

GRETCHEN WHITNEY HIGH SCHOOL/CERRITOS, CALIFORNIA/UNITED STATES OF AMERICA

NORTH DONNING HEEDWELL PRESENTS **AYNAH**



**NORTH DONNING
HEEDWELL**

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

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

<u>Annie Yau [12] (17)</u>	<u>Erik Wang [11] (16)</u>
<u>Vincent Wu [12] (17)</u>	<u>Tiffany Hou [10] (15)</u>
<u>Emily He [12] (17)</u>	<u>Priyanka Shah [11] (17)</u>
<u>Judy Chang [12] (17)</u>	<u>Deena Younan [10] (15)</u>
<u>Samuel Lau [11] (16)</u>	<u>Jeremy Wang [11] (17)</u>
<u>Justin Ho [11] (16)</u>	<u>Leah Huang [11] (16)</u>

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

Patty Cordova Kevin Nguyen

Competition July 27 - 30, we will be expected to finance our own travel to/from Nassau Bay, Texas, USA.

Patty Cordova
Responsible Teacher/Advisor Signature

3/30/12
Date



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1.0 EXECUTIVE SUMMARY

“In the brilliant, rocket-explosion of its youth, this country displayed to an incredulous world what greatness was possible to man.” With this quote, John Galt, in the famously acclaimed novel *Atlas Shrugged* by Ayn Rand, exalts man’s great strides toward ground-breaking advancements. In the field of aerospace, the possibilities of future innovations are not just mere mysteries of our imagination to ponder. We at Northdonning Heedwell believe in nurturing this curiosity to expand beyond the boundaries and push past the perceived limitations. To achieve this dream, we are proud and honored to present Aynah, *the Frontier of the Cosmos*.

Reflecting our accomplishments in the unexpected and the unknown, Northdonning Heedwell has incorporated reardonium to make a colony near Mercury possible. Not only is reardonium lightweight, strong, resistant to the heat, cold, and radiation, reardonium holds a great symbolic value of the strength and valor of the human race. To illustrate the glory of the past and to inspire the future, we have decided to centralize the colony around the theme of lost cities. These cities radiate a sense of mystique and supernatural awe that we want to instill within our own colony.

Aynah is the pioneer of cutting-edge technology and the spearhead of innovation and research into the new frontier of the planet Mercury. Its limited resources and sweltering heat make utilizing this planet daunting, yet it is because of this difficulty and unfamiliarity that excite and embolden us to challenge the forces of nature. Aynah's structure is specifically designed to maximize functionality for both research and leisure purposes and to provide protection from the solar heat. We have revolutionized the meaning of “efficiency” through our upgraded models of automated robots, solar panels, and wireless communication. To promote a green consciousness in our community, our Zero Waste Policy is the epitome of recycling and conservation. Nothing is wasted and everything has a purpose in Aynah. Our agriculture system produces only the freshest of produce and fish and offers a wide variety of diets to satisfy any resident.

This technological progression is only the tip of latent power of man's mind that has been increasing exponentially, allowing us to focus on the mining of reardonium, the mystery metal made of an ore found only on the unforgiving surface of Mercury. Equipped with the most accurate sonar detectors and the sturdiest frame to withstand any physical damage, the Voltron represents the next generation of efficient mining vehicles and robot hybrids. Completely self-sufficient, it is equipped with its own solar panels to create electricity and automated arms with the finesse to carefully excavate the raw resource.

While Aynah is partially a mining colony, it is also the place where 14,200 residents call home. To attempt to alleviate the sense of nostalgia and isolation from Earth, Aynah has several weather parks to mimic Earth's climate. However, Aynah, no matter how much we try to imitate Earth, will never be Earth. And, where some see this as a fruitless endeavor, we at Northdonning Heedwell embrace that difference. People come to Aynah to experience something novel, and that is exactly what we present them. From microgravity sports to virtual reality arcades to sightseeing Aynah's dazzling infrastructure, we deliver it all to the residents who will live comfortably in man's final frontier.

Yet, it is not the interwoven society that complements both business with pleasure that draws people to Aynah. It is the future, the unknown, the potential to surpass all expectations. That is what people see in this colony and that is why they come here: to witness Aynah's greatness as it expands and evolves into the avant-garde of science. As we enter a new age of exploration, Aynah will be the flaming torch of the Sun to lead mankind to take his first steps toward peaking at the Universe's intellectual design.



STRUCTURAL DESIGN

2.0 STRUCTURAL DESIGN

As the first settlement near Mercury, Aynah is envisioned to be a colony of strong manufacturing and transportation power. Consequently, Aynah is designed to have flexible, easily expandable manufacturing modules and port facilities.

2.0.1 Population. As the first settlement near Mercury, Aynah is able to accommodate 14,000 residents and up to 200 visitors with over 1,000,000 m² of down area designed for residential and commercial purposes.

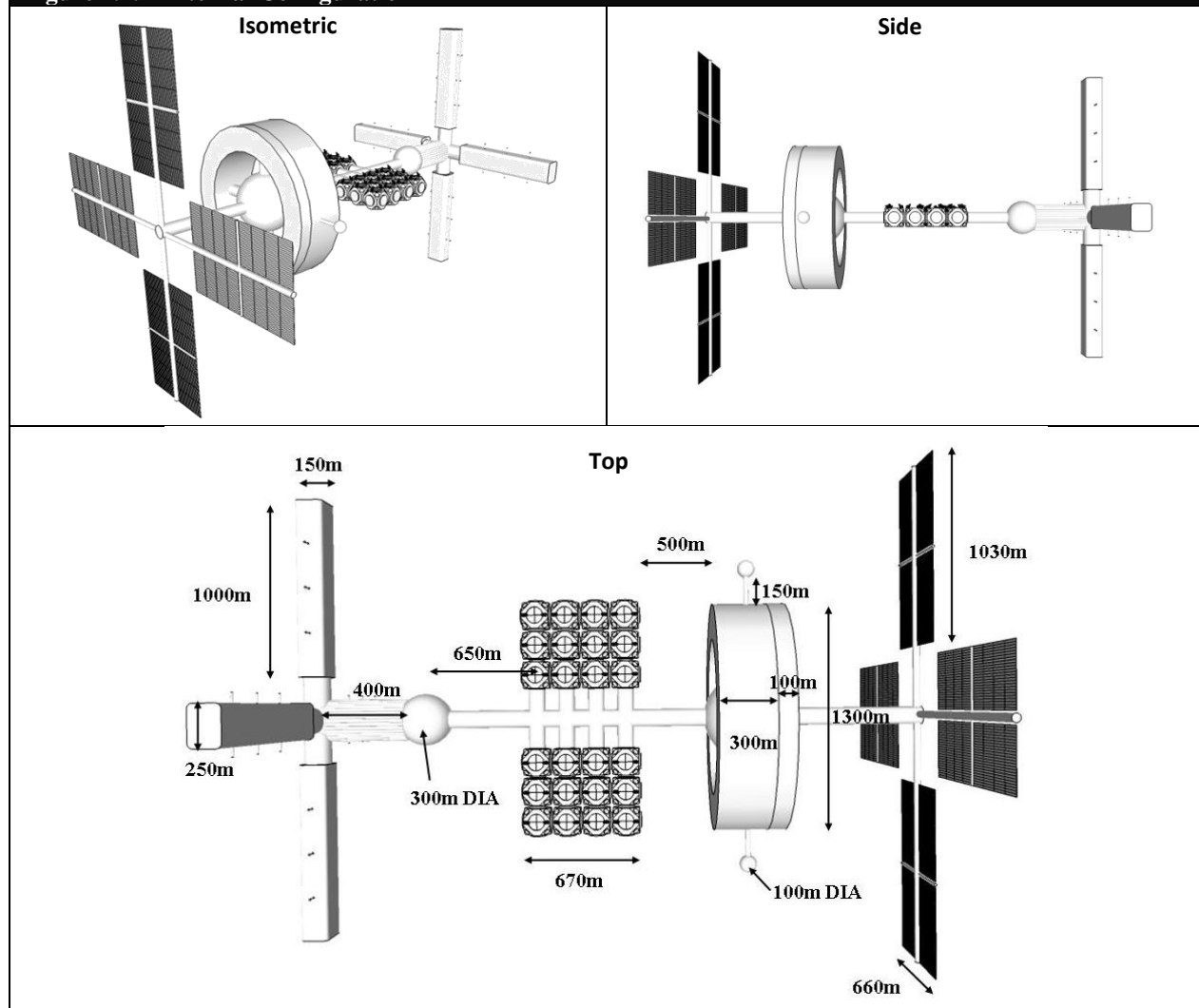
2.0.2 Natural View. Natural views of Mercury will be provided through transparent hull panels installed on the Pangaea ring, on the side facing away from the Sun.

2.1 EXTERNAL CONFIGURATION

2.1.1 External Design.

Each of Aynah's large structures is positioned to best optimize efficiency and reduce strain on the structure. Artificial gravity is only applied on areas designed specifically for human activities, namely the residential and commercial sectors. Aynah is in a sun-synchronous orbit around Mercury; therefore, the sun panels are positioned facing the Sun at all times to best maximize power generation for the colony.

Figure 2.1.1 External Configuration



2.1.1.1 Pangaea. The main ring of the colony, named Pangaea, Earth's supercontinent that formed 300 million years ago and split 200 million years ago, houses all agricultural, residential, and commercial activities. It also includes the two spherical pods, named Ithaca and Troy, extending from the major ring. The major ring will provide 0.7 G gravity, which most residents prefer, while Ithaca and Troy's larger distance from the center of rotation would generate 1 G gravity, as necessary for resident children's development.

2.1.1.2 El Dorado. Named after the legendary kingdom for its

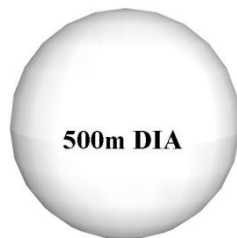


Figure 2.1.1.2
El Dorado

abundance in gold, El Dorado is used for all storage purposes, including robots, fuels, food, and etc. It is placed at the center of the Pangaea ring to enable easy access and retrieval of needed materials from within Pangaea.

2.1.1.3 Babylon. Aynah's manufacturing sector, named Babylon after the legendary ancient city famous for its well-fortified architecture, is responsible for refining and manufacturing reardonium. Each Babylon module

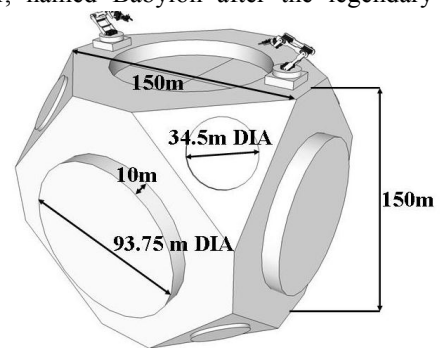


Figure 2.1.1.3 Babylon

manufacturing needs.

2.1.1.4 Kechries. Aynah's space port, named Kechries after the port of Greek city-state Corinth, contains 4 landing stations, which always face away from the Sun, since that is the direction most incoming vehicles come from. A lock-and-key mechanism is used to secure landing vehicles. Once a vehicle lands on the runway, an anchor rod extends to pin down the vehicle. Supplies and/or passengers are then unloaded through the rod. For take-offs, the anchor rod is released and the vehicle is loaded onto the rails, where the vehicle can launch towards its destination.

2.1.1.5 Solar Panels. Because of Aynah's proximity to the Sun and its Sun-synchronous orbit, solar energy is available at all times and Aynah will be supported by solely solar power. Large solar panels are installed facing the Sun to power all needs on the colony.

2.1.1.6 Niya. The central rod, named Niya after an ancient major hub on the Chinese Silk Road, connects all major parts of the settlements to facilitate transportation across the colony. Two maglev trains, travelling opposite directions, are installed.

2.1.2 Artificial Gravity. The main ring of Pangaea has an outer radius of 650 meters while the Ithaca and Troy pods are located 850 meters away from the axis of rotation. Since the majority of the residents prefer living at a 0.7 G environment, the main ring will rotate at 1.0 rpm to satisfy their

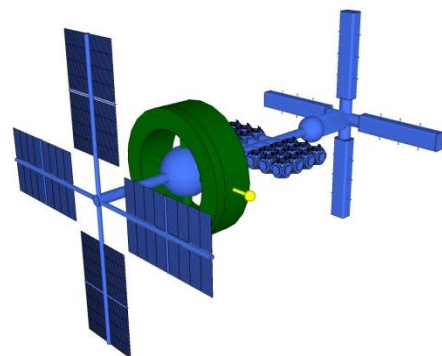


Figure 2.1.2 0-g Unpressurized, 0.7-g Pressurized, and 1-g Pressurized

preferences. Ithaca and Troy, however, will generate 1 G, and these two spheres are designated specifically for children, who require 3 hours of 1 G exposure every day. The low rotation rate also minimizes the Coriolis Effect. Pangaea is also the only rotating structure in the colony. Other structures remain stationary, thus reducing structural strain.

2.1.3 Pressurized Volumes. As with artificial gravity, only the regions dedicated for human activities are pressurized in order to eliminate unnecessary maintenance costs. As a result, pressurized volumes are identical to volumes with artificial gravity. The atmospheric pressure is maintained at 1 atm throughout. This greatly reduces side effects that newly arrived colonists may experience.

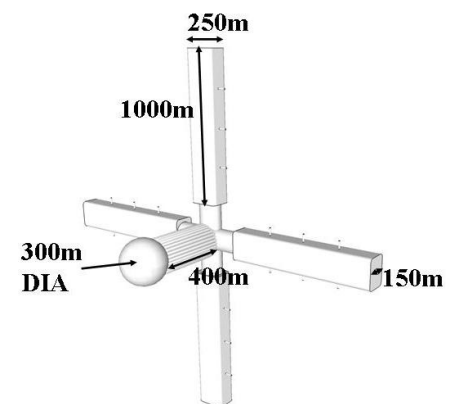


Figure 2.1.1.4 Kechries

2.1.4 Structural Interface between Rotating and Non-Rotating Sections.

The only intersection between rotating and non-rotating sections is located between El Dorado and Niya. To facilitate transition between the two sections, a system of pods is installed to move colonists and supplies from the stationary Niya to the rotating spokes. The slow rotation rate at 1 rpm enables the pods to easily transition between the rotating and non-rotating sections.

2.1.5 Hull Components. The outermost hull layer of Aynah will be constructed with reardonium, a lightweight, strong, and self-lubricating material that is also temperature and radiation resistant. The ideal properties of reardonium greatly simplify the need for a

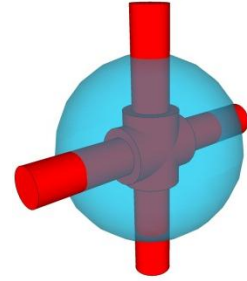


Figure 2.1.4 El Dorado and Niya

Reardonium	0.5 m
Vacuum	0.3 m
Reardonium	0.5 m
Vacuum	0.3 m
Reardonium	0.5 m
Self-healing RXF-1	0.2 m
Water	0.5 m
Self-healing RXF-1	0.3 m

Figure 2.1.5.1 Primary Hull

thick, diverse, multi-layered shield to protect the colony against debris and radiation. However, due to different structural needs, there will be two different types of hulls: the primary and the secondary. Both types of hulls are composed of reardonium, water, and self-healing RXF-1. However, primary hull, applicable to Pangaea, is made thicker to accommodate the strain experienced from artificial gravity. In addition, to allow for natural view of Mercury, the side of Pangaea facing directly away from the sun is made transparent. On the other hand, the secondary hull lacks the layer of water since reardonium provides for sufficient radiation protection for functions without human involvement.

2.1.5.1 Debris Protection. To guard against debris, the hull uses multiple layers to absorb heavy impacts. The first layer of reardonium is able to deflect most incoming particles. If the impact is strong enough to penetrate the topmost layer of reardonium, subsequent two layers of reardonium are spaced apart under by vacuum to further absorb the impact.

2.1.5.2 Radiation Protection. Reardonium is also radiation resistant. However, to sufficiently guard against the intense radiation experienced near Mercury, under the reardonium layers is a layer of water, meant to absorb further radiation. Lastly, the innermost RXF-1 layer is also very effective in shielding solar flares, cosmic rays, and secondary radiation.

2.1.5.1 Debris Protection. To guard against debris, the hull uses multiple layers to absorb heavy impacts. The first

Reardonium	0.5 m
Vacuum	0.3 m
Reardonium	0.5 m
Vacuum	0.3 m
Reardonium	0.5 m
Self-healing RXF-1	0.5 m

Figure 2.1.5.2 Secondary Hull

Table 2.1.5 Protection Material			
Material	Use	Maintenance	Properties
Reardonium	Debris shielding, radiation protection, structural support	Inspected weekly, topmost layer replaced every 2 years	Lightweight, strong, temperature resistant, radiation resistant, self-lubricating
Self-healing RXF-1	Radiation protection, debris shielding, structural support	Inspected monthly	Three times stronger, 50% better at shielding solar flares, and 15% better at deflecting cosmic rays compared to aluminum
Water	Radiation protection	Inspected weekly	Good heat insulator, absorbs radiation

2.1.6 Contingency. The design of Aynah makes survival and repair of the colony viable in the event of unforeseen disasters.

2.1.6.1 Quarantine. When quarantine is needed, large numbers of nanobots will be initiated and quickly bond with each other to construct walls around the section to be isolated. The usage of nanobots allow for extreme flexibility, as nanobots can simply be reprogrammed to bond differently according to the shape of the wall needed.

2.1.6.2 Hull Breach. Inside the hulls are deflated structures that can quickly inflate to seal the hull breach and provide a moderately rigid protection until further structural repair is applied.

2.2 INTERNAL CONFIGURATION

The design of Aynah allows accommodation for a wide range of activities. Being the settlement closest to Sun and geared towards mining, its functions can be classified into three major categories: residential, commercial, and industrial.

2.2.1 Residential. The residential area is located in the thicker ring of Pangaea. It contains all the residential housing that accommodate different family types to maintain and lead an Earth-like lifestyle.

2.2.2 Commercial. The commercial area is mixed in with the residential area, located in the thicker ring of Pangaea. This includes office buildings, banks, recreational facilities, and more that sustain Aynah's thriving economy.

2.2.3 Industrial. The Babylon manufacturing modules support Aynah's industrial and manufacturing functions. Located along Niya, these facilities take crude ore from the surface of Mercury and refine the ores into desirable properties by applying various acceleration and pressure as described in *2.4 Manufacturing Operations*.

2.2.4 Pangaea. Pangaea provides for Aynah's residential, commercial, and agricultural capabilities. A ring of width 400 meters, Pangaea is divided into two sections: 1 thinner ring of 100 meter thickness dedicated to agriculture and 1 thicker ring of 200 meter thickness purposed for all human-related commercial and residential facilities. The outside wall of the agricultural section will be the side facing the sun, and will be reinforced with reardonium and water to protect against radiation. The outer wall of the residential/commercial ring will thus be facing away from the sun, and that wall will be composed of transparent yet rigid materials to allow the colonists a natural view of Mercury and other planets beyond.

2.2.5 Niya. Niya, the central rod, provides for transportation across the colony. The rod is split into two levels. The upper level, of 50 meter vertical clearance, will contain two Maglev trains, traveling in opposite directions, and primarily transport cargo and supplies. The lower level, of 40 meter vertical clearance, will also contain two Maglev trains traveling in opposite directions, but will instead be dedicated towards passenger transport.

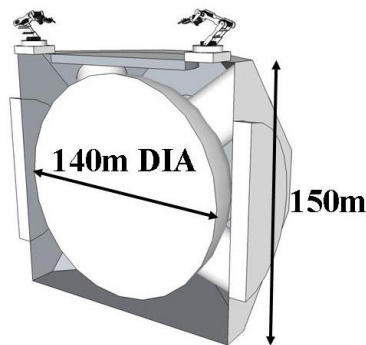


Figure 2.2.6 Babylon

2.2.6 Babylon. Babylon, the collection of manufacturing modules, provides for the industrial applications of the colony. Inside each module is a spherical centrifuge, able to spin up to 1.787 rpm to create a centripetal acceleration of 0.5 G. The centrifuge is also connected to air pumps that can pump helium, a non-reactive

noble gas, into the centrifuge as needed to create pressure of up to 20 psi.

2.2.7 Orientation of Down Area. Since Aynah's artificial gravity is maintained by centripetal acceleration, the down direction is pointed away from the center of rotation, as applicable to Pangaea, El Dorado, and the spokes.

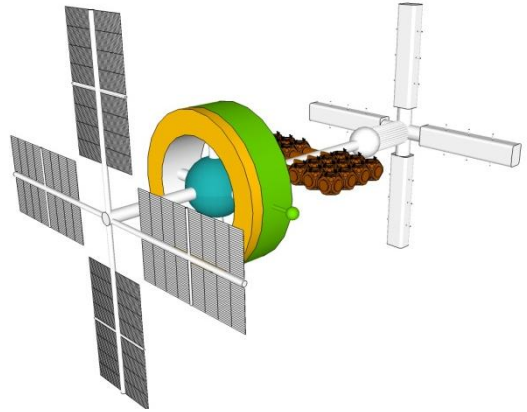


Figure 2.2 Agricultural, Industrial, Storage, Commercial, and Residential Areas

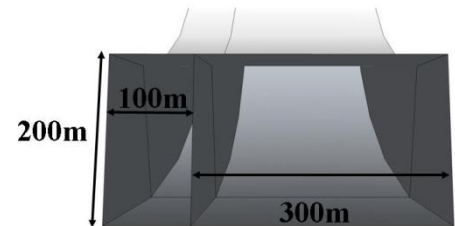


Figure 2.2.4 Pangaea

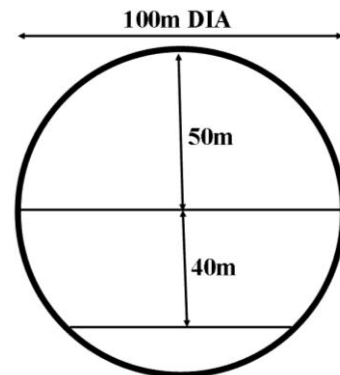


Figure 2.2.5 Niya

Table 2.2 Areas and Volumes

Component	Down area/ module (m ²)	Total Down Area (m ²)	Down Area %	Volume/ module (m ³)	Total Volume (m ³)	Volum e %
Pangaea	1,583,362	1,583,362	66.8%	266,407,046	266,407,046	30.6%
<i>Agricultural</i>	395,840	395,840	16.7%	66,601,764	66,601,764	7.7%
<i>Residential/Commercial</i>	1,187,522	1,187,522	50.1%	199,805,292	199,805,292	23.0%
El Dorado	785,398	785,398	33.2%	65,449,846	65,449,846	7.5%
Niya	N/A	N/A	N/A	23,561,945	23,561,945	2.7%
Babylon	N/A	N/A	N/A	3,375,000	81,000,000	9.3%
Kechries	N/A	N/A	N/A	167,278,759	167,278,759	19.2%

2.3 CONSTRUCTION SEQUENCE

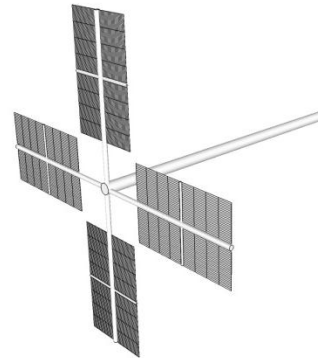
The initial steps of the construction of Aynah will depend on the existing manufacturing facilities on Mercury, which can produce components of up to 12 by 6 meters, which will be pieced together into desired structures. However, after Babylon manufacturing modules are constructed, Aynah will begin constructing its remaining structures through Babylon, which will be capable of producing components of up to 30 by 12 meters.

Table 2.3 Construction Sequence

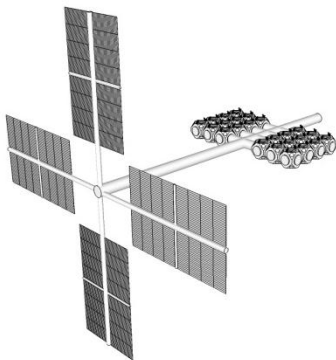
1. Reardonium components are transported from Mercury and assembled to form Niya.



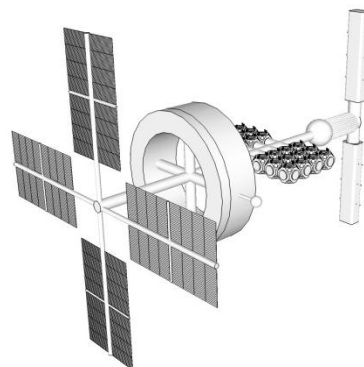
2. Solar panels are installed, as the major power source for Aynah.



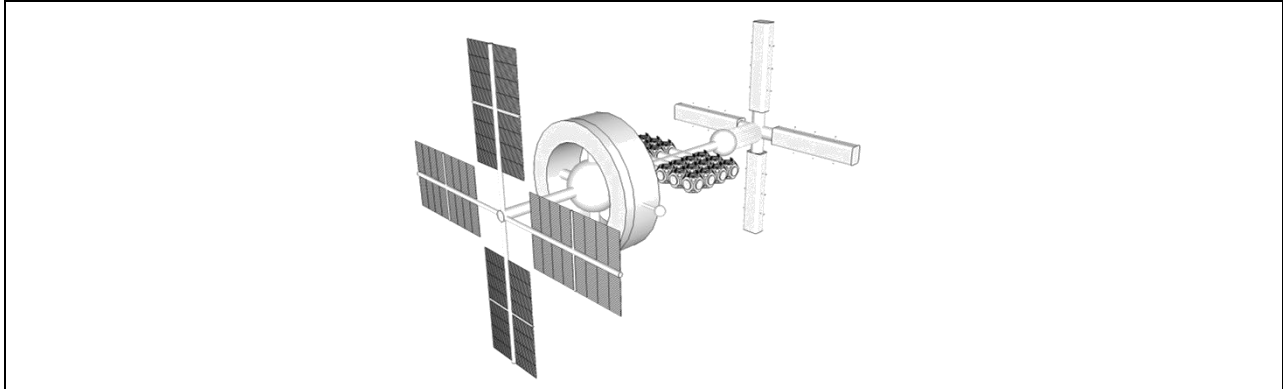
3. Babylon modules are installed and powered by the solar panels. Structural components are now refined in Babylon instead of on Mercury.



4. Pangaea and half of the landing stations in Kechries are built and installed. Pangaea is pressurized as needed.



5. The other half of the landing stations in Kechries are built and El Dorado is installed. Artificial gravity is initiated in Pangaea and El Dorado.



2.3.1 Pre-Construction. Before construction begins, a mobile headquarter is first launched in Mercury's orbit to accommodate the construction crew. Mining outposts on Mercury will provide the reardonium required to shape the required structures.

2.3.2 Construction. To allow for the production of larger components, the most pressing task of construction is to install the Babylon modules. Therefore, solar panels, Niya, and Babylon are the first structures to be built, in order to provide Aynah with the basic industries, power source, and structural support. Next, human quarters and port facilities are constructed.

2.3.3 After Construction. Residents will move in only after the colony is complete and functional and deemed safe through extensive testing. The mobile headquarters will support the construction crew and oversee the entire construction process until residents are brought in.

2.3.4 Initiation of Artificial Gravity. The propulsion thrusters will provide the initial torque to generate artificial gravity. As the centripetal accelerations gradually decline due to the slight friction, the propulsion thrusters will reapply torque as fit to keep the angular velocity of Pangaea to 1.0 rpm.

2.3.5 Construction Technique for Interior Structure. Interior structures can be manufactured from iron, a useful structural material that makes up to 70% of Mercury's core. To refine iron ores, the ores are first heated to over 900 C, separating iron from impurities, such as oxygen. Carbon is added to the mix, thus binding with oxygen to create and release gases like carbon dioxide. The resulting solids are wrought iron, alloys of iron and silicates. Wrought iron, a malleable metal, can be galvanized to prevent rusting and further manufactured into desired structures. On the other hand, wrought iron can also be further refined into steel by putting the wrought iron ores into a blast furnace along with limestone and carbon. The silicates in wrought iron will bind with limestone, and the resulting is pig iron, a purer form of iron. After, pig iron can be combined with carbon to make steel.

2.4 MANUFACTURING OPERATIONS

To create a diverse range of reardonium properties, Babylon modules on Aynah are constructed with capabilities of creating accelerations from 0 to 0.5 G and atmospheric pressure from 0 to 20 psi. Minimally refined reardonium ores are transported from the mining facilities on Mercury to Aynah. The mining spaceships from Mercury will unload the ores at Kechries, where Aynah's robots will take over and transport the ores to Babylon for further refining.

2.4.1 Centrifuge. Babylon contains a spherical centrifuge where the ores will be settled in after being transported from Kechries. The centrifuge, able to spin up to 1.787 rpm to generate 0.5 G, will spin at the velocity required to induce the desired properties from the reardonium ores. The torque necessary for rotation will be provided by the twist of the central rod inside the centrifuge. The rod will be powered by electricity from the solar panels.

2.4.2 Air Pumps. To alter atmospheric pressures, helium gas tanks are installed on the Babylon modules. Helium gas is chosen because it is light and easy to import. It is also an inert gas, therefore able to take up volume in the centrifuge and increase pressure without reacting with the reardonium ores or interfering with the refining

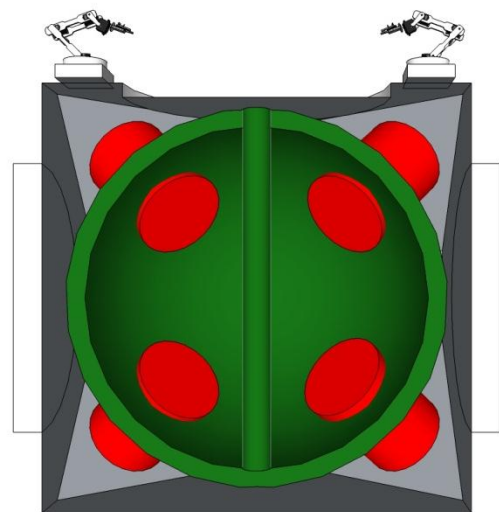


Figure 2.4 Babylon cross-section air pumps and centrifuge

process. The amount of helium pumped into the centrifuge is controlled by sophisticated robots. The amount must be carefully monitored to prevent accidents because pressure, within closed volume, is easily affected by temperature, an important factor in the refining process. Babylon modules will contain accurate monitors that will measure the temperature and other variables within each module to ensure that the centripetal acceleration supplied by the centrifuge and the atmospheric pressure created by the helium gas pumps are appropriate to ensure the desirable property of reardonium is induced.

2.5 RADIATION PROTECTION

The design of Aynah provides many lines of defense against radiation in all residential and commercial areas.

2.5.1 Protection by Location. No parts of the residential and commercial sectors are directly facing the Sun. The Pangaea ring is purposely divided into two separate sections, with the thinner agricultural ring on the side facing the sun and the thicker residential and commercial ring facing away. In addition, between the Sun and Aynah's Pangaea ring lie Aynah's solar panels that will power the colony. The solar panels, as a result, not only are exposed and able to absorb as much sunlight as possible, but also serve as a physical barrier blocking the Sun from Pangaea.

2.5.2 Protection by Hull Composition. To further protect residents from the Sun's intense radiation, Pangaea is made with the primary hull, as described in 2.1.5 *Hull Components*. The primary hull is made thicker not only to withstand the strain from artificial gravity, but also to more effectively shield off the intense radiation. The 0.5 meter layer of water within the hull, combined with three reardonium and one RXF-1 layers, will sufficiently minimize the dangers of radiation on Aynah.

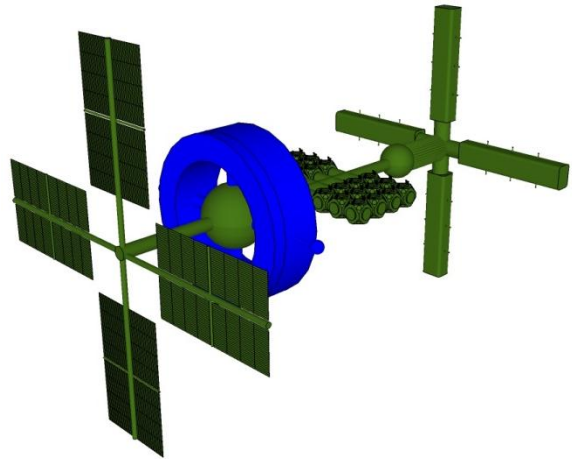


Figure 2.5 Primary Hull (protected by water) and Secondary Hull distribution



OPERATIONS AND INFRASTRUCTURE

3.0 OPERATIONS AND INFRASTRUCTURE

3.1 CONSTRUCTION MATERIAL SOURCES

3.1.1 Aynah Orbital Location. The space colony Aynah will orbit around Mercury about its poles from north to south perpendicular to its equator. By orbiting about its poles, the colony will always have part of its structure facing the sun. The part of Aynah that is towards the sun is the agricultural sector, allowing natural sunlight to shine on the food through semitransparent windows. The orbit will have an altitude of 350 km allowing the colony to fluctuate up or down if needed to. This altitude will provide easy access to the Mercury surface for reardonium mining. The colony will travel at 2.91 km/s from pole to pole. The colony will not incline towards the sun, allowing the agricultural section to receive as much sunlight as possible at all times.

3.1.2 Materials and Equipment Logistics. Materials and equipment that will be used to construct Aynah come from a variety of places but primarily from Earth, Belvestat, and Mercury itself in order to effectively utilize nearby materials and be as resourceful as possible. We can find resources such as silicon, potassium, magnesium, oxygen, and iron either on the Mercury's crust or atmosphere. Manufactured materials and robot parts will come from Belvestat to save transportation costs and the space experimentation costs. In Aynah's early construction stages, all the raw materials mined will be sent to Belvestat for processing and manufacturing. We will be receiving only a select few materials from Earth, such as nitrogen and carbon, within a three month window every two years.

Table 3.1.2 Construction Materials and Sources

Materials	Composition	Amount (m ²)	Source
Nisil	Nickel, Silicon	32,605,091	Mercury Soil
Water	Water	3,481,990	Mercury Soil
Reardonium	Reardonium	2,679,003	Reardonium Production

3.1.3 Transportation of Materials. The company's fleet of Ozymandias will provide long distance transportation materials and modular and robotic materials for the colony from either Belvestat or Earth to the construction site of Aynah. The Ozymandias space ships are maintained and serviced in orbit to greatly save transportation cost and space. Once arrived at Aynah, the material transport robot Jackal will unload and deliver the resources, materials, and equipment to the desired location on site. Aynah will also employ another spaceship named Rorschach to be used as transporting materials from Mercury to the space colony.

3.1.4 Storage of Materials. Because of the danger and difficulty of storing materials in a vacuum, we will temporarily store the materials in a one of the Ozymandias ships or in a completed port or cargo holding. For materials that are not easily damaged when exposed in a vacuum, they can be latched onto the outside of the not yet completed construction materials to save time and space to transport it.

3.2 COMMUNITY INFRASTRUCTURE

3.2.1.1 Atmosphere. The colony will constantly maintain .9 atm with the same atmospheric composition as Earth's. The atmosphere is kept at .9 atm because it will reduce the needed nitrogen since it is very expensive to import from Earth. The .1 atm difference will also put less pressure and strain against the hull and will not be noticeable by the people living in the colony while also saving a considerable amount of money. There will also be no atmosphere in the manufacturing modules and industrial sectors to further save money and to prevent any explosion that would require oxygen. To purify the air in the colony, we will be using High-Efficiency Particulate Air or HEPA which will remove 99.97% of all particles that are greater than .3 micrometers when they pass through and they are placed strategically and evenly spaced out across the colony. Along with each HEPA is an Ultra-Low Penetration Air (ULPA) filter piggy backed on it to remove at least 99.999% of all dust, pollen, mold, bacteria, and any airborne particles to enhance air filtration.

3.2.1.2 Climate. Aynah will try to emulate a Mediterranean climate with a temperature ranging from 20C to 30C and a humidity between 40% to 50% in the residential and the commercial areas of the colony. For industrial and agricultural sectors where specific temperatures are needed, there will be vacuum insulated panels to create the required temperature. There is a personal temperature and climate control in each of

Table 3.2.1 Atmospheric Composition (0.9 atm)

Gas	%	Volume m ³
Nitrogen	78	12,000,000
Oxygen	21	3,200,000
Carbon Dioxide	<1	155,000



Figure 3.2.1.3 Weather Park

the residents' dwellings to satisfy the inhabitants' preferences. There are vents throughout the colony that will take in carbon dioxide and release oxygen so there will be a constant stream of fresh air.

3.2.1.3 Weather Control. Aynah will install 3 weather parks in the residential spheres, each one modeling a season for the entertainment and viewing of the public. Each park will be monitored by the atmosphere and climate control system to make sure there is the correct amount of light, water, clouds, etc., to fit the season. The water used in creating rain and fog will be recycled constantly to ensure efficiency. The weather parks will psychologically help colonists adjust to the change of traveling from Earth to Aynah.

3.2.2 Agriculture. The harvesting and production of agriculture will be located on the center rod going through the main ring. This location was selected so that it is equal distance from all the commercial and residential area, thus make exporting the food out more efficient and faster. The exported food will be sent to processing, packaging, distribution plants that are located in the bottom and inner most layer of the ring. These plants are located near the commercial areas to make sure the transportation of the food is minimal.

3.2.2.1 Dynaponics. Aynah will be employing dynaponics which has several distinct advantages over any other growing method that justifies our usage. Dynaponics is a more efficient method in comparison to aeroponics in that it saves more money and energy, although they are both similar models and follow the same principle. Dynaponics also yields about 30 times more than geaponics while still maintaining the same level of taste and freshness. Because we are able to give the crops light 24/7 and control the temperature, we can grow food year round and it requires less equipment and nutrients, about 25 liters of water per plant as opposed to 70 liters for hydroponics and 300 liters for geaponics.

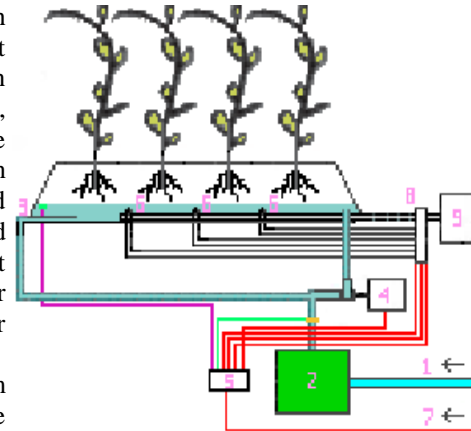


Figure 3.2.2.1 Dynaponics

3.2.2.2 Growth. The plants will be placed in a rectangular prism shaped structure that are 10m tall, 20m wide, and 15m long, where there are shelves for the harvesting robots to pull out and collect the agriculture. There will be several of these structures side by side for different crops but the bottoms will be open for all of them.

Underneath the prisms are flowing water that leads to several tanks of live fish. Lining the walls of the tunnel that carries the water are several tubes that will continuously shoot compressed air onto the top surface of the water. This will create a perpetual spray of water that will envelop the roots of the plants. The mini air cannons will be powerful enough to create enough spray that will reach even the highest of the roots. This is more cost and power efficient than aeroponics because it takes more energy to spray water rather than to spray air. Around the wall of drawers are also lined with OLED lights that will provide continuous artificial light onto the plants. The nutrients that are needed come naturally from human waste or fish waste. To ensure the safety of the colonists and the freshness, Aynah will not be using any synthetic hormones to increase the plants' growth rates and everything will be grown organically. We also practice a Zero Waste Policy where all the water is conserved and instead of importing nutrients, which will be very costly, we will be using fish waste as an alternative source.

3.2.2.3 Harvesting. Instead of having harvesting robots that will run between the dynaponic growing system and the packaging and storing plants, there will be several automated hands on top of the rectangular prism structures that will pick the agriculture and then lower them onto several long running treadmills located between the structures where they will transport the food to their respective packaging areas. There will sensory relays embedded and programmed in the hands to ensure that when harvesting, the food are not crushed or damaged. The hands are also responsible for replacing the food that has been taken out of the structure with seeds so the process can repeat itself. Within the structure are timers so the drawers will automatically open whenever the food is ripe and fresh for picking. Each structure will have different set timers since each vegetable and fruit has a different ripening period.

3.2.2.4 Cultured Meat. To satisfy the colonists' demand for meat, Aynah will be employing in vitro meat production to create a wide variety of synthetic options: beef, pork, chicken, etc. In vitro meat will be produced by getting a muscle tissue and giving it a protein that will make the tissue grow into larger portions of meat. The tissues will be placed in a bioreactor where there will be tubes connecting to it, allowing nutrients and oxygen to enter and help the tissues grow and fuse together and to allow any waste from the cells growth to exit. From there, we can genetically engineer the tissue to become any type of meat and modify the nutrient content so it will be healthier for the residents. For those who do not wish to consume the in vitro meat, we will also be producing meat substitutes made out of soy.



3.2.2.5 Fish. While we will be serving different types of meat to the colonists, there will also be a fresh supply of live fish in tanks near the agricultural sector of the colony. The two live fish that will be available for the buyers are tilapia and salmon. We have tilapia because it is able to live in any fresh water environment even if the water eventually becomes poor quality. Also, they reproduce rapidly and have a high tolerance for extreme density levels. salmon is popular among many cultures and will be served as a fancier and more expensive option. The tilapia and salmon will be in separate tanks since each have specific living conditions that need to be met. There will be temperature monitor and motion sensors inside each to ensure that the fish are living comfortably and there will be a feeder above that will release food on a set schedule. The water is constantly being cycled in and out to where fresh water is coming in while the dirty polluted one with the fish waste is recycled out and transferred to the underground tunnel where it will be used to water the dynaponic systems, serving as water as well as fertilizer.

3.2.2.6 Processing/Packaging/Storage. All the vegetables and fruits that are grown in the agricultural sector will be taken on to the processing and packaging plant where they will be sealed in an air tight vacuum packaging by using the thermoplastic wrapper polyethylene to ensure that freshness is maintained from the processing and packaging plant to the commercial/residential sector to sell. To do so, there is a temperature monitor in the package as well that tells the buyers the quality of the food. All food that is packaged and sent are kept within 3-5 Celsius in order to prevent rotting or any bacterial infection. There will be assembly lines, checked by robots and examined repeatedly for errors in misplacing the crops. There will be several assembly lines and machines that are reserved for different crops to ensure efficiency of the produces. Processing and packaging of the live fish and the in vitro meat will be on another different set of assembly lines since they require different processes.

3.2.2.7 Distribution/Selling/Emergency Storage. From the processing and packaging plant, the food will be split into two categories. The majority of the food will be sent to the commercial areas and be ready to sell to the residents on the colony. The other part of the food will go to an emergency storage in case there are disruptions in the agriculture sector or there is a sudden influx of people and the colony would need to prepare the necessary supplies. The storage will be located in each residential area to allow easy access and efficiency in times of crisis and the food will be recycled once every two months.

There will also be a storage of water for the colonists as well and any essential everyday items. The food and water supply, if properly used, can last a family of four for a week,

enough time for the colony to fix the interruption in agriculture or import supplies from outside of the Aynah.

Table 3.2.3 Electrical Power Generation					
Priority	Type	Electric Output	#	Allocation	Location
Primary	Solar	2,400,000 kW	4 solar panel fields	Cross shaped	End of the central rod
Secondary	Traveling Wave Nuclear Reactor	1,000,000 kW	Varies according to # of industrial modules	Industrial modules /agricultural ring	Industrial modules
Back Up	Rapid L Reactor	200 kW	Varies	Commercial Sector	Underground

3.2.3 Electrical Power Generation. Because Aynah orbits Mercury and is so close to the Sun, it is logical that we use solar power as our main source of electrical power generation. It is also one of the most cost-efficient methods out there in generating energy. Normally, due to the distance, other colonies located near the Moon and Mars receive scattered sunlight, although it is still effective. Aynah's solar panel, on the other hand, will be hit by concentrated sun beams with a solar constant that is 9.13 kW/m², which is about 6 times stronger than that of the Earth. This way, we are able to generate more energy and is collected more efficiently as well. We will also take advantage of the “peaks of eternal light”, high points where the sun is constantly radiating, whenever the colony orbits pass the poles. *For more information please refer to 3.4.*

3.2.3.1 Traveling Wave Reactor. Because of the massive power generation and efficiency of the Traveling Wave Reactor, the energy they generate will be used to power the heavy industry sectors and the

Table 3.2.3.2 Estimated Power Allocation/ Year	
Purpose	Power (kW)
Residential	40,000
Commercial	35,000
Heavy Manufacturing	400,000
Smelting	700,000
Research	50,000
Ports/ Spacecraft	200,000
Lighting/ Utilities	20,000
Agriculture	170,000
Communications	100,000
Climate Control	10,000
Transportation	170,000
Automations	150,000
Total	2,045,000

agricultural ring where there is a massive electricity requirement. It will run on what was previously thought as waste, Uranium 238 (U-238). In order to jump start the machine, it requires a small amount of Uranium 235 (U-235) which has a core containing most of U-238. The Traveling Wave Reactor will continuously reuse the waste that is produced until there is a miniscule amount left over that cannot be used, in which we will place it in a capsule and have it sent into the sun. This way, the colonists only need to refuel the reactors once every 10 years or so. With its low maintenance and relatively high energy output, the Traveling Wave Reactor is one of the safest nuclear energy generation

3.2.3.2 Rapid L Reactor. These reactors will be Aynah's emergency power source in the case that both the solar panels and Traveling Wave Reactors are no operational. These reactors will be placed within the commercial sector to supply power to it as well as the nearby residential areas. The Rapid L Reactor does not require a huge space seeing how its only 6 meters tall and 2 meters wide. Instead of using solid control rods like other nuclear reactors, the Rapid L has molten lithium-6 to effectively absorb neutrons in order to slow down the reaction and use molten sodium to cool down the reactor. With one Rapid L, we can produce 200 kilowatts of power and because of its size, it can easily fit in an basement or in between buildings to save space.

3.2.4 Distribution of Power. Because we are using both solar energy and nuclear reactors as our source of power generation, there are also two ways to distribute them in the colony. For solar energy, Aynah will use High Intensity Laser Power Beam as a source of wireless power transmission to the industrial sectors. Located on each heavy machinery is a vertical multi-junction voltaic cell that will convert the laser beam to electricity to be used with a laser generator located at top of the sector to continuously beam down energy and quantum cascade lasers to more effectively convert the solar energy to laser form. As for the nuclear reactors, because they are located near the residential and commercial sectors, it would inefficient to use lasers, whose primary usage is for long distance transfers. Instead there will be several superconductors passing at the top of each sector with WiTricity signals coming down supply power to all the houses and the commercial buildings and shops. WiTricity uses Two identical receptors in a single connection; one receiving coil is placed in the desired location for the reception while a transmitting coil is plugged in to a power source, which are the superconductors. The transmitting coil generates a magnetic field that induces a current in the receiving coil due to the identical resonance, thus distributing electricity across open space without the use of wirings. Within each building is another set of WiTricity receptors to distribute the power inside. These receptors are placed smartly with exact precision throughout the buildings and sectors in order to avoid gaps left open without an electrical connection or overlapping of fields that waste precious electricity. The electromagnetic field has no effect on humans or any biological organisms and will not be affected if objects interfere between the two coils.

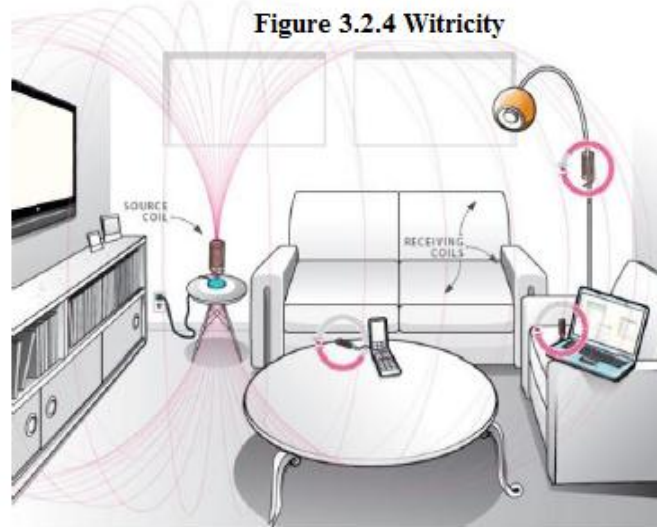


Figure 3.2.4 Witricity

3.2.5 Water Management. On average, a single person uses about 600 liters of water every day that includes drinking and washing.

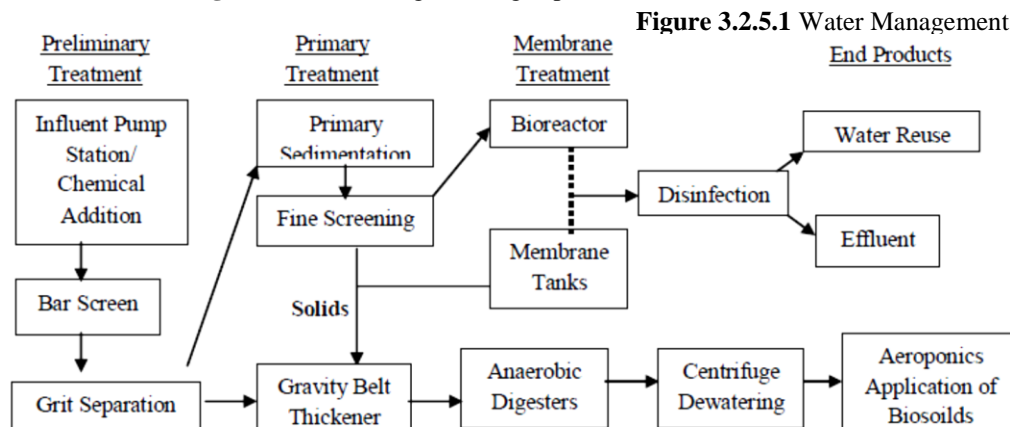


Figure 3.2.5.1 Water Management drinking and washing.

Therefore, to accommodate the 14,000 full time residents and 200 visitors, Aynah will need to continuously circulate 8,520,000 liters of water around the colony to meet everyone's

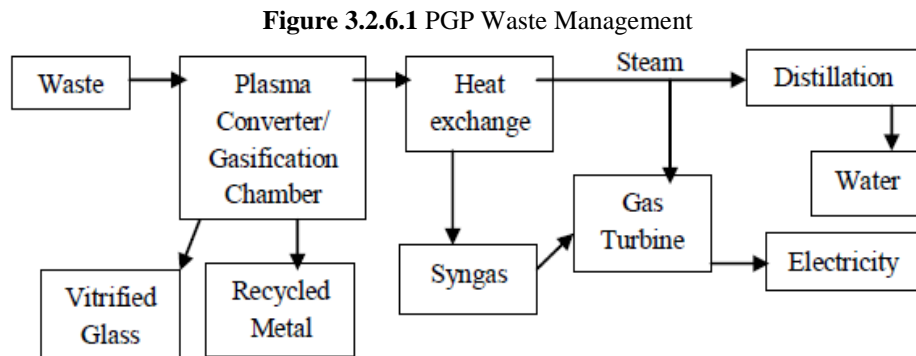
daily needs. We will primarily get our water from Mercury. There is ice on Mercury located at the bottom of some polar craters where they are in permanent shadow due to Mercury's tilt on the axis. The ice will be melted on the surface and transported back on our Rorschach ships to water treatment plants the main reservoir. There will be two main pipes that run throughout the colony to bring in fresh water and take away the used one back to the treatment plant, with numerous smaller pipes connecting to buildings and residents' homes.

3.2.5.1 Water Treatment. All water is monitored by sensors in the pipes to ensure that there is no contamination or leakage in the pipes when transporting the water to and from the Water/Waste Treatment Plant and the main water reservoir. The water enters the treatment center and goes through a series of filters of increasingly smaller holes to get rid of the bigger solid particles which will be diverted and go towards the Waste Treatment plant. After the last screening process, the water is deposited in a huge washer like machine where the spinning motion will force the smaller particles to coagulate and stick together. There will be a moment to allow the suspended particles to settle and be collected at the bottom of the tank. Finally, we will incorporate the membrane bioreactor (MBR) which will hold back miniscule particles and any microorganism. Finally, the water is treated with several chemical agents and exposed to electromagnetic radiation such as UV light. Two of the chemical agents that we will use for purification is chlorine and ozone. We will also add other agents such as lime or soda ash in order to balance the pH level of the water in order to make it safe for the drinker. To get rid of the remaining ions, we will put the water through electrodialysis which uses anions and cations to attract their opposites and draw them away from the water.

3.2.6 Waste Management. Whatever solid and waste that is extracted from the water treatment center is brought over to the waste treatment center to recycle because of our Zero Waste Policy. This policy takes the idea of reusing and recycling onto another level of sustainability. We believe that every material can be effectively and cost efficiently restructured and made to be practical in our society as well as benefit our environment. The eventual goal is to have zero household waste, zero industrial waste, zero energy waste, and zero toxic emissions. This policy also serves as a movement to make the colonists' more conscientious about recycling and forcing them to think of creative ways of reusing the same materials in different ways. We propose this idea in order to move Aynah towards a direction where the natural resources are not overused, the waste of any kind are minimal or zero, and the hope that we will one day achieve infinite sustainability in every respect.

3.2.6.1 Household and Industrial Waste.

To achieve our goal to achieve infinite sustainability, our system will split all incoming waste into organic or inorganic. For organic wastes, it will further be classified into liquid and solid. For liquid waste, it will be diverged to the Water



Treatment Plant in order to make the waste water into potable water. For the solid organic waste, it will be placed into sludge chambers where they will be dried to pellet form and all the water will be squeezed out and set to the Water Treatment Plant. The remaining pellets will be dissolved into the water that will be used to spray onto the crops in the agricultural sectors. Some of the organic waste and inorganic waste will be separated so they can go through the Plasma Gasification Process (PGP). Similar to incinerating the waste, the inorganic waste will be put into a controlled oxygen deficient environment to minimize the burning and fire to produce syngas and steam. Both will go towards a gas turbine to improve efficiency and produce electricity. The last byproduct that is produced is slag, a strong durable material that can be used in the construction of roads and buildings. The PGP system is the perfect system for our colony since it is environmentally friendly with no harmful toxic emissions and have useful byproducts for constructions and electrical power and thermal energy. In order to make the Zero Waste Policy more personal, Aynah will encourage the colonists to take initiatives in recycling and finding creative ways of reusing their waste.

3.2.7 Internal Communications. Internal communications on Aynah will use a peer-to-peer radio wave-based system with transmitters and receivers as it is the simplest and most cost-effective system while providing enough security and stability for the uses the station will require. The radio waves will be travelling along the 50kHz frequency, providing a wavelength long enough to readily pass through the solid objects in the station while also

being short enough to be easily transmitted and received. The peer-to-peer-based system will involve each household installing inexpensive routers and connecting to other routers to form an almost completely independent station-wide network of information transmission. Because of the inherent multi-path data lines, the failure of one or a few persons' routers will not compromise the speed or stability of the general network in any way. The Aynah internal network will also include six station with more powerful transmitters as a fail-safe, as well as to provide a security channel for personnel to use for communication.

3.2.7.1 External Communication. Because of the predicted high amount of data traffic that will be required of a link between Mercury and Earth, we will implement an infrared free-space optical communication system to address the issue of the necessity of high amounts of data transfer as well as the need to transmit information over the large distance between Earth and Mercury. Although traditional free-space communication systems are limited to a functional distance of several thousand kilometers, by using optical telescopes as beam expanders we are able to transmit signal over the millions of kilometers required for the interplanetary communication between Earth and Aynah. To prevent the possible hijacking of the signal we implement a laser N-slit interferometer which obscures the signal so any attempt to alter or access the signal will collapse the interferometric pattern. To maintain a constant line-of-sight communications line between Earth and Aynah the satellite will utilize a solar sail to provide continuous low-thrust propulsion. This alternative relay architecture is based on non-Keplerian orbits produced from such propulsion, and will enable continuous communications between Aynah and Earth by allowing the satellite to "hover" above Mercury out of its orbital plane.

3.2.8 Internal Transportation.

Primarily, the citizens will walk within their own respective residential spheres. There are bicycles available for longer destinations and as an alternative mode of transportation. However, for major and mass transit for the colonists to go from the one residential sphere to another or to the commercial sectors, there will be high speed Maglevs circulating within the transportation ring. The Maglevs use magnetic levitation to move forward and backward without any wheels or axles. This method of transportation will make travel smoother, quieter, and faster since there is no friction thus the acceleration can surpass those of normal railways. The Maglevs will run on both sides of the commercial sector to give easy access to the citizens and can go forward or backward, depending on the destination. The transportation ring will have three levels. The top level will be where

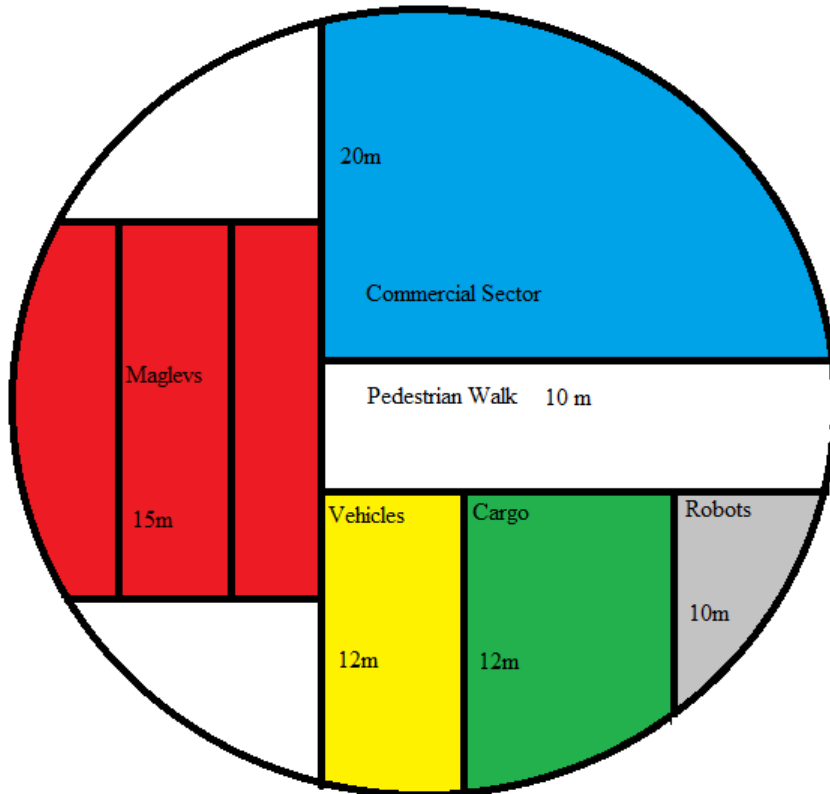


Figure 3.2.8 Internal Transportation

the stores begin and the pedestrian sidewalks to lead into the commercial area or to the station. The next level is for the Maglevs to operate on two specialized line to maximize efficiency for transporting. Under the Maglevs are transport routes where the robots, vehicles, and cargoes will travel. The bottom level will also travel along the entire colony, carrying agricultural and emergency goods and service robots. Connecting to the main ring are two pods known as Ithaca and Troy where there are schools for the children on the colony to attend. Connecting the two pods to the ring are two series of high speed elevators that goes roughly 40 meters per hour. Each motor within the elevator has a built that will continuously regenerate electricity, which helps reduce power consumption. There will be a central computer that will regulate how fast it is going and if it detects an error, it will trigger a mechanism to employ the breaks to grip the high intensity steel cables, which are coated with high heat and friction resistant

ceramic. The passengers will experience few vibrations and the elevators are completely insulated to make sure they are extra quiet. On top of each elevator is a fan to remove the air to alleviate the air pressure stress on the ears and body.

3.2.9 Day/Night Cycle. Because we are orbiting Mercury and there is a lack of atmosphere to reproduce a sky, we will be using OLED lights to simulate the 24 hour cycle like those on Earth. Because the OLED technology is so flexible, we can change the length of each day to simulate the seasons, which will correlate with the weather parks inside the colony. The lights are easy to maintain and only require a small amount of energy to keep it running throughout the day. This way, it will help the new colonists adapt to the psychological effects of arriving somewhere new if the time frame is still the same. There will be OLED technology lined all over the domes spheres so it shines everywhere, making the colonists feeling more at home.

3.3 CONSTRUCTION MACHINERY

3.3.1 Primary Construction Equipment/Machines. In order to greatly reduce the cost, time, and manpower of an onsite manufacturing of the colony, Aynah will use the most efficient method for its construction: the modular system. Building Aynah as one mammoth singularity holds several problems including the possibility lacking crucial resources and the sheer risk of having so many men and women operating and working in space. Therefore, the modular system subdivides Aynah into modules that can be manufactured independently of other parts, most likely on Bellevistat, and can then be used in a variety of functions that can fit into a variety of places. The modules can also satisfy the space demand for expansion by continuously adding on modules to fit the colony and colonists' needs.

3.3.2.1 Construction

Headquarters. The construction headquarters, known as Themyscira, will be constructed at Bellevistat and will be the first crucial machinery and equipment sent into the Mercury orbit. The headquarters will oversee and manage the entire construction sequence of Aynah, from start to finish. The headquarters will serve as an all in one system. It will house the few human workers that are needed to operate the systems and machines, the multiple robotic arms and apparatus to assemble, disassemble, and move around the modules, and a manufacturing center to give the construction process more flexibility, allowing changes to parts and structural components if necessary. Located at the top of the headquarters are import

and export ports where raw materials will enter straight into the manufacturing center and leave as finished modules. The manufacturing will be completely automated and will be done in a vacuum to prevent any mishaps and fires from affecting the other parts of the headquarters. The living quarters will branch out from the center while the robotic limbs will be spread out evenly and strategically on the surface of the headquarters to maximize efficiency in building the colony.

3.3.2.2 Materials and Transport. The most important first step is the find resources around the colony in order to create a self-sufficient entity from the start. There will be mines established on Mercury to get raw resources for the manufacturing center on Themyscira and for Bellevistat to create our modules. Using our fleets of Ozymandias, they will not only bring the hefty modules from Bellevistat to the Mercury orbit, they will also be the main tools used in the construction process. Ozymandias will be responsible for moving and shifting all the modules, modular rods,

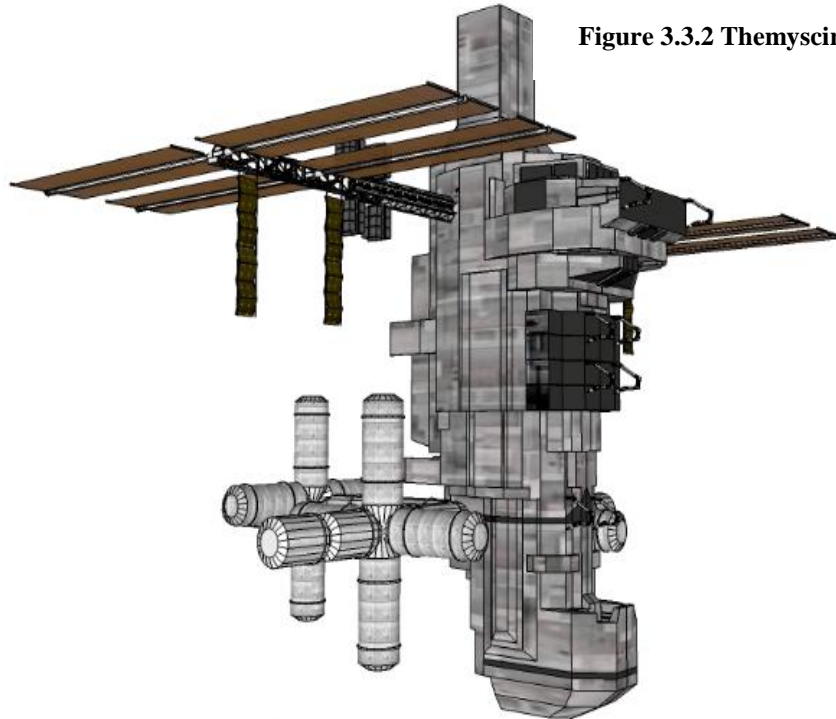


Figure 3.3.2 Themyscira

residential spheres, and commercial and industrial rings. Meanwhile, our smaller faster ships Rorschach will primarily be used for transporting raw resources and smaller equipment between Mercury, Themyscira, and Bellevistat.

3.3.2.3 Structural Assembly. Once all the materials are in orbit, all the modules will be assembled by several Jormungands robotic spacecrafts, equipped with robotic arms and specialized construction robots. There will be several refueling tankards to ensure that the construction process gets done as fast and safely as possible.

3.4 SOLAR PANEL AND ENERGY

3.4.1 Logistics. Solar Panels will be placed between the colony and sun, to maximize the surface area capable of harvesting energy. They will be located on the colony itself as opposed to the planet's surface, preventing them from having to transverse atmospheric gases and correspondingly leaving them purer while also eliminating the possibility of weather interference. Sunlight is concentrated and redirected onto solar panels by installing mirrors or lenses on all parts of the colony that are impractical for panel mounting. The harvested solar energy will then be converted into electrical energy on board via a thin film semiconductor layer and a rectifying antenna. The silver conducting wires will transfer the newly produced electricity into a storage vault, silver being used in this instance to preserve efficiency as a strong conductor. When the energy has been designated for a specific use, the antenna then emits a laser beam to a corresponding antenna on the planetary surface, which connects the energy with minimal loss.

3.4.2 Maintenance. A gamma ray detector (formed with Cadmium Telluride [CdTe] and Zinc [Zn]) is used to ensure the durability of the solar panels by giving forewarning of extreme gamma ray exposure. The toxicity of CdTe at high temperatures does not pose any health to humans or the environment. Thick glass sheets will cover the face of the solar panels, serving the dual purpose of magnifying the heat of the sun and protecting the panels themselves from completely naked exposure. There will be an emergency water shield in front of the glass, in the event that a flare spray occurs when the colony is within relatively close range of the sun. The water shield will only be activated in the event that the temperature sensors overload, and will henceforth provide a cascading screen of water. If the water were to exceed 370°C, the steam would be captured and used to turn a turbine/generator system and efficiently produce electricity via hydroelectric power. On the cells are nanoengineered antireflective coating which consists of several layers of silicon dioxide and titanium dioxide nanorods. This coating will allow the solar panel to absorb light from the entire spectrum regardless of what angle it hits the arrays.

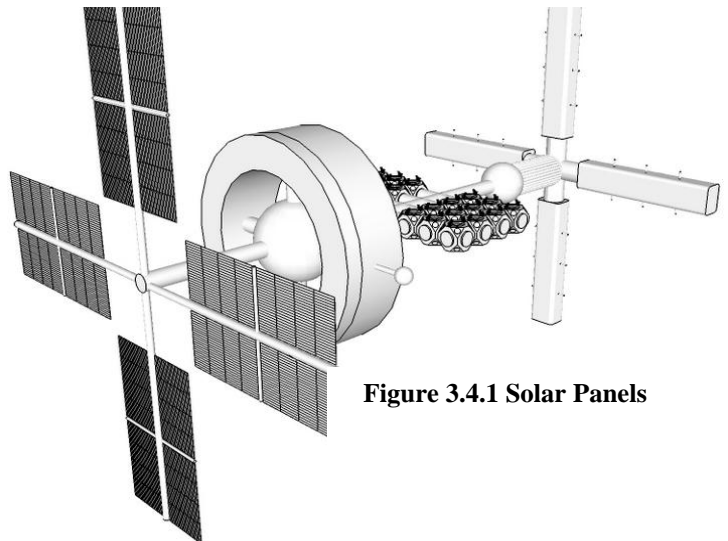
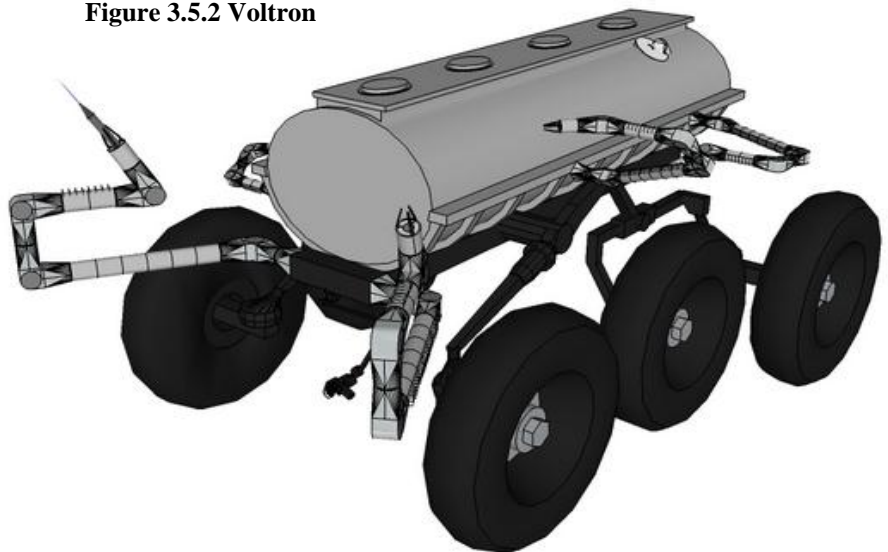


Figure 3.4.1 Solar Panels

Figure 3.5.2 Voltron



3.5 SURFACE EXCAVATING VEHICLE

3.5.1 Internal Hardware. In order to satisfy the high demand of reardonium, Aynah will employ the



use of the space mining and exploration vehicle named Voltron. To accommodate the various requirements and tasks the vehicle will need to fulfill it is necessary to implement a central circuit with flexible programming and communications technology. Because of the extreme variance of the ambient temperature on Mercury's surface, we utilize a SCDA (silicon carbide differential amplifier) integrated circuit, which is capable of functioning properly up to approximately 900K, well above the maximum surface temperature of Mercury, 700K. In addition, it is also able to perform well below Mercury's lowest surface temperatures of 80K. We include high-grade shock absorbers so that the circuit board will be able to handle the extreme conditions of Mercury. The chip has a communications component to be able to send information in real-time through X band radio waves. The majority of the internal components, as well as the exterior body parts, will be built mainly with reardonium because of its lightweight, strength, and protection from heat, cold, and radiation, all threats from Mercury. In order to make the Voltron stronger, we will couple the reardonium parts with the superalloy Iconel, which is austenitic nickel-chromium based. Iconel is oxidation and corrosion resistant and ideal for high temperatures and is very sturdy and strong to add support for the reardonium.

3.5.2 External Components. The robot utilizes six wheels that are made with vulcanized rubber in order to give Voltron more traction as it maneuver up hills and craters. They are mounted on a rocker-bogie suspension system, which minimizes the amount the rover moves up and down that may possible make it unstable and tip over as well as providing the ability to handle most alien terrain that the robot will encounter. Each wheel will have its own motor to ease the stress off the vehicle's engine and allowing flexibility in accommodating more difficult situations and more options to improvise a way out. The vehicle itself will function much like a tank truck, with a large compartment to hold the metal in transport. The metal itself will be stored in racks for ease of drop-off/pick-up. On the sides will be several automated robotic arms and mining equipment such as drills and lasers that will excavate the reardonium and break it up into manageable pieces for the arms to transfer them into the large compartment. The robotic arms will be equipped with sensors as well that will identify the resource as reardonium as well as handle them with care. At the front of Voltron will be another set of sensors using sonar for Voltron to navigate the Mercury terrain without the assistance of man. This way, it frees up human workers to oversee the entire excavation process rather than just focusing on individual vehicles. The sonar technology will allow the fully automated Voltron to navigate pass crevices and through high mountain tops to prevent any situation that may cause an impasse, thus delaying the mining process and lowering efficiency level.



HUMAN FACTORS

4.0 HUMAN FACTORS

The revolutionary colony Aynah is designed to provide the maximum comfort and excitement to residents adjusting and settling down in space. Aynah provides the latest innovative technologies for a vibrant new lifestyle.

4.0.1 Natural Sunlight. Aynah will be lighted with natural sunlight from windows located on the side facing away from the sun. Sunlight is available to the colony 24/7 and can be blocked during different times of the day.

4.0.2 Artificial Lighting. Roads will be illuminated with motion-detecting OLED lighting along their perimeters. These lights can sense any person, robot, or transportation system from up to 100 meters away to temporarily illuminate the surroundings. During busy times during the night, most of the commercial and residential sectors are continuously lighted.

4.0.3 Day/Night Cycle. Aynah will function on a 24 hour, 7 days a week Earth cycle. Regulation of sunlight penetration and the use of artificial lighting will allow the residents' circadian rhythms to adjust accordingly.

4.0.4 Views of Mercury. Aynah is designed to provide grand views of the surface of Mercury for residents to enjoy. Large windows and observatories will be located throughout the colony that face away from the sun.

4.0.5 Roads for Pedestrians and Vehicles. Residents will have access to all locations throughout the colony using our extensive road network. The roads will be shaped in a diamond-grid pattern to prevent long lines of sight (*see*

4.1 Community Layout)

4.0.6 Fine Foods & Dining. Aynah's five star dining restaurants are located in the heart of Aynah's commercial center Avalon for the bustle and excitement of high class dining. These restaurants are great social areas for visiting businessmen and tourists looking for a taste of the best variety of international cuisine.

4.0.7 Skies. OLED panels will line the upper walls and ceilings of the colony to illuminate the pods with skies of the cosmos. They will transition accordingly with our artificial 12 hour day/night cycle and include sunsets, starry skies, real-time views of outer space, and bright blue skies.

4.0.8 Psychological and Physiological Factors. There are several factors that arise when humans must live in space for an extended period of time. In order to prevent problems that may arise with the change of environment, we have proposed solutions to alleviate any discomfort.

4.0.8.1 Isolation. Many of our residents will be traveling to Aynah alone, leaving family and friends behind. To overcome fears of living alone, the community has been designed to encourage social interaction with other colonists. The commercial sectors have arcades, restaurants, theaters, and more that are constantly connected to other people on the colony and to those on Earth. At home, satellite systems allow residents to communicate with others on Earth.

4.0.8.2 Bone and Muscle Atrophy. Loss of bone and muscle mass is common when residents are exposed to a low G environment for a prolonged period of time. To counteract this, gyms are located around the commercial sectors for people to perform resistance training during special programs twice a week.

4.0.8.3 Disorientation due to the Coriolis Effect. In order to mitigate the discomfort and disorientation that newly-arrived residents may experience in their first couple of weeks due to the Coriolis Effect, we have reduced the rotation rate and will provide training sessions for all incoming colonists. These training sessions will be held by professional trainers who will engage the residents in various exercises to orient their bodies with different movements.

4.0.8.4 Claustrophobia. Since residents are living in a confined space, we have taken measures to utilize as much area as possible to increase living area. All homes are designed to save space but are arranged so that they provide the large open living rooms and views. (*see 4.2 Residences*)

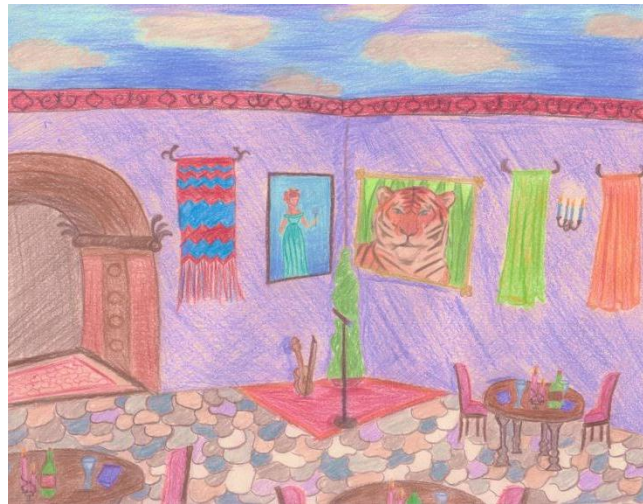


Figure 4.0.3 “The Jungle” Fine Dining Restaurant

4.1 MODERN COMMUNITIES

Aynah's mission is to always put humans first. We value the residents' comfort and place high living standards upon our communities. Our specific neighborhoods are designed to cater to different family types and will be located within walking distance of our commercial sectors for easy access to restaurants or shopping centers.

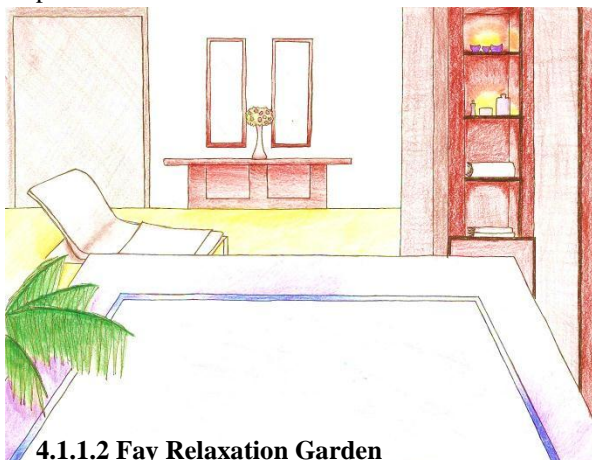
4.1.1 Facilities. Aynah will have a multitude of first-class facilities in the commercial sectors that will provide fun and healthy activities for residents' dreams of an out-of-space experience.

4.1.1.1 King Arthur Research University. The King Arthur Research University is a facility where the top scientists will gather to study. The University will be the heart of all aerospace studies and Mercury-based research.

4.1.1.2 Fay Relaxation Garden. The spa and garden will provide the residents with a place to relax and unwind from everyday troubles and stress. Only the top trained therapists will work at the spa. Aside from the traditional indoor spa, we will also have an outdoor garden spa with greenery to soothe the mind. Beside the outdoor garden spa, we will have a Zen garden.

4.1.1.3 Exercise Center/ Sports Complex. To keep the residents fit and healthy, Aynah will have an exercise center and sports complex. The exercise center will contain all the latest gym equipment. Trainers will lead the residents in exercises and help the people use the machines properly. Yoga trainers will help people balance their inner harmony. The sports complex will contain a gym, which can be altered into various sport fields. We will provide the residents with basketball courts, volleyball courts, badminton courts, and tennis courts and once a week, microgravity sports tournaments.

4.1.1.4 Merlin Center of Culture and History. This museum will be designed to educate the residents with interactive, hands on activities, live demonstrations and presentations. Not only will we have educational branches in the museum regarding space, history, science, and art, we will also have a neon art department.



4.1.1.2 Fay Relaxation Garden

Table 4.1.1 Variety and Quantity of Facilities			
Buildings	Quantity	Floor Area / Unit	Total Floor Area
Round Table Headquarters	1	7500	7500
Hospital	2	8000	16000
Market	4	3000	12000
Religious Facility	5	2500	12500
Bank	4	1000	4000
Transportation Station	1	5500	5500
Shopping District	2	20000	40000
Excalibur Theater	2	3500	7000
Large Restaurants	6	2000	12000
Small Restaurants	10	750	7500
Justice Center	2	2000	4000
Exercise Center/ Sports Complex	3	2250	6750
Small Clinic	3	900	2700
Weather Park	3	12500	37500
Fay Garden	2	1200	2400
Arcade	3	750	2250
Office Buildings	8	7500	60000
Merlin Center of Culture and History	1	10000	10000
Fine Dining (caviar)	2	1250	2500
Computer/Robot Repair Center	3	5000	15000
Visitor Center	1	2150	2150
Hotel	1	8000	8000
Waste/Water Management	1	5000	5000
Industrial District (Warehouse, backups)	1	13000	13000
Night Clubs	2	2200	4400
King Arthur Research University	1	20000	20000



4.1.1.5 Small Restaurants. For quick, family dining, small restaurants are located throughout Avalon and Camelot to provide delicious and nutritious food for adults and children. Friendly and efficient staff are always at hand to create a familiar and comfortable environment for families.

4.1.1.6 Weather Park. The weather parks are designed to simulate the weathers found on Mother Earth. People can enjoy the autumn leaves and the winter snow all without leaving the colony.

Table 4.1.2 Variety and Quantity of Consumables

Food	kg/ person/ day	kg/ person / yr	kg/ populatio n/ yr
Brown rice	0.25	91.25	1295750
Wheat	0.3	109.5	1554900
Soy	0.1	36.5	518300
Bell peppers	0.05	18.25	259150
Mushroom	0.1	36.5	518300
Cucumbers	0.05	18.25	259150
Spinach	0.1	36.5	518300
Broccoli	0.1	36.5	518300
Sweet Potatoes	0.1	36.5	518300
Onion	0.1	36.5	518300
Blueberries	0.1	36.5	518300
Strawberry	0.05	18.25	259150
Tomato	0.15	54.75	777450
Cantaloupe	0.05	18.25	259150
Tilapia	0.1	36.5	518300
Salmon	0.1	36.5	518300
Beef	0.1	36.5	518300
Chicken	0.15	54.75	777450
Pork	0.1	36.5	518300

4.1.1.7 Excalibur Arts Theater. The theater is the ultimate center of entertainment. People can watch movies with their choice of 2D, 3D, or 4D or indulge in live entertainment of operas, musicals, plays, and concerts.

4.1.2 Consumables. Aynah will farm and produce a variety of foods and consumables that were each chosen specifically for their nutritional value and appeal to our palates. All of the foods chosen are convenient to produce and can be prepared in many ways. They will be grown using dynaponics (*see 3.2.2.1 dynaponics*) and are calculated to provide food for visitors and for storage during unexpected contingencies. (*see Table 4.1.2*)

4.1.2.1 Bell peppers. Bell peppers are packed with vitamin A and C, which are essential in boosting the immune systems of the residents of Aynah. Bell peppers also contain fiber, folate, and vitamin B6, which promote heart health and reduce the risk of several cancers such as colon cancer. Red bell peppers, rich in vitamin B, can help alleviate stress and depression.

4.1.2.2 Blueberries. Blueberries contain minerals, vitamins, and antioxidants, which helps fight against harmful free radicals and protect against cancers, aging, degenerative diseases, and infections. Since blueberries contain chlorogenic acid, blueberries can be used to help lower blood sugar levels and control the blood glucose levels in people with type 2 diabetes. Blueberries have minerals such as potassium, manganese, iron, copper, and zinc, which aid in the production of red blood cells.

4.1.2.3 Caviar. Caviar, containing large amounts of minerals and vitamin A, C, and D, will be used to garnish dishes in our fine dining restaurants. Salmon caviar contains protein, which contains omega-3 fatty acids that supports eye health, brain function, cardiovascular health, and the immune system. Caviar can also lower the risk of cancers such as breast, colon, and prostate and can reduce the chances of heart attacks and strokes. Because caviar

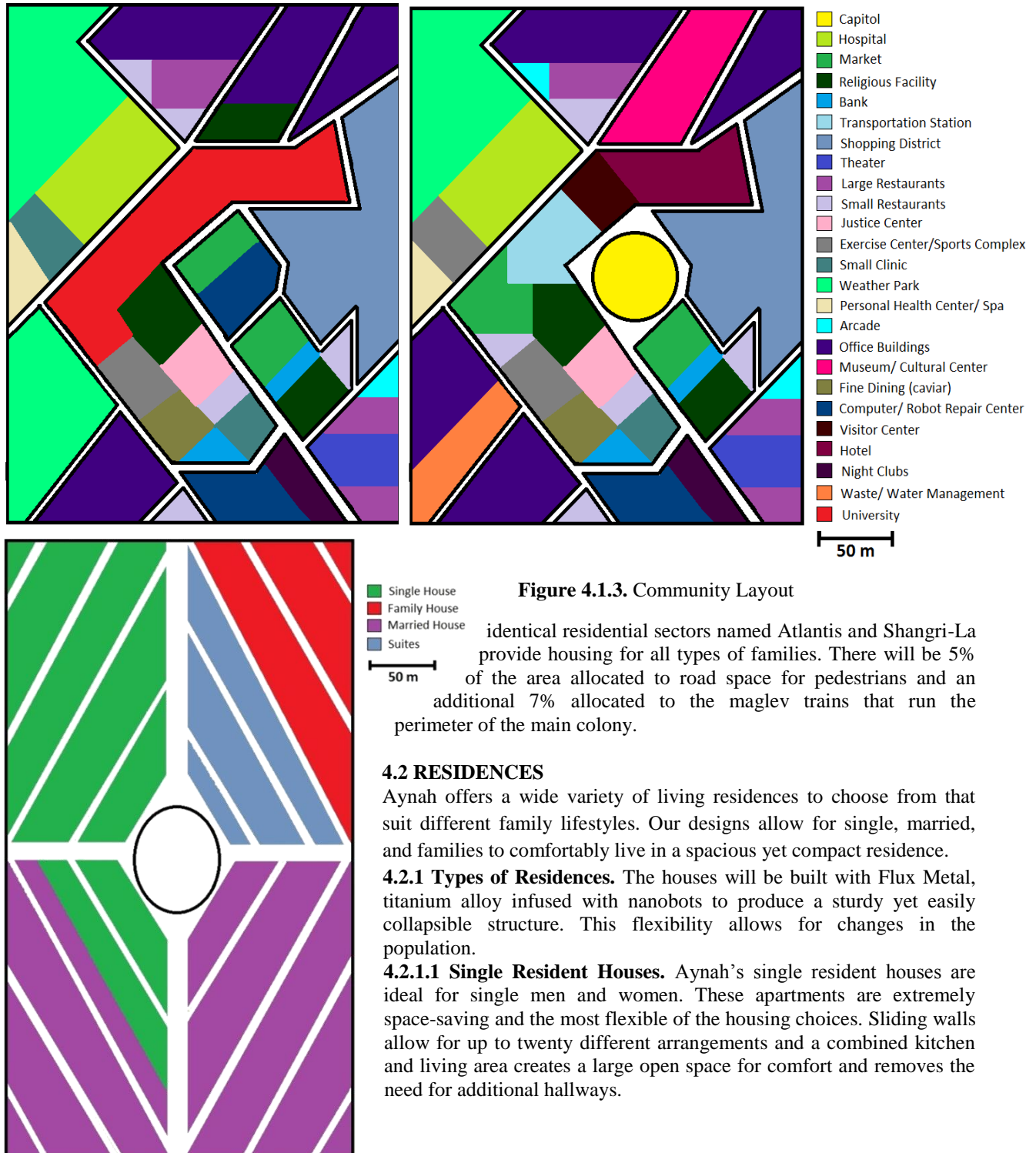
Table 4.1.3 Distribution and Quantity of Water and Consumer Goods

Water and Consumer Goods	Source	Consumption/ Person	Total Consumption	Method of Distribution
Water/day	Imported from Mercury	600 L	8520000 L	Water will be distributed to the colony by the pipe system.
Fabric/year	Fabric will be imported from Bellevistat at an initial amount and recycled	30 kg	426000 L	Fabric will be manufactured in the factories into clothing and furniture and distributed by maglev trains and robots.
Paper/year	Paper will be imported from Bellevistat and recycled and reused.	265 kg	3763000 kg	Paper will be transported by maglev trains to the commercial and residential sectors and distributed by robots to individual businesses and households.

contains high hemoglobin contents, it is recommended for patients recovering from serious surgery and chemotherapy.

4.1.3 Water and Consumer Goods. Water is imported from Mercury and distributed to every facility and house in the colony. Paper and fabric are necessary for daily uses and will be available to businesses and houses. (See Table 4.1.3 for details.)

4.1.4 Community Layout. The colony is divided into two main commercial sectors named Avalon and Camelot. Avalon holds the capitol and focuses on business while Camelot is dedicated to research and education. Two



4.2.1.2 Suites. Suites are the featured luxury residences of the colony and rooms up to two occupants. The shared suite encourages interaction and is recommended for the colony's scientists. Each suite contains a home theater, two bathrooms, and two spacious bedrooms with state-of-the-art workstations.

Type of House	People/ Unit	Quantity	Floor Area/ Unit (m ²)	Total Area (m ²)
Single	1	3000	65	195000
Family	3-5	710	120	85200
Married	2	3600	90	324000
Suites	2	1000	80	80000

4.2.1.3 Married House. The colony's married co-house structures provide couples with the perfect balance of traditional rustic feel and sophisticated contemporary architecture.

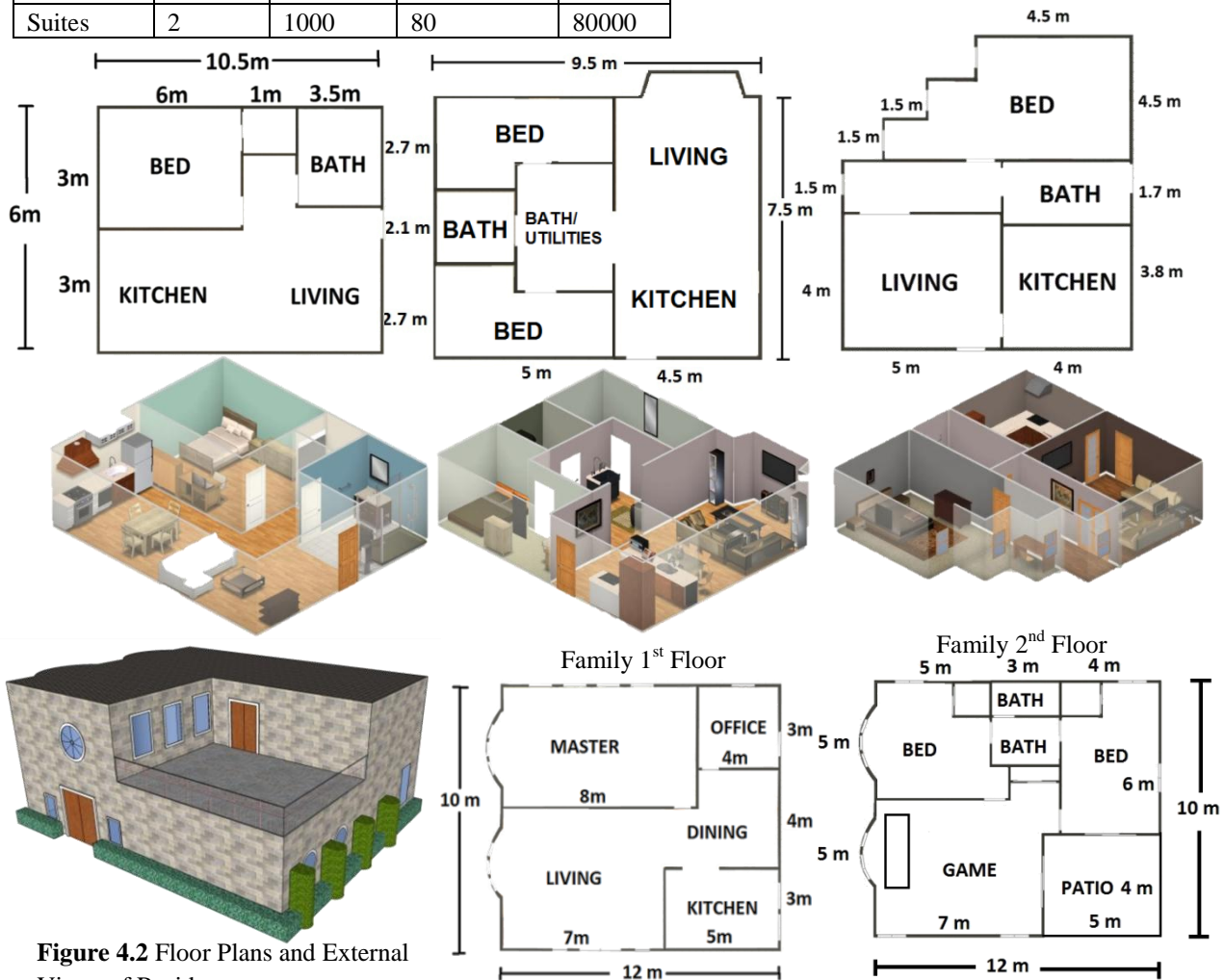


Figure 4.2 Floor Plans and External Views of Residences

4.2.1.4 Family House. The largest residence in the colony provides households with children a spacious and versatile living area, with three bedrooms, two bathrooms, an office, an entertainment room, and a patio. Each bedroom is equipped with the latest technology to monitor children's health. All furniture is child-proof.

4.2.2 Furniture. All furniture on Aynah is designed to be lightweight for materials that need to be imported and space-saving and minimalist. (See Table 4.2.1 for details.)

4.2.2.1 Sources of Furniture. All our furniture is either manufactured on the colony or imported depending on availability.

Item	Source	Single	Married	Family	Suites	Office Building
Chairs	Plastic, Manufactured	3	5	10	7	550
Dining Tables	Plastic, Manufactured	1	1	1	1	20
Bedding	Fabrics, imported	1	1	3	2	0
Office Workstations	Plastic and Glass, manufactured	1	1	3	2	500
Televisions	Glass, manufactured from silica	1	1	2	1	10
Toilets	Ceramics, manufactured from silica	1	1	2	2	25
Sinks	Ceramics, manufactured from silica	2	2	3	3	30
Showers	Ceramics, manufactured from silica	1	1	2	1	0

4.3 DEVICES AND TRANSPORTATION

4.3.1 Vehicles.

4.3.1.1 BLOX. The BLOX is a one of a kind folding bike that transforms personal transportation. Its carbonized structure and heavy standard frame allow the bike to be folded and carried within a briefcase. A suspension frame system of carbon fiber and Kevlar cables creates a rigid and supportive structure with the right balance of tension and compression. The modular BLOX can fit two wheels, one lightweight for use in Pangaea and one with extra grip and weight for areas with lower gravity.



Figure 4.3.1.1 BLOX

4.3.1.2 Maglev. For longer distances, residents are encouraged to board the maglev train that runs through the whole main colony. These frictionless trains will allow fast speed transportations for daily commutes between the residential and commercial sectors. When exiting Pangaea, maglevs provide a safe means of transportation to the lower gravity sectors of Aynah.

4.3.2 Devices and Systems for Safe Access.

4.3.2.1 No-Slip Grips. An extremely thin layer of corroborated rubber will be applied to most surfaces that require handrails and beneath shoes.



Figure 4.3.2.1 No-Slip Grips on Shoes

4.3.2.2 Tether System. There will be a tether system that consists of a twenty meter tether that is attached at all times to the user and the base and shorter tethers that users can connect to handrails, doors, and more to balance or position themselves.

4.2.2.3 Aim Advanced Alert (AAA). The AAA system is used to alert security officials by relaying a distress signal located on every resident's handheld devices when emergency assistance is needed. The signal is rapidly relayed by devices nearby to increase speed and breadth. As computer systems scan through the profiles of the owners of the handheld devices and detect someone who can assist the emergency, the devices emit a noise to alert the person in distress that there is help nearby. Security officials can pinpoint the source of the signal and receive

immediate descriptions of the emergency.

4.3.3 Spacesuits. Spacesuits are provided at each airlock for scientists to safely travel outside the colony.

4.3.3.1 Design of Spacesuits. Spacesuits will be composed of two parts, a skin-tight BioSuit designed to maintain body pressure while providing ease of movement and an exoskeleton that provides strength and protection.



Figure 4.3.3.1 BioSuit

4.3.3.1.1 Life Pack. The Life Pack, located behind the BioSuit, monitors body pressure, oxygen composition and vital signs such as heart rate and body temperature. It will adjust the BioSuit and exoskeleton accordingly to maintain constant and safe conditions for the user.

4.3.3.1.2 Headgear. The headgear will protect the user from any head trauma while displaying important information and vital signs. All communication can be processed in the headgear.

4.3.3.1.3 Robo-Glove. The Robo-Glove is designed to make lifting or gripping tools easier, by allowing the user to apply only 5 pounds of force to exert 20 pounds. A complicated system of actuators, sensors, and tendons allow the Robo-Glove to mimic a human hand and create a unique experience for the user.

4.3.3.2 Spacesuit Stowage. Spacesuits will be stored in compartments in the airlocks located around the colony.

4.3.4 Airlocks. Airlocks are located at all entrances and exits in the colony so every person will be able to adjust to the difference in gravity. Each entrance will have two



Figure 4.3.3.1 Exoskeleton

simultaneous airlocks to prevent debris from entering the colony and to allow people to adjust over a longer period of time. Each airlock can hold up to two people. The first airlock (Volume = 17.82 m^3) will reduce atmospheric pressure from 1 atm to 0.7 atm while the second (Volume = 17.82 m^3) will reduce the atmospheric pressure from 0.7 atm to 0.3 atm.

4.3.4.1 Procedure. The first airlock provides amenities such as bedding and water for two people to stay overnight to adjust as the atmospheric pressure slowly drops. Pure oxygen replaces the nitrogen and oxygen mix of air composition while donning of spacesuits begins. After donning, the person enters the second airlock with an atmospheric pressure of 0.7 atm. The remainder of the depressurization process begins until the pressure drops to 0.3 atm. One final check of spacesuits and airlock safety is made before the door to the exterior of the colony opens.

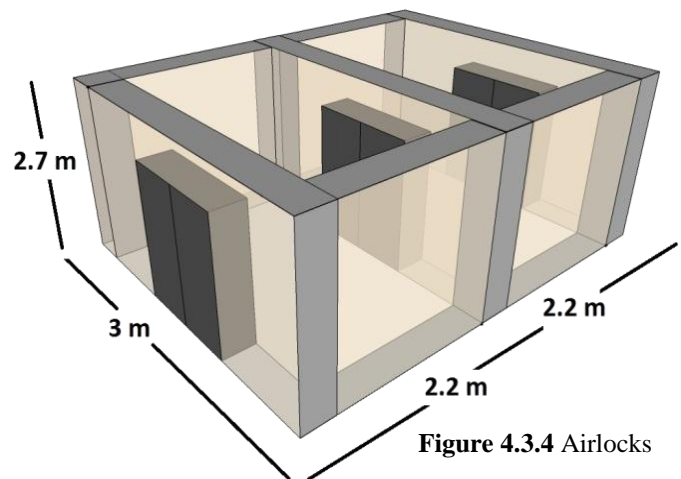


Figure 4.3.4 Airlocks

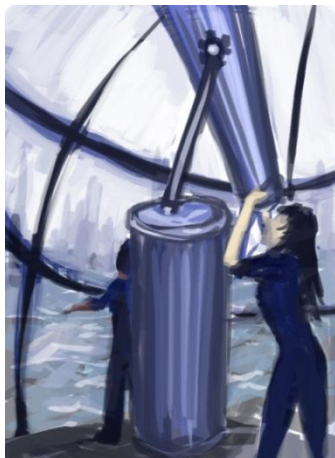


Figure 4.4.2 Learning in Schools

4.4 1G POD

4.4.1 Difference of

Gravity. In order to promote healthy children's growth and development, Aynah has created two separate spheres outside the main colony that will accelerate at 1G instead of 0.7G in the main colony (*see 2.1.1.1*) Studies have shown that children who spend at least 3 hours a day in 1G will be able to properly develop.

4.4.2 Schools. Children will attend schools in Troy and Ithaca daily for five hours a day. Elementary level students will have one teacher and one class to increase each student's attention and care. Students in Middle School and High School will attend an array of six classes over the week in a block schedule. There are regular field trips to the Research University and to different areas of the colony, such as the agricultural sector to enrich the learning experience. All subjects are taught.

4.4.3 Day Care. Day Care is provided from 1PM to 3PM daily for all students. Indoor recreation includes schoolwork help, arts, and other activities within the

room.

4.4.4 Sports. To promote an active lifestyle, large parks surround the schools and hold basketball, baseball, tennis, lacrosse, football, and soccer courts. A swim arena and track are indoors. Playground and outdoor sports time is provided seven days a week for children.

4.4.5 Weekend Education. Aynah strives to provide a well-rounded education for children. Art centers attached to the schools allow children to stretch their right brains and produce works of art. This specialized program will allow the Museum in the main colony to feature the children's artwork monthly. A focus class every Sunday helps children develop efficient working habits by engaging them in fun exercises. It is important that these children learn how to manage time, develop organizational skills, and be a leader to their peers.

Table 4.4 Sample Schedule of Ithaca and Troy Activities

Time	Monday-Fridays	Saturdays	Sundays
8AM-12PM	School	Art Center	Focus Class
12PM-1PM	Lunch	-	-
1PM-3PM	Day Care and Indoor Recreation	-	-
3PM-6PM	Playground and Outdoor Recreation	-	-

4.5 SURFACE INSPECTION VEHICLES

4.5.1 Human Monitoring of the Parts Curing Process. Each month, a team of two scientists will travel on the surface of Mercury to monitor the parts curing process.

4.5.2 Day Vehicle. Nicknamed the Titan, the day vehicle is designed to prevent radiation from penetrating into the cabin while maintaining a sound structure. The Titan features a closed faraday cage, which is impervious to outside electronic signals such as high energy wavelengths from the sun and radiation. A pre-programmed route will help humans reach the destination. The Titan is extremely sturdy and has a low center of gravity to stay grounded at speeds of 100 kilometers per hour. Evenly-spaced and treaded wheels tighten turns and allow more grip.

4.5.3 Night Vehicle. Nicknamed Shadow, the night vehicle will be the main vehicle used for surface travel on Mercury. It is guided with triangulation based on the colony and the outpost on Mercury. The efficient lithium-ion batteries and graphing batteries allow up to 800 kilometers on each charge. The Shadow features similar treaded wheels that reduce turning radius and allow for sturdier trips on the terrain. The minimal friction keeps the vehicle agile.

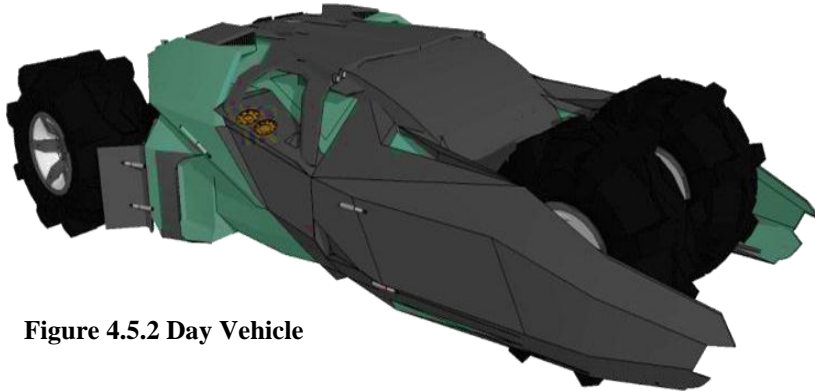


Figure 4.5.2 Day Vehicle

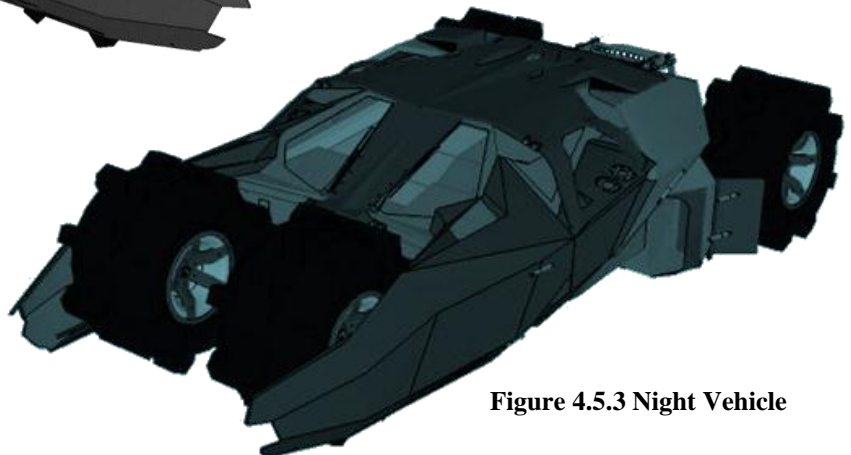


Figure 4.5.3 Night Vehicle



AUTOMATION DESIGN AND SERVICES

5.0 AUTOMATION DESIGN AND SERVICES

Automations in Aynah will serve to reduce the need for manual labor and allow the citizens of the colony to focus on the production of reardonium and study of the planet Mercury. As Aynah is intended to be the stepping stone into Mercury, Aynah's automated systems and robots must be able to adapt to extreme conditions, from the extreme heat, to the extreme radiation. Ergo, robots are designed to function despite losing components in a revolutionary new system that allows robots the ability to function in the harshest of environments. Not only will these robots be revolutionary, but the nature of the buildings themselves allow for an innovative new way to quickly place complicated structures in the harshest of environments in the shortest period of time.

5.0.1 Computing Specifications

5.0.1.1 Hardware Features

5.0.1.1.1 Memory. The colony's data servers will consist of interlocking non-volatile memristor latches which will effectively combine the random access memory, universal memory, processor cache and general storage together making it more cost and space efficient. In addition, with the combined processor cache and general storage, accessing and retrieving files will happen near instantaneously due to all the information being on site and ready for use. The non-volatile nature of the latches allows for nearly instantaneous boot and shut down procedures, increasing efficiency and productivity. Memory will be stored in holographic crystals allowing for a nearly unlimited amount of storage space that can be easily accessed at great speed. These crystals are read without moving parts thereby keeping information safe while allowing servers to answer quickly to replies while containing large amounts of data.

5.0.1.1.2 Processors. On Aynah, the computers will contain a processor made of multiple-core graphene chips. Graphene transistors can allow processors to achieve up to incredible speeds of 500 GHz due to their extremely electro-conductive nature. Multi-threaded programming will take full advantage of multi-core capabilities in order for the colony to use these processors with maximum efficiency.

5.0.1.1.3 Display. User interfaces across Aynah will use electrofluidic (EFD) displays, which will be haptic, allowing for interaction. These will also be accessible through personal devices allowing for greater functionality. Because EFD displays use water based ink technology, it is capable of high quality images while also retaining an energy efficiency surpassing that of LEDs.

Table 5.0.1 Computers				
Name	Amount	Dimensions (L*W*H in meters)	Memory	Purpose
PID-Personal Interface Device	Initially 20,500, 50 more per year	0.07*.03*0.0001	500 GB	Communications Device
Cerberus	Initially 10,300, 20 more per year	0.3*0.4*0.2	32 TB	Home Computer
Research and Business	2100	0.4*0.6*0.3	128 TB	Research and Business Computer
Server	850	0.6*0.5*1.0	1 PB	Colony



Figure 5.0.1.3 PID

to allow user to work wherever they are on the space station. Because these devices are made of graphene, these devices will also remain water

5.0.1.3 Personal Interface Device (PID). The PID will be a personal device that allows the user to access the residential server at any time they please. This device will be in a bracelet form and be made of graphene thereby leaving it extremely thin and light weight while flexible and stiff. This device will be unique to each user and respond only to the user's interface through finger print and DNA analysis. These devices can be taken off and folded out into a larger screen for better control and viewing purposes. They contain a wireless connection to the server which allows the user to access it at whatever time they please but does not allow for a direct connection to the main server. Business servers can also be configured

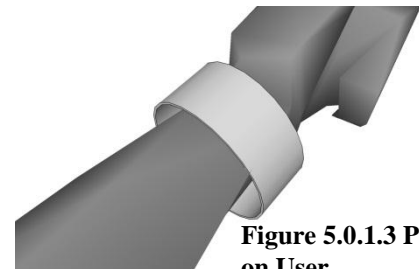


Figure 5.0.1.3 PID on User



resistant, heat resistant, and shock resistant due to the resilient structure of the material. In addition, when powered off, these devices will be rendered nearly transparent due to the thinness of graphene. With near transparency and extreme lightweightness, users can forget they are even wearing their PID. The PID can be voice activated as well.

5.0.1.4 Cerberus. Home computers will be provided with living arrangements in order to provide a more intelligent home. These computers, named Cerberus, will be able to operate every appliance in the house, giving residents complete control over energy usage and functions inside their home. Commands of both verbal and physical in nature will be relayed to the computer through a system of sensors allowing the resident the ability to direct and monitor the activity within his or her own home. *For more information, refer to Section 5.3.3.1.*

5.0.2 Software Specifications. Computer resources will maintain their efficiency through the use of intelligent programming systems running on self-reconfiguring FPGAs. Because the intelligent programming is based upon an evolutionary code, it is constantly reconfiguring the FPGA; ergo the colony's servers will improve at their tasks over time, radically improving efficiency when compared to static programs and processors which must be manually updated to account for new breakthroughs or equipment.

5.0.3 Robot Design Features

5.0.3.1 General Robotic Fabrication. Aynah will feature a revolutionary new system in which nanobots are produced through a series of components produced by genetically modified bacterium. The bacterium will create the components needed on a Nano scale and the nanobot is later placed together through an enzyme catalyzed reaction completely free of human interaction. This allows for the large scale creation of nanobots allowing for quickly replacement whenever needed. The chassis will mainly consist of 6061 aluminum alloy though for support some parts of the chassis will be constructed of titanium 6Al/4V alloy.

5.0.3.3 Location. Nanobots will pinpoint locations through an infrared signal that is amplified by the surrounding medium through which it is then guided by satellite or manual control on site. The communications to these nanobots will have a fairly high range for its small size due to the amazing qualities of the reardonium alloy used in the nanobot medium.

5.0.3.4 Energy Storage. Nanobots will be powered by a tiny graphene battery placed upon the exterior of the nanobot allowing to the nanobots to charge through heat conduction while storing charge in the surrounding metal through the use of other nanobots as dielectrics and the reardonium acting as a capacitor. The nanobots will be arranged into nanonets to prevent batteries from losing their charge capacity over time.

5.0.3.5 Recharging. Large vats of nanobots in medium will be placed near the edge of the space station to allow residue heat from the sun charge the nanobots. These vats would be rotated on a regular basis in order to prevent overheating of the nanobots.

5.0.3.6 Movement Chassis. The various chassis used for inside work mainly require a simple 4 wheel system to maneuver quickly and efficiently. In the case that more accuracy is needed robots will automatically switch to a significantly lower gear setting allowing for more precision and accuracy when it comes to completing tasks albeit moving at a slower rate.

5.1 AUTOMATION FOR CONSTRUCTION

5.1.0 Construction. The building of infrastructure will be done by a similar process though more permanent. The structure that is underground will first be mined out by the contemporary mining configuration and then walls and other structures will be supported by a more permanent form of reardonium. This form will include what are little more than electric field generators on a micrometer scale that will just keep the reardonium permanently in one form as a structure. Because of the lack of processing power needed, these generators will be cheaper and easier to use rather than kinetic machines. The generators will have two settings, one of which will render the reardonium into a very viscous liquid form similar to concrete and the other which will render the reardonium in solid form.

5.1.1 Transportation. The nanobot infused reardonium would form a basic 1 meter cubed size but can be combined together from their 1 meter cubed sizes into larger forms in which the processing power of these nanobots is dramatically increased. These larger forms include vehicles for transportation.

5.1.1.1 Transportation-External. Robots in the form of delivery will be on a larger scale not only for efficiency purposes but also for the necessity of the larger amount of computing power needed for these vehicles. Because these vehicles are made of reardonium and need very little moving parts, the vehicles will be ground based and slow, meaning that these vehicles will operate in close proximity to an actual vehicle rather than a large robot. A large robot is expected to be made of 75 cubic meters of this saturated reardonium which forms a robot approximately 6 meters tall, 6 meters wide and 13 meters long with approximately 285 cubic meters of room inside free for materials of which it may carry 8 containers of mining robots (2 meters by 6 meters by 2.5 meters) or 100 colonists or 15 scientists with their equipment. These robots can carry large amounts of materials meaning that each successive trip



to and from a central base will bring back large amounts of pure already refined material. These large robots could also be used as a type of mobile laboratory in which scientists move in equipment and have a large mobile center in which they could use as a forward operating base in the field. In addition to human and materials transportation, these monoliths can easily deploy robots from its center to set up a forward mining base, allowing for completely autonomous mining bases to be set up quickly and efficiently.

5.1.1.1 Transportation-Internal. Internally, the transportation will be handled by maglev trains. These two trains are in two separate circuits in which the upper level will include a human transportation system throughout the facilities while the lower level will be responsible for the transportation of robots, materials and supplies throughout the facilities. The transportation of robots will be in large metal containers of 2 meters by 6 meters by 2.5 meters allowing for 30 mining size robots to be transported in one container.

5.1.2 Interior Finishing. Interior finishing will be completed by Chassis Type I bots with both a Type I and Type II configuration for inside work. (*Refer to Table 5.2 for Interior Robots*)

5.2 AUTOMATION FOR MAINTENANCE, REPAIR, AND SAFETY FUNCTIONS

Name	Purpose	Equipment	Dimensions/Density (L*W*H in meters)	Number
NanoBot Type I	Lower processing power, used for routine maintenance and tasks that do not require as much finesse	Smaller in size, requires less energy to function. Easy to mass produce in order to rebuild, programming is done through a wireless interface that allows “swarms” to be easily configured.	Density of 1 nanobot per every 1.5 nanometers, weighing at 1×10^{-19} grams per bot	2 metric tons
NanoBot Type II	Higher processing power, used for sensitive and delicate tasks that require finesse	Energy intensive and has trouble working far from a power source. Larger in size comparably but more difficult to manufacture. Programming is done through a wireless interface that allows “swarms” to be easily configured.	Density of 1 nanobot per every 2.5 nanometers, weighing at 5×10^{-19} grams per bot	500 Kg
Chassis Type I	Internal structure inspection and maintenance (accepts both type I and type II nanobots)	Ultrasonic sensor, storage compartment for flux metal, tracked drive system for extra torque	0.5*0.3*.75	600
Chassis Type II	Provides friendly guidance to residents in need. Works as security to subdue threats (accepts type II nanobots)	Wheels, interface port for individualized assistance, nonlethal active denial system, backscatter X-ray, 3-D touch screen interface, net launcher	0.2*0.5*2.5	800
Chassis Type III	Medical treatment, emergency transportation (accepts type II nanobots)	Wheels, stretcher, blood transfusion, defibrillator, vitals monitor, surgical arms, first-aid medicines, conveyor belt for picking up patients, sirens & lights, features back up battery system	2.0*1.0*1.0	400

5.2.1 Emergency External Repairs. Sensor systems integrated within the hull of the space station will automatically detect and identify areas where there are stress levels upon the metal exceeding safety levels in order to pinpoint areas where leaks are most likely to occur. This will prevent such breaches in the station from occurring. In the extreme solar environment, the robots are formed with reardonium faraday cage arrangement, which allow them the ability to survive for long periods of time in the event of a solar flare.

5.2.1.1 Reardonium Body. Due to the ability of the reardonium to form different properties under different circumstances, the electromagnetic field generated by the nanobots will be most conducive to giving the reardonium



different properties at different times such as a rigid structure. This will provide a temporary strength to weak parts in the robot, a more flexible body in a situation that requires a part of the robot to temporarily patch up holes quickly, or even a combination of both when a seal needs to be made immediately but hold out for a period of time. Also, this body will be resistant to much of the radiation and heat that Mercury has to go through due to its close proximity to the sun. Reardonium also has the ability to be resistant to the extreme cold that these robots may experience when on the darker side of colony.

5.2.1.2 Faraday Cage. The nanobots are enclosed within miniature faraday cages through which they may both manipulate their surrounding metal through the expansion and manipulation of the internal electromagnetic fields. But because of the faraday cage, external electronic fields will not affect the nanobots. These faraday cages will be interlocked during periods of deactivation, allowing the nanobots to communicate to each other and the colony when there is no solar flare. In case of a solar flare, the cages will close and the nanobots will continue to work autonomously.

5.2.2.1 Contingency Plans

Table 5.2.2.1 Contingencies

Contingency	Initial Response	Secondary Response	Time to Complete Initial Response
Biological/ Chemical Leak	Quarantine infected area and evacuate citizens. Addition Chassis Type III bots dispatched to treat affected residents.	Fix the source of the leak. Monitor residents for adverse effects.	~15 minutes
Computer Virus	Quarantine affected systems. Identify and eliminate malware.	Replace lost files. Resume normal operations.	~20 milliseconds
Cyber-Security Breach	Quantum cryptography locks out intruder and encryption key changed.	Locate and arrest eavesdropper through IP.	~Instantaneous
External Communications Failure	Switch to backup servers. Reestablish connection.	Diagnose and repair cause of failure. Send automated probe to investigate/repair communications satellites if communications remains down.	~40 seconds
Fire	Evacuate nearby civilians to shelter. Isolate sector. Chassis Type I extinguishes fire through asphyxiation using metal	Repair damage caused by fire with Chassis Type I. Vent contaminated air, restore air quality.	~3 minutes
Abnormal Stress on Portions of Hull	Chassis Type I dispatched to further analyze the cause of the abnormal stress	Abnormal stress is relieved and Chassis Type I fix any problems that may have arisen	~3 minutes
Minor Hull Breach	Chassis Type I immediately dispatched to seal the hull breach.	Deploy additional Chassis Type I to provide a permanent seal.	~1 minute
Major Hull Failure	Large amount of Chassis Type Is are dispatched to seal hull while Chassis Type IIs will evacuate citizens to pressurized shelters.	Repair hull with Chassis Type I to provide a permanent seal.	~3 minutes
Power Failure	Load switches to silver-zinc ion super capacitors.	Analyze and repair power grid.	~20 seconds
Physical Security Threat	Deploy Chassis Type II. Apprehend threat. In case of injury, send in Chassis Type III as well	Repair collateral damage.	~5 minutes
Solar Flares	Solar activity reported by satellites. Evacuate citizens to shelters.	Restore normal operations.	~5 minutes

5.2.7 Emergency Shelter. During emergencies, all affected citizens will be informed both through a priority message to their personal devices, as well as through a colony-wide broadcast and siren system. Both Chassis Type I and Type II will also help direct citizens to the nearest shelter, each of which will be visibly marked and contain its own atmosphere and food supplies. In addition, Chassis Type IIIs will begin to assemble at shelters in order to

provide medical attention to anyone who requires it. There will be shelters in every residential area composed of a reardonium alloy that allows the shelter maximum protection from the harmful effects of solar flares.

5.2.3 Security Automation. Patrol robots, Chassis Type II systems equipped with a type II nanobot infused medium, will be able to subdue individual suspects through the use of its active denial system, a non-lethal heat ray that induces a painful heat sensation on a target's skin. In addition, residents will be able to summon additional Chassis Type II systems through the interactive touch screen interface as well as provide guidance to residents. In case of a larger scale problem such as a riot, groups of Chassis Type II systems will be summoned to use their active denial system to split apart crowds thereby making it easier for the individual apprehension of each subject.

5.2.3.1 Authorized Personal Access. Authorized Personal may only access their data through certain secure stations located throughout the station. These secure stations will be connected to the central sever through a series of highly secure fiber optic landlines in order to prevent the interception or falsification of wireless signals to the central terminal. These stations will lie in secure areas of the facility, where users must use their personal identification cards along with a complicated series of biometric scans through a gel pad saturated with sensors that will detect everything from finger print analysis to DNA analysis from dead skin cells and blood pressure. A sophisticated surveillance system that will also identify based upon facial recognition and gait analysis. In the case that an unauthorized person attempts to access the central server several times in succession, the terminal will lock itself down until access is granted again through the central server and this person is identified and apprehended by a Chassis Type II bot. Data used in these servers will also be protected through quantum encryption thereby making it impossible to access the data without going through a specified secure station and having the proper access. Data may also only be accessed pertinent to the user's field of work, making it impossible for a user to access data for unauthorized purposes without personal identification.

5.2.3.2 Apprehension Protocol. Apprehension Protocol requires two verbal warnings before a forcible apprehension is attempted. These warnings will be given over loudspeakers in order to ensure that the suspect knows to surrender or be forcibly apprehended. Should the suspect resist arrest or attempt to flee, the Chassis Type II robots are authorized to use their non-lethal active denial systems to stun the suspect before using the net launcher to subdue the suspect. In order to prevent cases where there maybe collateral damage, the number of Chassis Type II robots, that are authorized to use their net launcher, is equal to the number of suspects thereby reducing the risk that an innocent bystander is hurt or injured by a net launcher.

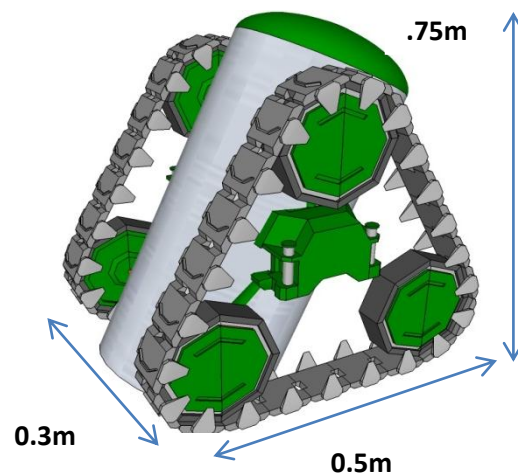
5.3 AUTOMATION FOR PRODUCTIVITY, LIVABILITY, AND CONVENIENCE

5.3.1 Personal Interface Device (PID). The device will naturally conform to the user's wrist with a firm grasp allowing the device to charge through its graphene batteries by leaching residue body heat. Through electromyography, PID can read the nerve signals sent to muscles of the larynx associated with speech and with training, can allow users to mimic telepathic abilities by recognizing speech without the user having to physically speak. The recognition of speech is only limited to a specific level of intention with some basic training to use and prevents any background thoughts from being converted into speech. PID will also utilize bone conduction to allow users to listen without earphones. An acousto-optic light modulator equipped with a tiny ultrasound generator is built into the PID unit and can be detached and used in synchrony with PID to display full 3-D holograms that provide sensation when touched.

5.3.2 Maintenance. Maintenance will be mainly carried out by Chassis Type I robots which feature dual configurations allowing for either a Type I or Type II nanobot metal to be used for direction.

5.3.2.1 Type I Configuration. A Type I nanobot metal when used in a Chassis Type I will most likely be responsible for moving around equipment and material onboard the space station, and on the surface of Mercury. These robots will be responsible for much of the heavy lifting and transportation of materials on the settlement. In addition, these robots will be tasked with the simpler repair missions that just require additional flux metal or other material. The Type I Configuration will be outfitted with limited human interaction protocols because it is used in situations inhospitable to humans and rarely will be used in a

Figure 5.3.2.1-Chassis Type I



situation where human interaction is needed or possible. This is because the Type I Configuration does not contain the same amount of processing power as does the Type II, making it more difficult to install additional operating procedures in the nanobot swarm.

5.3.2.2 Type II Configuration.

5.3.2.2.1 Chassis Type II. A Type II nanobot metal used in a Chassis Type I will be responsible for interior finishing in residential and business areas. These robots will be mainly used in the interior of the colony but also responsible for delicate external repairs. In the case of external repairs, these nanobots will be used due to the extended dexterity of the robot, allowing for the robot to perform tasks with more precision and accuracy. For example, in the case of a hull breach, the Type I nanobots will be used to patch up the breach but Type II nanobot in a Chassis Type I will likely be required to repair broken wiring or to replace sensors. Chassis Type I's with a Type II configuration will also be used in residential and business areas for janitorial tasks. These Type II nanobots will be given extended human interaction protocol to interact with humans safely and for residents to feel comfortable around these robots. Chassis Type II robots also come equipped with a port through which users may connect using their PIDs in order for a more personalized interaction.

5.3.2.2.1 Chassis Type III. The Chassis type III will consist of a significantly larger amount of nanobots than the other two chassis due to the sensitive and delicate nature of the work that it must do. Therefore, the nanobots are specially reprogrammed for surgical and medical tasks, making drug delivery more accurate and surgery less risky with accuracy down to the nanometer. In addition, these robots will serve as

mobile clinics with the ability to diagnose and treat minor diseases and ailments, serving as effective ways for residents in Aynah to remain healthy while still being able to work with optimal efficiency. The Chassis Type III will also feature a backup energy supply in order to continue providing life support or medical attention in the event that the nanobots run out of charge prematurely or an electromagnetic pulse from a solar system manages to pass through the station walls and through the faraday configuration of the nanobots. This redundancy system allows for more patient safety and preparation for a last case scenario.

5.3.3 Networking Configurations

5.3.3.1 User Cloud. Every resident of the space colony will be given a complimentary II (Individual Interface), with wireless connectivity capabilities. It uses ultra-high frequency radio waves to maximize the amount of information that can be sent. It has an effective communication range of 2 km, and can send information at a rate of 10 megabytes a second. It can communicate with receiver stations specifically designed to pick up interface signals and connect to the colony's information network. There is also a peer-to-peer network system for use by those in the vicinity.

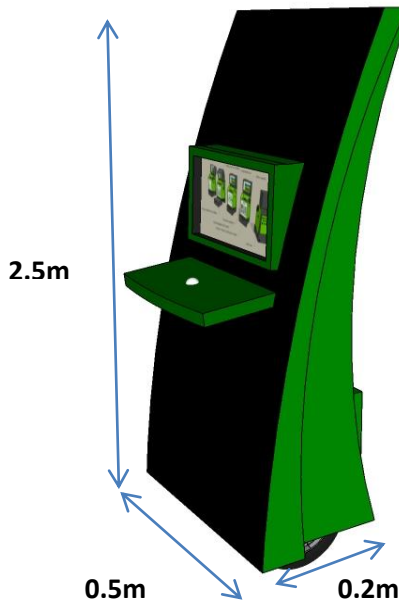


Figure 5.3.2.2 Chassis Type II

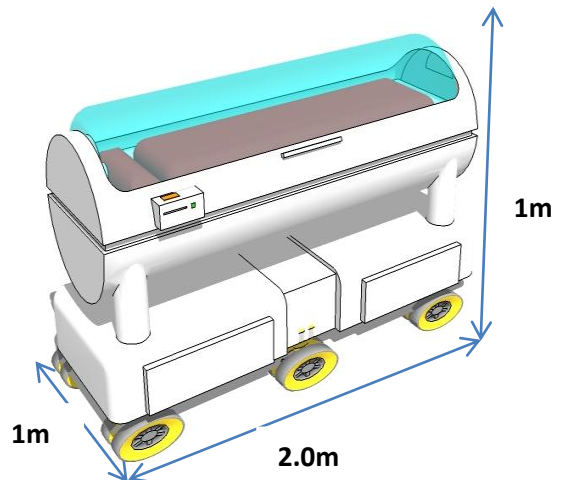


Figure 5.3.2.1 Chassis Type III

5.3.3.2 Wireless Signal Receivers. These can communicate with the various receiver stations designed to pick up the ultra-high frequency which the interfaces use to maximize bandwidth. The receiver station then relays the information to a regional server, where it is then sent to its destination. These receivers use quantum algorithms to minimize loss of data from receiving simultaneous signals.

5.3.3.3 House Lines. Each house has a direct fiber optic line connecting it to a regional server. It uses quantum entanglement technology to permit instantaneous transfer of over 10 GB/s of data. This is achieved by having reardonium metal wires keep subatomic particles entangled over a long distance.

5.3.3.4 Server Firewall. Every regional server has a physical firewall to filter out malicious or corrupt data. The firewall has a processing speed of over 100 Tb/sec, as well as quantum technology to process simultaneous requests to minimize time taking to analyze incoming packets.

5.3.3.5 Regional Server. These servers handle the most traffic out of all the servers on Aynah, and have been

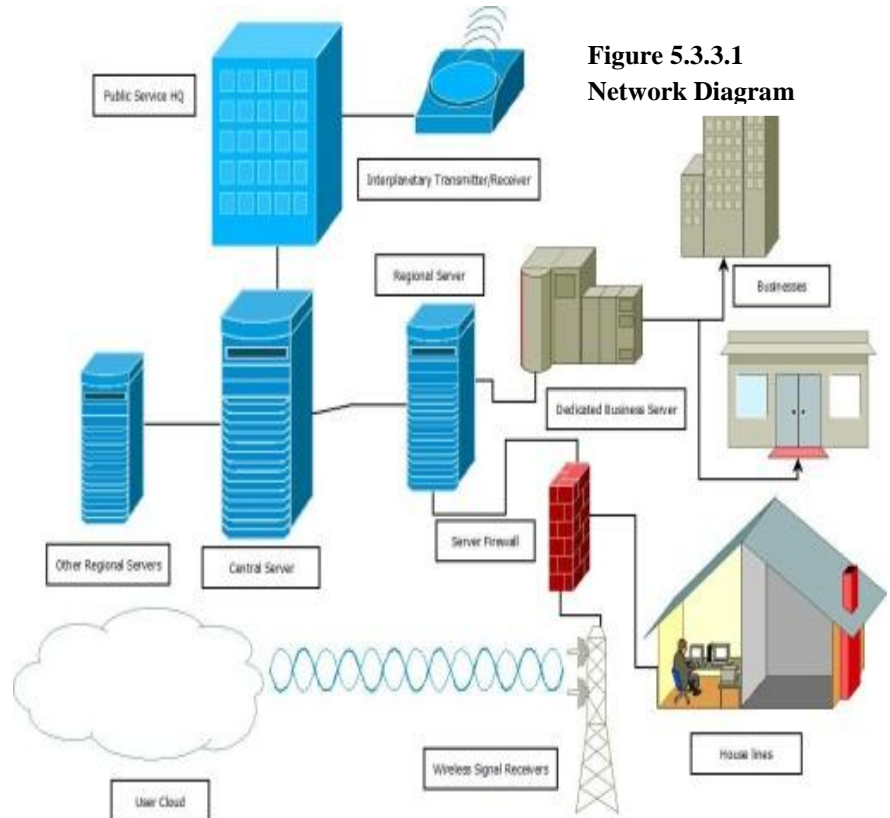
accordingly equipped with the capability to process over 1 Pb of data per second. The regional server receives information from 3 main sources: the central server, the firewall server, and a business-dedicated server. Likewise, the regional server will send data to the same 3 sources, depending on the destination. Business orders will be sent to the business dedicated server. Messages in the same region will be sent to the firewall, and messages for other regions will be sent to the central server to be relayed to the other regional server.

5.3.3.6 Business Dedicated Server. The business sectors will be given their own server to better coordinate logistics, as well as provide a more secure means of communication. The main purpose of the server is to provide a more direct route for supply-demand and sales data, orders for raw materials and a gauge of consumer interest.

5.3.3.8 Central Server. The central server handles messages from both regional servers, as well as from Public Services HQ. All messages that travel from region to region are relayed through the central server, with the exception of messages from interface within the range of more than one wireless signal receiver. This server has a direct quantum link to the other three servers, like that of the house lines. However, as there is no intermediary like the firewall, the communications are untraceable or intercept-able, at least on route. Central servers handle modest traffic, and have been equipped with 250Tb/sec processing power.

5.3.3.9 Public Service HQ. This is a regulation building, and handles public services. It may issue periodic PSA about solar flares and other possible events that may affect civilian life. It also handles communication from earth, from its C.414 communication module. It receives low traffic on a daily basis, but has 500 Tb/s rate of transfer and processing to address emergency situation in which there may be a flood of requests.

5.3.3.10 Communication module C.414. This module uses quantum entanglement to provide instantaneous communications with earth. This achieved by creating two entangled particles, freezing one in a state of suspension, and transporting one of the particles to Aynah, while the other one remains behind on Earth. There is a bit rate transfer of approximately 50 Gb/s with this method. It also has a backup long-range radio transmitter with allows for 10 Gb/s communication with earth with a variable delay time from between 5-15 minutes, depending on the position of Mercury and Earth.



**Figure 5.3.3.1
Network Diagram**

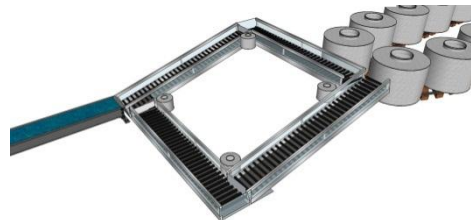
5.4 REARDONIUM MANUFACTURING

5.4.1 Refining Raw Ore. Unloading raw ore will be mainly done by the mining robots. Most of this raw ore will consist of almost pure reardonium with very few impurities. In order to further purify this ore, the robots will drop the unrefined ore into large tanks of concentrated sulfuric acid. From this, the reardonium will ionize and once the sulfuric acid is neutralized to a pH of 7, the ionized ore is then carried over on a conveyer belt and then the various other metal ions are extracted through precipitation reactions. These reactions take place in the moving conveyer belt which allows the heavy precipitates to sink to the bottom while the reardonium ion floats in solution. When the solution is purified enough for refining, the solution is electrolyzed to get reardonium. This reardonium is then manufactured in either plate or bar form to sell, or a portion is used as material to produce alloys on the space station. This is sorted out in accordance to a human operator who decides which percentage of reardonium will arrive where. This allows for the automated system to evenly divide up the reardonium in accordance to the commands of a human operator.

Table 5.4.1 Refining Ore		Dimensions (L*W*H meters)	Number in
Name	Purpose		
Processor Part I	In order to keep ions from settling or precipitating on the sides of the vats containing sulfuric acid, these processors while ensure that the metal ions remain dissolved in solution. In addition, these processors heat up the solution of sulfuric acid slightly in order to improve saturation and discourage precipitation. (Figure 5.4.1.1)	3*3*3	25
Processor Part II	Works as a conveyer belt in which the solution is moved through a series of stations in which each station puts the ionized solution through a repeated battery of hydroxide, sulfide, sulfate and carbonate solutions in order to precipitate and remove any other metal ions present in the solution. These stations will repeat the process several times in order to ensure all the metal ions have precipitated from the solution. (Figure 5.4.1.2)	9*3*1	100
Processor Type III	The metal ion solution will then be electrolyzed in order to cause the metal to solidify in solution. By running an electric current through the solution, the metal will reduce thereby forming around the cathode. The cathode will then be removed and the metal ore will be sanded off and then moved to the curing process. (Figure 5.4.1.3)	9*3*2	50



Figure 5.4.1.1 Process Part I



**Figure 5.4.1.2
Process Part I**

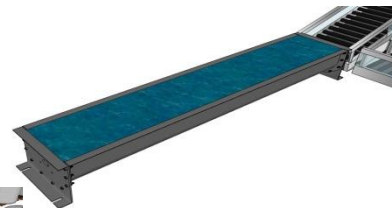


Figure 5.4.1.3 Process Part III

5.5 ON-SURFACE OPERATIONS

5.5.1 Handling Reardonium. The robots responsible for the unloading the shuttles will be of the same make of the robots responsible for the curing procedures.

5.5.2 Curing Procedures. Through the operations shuttle, the parts are transported down to the surface. The metals are first annealed multiple times in the hot Mercury climate by allowing the refined ore to reach extremely high temperatures and then allowing for the metal to cool down slowly. Robots responsible for this will feature an insulated portion that will remove the source of heat from the metal (the sun) and then allow the metal to cool slowly over a period time. Then the process is repeated multiple times, but because the process is the same, the robots will be completely autonomous, making the process as free of human error as possible while also remaining at maximum efficiency.

The second step in the process involves age hardening (also known as precipitate hardening) in which malleable materials such as reardonium may be further strengthened to avoid additional stress upon the metal. The age hardening involves a very careful balance between causing the metal to become supersaturated while simultaneously being allowed to precipitate in the supersaturated solution thereby producing optimum structures for the metal. This step the process will happen once every three repetitions of the annealing process therefore allowing the metal to strengthen over a period of time while still retaining much of its original properties. (*See Operations section 3.5 for curing procedures*).

5.5.3 Day and Night Configurations. These robots are able to operate in both night and day and survive extreme temperatures. The reardonium metal alloy shell protects these robots. In addition, in the case of a solar flare, the nanobots are able to form a miniature faraday cage by creating a vacuum in the immediate area it is in thereby causing any sort of harmful electromagnetic pulse to pass harmlessly by the robot. When this occurs, the robot automatically enters a “safe” configuration in which it remains closed off to outside signals until the last of the electromagnetic forces had passed.

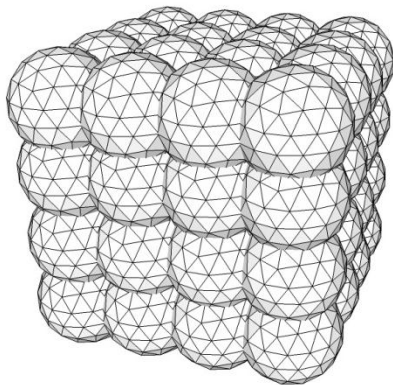
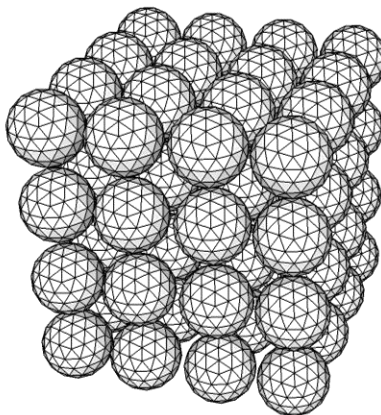


Figure 5.5.1.1
Normal “Night”
Configuration



The nanobot spheres are interconnected and are able to communicate not only with each other but with other devices nearby.

Figure 5.5.1.2 Normal “Day” Configuration. As shown, the nanobot spheres are no longer interacting with each other, forming a series of faraday cages safe from outside electromagnetic interference.

Figure 5.5.2 Operations Shuttle



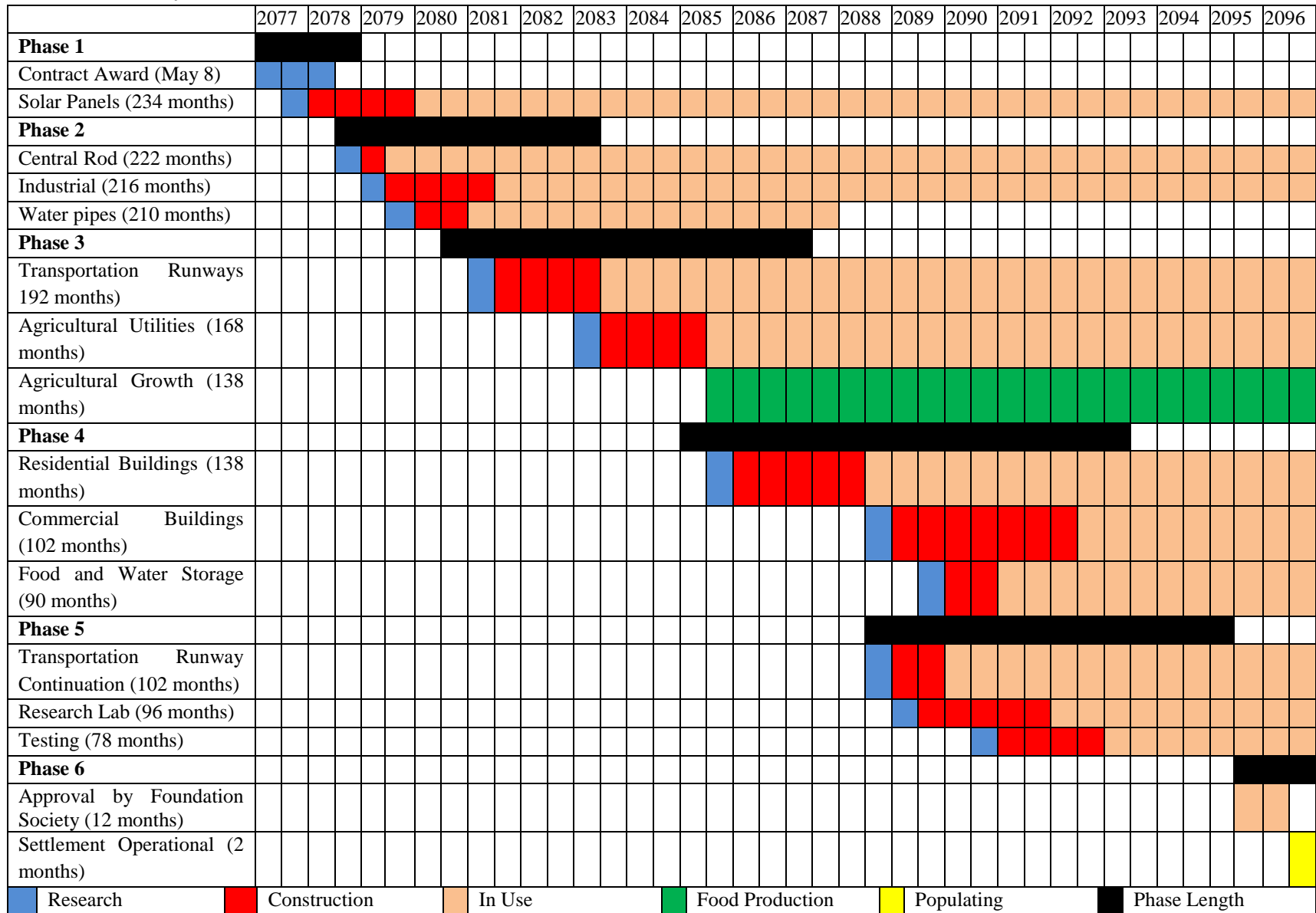


SCHEDULE AND COST



6.0 SCHEDULE AND COST

6.1 Schedule – 19 years





6.1.1 Schedule Explanation. Phase 1 begins with the Contract Award on May 8th, 2077. We at Northdonning Heedwell immediately begin initial research. After we have carefully planned and elaborated specific order of procedure, we begin installing solar panels by the 8th month. After the Central Rod is completed in Phase 2, operations will begin collecting appropriate resources to for manufacturing on-site materials. Food production will begin during the 6th month of 2085 during Phase 3. Enough food will be produced by the time the food and water storage is constructed in Phase 4. By the end of Phase 5, the settlement will be completed. People may start moving into the operational colony by the 7th month of 2096 in Phase 6.

6.2 COSTS

Table 6.2.1 Cost Labor During Construction					
Jobs	ANNUAL SALARY (In thousands)	Number of Years	People	Construction Phases	Total (In Millions)
Foreman	\$190	19	25	1-6	\$90
Robotic Technicians	\$165	19	115	1-6	\$361
Electricians	\$125	19	250	2-5	\$593.8
Pilots	\$145-215	19	60	1-6	\$156
Geologists	\$215	10	5	1-5	\$10.8
Construction Engineer	\$130	19	200	1-5	\$494
Mechanical Engineer	\$140	19	230	1-5	\$611.8
Chemical Engineer	\$140	15	100	1-5	\$210
Electrical Engineer	\$130	15	100	1-5	\$195
Software Engineer	\$115	10	225	3-5	\$259
Subtotal: \$2.98 Billion					

Table 6.2.2 Cost of Operations (During Construction)				
Operation	Cost per year	Number of Missions (Per Year)	Years in Operation	Total Cost
Cargo Transportation	\$107,692,000	2	17	\$1.4 Billion
Passenger Transportation	\$9,923,000	2	9	\$129,000,000
Manufacturing	\$146,000	N/A	15	\$27,568,000
Production	\$7,586,000	N/A	16	\$48,525,000
Solar Cell Manufacturing Devices	\$158,000	N/A	148 days	\$67,000
Subtotal: \$1.61 Billion				

Table 6.2.3 Cost of Equipment			
Equipment	Cost per unit	Amount	Total
Solar Cell Manufacturing Device	\$37 Million	1	\$37 Million
Mobile Headquarters	\$50 Billion	1	\$50 Billion
Robotic Support Ships	\$28 Billion	3	\$84 Billion
Subtotal: \$134 Billion			

Table 6.2.4 Cost of Construction Materials			
Materials	Volume(m³):	Price per unit(m³):	Total Price
Reardonium	1,102,771	\$145,089	\$160 Billion
Water	459,064	\$1,421	\$652 Millions
Self-Healing RXF-1	310,211	\$5,322	\$1.7 Billion
Iron	1,509,337	\$35,012	\$53 Billion
Subtotal:\$215 Billion			



Table 6.2.5 Raw Materials

Material:	Unit Cost (per kg):	Mass (kg):	Total Cost:
Nitrogen	\$1.34	130,491,704	\$134.8 Million
Oxygen	\$1.13	40,151,293	\$42.3 Million
Silica *	-----	-----	-----
Carbon Dioxide	\$1.10	3,628,953	\$4.5 Million
Hydrogen	\$1.05	25,078,107	\$30.2 Million
Calcium	\$110.00	455,139	\$52.07 Million
RXF-1 Polyethylene	\$5.63	957,489	\$36.7 Million
Calcium Hypochlorite	\$5.95	277,654	\$1.85 Million
Rubber	\$7.41	1,547,230	\$9.44 Million
Carbon	\$2.43	251,013	\$1.46 Million

Subtotal: \$311.6 million

***Material found on Mercury**

Table 6.2.6 Cost of Robots

Type	Cost Unit	Per	Total Unit	Total (in Millions)
Nanobot Type I	\$17.5 Million	2 metric ton		\$16,554
Nanobot Type II	\$15.3 Million	1 metric ton		\$10,136
Chassis Type I	\$4.21 Million	600		\$8,467
Chassis Type II	\$12.8 Million	800		\$9,675
Chassis Type III	\$8.5 Million	400		\$8,845
Processor Part I	\$4.2 Million	25		\$139
Processor Part II	\$3.4 Million	100		\$346
Processor Part III	\$3.1million	50		\$157
Curing Robot	\$2.7 million	250		\$634

Subtotal: \$54.7 Billion

Table 6.2.7 Cost of Computers

Computers	Memory	Cost per unit	Number of Units	Total Cost
Personal Interface Device (PID)	500 GB	\$600	15000	\$9 million
Cerberus (Personal Computer)	20 TB	\$4500	12540	\$41.2 million
Research & Business	50 TB	\$11,000	1000	\$21 million
Server	1 PB	\$212,000	50	\$170 million
Subtotal: 241.2 million				

Table 6.2.8 Income

Source of Income	Income
Deuterium Exports	\$1.2Billion
Miscellaneous Exports	\$40 Billion
Research and Patents	\$1.5 Billion
Tourism	\$20 Million
Subtotal: \$42.72 Billion	

Table 6.2.9 Operating Costs

Operation	Cost
Production	\$20 Million
Consumables	\$2 Million
Manufacturing	\$10 Million
Maintenance	\$15 Million
Subtotal: \$47 Million	

Total Cost of Construction
\$408.9 Billion

Annual Revenue
\$42.72 Billion

Years to Cover Construction Costs
9.6 Years



BUSINESS DEVELOPMENT

7.0 BUSINESS DEVELOPMENT

7.0.1 Refining and Manufacturing Reardonium Parts.

Aynah is equipped with sophisticated manufacturing facilities, thus enable efficient and effective refining of reardonium parts.

7.0.1.1 Raw Metal Processing. Reardonium will be processed and handled by Processor Part I, II, and III. The transport of raw metals will be performed by appropriate manufacturing robots. The Processor will use various pH, hydrochloric acids, and various ionizing techniques to remove dust, grits, and other unnecessary, tiny debris in order to further purify and isolate the reardonium from the raw materials.

7.0.1.2 Manufacturing Capabilities. Babylon modules, equipped with advanced centrifuges and helium pumps, will provide the gravity and pressure needed as monitored by sophisticated robots.

7.0.1.3 Hazardous Operations. There is 500 meters of space between Pangaea, the main ring where human activity is located, and the Babylon manufacturing modules. Furthermore, both Pangaea and Babylon are constructed with rigid reardonium hull, thus further minimizing the risks of hazardous manufacturing.

7.0.1.4 Efficient Transportation. All manufacturing modules are connected and attached to the central rod, Niya, making for easy transportation. The modules are also reasonably close at 650 meters away from Kechries, which provides for transportation into and out of Aynah. This distance places Babylon safely separated from other parts of the colony, yet at an advantageous spacing to enable efficient transport.

7.0.2 Receiving and Shipping Reardonium Parts.

To enable commercial trade of reardonium products, Aynah is equipped with Kechries, our efficient and large port facility, that ensures quick transporting and packaging of reardonium products. Our colony is also equipped with mining, packaging, and inspection robots that ensure our output products are of utmost quality.

7.0.2.1 Inspections and Quality Checks. Before reardonium parts is sent to Babylon modules and Processor Parts for further refinement, mining robots and other robotic monitors will perform inspections and quality to checks to ensure the purity of reardonium parts and the quality of mining processes.

7.0.2.2 Packaging. Packaging robots embedded within Babylon modules will package reardonium as necessary after the desired properties are induced into the reardonium parts. For sale, reardonium can be packages into plate or bar forms. It can also be used as construction materials. The reardonium parts will be packaged into shipping containers made of thin reardonium or nilil sheets. These strong materials are used to ensure the reardonium products inside are sufficiently protected and isolated from the harsh outside environment. Rigid protection is necessary because our customers will come from throughout the solar system, which will vary greatly in environmental variables.

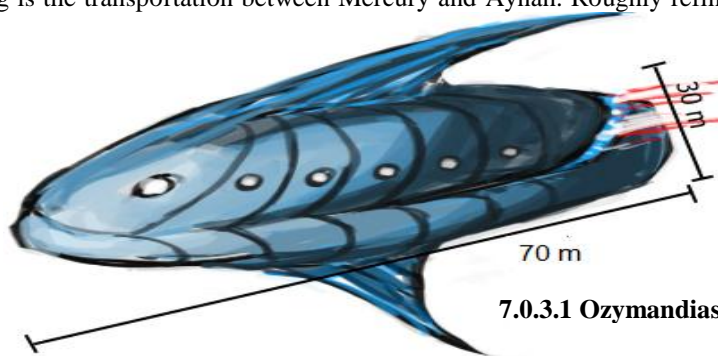
7.0.2.3 Automation of Processes. Nearly all manufacturing, packaging, and shipping processes are automated by Processor robots, mining robots, and packaging robots. Human intervention is allowed, but in general, all processes is monitored by sophisticated computers.

7.0.3 Port of Entry for Mercury.

Another key step of reardonium manufacturing is the transportation between Mercury and Aynah. Roughly refined parts are first collected from on-surface manufacturing sites on Mercury then transported to port facilities on Mercury.

7.0.3.1 Interorbital Transportation.

Transportation between various colonies, spaceliners, and space modules will be provided by Aynah's fleet of Ozymandias, which are strong, large transportation spaceships dedicated to the transportation of construction materials and manufactured reardnoium.



7.0.3.1 Ozymandias

7.0.3.2 Transportation to/from Mercury.

Large packages will be carried by Ozymandias, if the travel distance required is great. However, in most cases, cargo or passengers will be transported by Rorschach transport modules. Rorschach will be primarily used to transport raw resources and small equipment in between Aynah and Mercury.



7.0.3.3 Cargo warehousing. Storage in Aynah is concentrated primarily in the El Dorado sphere. Cargo from incoming spaceships will be unloaded by robots at Kechries and transported to El Dorado via the Maglev trains in Niya. The cargo will be stored in El Dorado until the other spaceships is docked on Kechries, at which time the cargo will be transported back to Kechries via Maglev trains in Niya.

7.0.3.4 Cargo transporting. Cargo transport between Kechries and El Dorado is provided by Maglev trains in Niya. The upper level of Niya is specifically designed for this function, while the lower level is designed for passenger transport.



APPENDICES



8.0 APPENDIX A

8.A.1 Efficiency of Moving In-Process Products. Metalworking modules attached to Aynah can also produce the components that are assembled into final products in the heavy manufacturing modules to serve as an alternative to importing. As a result, the heavy manufacturing modules have been paired with the metalworking modules on each set of universal mating ports, greatly reducing time and increasing efficiency. Furthermore, this industrial region is located in easy access ports on Aynah that will allow easy movement of raw materials into the colony and finished goods out of the colony.

8.A.2 Mining/Transportation. The mining process will begin with our Mercury terrain vehicle Voltron, whose engineering components contain reardonium itself and several other strong and heat resistant metals. This allows the Voltrons to be able to travel to a variety of places with large deposits of raw crude metal. Through its mechanical arms, drills, and lasers, each Voltron will mine the resources and deposit them into the empty part of its body. Because of solar panels on the vehicle outer frame, the Voltron will very seldom run out of fuel and because of its sonar sensors, it is completely independent and needs little to no human maintenance. The Voltron then travels to a large Mercury terrain base where Aynah's Rorschaches will be stationed to transport the raw reardonium back the colony for refinement. After the refinement, manufacturing, and curing process is finished and we have reardonium in its final product, Aynah will then either employ it for its own usages or export it using the colony's fleet of Ozymandias for long distance shipping to either Earth or other colonies.

8.A.3 Refinement. The refining process for reardonium metal will involve purifying the more valuable metal from the raw ore using hydrometallurgy to extract the metal followed by electrolysis to obtain the purified raw metal. These metals can then be alloyed to create the reardonium metal that is desired. The extraction process begins at an refining facility with the pulverization of the raw ore through several steel stamps that will come down onto the raw ore to break it up into fine particles (15 minutes). In the second step, the powdered ore will then be gathered in a pile and will be sprayed with sulfuric acid, which will percolate through the powder, dissolving the desired metals as ions into solution. (60 minutes) The gases produced from this process, most notably hydrogen, can be easily recaptured for future use. The ion-rich solution will be gathered at the bottom of the pile and will be pumped through to the next stage of the refining process. Ore that still contains significant amounts of metal after this process can then be agglomerated through a centrifuge and passed on to a more thorough refining area, if deemed worthwhile (30 minutes). After the collection of the metal-rich solution, the mixture must undergo concentration and separation of the metal ions that are desired, which is the goal of the third stage of the refining process. We will use selective chelating agents in this step, which are certain compounds that are engineered to each bind only to a specific metal ion. By introducing each agent in turn and manipulating the pH of the solution we can extract the individual metal ions relatively easily and quickly (30 min). Once the ions are separated, we can then recover the chelating agents for use once again, as they are not consumed in this process. In the fourth and penultimate stage of the refining process, each metal ion solution is electrolyzed individually using the electricity generated from the sun-synchronous Mercury polar orbit provided by the Foundation, depositing the pure desired metal at the cathode of each cell where it can be obtained and sent to a neighboring facility for alloying and manufacturing (120 minutes). The oxygen created at the anodes can be collected and recycled. The total time needed to finish the extraction process is approximately 255 minutes for an average-sized ore sample. Once collected and sorted, the raw metals will be transported to a furnace where they will be alloyed into uncured reardonium for manufacturing. (45 minutes)

8.A.4 Manufacturing and Curing. Once the raw reardonium is obtained from the refining facility they will be sent to a neighboring facility for shaping and manufacturing. As a demonstration of the variety of possible shapes and properties we can manifest in reardonium, the manufacturing process of a frame for sunglasses and the manufacturing process of a 100 by 40 foot construction panel will be outlined here. After the reardonium is first obtained from the refining department, it will first be shaped into the desired shape and then be subjected to various metalworking treatment processes to produce the properties that we desire for the specific part. For the sunglasses frame, we choose to melt down the reardonium and pour it into a die cast under 20 psi of air pressure because of die casts' good detail, quality and consistency (60 minutes). For the construction panel, we will use a cold rolling technique which will create a stress resistant panel of metal approximately .4 cm thick under 0.1 g's of gravity (60 minutes). The shaped products will then have to be cured to amplify specific characteristics that will vary for different purposes. The sunglasses frame and the construction panel will be transported down to the surface of



Mercury for this unique curing process using our Rorschach vehicles (60 minutes), where they will stay for approximately one Earth year while being moved around various locations with our Voltron robots, annealing and hardening under the range of temperatures on Mercury (See 5.4.2 and 3.5 for greater detail). Once cured, the finished products are transported back to Aynah (60 minutes) and are ready to be shipped and used. The approximate total time required for each part will be 3 hours, excluding the 1 Earth year curing time.

8.A.4 Equipment. In order to minimize any sort of human injury or danger, the refinement process is designed to be as human independent as possible. Machine maintenance and checkups will be done by robots and checked by personnel on the station. Everything that is done is completed by automated machines that are either constructed there on Aynah or are imported from elsewhere. While the refining and manufacturing process is thorough, the facilities required will be low-cost and energy-efficient because we will be able to reuse many of the chemicals and parts used in the process.



Appendix B

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Whitney High School 2010 Aresam Proposal

Whitney High School 2011 Astoria Proposal



APPENDIX C. Compliance Matrix

2 STRUCTURES

	Requirement	Location in Proposal	Page
2.0.0	Provide a safe and pleasant environment for 14,000 full-time residents and 200 short-term visitors	2.0.1 Population	3
2.0.1	Enable residents to have natural views of Mercury	2.0.1 Population	3
2.1.0	Identify attributes and uses of large enclosed volume	2.0.2 Natural View	3
2.1.1	Show dimensions of major hull components and design features	2.1.1 External Design 2.1.1.1 Pangaea; 2.1.1.2 El Dorado 2.1.1.3 Babylon 2.1.1.4 Kechries 2.1.1.5 Solar Panels 2.1.1.6 Niya	3-4
2.1.2	Specify volumes where artificial gravity will be supplied	Figure 2.1.1 External Configuration	3
2.1.3	Specify structural interface between rotating and non-rotating sections	2.1.2 Artificial Gravity	4
2.1.4	Specify rationale for selected rotation rate and artificial gravity magnitude	2.1.4 Structural Interface between Rotating and Non-Rotating Sections	5
2.1.5	Show capability to isolate at minimum any two separate habitable volumes in case of a depressurization or other emergency	2.1.2 Artificial Gravity	4
2.1 Min Req	Overall exterior view of settlement, with major visible features (e.g., solar panels, antennas), show rotating and non-rotating sections, pressurized and non-pressurized sections, and indicating functions inside each volume (e.g., port, residential areas, and agriculture)	2.1.6 Contingency 2.1.6.1 Quarantine 2.1.6.2 Hull Breach	5
2.2.0	Specify percentage allocation and dimensions of interior residential, industrial, commercial, agricultural “down surfaces” with labeled drawings	2.1.1 External Design 2.1.1.1 Pangaea 2.1.1.2 El Dorado 2.1.1.3 Babylon 2.1.1.4 Kechries 2.1.1.5 Solar Panels 2.1.1.6 Niya 2.1.2 Artificial Gravity 2.1.3 Pressurized Volumes 2.1.4 Structural Interface between Rotating and Non-Rotating Sections 2.1.5 Hull Components 2.1.5.1 Debris Protection 2.1.5.2 Radiation Protection 2.1.6 Contingency 2.1.6.1 Quarantine 2.1.6.2 Hull Breach	3-5
2.2.1	Show orientation of “down surfaces” with respect to overall settlement design, and vertical clearance in each	Figure 2.2 Agricultural, Industrial, Storage, Commercial, and	6-7

	area	Residential Areas Table 2.2 Areas and Volumes	
2.2	Overall map or layout of interior land areas, showing usage of those areas	Figure 2.2.4 Pangaea Figure 2.2.5 Niya Figure 2.2.6 Babylon	6
2.3.0	Describe the process required to construct the settlement, by showing the major assembly sequence	Figure 2.2 Agricultural, Industrial, Storage, Commercial, and Residential Areas	6
2.3.1	Specify when artificial gravity will be applied	2.3.1 Pre-Construction 2.3.2 Construction 2.3.3 After Construction Table 2.3 Construction Sequence	8
2.3.2	Manufacturing facilities that produce components no larger than 40 by 20 feet	2.3.4 Initiation of Artificial Gravity Table 2.3 Construction Sequence	7-8
2.3.3	Early manufacturing areas of at least 100,000 square feet with 60 foot ceiling height that enable product of components up to 100 by 40 feet	Table 2.3 Construction Sequence	7-8
2.3.4	Describe a construction technique for interior structures making use of minimally refined materials from the Mercury surface	2.3.5 Construction Technique for Interior Structure	8
2.3 Min Req	Drawing(s) showing at least five intermediate steps of settlement assembly, and method of initiating rotation for artificial gravity	2.3.1 Pre-Construction 2.3.2 Construction 2.3.3 After Construction 2.3.4 Initiation of Artificial Gravity 2.3.5 Construction Technique for Interior Structure Table 2.3 Construction Sequence	7-8
2.4 Min Req	Show how manufacturing areas will provide required ranges of conditions for reardonium parts production. The process requires varying accelerations from 0 to 0.5 g and atmospheric pressure varying from vacuum to 20 psi.	2.4 Manufacturing Operations 2.4.1 Centrifuge 2.4.2 Air Pumps	8-9
2.5.0	Residential areas and commercial areas must be on the opposite side of the settlement from the sun	2.5.1 Protection by Location	9
2.5.1	Residential and commercial areas must be completely surrounded by a 20-inch layer of water	2.5.2 Protection by Hull Composition	9
2.5 Min Req	Configuration drawings that show protection for areas occupied by humans.	Figure 2.5 Primary Hull and Secondary Hull	9

3 OPERATIONS

	Requirement	Location in Proposal	Page
3.0	Facilities and infrastructure necessary for building and operating Aresam space settlement	3.0 Operations and Infrastructures	11
3.1.0	Mercury orbital location reasons	3.1.1 Mercury Orbit Location	11
3.1.1	Sources of materials and equipment used in construction and in settlement operations	3.1.2.1 Materials and Equipment Logistics	11
3.1.2	Means for transporting those materials to Aynah	3.1.3 Transportation of Materials	11
3.1.3	Means of storing the material	3.1.4 Storage of Materials	11
3.1 Min	Table identifying types, amounts, and sources of construction materials	Table 3.1.2 Construction Materials and Sources	11

Req			
3.2.0	Elements of basic infrastructure	3.2 Community Infrastructure	11
3.2.1	Identify air composition, pressure, and quantity	3.2.1.1 Atmosphere 3.2.1.2 Climate 3.2.1.3 Weather Control	11-12
3.2.2	Include growing, harvesting, storing, packaging, delivering, selling of food, emergency storage	3.2.2 Agriculture 3.2.2.1 Aeroponics 3.2.2.2 Growth 3.2.2.3 Harvest 3.2.2.4 Culture Meat 3.2.2.5 Fish 3.2.2.6 Processing/Packaging/ Storage 3.2.2.7 Distribution/Selling/Emergency Storage	12-13
3.2.3	Specify kilowatts distributed to habitable areas for electrical power	3.2.3 Electrical Power Generation 3.2.3.1 Traveling-Wave Reactor 3.2.3.2 Rapid L Reactor 3.2.4 Power Distribution	13-14
3.2.4	Specify required water quantity and storage facilities	3.2.5 Water Management 3.2.5.1 Water Treatment	14-15
3.2.5	Specify recycling and/or disposal of household and industrial solid waste	3.2.6 Waste Management 3.2.6.1 Household and Industrial Waste Treatment	15
3.2.6	Specify devices and central equipment of internal and external communication systems	3.2.7 Internal Communications 3.2.7.1 External Communication	15-16
3.2.7	Show routes and vehicles, with dimensions of internal transportation systems	3.2.8 Internal Transportation	16
3.2.8	Specify schedule and mechanisms/operations for providing day/night cycles	3.2.9 Day/Night Cycle	17
3.2 Min Req	Provide chart(s) or table(s) specifying quantities required of air, food, power (for residents), water, waste handling, communications devices, and internal transport vehicles	Table 3.2.1 Atmosphere Table 3.2.3 Electrical Power Generation Figure 3.2.8 Internal Transportation Figure 3.2.5.1 Water Treatment Figure 3.2.6.1 PGP Waste Management	11, 13- 16

3.3.0	Show conceptual designs of primary machines and equipment employed for settlement construction, especially for exterior hull and interior buildings assembly.	3.3.1 Primary Construction Machines/Equipment 3.3.2.1 Construction Headquarters	17
3.3.1	Describe materials, components, and/or subassemblies delivered to the machines, and how the machines convert delivered supplies into completed settlement structures	3.3.2.2 Materials and Transport 3.3.2.3 Structural Assembly	17-18
3.3 Min Req	Include drawing(s) of primary construction machinery, showing how it shapes and/or manipulates raw materials or structural components into finished form	Figure 3.3.2 Themyscira	17
3.4.0	Using solar panels	3.4 Solar panel and Energy	18
3.4.1	Location and movement of energy	3.4.1 Logistics	18
3.4.2	Maintenance and internal designs	3.4.2 Maintenance	18
3.4 Min Req	Show solar panels in drawing(s) depicting Aynah design.	Figure 3.4.1 Solar Panels	18
3.5.0	Surface mining vehicle	3.5 Surface Excavating Vehicle	18
3.5.1	Internal hardware and components	3.5.1 Internal Hardware	18-19
3.5.2	External structure and attached equipment	3.5.2 External Components	19
3.5 Min Req	Provide drawing(s) of vehicle(s) for moving reardonium parts on Mercury surface	Figure 3.5.2 Voltron	19

4 HUMAN ENGINEERING

Requirement		Location in Proposal	
4.0.0	Provide natural sunlight and views of Mercury	4.0.1 Natural Sunlight	21
4.0.1	Establish roads and paths between residential and commercial areas in a diamond-grid pattern	4.0.2 Roads for Pedestrians and Vehicles 4.1.4 Community Layout Figure 4.1.4 Community Layout	21, 24
4.0.2	Minimize motion that causes mild discomfort due to Coriolis effects	4.0.8.3 Disorientation due to the Coriolis Effect	21
4.0.3	Arrange buildings to enable route selection to minimize the need to round acute corners	Figure 4.1.4 Community Layout	24
4.1.0	Provide services in comfortable modern communities	4.1 Modern Communities 4.1.1 Facilities Table 4.1.1 Variety and Quantity of Facilities	22, 23
4.1.1	Provide variety and quantity of consumer goods	Table 4.1.3 Distribution and Quantity of Water and Consumer Goods 4.1.3 Water and Consumer Goods	23, 24

4.1.2	Include public areas with long line of sight	4.0.8.4 Claustrophobia 4.1.1.6 Weather Park	21, 23
4.1.3	List major types of consumables and quantities	Table 4.1.2 Variety and Quantity of Consumables 4.1.2 Consumables	23
4.1.4	Depict ways of distributing consumables to residents	Table 4.1.3 Distribution and Quantity of Water and Consumer Goods	23
4.1 Min Req	Include maps (including distance scale and percentage of land allocated for roads) of community/ location of amenities	Figure 4.1.4 Community Layout	24
4.2.0	Provide designs of typical townhouse residences, clearly showing room designs	4.2 Residences Figure 4.2 Residences	24, 25
4.2.1	Identify sources of furniture and appliances	Table 4.2.2.1 Furniture Sources and Quantities 4.2.2.1 Sources of Furniture.	26
4.2 Min Req	External drawing and interior floor plan of at least 4 home designs, area for each residence design, number required for each design	Figure 4.2 Residences	25
4.3.0	Provide designs of systems/devices/vehicles intended for use outside of gravity volumes will emphasize safety	4.3 Devices and Transportation; 4.3.1.1 BLOX 4.3.1.2 Maglev 4.3.2 Devices and Systems for Safe Access 4.3.2.1 No-Slip Grips 4.3.2.2 Tether System 4.3.2.3 Aim Advanced Alert (AAA) Figure 4.3.1.1 BLOX Figure 4.3.1 No-Slip Grips on Shoes	26
4.3.1	Show spacesuit stowage and airlock designs	4.3.3 Spacesuits 4.3.3.1 Design of Spacesuits 4.3.3.2 Spacesuit Stowage 4.3.4 Airlocks 4.3.4.1 Procedure Figure 4.3.4 Airlock	27
4.3 Min Req	Provide drawings of handrails, tethers, cages, etc. enabling safe human access to any location on/in low g areas	Figure 4.3.1 No-Slip Grips on Shoes	26
4.4 Min Req	Drawing means for children to spend time in 1g	Figure 4.4.2 Learning in Schools	27
4.5.2	Provide surface vehicles for humans to inspect Mercury during both night and day	4.5 Surface Inspection Vehicles 4.5.2 Day Vehicle. 4.5.3 Night Vehicle	28
4.5 Min Req	Include drawings of surface vehicles for humans on Mercury	Figure 4.5.2 Day Vehicle Figure 4.5.3 Night Vehicle	28

5 AUTOMATIONS

	Requirement	Location in Proposal	Page
5.0.0	Specify numbers and types of computing devices, electronic tools, servers, network devices, robots, and	5.0.1 Computing Specifications Table 5.0.1 Computers	30

	community and business operations	5.1.0 Construction Table 5.2 Interior Robots 5.3 Automation for productivity, livability and convenience Figure 5.3.3.1 Network Diagram Table 5.4.1 Refining Ore 5.5.2 Curing Procedures	
5.0.1	Describe types of data storage media, data security, and user access to computer networks.	5.0.1.1.1 Memory 5.2.3.1 Authorized Personnel Access	30
5.0.2	Show robot designs indicating dimensions and illustrate how they perform tasks.	Table 5.2 Interior Robots Table 5.4.1 Refining Ore	32
5.1.0	Describe use of automation for construction.	5.1 Automation for Construction	31
5.1.1	Consider automation for transportation, delivery of materials and equipment, assembly of settlement, and interior finishing.	5.1.0 Construction 5.1.1 Transportation 5.1.2 Interior Finishing	31
5.1 Min Req	Drawings show automated construction, and assembly devices—for exterior and interior apps and illustrate how they operate.	Figure 5.3.2.1-Chassis Type I Figure 5.3.2.2 Chassis Type II Figure 5.3.2.1 Chassis Type III	34
5.2.0	Specify systems for maintenance, repair, and safety functions; back-up systems and contingency plans.	5.2 Automation for maintenance, repair, and safety functions	32
5.2.1	Provide robots required for emergency external repairs must survive and accomplish tasks in extreme solar flare activity.	Table 5.2 Interior Robots 5.2.1.1 Reardonium Body 5.2.1.2 Faraday Cage	32
5.2.2	Describe means for authorized personnel to access critical data and command computing and robot systems.	5.2.3.1 Authorized Personnel Access	34
5.2.3	Include descriptions of security measures to assure that only authorized personnel have access.	5.2.3 Security Automation 5.2.3.2 Apprehension Protocol	34
5.2 Min Req	Include a chart or table listing anticipated automation requirements for operation of the settlement, and identifying systems and robots to meet each automation need.	Table 5.2 Interior Robots Table 5.4.1 Refining Ore	32
5.3.0	Describe devices to enhance livability in the community, productivity, in work environments, and convenience in residences.	5.3 Automation for productivity, livability and convenience	34
5.3.1	Emphasize use to perform maintenance and routine tasks, and reduce requirements for manual labor.	5.3.2 Maintenance	34
5.3.2	Provide for privacy of personal data and control of systems in private spaces.	5.3.3.4 Server Firewall	36
5.3.3	Describe devices for personal delivery of internal and external communications services, entertainment, info, computing, and robot resources.	Table 5.0.1 Computers	30
5.3 Min Req	Drawings of robots and computing systems and that people will encounter in Aynah, and diagrams of networks and bandwidth requirements to enable connectivity.	Figure 5.3.2.1-Chassis Type I Figure 5.3.2.2 Chassis Type II Figure 5.3.2.1 Chassis Type III Figure 5.3.3.1 Network Diagram	34
5.4.0	Provide automation for efficiency of reardonium manufacturing processes, including unloading raw ore arriving from Mercury's surface, moving ore through refining processes, forming and handling parts, and unloading/loading parts sent to Mercury's surface for curing.	5.4 Reardonium Manufacturing	37
5.4	Provide drawings of robots for reardonium parts	Figure 5.4.1.1 Process Part I	37

Min Req	manufacturing and handling.	Figure 5.4.1.2 Process Part II Figure 5.4.1.3 Process Part III	
5.5.0	Provide robots for operations on the Mercury surface to handle reardonium parts, including turning parts over to get a better material cure, and loading/unloading parts on vehicles described in paragraph 3.5.	Figure 5.5.2 Curing Transport	38
5.5 Min Req	Include drawings surface robots, showing how they manipulate parts on the surface, and depicting “safe” configuration.	Figure 5.4.1.1 Process Part I Figure 5.4.1.2 Process Part II Figure 5.4.1.3 Process Part III Figure 5.5.2 Curing Transport Figure 5.5.3.1 Normal “Night” Configuration Figure 5.5.3.2 Normal “Day” Configuration	37

6 SCHEDULE AND COST

	Requirements	Location in Proposal	Page
6.1	Include durations and completion dates of major design, construction, and occupation tasks, depicted in a list, chart, or drawing	6.1 Schedule	40
6.2	Provide 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.	6.2.1 Cost Labor During Construction 6.2.2 Cost of Operations 6.2.3 Cost of Equipment 6.2.4 Cost of Construction Material 6.2.5 Raw Materials 6.2.6 Cost of Robots 6.2.7 Cost of Computers 6.2.8 Income 6.2.9 Operating Cost	41-42

7 BUSINESS DEVELOPMENT

	Requirement	Location in Proposal	Page
7.0.1	Infrastructure for refining and manufacturing reardonium parts	7.0.1 Refining and Manufacturing Reardonium Parts	44
7.0.1.1	Capability for handling and processing raw ore from the surface of Mercury, including systems to prevent dust and grit from entering habitable areas	7.0.1.1 Raw Metal Processing	44
7.0.1.2	Manufacturing capability in various gravity and pressure environments	7.0.1.2 Manufacturing Capabilities	44
7.0.1.3	Hazardous manufacturing operations are separated from areas humans occupy (e.g., residential and commercial areas)	7.0.1.3 Hazardous Operations	44
7.0.1.4	Manufacturing areas must be arranged to enable efficient movement of parts through production processes	7.0.1.4 Efficient Transportation	44
7.0.2	Receiving and shipping reardonium parts	7.0.2 Receiving and Shipping Reardonium Parts	44
7.0.2.1	Perform inspections and quality checks of reardonium parts returning from curing processes on the surface of Mercury	7.0.2.1 Inspections and Quality Checks	44
7.0.2.2	Install completed parts in standard shipping containers or on pallets for delivery to customers throughout the solar system	7.0.2.2 Packaging	44
7.0.2.3	Automate routine processes	7.0.2.3 Automation of Processes	44
7.0.3	Port of Entry for Mercury	7.0.3 Port of Entry for Mercury	44



7.0.3.1	Operate a fleet of interorbital shuttles to transfer personnel and cargo in standard shipping containers from/to interplanetary spaceliners	7.0.3.1 Interorbital transportation	44
7.0.3.2	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	7.0.3.2 Transportation to/from Mercury	44
7.0.3.3	Provide cargo warehousing for customs purposes and storage while waiting for transfer to other ships	7.0.3.3 Cargo warehousing	45
7.0.3.4	Provide vehicles/systems for moving cargo containers between ships and warehousing	7.0.3.4 Cargo transporting	45