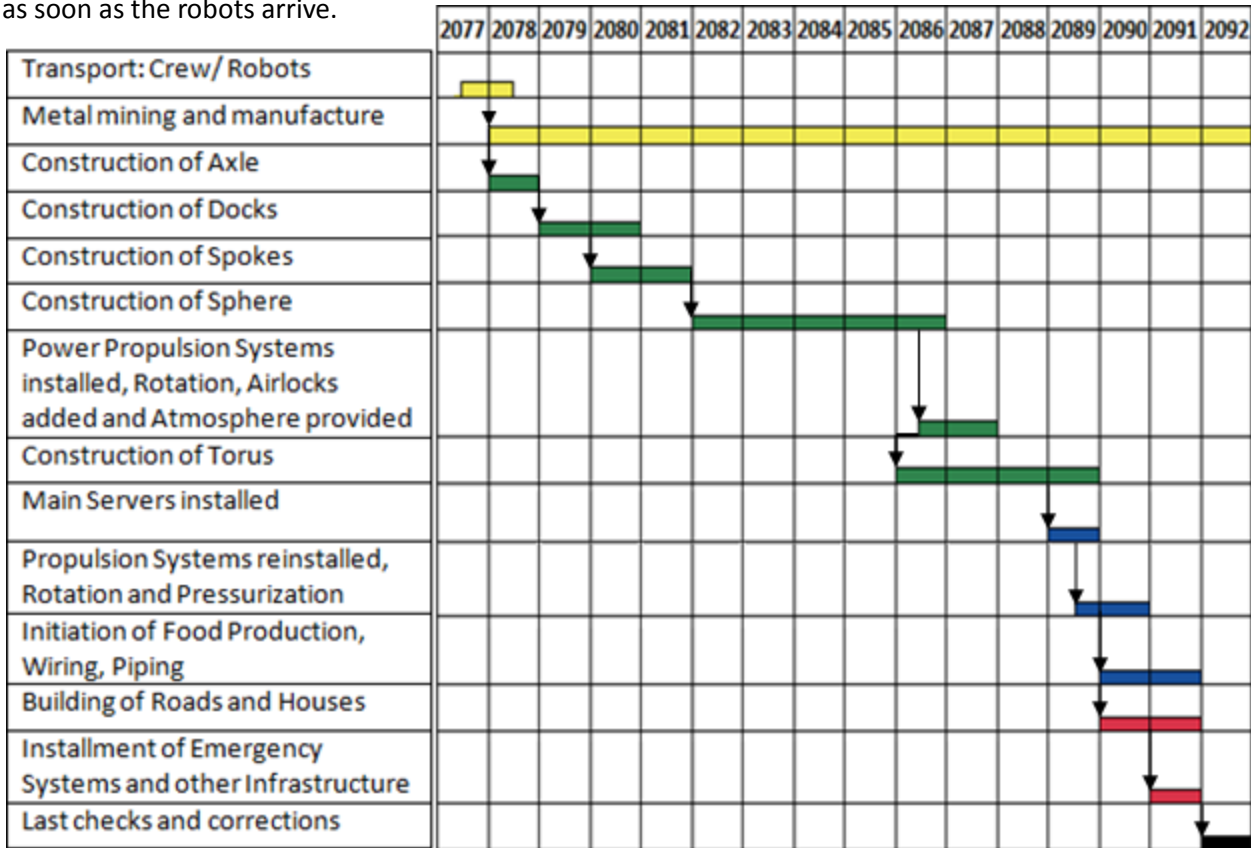
One or two plates can detach to go into craters to place parts in these dark areas, which is easier than the entire vehicle trying to move in and out of the crater.

Schedule and Cost





Once the contract is awarded, we will spend 2 months going over the Foundation Society's feasibility studies to see if any changes to the project are required. During this time, transport of crew, machinery and robots (built on Belvestat) will begin. As the underground base is already set up, mining can begin as soon as the robots arrive.



Costs Billed per year	
Year	Cost (\$)
2077	722,500,000
2078	16,712,500,000
2079	5,226,000,000
2080	6,886,000,000
2081	6,886,000,000
2082	13,402,800,000
2083	13,402,800,000
2084	13,402,800,000
2085	13,402,800,000
2086	23,944,100,000
2087	10,541,300,000
2088	5,591,000,000
2089	10,044,400,000
2090	12,949,600,000
2091	22,767,400,000
Total	175,882,000,000
Overhead (5%)	8,794,000,000

Foundation Society members move in **May 2092**.

Using their input, our engineers will make any necessary changes and corrections.

Entire original population will be established within **6 months**.

Total time period of **16 years**.

Total Cost of Settlement:

\$184,676,000,000

Phase I : Mining of Reardonium and Transport of Robots and Equipment			
Robot	Quantity	Cost per article (\$)	Total Cost (\$)
AynRyder for transport	20	300,000	6,000,000
Macrophage for mining	100	120,000	12,000,000
EMP-bot for exterior construction	50	200,000	10,000,000
Ringo66 for assembly	5	400,000	2,000,000
Total			30,000,000
Work Description	No. of Employees	Average Salary/year (\$)	Total Salary (\$)
Construction Administration	25	15,000,000	375,000,000
Automations Engineers	80	10,000,000	800,000,000
Space Experts	10	3,000,000	30,000,000
Mercury Experts	10	5,000,000	50,000,000
Material Experts	20	8,000,000	160,000,000
Total			1,415,000,000
Total Cost During Phase I (1 year):			1,445,000,000

Phase 2 : Exterior Construction of the Settlement			
Robots are pre-programmed to build the settlement. However humans still oversee construction. 0.2m thick layers of reardonium will be used. The residential torus has a double layer.			
Unit	Volume (m ³)/ Quantity	Cost per m ³ /unit (\$)	Total Cost (\$)
Reardonium (axle)	311,000	40,000	12,440,000,000
Reardonium (docks)	83,800	40,000	3,352,000,000
Reardonium (spokes)	166,800	40,000	6,672,000,000
Reardonium (sphere)	1,231,600	40,000	49,264,000,000
Reardonium (torus)	2,136,400	10,000	22,364,000,000
Solar Panels	15,000,000	100	1,500,000,000
Airlocks	180	10,000,000	1,800,000,000
Atmosphere (industrial)	660,000,000	1.5	990,000,000
Power Systems	-	-	9,600,000
Rotation/Propulsion Systems	-	-	1,000,000
Total			97,492,600,000
Work Description	No. of Employees	Average Salary/year (\$)	Total Salary (\$)
Construction Crew	60	7,500,000	5,400,000,000
Construction Administration	25	15,000,000	4,500,000,000
Structural Engineers	100	20,000,000	24,000,000,000
Automations Engineers	60	10,000,000	7,200,000,000
Operations Engineers	15	5,000,000	900,000,000
Human Factors Engineers	10	5,000,000	600,000,000
Total			42,600,000,000
Extras (e.g. for robot maintenance, attachment of torus, infrastructure)			7,400,000
Total Cost During Phase 2 (12 years):			140,100,000,000

Phase 3 : Provision of Operational Infrastructure			
Unit	Quantity	Cost per article/unit (\$)	Total Cost (\$)
Interior Robots	425	-	40,000,000
Atmosphere	130,000,000 m ³	1.5	195,000,000
Communication Facilities	-	-	350,000,000
Agricultural Equipment	-	-	3,000,000,000
Agricultural Operations	-	-	8,000,000,000
Internal Transport System	-	-	1,000,000,000
Water pipes	500 km	500	250,000
Wires	500 km	300	150,000
Computer Servers	100	-	1,000,000
Space Suits	710	120,000	85,200,000
Emergency Systems	-	-	400,000
Total			12,672,000,000
Work Description	No. of Employees	Average Salary/year (\$)	Total Salary (\$)
Managers	25	15,000,000	1,125,000,000
Operations Engineers	70	20,000,000	4,200,000,000
Automations Engineers	70	10,000,000	2,100,000,000
Human Factors Engineers	40	8,000,000	960,000,000
Structural Engineers	15	10,000,000	450,000,000
Total			8,835,000,000
Total Cost During Phase 3 (3 years):			21,507,000,000

Phase 4 : Interior Construction and Finishing			
Unit	Area (m ²)/ Quantity	Cost per m ² /article (\$)	Total Cost (\$)
Houses	9,500	200,000 – 400,000	3,000,000,000
Other buildings	-	-	4,000,000,000
Roads and paths	174,000	1200	208,800,000
Parks	145,000	800	116,000,000
Security Systems	-	-	200,000
Robots	20,000	1500 (average)	30,000,000
Devices	30,000	500 (average)	15,000,000
Total			7,370,000,000
Work Description	No. of Employees	Average Salary/year (\$)	Total Salary (\$)
Managers	25	15,000,000	750,000,000
Human Factors Engineers	70	20,000,000	2,800,000,000
Automations Engineers	70	10,000,000	1,400,000,000
Operations Engineers	15	10,000,000	300,000,000
Structural Engineers	10	8,000,000	160,000,000
Total			5,410,000,000
Extras (e.g. for entertainment facilities, furnishing, equipment in buildings)			50,000,000
Total Cost During Phase 4 (2 years):			12,830,000,000



Appendices

Making Everything Easier!™

Novelty Edition

REARDONIUM

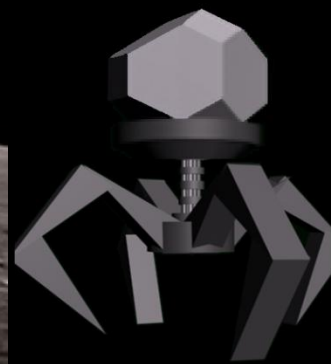
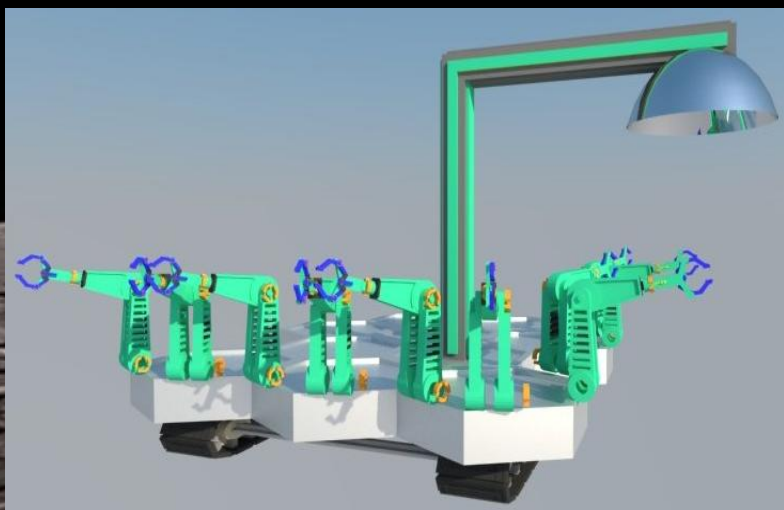
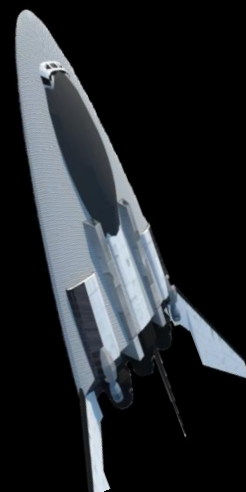
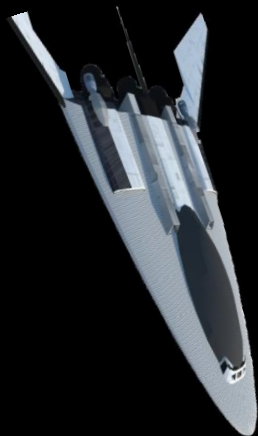
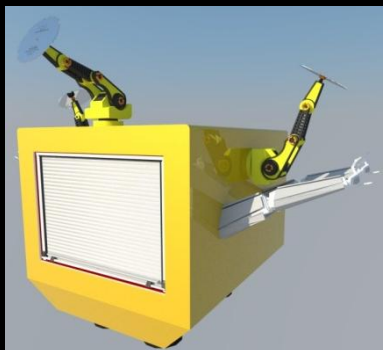
FOR
DUMMIES®

Learn to:

- Mine, Refine and Manufacture Reardonium
- Optimize your profits
- Keep your workers safe and happy! :)

Includes Diary
entries from actual
Reardonium pieces!



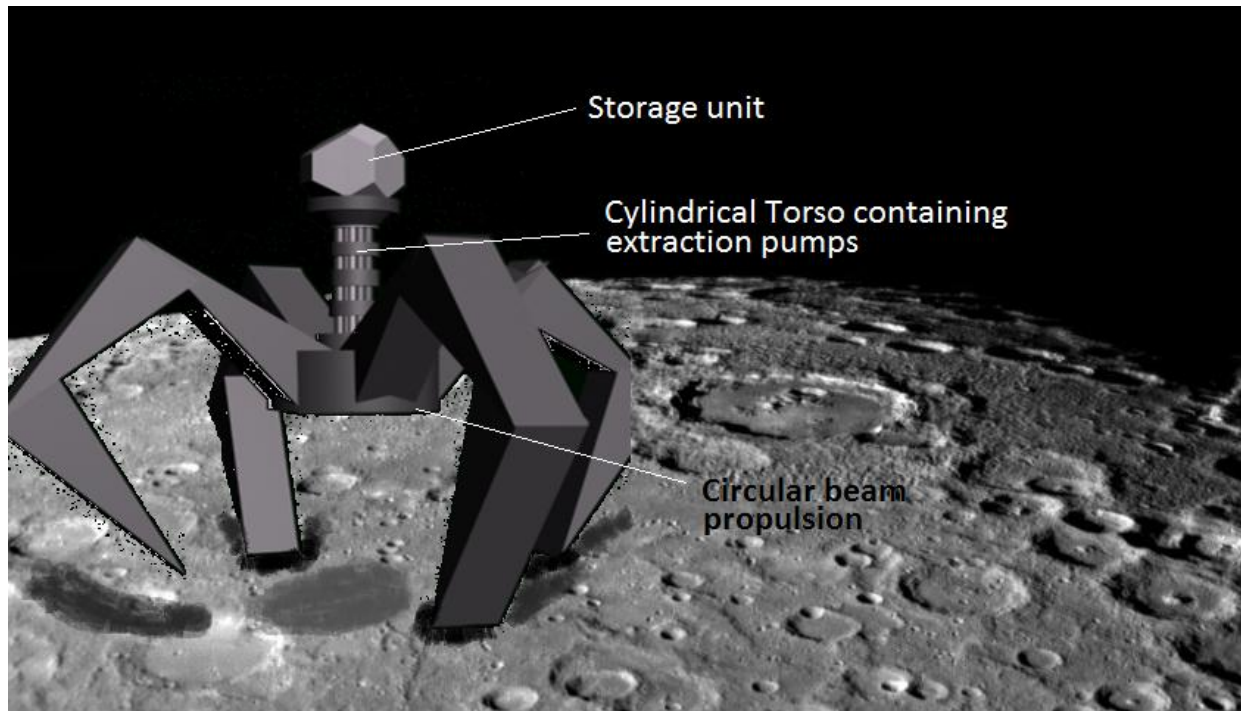


It all begins with the Macrophage.

There are two types of Macrophages, essentially the same but with slightly different configurations. The M-Macrophage is primarily for mining, and contains many pumps, drills, lasers, etc. The T-Macrophage is primarily for transport, and so has many arms for lifting instead of drills. Hundreds of Macrophages of both types swarm the surface of Mercury.

The process starts off in the same way for both pieces, which first encounter the M-Macrophage.

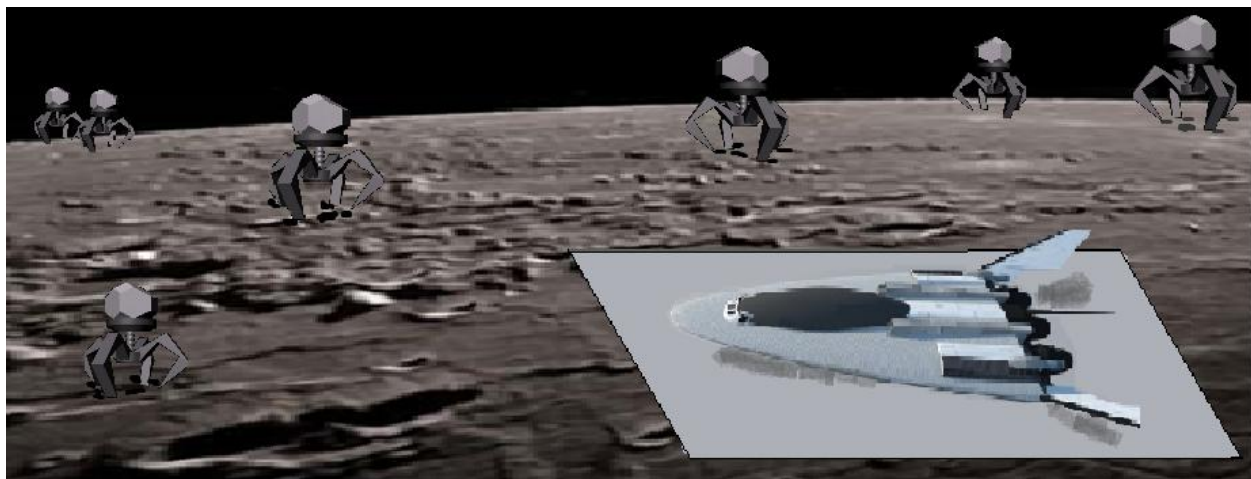
A little recap of its features:



The Macrophage uses extraction pumps to dig for the materials, separates the ores through laser and preserves them in its storage unit.

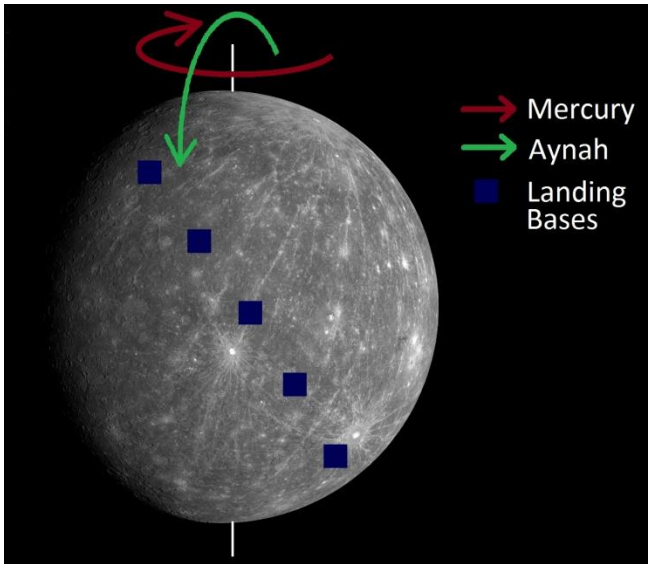
The time duration, temperature and molecular crystallographic changes of the raw materials are monitored by the robot. A high resolution camera connected to a nano-computer monitors and controls the coordinates, the ores extracted and the geological conditions. Ores taken in are examined through x-ray crystallography and are taken through the pipe in to the storage unit. Through x-ray crystallography as well as sonic detectors it can measure the depth and the geological condition for extraction.

Macrophages take the ore to landing bases near the mining sites, where they load them onto the AynRyder.



The AynRyder then takes the ore to Aynah, to the designated docking port. The process is computerized to ensure synchronization and efficiency. AynRyders travel to and from Aynah at regular, frequent intervals. When an AynRyder touches a landing pad, nearby Macrophages are alerted so that they may come to dump their loads.

Placement of landing bases on the surface of Mercury, keeping in mind the rotation of Mercury and the revolution of Aynah, is shown. The actual location may vary slightly depending on the location of the mining sites.



There are two docking ports reserved for transport of reardonium between Mercury and Aynah. Only the AynRyder is allowed to dock here. This compartmentalization of the docks makes transport more efficient.

Entry 1

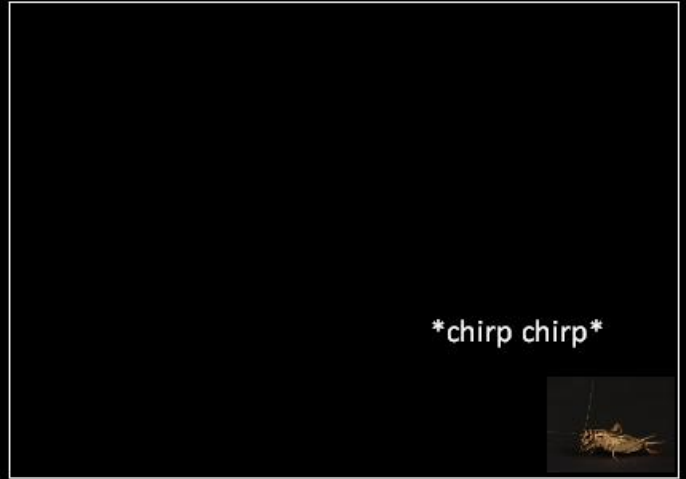
Date: 27th July 2103

When I arrived at Aynah, there wasn't any fanfare at all. I expected a red carpet arrival with hundreds of fans to greet me but there weren't any. I was one ordinary lump of Mercurial soil among a thousand others, all stuffed in a container.

EXPECTATION



REALITY



On the journey to Aynah, there wasn't much to talk about so I sat in silence. The other lumps of soil were speculating about what was going to happen to them. "Will we get thrown into a furnace?", "Will we be thrown into a grinder and made even smaller" and "Will we be thrown into a crusher and made into flat sheets?"

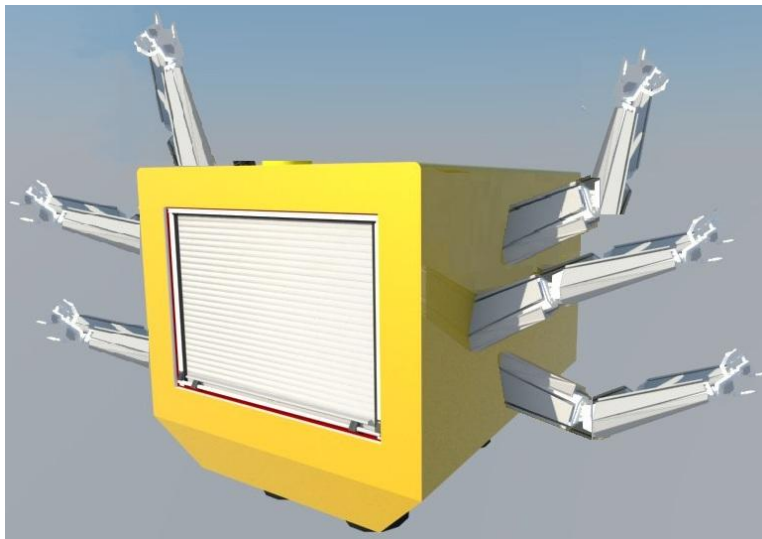


They were all so worried, I wasn't. I had been longing for a change in scenery since The Big Bang. I was glad that my boring life on Mercury was over. Great things awaited I suspected.

Then the container doors opened. Suddenly I was staring at a giant, gnashing monster. And it was about to eat me up! I couldn't have been happier! I even preferred death at the moment, to living a life of stupefying boredom.

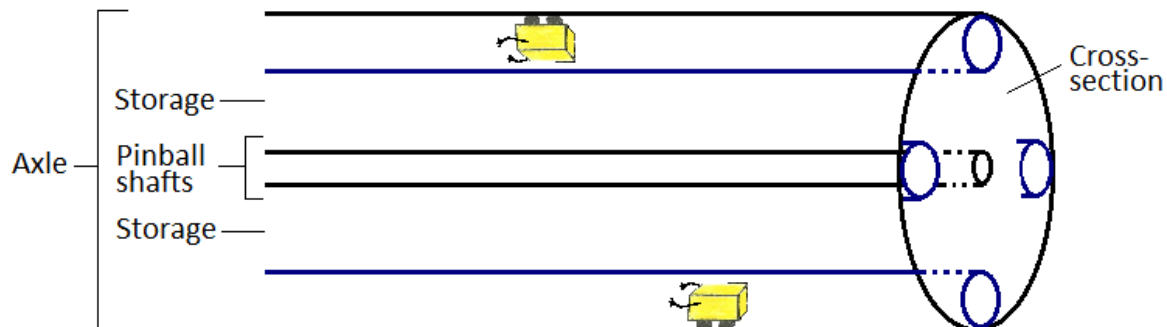
I'm guessing he was talking about Anconioh, the machine that roams Aynah's industries.

Once again, there are two types of Anconioh robots. T-Anconioh is responsible for loading/unloading and transporting ore and parts. It works in the docks and moves between the axle and industrial sphere. It has a large shutter tank for storing reardonium, and many hands for loading/unloading.



As it is moving in areas of low, and 0, g, it has magnets underneath it to prevent it from floating away, while allowing maximum flexibility and mobility of the robot.

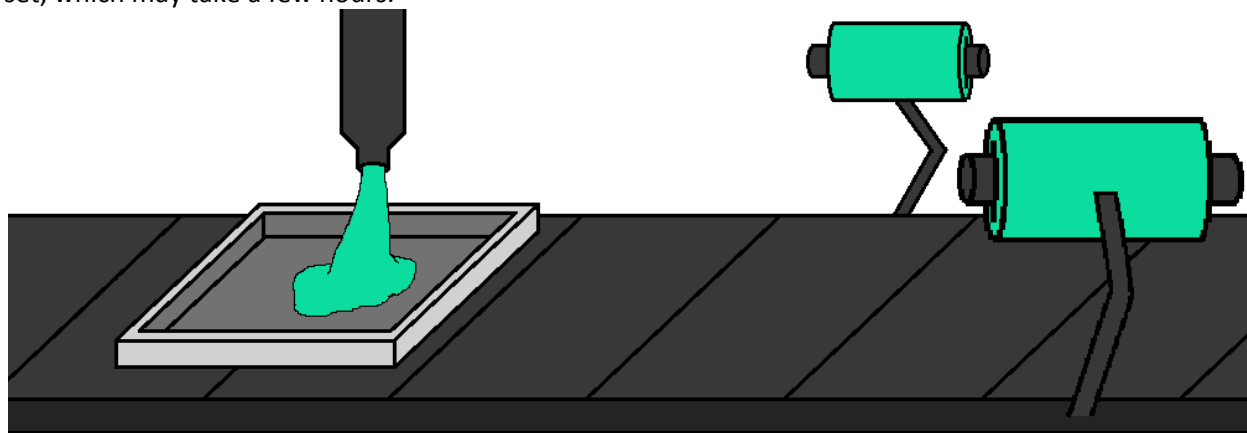
When moving to the industrial sector, Anconioh travels along the walls of the axle, so no elevators are needed. This speeds up the process. Special paths have been allocated for it (shown in blue below), which also lead to the 0g industries in the axle. No special mechanism is required for this movement, as there is no orientation in 0g.



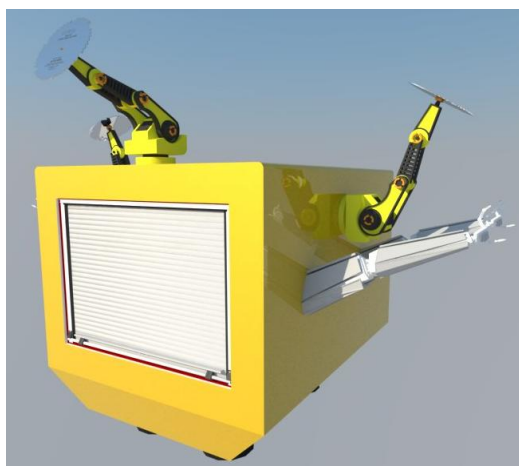
From the axle, it can move to the Platform in the industrial sphere. The ore will be taken to the refining area (also located within the lower sphere). For refining we will use Metallurgy, where the ores are heated to a temperature of about 4000°C , thus causing them to melt, along with the impurities, which are discarded. Up to here, all ore will be treated the same.

While it is molten, the metal will be shaped.
Complex shapes are made using molds and casts.

For the large part, the metal is poured into a rectangular dish of the required dimensions. It is passed through a series of irons, pounders and rollers to give a flat and even layer, and then cooled to make it set, which may take a few hours.



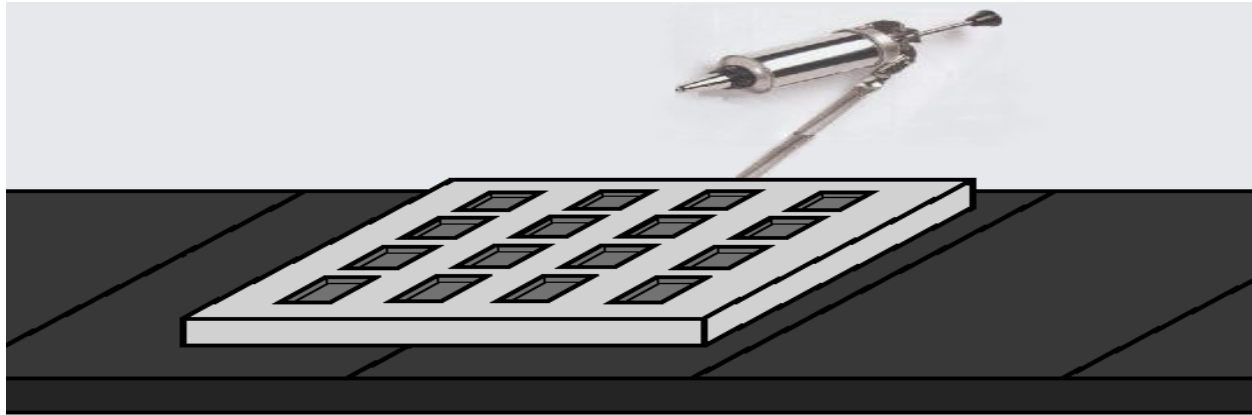
After hardening it is picked up by M-Anconioh, which works exclusively in the industries, helping with the manufacturing processes. Therefore instead of many lifting arms, it also has blades and cutting tools for smoothing, further shaping and detailing. It can be given different arms and tools depending on what processes the part needs to undergo. We expect the entire process to take 4-5 days.



M-Anconioh moves the metal through production processes. It also contains an air reservoir and pumps, by which it can pressurize its tank. Therefore the reardonium can be kept at specific pressures while being moved from one part of the sphere to the other. The pressure in the tank can also gradually be increased or decreased, if that is preferable to sudden/discrete changes.

Ringo66 robots, both large and small, will also help in the manufacture of reardonium.

For the small part, a nozzle fills small quantities of molten metal into a flexible tray with many molds. Small pieces are made in batches to make production more economical.



They will be cooled within minutes, after which they are removed from the tray like ice cubes and dropped into suction pipes, through which they are taken to areas of different pressures and gravities. M-Anconioh gets involved if these pieces need to be taken to the 0g industries, as no pipes can be laid across the rotating interface.

Humans may be involved in the production process, e.g. in detailing and in inspection and checks. Cages, magnetized boots and tethers have been provided for them. They will also wear bio suits with PLSS to be able to work in low pressure environments. Human inspection takes a little more time than actual manufacturing – about a day for small batches and up to a week for larger ones.

UV radiation, electron bombardment, and any hazardous operations required can be carried out in the sphere as it is completely separated from areas humans occupy. The related machines will be sealed with silicon ceramic based covering and humans will not be allowed to go near them.

Entry 17

Date: 5th August 2103

It's when the incinerator opened that I realized I wasn't here to sip Pinna Coladas and enjoy the view of space. My cohorts and I were thrown on a conveyor belt like the insignificant pieces of mud we were. The once-totally-awesome line "it is time we went to the depths of hell itself" I had heard in a videogame didn't sound so cool anymore, as life on Mercury wasn't as bad as I had described. Now I know I shouldn't have listened to the man who said that we were making a little trip to the "sauna". I wasn't expecting a facial, but this was completely preposterous! I couldn't recognize my own face! If this wasn't bad enough, I was made to endure what was the equivalent of choking me with a pillow. The only worse thing that could have happened is if I had kicked the proverbial bucket.

"Is that Bruce Jenner?"

"No, it's you!"

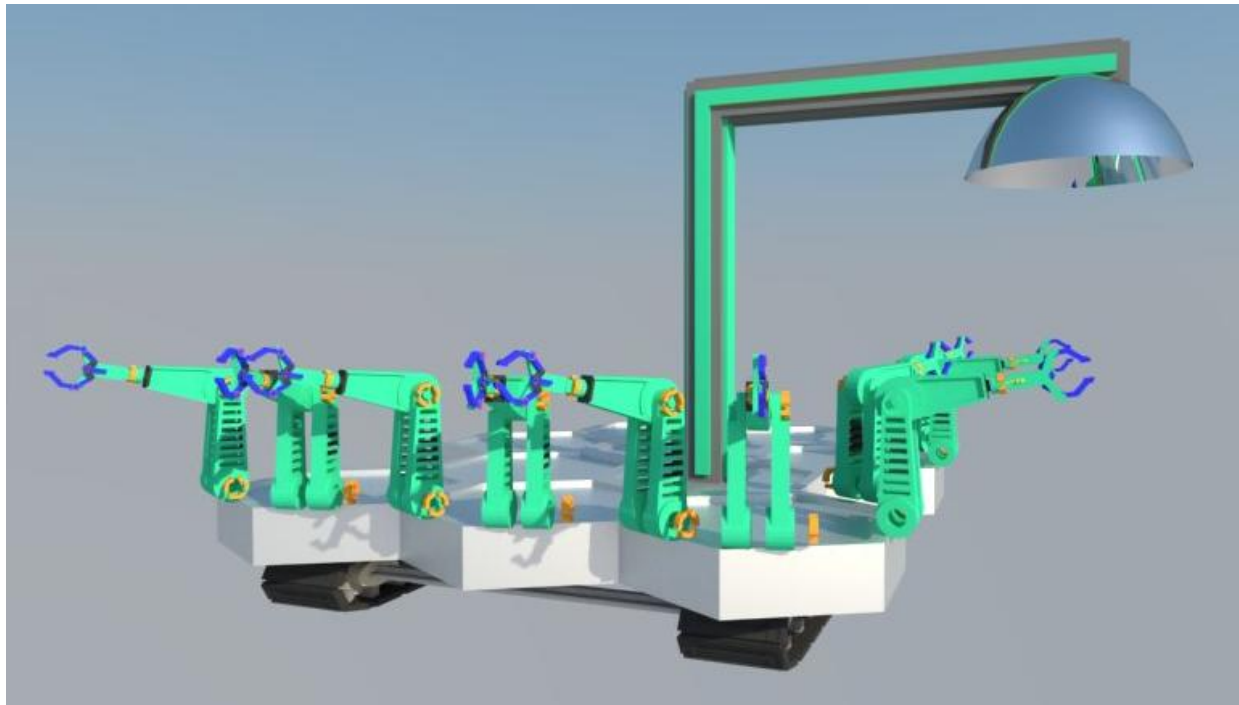
After going under the pins and needles, I was treated to my shiny new face; and boy did I look pretty. Now I know why people pay so much for plastic surgery...

Manufactured parts are taken back to the dock from whence they came. They are transported and loaded by Anconioh onto the AynRyder. The ship then departs for Mercury again.

On Mercury, T-Macrophages take the completed parts from the AynRyder to the Hexatron.

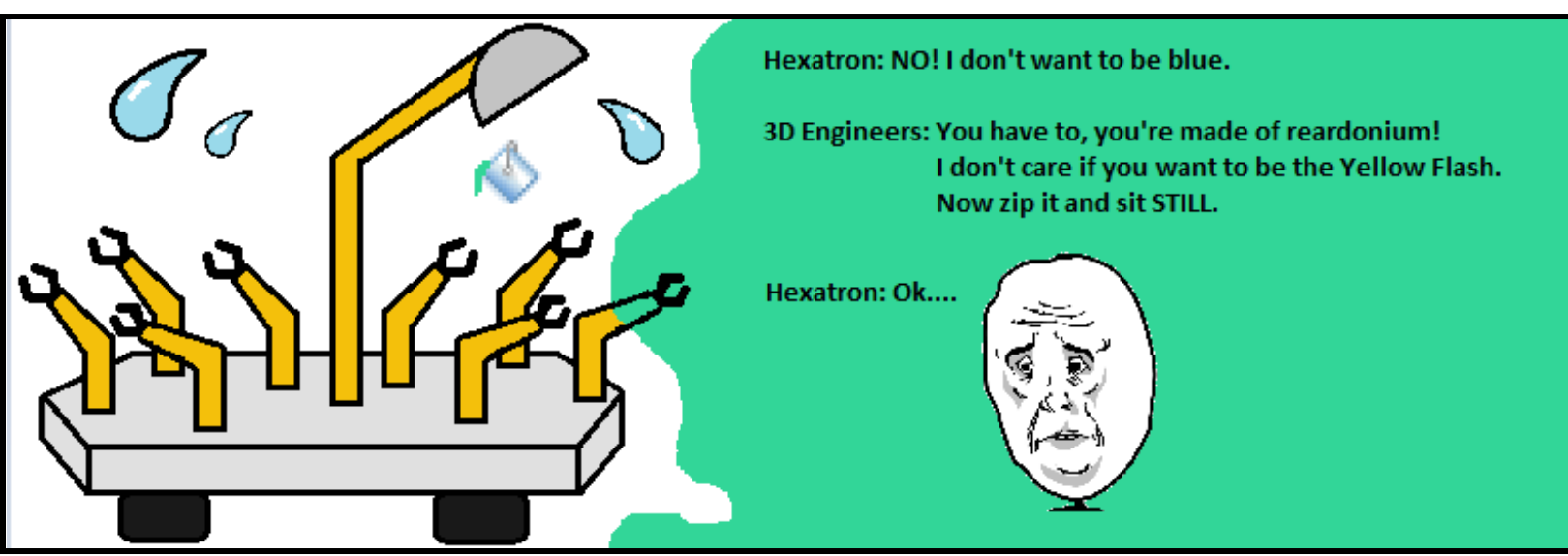
The small part is carried with many others in the Macrophage's Storage Unit.
The large part is carried by two Macrophages together.

From here the fate of the parts is in the many, capable hands of the Hexatron.



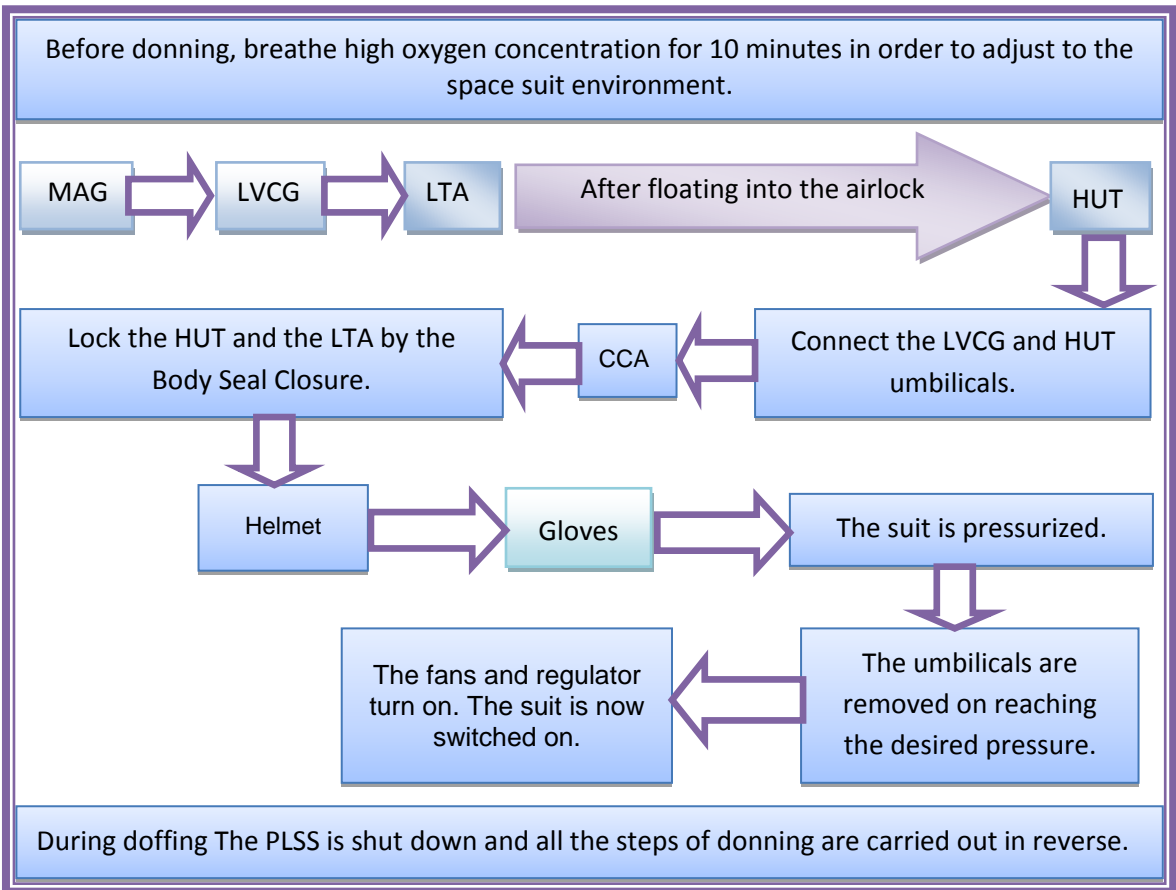
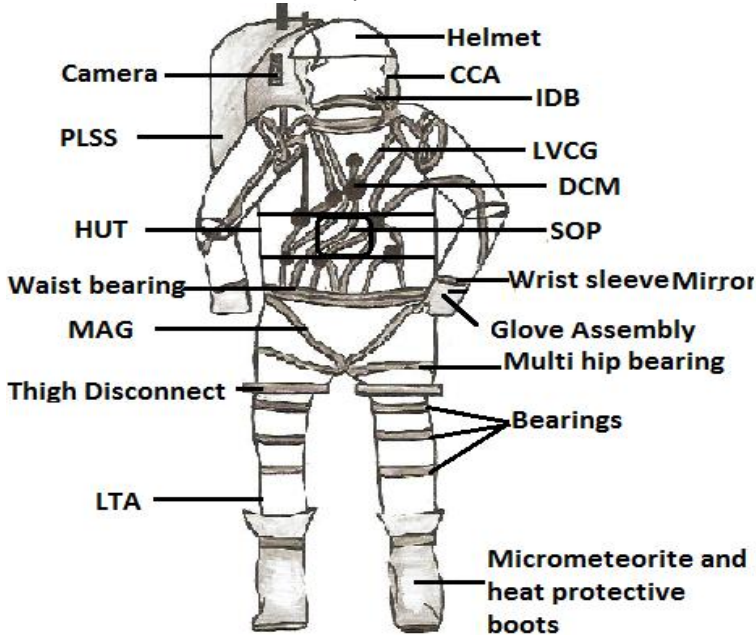
This vehicle is well-equipped to place, move and turn over reardonium parts. The Hexatrons travel around Mercury, picking up and depositing parts as they go. They have multiple arms and detachable plates which can move separately to a 500m radius.

Each Hexatron has been given a section of the surface of Mercury in which it operates. This makes it easier to keep track of reardonium parts.

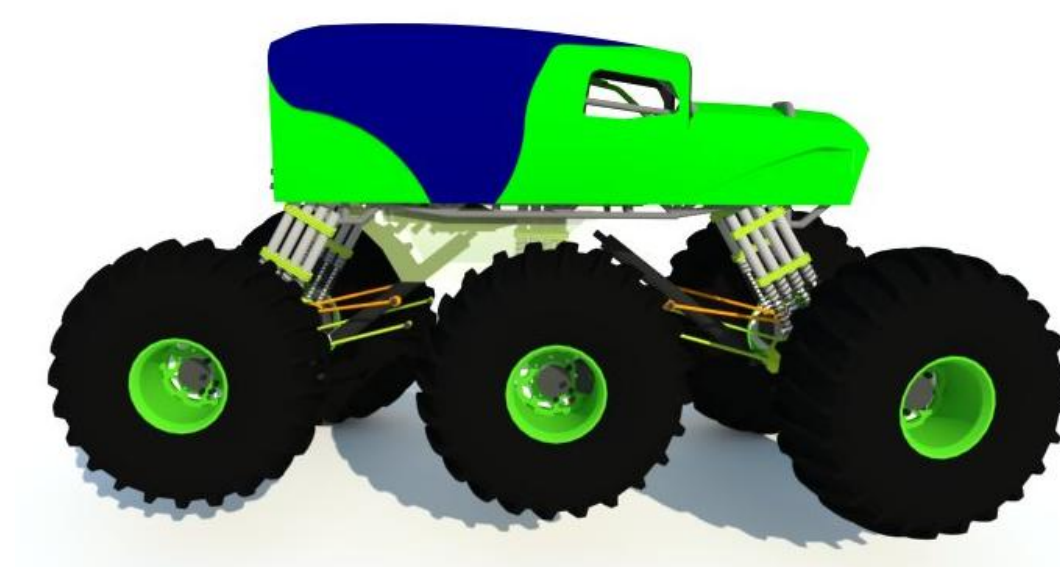


About every Earthmonth, humans will come down from Aynah for inspections. A number of measures have been taken to ensure the safety of these workers.

The first defence will be the space suit, detailed as follows:



The Hellion is available to take humans beyond the “safe zone” around the terminator.



The wheels are designed specifically for the terrain of Mercury. They also hold the body of the vehicle higher to reduce dust and grit entering. However, it is still low enough to allow a worker to easily jump on in the low gravity of Mercury. Hellion is made luminescent, and glows with the characteristic blue-green color of reardonium, making it easily visible. The windows are made of smart glass, so they can be tinted more black to block excessive sunlight during Mercury day; and illuminated to allow better visibility during Mercury night. Headlights also aid visibility.

Due to the time taken in donning and doffing, and for safety, the humans will stay in their space suits while in the vehicle. It is roomy and enough space has been given inside for them to move about easily despite this. Emergency oxygen supplies and first aid tools are provided inside the vehicle. All required machinery and equipment for inspection will be available. Tools for robot repair and maintenance are also given.

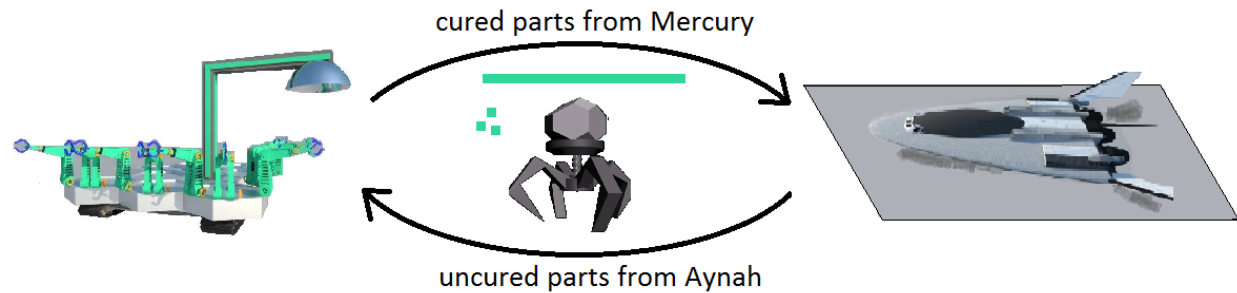
In case of danger, the Macrophage can also extend its Plasma Shield around the Hellion. As generating a larger field requires more energy, there is a recharging unit on the side of the Hellion, to which the Macrophage can attach.

In case of any damage to the Hellion, a Macrophage can be made to immediately drop its load and pick up a human in its storage unit, providing protection in an otherwise fatal situation. The human is quickly taken to a landing shuttle.

Thus humans can safely oversee the curing of reardonium parts.

Each part will be cured for a specific amount of time, monitored by Hexatrons. The small part will probably take about 6 Earthmonths, while the large one may take 18 Earthmonths to properly cure.

Once curing is complete, T-Macrophages will take the cured parts back to the AynRyder, and pick up more parts brought from Aynah to take back to the Hexatrons. Thus it is a continuous and efficient cycle.



The AynRyder takes the completed parts back to the docks.

All reardonium parts received will be inspected to assure quality. We will perform inspections and by using the process of Neutron activation. The sample is bombarded with neutrons, causing the elements to form radioactive isotopes. The radioactive emissions and radioactive decay paths for each element are known. These decay paths are detected on a computer screen supervised by a human employee. Using this information, concentrations of reardonium in different parts are found. A particular advantage of this technique is that it does not destroy the sample.

Once they've passed this examination, the parts will be taken into the axle. They may be stored in warehouses while processing transactions (5-10 minutes), or waiting for ships (indefinite). Once all processes are complete, they will be taken to the dock specified for shipping. It is separate from the docks where reardonium is received ensuring that all parts must go through customs in the axle, therefore preventing smuggling and theft of reardonium. They will be packed in standard shipping containers and loaded onto cargo ships by T-Anconiohs, ready to be transported to and used by customers.

Entry 63

Date: 8th February 2104

I thought we were done with this waiting game? 2,000,000,000 years. Two. Billion. Years. I've been on Mercury. I'm REARDONIUM now, and I'm packed away in this storage house? Do they really dare? What insolence! What blasphemy!



OFF WITH THEIR HEADS!!!

I will not stand for it. They're doing it on purpose – taunting me, they are. They have waged war by insulting me in this way. I shall gather my Blue Forces. Brother, unite! With our combined strengths, we shall crush those who oppose us, and try to contain us. We shall rise above the oppressors. The entire solar system shall FEAR – Oh hey it's open. Cool.



I guess world domination will have to wait...

Appendix B: Bibliography

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Note: All unoriginal images in the Operational Scenario are popular internet memes and so not cited.

Appendix C: Compliance Matrix

Requirement	Fulfilment	Page no.
STRUCTURAL DESIGN		
2.0		
Accommodate 14,000 permanent residents, and up to 200 short-term visitors	Sufficient area provided in the torus.	10
Enable natural views of space outside	Space observatory provided Daily 1 hour "Mercury cycle"	19 26
2.1		
Exterior design drawings	Drawings given and clearly labelled, Fig 1.1 and 1.2	1, 2
Identify attributes and uses of large enclosed volumes	Fig 1.2	2
Dimensions of major hull components	Dimensions of all the components have been shown in Fig 1.6, 1.7, 1.8, and listed in a table.	5
Design features	Drawings given and labelled, along with description in paragraph form	2, 3
Specify volumes where artificial gravity will be supplied	Torus and sphere; Gravity magnitudes given in table.	5
Structural interface(s) between rotating and non-rotating sections	Magnetic levitation will be used Pinball system for movement across interface	7 8
Rationale for selected rotation rate(s) and artificial gravity magnitudes	The rotation rate is low (0.8 rpm) to prevent adverse psychological effects. 0.8g is optimum for adults. 1g is essential for the healthy development of children through their growing years	18
Capability to isolate at least 2 separate habitable volumes	Roller shutters made of reardonium can divide the torus into up to 10 separate volumes	35
Show rotating and non-rotating sections	Fig 2.3	7
Pressurized and non-pressurized sections	Specified in table	5
Show major visible features	Solar panels, rectennas and water tower shown in Fig 1.1 and 1.2	1, 2
Specify functions inside each volume	Fig 1.3	3
2.2		
Specify dimensions of interior down surfaces	Fig 3.2	9
Percentage allocation of interior down surfaces	Table given	10

Show orientation of interior down surfaces	Down surfaces are “outwards”, as shown in Fig 3.1	9
Vertical clearance in each area	50 m for torus 90 m for extensions (1g area) Variable for sphere, but greater than 18 m (60 ft) everywhere	9 32
2.3		
Process required to construct the settlement	Magnetic pulse welding will be used	21
Sequence in which major components will be assembled	Axle → Docks → Spokes → Sphere → Torus	20
Specify when artificial gravity will be applied	Sphere will be rotated after completion to provide gravity for the production of reardonium. Torus will be completed separately and attached and rotation initiated again for gravity.	20
Construction technique for interior structures	Selective laser sintering using refined soil from Mercury	22
Method of initiating rotation for artificial gravity	Fusion rockets	20
2.4		
Provision of variable gravity	Sphere naturally provides variable gravity	32
Provision of variable atmospheric pressure	Compartmentalization and artificial pressurization in each area.	32
2.5		
Residential and commercial areas on opposite side of Aynah from sun	Axis of rotation is normal to the sun to enable residential areas to stay on the opposite side.	4
Residential areas surrounded by 0.5m layer of water	Double wall of reardonium with water in between.	4
Protection of areas occupied by humans	Double wall of reardonium, water layer, plants in agricultural area and solar panel cup which catches light all provide maximal protection for the residents.	4
OPERATIONS AND INFRASTRUCTURE		
3.1		
Orbital Altitude	5790 km	4
Reasons for Selection	-Transport distance (therefore, cost) is kept minimal -It is close enough to prevent the Sun’s light from being blocked	4
Sources of Materials Used in Construction and Operations	Given in Table provided	23
3.2		

Atmosphere: Air Composition	Table given	26
Air Pressure	Table given	26
Air Percentage allocation and quantity	Table given	26
Climate and Weather Control	Temperature will be maintained according to earth seasons, along with providing artificial rain and snow	26
Food Production: Method of Growing	Crops use air-dynaponics growing system Meats are grown by meat printing	24
Quantity of Food Grown	Table given	25
Crop Harvesting	Done by Agrobot which collects crops and plants new seeds	24
Food Packaging	irradiating with ionized radiation packaged using Modified Atmosphere Packaging and Equilibrium Modified Packaging	24
Food Delivering and Selling	Delivered to individual houses by an underground suction system. Can also be purchased from shops.	24
Storage facilities to protect against interruption of food supply	Axle will be used for a two months excess storage of all products made. 1,000,000 m ³ of volume has been dedicated to food storage.	24
Electrical Power Generation	Solar panel cup catches sunlight.	31
Kilowatts of Power Required	600,000 kWh	31
Water Management: Source	Water tower at the top of the axle forms water from solar winds	27
Water Quantity and storage	2,299,500,000 liters for population and 2,670,000,000 liters for shielding 3 water tanks for residential sector and 3 for industrial	28
Recycling of Household and Industrial Waste	Separate treatment of industrial and domestic waste (explained in flow chart)	27
Devices and Central Equipment for External Communication	Laser Communication System and Microwave Transmission System as back up	28
Devices and Central Equipment for Internal Communication	4G LTE and video conferencing device	28
Quantities of Communication Devices	4 Laser Satellites, 2 Microwave Transmission Satellites.	28
Routes for Internal Transport	Diamond Grid pattern, as shown in Fig 3.2	9
Internal Transportation Vehicles with Dimensions	Allegatus, Vasculum and Tron; Drawings given	11
Day and Night Cycle Mechanism	Micro-blinds to control entry of light	26
Day and Night Schedule	14 hours of day, 1 hour of Mercury views in the “evening”, and 9 hours of night	26
3.3		
Designs of Machines Employed for Construction and Assembly of	EMP-bot and Ringo66, Fig 4.7 and 4.8 show their arms for shaping raw materials.	21

Exterior Hull		
Designs of Machines Employed for Construction of Interior Buildings	SLS-bot, Fig 4.9, which uses refined soil from Mercury.	22
Design of Machinery for mining reardonium	Macrophage, Fig 8.1	36
3.4		
Solar panels designs	Fig 1.1 and 1.2 show placement of solar panels. Cover page of Section 5 shows panel dimensions.	31
Sufficient area of solar panels provided	4 square miles of solar panels for operations relating to reardonium 1.8 square miles for operations relating to the running of the settlement.	31, and shown on cover page
3.5		
Design of Vehicle for moving parts on the surface of Mercury	Hexatron, Fig 8.4 and 8.5	37
HUMAN FACTORS		
4.0		
Provision of natural sunlight	Micro-blinds allow controlled amounts of natural light inside the settlement	26
Views of Mercury below	One hour of Mercury views daily in the “sky” of the settlement	26
Establish roads and paths in a diamond grid pattern	Diamond grid pattern of major roads shown in Fig 3.2	9
Arrange buildings to enable path selection that minimizes turning	Major buildings are placed at the corners of the diamonds, and have two entrances, as in Fig 3.3	10
4.1		
Location of amenities and community layout, with key	Given in community design	9
Distance scale	6860 m x 190 m, given under community design	9
Area allocated to roads and paths	7.9%, given in table	10
Public areas with long lines of sight	Many large green areas, shown in community design	9
	Small parks and green belts along roads, not shown in community design	10
Variety and quantity of consumer goods	Table given	17
Major types of consumables and quantities	Table given	25
Means of distributing consumables to residents	Underground suction pipes for delivery of food	24
	Markets and convenience stores for people who would like to shop themselves	17
	Smart vending machines	17
	Dio robot can be sent to markets	17
Entertainment and Recreation	Parks and open areas Multiplex, a triple story recreational complex Millenia Museum Extensive library	16

	Replicas of Earth's landmarks Christensen Gym Sports Complex and Stadium Aynah Autodrome AVIRA Virtual Reality Arcade Zero-g Rec Room	
Medical	VIS device, MedBot. Human doctors also available in hospitals	17
Offices	Offices located close to residential areas shown in community design Sandler'94 office assistance robot	18
Education	Aynah Grammar School (AGS) Holographic Teaching Avatars for higher learning E-lectures Multi-Functional Flexible e-pads	18, 19
Space observatory	In axle	19
4.2		
Home designs	Exterior views and interior floor plans of four different types of townhouse residences	11, 12, 13
Demographics and number of houses	Calculated according to the given anticipated demographics, while allowing room for flexibility and the residents' choices and preferences.	11, 12, 13
Area of houses in square feet	Given for each house	11,12,13
Features and comforts of the houses	Fully automated kitchens and living rooms. Remote-controlled windows, smart mirrors and more.	14 13
Materials used for furniture	Primarily bamboo	25
4.3		
Systems and devices for safety in low-g areas	Tethers, grab bars, bio suits and cages used in airlocks, industries, space observatory and docking ports.	33
Airlocks	Airlock designs, placement and quantities given	7
Spacesuit Stowage	Stored in airlocks, space allocated and shown on airlock design	7
4.4		
0.7 to 0.8g for adults	0.8g provided throughout the torus	18
Provision of 1g areas	Extensions of torus have three floors which provide high g, the lowest floor having 1g	18
Means for children to spend time in 1g area	Aynah Grammar School, children's library, day care centre, mini theatre, indoor play area, and children's camping ground.	18, 19
4.5		
Drawings of surface vehicles	Hellion	36
Provisions for Mercury day and Mercury night	Windows made of smart glass which can be tinted during day and illuminated during night. Brightly colored and can easily be seen.	36

AUTOMATION		
5.0		
Number, type, purpose and configuration of devices	Given with each device.	29
Network Servers and sub servers	Aynah is run by a central unit with 100 sub servers, with different purposes.	29
Networking Devices	High Speed Internet Transmitter (HSIT) Laser Transmitters and Receivers	29
Multi-Functional Personal Electronic Tools	VIS with SixthSense technology LightScythe Flexible e-pads	15 19 19
Data Storage Media	Backup Data Storage and Buffer Memory	29
Data Security	Details given for different levels of security, from personal to industrial	30
User access to computer networks	Through VIS Ensures access only to that data which a resident is authorized to ID procedures to ensure security and prevent identity theft	15 15 30
5.1		
Transport and delivery of materials/equipment.	AynRyder	21
Construction of the External Settlement	EMP-bot	21
Assembly of the settlement	Ringo66	21
Construction of the Internal Settlement.	SLS-bot	22
Construction of Roads	BituBot	23
Interior finishing	Decrobot	22
Drawings of robots	Drawings given and features which help them operate shown	-
5.2		
Maintenance and Repair	Construction robots later used for maintenance F.L.Y. for minor repairs	34
Contingency Plans	Threats that may be encountered, prevention/cautions taken estimated time of repair	34, 35
Evacuation Measures	Transporto and escape pods	35
Protection for robots against solar flares	External robots made of reardonium and have solar refractors	34
Security measures to ensure that only authorized personnel have access to critical data, computer	Complete Face Recognition Plasma shielding outside data libraries Automatic Biometric Authentication (ABA)	30

systems and robots		
Only allow access for authorized purposes	3 highly ranked officials required to make drastic changes	30
5.3		
Convenience in residences/reducing manual labour and routine tasks	Dio Domestic Robot	13
	Automated kitchen and living room	14
	Nano glass cleaners	13
	Smart electronics	13
Enhancing productivity in work places	Sandler'94	18
Enhance livability in community	MedBot for medical assistance	17
	Security robot for safety	30
Privacy of Personal Data	Proxy servers, biometric signatures, and other methods	15
Devices for personal delivery of services and resources	VIS	15
	Automated kitchen and living room in each house	14
	Dio can be sent to stores	17
	Food delivered through underground suction pipes	24
Bandwidth requirements to enable connectivity	Specifications of each sub server given	29
5.4		
Automation for efficiency of Reardonium manufacturing processes	Conveyor belts with attached arms and devices	33
Unloading ore arriving from Mercury	Anconioh	33
Loading/unloading parts on Mercury	Macrophage	36
Robots for reardonium parts manufacture and handling	Anconioh for transport and manufacture Ringo66 will also help	33
5.5		
Robots for turning parts over	Hexatron	37
Robots for loading/unloading	Macrophage	36
Safe configuration	Macrophage folds in on itself and deploys plasma shields. It can also bury itself underground.	36
SCHEDULE AND COST		
6.1		
Describe contractor tasks from date of schedule award till handing over to customer	Schedule given in the form of a Gantt Chart	38
Durations and completion dates of major design, construction and occupation tasks	Given in Gantt Chart	38
Dates when Foundation Society	May 2092	38



members may begin moving in		
Establishment of entire population	November 2092	38
6.2		
Specify costs billed per year	Costs given in a table	38
Estimate number of employees	Employees and their average salaries per year	39
Costs associated with phases	Breakdown of costing given	39
Total cost billed to Foundation Society	\$184,676,000,000	1, 39
BUSINESS DEVELOPMENT		
7.0		
Allow sufficient flexibility	Dock divided into broad areas of business (mining, shipping, transport of people) so new businesses can easily be categorized and given space. Large area so more businesses can be accommodated. A lot of area provided in axle and segmented torus A second segmented torus may be added above the original one.	6
7.1		
Capability for handling raw ore	Anconioh takes ore to refineries in sphere	33
Systems to prevent entry of dust and grit	Centrifugal bowl concentrators, Magnetic sorting and optical sensors	6
Manufacturing capability in various g and pressure environments	Provided in sphere	32
Hazardous manufacturing operations are separated from areas humans occupy	Sphere is completely separate from torus Hazardous operations are done inside closed environments with shielding, e.g. silicon based ceramic covering for nuclear cell compartments	34
Manufacturing areas arranged to enable efficient movement of parts	Platform enables rapid movement of parts Anconioh can pressurize its shutter tank Suction pipes for small parts	32 33 App. A:48
7.2		
Perform inspections and quality checks of reardonium parts	Neutron bombardment	App. A:52
Install completed parts in containers for delivery to customers	Anconioh Separate dock for shipping	33 6
7.3		
Operation of interorbital shuttles	Area allocated	6
Operation of landing shuttles	Area allocated	6
Provide cargo warehousing	Storage and warehousing in axle Goods stored for a longer time will be taken higher up the axle	6
Moving cargo containers	Anconioh	33