Northdonning Heedwell

Aynah

University High School, Irvine, CA, USA

19th Annual International Space Settlement Design Competition

Proposing Team Data 2012

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1.0

EXECUTIVE SUMMARY

1.0 Executive Summary

As humans, we have expanded our boundaries far beyond what our predecessors could have ever imagined. In the past, we have expanded to the Moon, to Mars, and to even the asteroid belt. Now, in 2077, we at Northdonning Heedwell are proud to present our design to further expand our boundaries in the direction of the source of life in our solar system, to Mercury. Following in the footsteps of its many predecessors, Aynah will become both a comfortable residence for its population and a reliable source of the miracle metal, reardonium.

Aynah's innovative design is based around the comfort and well-being of its residents while ensuring smooth operations between Mercury, Earth, and Earth-based settlements:

- Carefully planned *community designs* will provide optimal comfort for residents, fostering a modern, progressive environment.
- Innovative *robotic technology* will be implemented to improve the lives of residents and provide automated assistance to the maintenance of the settlement at large.
- A *manufacturing center, Kratos*, which will handle all heavy manufacturing, including the refinement of raw ore and the production of reardonium
- A *port facility*, *Genis*, will be the center of all incoming and outgoing traffic and provide state-of-the-art repair facilities for all damaged ship.
- The latest advances in economically- and environmentally- friendly living, work, and recreation will be used, such as aquaponically-grown vegetation and large, open parks

Upon completion, Aynah will be capable of housing 14,000 permanent residents and a transient population of 200 visitors in the main residential torus, *Irving I*. Aynah's vast array of automated systems, designed to facilitate and smooth operations and maintenance of the settlement, will be monitored at every step by trained technicians. Safety and contingency plans have been defined in detail to ensure the utmost safety of this population.

Construction of Aynah will begin as soon as its design is approved: Foundation Society members are projected to be able to move in by April of 2099. All other ventures will be able to settle by September of 2099, and the full population is expected to be established no later than July of 2100. The settlement's exports and services will ensure that it pays for itself in less than twenty one years.

Aynah's aim is to provide residents, businessmen, and tourists with the comforts of home while pushing the limits of a new frontier in space colonization. In time, Aynah will blossom into a bustling trade and commercial hub for space settlements, providing golden opportunities for entrepreneurs and creative minds of future generations. In the pages following, Northdonning Heedwell presents its design for Aynah: the future of space commerce, culture, and colonization.

2.0

structural design

2.0 Structural Design

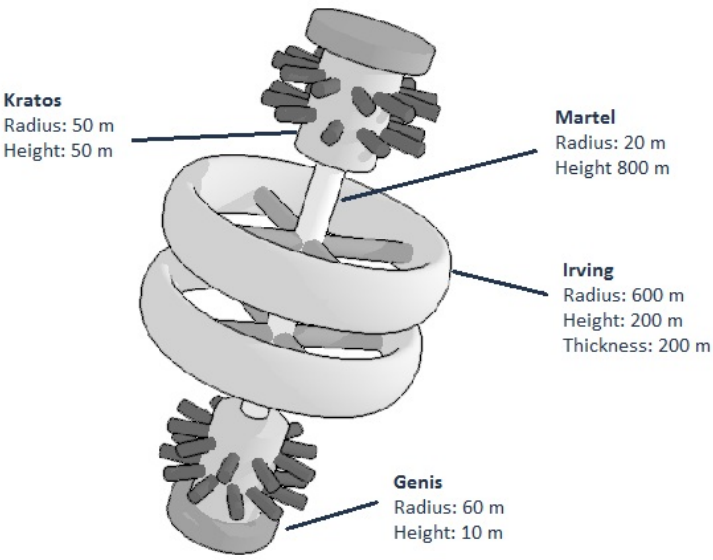


Figure 2.1.1 Exterior Design

2.1 Exterior Design

2.1.1 Exterior Design Overview

Aynah will be made up of two pressurized torus structures, *Irving I* and *Irving II*, both rotating around the central axis, *Martel*. Due to the rotation of the settlement, *Irving I* will serve as the main residential area for the settlers since it is further from the sun. *Irving II* will be dedicated to commercial, agricultural, and miscellaneous areas which require minimal human activity and maintenance. It will also be a temporary residential area for emergencies. Each torus will be attached to the central axis by four spokes. Each spoke will also serve the purpose of transporting residents and cargo between the tori and central axis.

Each ends of the central axis are manufacturing cylinders, *Kratos I* and *II.* The cylinders will contain both pressurized and non-pressurized sections, operating in approximately zero gravity. all operating in zero gravity, *Kratos I* and *II* will handle the manufacturing of various materials, mainly reardonium.

Attached to the manufacturing cylinders are ports *Genis I* and *II*. These ports will allow spacecrafts to travel to and from Earth and other colonies, which is important for the large transient population. The port will also be essential in accepting spacecraft carrying the raw mined materials from Mercury and asteroids.

The central axis, *Martel*, will provide transportation for residents as well as cargo between *Irving I* and *I, Kratos I* and *II,* and *Genis I* and *II.* Each structure will be composed of materials that will protect the settlement against radiation. Satellite *Volt* will hold the central control system for Aynah.

Structures	Dimensions	Total Surface Area	Total Volume
Irving I Pressurized Rotating Torus (95% residential)	Radius: 600 m Height: 200 m Thickness: 200 m	2368705.056 m^2	14804406.601 m^3
Irving II Pressurized Rotating Torus (5% residential)	Radius: 600 m Height: 200 m Thickness: 200 m	2368705.056 m^2	14804406.601 m^3
Martel Central Axis	Radius: 20 m Height: 800 m	103044.239 m^2	1005309.649 m^3
Kratos I Manufacturing Cylinder	Radius: 50 m Height: 50 m	31415.927 m^2	392699.082 m^3
Kratos II	Radius: 50 m	31415.927 m^2	392699.082 m^3

Manufacturing Cylinder	Height: 50 m		
Genis I Spaceport	Radius: 60 m Height: 10 m	26389.378 m^2	113097.336 m^3
Genis II Spaceport	Radius: 60 m Height: 10 m	26389.378 m^2	113097.336 m^3

Table 2.1.1 Structure Dimensions

2.1.2 Artificial Gravity and Rotation Rate

Key:
a = acceleration towards center of mass
v = velocity of object (in meters/second)
r = radius from central axis (600m)
p = period of rotation (in seconds)

Given that:
The centripetal acceleration due to velocity is a = (v)^2/ r
And that v = ð^2*r/p^2, and centripetal acceleration = 0.7 g = (9.8 m/s)(0.7) = 6.86 m/s

We have: 6.86 = (4ð^2 x 600)/p^2, and p = 58.762 seconds
Using proportions, 58.762/60 = 1/x, we get x = 0.97837 rpm.

Therefore, both *Irving I* and *II* rotate at a speed of 0.97837 rpm – though they rotate in opposite directions – to generate and artificial gravity of 0.7g. As the rotational speed is sufficiently under 3 rpm, human residents will not experience physiological discomforts set by the Coriolis Effect. The 0.7g is enough to prevent osteoporosis and muscular degeneration of human tissues while less than Earth's gravity so that maintenance expenses on repairs of strained structures will be significantly reduced. The counter rotations of two main tori are set in order to prevent hyper-speed rotation of the central axis that two tori rotating the same direction would cause.

2.1.3 Pressurized and Non-Pressurized Sections

Aynah will have both pressurized and non-pressurized volumes. *Irving I* and *II* will be pressurized to accommodate human residency, except for some manufacturing facilities. Parts of *Kratos I* and *II* will be pressurized to enable human activity if necessary, while other parts will be maintained at various pressures to accommodate the manufacturing of reardonium. The central axis *Martel* and the spokes connecting the two tori will not be pressurized. They will be used mainly for transportation and storage. All pressurized areas will be maintained at a constant pressure of 13.5 psi.

2.1.4 Volume Isolation

In case of an emergency such as a hull breach, Anyah will be able to isolate each of its structures at any given time if necessary. Each of the eight spokes connecting *Irving I* and *II* to the central axis *Martel* may be isolated during an emergency. If an issue were to occur at the spokes, it may be removed at once. If an issue were to occur within a torus, either *Irving I* or *II,* residents will be asked to evacuate from the area and either be transported to the other torus or any other safe structure. Airlocks will be spaced every 50m to quarantine affected segments of the torus. All connecting sections will be separated by airlocks to ensure safety for residents. *Kratos I* and *II* and *Genis I* and *II* may also be isolated from the central axis. Workers and necessary cargo will be transported through *Martel* into a safe structure. Airlocks will also be maintained.

2.2 Interior Design

2.2.1 Tori Down Surfaces

Aynah focuses on creating a safe environment and settlement through careful planning of area allocations. The torus shape was chosen for the habitat because of its large volume, clear visual horizon for orientation, and versatility in accommodating a variety of internal arrangements. The table below specifies percentage allocation and dimensions of total down surfaces of the two tori:

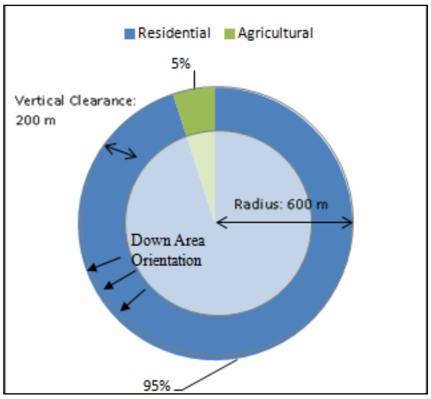
Section	Down Area (m²)	Percent Allocation
RESIDENTIAL NEIGHBORHOOD		
Residential	150796.4	10%
Hospitals/Health Research	7539.82	0.50%
Schools	218654.78	14.5%
Recreation/ Open space	376991	25%
AGRICULTURAL/FOOD PRODUCTION/WASTE PROCESSING		
Agricultural	211114.96	14%
Livestock	150796.4	10%
Processing, Drying, Storing	90477.84	6%
Waste and recycling	60318.56	4%
MANUFACTURING		
Non-pressurized	27143.352	1.8%
Pressurized	120637.12	8%
MISCELLANEOUS		
Electrical distribution	3015.928	0.20%
Communications	150.7964	0.01%
Entrances to Communities	753.982	0.05%
Miscellaneous	89573.0616	6%
TOTAL	1507964	100.06%

Table 2.2.1 Tori Allocations

*The calculations are approximate, and due to rounding errors during calculations, totals may not add up completely to 100%

Section	Total Area (m²)	% Total
Residential	753982	50.00%
Commercial	147780.5	9.80%
Agricultural	512707.8	34.00%
Misc.	93493.77	6.20%

Table 2.2.2 Tori Down Surfaces



2.2.2 Irving I

In rotation, Irving I will consistently be on the opposite side of the settlement from the sun to protect humans from high levels of radiation. Because Irving I is safer for humans than Irving II, a major portion of Irving I will consist of residential land. The residential torus will feature housing, recreational parks and facilities, hospitals, research centers, service industries, all in a pressurized, 1 g environment to simulate comfortable Earth life.

A small portion of this torus will serve agricultural purposes, while the bulk of the agricultural land on the settlement will be located on Irving II. The agricultural sector on Irving I provides redundancy; in case Irving II is ruptured or transportation between the tori fails, Irving I will independently supply food and other necessities for residents.

Diagram 2.2.1 Overhead view of Irving I

Section	Area (m^2)	% Irving I	% Total Area
Residential	716282.9	95.00%	95.00%
Commercial	0	0.00%	0.00%
Agricultural	37699.1	5.00%	7.35%
Misc.	0	0.00%	0.00%

Table 2.2.3 Irving I Allocation

2.2.3 Irving II

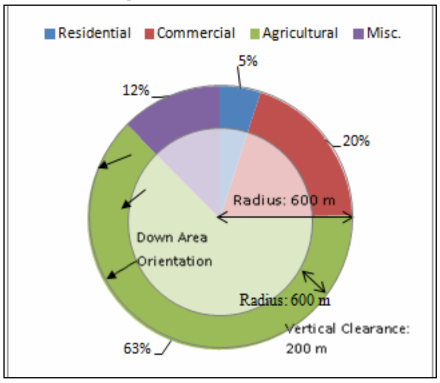


Diagram 2.2.2 Overhead View of Irving II

Because Irving II is on the side of the settlement closer to the sun's radiation, it is dedicated to commercial, agricultural, and miscellaneous areas which require minimal human activity. Residential areas occupy only 5% of the total torus. The few residents on Irving II will oversee processes throughout all sections, while specialized robots operate such processes at highly-profitable productivity levels.

Irving II will handle industries that require Earth gravity to operate. Agricultural produce and factory goods will be transported daily through the central axis for consumption by residents.

Section	Area	% Irving II	% Total Area
Residential	37699.1	5.00%	5.00%
Commercial	147780.5	19.60%	100.00%
Agricultural	475008.7	63.00%	92.65%
Misc.	93493.77	12.40%	100.00%

Table 2.2.4 Irving II Allocation

2.2.4 Manufacturing Kratos I & II

Kratos I & II, located on opposite sides of the central axis, process reardonium in various accelerations from 0 to 0.5 g. Refining spokes around the cylinder allow manufacturing nodes to be placed at different distances from the center of rotation – this will produce distinct accelerations, which meet the requirements of reardonium processing. The zero-G cylinder maximizes productivity, making it ideal for heavy industry. Due to its zero gravity nature, the tables provide volume allocations rather than down area allocations.

Section	Volume (m^3)	% Total
Manufacturing (Readonium)	628318.5307	61.54%
Manufacturing (General)	99352.86767	9.73%
Storage	280779.8434	27.50%
Central Axis	12566.37061	1.23%
Total	1021017.612	100.00%

Table 2.2.5 Kratos I and II Allocation

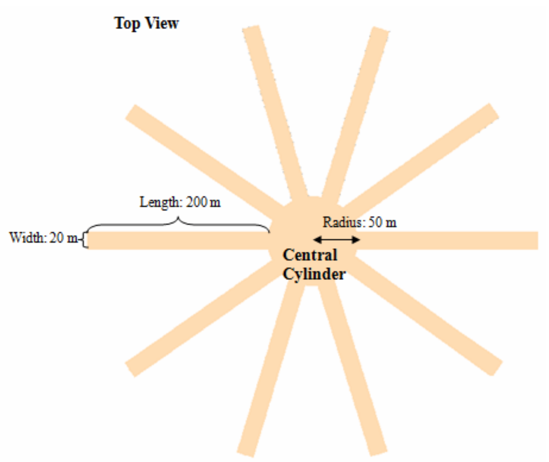


Figure 2.2.1 Overhead View of Kratos I and II

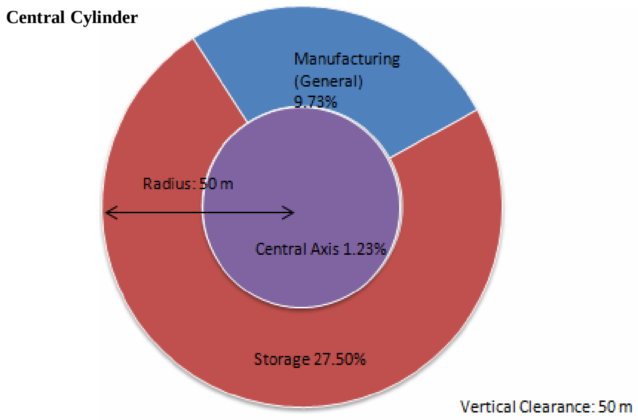


Diagram 2.2.3 Kratos I and II

2.2.5 Docking Stations Genis I & II

Genis I and Genis II will handle the docking and launch of spacecraft as well as loading and unloading operations. Since the docking stations are connected to the central axis, raw materials, processed goods, and other imported items can be transported to the manufacturing cylinders and throughout the settlement. Both docks will operate in zero gravity and pressure, with a pressurized area to accommodate human travelers.

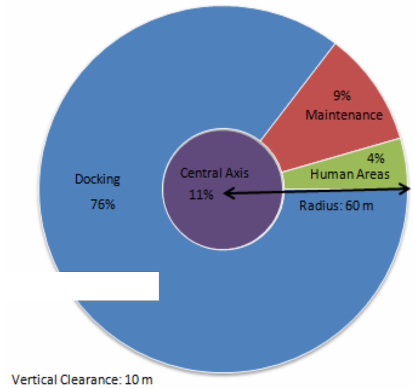


Diagram 2.2.4 Genis I and II

Section	Volume (m³)	Percent Volume
Docking	85953.975	76.0%
Maintenance	10178.760	9.00%
Human Areas	4523.893	4.00%
Central Axis	12566.371	11.0%
Total	113097.336	100.%

Table 2.2.6 Genis I and Ii Allocation

2.2.6 Central Axis Martel

The main purpose of the central axis is to provide efficient transportation throughout all parts of the settlement. Its zero-g environment optimizes transportation rates since less energy is required to move objects. The constant flow of cargo from Irving II to supply the largely residential Irving I requires an extensive and effective transportation system. Each of the four sections of the central axis carries a specific cargo upwards and downwards through a series of capsules. The capsules on one side of the central axis transport passengers, while those on the other side handle cargo such as agricultural produce, factory goods, and other human necessities, as well as construction parts and robots. It will also transport manufactured reardonium from the manufacturing nodes to the tori during the construction process.

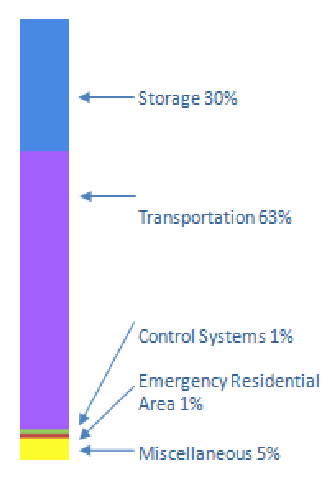
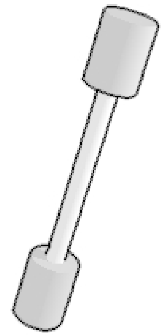
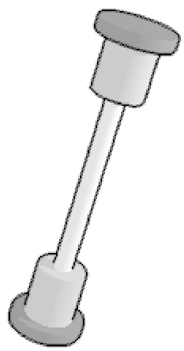
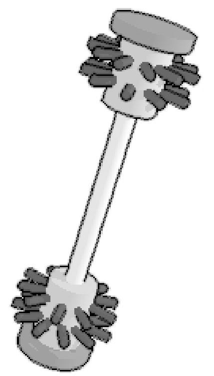


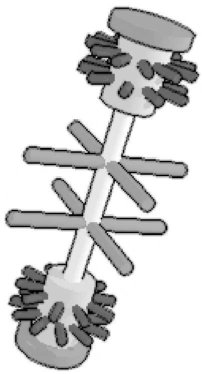
Figure 2.2.5 Martel

Section	Volume (m³)	Percent Volume
Storage	301592.8947	30%
Transportation	633345.079	63%
Control Systems	10053.09649	1%
Emergency Residential Area	10053.09649	1%
Miscellaneous	50265.48246	5%
Total	1005309.649	100%

Table 2.2.7 Martel Allocation

2.3 Construction

	
Step 1: The central axis *Martel* is constructed. The fission reactors begin producing power for basic operations. The transportation capsules and system is constructed. Estimated time: 3 years	Step 2: *Kratos I* and *II* are constructed. Manufacturing operations begin and specified areas are pressurized. Estimated time: 3 years
	
Step 3: *Genis I* and *II* are constructed and begin operations. Docking ships are able to deliver materials, which directly transfer into the manufacturing cylinders. Estimated time: 2 years	Step 4: Refining spokes are constructed around *Kratos I* and *II*. Each spoke consists of multiple chambers pressurized at different levels. Estimated time: 2 years

	
Step 5: The eight main spokes are constructed with transportation capsules and systems. Estimated time: 3 years	Step 6: *Irving I* and *II* are constructed and pressurized. Estimated time: 5 years
	
Step 7: The interior of *Irving I* and *II* are constructed. Settlement is finalized and people moved in. Estimated time: 2 years	

2.4 Reardonium Manufacturing Facilities

Designed with back-up redundancies and broad spectra of environments, the reardonium manufacturing facilities are located near the two opposing docks of the Aynah Settlement to ensure maximum efficiency as well as protection against total manufacturing malfunction. In addition, much like the residential tori, the two opposing manufacturing facilities will be counter rotating, preventing an uncontrolled spin of the central axis.

Structures	Rotational Speed	Distance from Martel	Applied Artif. Gravity	Dimensions	Volume	Atmospheric Pressures
Kratos I	**1.33735503**	**50m**	**0.0-0.1g**	**R = 50m, H = 50m**	**392699.08169m^3**	**0-20 Psi**
K1 - 0	"	**250m**	**0.1-0.5g**	**R = 10m, H = 200m**	**62831.85307m^3**	**0 Psi**
K1 - 1	"	"	"	"	"	**1 Psi**
K1 - 2	"	"	"	"	"	**2 Psi**
			…			
K1 - 19	"	"	"	"	"	**19 Psi**
K1 - 20	"	"	"	"	"	**20 Psi**
Kratos II	**-1.33735503**	**50m**	**0.0-0.1g**	**R = 50m, H = 50m**	**392699.08169m^3**	**0-20 Psi**
K1 - 0	"	**250m**	**0.1-0.5g**	**R = 10m, H = 200m**	**62831.85307m^3**	**0 Psi**
K1 - 1	"	"	"	"	"	**1 Psi**
K1 - 2	"	"	"	"	"	**2 Psi**
			…			
K1 - 19	"	"	"	"	"	**19 Psi**
K1 - 20	"	"	"	"	"	**20 Psi**

Table 2.4.1 Manufacturing Pressures

The two opposing manufacturing facilities each feature environments in which all combinations of integer-unit atmospheric pressures of 0-20 psi and continuous 0-0.5 g units of gravity are present. Due to reardonium's ideal properties and versatile usage, maximum output of the material is desirable, and thus the manufacturing sector will be designed to have two copies of all these various environments to allow for redundancy and increased output.

While artificial gravity present in the manufacturing environment will have a continuous range of gravities (0 – 0.5g), the atmospheric pressure will require the usage of airlocks, and thus differently pressurized sectors will hold a specified integer amount of atmospheric pressure within their respective chambers, 0 – 20 Psi without repeating integers. Upon necessity, adjustments less than or equal to ±0.5 psi will be made to any of these chambers so that the psi range continuously covers all of the required 0-20psi.

The spokes of the reardonium production sites are for the differently specified atmospheric pressures and designed so that a loss of one spoke by a flying material will impede in a minute portion of the entire production.

The intersection of the central axis and the manufacturing sectors will be where the zero gravity environments will be present and will also be the location of the central controls of reardonium production. The convenient central location of this radial structure will allow for fast processing and direct contact with all manufacturing spokes which serves as an ideal setting for the central controls.

2.5 Radiation Protection

Due to the settlement's location, residents will be exposed to adequate amounts of radiation from the sun. Most components were selected to minimize the impact and provide structural support to create a safe living space. The following list of materials are in order from exterior to the interior side of the settlement.

Materials/Amounts	Usage	Properties
Raguard – 0.03 m	Radiation Protection (Overall)	Has a diverse application through its ability to be coated; provides X-ray radiation shielding
Silica Aerogel – 0.05 m	Thermal Protection	A light solid that serves as an infrared radiation shield material
Depleted Uranium – 0.05 m	Radiation Protection (Beta)	Blocks beta particle penetration by a

		factor of ½ every 0.2 centimeters; beta particle penetration is reduced to 1/32 of the original amount
Reardonium – 1 m	Structural support, thermal protection	Accessible on Mercury, provides structural support, easily malleable
Stainless Steel – 0.1 m	Dividing the layer of water	Containing sufficient amounts of chromium, stainless steel will not rust when in contact with water
Water - 0.6 m	Radiation Protection from sun	Greatly attenuates radiation (x-rays, ultraviolet, etc.) given off from the sun
Stainless Steel – 0.1 m	Dividing the layer of water	Containing sufficient amounts of chromium, stainless steel will not rust when in contact with water
Feldspar - 5 m	A firm ground for the settlement's building basis of structures	Common on the surface of Mercury, easily accessible and provides support
Packed Soil – 0.5 m	Primary type of ground that gives the settlement an earth-like atmosphere	Reduces any leftover radiation

Table 2.5.1 Major Hull Components

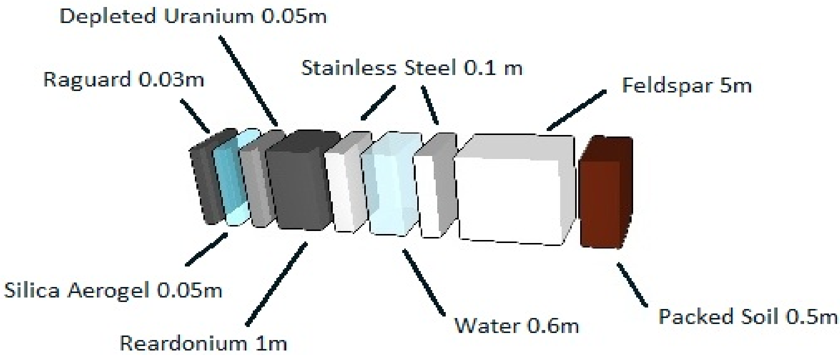


Figure 2.5.1 Major Hull Components

3.0

Operations + Infrastructure

3.0 Operations and Infrastructure

In providing the best facilities for new settlers on Aynah, Northdonning Heedwell will carefully take into account the smooth and concerted operation of all systems. It is our highest priority to ensure that construction and operation take place seamlessly, enabling and freeing residents to work and live comfortable, safe lives.

3.1 Orbital Specifications and Construction Material

3.1.1 Orbital Location and Specifications

Aynah will be located in a Sun-facing polar Mercury orbit at 87° inclination and between 1420 km (periapsis) and 1580 km (apoapsis) altitude from the Mercury surface. Several important considerations have been taken into account during selection of this orbit. First, the altitude is within the Mercurian magnetosphere, allowing protection from incoming solar radiation that may interfere with settlement day-to-day activities and communication. Second, the altitude is at a reasonably close distance to allow for operations and transportation to occur between the Mercurian surface and the settlement. Third, the altitude is simultaneously at a reasonably far distance to limit drag and thus reduce the need for fuel for propulsion to keep the settlement within orbit. Fourth, the rotation of Mercury and the orbit of the settlement allows for coverage of the entirety of Mercury's surface, allowing for a wide range of locations for reardonium production and processing.

3.1.2 Sources and Transportation of Construction Material and Equipment

Processed Material	Source	Transporation	Storage
7075-T651 Aluminium Alloy 18KhGNMFR Steel Alloy	Alaskol, Astoria, Balderol, Bellevistat, and Mercury	Commercial Spacecraft and SageCraft	Irving II Torus
6.6.2 Titanium Alloy	Mercury	SageCraft	Irving II Torus
Reardonium	Mercury	SageCraft	Irving II Torus
Fused Silica Glass	Mercury	SageCraft	Irving II Torus
Mercury Regolith	Mercury	SageCraft	Irving II Torus
Silica Aerogel	Mercury	SageCraft	Irving II Torus
Raguard	Earth	Commercial Spacecraft	Irving II Torus
Water	Alexandriat, Astoria, Bellevistat, Columbiat, and Earth	Tenebrae Rocket Propulsion System	Raine Tank
Helium-3 Deuterium	Earth	Tenebrae Rocket Propulsion System	Raine Tank
Hydrazine	Earth	Zelos Transport Vehicle	Raine Tank
Uranium-238	Earth	Zelos Transport Vehicle	Raine Tank
Depleted Uranium	Earth	Zelos Transport Vehicle	Raine Tank
Silicon Photovoltaic Cells Electronics	Alexandriat, Bellevistat, Columbiat, and Earth	Zelos Transport Vehicle	Irving II Torus
Polyethylene Foam	Alexandriat and Bellevistat	Commercial Spacecraft	Irving II Torus

Table 3.1.1 Construction Material Transportation

3.2 Settlement Infrastructure

3.2.1. Atmosphere, Climate, and Weather Control

Aynah's atmospheric composition will be roughly similar to that of Earth's to provide for the health and psychological comfort of residents. Due to cost and convenience, all trace gases have been eliminated from Aynah's atmosphere. Although atmospheric pressure has also been slightly reduced to 0.85 atm to reduce costs, the partial pressure of oxygen will be maintained at levels similar to Earth's. Air will be continually recycled and extensively filtered using HEPA technology to remove physical and biological contaminants as well as UV and ozone technology to further remove biological and chemical contaminants. Excess carbon dioxide will be removed using the Bosch reaction: CO2 (g) + 2H2 (g) → C (s) + 2 H2O (g). The electrolysis of water will regenerate oxygen for atmospheric replenishment and the hydrogen needed to continue the reaction.

Aynah will experience four distinct "seasons" marked by gradual changes in both temperature and humidity. Depending on the season, temperatures will vary from 15 ˚C to 25 ˚C, while humidity will vary from 35% to 45%. Additionally, the "seasons" will be in the Earth's three-month cycles to increase familiarity to the residents.

To further simulate an Earth-like environment and provide familiarity to residents, several weather parks located around residential areas will simulate weather conditions such as rain, snow, fog, wind, etc. In addition to providing familiarity, weather parks isolate adverse weather conditions that may severely affect Aynah's sensitive equipment.

Residential Atmosphere

Component	Percentage	Pressure (kPa)	Volume (m^3)	Weight (kg)
Nitrogen (N_2)	52.59%	53.291	8,293,875.08	10,375,637.7
Oxygen (O_2)	44.76%	45.358	7,059,019.75	10,087,339.2
Carbon Dioxide (CO_2)	0.71%	0.724	111,972.833	221,370.291
Water Vapor (H_2O)	1.94%	1.952	305,953.939	245,986.967
Total	100.0%	101.325	15,770,821.6	20,930,334.2

Manufacturing Atmosphere

Component	Percentage	Pressure (kPa)	Volume (m^3)	Weight (kg)
Nitrogen (N_2)	84.39%	58.187	53,023.802	66,332.7763
Oxygen (O_2)	15.61%	10.763	9,808.052	14 015.7063
Total	100.0%	68.950	62,831.854	80,348.4826

Table 3.2.1 Atmospheric Compositions

3.2.2 Food Production

Figure 3.2.1 Aquaponics System

Aynah will employ automatic "conveyor-belt" aquaponics systems in order to efficiently grow and harvest both vegetables and fish. Aquaponics bypasses the limitations of its component systems, aquaculture and hydroponics, but simultaneously possesses the advantages of both systems.

Aquaponic systems allow us to simultaneously grow trays of vegetables while also providing the settlement with a constant supply of high-protein fish like tilapia and carp and other types of seafood. The waste they produce will be converted into nitrogen and used as nourishment for the vegetables. Vegetables not suited for this system will be grown using a Ferris-wheel-type system, where plants are grown in porous vermiculite trays in a rotating cylinder cart that periodically dips into a water-based nutrient trough. Additionally, the diet of fish and vegetables on Aynah will be further supplemented with in-vitro meat grown in laboratory-farms. Food growth will take place in controlled and isolated environments, with plants being coated in genetically-modified bacteria that glow in the presence of diseases or pests. Lighting will be provided by

LEDs at specific wavelength to maximize efficiency for plant growth.

Vegetables will be harvested using an automatic robot system, using mechanical noses to detect the presence of specific alcohols to determine ripeness and accordingly harvest ripe vegetables. Fish will be harvested by a similar robot system that will harvest them based on size and other pertinent factors.

Food for immediate distribution will neither be freeze-dried nor vacuum-sealed, but packaged in reusable polyethylene containers. Liquids will also be packaged in reusable pouches. Used containers and pouches will be deposited in bins located throughout the settlement and collected every 2 days for reuse.

After being packaged, food will be delivered to restaurants and grocery stores in the maglev system described in Section 3.2.7. Restaurants and grocery stores can then distribute food out to those who require it.

Food can be bought individually in grocery stores and restaurants. To minimize food waste, people will only be able to purchase a limited amount of food. Should they need to purchase larger amounts of food for any event, they may apply for this at a community center. Food that has been on sale for more than 3 days shall be freeze-dried and vacuum-sealed for storage. In addition, residents' food intake may be monitored if the resident shows signs of eating habits that may prove detrimental to health on the settlement.

3.2.3 Electrical Power Generation

Initially, power for Aynah will be produced by five Traveling Wave Reactors (TWR) units on the surface of Mercury. They will provide a combined power output of 1 gigawatt an hour. After solar power has been established, these TWR units will power all facilities on the planet's surface and serve as a backup for the settlement. The Volt Satellite System will consist of two solar power satellites (SPSs) in a sun-synchronous Mercury orbit will function as the main power generation source for Aynah, due to the plentiful abundance of solar radiation. The solar panels will be made of multi-junction photovoltaic cells with a conversion efficiency of approximately 40%. These cells consist of several thin layers which allow the cell to absorb more of the solar spectrum. Overall, the satellites will possess a combined area of 15 square kilometers, leading to a combined power output of 17 gigawatts an hour. The total power output will suffice for reardonium production, all regular day-to-day activities of Aynah, and a surplus of power for emergency uses. Excess power will be stored in carbon nanowire batteries, chosen for their extreme power density. These will be located throughout Aynah, in major components; a power failure in any area will automatically activate the battery, providing energy for up to six months.

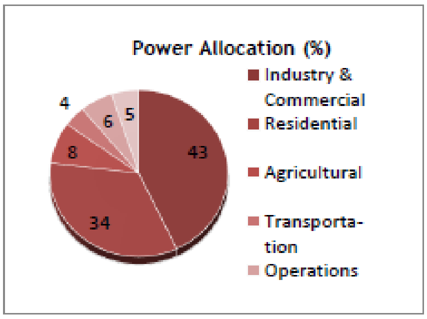


Figure 3.2.2 Power Allocation

3.2.4 Water Management

100 liters of water per capita per day will be provided to the citizens of Aynah. For the population of 14,000 full-time residents and 200 short-term visitors, the total amount of required water is 1,420,000 liters. Taking into account the needs of food production and other functions, 5,000,000 liters of water will be available for use. The source of this water will be three of the current existing settlements: Alexandriat, Bellevistat, and Columbiat. Additional water will be sourced from Astoria and Earth. During each of the six phases of construction, approximately 28,000 liters of water will be taken from each settlement, amounting to 84,000 liters per phase. Using water reclamation techniques, approximately 95% of the water will be recycled, leaving 4,750,000 liters of usable water. Every six month, water will be obtained from Alexandriat, Bellevistat, and Columbiat to replenish the water supply.


Figure 3.2.3 Water Storage Tank

Usable water will be stored in a total of 100 storage tanks, each holding 50,000 liters, placed throughout the settlement. There will be 30 storage tanks within the residential tori (1,500,000 liters), 40 storage tanks within the manufacturing and agricultural tori (2,000,000 liters), 25 storage tanks within the central axis (1,250,000 liters), and 5 storage tanks in the ports (250,000 liters).

3.2.5 Household and Industrial Waste Management

The WWTC (Waste and Water Treatment Center) will be located in the central axis for convenience. All household and industrial solid waste disposed of in Aynah will first be screened for any recyclable materials, then recyclable materials will be divided into their respective categories, processed into its raw form, and sent back to the industrial sector for reuse, to minimize the total waste produced by Aynah. The remaining materials are able to undergo anaerobic digestion processed by microorganisms into biogas, waste water, and digestate. Waste water will undergo further treatment and processing for recycling (and future use for human and industrial purposes, as well as aquaponics systems), while digestate will be used as a soil conditioner. The biogas will be further processed with amine gas treating (to remove hydrogen sulfide and carbon dioxide), and the Bosch reaction (to convert hydrogen and carbon dioxide to carbon and water). Remaining waste shall be disposed of by plasma arc waste disposal, resulting in syngas and slag (used as a soil conditioner). Despite the high energy usage of plasma arc waste disposal, the resulting syngas will produce enough energy to cover the energy used.

3.2.6 Internal and External Communications

Communication to and from Earth, other satellites, and space colonies will take place via laser-based communications systems. Lasers provide the highest transfer speeds for long-range communication and do not utilize excessive energy. In the event of a failure in the laser communication system, backup radio satellites will automatically begin relaying information.

In order to deal with time delays between Earth and the settlement, a time telescope technique will be employed. While the lasers used in communications cannot be sped up, the amount of information they carry can be increased. The length of each laser pulse will be shrunk into 1/27th its original size by 2 lens working together like in a simple telescope. A similar system on the receiving end will then decompress the data into a form regular systems can read. Unfortunately, this system cannot be employed should there be a failure in laser communications. Therefore, radio communications will still have an approximate half-hour of delay. The three power generating satellites orbiting Mercury will host the laser communication systems, as well as the backup radio systems.

3.2.7 Internal Transportation

All vehicles will use an electrorheological fluid will be used for braking and shock-absorbing purposes. In the case the magnetic fields controlling a vehicle fail, an electric field will activate within the vehicle to increase the viscosity of the fluid and stop the vehicle.

The main form of human transportation will be walking, to ensure the population receives the required amount of exercise. Bicycles and wheelchairs, for the handicapped, will also be provided for the resident's use. In the case of an emergency, the cargo transportation can be used to ferry people to safe areas.

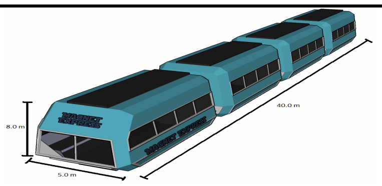
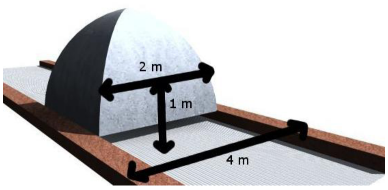
Vehicle Name	Image	Details
Elevated Cargo Rail System		The cargo rail will be used to carry goods and large cargo above the pedestrian floor of the tori. In an emergency, this can be used to ferry people as well.
Magnetic Rail Pod		Pods will be used to transport goods as well as people between the central axis and tori. Pods will use magnetic levitation technology to carry its passengers.

Table 3.2.1 Internal Transportation

3.2.8 Day/Night Provisions

LED lights will be placed on the ceilings of residential areas and will be managed from the central axis. They will be programmed to brighten in the morning, and then begin to dim in early afternoon, finally ending in near-total darkness in the evening. The cycle will operate on the basis of an Earth day to facilitate communications. Different schedules will be used for different seasons to increase psychological comfort for the residents – in the summer, the lights will brighten from 5 AM until 3 PM, then darken until 7 PM; in the fall, the lights will brighten from 6 AM until 2 PM, then darken until 6 PM; in the winter, the lights will brighten from 7 AM until 1 PM, then darken until 5 PM; and in the spring, the lights will again brighten from 6 AM until 2 PM, then darken until 6 PM. In between each season, one week‘s time will be used to make a smooth, slow transition to the next season‘s time schedule. At nighttime stars will be projected, and a projected moon will follow the phases of Earth‘s moon.

3.2.9 Commodity Contingency Plans

Although agricultural areas on Aynah will be carefully isolated from the remainder of the settlement to prevent any possible blight, we acknowledge the possibility of such a disaster on the settlement. As described in section 3.2.2, food sufficient for up to ten months will be stored in freeze dried form in food storage grids in the central axis. As soon as agricultural operations commence, this store will be built up; in addition, any surplus goods will be stored in food storage grids in communities in the event of a failure in the central axis.

Figure 3.2.4 Food Storage Grid

3.3 Settlement Construction and Machinery

3.3.1 Exterior Hull Assembly

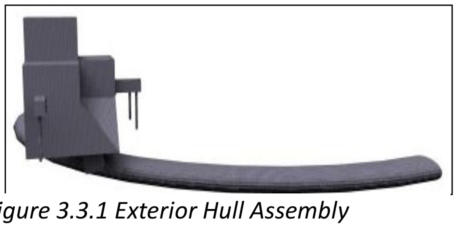


Figure 3.3.1 Exterior Hull Assembly

The hull will be assembled first in a skeletal structure to provide a foundation for the components to be added. Hull assembly robots will then travel along the structure and piece together the hull. Each hull assembly robot is specialized for a specific portion of the hull: one may add windows; one may add a regular hull exterior piece. Portions of the skeletal structure are encoded so that a hull assembly robot can read it with a laser and identify precisely what type of hull piece belongs there. Each hull assembly robot is stocked with a supply of the hull piece it is specialized for: for example, a window assembly robot would be stocked with 50 window pieces. The robot can drop and lock the piece onto the structure, moving on to make way for more robots. In total, there will be four layers applied in a series of staggered panels, to ensure rapid assembly and adequate protection. Gaps between panels will be filled with insulation, to add further redundancy.

3.3.2 Interior Building Assembly

Buildings will be constructed using a framework of identical, interlocking panels. This allows for both quick, stable construction of buildings, as well as easy replacement of panels in the case of damage. Buildings will be constructed in two stages. Firstly, the building's frame will be assembled. Panels will be interlocked to form walls, which will then be erected and interlocked to form a building. Then, other panels will be used to create floors, ceilings, and interior walls. Secondly, the building will be finished using a team of construction robots. For example, there will be separate robots for power, water, roofing and flooring, furniture, detailing, and other specialized needs. These robots can also be called for repairs in the event that they are required. Finally, gaps between each panel will either be filled for insulation or used as passages for electrical and communication systems. In the case of specialized buildings (i.e. research laboratories or manufacturing facilities), they will be built to the specifications of the customer.

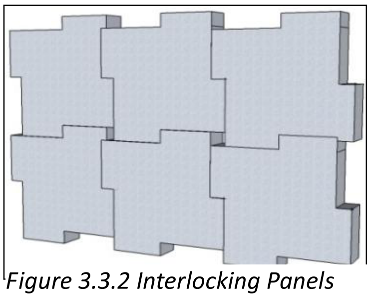


Figure 3.3.2 Interlocking Panels

3.3.3 Transportation Assembly

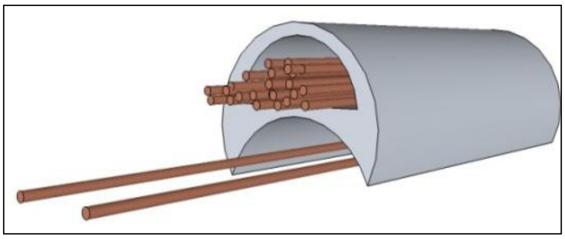


Figure 3.3.3 Rail Assembler

Railway systems in the settlement will be assembled by a machine. It will be stocked with a supply of rail segments and will lay them out along the appropriate pathway, and will have the capability of initiating the magnetic levitation system in the rails by inducing their magnetic polarity and alternating the polarity on each rail segment. Vehicles will be separately assembled and brought to the railway line once the rails are assembled.

3.4 Reardonium Production Power Supply

In order to meet the power requirements for the anticipated production of reardonium, approximately four square miles of solar panels will be included in the design of the solar powered satellites that will serve as the main power source of the settlement. This will be further supplemented by five Traveling Wave Reactors on the surface of Mercury.

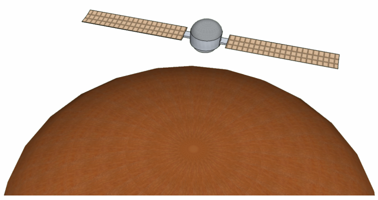


Figure 3.4.1 Solar Satellite

3.5 Reardonium Curing Processes

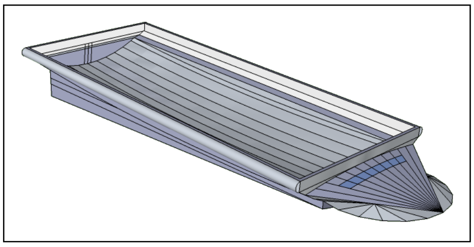


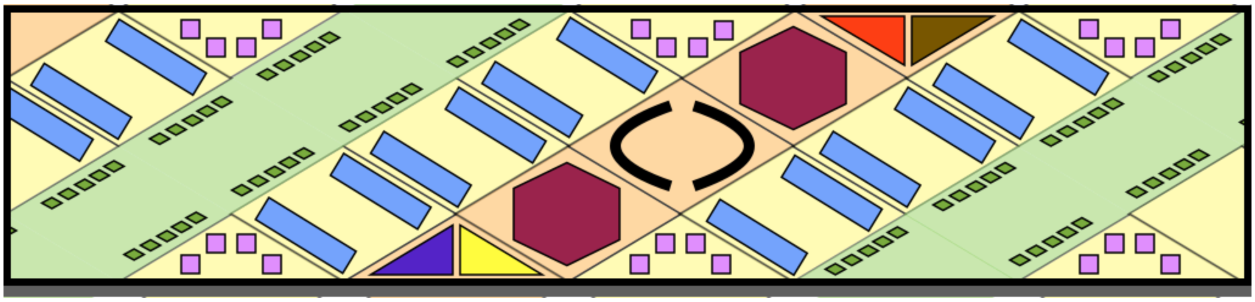
Figure 3.5.1 Reardonium Transportation Ship

For the curing process of reardonium parts, large flatbed cargo ships will be used to ferry the parts across the surface of Mercury. They will all be covered with an aluminum and reardonium shell to protect against radiation,with with three arms on the backside to load and unload parts. While each ship can be autonomous or operated remotely, a small cabin will be included with each truck for people to driver personally. To ensure the safety of drivers, they will be required to wear spacesuits while operating the vehicle. Five locations will be used for production of reardonium, each with a landing area for transportation ships, a Traveling Wave Reactor (See section 3.2.3), and a “garage” for vehicle storage. While not in use, the flatbed ships will be stored the “garage”, along with robots and vehicles for human transportation.

4.0

human factors

4.1.1 Community Design



100 m

6% Pathways

Community Design Key			
Shopping Center	Management (Security Center)	Series of "Dorm Designs"	Rural Region (Parks)
Stacked Interlocking Towers	Diamond House	Business Center (Office Towers)	Suburban Region
Hospital	Research Center	Crystal View Towers	Urban Region

Residential Torus:

Manufacturing Torus:

4.1.2. Psychological Effects

Table 4.1.2 offers psychological conditions that must be taken into account on the Aynah space settlement as well as acceptable measures of alleviating these conditions. As Aynah requires its residents to adjust to an entirely new environment in space, a primary goal of the settlement is to reduce the psychological stress associated with moving and adapting to a new environment. By designing our settlement with certain features aimed towards eliminating typical causes of psychological stress, the psychological conditions as indicated in the table are not expected to be experienced.

Table 4.1.2. Psychological Effects

<table>
<tr><th>Psychological Problem</th><th>Effects</th><th>Solution</th></tr>
<tr><td>Coriolis Effect</td><td>In a settlement where gravity is generated by a centrifugal force, the speed of the rotation can cause people's heads to spin and their vision to blur</td><td>- Create long diagonal lines of sight
- Along streets, ~ 350 meter line of sight
- Diagonal-grid pattern
- No abrupt turns
  - 30° angle turns are mitigated by transept streets</td></tr>
<tr><td>Solipsism</td><td>When the environment becomes too artificial or controlled, people no longer believe that they exist in reality; the present world seems to be a dream because events are either too predictable or the landscape is too artificial</td><td>- Long lines of sight, so that people view a landscape that is large and not controlled (large parks)
- Prominently display plants and parks into the design to show things that grow and change over time
- Horizon is lighted to appear larger</td></tr>
<tr><td rowspan="4">Cultural Blending</td><td>Aynah will be an international settlement; in order to make everyone comfortable, the settlements must satisfy various cultural trends</td><td>- Three different community areas (Rural, Suburban, Urban) that closely match the three defined communities that many psychologists believe people prefer

- People will be matched to a community based on their preference and psychological test results)</td></tr>
<tr><td>Individualistic and Isolationistic (Rural)
People within this community are independent and self-sufficient; they prefer a private living environment rather than a more social living environment in which basic facilities are shared</td><td>- Live in individual houses
- Have their own garden to grow plants, crops, etc.

- Diamond building
- Green area on map</td></tr>
<tr><td>Heterogenistic , Mutualistic and Symbiotic (Suburban)
People within this community believe in harmony and cooperation; each community is created with variety and many distinct elements are included in the community</td><td>- People within this community believe in harmony and cooperation and like to share basic facilities
- Community gardens and shared buildings plans

- "Dorm" building, shared living spaces
- Yellow area on map</td></tr>
<tr><td>Homogenistic and Hierarchal (Urban)
Everyone within this community shares similar beliefs and are of the same ethnicity; the community is divided into individual sections (housing in one section, industrial facilities in another, recreational facilities in another, etc.)</td><td>- The urban area places housing in certain blocks and businesses in the others

- Tower Design
- People with different jobs live on different floors so that they live near people with similar beliefs as them
- Orange area on map</td></tr>
</table>

4.1.3 Consumables

Table 4.1.3 provides expected yearly figures of consumables. The figures are susceptible to change in relation to demographic changes and the needs of Aynah's residents. These products will be mass produced on the settlement as well as imported from Earth and should be regularly available in general stores located on Aynah.

Table 4.1.3 Distribution of Consumables

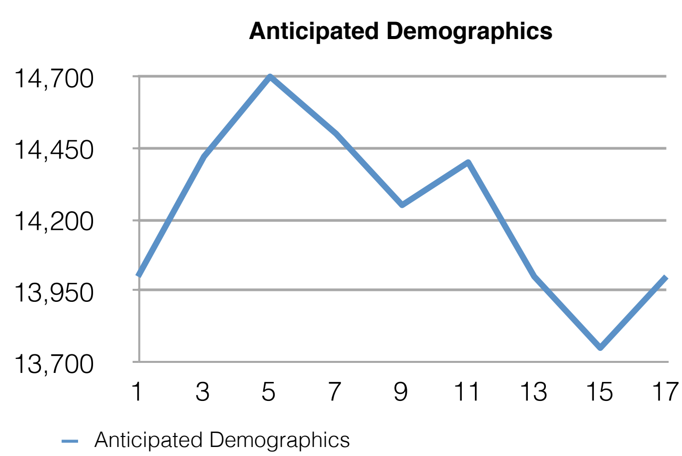
Consumable	Amount (R)**	Amount (T)**
Food	2,235,624 kg/yr	8,384 kg/yr
Water	54,983,600 kg/yr	785,480 kg/yr
Oxygen	2,682,750 kg/yr	9,581 kg/yr
Hygiene Products	613,200 kg/yr	2,190 kg/yr
Pharmaceuticals	51,100 kg/yr	182 kg/yr
Paper Products*	128,520 kg/yr	459.2 kg/yr
Clothing*	5,619 articles/yr	40 articles/yr
Shoes*	3,818 pairs/yr	40 pairs/yr
Electronics	34,364 items/yr	240 items/yr
Kitchen Appliances	2,075 items/yr	20 items/yr
Furniture	82,727 items/yr	638 items/yr
Research Materials	7,000 items/yr	25 items/yr

*** Figures may vary. Figures are estimate**
**** R - Residential (14000) ; T – Transient (200)**

4.2.1 Demographic Trends

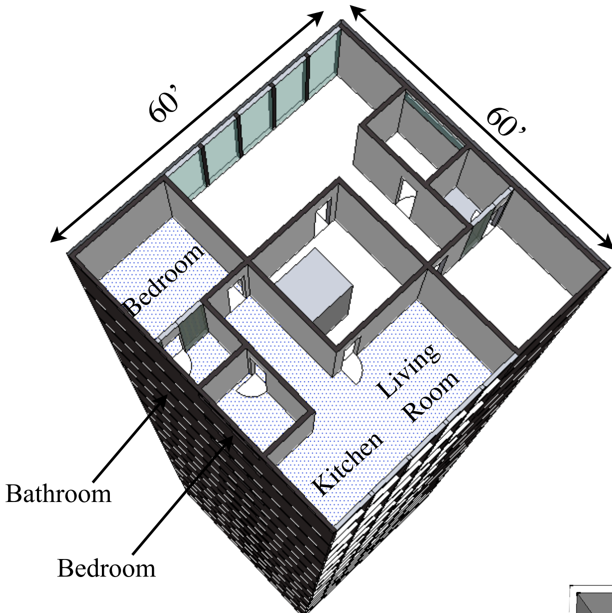
Expected demographic figures are illustrated in Table 4.2.1. All figures are rough estimates derived from the initial demographics provided in the RFP and adjusted according to a predictable population trend. The transient population was not factored within the graph. Based on the data from Table 4.2.1., Aynah will be built with flexible residences capable of accommodating a full-time population of around 14,000 people (±1000). The large dip is a result of the initial group of children leaving the settlement (at 18) to experience several years on Earth as part of their well-rounded education.

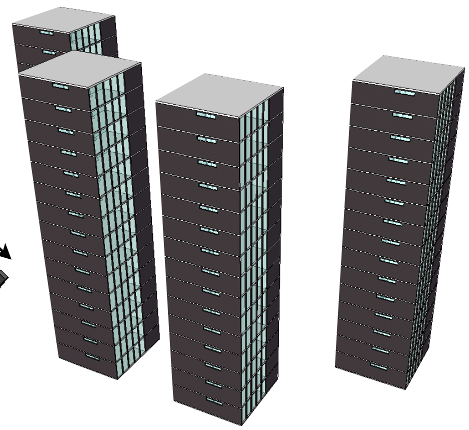
Table 4.2.1 Demographic Changes (year 0-17)



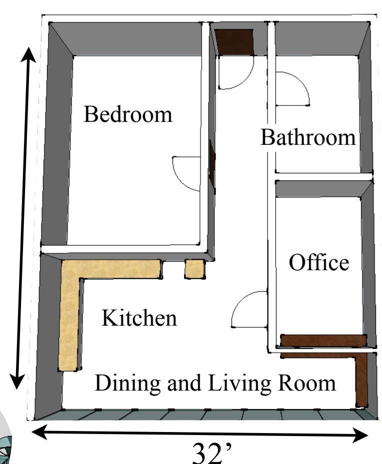
4.2.2 Housing Designs

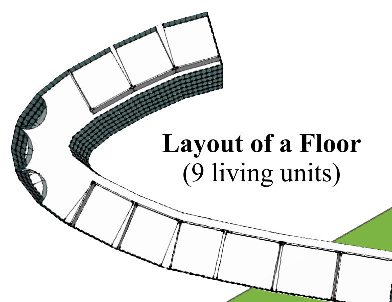
House Type	Residency Type	Average Square Feet	Number of Buildings Required	Number of People Housed
Diamond House	Couples, Family	2200	240	720
Stacked Interlocking Towers	Single, Couples, Family	1600	80	9600
Connected “Dorm” Units	Singles, Couples	2000	50	3200
Crystal View Towers	Singles, Couples, Family, Transient	1152	8	3240
				16,760



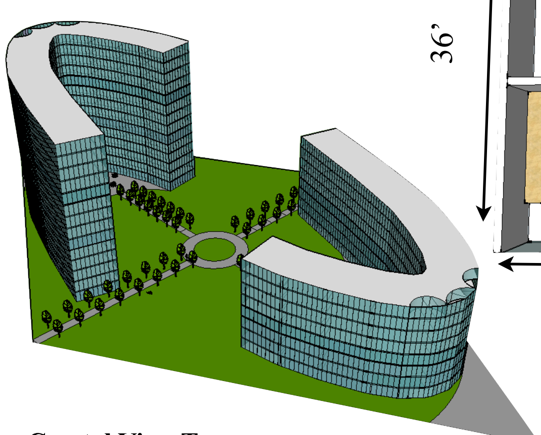


Stacked Interlocking Towers
These towers feature a central elevator and two “interlocked” houses per level. This residency is idea for urban singles, couples, and growing families and features two bedrooms and one large bathroom. The two different apartments (one in beige and the other in blue) interlock together on one floor. These houses feature large windows to provide maximum light into the home, thereby reducing energy requirements and providing a large view of the settlement..

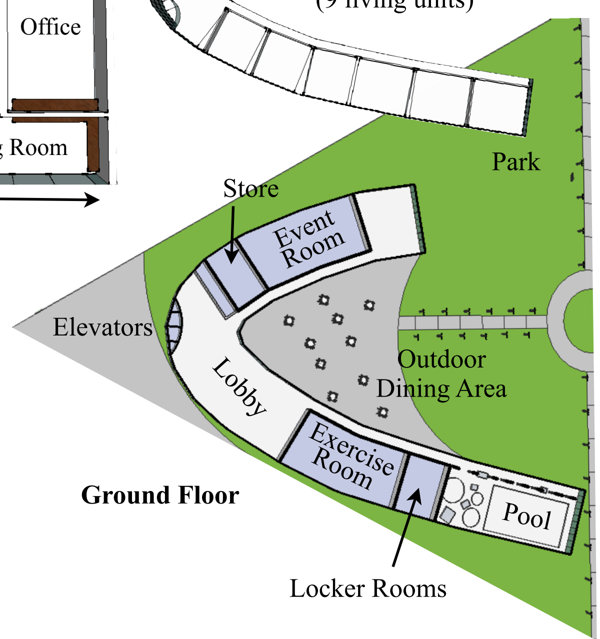




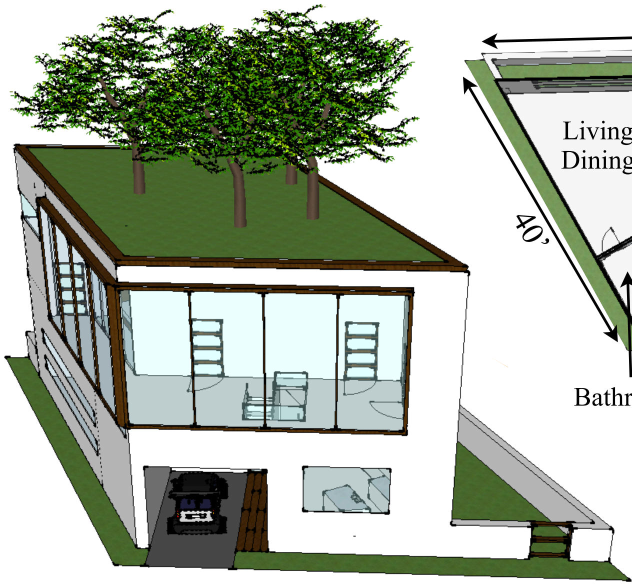
Layout of a Floor
(9 living units)

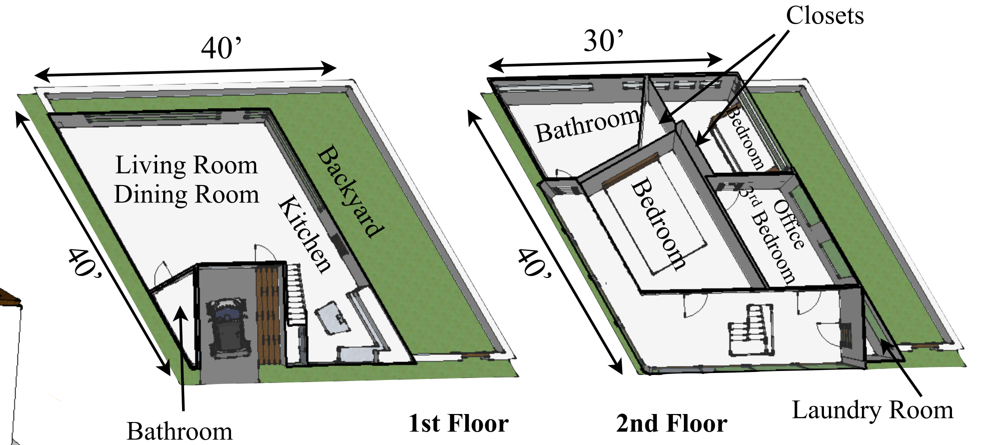


Crystal View Towers
These large towers are at the center of each community, serving as the heart of the urban centers. Each floor is prefabricated and can be stacked on top of each other with cranes and wielded with robots, thus reducing the costs of construction.



Ground Floor

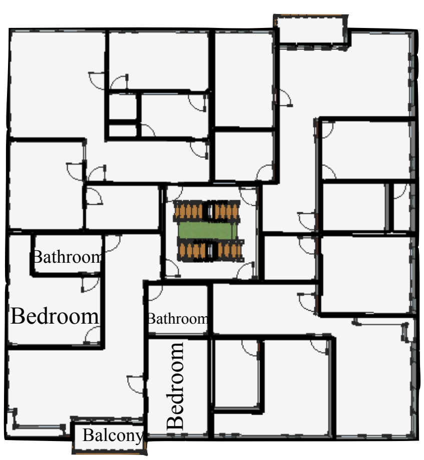




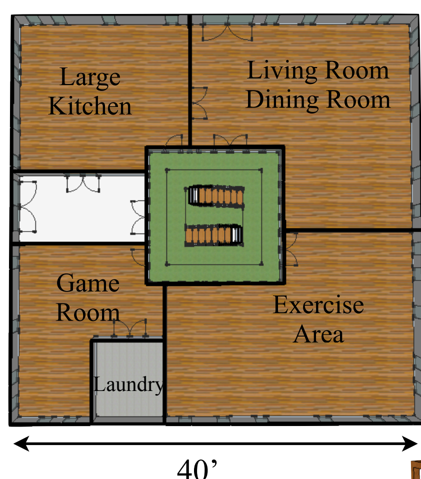
Diamond Houses
These individual homes are ideal for families, featuring our largest home size (2400 ft^2). These houses line the park areas, emphasizing the rural, individualistic theme that many of our residents desire.

Connected "Dorm" Units
This housing plan emphasizes communal spaces. It is ideal for single people and young families. Residents share a communal floor with 4 to 8 other people, while each person or couple has an individual second floor living space that is accessed through a locked door. *The building alternates between a communal floor and an individual living area, providing room for up to 24 people in one building.*

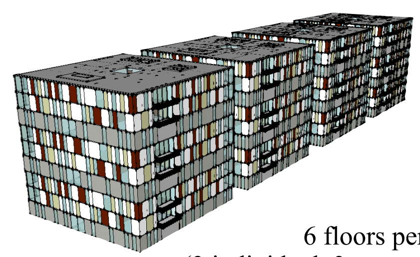
Individual Floor (4 locked living spaces)



Communal Floor



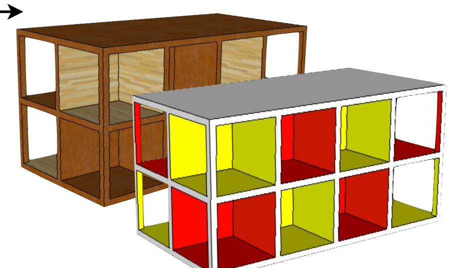
Each person/couple gets 2000 feet of space. 1600 communal, 400 private.



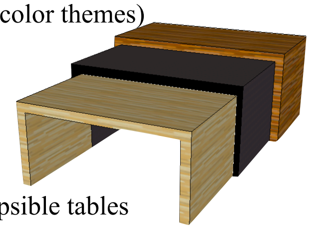
6 floors per unit
(3 individual, 3 communal)

4.2.3 Furniture

Furniture will be purchased from Earth in disassembled units. Residents will be able to select their furniture before arriving at Aynah from catalogues and these will be assembled in their homes upon their arrival. Later furniture demands can either be purchased from the colony's furniture store (featuring locally crafted furniture as well as Earth-manufactured pieces available upon request). *All furniture will conserve space, with collapsible portions, fold-outs, or multiple purposes.*

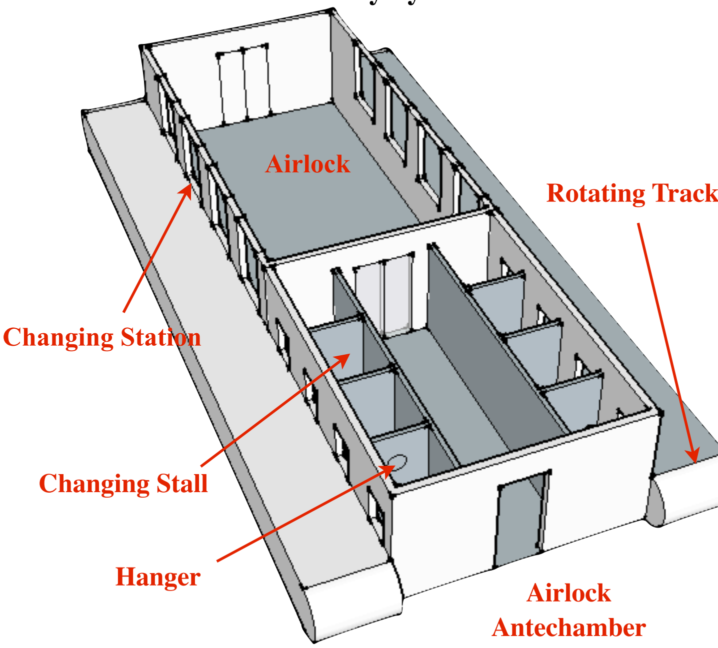


Storage unit and small table
(2 different color themes)



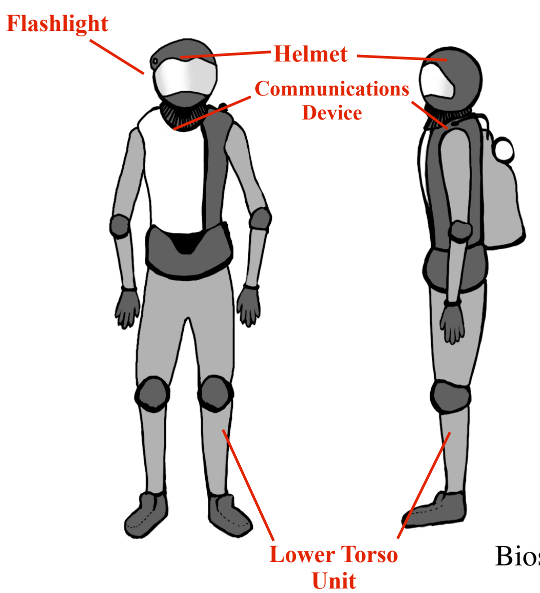
Collapsible tables

4.3.1 Airlock Safety System

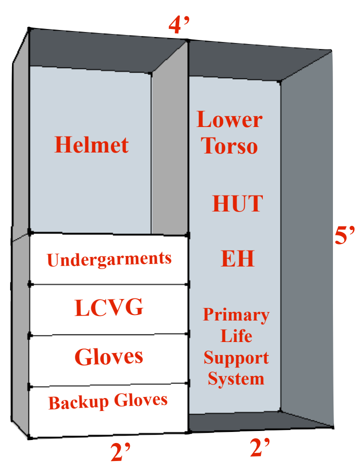


Spacewalkers will enter the Airlock Antechamber Changing Room. The first steps in donning the spacesuit will occur here. Lining the Airlock Antechamber are two rotating tracks. In each changing stall, there is a keypad in which the spacewalkers will type in their customized pin numbers. This activates the rotating track and brings the spacewalker's personal Spacesuit Storage Bin (SSB). The SSB arrives at the room, with only the drawers appearing in the window of the changing stall. Once the contents of the first two drawers are removed, the SSB moves to the next room and awaits the spacewalker at his or her corresponding changing station. The first room, the antechamber, contains eight changing stations and is depressurized to 70 kilopascals. After the first stages of the spacesuit donning procedure, spacewalkers enter the airlock. The remaining portion of the spacesuit is put on. Robots check the spacesuit for accurate donning, and once this is completed, the airlock is depressurized to 30 kilopascals. Once all air is removed, the suit is checked for leaks. If the suits pass inspection, then the outside hatch is opened.

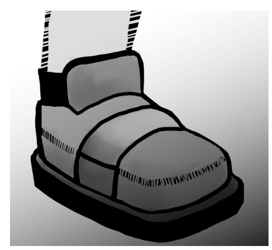
4.3.2 Other Safety Devices



Biosuit Design



Spacesuit Storage Bin



Magnetic footwear

To move between parts of the settlement, there will be human transportation capsules in the spokes (torus to axis) and the axis itself.

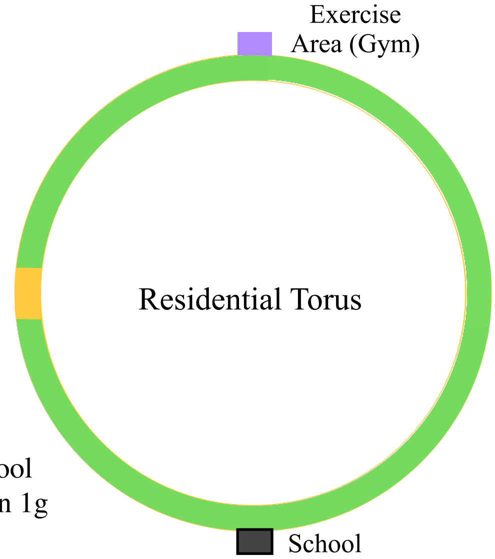
Humans will wear tethers when repairing the outside of the settlement and must communicate with the settlement at least twice every hour.

Foot rails will be present on all parts of the settlement, and all spacesuits will be equipped with magnets to prevent detachment from the outside of the settlement.

Spacesuit Storage

1. Enter the airlock and proceed to the changing station. Once the pressure is increased to 70 kilopascals, an alarm will sound.
2. Remove the outer gloves, helmet, and inner gloves and store in the suit storage bin's appropriate location.
3. A robot unlocks the closer rings between the Lower Torso and the Hard Upper Torso (HUT).
4. Deattach the Primary Life Support System from the Electrical Harness (EH) and the Liquid Cooling and Ventilation Garment (LCVG).
5. Remove the Primary Life Support System from the back of the HUT and hang in the bin.
6. Detach the EH from the HUT and place in the storage bin.
7. Hook the HUT on the hanger located on the wall. Once secured, the hanger will pull the HUT upwards. Slip out of the HUT.
8. Remove the in-suit drinking bag from the HUT.
9. Remove the Lower Torso and hang in the bin.
10. Exit the airlock and proceed to the Airlock Antechamber Changing Room.
11. Enter the assigned changing stall and remove the LCVG.
12. Remove the Urine Collection Device or Disposable Absorption and Containment Trunks.
13. Receive medical examination before leaving the changing stall.

4.4.1 School Location



The school school will be 150 meters below the "ground" of the rest of the settlement. This change in distance allows the school to be in 1g. Children, starting at age 4, will be expected to go to the school for 4 to 7 hours per school day, 5 days a week.

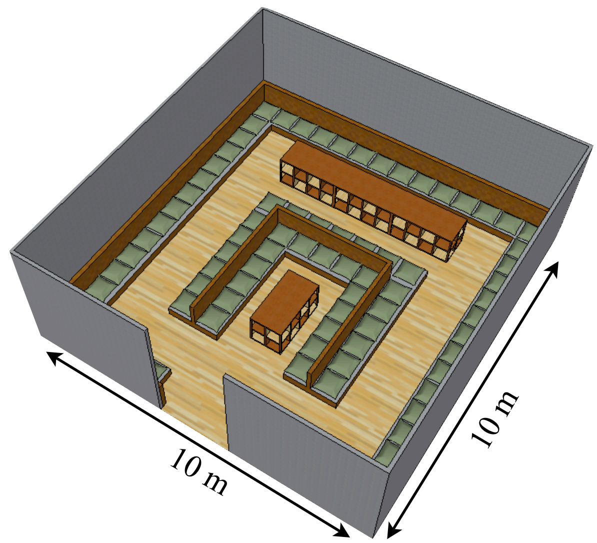
Parents will be encouraged to bring their children (under age 4) to the school's playground so that their children can be in 1g as they grow. On weekends, the playground will be opened up so children can exercise in 1g on those days as well.

To achieve balance, on the opposite side of the torus from the school will be an exercise area and people will be able to exercise there in 1g to maximize muscle development any day of the week.

4.4.2 Elevator Design

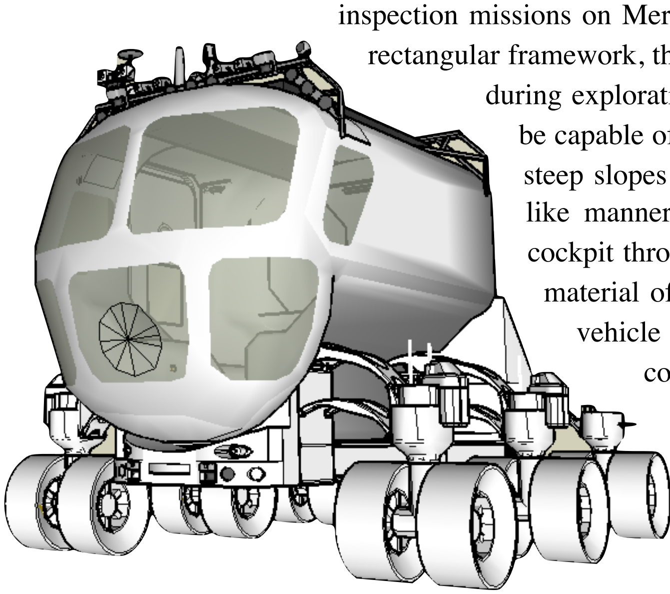
To transport the children to the school, there will be several trips down to the school area. Large elevators will run on shifts, carefully moving down 150 meters to the school area. These elevators are capable of moving 40 school children per trip.

Each elevator features storage compartments and individual seats. Students will fasten their seat belts before movement so that they are absolutely safe during their daily trip to and from school.



4.5.1 Mercury Exploration Vehicle

The Mercury Exploration Vehicle (MEV) will be the manned surface vehicle used for conducting inspection missions on Mercury. Designed with a pressurized cabin supported by a rectangular framework, the MEV is able to house two astronauts for up to 14 days during exploration missions. The wheels of the exploration vehicle will be capable of rotating 360 degrees, thus allowing the vehicle to climb steep slopes or maneuver through rocky terrain in a sideways, crab-like manner. In addition, the vehicle will provide windows in its cockpit through which astronauts will be able to observe the surface material of Mercury without leaving the cabin of the vehicle. The vehicle will also have suit-ports where spacesuits will be conveniently stored and astronauts can safely enter or exit the vehicle through airlock systems. If the astronauts wish to further study any surface material, the cabin is removable, thus allowing astronauts to carry heavy loads on the vehicle's frame.



automation
design +
services

5.0 Automation Design and Services

5.0.1 Types and Numbers of Computers

Name	Description	Specifications	Number
Turing (Personal Device)	This personal computing device provides organizational/productivity apps, a camera/camcorder, entertainment through games, and Internet access throughout the settlement in a handy, portable, tablet-like device.	50 GHz, 1 TB RAM, 5 PB SSD, 72 hr battery life	15000
Fermat (Business Computers)	These computers are used for more intense processing activities. They will be able to run more computer-intensive tasks, and there will be special business-oriented programs. They will be able to store more information, as they are meant for businesses.	125 GHz, 6 TB RAM, 80 PB SSD	2000
Pascal (Server)	Servers will be able to run all automated systems in the settlement automatically, everything from environmental control to keeping time will be controlled through the servers. Backup systems will be set up in some servers, as the servers are able to hold a significant amount of memory.	500 ExB, 100 petaflops	250
Babbage (Personal Computer)	This personal computer will be available in every household. The computer will be powerful enough to function as a gaming console, movie player, and control the systems in each house. The computer can also provide fast internet access around the settlement.	100 GHz, 4 TB RAM, 60 PB SSD	6000
Gauss (Virtual Reality System)	This simulator will be available in "Virtual Reality Cafes" which allow people to simulate business and research activities, as well as entertainment. Users will be immersed in semi-customizable environments, and they will be available for a small fee. Each cafe will be able to connect to the systems of the other Cafes.		40 Cafes, with 50 systems each

Table 5.0.1 Types and Numbers of Computers

5.0.2 User Hierarchy in System

Type of User	Description	Number
Network Administrator	These administrators overlook the systems around the settlement. They will have access to all systems, but will need permission to access certain systems such as the medical bots or confidential information.	7
Database Administrator	Database administrators manage the data and partition the data to increase efficiency in the systems.	15
Communications and Operation Managing Operators (COMO)	COMOs are each in charge of specific automated systems and ensure that there are no problems or errors in the systems. They keep the systems running smoothly, and are also in charge of communications infrastructure.	30
Computer Technicians	Computer Technicians are in charge of updating the system software. They ensure that the users' devices function properly.	200
Advanced User	Advanced Users can perform repairs on systems. They can both report and respond to problems encountered around the settlement. They can	40 Per Community

	access a central database, and override automated tasks, but only with permission.	
Basic User	Basic Users are average settlers, who use their accounts for entertainment, scheduling events, using the internet, communications, and other normal tasks. They can report any errors they find throughout systems in the settlement.	14000+

Table 5.0.2 User Hierarchy System

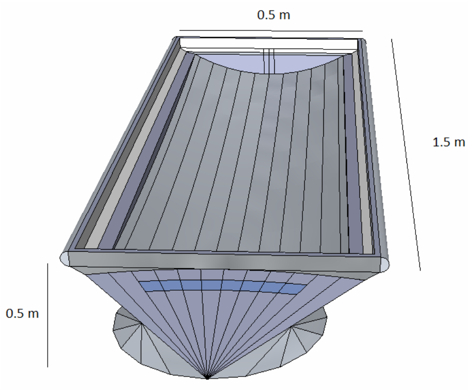


Figure 5.1.1: Leibniz

5.1 Construction

Construction on Aynah will be simple yet efficient due to our innovative robotic technology and construction methods. Our construction methods and robots are made so that they will be able to build both buildings and infrastructure quickly and efficiently. The way that the settlement will be built makes it easy for future maintenance and repair to be performed. There will be separate construction robots for interior and external construction. Because of our high-caliber robots, construction can proceed with minimal delay and human error.

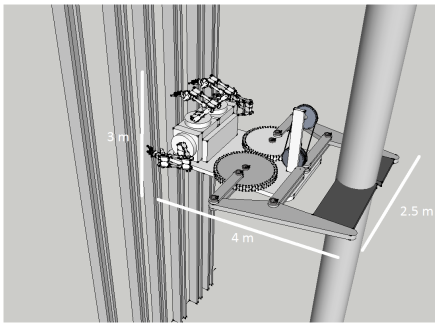


Figure 5.1.2: Descartes

Our main construction robots, the versatile Descartes, are armed with omnitools. Measuring 3m x 4 m x 2.5 m, Descartes have omnitools allow them to construct buildings by welding, bolting, etc. The Descartes have legs that will help adhere to the surfaces that they are building on for balance.

5.1.1 Types of Construction Robots

Robot Type	Description	Dimensions
escartes (External onstruction/Repair)	Armed with omnitools on 3 of their 8 legs and adhesive suction cups on their 5 other legs, they are suitable for construction on almost any surface.	H: 3m L: 4m W: 2.5m
Leibniz (Transport Robot)	These robots with adjustable dimensions will be used to transport materials. The robots are constructed of a strong steel hull, and use wheels for transportation. They will be able to be programmed to travel from one location to another, and they have a load of 250 to 750 kg.	Differs depending on the material carried
uler (Design Robot)	These robots are used to design and remodel rooms. They can be requested by settlers to change the look of the room. While there are pre-set schemes in the colors of the walls, the layout of the furniture, etc., the rooms can also be custom-made by the settlers themselves.	H: 1.5m L: .4m W: .5m
Bernoulli (Interior Repair/Construction Bots)	These robots will be built to be able to perform careful repairs and installations of furniture, household appliances, and also interior infrastructure such as water lines.	H: 1 m L: .5 m W: .5 m
Euclid (Electricity Repair/Construction Bots)	The power grid of the settlement will be maintained and constructed by these robots. They contain gauges to detect power shortages or surges, insulation to protect any frayed/loose wiring,	H: .2 m L: 2 m W: .2 m

	and the necessary tools to remove faulty wiring and install new wiring.	

5.2 Maintenance, Repair, and Security

Aynah's state of the art computer mainframe ensures Aynah runs at maximum efficiency at all times. Investors and citizens can live in peace and security knowing everything is as it should be. Automatic measures are implemented to protect Aynah and ensure the safety of the residents. Easy to remember disaster plans keep residents ready to keep themselves safe during emergencies.

5.2.1 Maintenance

Maintenance of Aynah is automatically taken care of by Aynah’s central computer. Routine tasks are scheduled in advance but can be changed as necessary. Descartes can be called in to repair or construct anything necessary on the settlement. All robots are encased in a thin but strong layer of protective reardonium to prevent damage and heat dissipation.

5.2.2 Contingency Plans

To ensure the safety of all of Aynah’s inhabitants, many automated response systems have been set up for possible disasters.

Emergency Types	**Security Measures**
Fires	Gas detectors will identify the class of fire Class A: Sprinklers will turn on Class B, C, D, and K: CO2 extinguishers will be activated until humans in area are evacuated. When evacuation is finished, O2 is shut off for the area, and bicarbonate dust is scattered to put out the fire. Specialized fire-fighting robots can be dispatched to fires. They will be able to assess the magnitude of the fire and take the proper precautions to minimize damage.
Solar Flares	All robots that are expected to experience solar radiation (such as surface robots) will be outfitted with alternating layers of reardonium, aluminum, and insulating foam instead of a thin layer of reardonium in order to create a Faraday cage and protect the inner electronics. The thickness of the layer will be greater than the skin depth, thus preventing the skin effect and ensuring that the robot is insulated.
Floods	Automatic sensors will detect floods and leaks and close off affected sectors. Robots will be deployed to pump out the water and check radiation levels.
Computer Server Failure	There are multiple backup generators located throughout the settlement which will be able to continue vital operations in the settlement. Servers will be backed up multiple times and saved in different locations throughout the settlement and saved in a server stored on Earth. They are activated automatically should the central server fail.
Rogue Personnel	Security bots and cameras identify, isolate, and remove suspects using non-lethal means to be interrogated later by appropriate personnel.
Hull Damage	External repair bots will be sent outside to survey damage and fix if necessary. In case of serious damage, sections can be cordoned off and quarantined.
Disease (Epidemic)	Infected individuals will be quarantined and treated appropriately. Chung will be able to provide early warning signs of the disease and isolate most of the contaminated inhabitants early.

Table 5.2.2 Contingency Plans

To ensure all inhabitants know what to do in case of emergency, mandatory safety drills will occur twice a year simulating disasters. All visitors will be given booklet with directions on emergency procedures prior to entering Aynah.

5.2.3 Security

To maintain the security of the settlement, many measures have been implemented. Each backup generator located in the settlement will require three COMO security verifications to activate manually.

Each settler is assigned a name and required to have a password of a mininum of 16 digits consisting of letters, numbers, and symbols. All Advanced Users and above will require fingerprint identification and pattern in a 5x5 matrix.

Settlers will have free access to areas in the computer network that pertain to their jobs but will require approval to access other sections. Construction and remodeling projects can also be requested but must be approved by administrators before completion.

5.3 Ease of Living

Aynah's settlers need not worry about many of the mundane tasks we are used to here on Earth, because we have designed multiple systems for automating household chores and other everyday tasks. Not only will the settlers have a great environment at home and in the workplace, but they will also be able to enjoy many forms of entertainment.

5.3.1 Automation for Routine Tasks and Maintenance

Menial tasks such as vacuuming, getting the groceries, cooking, or refilling prescriptions are no longer a problem thanks to our assortment of robots. The cleaning robots are scheduled by the settlers themselves to straighten up the residences. With their built-in cleaning systems, these robots do a thorough job of making a more habitable and organized environment for settlers.

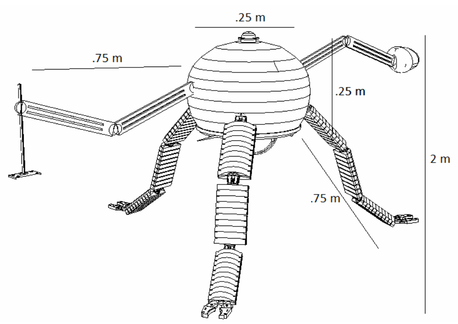


Figure 5.3.1 Reimann

In addition, Godel butler-bots are available for the settlers to order a meal from a menu. Food is fetched from a central kitchen, and in lieu of a pre-cooked meal, settlers can also request ingredients to cook their own food if they wish.

Healthcare on the settlement will be convenient. After a checkup, doctors can program our Kepler nurse-bots to issue medicine, check the vital systems for any problems, and attempt to diagnose patients for problems. To prevent any medical equipment or medicine to get in the hands of the wrong people, doctors will be able to securely program the Kepler with encryption to prevent hacking or other abuses. Special Kepler systems will also be present to assist the elderly or disabled, reminding them to take their medicine, help them in emergencies, and perform simple tasks.

Newton is a robot which acts as an assistant/runner for businesses and laboratories. Newton will be able to deliver goods, retrieve materials, refill supplies, and other simple tasks around the average office. In labs, Newton acts as a lab assistant with its simplified omnitool, which acts as more of a holder/hand rather than a tool. This allows Newton to handle more dangerous materials, minimizing potential hazards for the settlers.

5.3.1 Types of Maintenance and Assistance Robots

Robot Type	Description	Dimensions
Reimann (Cleaning Robots)	Reimann cleaning robots are programmable using the personal computer as well as the personal device. They can be scheduled to clean the living spaces at times convenient for the settlers. Cleaning robots have built in vacuums, furniture polishers, sanitizers, and other necessary tools for tidying up the settlement. The legs on the Reimann have expanding arms that are also vacuums.	H: 2 m L: 1 m W: 1 m
Godel (Butler-Bots)	Godel butler-bots can be requested at any time of the day. Settlers set a schedule of their breakfast, lunch, and dinner, and the Butler-Bots are sent to their room at those times. Settlers can request either an already-cooked meal from a central kitchen, or raw produce if settlers prefer to cook themselves. Butler-Bots also	H: 1 m L: .5 m W: .5 m

	collect dirty dishes and send them back to the central kitchen for cleaning.	
Kepler (Nurse-Bots)	With the Kepler, doctors can securely program "Nurse-Bots" for settlers to give and refill proper amounts of medicine. Doctors will also have robots and other automated systems that can get the temperature of a patient, check their vitals, and report important information back to the doctors. All healthcare robots will be outfitted with anti-bacterial coverings.	H: 1.5 m L: .3 m W: .3 m
Newton (Business/Work Assistant)	Newton drones will be available for businesses to carry out typical tasks, such as acting as a messenger to deliver hard-copies of reports. They will also be able to help in labs as well, handling potentially dangerous materials with a specially-modified omnitool meant for carrying items.	H: 1.5 m L: .5 m W: .5 m

Table 5.3.1 Types of Maintenance and Assistance Robots

5.3.2 Entertainment

As part of the entertainment systems on Aynah, all settlers are given Turing, personal devices with both games and productivity apps. Not only will settlers be able to use these apps in this portable, easy-to-use device, but they will also have internet connection all over the settlement. This means that they can schedule and control different systems, such as the cleaning robots. In the residences of settlers, there will be Babbage, personal computers which are powerful enough to run intensive games, play movies, and can also control the systems in the settlers' residences. They too have internet access.

Exercise centers provided to the settlers are extremely high-tech. The centers are outfitted with the most advanced training equipment, a gym, and also indoor basketball courts and tracks. Settlers will also be able to get suggestions for customizable training regimens using these advanced systems.

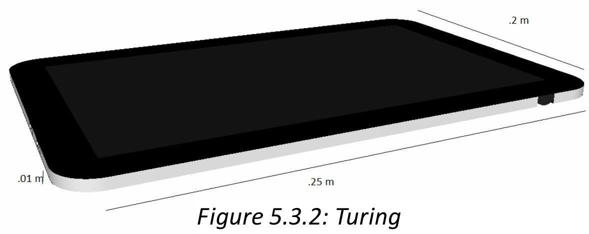


Figure 5.3.2: Turing

A Smart Wall is an optional addition to the living rooms of the settlers' residences. The Smart Wall is essentially a giant tablet which can project movies and games, display different scenery, or show different widgets, including ones for news and daily events around the settlement.

A major source of entertainment comes in the form of the Virtual Reality Cafes. These cafes include highly sophisticated simulators, capable of running simulations for both business and entertainment needs. These include role-playing games, researching experiments, and much more. These semi-customizable environments will be available for a small fee, and each system is linked with all the other systems across all cafes in the settlement.

5.3.3 Automation for Businesses and Networking

In Aynah, businesses will be provided with Fermat, business-specific computers. These computers are even more powerful than the normal personal computers, and they include business-specific programs such as spreadsheet programs and word processors. With a significant amount of storage, they are perfect for the business environment.

The Pascal server system automates the majority of the systems around the settlement. Not only will they serve to automate different processes, but they will also back up vital information and transmit it to several locations on Earth in case of a catastrophe.

Aynah will solve privacy problems by issuing settler-specific ID cards linked to a similarly settler-specific account. The network infrastructure will be set up so that people will be able to connect to all parts of the settlement at any time for the convenience of workers that need to control robots/systems. However, security systems (such as encryption) will be set up to ensure that the accounts are only used by the settler, and that the account has the necessary permissions to control a system. The simplest systems include a fingerprint and password check, but for more security-sensitive accounts, there will be more security systems, such as a personalized pattern or an eye scanner.

Aynah will also provide quick networking not only within the settlement, but with Earth. Inside the settlement, fiber-optic cables allow for extremely fast connections, and the wireless connections are also rapid. These advanced networking systems allow the transfer of data to be extremely efficient. During downtimes, the servers are updated with a cache of frequently used websites for quicker access. Dedicated servers and systems will be set up for time-sensitive and extremely important information when such information is necessary to be sent to Earth. Although lag-time issues may not be completely gone on the settlement, the networking systems are set up to minimize this problem.

5.4 Efficiency of Reardonium Manufacturing

Aynah's advanced computer system and ingenious use of automated technology ensures the manufacturing and handling of reardonium is efficient and easy. Thanks to the dedication and hard work of Aynah and Northdonning Heedwell leaders, reardonium can be used as a source of income for Aynah's residents for years to come.

Reardonium ore is automatically unloaded by Descartes onto Leibniz. Leibniz transports the ore to Aynah’s refining centers. Ore is then automatically placed into the refining center by Descartes. The ore is refined using an assembly line, ore passes through step by step until the ore has been formed into usable parts. After the ore is ready to be cured, it is placed back into Leibniz by Descartes and tranported back Aynah’s docks to be sent to Mercury for curing.

5.5 Handling Reardonium Parts on Mercury

Numerous mobile Terran Mining Systems (TMS) will handle all mining operations on the Mercurian surface and transport the ore to centralized storage areas (Raynor) located throughout the Mercurian surface. The TMS consists of subunits of individual MinerPro Robots and a central Nexus mothercraft - each subunit is protected from solar flares and Mercurian dust with a titanium and aluminium alloy exterior, and will be remotely controlled by an automatic server on Aynah. The Nexus mothercraft will transport MinerPro robots from Raynor to previously determined mining locations, send out MinerPro robots for mining, and receive the mined ore to transport it back to Raynor. The MinerPro will mine and extract ore required for the production of reardonium. Electromagnetic imaging probes located on each of the solar power satellites (SPS) on the Volt Power System will discover areas with high amounts of ore on the surface. The MinerPro will further employ their Thermal Evolved Gas Analyzer to further detect areas of high ore concentration and mine them. Each MinerPro contains a carbon nanowire battery, able to power the robot continuously for 48 hours. The MinerPro will drill through the surface, use vacuum suction to collect loose debris, and distinguish usable ore from waste materials using microwave mass spectrometer sensors (MMS). Desirable ore will be stored inside the MinerPro, and once storage is full, the MinerPro will travel back to the Nexus mothercraft and deposit its ore. This process will repeat until the Nexus mothercraft cannot store any ore. Having been filled, the Nexus mothercraft will travel to Raynor to deposit the ore within the warehouse. In a normal mining operation, each Terran Mining System will be able to mine and transport a total of two metric tons of ore in 36 hours.

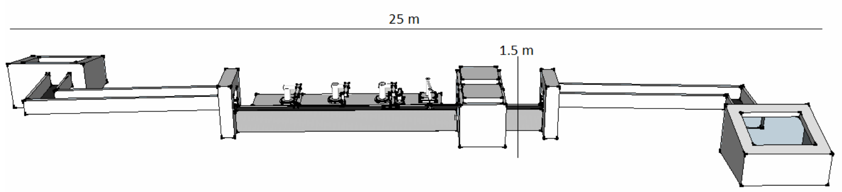


Figure 5.5.1: Assembly Line

Stored ore will wait for approximately 12 hours at Raynor until it is transported onto Nova cargo ships bound for the settlement. Raynor contains several warehouses for storage of ore and repair facilities for non-operational components of the TMS - these robots will be repaired by both humans and repair robots. Each Nova cargo ship is able to transport twenty metric tons of ore to and from Raynor and Aynah in a round trip journey of approximately 6 hours. Nova cargo ships will be outfitted with a thick layers of aluminum and reardonium, separated by strips of insulation in order to prevent damage from solar flares. The thickness of the hull will be greater than that of the skin depth, thus preventing the skin effect and establishing a Faraday Shield to protect the Nova’s inner electronics. This will allow the cargo ship to assume a “Safe Configuration” when the sun becomes increasingly active in its electromagnetic impulse activities. The Nova will be piloted by computers that have advanced navigational systems that will allow the ship to navigate through space. There will be a small cockpit for a human pilot in case of computer malfunctions. The exterior of the Nova will be coated with special solar cells that utilize singlet exciton fission to gather more energy from the sun. The solar cells will be linked to lithium ion batteries that will store electricity and supply energy during nighttime.

Nova will dock in the settlement, where the raw ore will be unloaded off the ship, refined, cast into parts, and loaded back onto cargo ships for curing on the Mercurian surface. These processes will be done in an assembly line fashion, which will significantly improve the production and cost efficiency of reardonium production on Aynah. Raw ore will be transferred from the cargo ships to large containers that will feed into a complex network of assembly lines. These assembly lines will all eventually lead to the central Hades Smelting Furnace, where various combinations of extremely high heat and pressure will create and isolate different varieties of unrefined molten reardonium alloys. Molten reardonium alloy will be initially poured into titanium-steel alloy molds to be shaped into 1 metric ton ingots. Ingots will be moved by conveyor belt to a storage area inside Aynah until further processing of the reardonium alloy is necessary. Human inspectors will then visually inspect reardonium ingots, and take random samples from each batch in order to ensure the highest possible quality and consistency between each batch. Approximately 4 hours will elapse between the raw ore being unloaded off of Nova and ingots being transported to a storage area inside Aynah and product testing.

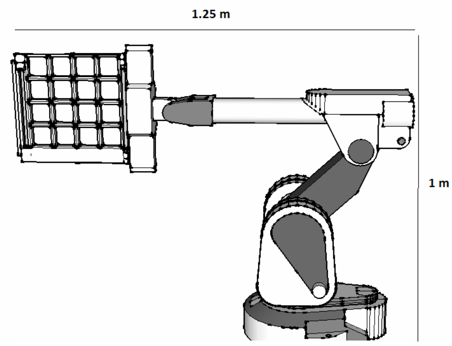


Figure 5.5.2: Raine Curing System

Constructed reardonium parts will be transferred onto conveyor belts leading to the Nova cargo ship, where they will be transported back to the Mercurian surface in a journey of approximately 3 hours. Nova cargo ships will transport constructed and processed parts to a centralized storage area (Kerrigan). Kerrigan will store uncured processed parts as well as cured processed parts, and also contain repair facilities for inoperable robots. Constructed and processed parts will wait in storage for up to two weeks in order to adjust to Mercurian conditions, and then will be loaded onto the computerized and robotic Raine Transport/Curing Systems (RTCS), which will automatically shuttle parts to and from various locations in Mercury in order to acquire desired curing properties. Each RTCS will receive a previously determined itinerary from a remote computer server for the curing of the loaded reardonium parts. The RTCS contains three extendable robot arms for automatic loading of reardonium parts, and is powered by ultra-efficient photovoltaic cells coated on the exterior of the RTCS. Excess power will be stored in lithium ion batteries. The RTCS further is covered with a reardonium/aluminium/titanium alloy for protection from both radiation and extreme temperature variations. Curing of the reardonium parts will take approximately one year, depending on the specific reardonium part being cured. Once the curing process is complete, the RTCS will transport the cured parts back to Kerrigan for storage (a wait of up to three days) until Nova cargo ships will transport cured parts back to Aynah in a journey of approximately 3 hours.

Completed reardonium products will be loaded off of Nova cargo ships through assembly lines into another centralized storage area, where shipping details and specification will be worked out by both humans and computer systems. Reardonium products will be packaged and then loaded into commercial transport spacecraft, and delivered to customers.

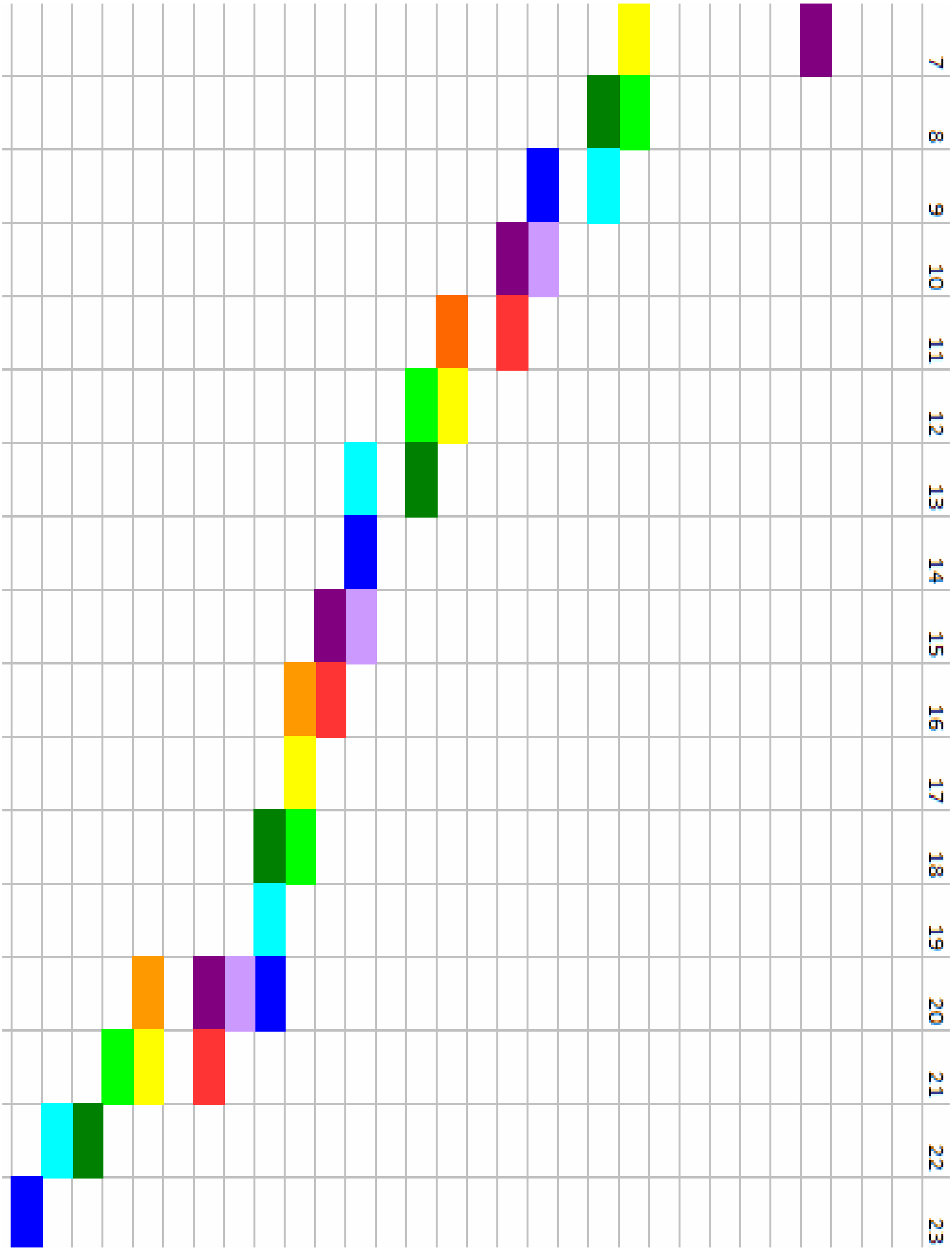
6.0

Schedule + Cost

6.0 Costs and Scheduling

6.1 Schedule

Years After 8 May 2077	Workers	Approximate Cost (USD)	1	2	3	4	5	6
Phase 1		$46,335,758,700						
Research & Development	200							
Approval by Foundation Society	N/A			December 2078				
Robot & Subsystem Development	250							
Central Command systems set up	150							
Communications systems set up	50							
Volt Satellite System constructed	80							
Martel Central Axis constructed	200							
Phase 2		$15,445,252,900						
Kratos I and II Manufacturing System constructe	200							
Manufacturing Operations begin	50							
Phase 3		$30,890,505,800						
Genis I and II Port Facilities Constructed	200							
Ports commence operation	50							
Phase 4		$15,445,252,900						
Reardonium Refining Spokes constructed	150							
Reardonium Manufacturing commences	50							
Phase 5		$30,890,505,800						
Spokes for Tori constructed	80							
Phase 6		$46,335,758,700						
Irving I and II Constructed	150							
Interior finishing in Irving I and II	Robotic							
Establishment of Atmosphere	N/A							
Transportation set up	50							
Phase 7		$30,890,505,800						
Debugging and Final System Tests	50							
Tori Rotation Commences	N/A							
Foundation Society welcomed	N/A							
All other colonists welcomed	N/A							
Full population welcomed	N/A							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6.2 Costs

Technology	Cost	Quantity	Total Cost	Annual Upkeep
uPad (Personal Device)	$1,300	15000	$19,500,000	$540,000
Business Computers	$2,000	2000	$4,000,000	$210,000
Servers	$20,000	250	$5,000,000	$200,000
Personal Computers	$800	6000	$4,800,000	$240,000
Virtual Reality Systems	$41,000	2000	$82,000,000	$8,200,000
Network Administrators	$43,000	7	$301,000	$92,000
Database Administrations	$37,000	15	$555,000	$150,000
Operations Administrators	$35,000	30	$1,050,000	$240,000
Advanced Users	$50,000	160	$8,000,000	$1,230,000
Basic Users	$26,000	14000	$364,000,000	$24,200,000
Octobots	$540,000	5000	$2,700,000,000	$138,000,000
Robox	$400,000	3000	$1,200,000,000	$78,000,000
Desi-Bots	$450,000	3000	$1,350,000,000	$81,000,000
Interior Construction Robots	$520,000	3000	$1,560,000,000	$96,000,000
Electricity Construction Robots	$480,000	3000	$1,440,000,000	$84,000,000
Cleaning Robots	$450	3000	$1,350,000	$70,313
Butler-Bots	$10,000	2000	$20,000,000	$2,400,000
Nurse-Bots	$15,000	2000	$30,000,000	$2,100,000
Grumios	$40,000	2000	$80,000,000	$8,000,000
Development			$350,000,000	
TOTAL			$9,220,556,000	$524,872,313

Transportation	Cost	Quantity	Total Cost	Annual Upkeep
Interorbital Shuttles	$3,120,000	24	$74,880,000	$6,760,000
Landing Shuttles	$2,980,000	24	$71,520,000	$7,161,600
Overhead Crane Systems	$1,250,000	2	$2,500,000	$203,000
Commercial Spacecraft	$2,160,000	20	$43,200,000	$4,620,000
SageCraft	$1,600,000	15	$24,000,000	$3,005,000
Tenebrae Rocket Propulsion System	$1,760,000	12	$21,120,000	$2,138,800
Zelos Transport Vehicle	$1,430,000	12	$17,160,000	$2,324,200
TOTAL			$254,380,000	$26,212,600

Annual Wages	Wages	Number Employed	Total Cost
Teachers	$35,000	30	$1,050,000
Technicians	$165,000	1300	$214,500,000
Researchers	$120,000	120	$14,400,000
Industrial Workers	$80,000	7900	$632,000,000
Doctors	$150,000	150	$22,500,000
Commercial Workers	$90,000	8200	$738,000,000
Government Officials	$120,000	650	$78,000,000
Security Personnel	$57,500	200	$11,500,000
Planner	$200,000	60	$12,000,000
TOTAL			$1,723,950,000

Communication	Cost	Quantity	Total Cost	Annual Upkeep
Fiber Optic Cables	$15	375000	$5,625,000	$112,500
Lasers	$6,000	15	$90,000	$4,500
Intercom	$5,000	1	$5,000	$350
Wireless LAN	$550	250	$137,500	$6,875
Satellites	$1,050,000	5	$5,250,000	$682,500
Development			$1,500,000	
TOTAL			$12,607,500	$806,725

Materials	Cost	Quantity	Total Cost	Annual Upkeep
Nitrogen (m^3)	$60	471267000	$28,276,020,000	$0
Oxygen (m^3)	$0.30	407385000	$122,215,500	$0
Carbon Dioxide (m^3)	$0.01	7155000	$71,550	$0
Water (m^3)	$15	540	$8,100	$810
Demron Cloth (m^2)	$300	25000000	$7,500,000,000	$300,000,000
Silica Aerogel (m^2)	$6	1250000000	$7,500,000,000	$300,000,000
Polyethylene Foam (m^3)	$324	75000000	$24,300,000,000	$972,000,000
6061-T6 Aluminum Alloy (kg)	$12.70	1000000000	$12,700,000,000	$508,000,000
Steel Alloy Grade 18KhGNMFR (kg)	$15.64	750000000	$11,730,000,000	$462,000,000
Uraniuam 235/238 (kg)	$69.76	300000	$20,928,000	$5,840,000
Raguard (m^2)	$350	12500000	$4,375,000,000	$246,000,000
Ring Motor	$100	2	$200	$1,000
Steel Cargo Box	$125	350000	$43,750,000	$2,500,000
TOTAL			$96,567,993,350	$2,796,341,810

Landscaping	Cost	Quantity	Total Cost	Annual Upkeep
Trees	$10	10000	$100,000	$2,000
Grass (m^2)	$8	250000	$2,000,000	$2,000
Packed Soil (m^3)	$2	1187313	$2,374,626.82	$1,600
TOTAL			$4,474,626.82	$5,600

Housing	Cost	Quantity	Total Cost	Annual Upkeep
Diamond Houses	$3,205,000	240	$769,200,000	$291,898,688
Stacked Interlocking Towers	$2,714,000	80	$217,120,000	$97,298,625
Connected Dorm Units	$2,221,000	50	$111,050,000	$85,135,575
Crystal View Towers	$3,942,000	8	$31,536,000	$33,680,438
School	$800,000	1	$800,000	$469,333
Parks	$750,000	6	$4,500,000	$2,235,750
Community Centers	$1,350,000	3	$4,050,000	$1,842,750
Research Facilities	$2,720,000	4	$10,880,000	$2,800,525
Offices	$2,540,000	4	$10,160,000	$2,705,275
Library	$2,150,000	1	$2,150,000	$928,000
Entertainment Centers	$2,980,000	8	$23,840,000	$6,204,100
TOTAL			$1,185,286,000	$525,199,058

Construction Costs	Total Cost	Total Annual Costs
Technology	$9,220,556,000	$524,872,313
Transportation	$254,380,000	$26,212,600
Wages	$12,000,000	$1,711,950,000
Communication	$12,607,500	$806,725
Materials	$96,567,993,350	$2,796,341,810
Landscaping	$4,474,626.82	$5,600
Housing	$1,185,286,000	$525,199,058
Transportation Costs	$108,976,243,129	$5,253,359,230
TOTAL	$216,233,540,605.82	$10,838,747,336

Annual Revenue	Total Income
Tourism	$1,188,535,000
Recreation	$823,504,000
Hotels	$860,010,000
Net Trade Revenue	$8,041,477,000
Manufacturing	$10,201,290,000
Private Contracting & Advertising	$193,214,000
TOTAL	$21,308,030,000

Amount of Time to Break Even

216233540605.82 + 10838747336x = 21308030000x

216233540605.82 = 10469282660x

x = 20.654 years

21 years to break even

7.0

business development

7.0 Business Development

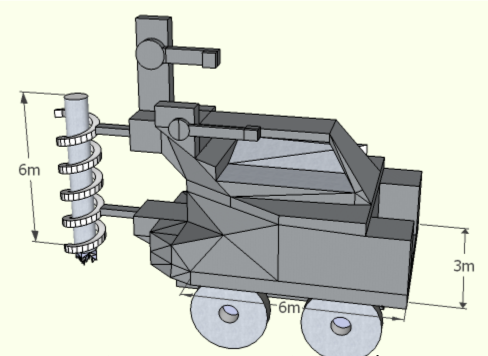

Figure 7.1.1 Ore Mining Robot

7.1.1 Production of Reardonium

Raw ore that is collected from the surface of Mercury will be sent to a base unit, where programmed robots will separate the minerals based on their composition. The base unit will be composed of various compartments. The raw ore will be collected at the front of the unit; robots will then work to analyze and separate the minerals. Depending on the type of mineral, the rocks will be placed on a given conveyer belt, where they will be crushed into a fine powder before being delivered to a designated slot. The minerals will be divided into containers, where they can conveniently be packaged and later delivered to various settlements.

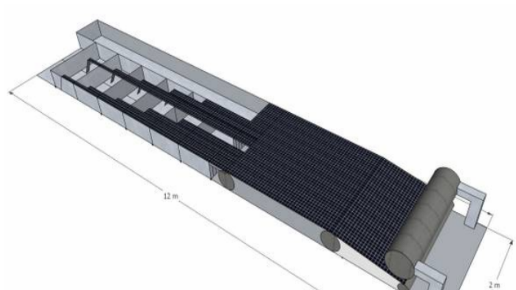

Figure 7.1.2 Sorting Conveyor Belt

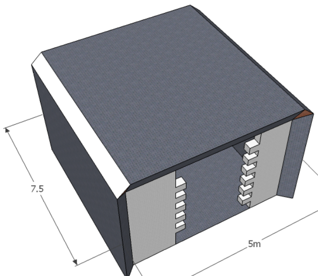

Figure 7.1.3 Airlock

To prevent debris from entering habitable areas, airlocks will act doubly as a barrier between ore-processing centers, ore-handling centers, and settlements. Robots from the ore-handling operations will undergo a decontamination process. Electron guns from both sides of the airlock will strike the robots with negative ions. Next, latches from the side of the airlock will open to expose positively charged magnetic plates. The positively charged plate will attract the negatively charged dust particles, thus removing the debris from the robots. Once the dust particles have been captured by these plates, the plates will retract into the latch, ensuring that no dust particles will enter into habitable areas.

7.1.2 Manufacturing Capability in Various Environments

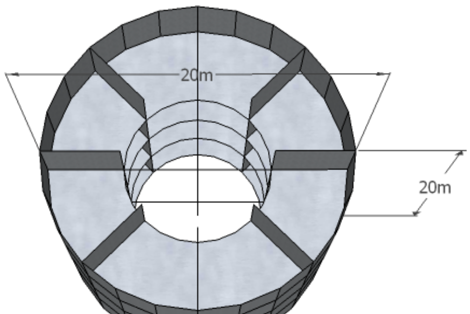

Figure 7.1.4 Storage Structure

The reardonium manufacturing procedure involves developing and storing the reardonium parts in a tube-shaped structure with various pressure and gravity environments. The tube is formed of multiple layers; each layer has eight chambers. The floors farthest from the space station are subjected to the most gravitational pull, while the floors closest to the station experience the least pull. Within each of the floors, the chambers are pressurized differently according to manufacturing standards and customer- specified properties of the reardonium alloy. In effect, the system allows manufacturing processes to be in different gravities, depending on floor location, and pressures, determined by the part's chamber placement. The diverse gravities will enable significant variation in the desired properties of the reardonium parts made in the settlement. Robots travel along tracks at the center of the tube to move parts to and from the chambers.

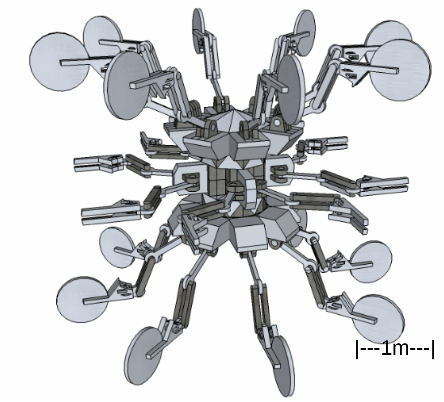

Figure 7.1.5 Transport Robot

7.1.3 Manufacturing Locations

All manufacturing operations will occur in the area between the ends of the central axis and the docking rings. Hazardous manufacturing operations will thus be separated from areas human occupy, such as residential and commercial areas which are on the tori in the middle of the central axis. Manufacturing areas will also enable efficient movement of parts through the production processes. Imported or extracted manufacturing materials will enter the settlement through the docking rings at the very ends of the central axis. They will then be sent to the industrial area right below or above the rings. Materials that must be processed in different gravity or pressure environments will be moved to various floors and chambers, as discussed in 7.1.2. They will then be transported back to the manufacturing center for further processing. Products that have undergone complete processing will be moved back to the docking rings. The other finished products will be transported through the central axis to the settlements for distribution or marketing. By using the structure of the settlement to increase the efficiency of the processes, materials undergo the least distance of transport before they become finished products.

7.2 Receiving and Shipping Reardonium Parts

7.2.1 Methodology for Reardonium Quality Checks

The reardonium parts will be inspected for quality and functionality. All parts from the surface of Mercury will be sent to the Reardonium Testing Center (RTC), located on Mercury itself. In this center, the reardonium will be tested for its malleability, capability of self-lubrication, and ability to provide protection from extreme temperatures. The exterior of the RTC will have a reardonium surface, which will provide shelter for the tested parts. Two-hundred fifty reardonium parts will be tested per day. Defective parts at any step of the testing process will be expelled from the chamber

7.2.2 Testing for Reardonium Malleability at Extreme Temperatures

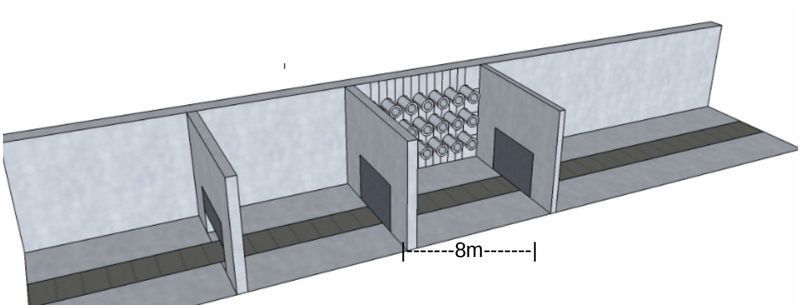

Figure 7.2.1 Reardonium Processing Center

The reardonium will first be sent to the storage center of the facility. A machine similar to a conveyer belt will transport the reardonium parts between compartments. Each section of testing will be separated by partitions made of reardonium. The reardonium parts will first be transported from the storage section to the heat-testing chamber. This resourceful method of testing will utilize Mercury's high day temperatures. The compartment will be built of conducting materials so that the extremely hot temperatures of Mercury outside will be transmitted to the inside of the compartment.

Next, the malleability of the reardonium will be tested by compressing it with a force of 1.0×10^9 Pa. After measuring the volume change, the bulk modulus of the reardonium parts will be calculated. The standard reardonium bulk modulus will be measured prior to the testing. If the calculated bulk modulus is equal to or above the standard bulk modulus, the reardonium parts will proceed to the next round of testing.

At night time, the reardonium parts will be tested in a similar process. The nighttime Mercury temperatures will be used to test the reardonium's response to extremely cold temperatures. After remaining in this chamber for several hours, the reardonium will then be tested for its malleability once again.

7.2.3 Testing for Reardonium Self-Lubrication and Subsequent Packaging

Following the malleability testing, the reardonium parts will be transported to the self-lubrication testing compartment, where a special gas that reacts with reardonium's self-generated lubrication will be released into the air. This identity of the gas will be determined once the properties of reardonium's lubricant are researched in more depth. Following such testing, the reardonium parts will be moved to the storage section, where they will be organized into standard shipping containers. These containers will be transferred to ion thrusters, where they will be shipped to various locations.

7.3 Port of Entry for Mercury

7.3.1 Physical Properties of Interplanetary and Landing Shuttles

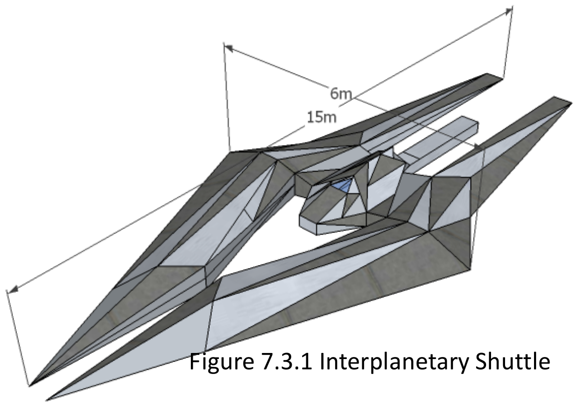

Figure 7.3.1 Interplanetary Shuttle

There will be two ports on Aynah, one on each end of the central axis. The ports will be a small ring within the industrial ring. Each rotating ring will hold twelve separate compartments within which individual shuttles will dock. Six compartments per ring will be allocated to interplanetary shuttles, with the other six being designated for landing shuttles. The two types of shuttles will alternate along the ring for compartmentalization purposes. Three interplanetary and three landing shuttles will be stored in each port ring for emergencies or when other shuttles need to undergo long-term repairs.

The interplanetary shuttles, which are magnetoplasmadynamic thrusters five meters in width and twenty-five meters in length, will be constructed from reardonium so that they will be able to endure extreme temperatures. They will transfer personnel and cargo in standard shipping containers from and to interplanetary spaceliners. The landing shuttles will be procured through contracts separate from the Aynah acquisition, and will transfer personnel and cargo to and from Mercury. They will be reinforced with a layer of reardonium to prepare for the extreme temperatures and radiation on the surface of Mercury.

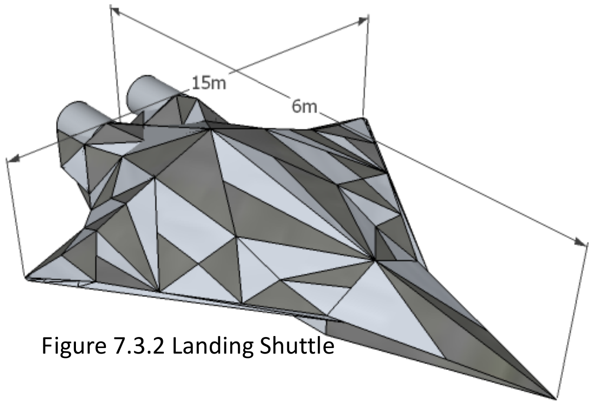

Figure 7.3.2 Landing Shuttle

7.3.2 Docking Procedures for Interplanetary and Landing Shuttles

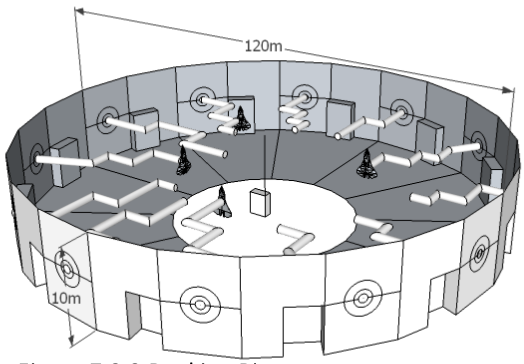

Figure 7.3.3 Docking Ring

When the shuttles approach the port rings, radio waves will be emitted from the shuttle compartments to the shuttles to guide them safely to dock. The shuttles will then unload their personnel and cargo. Personnel will be introduced to a rest and relaxation center for a few hours until they are ready to return to the settlement, at which point they will be transported through the central axis. Cargo will be warehoused for further transport, as described in 7.3.3. Automated robots will use electron guns, as described in 7.1.1, to remove dust or other foreign particles. Maintenance robots will detect and fix problems in the shuttles. In each compartment will also be a tank of hydrogen gas to refuel the magneto-plasmadynamic thrusters. The landing shuttles will be fueled by other gases if they are ion thrusters, or by liquid oxygen and hydrogen if they are liquid-based, both of which woud be procured by import from other settlements or from Earth. Finally, both types of shuttles will be covered with a biodegradable plastic film to help protect from further interplanetary contamination.

7.3.3 Cargo Warehousing

Cargo will be stored in the port rings following their unloading from the interplanetary or landing shuttles. There will be two compartments for cargo storage; one will hold reardonium and reardonium parts, while the other will hold other commodities or supplies, such as imported material from other colonies or cargo to be transported to interplanetary liners. A smaller quarantine center will be between the two storage compartments to hold foreign substances that may or may not prove harmful. Cargo in the quarantined warehouse will be transported to a quarantine research center to undergo further testing. Cargo will be transported from the ships to the warehouses through an overhead crane system. Then, on entry to the warehouses, it will be automatically packaged and labeled in standard shipping containers based on size. There it will await transport to its respective manufacturing centers or to various export vehicles.

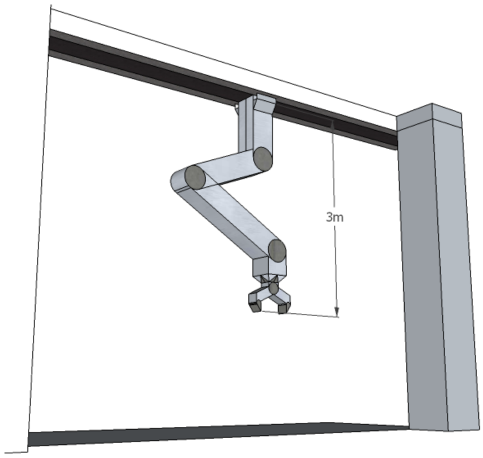

Figure 7.3.4 Crane Transport System

8.0

appendix

a. detailed assesment
b. references
c. compliance matrix

8.0 Appendices
8.1 Operational Scenario

Reardonium Mining, Production, and Processing

Numerous mobile Terran Mining Systems (TMS) will handle all mining operations on the Mercurian surface and transport the ore to centralized storage areas (Raynor) located throughout the Mercurian surface. The TMS consists of subunits of individual MinerPro Robots and a central Nexus mothercraft - each subunit is protected from solar flares and Mercurian dust with a titanium and aluminium alloy exterior, and will be remotely controlled by an automatic server on Aynah. The Nexus mothercraft will transport MinerPro robots from Raynor to previously determined mining locations, send out MinerPro robots for mining, and receive the mined ore to transport it back to Raynor. The MinerPro will mine and extract ore required for the production of reardonium. Electromagnetic imaging probes located on each of the solar power satellites (SPS) on the Volt Power System will discover areas with high amounts of ore on the surface. The MinerPro will further employ their Thermal Evolved Gas Analyzer to further detect areas of high ore concentration and mine them. Each MinerPro contains a carbon nanowire battery, able to power the robot continuously for 48 hours. The MinerPro will drill through the surface, use vacuum suction to collect loose debris, and distinguish usable ore from waste materials using microwave mass spectrometer sensors (MMS). Desirable ore will be stored inside the MinerPro, and once storage is full, the MinerPro will travel back to the Nexus mothercraft and deposit its ore. This process will repeat until the Nexus mothercraft cannot store any ore. Having been filled, the Nexus mothercraft will travel to Raynor to deposit the ore within the warehouse. In a normal mining operation, each Terran Mining System will be able to mine and transport a total of two metric tons of ore in 36 hours.

Stored ore will initially be separated into different minerals by composition using mass spectroscopy on sorting robots. Separate minerals will be placed on a given conveyor belt and then crushed into a fine powder before being delivered to a designated slot and placed into separate containers. Separated ore and minerals will then wait for approximately 12 hours at Raynor until it is transported onto Nova cargo ships bound for the settlement. Raynor contains several warehouses for storage of ore and repair facilities for nonoperational components of the TMS - these robots will be repaired by both humans and repair robots. Each Nova cargo ship is able to transport twenty metric tons of ore to and from Raynor and Aynah in a round trip journey of approximately 6 hours. Nova cargo ships will be outfitted with thick layers of aluminum and reardonium, separated by strips of insulation in order to prevent damage from solar flares. The thickness of the hull will be greater than that of the skin depth, thus preventing the skin effect and establishing a Faraday Shield to protect the Nova's inner electronics. This will allow the cargo ship to assume a "Safe Configuration" when the sun becomes increasingly active in its electromagnetic impulse activities. The Nova will be piloted by computers that have advanced navigational systems that will allow the ship to navigate through space. There will be a small cockpit for a human pilot in case of computer malfunctions. The exterior of the Nova will be coated with special solar cells that utilize singlet exciton fission to gather more energy from the sun. The solar cells will be linked to lithium ion batteries that will store electricity and supply energy during nighttime.

Nova will dock in the settlement, where the raw ore will be unloaded off the ship, refined, cast into parts, and loaded back onto cargo ships for curing on the Mercurian surface. These processes will be done in an assembly line fashion, which will significantly improve the production and cost efficiency of reardonium production on Aynah. Raw ore will be transferred from the cargo ships to large containers that will feed into a complex network of assembly lines. These assembly lines will all eventually lead to the central Hades Smelting Furnace system, where various combinations of heat, pressure, and gravity will create and isolate different varieties of unrefined molten reardonium alloys. These different combinations will be controlled and manipulated in the various chambers of the tube-shaped structure in which the reardonium production is contained in. Molten reardonium alloy will be initially poured into titanium-steel alloy molds to be shaped into 1 metric tons ingots. Ingots will be moved by conveyor belt to a storage area inside Aynah until further processing of the reardonium alloy is necessary. Human inspectors will then visually inspect reardonium ingots, and take random samples from each batch in order to ensure the highest possible quality and consistency between each batch at the Reardonium Testing Center, where reardonium alloys will be tested for malleability at extreme temperatures, self-lubrication, and other properties of reardonium alloy. Approximately 4 hours will elapse between the raw ore being unloaded off of Nova and ingots being transported to a storage area inside Aynah and product testing.

Construction and Processing of Small Reardonium Rotor Assembly

Reardonium ingots for the production of a small reardonium rotor assembly and other small reardonium parts will be constructed and processed in the Koprulu Sector of the manufacturing area. Ingots will be transferred back by conveyor belts to be molten in a high-temperature furnace (Pluto Furnace) in the Koprulu Sector, and poured into previously computer laser-crafted titanium-steel molds. These molds consist of millions of pins, attached to tubes to a source of nitrogen or argon gas. A computerized central system will dictate the pressure of the gas within the tube. The higher the pressure, the more elevated the steel pin is. Thus, the computer can create a complex, adjustable mold by varying the pressures within the gas tubes to create an indent. Through this method, the rotor assembly can be accurately produced on an extremely efficient and small scale. Once molded into its desired shape, the molded rotor assembly will be subjected to a blast of cold water and oxygen in order to become rapidly cooled into its permanent shape. Other reardonium parts smaller than one cubic foot will be constructed through this molding process - reardonium parts larger than one cubic foot but smaller than one hundred cubic feet will be constructed and processed through a similar method, except with larger molds. Construction and processing of such small parts, in batches of 500 parts, will take approximately 2 hours and 30 minutes.

Construction and Processing of 100 by 40 Foot Reardonium Construction Panel

Reardonium ingots for the 100 by 40 foot reardonium construction panel, as well as any reardonium parts larger than one hundred cubic feet, will be constructed and processed in the Braxis Sector of the manufacturing area. Multiple ingots will be transferred through a maglev transport train to the Braxis Sector, where it will be molten down in a large high-temperature and high-pressure blast furnace (Tartarus Furnace). At a certain combination of temperature and pressure, molten reardonium alloy will transform into a supercritical fluid, allowing for easier transfer into molds and shaping into large parts. The supercritical reardonium fluid will be poured into specialized aerogel molds preconstructed with computerized systems for optimal accuracy, and then rapidly cooled in a vacuum chamber. Construction of each individual large part will take approximately 3 hours.

Reardonium Part Transport, Curing, and Distribution

Constructed reardonium parts will be transferred onto conveyor belts leading to the Nova cargo ship, where they will be transported back to the Mercurian surface in a journey of approximately 3 hours. Nova cargo ships will transport constructed and processed parts to a centralized storage area (Kerrigan). Kerrigan will store uncured processed parts as well as cured processed parts, and also contain repair facilities for inoperable robots. Constructed and processed parts will wait in storage for up to two weeks in order to adjust to Mercurian conditions, and then will be loaded onto the computerized and robotic Raine Transport/Curing Systems (RTCS), which will automatically shuttle parts to and from various locations in Mercury in order to acquire desired curing properties. Each RTCS will receive a previously determined itinerary from a remote computer server for the curing of the loaded reardonium parts. The RTCS contains three extendable robot arms for automatic loading of reardonium parts, turning of reardonium parts during the curing process, and is powered by ultra-efficient photovoltaic cells coated on the exterior of the RTCS. Excess power will be stored in lithium ion batteries. The RTCS further is covered with a reardonium/aluminum/titanium alloy for protection from both radiation and extreme temperature variations. Curing of the reardonium parts will take approximately one year, depending on the specific reardonium part being cured. Once the curing process is complete, the RTCS will transport the cured parts back to Kerrigan for storage (a wait of up to three days) until Nova cargo ships will transport cured parts back to Aynah in a journey of approximately 3 hours.

Completed reardonium products will be loaded off of Nova cargo ships through assembly lines into another centralized storage area, where shipping details and specification will be worked out by both humans and computer systems. Reardonium products will be packaged and then loaded into commercial transport spacecraft, and delivered to customers.

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8.3 Compliance Matrix

Requirements	Subsections	Page
1.0 - Executive Summary	N/A	1
2.0 - Structural Design -Provide a safe and pleasant living and working environment for a population of 14,000 full-time residents and up to 200 transient residents	N/A	2
2.1 - Exterior Design -Overall exterior view of settlement -Indicate dimensions of major settlement structures -Show rotating and non-rotating sections -Show pressurized and non-pressurized sections -Indicate functions inside each volume -Show capability to isolate at least two of ten separate volumes.	 2.1.1 2.1.2 2.1.3 2.1.4	2-3
2.2 - Interior Design -Overall map or layout of interior land areas -Show usage of areas -Show drawings with dimensions of residential, industrial, commercial, agricultural, and other sections	2.2.1 2.2.2 2.2.3 2.2.4 2.2.5 2.2.6	3-7
2.3 - Construction -Show at least 5 intermediate steps of settlement assembly -Specify approximate time steps -Show method of initiating rotation for artificial gravity	2.3	8-9
2.4 - Manufacturing of Reardonium -Specify environments for reardonium production -Show dimensions structures for various environments	2.4	9-10
2.5 - Radiation Protection -Indicate material used for structures occupied by humans -Cross section of materials, including a 0.6 layer of water for radiation protection -Material amounts and properties specified	2.5	10-11
3.0 Operations and Infrastructure -Describe facilities and infrastructure necessary for building and operating the Aynah space settlement and its communities.	N/A	12
3.1 Orbital Specifications and Construction Material -Identify sources of materials other than reardonium, and equipment to be used in construction, then in settlement operations after construction is complete	 3.1.1 3.1.2	12
3.2 Infrastructure -Identify air composition, pressure, and quantity, and describe climate control. -Describe food production: growing, harvesting, storing, packaging, delivering, selling. -Describe how power will be generated (specify kW), distribution, and allocated. -Describe water management (quantity and storage facilities). -Describe household and industrial solid waste management (recycling, disposal). -Describe internal/external communication devices & central equipment. -Describe internal transport systems (show routes, vehicles, dimensions). -Describe day/night cycle provisions (schedules and mechanisms required). -Define storage facilities in case of interruption in food or commodities for up to ten months.	 3.2.1 3.2.2 3.2.3 3.2.4 3.2.5 3.2.6 3.2.7 3.2.8 3.2.9	13-16
3.3 Construction Equipment -Show designs of machines for settlement construction, especially hull and interior buildings	 3.3.1	16-17

and structures. -Describe necessary materials and how machines create the structures.	 3.3.2	
3.4 Reardonium Production Power Generation -Show solar panels for reardonium power requirements	 3.4.1	17
3.5 Reardonium Curing Process -Show vehicle for moving reardonium parts on Mercury surface	 3.5.1	17
4.0 - Human Factors - Establish a diamond-grid patterned community - Provide natural sunlight and views of Mercury	N/A	18
4.1 - Community Design - Provide maps of settlement - Design the community with long lines of sight - Provide a variety of consumables and specify means of distributing them to the people - Provide a distance scale and identify the percentage of land area allocated to roads and pathways	4.1.1 4.1.2 4.1.3	18- 20
4.2 - Residential Plans - Design four different housing plans to accommodate singles, couples, and families - Show external views and floor plans of each residency - Identify sources and manufacturing of furniture items	4.2.1 4.2.2 4.2.3	20- 22
4.3 - Safety Systems - Design systems that enable safe access for humans to all parts of the settlement - Show airlocks and spacesuit stowage procedures to enter/exit habitable areas	4.3.1 4.3.2	23
4.4 - Full Gravity Areas - Draw and explain means for children to stay in 1g for at least 3 hours a day	4.4.1 4.4.2	24
4.5 - Mercury Rover - Provide a surface vehicle for humans to monitor the curing process on Mercury - Show images of the vehicle	4.5.1	24
5.0 - Automation Design and Services -Specify numbers and types of computing and information processing devices, multi-function personal electronic tools, servers, network devices, and robots required for Aynah's operations -Describe types and capacities of data storage media, data security, and user access to computer networks -Show robot designs, indicating dimensions and illustrating how they perform tasks	5.0.1 5.0.2	25- 26
5.1 - Construction -Drawings showing automated construction and assembly devices for both interior and exterior applications, illustrating how they operate	5.1.1	26- 27
5.2 - Maintenance, Repair, and Safety -Chart/Table listing anticipated automation requirements for operation of the settlement -Identify particular systems and robots to meet each automated need	5.2.1 5.2.2 5.2.3	27- 28
5.3 - Livability, Productivity, and Convenience -Drawings of robots and computing systems that will be encountered -Diagrams of networks and bandwidth requirements to enable connectivity	5.3.1 5.3.2 5.3.3	28- 30
5.4 - Efficiency of Reardonium Manufacturing Process -Drawings of robots for reardonium parts manufacturing and handling	5.4	30
5.5 - Handling Reardonium Parts -Drawings of surface robots, showing how they manipulate parts on the surface -Depict "safe" configuration	5.5	30- 31
6.1 – Schedule - Durations and completion dates of major design, construction, and occupation tasks, depicted in a list, chart, or drawing	6.1	32- 33

6.2 – Costs - Chart(s) or table(s) listing separate costs associated with different phases of construction, and clearly showing total costs that will be billed to the Foundation Society	6.2	34-36
7.0 – Busines Development	N/A	37
7.1 – Infrastructure for Refining and Manufacturing Reardonium Parts - Capability for handling and processing raw ore from the surface of Mercury, including systems to prevent dust and grit from entering habitable areas - Manufacturing capability in various gravity and pressure environments - Hazardous manufacturing operations are separated from areas humans occupy (e.g., residential and commercial areas) - Manufacturing areas must be arranged to enable efficient movement of parts through production processes	7.1.1 7.1.2 7.1.3	37-38
7.2 – Receiving and Shipping Reardonium Parts - Perform inspections and quality checks of reardonium parts returning from curing processes on the surface of Mercury - Install completed parts in standard shipping containers or on pallets for delivery to customers throughout the solar system - Automate routine processes	7.2.1 7.2.2 7.2.3	38
7.3 – Port of Entry for Mercury - Operate a fleet of interorbital shuttles to transfer personnel and cargo in standard shipping containers from/to interplanetary spaceliners - Operate a fleet of landing shuttles (procured through contracts separate from the Aynah acquisition) to transfer personnel and cargo to/from the surface of Mercury - Provide cargo warehousing for customs purposes and storage while waiting for transfer to other ships - Provide vehicles/systems for moving cargo containers between ships and warehousing	7.3.1 7.3.2 7.3.3	39-40
8.0 – Appendices	N/A	41
8.1 – Operational Scenario - Select one small (less than one cubic foot) and one large (100 by 40 foot construction panel) part made of reardonium after Aynah is operational. - Show the processes each part goes through, from mining on the surface of Mercury to shipping as a completed product - Show and describe requirements for every facility, every major piece of equipment, every vehicle, every robot, and every human interaction each part encounters - Estimate the time required for each part to go through its processes.	8.1	41-43
8.2 – Bibliography / References	8.2	43-47
8.3 – Compliance Matrix	8.3	48-51