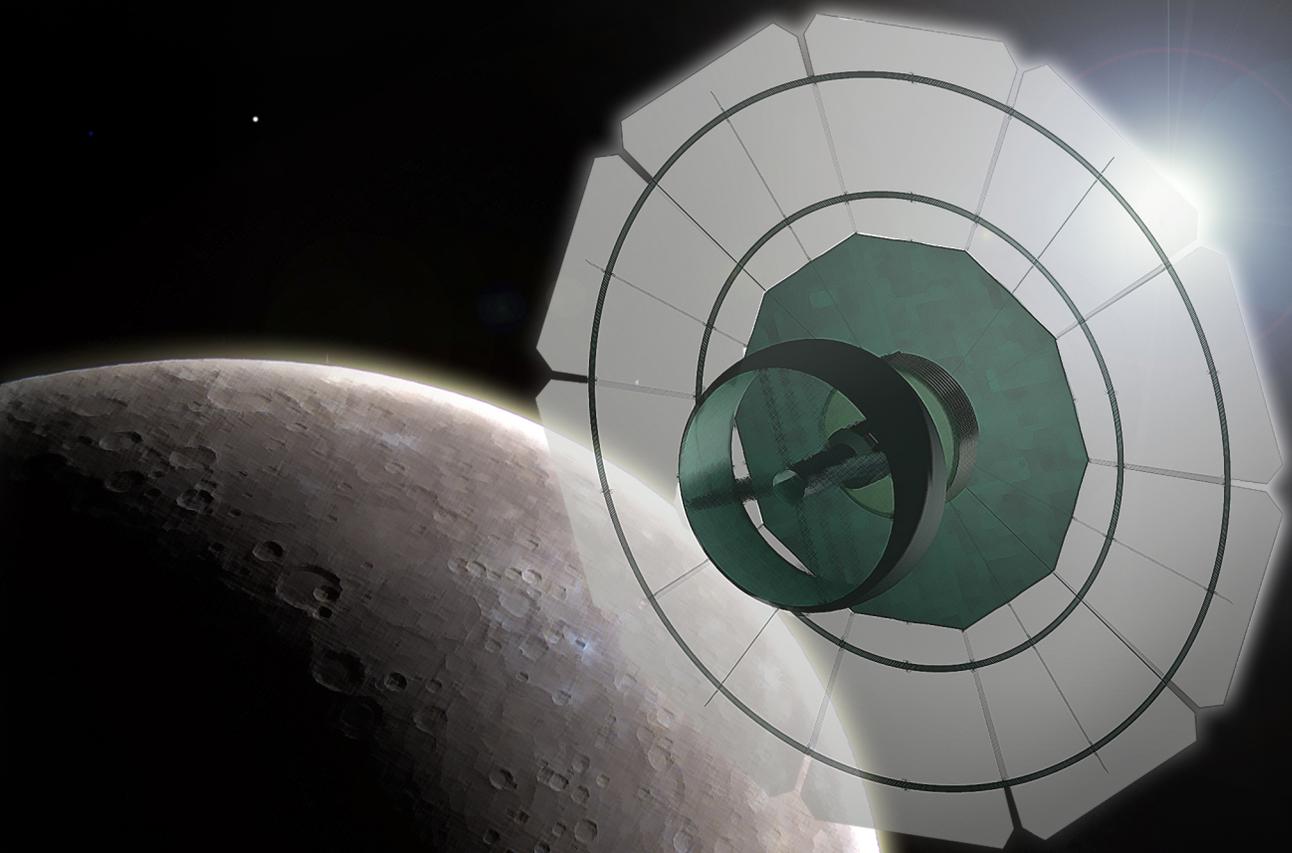


# AYNAH



**PRESENTED BY NORTHDONNING HEEDWELL**

**EDGEWATER HIGH SCHOOL  
3100 EDGEWATER DRIVE  
ORLANDO, FL 32804**

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

Name of responsible teacher/advisor: Kevin B Rucks  
 School (or other Group Name): Edgewater High School  
 School Address: 3100 Edgewater Drive  
 School Address (2nd line): Orlando, Fl 32804  
 School City, State, ZIP or Postal Code: Orlando, Fl 32804  
 Country: US  
 Daytime Telephone at School: 407-835-4900  
 Message Telephone: 407-845-4900 ex 606.4805  
 Fax Number: 1-407-245-2758  
 e-mail address: [kevin.rucks@ocps.net](mailto:kevin.rucks@ocps.net)  
 Last day of school before Summer 2012: 2-Jun

Contact information for responsible teacher/advisor when school is not in session:

Name if different from above: Kevin Rucks  
 Address: 2917 Carcross Street  
 Address (2nd line): Orlando, Fl 32837  
 City, State, ZIP or Postal Code: Orlando, Fl 32837  
 Country: US  
 Telephone (also evenings / weekends): 1-239-246-9247  
 e-mail address: [kevin.rucks@ocps.net](mailto:kevin.rucks@ocps.net)

Name of alternate contact person (may be a student): Jonathan Axel Schroder  
 Telephone X day X eve X weekend: 407-590-1977  
 e-mail address: [president.tempus@gmail.com](mailto:president.tempus@gmail.com)

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

<u>Taylor Krublitt [11] (17)</u>	<u>Pau Kim [11] (17)</u>
<u>Kara Weeden [12] (18)</u>	<u>Jasper Zaporteza [10] (16)</u>
<u>Jonathan Axel Schroder [12] (18)</u>	<u>Charles Glazier [12] (18)</u>
<u>Libba Van Eepoel [12] (18)</u>	<u>Marcus Smith [10] (16)</u>
<u>Casey Wolf [12] (18)</u>	<u>Gina Dignam [11] (17)</u>
<u>Aaron Thomas [12] (18)</u>	<u>Tyler Tripp [11] (17)</u>

Names of two adult advisors currently expecting to attend the Finalist Competition:  
Chelsea Rohrer Michael Galletti

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

Kevin Rucks

---

Responsible Teacher/Advisor Signature

4/2/2012

---

Date



## Table of Contents

1.0 Executive Summary .....	1
2.0 Structures .....	2
2.1 External Views .....	2
2.1.1 Hull Composition .....	2
2.1.2 Enclosed Volumes .....	3
2.1.3 Artificial Gravity .....	3
2.1.4 Isolation of Volumes .....	4
2.2 Down Surfaces .....	4
2.2.1 Allocation of Down Surfaces .....	4
2.2.2 Vertical Clearance .....	5
2.3 Construction Sequence .....	6
2.3.1 Phases of Construction .....	6
2.3.2 Method of Rotation .....	6
2.3.3 Interior Construction .....	7
2.4 Reardonium Manufacturing Facilities .....	7
2.4.1 Industrial Complex .....	7
2.4.2 Industrial Control Deck .....	8
2.5 Radiation Mitigation .....	8
2.5.1 Shield .....	8
2.5.2 Human Occupied Areas .....	8
3.0 Operations and Infrastructure .....	9
3.1 Location and Construction .....	9
3.1.1 Location .....	9
3.1.2 Material Sources .....	9
3.1.3 Equipment .....	10
3.2 Community Infrastructure .....	10
3.2.1 Atmosphere .....	10
3.2.2 Food Production .....	10
3.2.3 Electricity .....	11
3.2.4 Water Management .....	12
3.2.5 Solid Waste Management .....	12



3.2.6 Communications .....	13
3.2.7 Transportation .....	13
3.2.8 Day/Night Cycle.....	15
3.3 Construction Mechanics and Procedure.....	15
3.3.1 Exterior Construction .....	15
3.3.2 Interior Construction.....	15
3.4 Solar Panels .....	16
3.5 Tortoise Curing Vehicle .....	16
4.0 Human Factors .....	17
4.0.1 Natural Views .....	17
4.0.2 Paragon Grid Community.....	17
4.1 Community Design .....	17
4.1.1 Community Layout.....	17
4.1.2 Entertainment, Fine Dining, and Recreation .....	18
4.1.3 Consumer Goods.....	18
4.1.4 Distribution .....	18
4.2 Residential Design .....	19
4.2.1 Housing .....	19
4.2.2 Amenities .....	21
4.3 Low-G Accommodations .....	21
4.3.1 Zero-G Safety .....	21
4.3.2 Systems and devices for Low-G safety.....	22
4.4 Gravitational Therapy .....	22
4.4.1 Children .....	22
4.4.2 Adults .....	22
4.5 'Comet' Surface Vehicles .....	23
5.0 Automation .....	24
5.1 Construction.....	24
5.1.1 Welding bot.....	24
5.1.2 Exterior Construction Bot .....	24
5.1.3 Thruster Control and Monitoring System .....	24
5.1.4 Interior Construction Bot .....	24



5.2 Settlement Maintenance & Operation .....	25
5.2.1 Operations Robotics.....	25
5.2.2 Security Protocol.....	26
5.2.3 Contingency Plans .....	26
5.3 Human Factors Robotic Systems.....	27
5.3.2 Networking.....	29
5.4 Industrial Automation .....	30
5.4.1 Centrifugal Cargo Train .....	30
5.4.2 Robotic Loading System .....	30
5.4.3 Mobile Refinery.....	30
5.5 Reardonium Tending Bots.....	31
5.5.1 Cormorant Shuttle .....	31
5.5.2 Tortoise Reardonium Curing and Flipping Vehicle.....	31
6.0 Schedule and Cost.....	32
6.1 Schedule of Contractor Tasks.....	32
6.2 Costs by Phase of Construction.....	32
6.2.1 Structures Costs .....	32
6.2.2 Operations Costs.....	33
6.2.3 Human Factors Costs .....	33
6.2.4 Automation Costs.....	34
6.2.5 Total Billing.....	34
7.0 Business and Development.....	35
7.1 Commercial Ventures .....	35
7.2 Industrial Projects .....	35
7.2.1 Industrial Complex .....	35
7.1.1 Industrial Control Deck .....	35
7.2.2 Production Flow .....	36
7.3 Port of Entry.....	36
7.3.1 Orbital Shuttle Fleet.....	37
7.3.2 Landing Shuttle Fleet .....	37
7.3.3 Cargo Warehousing.....	37
7.3.4 Systems for loading and unloading.....	37



---

8.0 Appendices.....	39
A. Operational Scenario .....	39
B. Bibliography .....	40
Operations .....	40
Human Factors .....	41
Automation .....	42
Business Developments .....	42
Cover Art .....	43
C. Compliance Matrix.....	44

# EXECUTIVE SUMMARY



**HIGH ACHIEVEMENT  
ALWAYS TAKES PLACE  
IN THE FRAMEWORK  
OF HIGH EXPECTATION.  
-CHARLES KETTERING**



## 1.0 Executive Summary

The Foundation society's previous commercial ventures have all been grand successes. Northdonning Heedwell is proud to present this design for the next profitable undertaking of the Foundation Society: Aynah a port of entry for Mercury and a major facility for the manufacture of reardonium.

Aynah will be built with a heavy industrial demand in mind. Aynah's Industrial Complex will allow for the rapid manufacturing and shipping of reardonium parts, and its many industrial sectors will provide the proper production environments for reardonium pieces. With a large and efficient docking facility, Aynah will be able to provide for import and export traffic, as well as being a port of entry for Mercury and providing for residents. The entire settlement will be protected by its large reardonium shield, and all structures, incoming ships, and operating robots under it will be protected from intense solar activity.

The efficiency and profitability of manufacturing reardonium products extends past the settlement as well. One of the exclusive features in Aynah's construction process is a fleet of mobile refineries, which allow for a production of a vast array of objects from mined or reclaimed materials. When construction of Aynah is finished, these mobile refineries will be repurposed into their core modules to support Foundation Society industrial operations. The station's shield features massive solar petals, fueling the settlement's immense energy demand for the production of reardonium parts. Through this focus on industry, Northdonning Heedwell has not forgotten about its human inhabitants—Aynah's Residential Torus will focus on an Earth-like habitation, from fresh air to plentiful clean water.

In fact, Aynah's residents will have more than just their basic needs supplied. Residents will enjoy comfortable homes and the latest technological and automated services in carefully planned communities filled with exciting entertainment venues back dropped by beautiful natural views of Mercury. On the surface of Mercury, the environmental challenges of an alien terrain have been conquered. Aynah's primary surface vehicle, the 'Comet', will employ built-in ground penetrating radar systems to map the sub terrain for valuable ore and potential hazards. We have made the protection of humans on the surface, and in orbit, one of our top priorities.

Northdonning Heedwell's automation is built for strong production flow with minimal errors. The entire process of reardonium manufacturing is completed by robotics, from early construction of facilities to completion of the largest and most intricate reardonium parts. The 'Cormorant' shuttle will act as Aynah's primary surface-to-station shuttle. Specialized storage systems allow it to carry anything from raw ore to 'Comet' surface vehicles—even other, folded cormorants. Aynah is also equipped with automation for its inhabitants, from a fleet of robots which completely customize the Messenger Stadium in hours, to the most delicate contact lenses which can provide a heads-up display for wearers. Automation is a huge portion of fulfilling Aynah's purpose, and this design highlights efficiency in all automated tasks.

Every facet of Aynah's design has been built with the prosperity of the Foundation Society in mind. Northdonning Heedwell has taken great steps to ensure safe investing and a promise of great returns. Aynah will recoup original costs to the Foundation Society within a short time. Northdonning Heedwell hopes to continue a successful business partnership with the Foundation Society through a contract for Aynah.

# STRUCTURES



**I DON'T BUILD IN ORDER  
TO HAVE CLIENTS.  
I HAVE CLIENTS  
IN ORDER TO BUILD.**

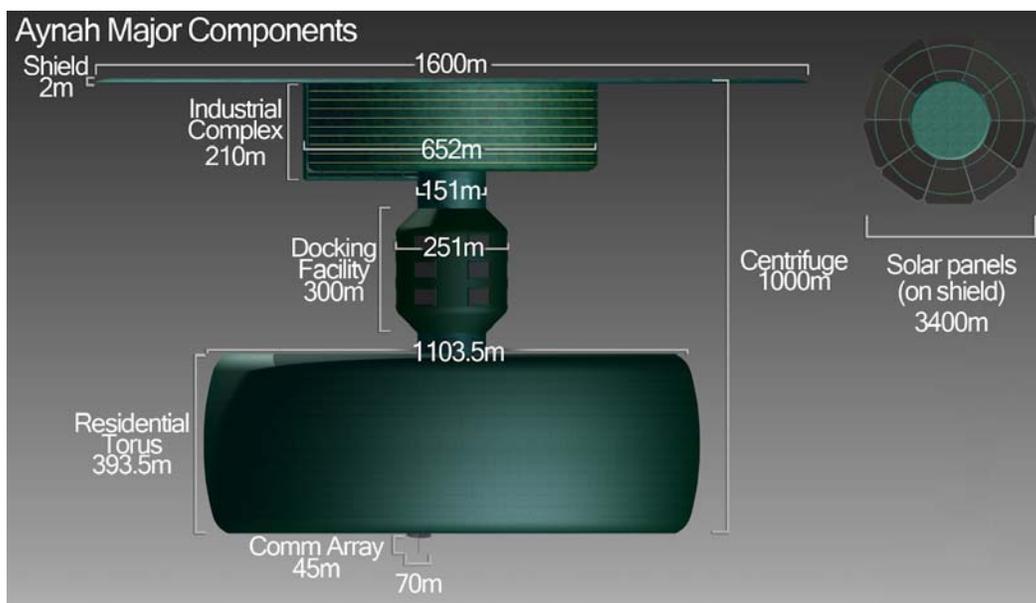
**-AYN RAND**

## 2.0 Structures

Aynah's design will provide a pleasant and productive environment for its community of 14,000 people. Its location in polar orbit above Mercury will allow uninterrupted exposure to sunlight, while its configuration will allow industrial operations to function without coming in contact with Aynah's residents. Natural views of Mercury will be projected from live feeds.

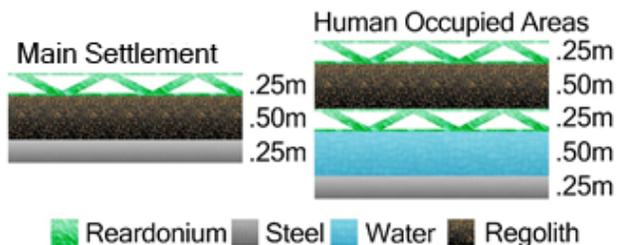
### 2.1 External Views

Aynah's shield will give protection to humans, robotics, and incoming ships from the sun. The Industrial Complex will serve all of the Foundation Society's industrial needs for operations on Mercury. The Docking Facility will initially house 24 Cormorant shuttles and visiting ships and serve as a storage and shipping point for cargo. The Residential Torus will contain Aynah's residential community.

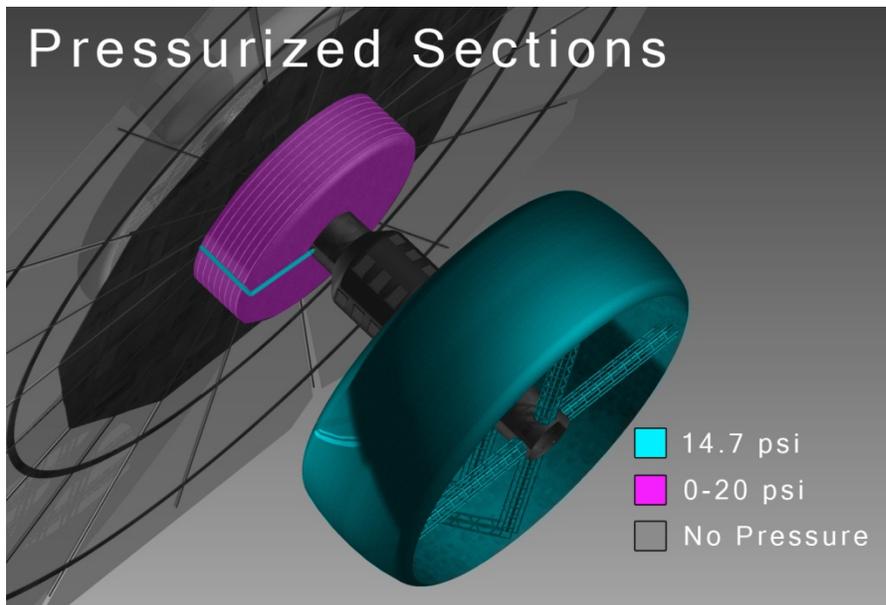


### 2.1.1 Hull Composition

All hulls on the station will be composed of steel, regolith, and reardonium. All human-occupied volumes will contain an additional half meter layer of water.



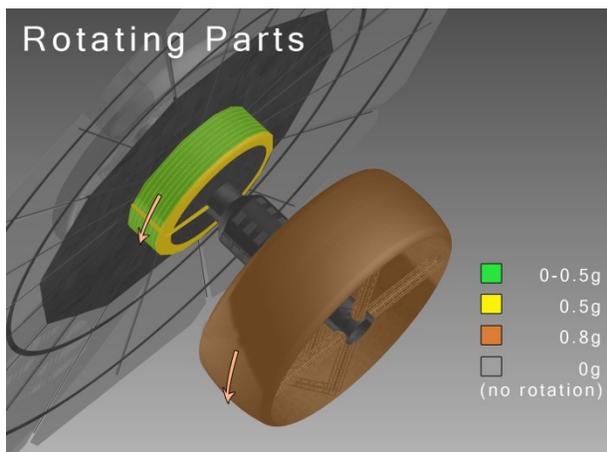
## 2.1.2 Enclosed Volumes



## 2.1.3 Artificial Gravity

Aynah's Residential Torus will spin at 0.8g in compliance with human gravity preferences. Nine out of the ten discs that make up the exterior of the Industrial Complex will spin at variable velocities, from 0g (no rotation) to 0.5g. The first disc of the Industrial Complex, and the attached Industrial Control Deck (refer to 2.4.2) will always spin at 0.5g, facilitating a gravity-stable environment for humans. The rest of Aynah's structure will not spin.

Structural interfaces between rotating and non-rotating sections will include gravity interface rails, interface trains, and a loading depot. Pictured is the gravity interface between the interior centrifuge and the residential spokes. The gravity interface rail will sit above rotating sections of the centrifuge, and sections will move when a train maneuvers into or out of a spoke. Humans and cargo will be loaded onto trains through the loading depot. There will be one gravity interface train per spoke. Refer to 3.2.7 for operation of gravity interfaces.



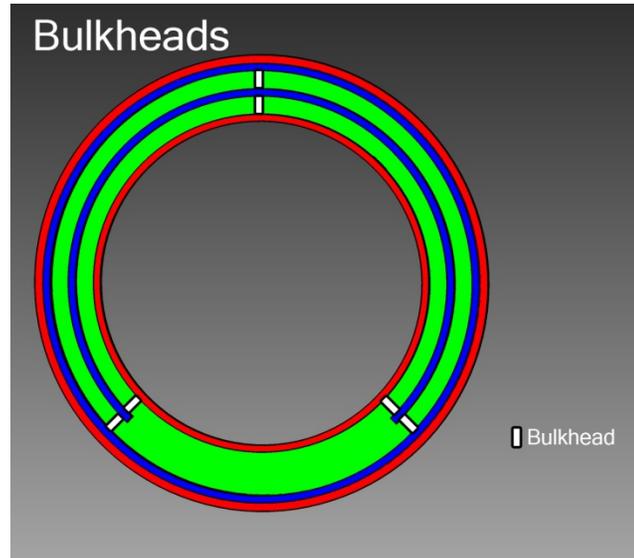
## Gravity Interface

- Gravity Interface Train
- Gravity Interface Rail
- Rotating Section
- Loading/Maint. Depot
- Spoke to Residential Torus



## 2.1.4 Isolation of Volumes

Aynah's residential structure is composed of two large residential floors with an 800m long opening in the top floor(2.2.1), allowing for a larger 45m vertical clearance(2.2.2). In the event of an emergency, settlement administrators will sound alarms and begin to deploy bulkheads.



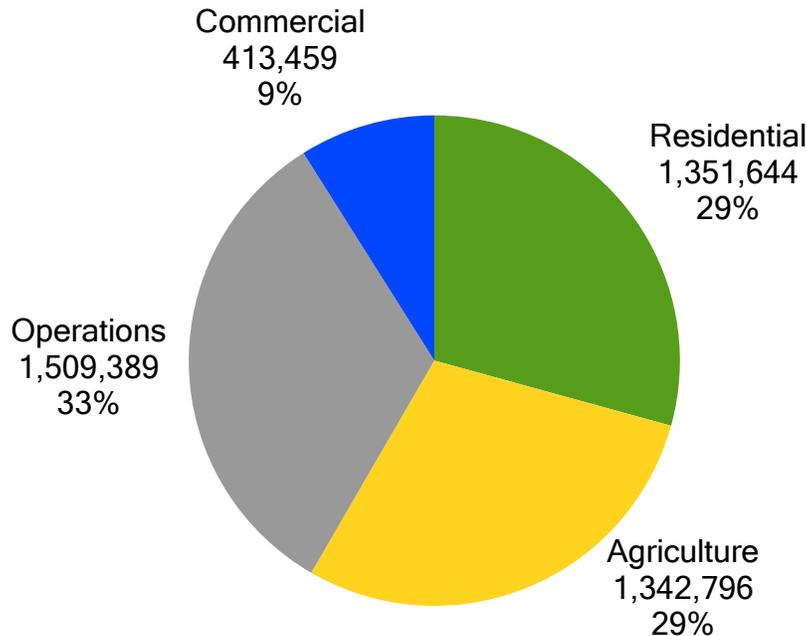
## 2.2 Down Surfaces

Aynah's residential layout is composed of two main settlement floors and two storage floors.

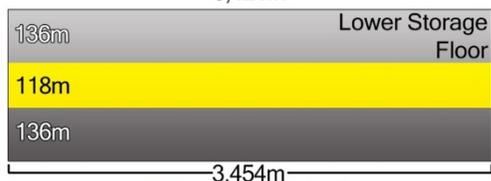
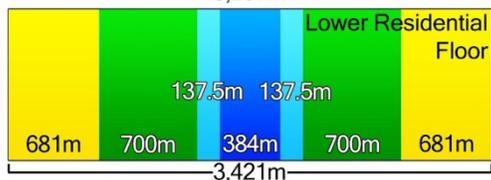
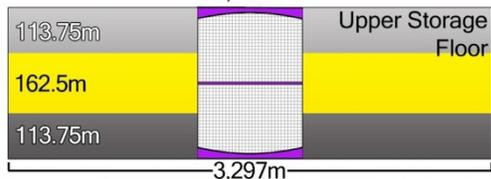
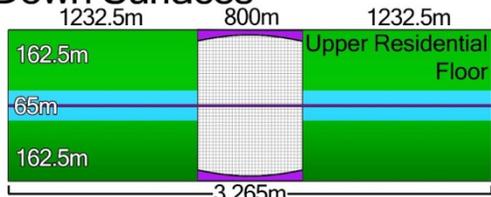
### 2.2.1 Allocation of Down Surfaces

Most of Aynah's residential space is located in the Upper Residential Level; whereas most trade and business allocations are located in the Lower Residential Level. Agricultural space, robotics and settlement storage, and room for operations infrastructure are located in the upper and lower storage levels.

## Down Surface Allocations



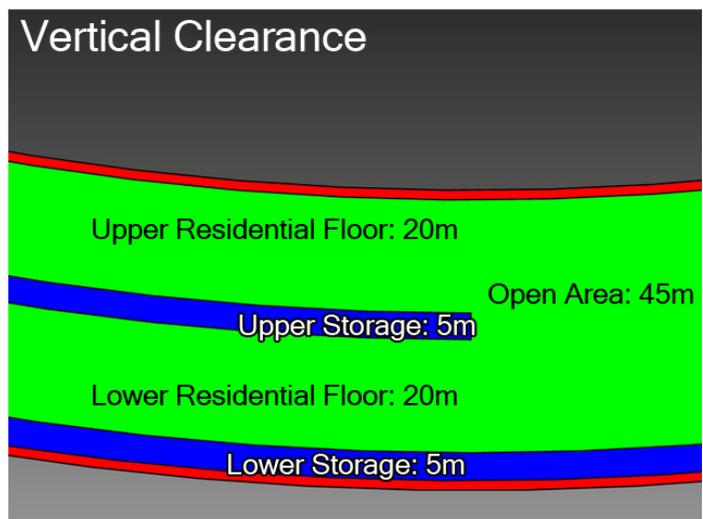
## Down Surfaces



Level	Total (m <sup>2</sup> )	Total (m <sup>3</sup> )
Lower Residential Floor	1,335,360	26,219,732
Upper Residential Floor	1,274,130	24,994,512
Lower Storage Floor	1,347,840	6,708,086
Upper Storage Floor	1,286,220	6,401,780
<b>Total</b>	<b>5,243,550</b>	<b>64,324,110</b>

### 2.2.2 Vertical Clearance

Each Residential Torus floor will be twenty meters high. Each storage floor will be 5 meters high. Residents in the Upper Residential Floor will experience a gravity of .76g, while residents in the Lower Residential Floor will experience a gravity of .8g. 800 meters of the Upper residential floor will be open to the Lower Residential Torus, allowing a 45m ceiling.



## 2.3 Construction Sequence

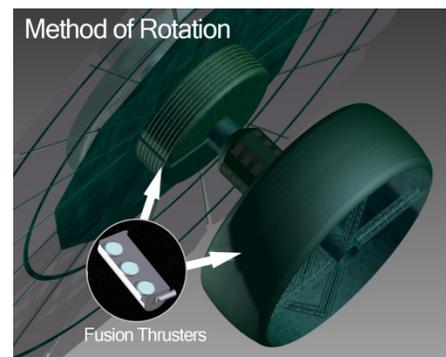
### 2.3.1 Phases of Construction



Phase	Name	Description
1	Wells	Docking facility will arrive in the orbit of Mercury. Robots and construction materials housed inside will be deployed.
2	Verne	Construction of the 'Upper' centrifuge skeleton will begin.
3	Asimov	Construction of a 400m radius shield will begin.
4	Drake	Construction of the Industrial Complex. Industrial Complex initiates rotation via thrusters(refer to 2.1.3)
5	Bradbury	Construction of 'Lower' centrifuge and habitat ring spokes. Industrial Complex comes online, allowing reardonium parts manufacturing in-orbit. Expansion of the shield to 800m radius.
6	Herbert	Construction of the habitat ring and communications disc. Habitation ring initiates rotation via thrusters (refer to 2.1.3)
7	Clark	Construction of Aynah base structure complete. Solar panel petals will begin to be affixed to the outer portion of the shield.
8	Heinlein	Mobile refineries will be reconfigured for interior structures. Construction of Aynah's interior.

### 2.3.2 Method of Rotation

Rotation of the Residential Torus and the industrial discs will be performed by fusion thrusters located on the outer circumference of each structure. These will provide the 72 mega Newtons of force required to accelerate the disc to 0.8g over the span of one Earth year. The final tangential velocity of the Residential Torus will be 67.4m/s. Reversible fusion thrusters installed on each of the ten industrial discs will allow stable changes in gravity from 0-0.5g over the course of a week. Each of the discs will spin independently of each other and can rotate at any acceleration within the 0-0.5g spectrum.



### 2.3.3 Interior Construction

Once construction of Aynah is completed, Aynah's mobile refineries (refer to 5.4.3) will be repurposed for the creation of interior structures parts. Regolith, once used for construction of Aynah's hull, will be used to make housing parts and furniture using its 3D printers. The reassignment of mobile refineries to interior construction parts will be fairly straightforward, merely requiring a change in 3D printing schematics and the addition of hydration modules for regolith concrete.

Completed regolith housing parts and furniture will be transported to the Residential Torus and assembled by interior construction bots (refer to 5.1).

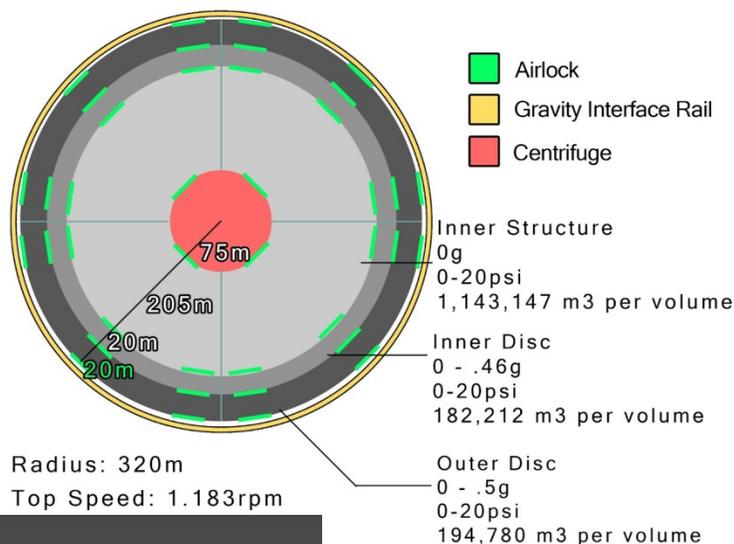
### 2.4 Reardonium Manufacturing Facilities

Aynah's extensive industrial facilities, located in the Industrial Complex, will host all reardonium production and manufacturing projects on the station. Modules from mobile refineries (refer to 5.4.3) will be reconfigured to operate in the Industrial Complex, supplementing industrial operations.

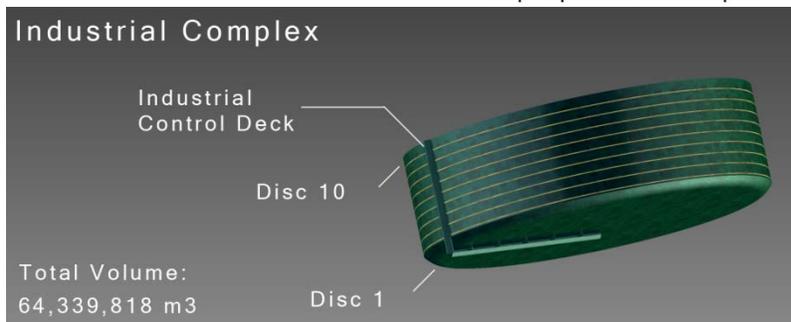
#### 2.4.1 Industrial Complex

The Industrial Complex is a structure directly behind Aynah's shield composed of one large non-rotating substructure and ten spinning discs on its exterior. The bottom 'control' disc will always rotate at 0.5g. The nine other discs will rotate independently of each other, allowing each to spin at a different rotational rate. Each disc is composed of eight separate factories and one large non-rotating 0g industrial area. Each of the 12 volumes in each disc have the capability to pump gases in or out, allowing for varying pressure limits between 0 and 20psi.

### Industrial Disc Cross-Section



Radius: 320m  
Top Speed: 1.183rpm



## 2.4.2 Industrial Control Deck

The Industrial Control Deck runs from the 'bottom' industrial floor to the tenth rotating disc in the complex. Life-support systems and administrative/observational facilities will be included in the interior of the control deck.

The Industrial Control Deck houses ten trams that can move along each disc's gravity interface rail, matching velocities and allowing an easy interface between discs and the Industrial Control Deck.

## 2.5 Radiation Mitigation

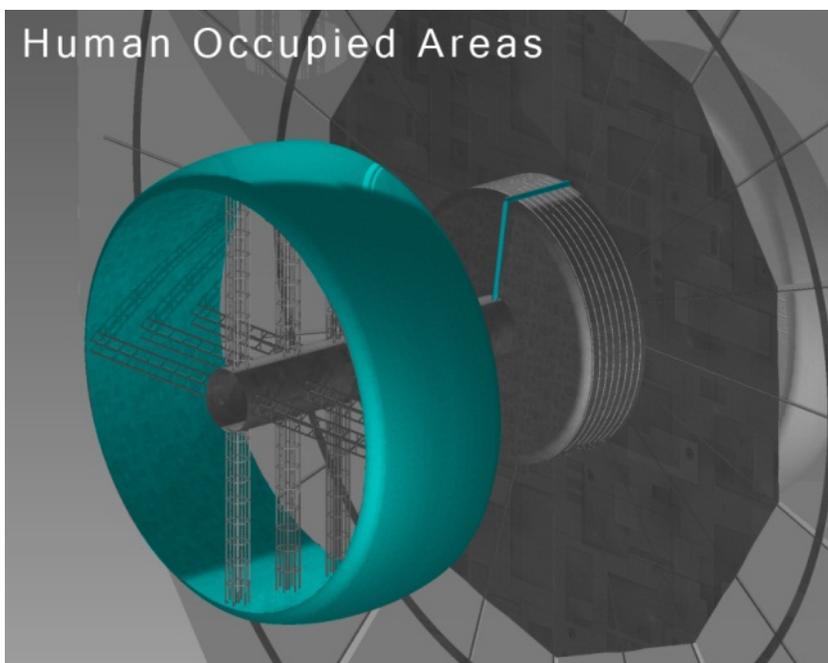
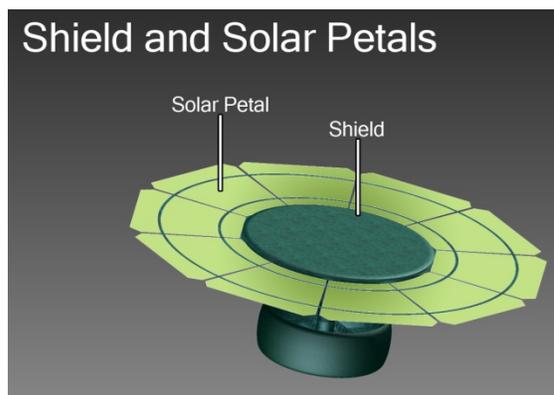
### 2.5.1 Shield

Aynah's settlement and facilities will be protected from the Sun by its shield, which will always face the sun (refer to 2.1.1 for shield composition). The shield will also act as a barrier against light from the sun, casting an umbra large enough to protect the habitation ring on the far side of the station and any nearby ships or robotics under it. The shield will house an array of hybrid thermal/solar collectors, and liquid sodium will be run through the interior of the shield to sustain cooling.

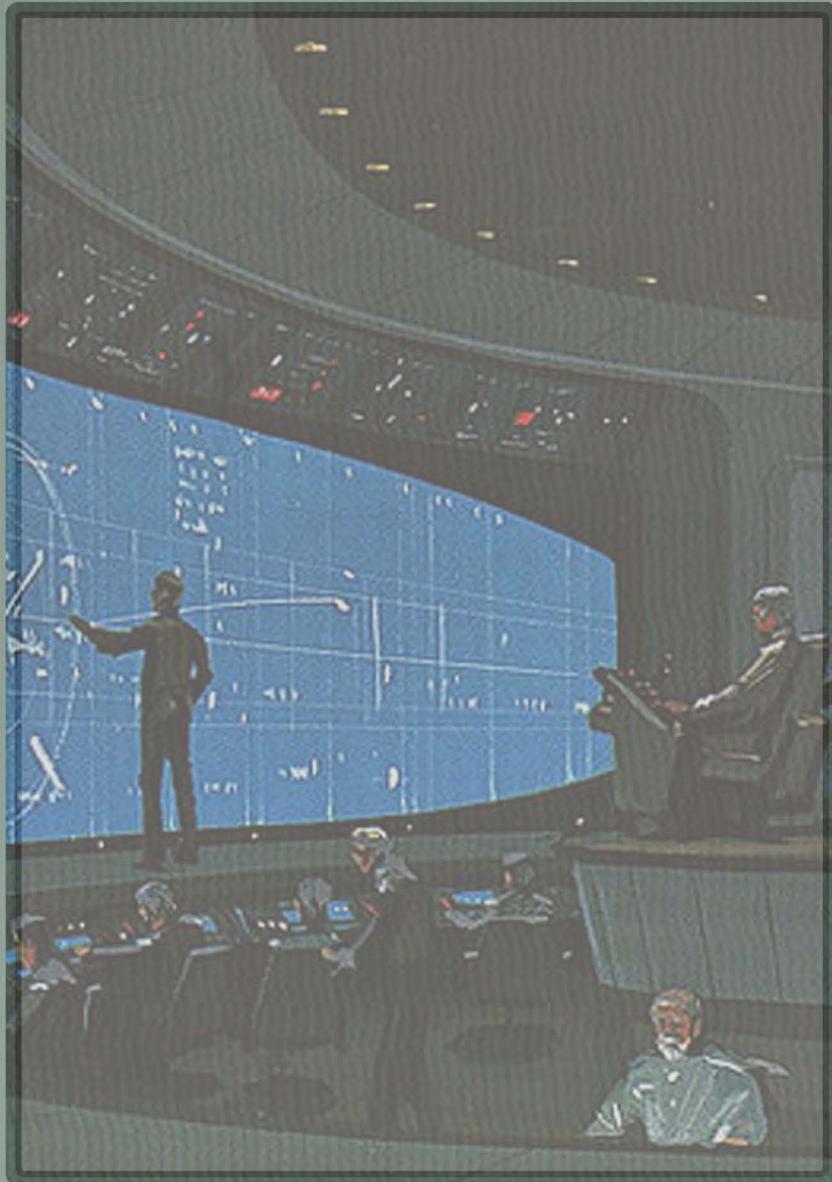
Aynah's ten solar petals will be constructed on the exterior of the shield, and will act as Aynah's main power source.

### 2.5.2 Human Occupied Areas

Human inhabited areas will be encased in a 0.5m layer of water. This includes the Industrial Control Deck and the Residential Torus.



# OPERATIONS



**OUR PROBLEMS ARE  
MAN-MADE, THEREFORE  
THEY MAY BE SOLVED  
BY MEN.**

**-JOHN F. KENNEDY**

### 3.0 Operations and Infrastructure

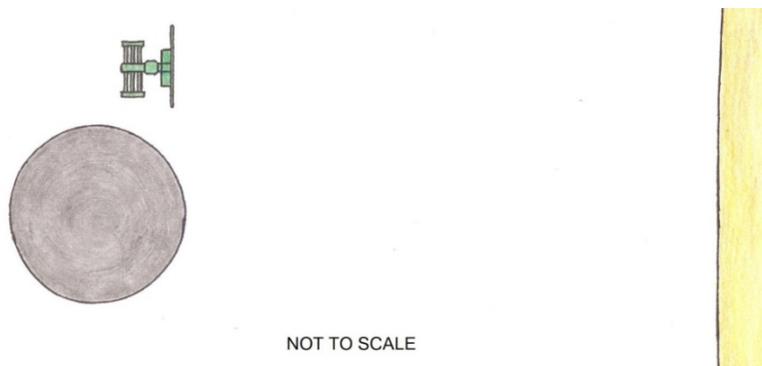
Station Operations on Aynah will provide for a safe and healthy environment for all residents while implementing necessary and efficient infrastructure for Aynah's industrial processes and reardonium refining needs.

#### 3.1 Location and Construction

Aynah will face the sun in a polar orbit around Mercury. The docking facility, which will be the first structure in Aynah, will be shipped to Mercury and manufactured from steel, but will be plated with reardonium as materials are available. The settlement will be manufactured primarily of reardonium and Mercurian regolith, and human-occupied areas will be encased in a 0.5m layer of water.

##### 3.1.1 Location

Aynah will orbit Mercury at a distance of 250 km from the surface in a sun-facing polar orbit. The polar orbit will allow the station to remain constantly exposed to the sun and thus provide optimal power output.



##### 3.1.2 Material Sources

Material	Purpose	Source	Quantity
Helium-3	Fusion Propulsion	Mercury, Balderol	4 metric tons
Regolith	Hull, Shield, Robots	Mercury	5,035,623,000 kg
Steel	Hull, Shield	Balderol	12,275,034,000 kg
Reardonium	Hull, Shield	Mercury	2,469,430 m <sup>3</sup>
Thorium	Thorium reactors in vehicles	Earth	1 metric ton
Sodium	Shield	Earth	10 metric tons
Polyvinylidene Chloride	Food Storage	Earth	16,434,785 kg
LEDs	Lights	Earth	540 billion units



### 3.1.3 Equipment

The initial construction equipment for Aynah will be shipped from Earth to Aynah's docking facility (refer to 2.1). This includes a fleet of construction robots, skeletal components for the centrifuge, and other construction supplies.

### 3.2 Community Infrastructure

Station operations on Aynah will utilize efficient processes for life support functions to create a safe and healthy environment for all residents.

#### 3.2.1 Atmosphere

Gas	Percentage of Atmosphere	Quantity
Nitrogen	79%	50,816,000 m <sup>3</sup>
Oxygen	21%	13,508,110 m <sup>3</sup>

Aynah's pressure will be kept at 1 atm. Humidity will be kept at 40% to be comfortable for inhabitants. Aynah will use atmosphere and temperature monitors to regulate temperature based on the station's season (refer to 3.2.8). For atmospheric cleansing, air from the residential and industrial areas will be routed to a separate chamber and exposed to monoethanolamine. The monoethanolamine will bond with carbon dioxide, separating it from the air by cooling so that it settles to the bottom of the chamber. The mixture is then pumped through carbon steel pipes containing inert gas and is heated by excess heat from the waste process (refer to 3.2.5). This breaks the monoethanolamine and carbon dioxide bonds, and the carbon dioxide is then collected and routed into the agriculture areas for plant consumption.

	<i>Summer</i>	<i>Autumn</i>	<i>Winter</i>	<i>Spring</i>
Day	26°C (78° F)	21°C. (70° F)	18°C (65° F)	22°C (72° F)
Night	22°C (72° F)	19°C (66° F)	15°C (60° F)	20°C (68° F)

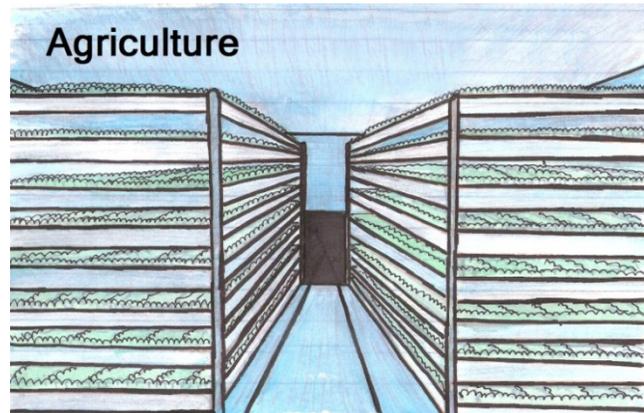
#### 3.2.2 Food Production

Product	Grams per person per day	Total kg produced per year	Total kg/month for contingency
Grains	400	2,044,000	14,194
Fruits	350	1,788,500	12,420
Vegetables/Legumes	450	2,229,500	15,480
Meat Products	175	894,250	6,210
<b>TOTAL</b>	<b>1375</b>	<b>6,956,250</b>	<b>48,304</b>

Food for 14k per year	Contingency per month	Total food required per year
6956250 kg	48305 kg	7,535,908 kg

Agricultural Allocations	Surface Area
Residential Level Storage Agriculture	405,750.5 m <sup>2</sup>
Lower Level Agriculture	531,295 m <sup>2</sup>
Lower Level Storage Agriculture	405,750.5 m <sup>2</sup>
<b>TOTAL</b>	<b>1,342,796 m<sup>2</sup></b>

Crops will be grown in microgravity on the storage floor to promote growth, using red and blue LEDs in place of sunlight to reduce evaporation. The station will utilize dynaponics; a process in which air is pumped through a shallow reservoir solution to spray roots. The use of dynaponics will reduce the amount of water and area needed while increasing the rate at which plants grow. The agricultural center will be a large rectangular greenhouse containing eight terraces stacked upon each other. The terraces will run along the walls, leaving space in the middle for robots to maneuver and maintain the crops. Harvesting will be carried out by the Harvest Bot (refer to 5.2.1). Once harvested, packaged food will be transported by a series of pneumatic tubes to individual quarters, restaurants, or storage.



Bio-printing will be used to assemble meat products. Bio-printers will print layers of cells to produce tissue, which will be closely regulated for nutrients and texture. Every resident will have access to food in their home, while special meals will be prepared and sold by restaurants and marketplaces (See 4.1.2). Food storage will be kept at 2° C with low lighting to prevent food spoilage. The food will be vacuum-sealed in polyvinylidene-chloride wrap to ensure freshness. 200,000 kg of preserved food will be stored separately in case of a food contingency such as blight or epidemic. This will be enough food to support the settlement for up to one month until food production is reestablished. All food will be stored in the one of the two storage levels of the Residential Torus.

### 3.2.3 Electricity

Electricity for Aynah’s residents will be supplied mainly by hybrid thermal/solar collectors on the surface of the shield. The waste system of Aynah will act as an auxiliary power source in case of major power grid failure.

#### 3.2.3.1 Main Power

Power for Aynah will be generated by a hybrid photovoltaic/thermal solar collector system and an array of auxiliary solar panels built into the station’s shield (refer to 3.4). Liquid sodium will be used in the thermal collector for cooling of the shield and heating of water, which will be used to spin turbines to generate electricity. An area of 742,200 square meters on Aynah’s shield will be set aside for power production, capable of producing up to 11 GW of power

Role	Allocation
Residential	20,000 kW
Industrial (not including reardonium)	3,000,000 kW
Automated Systems	60,000 kW
Contingency	20,000 kW
Reardonium Production	38,000,000 kW
Other Surface Operations	400,000 kW
Total	42,400,000 kW

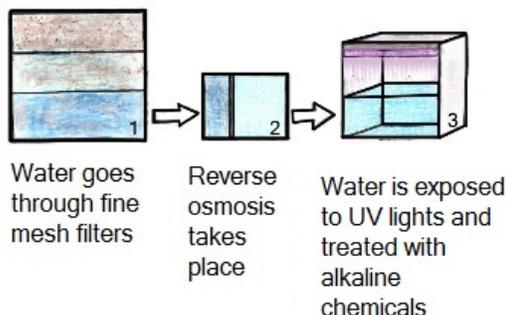
### 3.2.3.2 Auxiliary Power

The waste system on Aynah will produce 1 MW of power, enough to power food production (excluding robots), water purification, and air purification. This will be used to power the life support system in the event of main power grid failure. The excess power will be stored by compressing nitrogen gas into liquid and allowing it to expand and spin a turbine to create contingency power.

The electricity generated by the residents' bicycles will be sent to the main power supply, but this will only generate 50-500 kW at any time, so it will at best serve as a contingency.

### 3.2.4 Water Management

Water on Aynah for residential use will first be sent through fine mesh filters to separate solid wastes and large bacteria. It will then undergo reverse osmosis, in which a semi-permeable membrane will filter out undesirable minerals. Finally, the water will be exposed to UV lights and treated with alkaline chemicals to retain a proper pH balance. For processing industrial wastewater, Aynah will implement a carbon filtering process. Contaminants will bond with activated carbon while allowing other substances to pass through. The purification processes will take place on the maintenance level. Water will be available in reservoirs on every floor. The residential water system will be kept separate from the agricultural and industrial water systems to avoid any potential contamination. Current advances in fusion propulsion technology will allow water to be quickly and efficiently imported to Aynah from Earth.



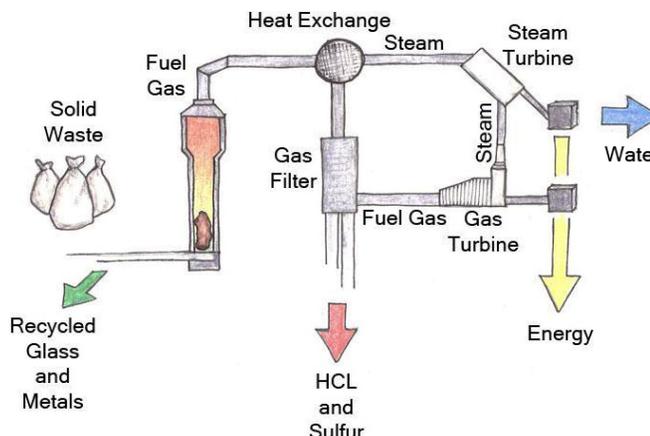
Purpose	Amount
Agricultural	80,000 L
Industrial	800,000 L
Residential	296,800 L
Reserve	375,000 L
Hull	1,451,416,000 L
Total	1,452,967,800 L

### 3.2.5 Solid Waste Management

Plasma Gasification will be used to recycle Aynah's waste. Waste will be routed to processing facilities throughout the Residential Torus and industrial disc through a series of tubes to a storage area where industrial, medical, and residential wastes will be separated and held until they can be processed. The process will begin by using a plasma torch to heat the waste. This will transform the inorganic materials into slag that will be quenched and refined into metals and glass. The organic materials become gas in the absence of oxygen and leave the chamber. The heat exchanger then cools the gas down to 132 C and makes high-pressure steam to power a steam turbine. The gas is then sent through a filter to remove any metal and glass particulate matter, as well as hydrochloric acid and sulfur. Gas turbines will combust the purified gas and produce additional steam for the steam turbine. The steam is then

condensed and processed with other wastewater. The energy produced will power the waste system, air purification system, and act as a source of contingency power for life support (refer to 3.2.3.2). Waste will be collected from houses and transported to the processing facility via a pneumatic tube system independent from the food tubes.

Source	Waste Processed
Residential	9,400 metric tons
Industrial	5,500 metric tons
Agricultural	670 metric tons
<b>Total</b>	<b>15,570 metric tons</b>



### 3.2.6 Communications

Communication Device	Number of Devices	Location of Devices
WristWatch	15,000	Residents
Industrial Communication Server	1	Industrial Zone
Residential Communication Server	1	Residential Torus
Logistics Communication Server	1	Docking Facility
Administration Server	1	Residential Torus
Mercury Satellites	5	Orbiting Mercury
Aynah Satellite	1	L2 Lagrange Point
Aynah Communications Disc	1	Edge of Centrifuge

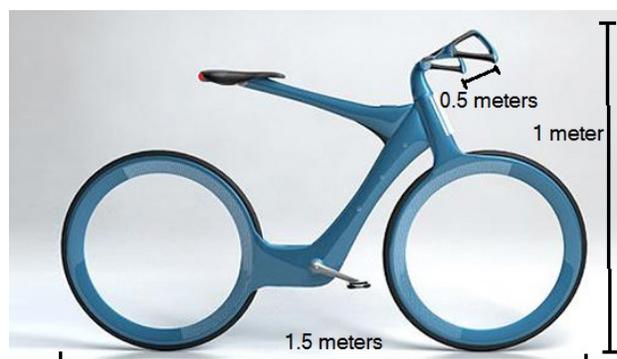
The WristWatch will be used by the residents and transients on the station for their personal communication (refer to 5.3.1.6).

Satellites orbiting Mercury will be used for a locational positioning system on the surface. These satellites will also be equipped with solar monitoring devices to gather data about solar activity and predict blackout periods so that necessary precautions may be taken. Satellites around both Earth and Mercury will provide communications between Aynah, the surface of Mercury, Foundation Society settlements, and Earth. The Aynah Receiver will be used to receive transmissions from other satellites.

### 3.2.7 Transportation

#### Bikes

Bicycles will be available for resident use throughout the Residential Torus. Terminals evenly spaced throughout the torus will dispense bikes to residents and receive them at their destination. A resident with a bicycle will be able to reach any point in the Residential Torus with a ten-minute ride. The spokeless wheels of the bike are lined with magnets so that residents create an electric

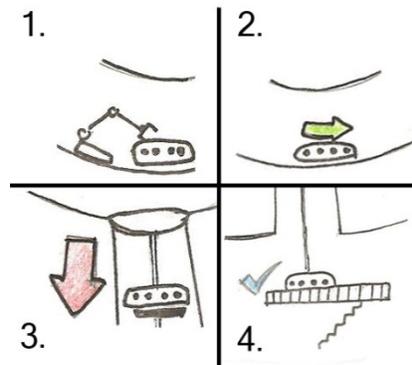


current while peddling it. This energy is stored in the bike and sent to the public power supply when the vehicle is returned to a terminal.

### Gravity Interface Trains

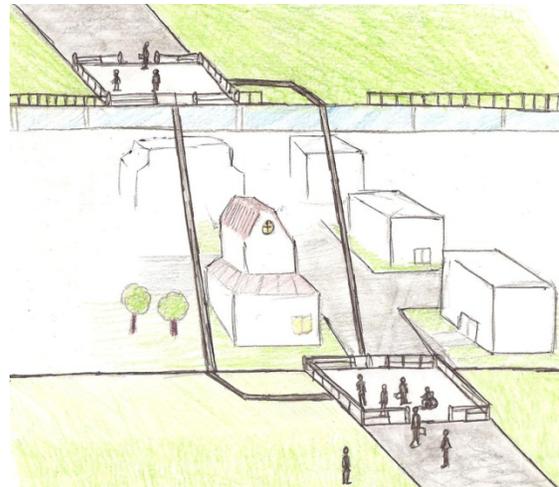
The gravity interface train line will allow easy movement between the 0.8 gravities of the Residential Torus and the 0g centrifuge. There will be twelve different train lines running from the centrifuge to the Residential Torus, eight for transporting cargo and four for transporting humans. First, cargo is loaded onto each of the 8m long trains. Once cargo is secure, the train begins moving to match a rotating spoke's rotational speed. When rotational speed is matched and the train is positioned above a spoke, the rail section above the spoke will unlock, and gravity will pull the train down the spoke. Once the train arrives at loading facilities in the Residential Torus, movement from 0g to 0.8g is complete.

### Gravity Interface



### Residential Elevators

A system of moving platforms will transport residents from the first floor to the second floor in the Residential Torus while providing an open view of the city. The platforms will be able to carry up to 50 people at a time and will travel at reduced speed for safety and to provide an optimal viewing experience.



Transportation Device	Features	Routes	Units	Dimensions
Gravity Interface Train Lines	Seating or cargo restraints depending on load	Residential Torus to Centrifuge	12	8 x 5 x 5 meters
Residential Elevators	Moving people between levels of Residential Torus.	Between levels of Residential Torus.	6 pairs	18 x 2 x 20 meters
Bikes	Civilian use	Residential Torus.	14000	1.5 x 1 x .5 meters
Education Center Train	Increased gravity environment and school for children.	On the residential level of the torus	1	150 x 12 x 4.6 meters

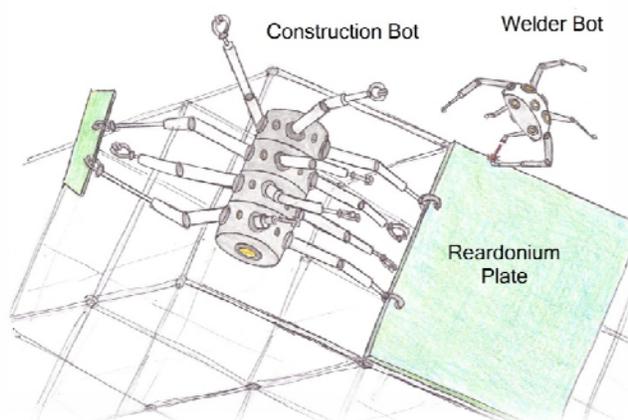
### 3.2.8 Day/Night Cycle

The station will use Earth Greenwich Mean Time (GMT) and will have a day and night cycle that follows Greenwich, in length of day and season. Common areas and most corridors will have high ceilings, which will have natural lighting LEDs to simulate the Earth's sky, and will include images of the sun, stars, astronomical events such as meteor showers, and optional weather patterns. At night there will be real-time images of Mercury moving across the sky in place of Earth's moon. Slight temperature changes will accompany changes between day and night and seasons, but they will not be so drastic as to create discomfort for the inhabitants. Slight thermal differences in separate areas can be utilized to create light breezes.

### 3.3 Construction Mechanics and Procedure

#### 3.3.1 Exterior Construction

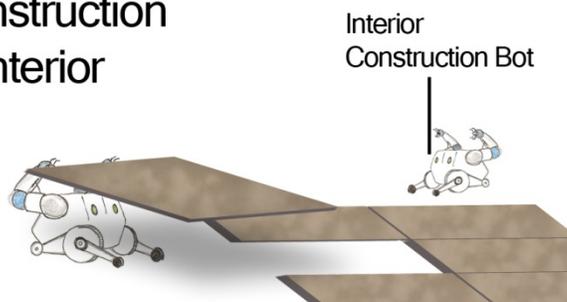
Station Construction on Aynah will be fully automated. Raw ore mined from the surface will be shuttled by Cormorants to a Mobile Refinery in orbit (refer to 5.4.3). Cormorants will interface with the Mobile Refinery and retrieve machined parts, ready to use for construction. External assembly robots (refer to 5.1.2) and Welding Bots will move and weld hull and shield pieces into place until the structure is enclosed and rotating. Smaller interior assembly robots (refer to 5.1.4) will then operate within the now functioning artificial gravity environment to finish industrial and residential facilities.



#### 3.3.2 Interior Construction

Construction of Aynah's interior will involve the reassignment of mobile refineries (refer to 5.4.2) to the construction of housing parts, furniture, and community infrastructure. The ability to turn Mercurian regolith into a concrete will be facilitated through the addition of hydration modules and molding chambers. Components produced by the mobile refineries will be transported to Aynah with Cormorant shuttles. Interior construction bots will assemble these pieces into finished structures.

### Construction of Interior

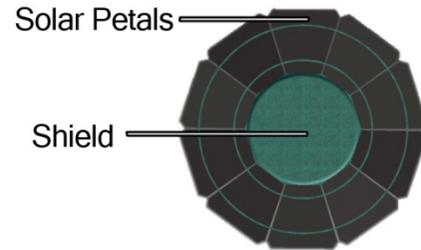


### 3.4 Solar Panels

Once construction of the shield is complete, an array of 10 solar panels will be constructed on Aynah to facilitate reardonium production. Each 442,000 m<sup>2</sup> sized panel will produce 3.1 gW and be composed of 50 smaller panels for ease of construction. The orientation of the panels around the shield will provide optimal exposure to sunlight.

Construction of Aynah's solar petals will begin with the completion of the shield, and construction will be performed by exterior construction bots.

### Power Arrays (Aynah facing Sun)



### 3.5 Tortoise Curing Vehicle

Transportation of reardonium parts over the surface of the planet will be carried out by large solar powered Tortoise curing vehicles (refer to 5.5.2). A variety of parts slated to be cured will be placed on 33 m x 13 m sheets of aluminum. The Tortoise curing vehicles will drive over a sheet and extend several robotic arms to grapple and lift it into the vehicle's cargo bay. The underbelly of the vehicle will be equipped with many different robotic arms to flip and turn the various pieces for their next soak cycle. Each vehicle can carry up to 12 sheets at a time. The roof of each Tortoise will be covered with 1575 m<sup>2</sup> of solar panels for power. They will be constructed with strong suspension and the ability to travel at relatively rapid speeds in the light gravity of Mercury. Reardonium parts ready for cold soak will be relocated to the night side of Mercury. Maintenance will be periodically performed by humans using the Comet vehicles (refer to 4.5). Initially, 15 vehicles will be provided for operations on Mercury's surface.

# HUMAN FACTORS



**IF EVERYONE IS MOVING  
FORWARD TOGETHER,  
THEN SUCCESS  
TAKES CARE OF ITSELF.  
-HENRY FORD**

## 4.0 Human Factors

Aynah takes pride in providing a society that fulfills the needs of its constituents. Through ingenious technology and visionary designs, this urban-metropolis inspired society brings together all of the fascinating and rewarding opportunities Mercury has to offer. From captivating urban environments, to alluring parks and a community-centered populace, it is guaranteed there is no place like space.

### 4.0.1 Natural Views

To provide natural views of space and sunlight, OLED screens along the side and roof of the Residential Torus will display a day/night cycle each day as it would on earth. The projected sun image will blend to create a pseudo transition from Earth sunlight to a real-time camera view of Mercury that will rise like the moon with natural views of space in the background. This natural cycle of sunrise and sunset will stimulate proper circadian rhythm.



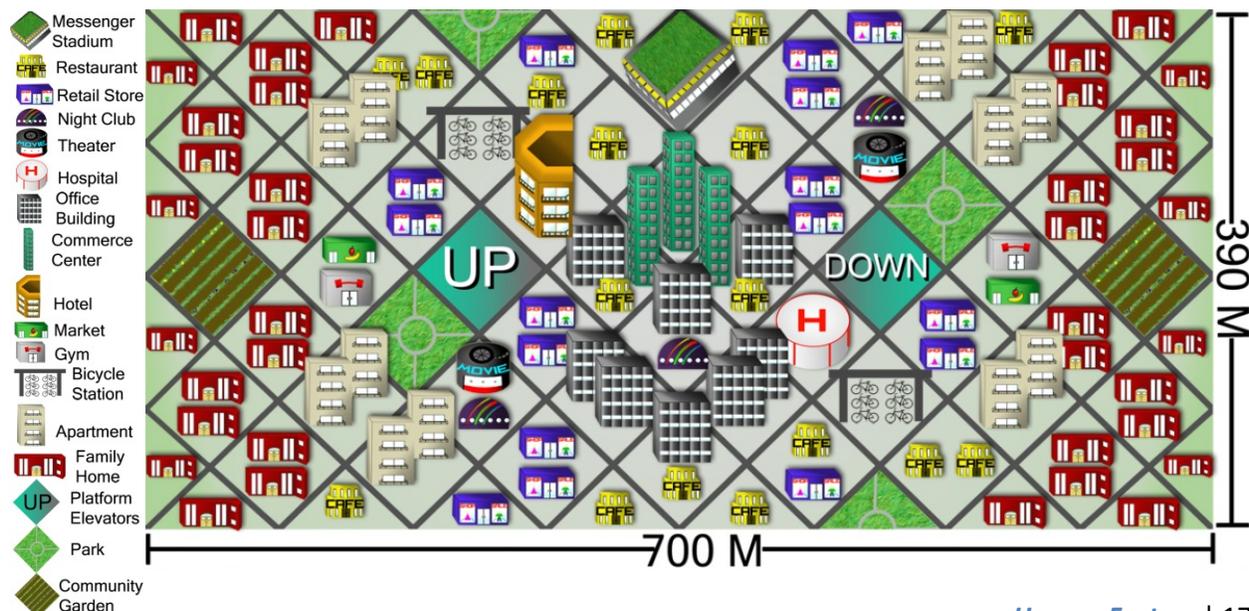
### 4.0.2 Paragon Grid Community

The roads and pathways will be designed in a diamond grid pattern. To minimize head turning, large buildings will be raised and the space underneath will be used for community events. With access underneath buildings, the use of corners will be eliminated to compensate for the Coriolis effect.

## 4.1 Community Design

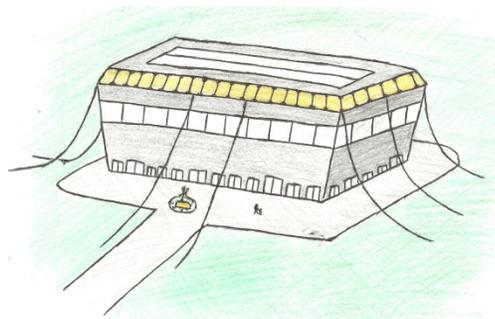
### 4.1.1 Community Layout

The Aynah Community will consist of a lower and an upper floor. The lower floor will be composed of a trading district in the center surrounded by commercial, residential and agricultural areas. In the map above, agricultural areas have been omitted as they are not inhabited by humans. The commercial area will contain facilities such as a hospital, gyms, markets, restaurants and cafes, night clubs, cinemas, the Messenger Stadium, and apartment complexes for those who prefer an upbeat city life. The upper floor will be primarily residential and contain parks, community gardens, family homes and apartment complexes for residents who prefer a serene suburban environment. Roads and pathways will be allocated 8.5% of Aynah's down surface area.



## 4.1.2 Entertainment, Fine Dining, and Recreation

Residents of Aynah will be able to experience cutting edge entertainment within the Messenger Stadium. The Stadium, located at the heart of the lower level community, will be constructed primarily of reardonium and will serve as a multipurpose venue for entertainment such as concerts, competitions, sport games, scientific exhibitions and other community based events. In this communal structure, residents will be able to take part in a new sport called Coriolis Cart, in which drivers will race through themed tracks in a small vehicle and will be presented with tangent and augmented reality obstacles created and enhanced by the Coriolis effect. For example, participants who may be in a nature based environment will have to evade trees or other wildlife that may appear in their path. They will also have to concentrate on overcoming the Coriolis effect by focusing on maintaining depth perception.



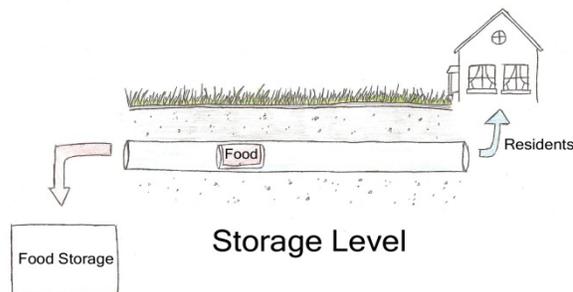
Commercial and business areas will also provide means of entertainment with stimulating gathering places like night clubs, shops, cafes, and cinemas. Along with the Messenger Stadium and urban relaxation spots, there will be adventure based parks placed throughout both rings of the station, providing residents with hiking trails and other outdoors activities. Building interiors will project images of space phenomena on the ceilings and waiter bots will help serve customers (refer to 5.3.1.3). In order to provide variety and familiarity, eateries will serve delicious multicultural food.

## 4.1.3 Consumer Goods

Categories	Products Needed per Year	Description	Source
Toiletries	2,416,375 items	Soap, toothbrushes, hairbrushes, makeup, toothpaste and personal hygiene products	Primarily Earth, Colombiat
Clothing	4,026,445 products	Shirts, pants, jackets, socks, undergarments, spacesuits	Primarily Earth, Colombiat
Food	7,535,908 kg	Meats, vegetables, fruits, grains, dairy, etc	Aynah
Medicinal	782,426 products	Prescription and over the counter medications, herbal remedies, hospital supplies, etc	Aynah, Colombiat, and Earth

## 4.1.4 Distribution

Consumer goods will be available to residents primarily through markets at various locations on the station. In addition, The Pneumatic Delivery System (refer to 5.3.1.4) can deliver food, toiletries, and pharmaceuticals from storage areas to homes in the event that someone cannot or does not want to go the market. These items will be ordered from each resident's personal WristWatch device (refer to 5.3.1.6).

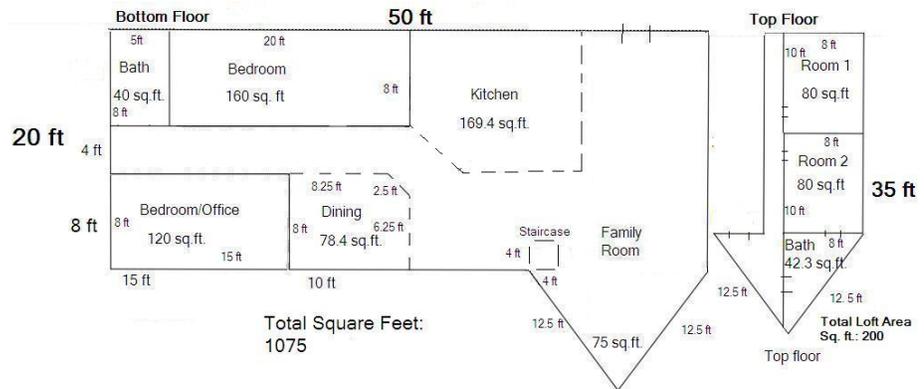


Produce will also be supplied by community gardens where residents will have the opportunity to grow their own food. These gardens will encourage healthy eating habits and strengthen camaraderie among the residents.

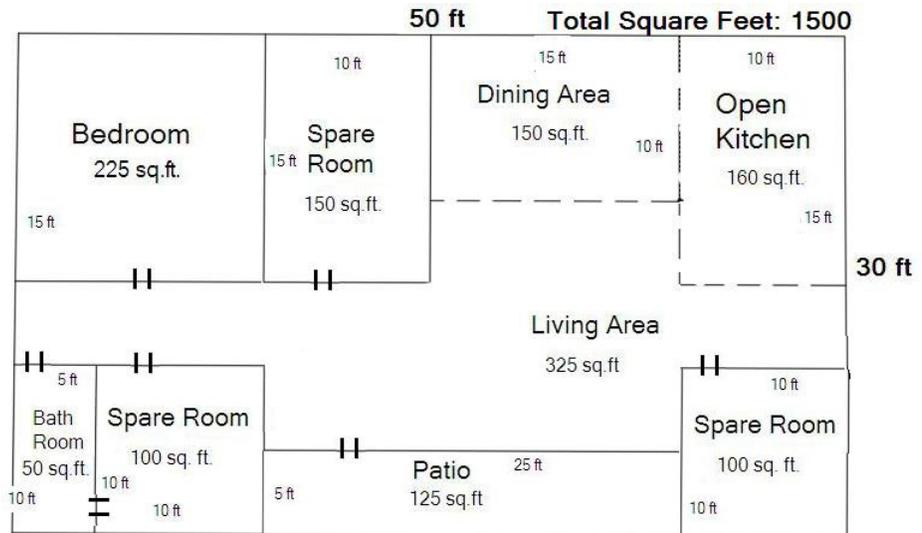
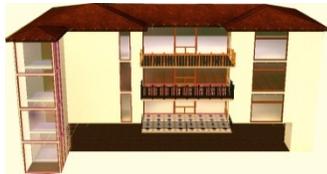
## 4.2 Residential Design

### 4.2.1 Housing

Homes on Aynah are designed to tailor to many living styles. The first plan is a large family residence. It features multiple bedrooms to accommodate parents with children.



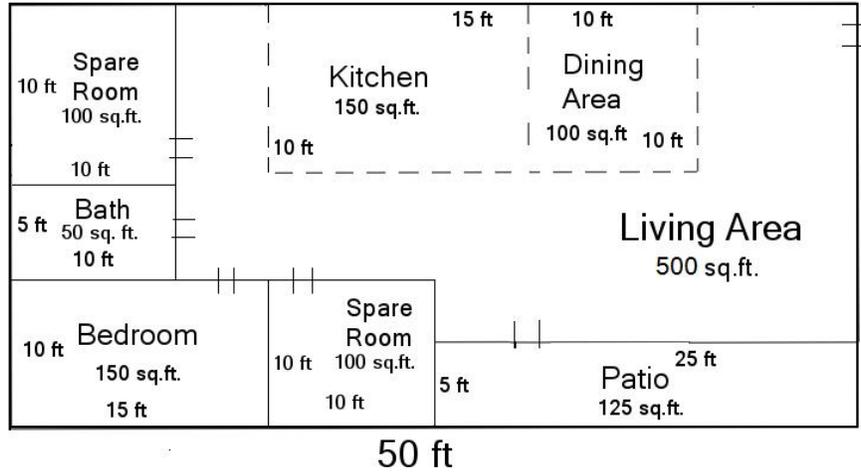
The second plan is initially a home for singles with extra guest rooms and offices. This design can easily transform from a posh bachelor pad to a comfortable family home by using movable walls (refer to 4.2.2).



The third design is also a single resident apartment home that is space efficient with an open floor plan, a large patio and easy room accessibility.



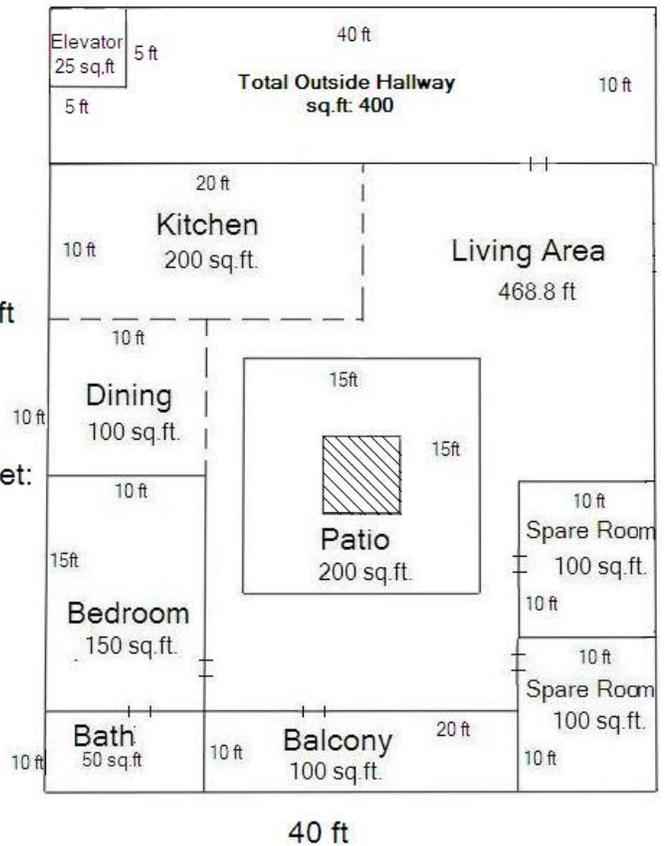
25 ft



The fourth design is a penthouse style residence with a courtyard in the center for a fountain view, making it a harmonious place to live. The floor plan may also be transformed into a family home.



Total Square Feet:  
1575 ft



Transients staying for an extended period of time will be housed in one of the last two home designs. Each of these plans are versatile and efficiently sized to accommodate a transient's short stay. To promote assimilation and community interaction, 1.5% of the rooms in the apartment buildings will be reserved strictly for transients so they can be integrated into the community. Hotels will also be available in the urban area of Aynah for any visitors staying for a shorter period of time.

#### 4.2.2 Amenities

Houses will incorporate innovative room designs and human related technology to create a tranquil and convenient lifestyle for residents. The Aynah community has a focus on healthy sustainability, so homes will be made with synthetic and organic materials to be more durable and less costly. Residents will be encouraged to own plants placed in special pots that monitor energy usage. The plants will be watered in correspondence to how wisely energy is used in the home to increase awareness of environmental conservation. Furniture will be customizable so each resident can choose their comfort preference. Movable walls will be in place in all rooms except areas with plumbing so that every house design can change to fit the owner’s wants and needs.



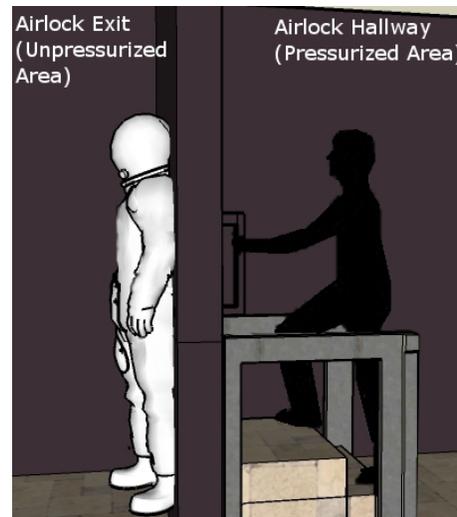
Aynah homes will include various automated functions which improve quality of life. Cleaning bots will be available to eliminate menial tasks such as mopping or dusting, while toilet systems and trash bots will take care of dirty jobs. Consumable necessities can be sent directly to homes for convenience via the Pneumatic Food Delivery System (refer to 5.3.1.4). In the event that a resident is in need of medical assistance, the Triage Health Assessment System (refer to 5.3.1.5) will notify paramedics. Residents will have the option of having a large OLED screen installed in their homes as a multimedia entertainment system (refer to 5.3.1.7). With this, residents within a community will be able to interact with games, shows and other media created exclusively for Aynah’s community. Residents will be able to control all the above systems in their homes via their WristWatches.

Good	Source
Furniture	Furniture will be obtained primarily from Earth, however, bamboo will be grown in the agricultural section, and will be used for furniture.
Appliances	Common appliances, such as kitchen devices, will be imported from Earth; however space-related appliances are uniquely manufactured in Aynah (Such as any bots used throughout the community, WristWatches, interactive work tables, along with any educational or work related inventions created for the use in Aynah.)

#### 4.3 Low-G Accommodations

##### 4.3.1 Zero-G Safety

Spacesuits will be attached to the outside of the innermost airlock room, but within the docking or exiting area, to prevent outside elements from entering the station. Spacesuits will feature data monitoring systems such as suit pressure, inner and outer temperatures, and a re-breather system. The airlock room will be a hallway with multiple suit donning and doffing stations. Due to low gravity in the airlock room, handrails, and other safety measures will be installed for assistance in space suit entry. These same safety measures will be present in every lower gravity area.





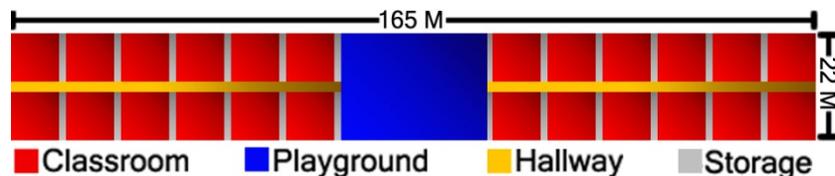
### 4.3.2 Systems and devices for Low-G safety

Safety for humans outside of artificial gravity will be ensured through the use of heads-up display contact lenses (refer to 5.3.1.8) and health systems integrated within each person's personal WristWatch. These contact lenses will be used for operation of powered vehicles, and be a function within industrial and commercial areas. The lenses will provide situation-based instruction displays for the user by showing tools and devices needed for operation. To monitor the resident's physical conditions during operation, the WristWatch will have a built-in sensor over the ulnar artery to monitor blood pressure, heart rate, hydration levels, and blood toxicity.

## 4.4 Gravitational Therapy

### 4.4.1 Children

Aynah's education center will be located on a moving train on the top residential floor. The train will revolve along the edge of the community of this level at 71.42 m/s in relation to the stationary centrifuge (moving 4m/s relative to the torus), creating a 1g environment. By attending school on a daily basis, the children will be undergoing their required gravitational therapy. The school schedule will consist of 3 consecutive 3-hour long shifts spent on the train split up by age group. The train will contain multiple class rooms that can accommodate ten children each and a playground. Windows on the train allow for views of the passing settlement.

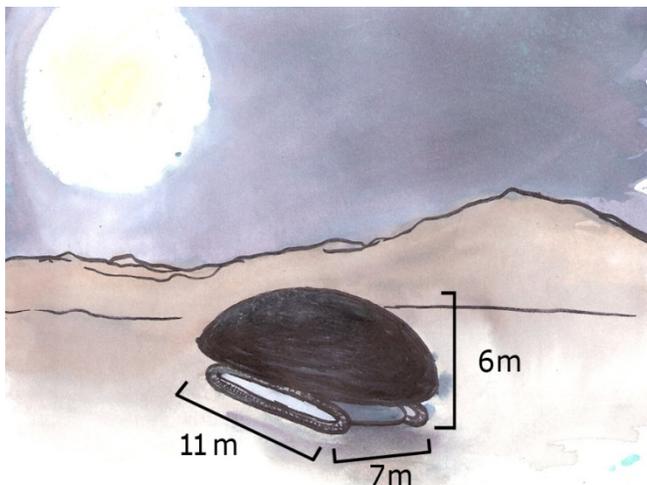


### 4.4.2 Adults

Adult residents will integrate exercise into their daily commute through the use of a community bicycle rental program (refer to 3.2.7). Adult residents will be encouraged to exercise in the .8g ring of the station to ensure workout efficiency. Parks with hiking trails and exercise focused activities will be scattered around the station. Residents will be encouraged to work out on a normal basis and will be given a weekly goal to meet or surpass. A reward system will be set in place in the event that a resident meets or surpasses his/her goal, with rewards in the form of points that residents may accumulate or redeem for prizes such as Messenger Stadium passes or theater viewings.

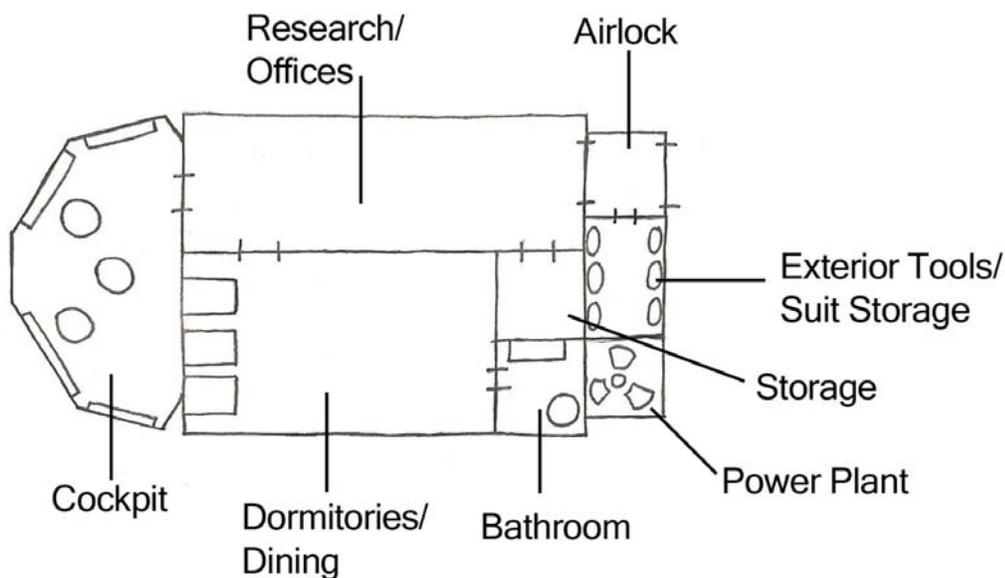
## 4.5 'Comet' Surface Vehicles

The Comet will be used in order to transport humans across the surface of Mercury. Comet surface vehicles will be transported to Mercury via the Cormorant shuttle (refer to 5.5.1) and will primarily be used to transport humans for inspection jobs. This vehicle will be made of reardonium, will run on a 4 MW thorium nuclear reactor, and will be able to reach speeds of 75 km per hour. It will be able to traverse the terrain of Mercury and withstand the temperatures of Mercury's environment. Blind spots will be viewed through LCD screens.

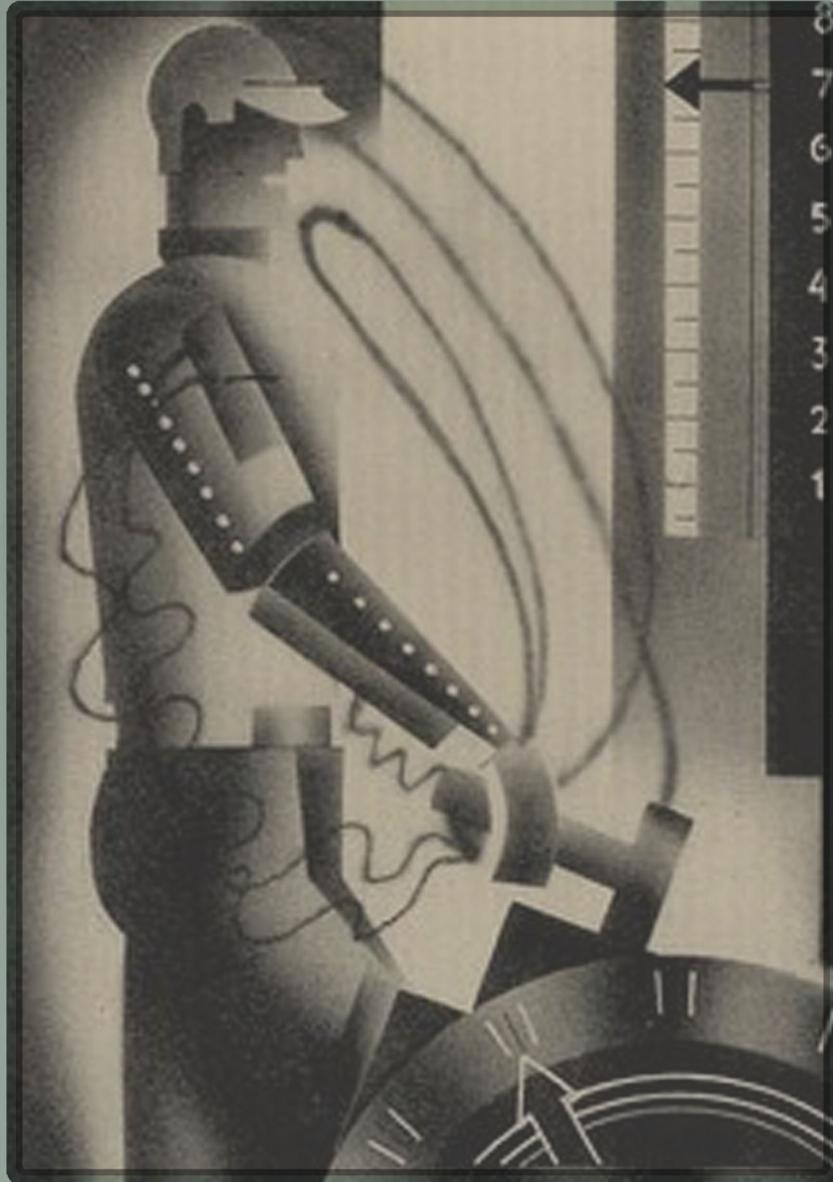


The multipurpose Comet will be equipped with an Oracle Ground Penetrating Radar (refer to 5.3.1.9) to detect any potential dangers below the planet's surface, along with mapping the surrounding sub terrain to assist in the geologic mapping of Mercury. To provide protection against imminent solar flares, reardonium plates within the Comet's shield will lock down and create a self-contained protected environment for vehicle passengers (Figure 2) (refer to 5.3.1.10). In the event of an evacuation emergency, survival supplies are easily accessible to any passengers aboard the Comet. After a solar event or other damage occurs, a Repair and Survival System (refer to 5.3.1.11) will ensure proper functioning of the vehicle.

## 'Comet' Surface Vehicle Layout



# AUTOMATION



**EVERY GREAT ADVANCE  
IN SCIENCE HAS ISSUED  
FROM A NEW AUDACITY  
OF IMAGINATION.**

**-JOHN DEWEY**

## 5.0 Automation

Automated systems aboard Aynah will allow for maximum productivity while enhancing livability for humans aboard. An assortment of robots will tend to all industrial, logistical, and domestic needs aboard the settlement, while extensive monitoring systems will ensure safety, productivity, and comfort.

### 5.1 Construction

Construction of the settlement and regulation of its rotational rates will be performed by four types of robots. Materials from the surface of Mercury and Mobile Refineries will be sent to Aynah's docking facility where robotic loading systems and centrifugal cargo trains will hand materials off to these robots.

#### 5.1.1 Welding bot

Welding bots will work together with Exterior Construction bots to weld aligned pieces into place. It has four arms for holding onto parts and uses two welding torches to weld Aynah's structural components together.

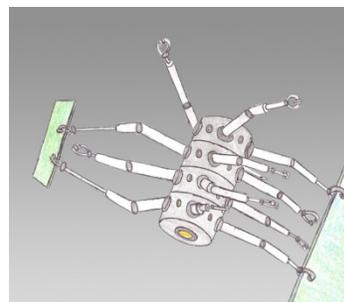
Quantity: 1,200



#### 5.1.2 Exterior Construction Bot

Exterior Construction bots have 14 arms for the transporting and manipulating of station components in space. They will interact with Welding Bots to construct the settlement.

Quantity: 300



#### 5.1.3 Thruster Control and Monitoring System

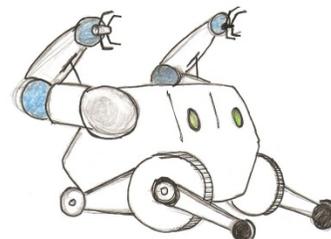
Thruster Control and Monitoring Systems will be responsible for monitoring and regulating the rotational rates of Industrial Complex discs and the Residential Torus. They will be located on intervals along the outside of each rotating piece and interfaces between rotating and nonrotating objects. Station administrators will interact directly with Thruster Control and Monitoring Systems to observe, alter, and correct rotational rates.

Quantity: 150

#### 5.1.4 Interior Construction Bot

Interior Construction Bots are responsible for the construction of Aynah's Residential Torus and Industrial Control Deck. They will operate in groups of up to 80 to quickly assemble houses and community infrastructure.

Quantity: 800





## 5.2 Settlement Maintenance & Operation

Exterior settlement maintenance will be performed primarily by Exterior Construction Bots and Welding Bots. All maintenance behind Aynah’s shield will not be affected by intense solar activity, and reardonium-plated Exterior Construction Bots will be able to repair solar panels and hull damage on the shield even during solar flare activity.

### 5.2.1 Operations Robotics

Name	Purpose	Quantity
Agricultural Harvesting Bot	- Harvests produce and moves produce to food preparation facilities.	6,000
Servers for Data processing and Storage	-Provides storage and communication between residents of Aynah, Earth or other settlements, and surface of Mercury	3
Communication Satellites	Locational positioning system. Provides communications between Mercury, Aynah, Earth, and other space settlements. Delivers natural views of Mercury to Aynah.	8
Exterior Kinetic Damage Monitor	All kinetic damage monitors work together to provide exterior integrity checks. If hull breach is imminent, alerts all administrative personnel and arms bulkheads for deployment.	1,500
Bulkheads	Will contain areas if isolation of volumes is required.	6 sets of 10
Exterior Temperature Monitoring System	Performs exterior settlement temperature analysis, alerts administrators to temperature anomalies.	500
Water Monitoring System	Performs water quality tests, alerts administrators to contamination. Attempts to mitigate effects of contamination via containment and shutoff	2,000
Air Regulation System	Regulates air temperature, monitors air quality, alerts administrators to contamination. Attempts to mitigate point-source contamination via containment and shutoff.	100

### 5.2.2 Security Protocol

Aynah's security protocol allows for a flexibility of human-computer interfacing depending on user role. Transients will only need Smart ID Cards to access permitted facilities, while residents will only need passwords to go about their daily lives.

Security Level	Authorized Personnel	Security Measures
0	Transients	Smart ID Card
1	Residents	Password
2	Industrial and Logistics Employees	Password and Fingerprint
3	Integral Settlement Personnel and Administrators	Password and Retinal Scan

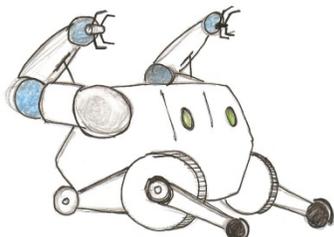
### 5.2.3 Contingency Plans

Contingency	Involved Systems	Contingency Plan
Hull Breach	Bulkheads, Exterior Kinetic Monitoring Systems	Exterior Kinetic Monitoring Systems will arm bulkheads if damage is imminent. Settlement administrators will contain affected areas if damage is severe.
Water Contamination	Water Monitoring Systems	If point-source contamination is discovered, water monitoring systems will alert administrators and contain water flow.
Air Contamination	Air Monitoring Systems	If point-source contamination is discovered, air monitoring systems will alert administrators and contain air flow.
Depressurization	Exterior Kinetic Monitoring Systems, Air Monitoring Systems	Bulkheads will arm; air flow will stop to the affected area. Administrators will be notified.
Fire	Air Monitoring Systems, Temperature Monitoring Systems	Administrators will be notified; if life is present, air will be filtered through affected areas, and smoke will be contained. If no life is present, all air will be removed.
Epidemic	Triage Health Assessment Systems	Sick residents will be quarantined to their homes and medical staff/supplies will move to them.
Medical Emergency	Triage Health Assessment Systems	Medical staff will be alerted.

## 5.3 Human Factors Robotic Systems

### 5.3.1.1 Stadium and Assembly Bot

Stadium and Assembly bots are repurposed interior construction bots (refer to 5.1.2) used for the assembly and preparation of community events. The Messenger Stadium (refer to 4.1.2) will utilize groups of these robots to reconfigure stadium setups at a moment's notice.



Quantity: 800

### 5.3.1.2 Illusionist

The Illusionist augmented reality system will be employed within the Messenger Stadium and used primarily for Coriolis Cart. 15 separate systems will work together to ensure seamless and immersive gameplay.

Quantity: 15



### 5.3.1.3 Monsieur Gallant

Monsieur Gallant will serve as Aynah's sales associate, cook, and server. Specific customer data, such as food related allergies and names will be shared between all Monsieur Gallant robots.

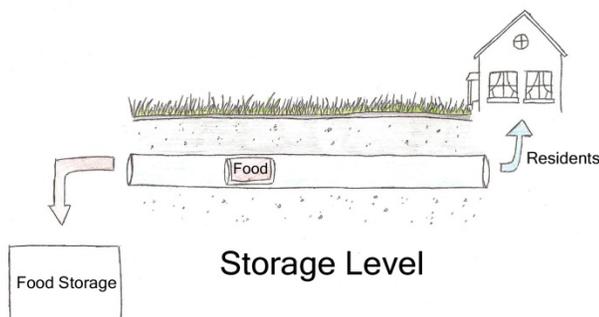
Quantity: 200



### 5.3.1.4 Pneumatic Delivery System

Aynah's Pneumatic Delivery System will be responsible for the delivery of food, medical supplies, and toiletries. Storage facilities under residential levels will be able to distribute goods to every resident with ease. A separate Pneumatic Delivery System will act as a waste intake for the community, and will deliver trash to waste facilities.

Quantity: 2 per home



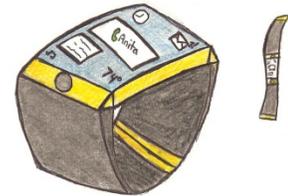
### 5.3.1.5 Triage

The Triage Home Health Assessment System is used to communicate with residents in need of medical assistance and to alert paramedics if required. The Triage is built into every home and integrated into the walls.

Quantity: 1 per home

### 5.3.1.6 The WristWatch

The WristWatch is Aynah's main communication and community interface device. Residents can send messages, call others, access Aynah's communication network, and interact with their houses away from home. Additionally, the WristWatch monitors vital signs and alerts medical professionals if assistance is required.



Quantity: 15,000

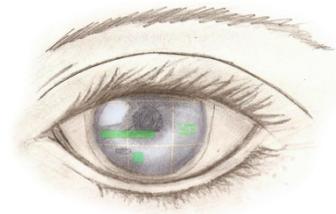
### 5.3.1.7 Social Media & Entertainment System

Social Media & Entertainment Systems, located in every residence, will provide many entertainment options and interactive activities for Aynah's residents. The social media & entertainment system is a large flexible OLED screen that can adhere to positions chosen by residents, allowing for screens to be anywhere with a flat surface.

Quantity: 1 per home

### 5.3.1.8 HUD Contact Lenses

HUD Lenses will be used for pilots and logistics and industrial personnel. They will provide information on the contents of cargo containers, parts assembly, industrial routes and plans, and distances between objects or waypoints.



Quantity: 5,000

### 5.3.1.9 Oracle Ground Penetrating Radar

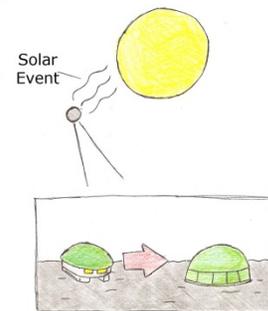
The Oracle ground penetrating radar will be used on all 'Comet' surface vehicles to map the sub terrain for hazards and potential ore deposits. By communicating with other Oracle systems, maps of Mercury's sub terrain will be compiled, and will aid geologists and engineers on future underground projects.

Quantity: 1 per Comet Surface Vehicle

### 5.3.1.10 'Comet' Shield System

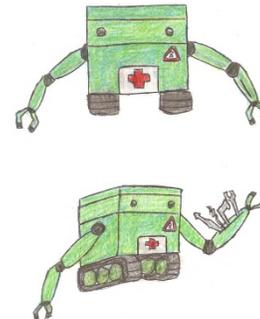
Each Comet surface vehicle's reardonium shield will have locking reardonium plates installed underneath it. In the event of an imminent solar flare, the vehicle will stop and the reardonium plates will slide out to meet Mercury's surface, forming a barrier to protect the comet at all angles from radiation.

Quantity: 1 per 'Comet' Surface Vehicle



### 5.3.1.11 Comet Repair and Survival Unit

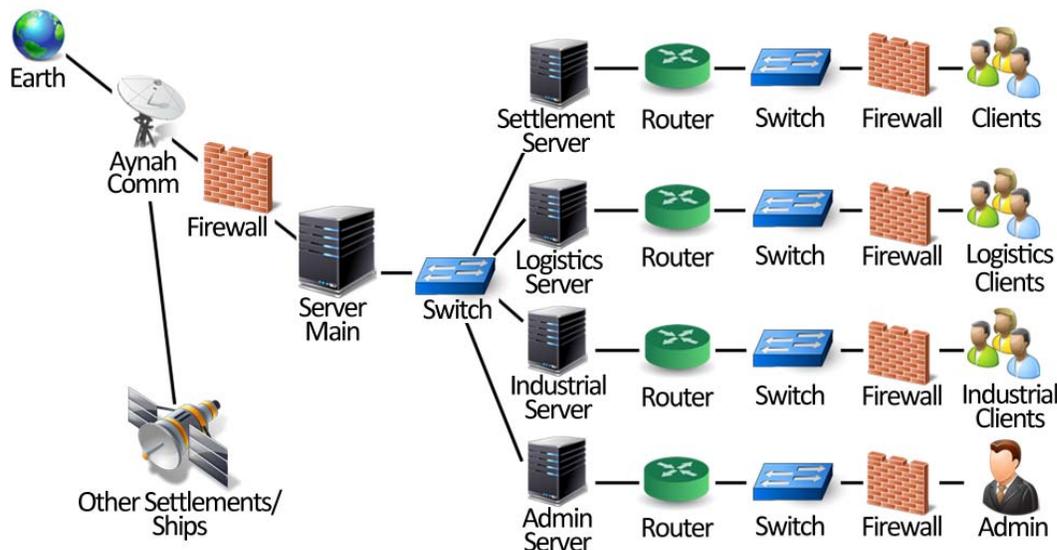
If repairs are required on the Comet, the Comet Repair and Survival Unit can be activated, and will be able to make exterior or interior repairs. It comes equipped with an array of tools with which it can manipulate. If an evacuation of a surface vehicle is required, the robot contains a cache of emergency medical and food supplies which may be removed.



Quantity: 1 per 'Comet' Surface Vehicle

### 5.3.2 Networking

All non-Aynah based transmissions will be received by Aynah's Communications disc. Administrators will have access to all settlement systems, including control over Industrial and Logistics activities. Logistics and Industrial Clients, including associated robots, will maintain direct communication with each other to allow for an efficient production flow. Backup servers will store all server data, including Aynah's main server.



All clients will have 5 terabytes of data allotted to them, and client bitrates will be 10Gbit/s wirelessly. All servers will contain 70 petabytes of data, and Aynah's total storage capacity will be 1.13 exabytes.

User Group	Server Data Capacity	User bit-rate
Logistics Clients	70 petabytes	10 Gbit/s
Residential Clients	70 petabytes	10 Gbit/s
Industrial Clients	70 petabytes	10 Gbit/s
Administrators	70 petabytes	10 Gbit/s
Main Server	300 petabytes	100 Gbit/s
Backup Servers	580 petabytes	100 Gbit/s
Total	1160 petabytes	N/A

## 5.4 Industrial Automation

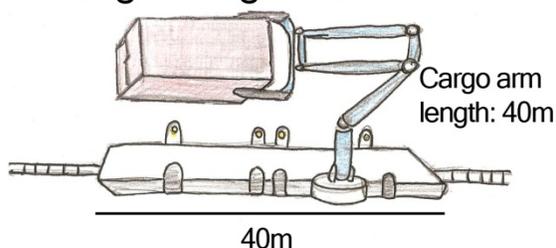
### 5.4.1 Centrifugal Cargo Train

Centrifugal cargo trains within the centrifuge will move on rail to any location within the kilometer length of the centrifuge. These trains are equipped with cargo container restraints and a large robotic arm 40 meters in length for picking up and setting down boxes.

These trains will interface the most with any cargo containers, and have lengths variable to Aynah's logistic needs. The train pictured here has the capacity to hold two cargo containers, each 15 meters in length.

Centrifugal cargo trains and robotic loading systems will be responsible for the movement of parts throughout the centrifuge, docking facility, and Industrial Complex.

### Centrifugal Cargo Train

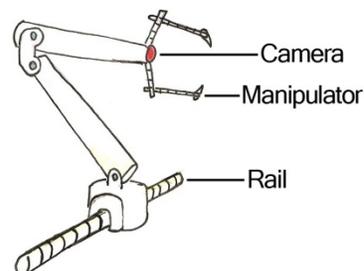


### 5.4.2 Robotic Loading System

Loading of cargo to or from any docked vessels within Aynah's docking facilities will be completed by groups of robotic loading systems. The robotic loading system will be able to interface with any configuration of ship design, and its grabbing arm will be able to manipulate objects of any size.

Robotic loading systems will also be used in industrial processes within Aynah's Industrial Complex, working together with centrifugal cargo trains.

### Robotic Loading System

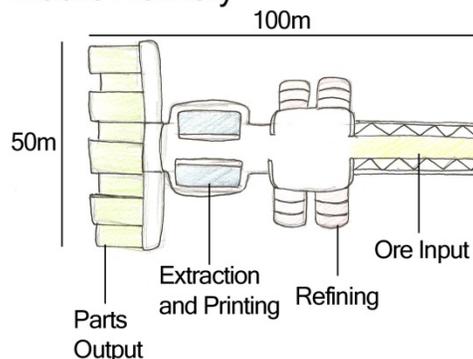


### 5.4.3 Mobile Refinery

Aynah will employ large mobile refineries to facilitate the refinement and construction of parts in orbit. These mobile refineries are modular, able to be equipped for a wide variety of tasks including the formation of regolith concrete, the construction of exterior and interior parts, and the assembly of other robots. Once Aynah's mobile refineries are no longer required for construction purposes, their modular design will enable core modules to be transported and reconfigured for operation within the Industrial Complex.

Pictured is a mobile refinery equipped with 3D printing systems, 16 centrifugal refinement chambers, and a 2500 m<sup>2</sup> space for parts output. Unrefined ore will be moved through the ore input chamber, where

### Mobile Refinery



they are sent to centrifugal refining chambers, melted, and spun. Once refined ore has been spun, it is removed and sent to an extraction and printing chamber, where parts are machined. Machined parts will be sent to the parts output section of the refinery, where it is packaged in cargo containers and ready for shipping.

## 5.5 Reardonium Tending Bots

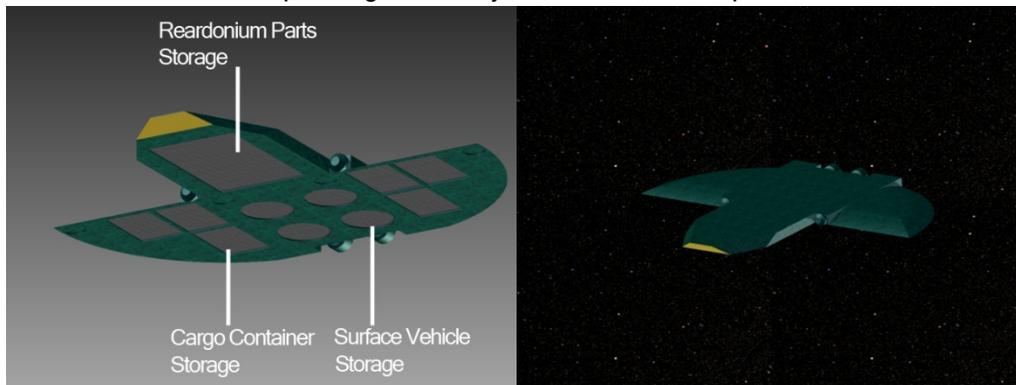
### 5.5.1 Cormorant Shuttle

The Cormorant shuttle is a fusion-propelled all-purpose transport vessel. Its wingspan is 90 m, and it is 100 m in length. The entire underside of the cormorant is used for transporting reardonium parts, Comet land vehicles, and cargo containers.

Pictured is a Cormorant with the cargo capacity for 6 cargo containers, 4 Comets, and 400 m<sup>2</sup> of allotted reardonium cargo space. The cargo space allotment, between reardonium parts, land vehicles, and cargo containers are able to be modified per Cormorant shuttle to suit industrial, commercial, or logistics requirements. Cargo is loaded and secured to the Cormorant by way of retractable cargo arms.

For maintenance and storage within the docking facility, the wings and head of the craft are foldable, creating a 40m x 45m x 30m, easily transported entity. It is even possible for one Cormorant shuttle to carry another folded Cormorant.

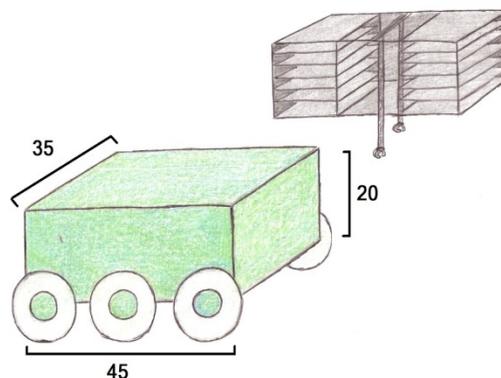
Newly fitted Cormorant shuttles will be plated with reardonium in order to protect them from solar radiation. Cormorants operating behind Aynah's shield will be protected from radiation.



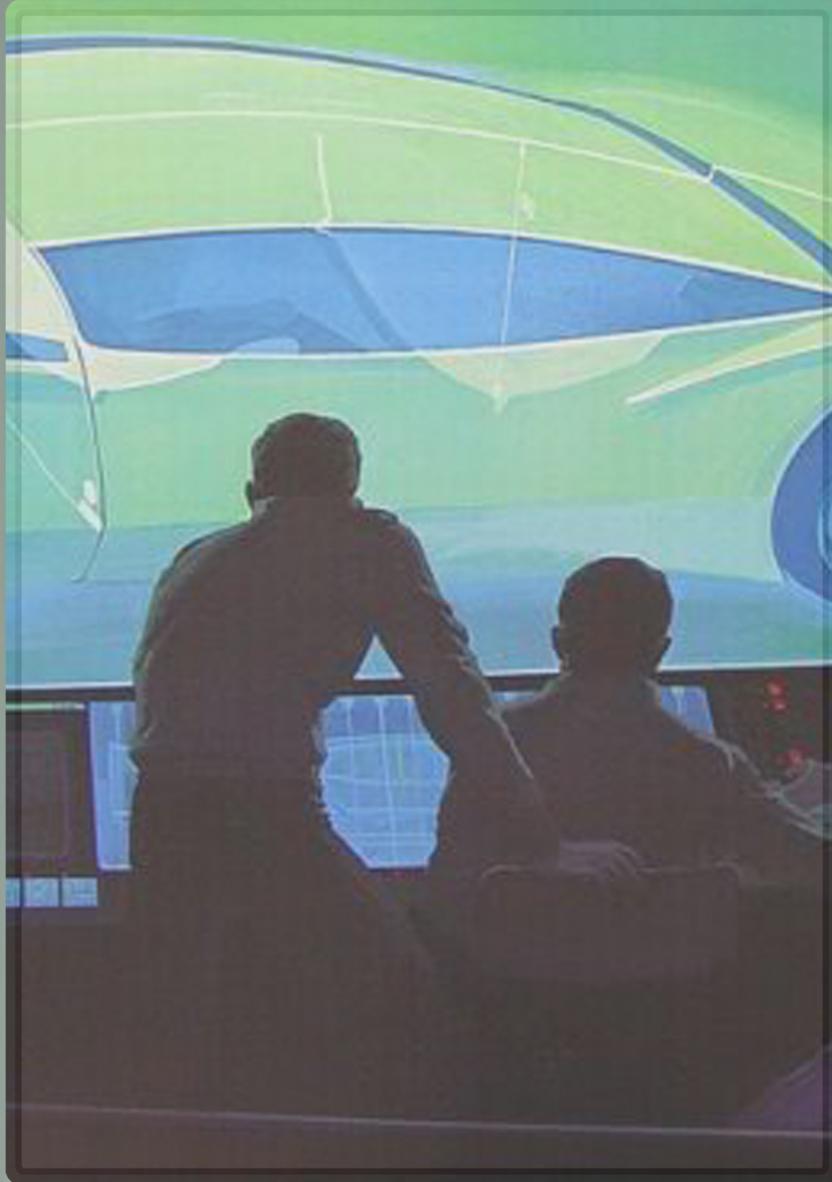
### 5.5.2 Tortoise Reardonium Curing and Flipping Vehicle

The Tortoise is a massive unmanned vehicle plated in reardonium. Its interior is made up of 12 storage compartments, each big enough to house Reardonium sheets 100 feet by 40 feet in size. Transportation of reardonium parts to loading or curing areas, part flipping, and reardonium monitoring will be completed by the Tortoise.

The retractable arms of the Tortoise allow it to move parts into its cargo hold and flip curing parts with ease. The vehicle's solar panel-covered roof generates enough power in sunlight to propel it at top speeds of 30 km/h, allowing it to outpace the rotational velocity of Mercury if necessary. Essential systems on the Tortoise are protected by its reardonium hull.



# SCHEDULE AND COST

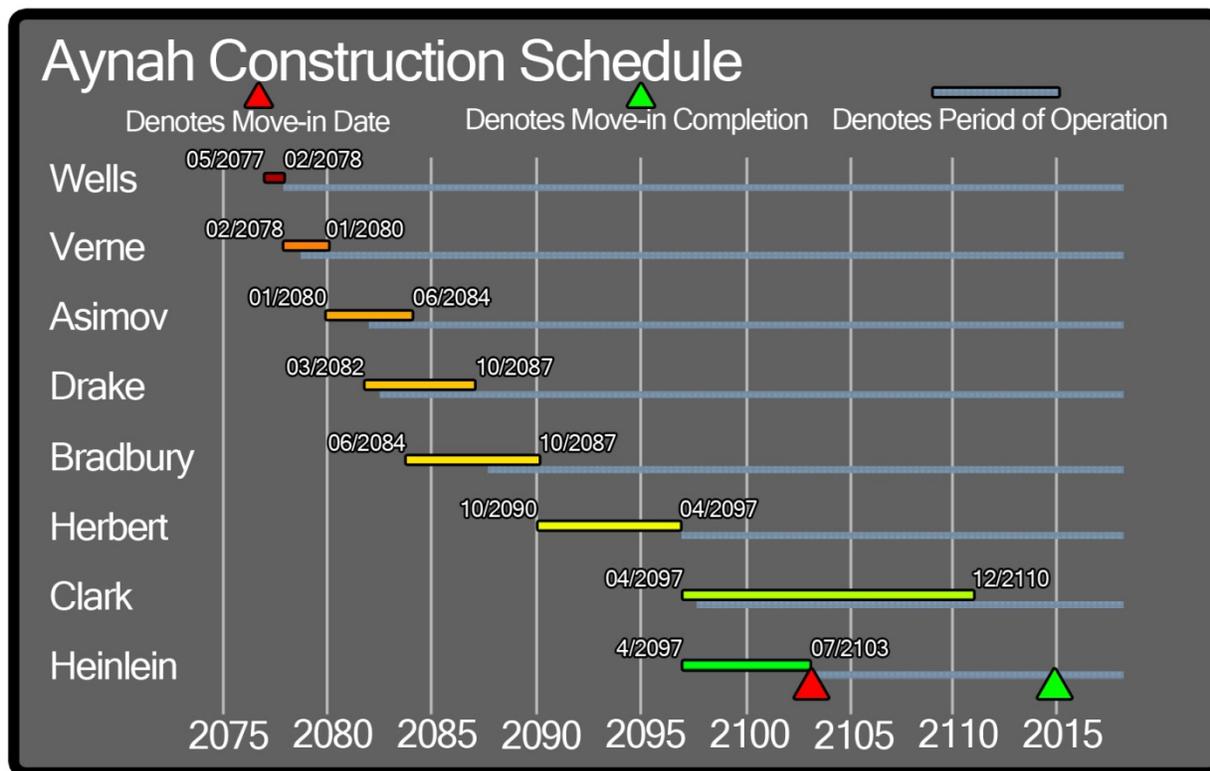


**THINK OF YOURSELF  
ON THE THRESHOLD OF  
UNPARALLELED SUCCESS.  
A WHOLE, CLEAR, GLORIOUS  
LIFE LIES AHEAD OF YOU.  
-ANDREW CARNEGIE**

## 6.0 Schedule and Cost

Aynah's schedule and cost entails every expense from initial launch of Aynah's docking facility to full operation and habitation. Consult 2.3.1 for detailed information on construction phases.

### 6.1 Schedule of Contractor Tasks



### 6.2 Costs by Phase of Construction

#### 6.2.1 Structures Costs

Material	Total Units	Source	Cost
Reardonium	2,469,430 m <sup>3</sup>	Mercury	See 6.2.4 Automation
Regolith	5,035,623,000 kg	Mercury	See 6.2.4 Automation
Steel	12,275,034,000 kg	Balderol, Mercury	\$1,546,654,284
Water	1,451,416,000 kg	Earth	\$551,538,080
<b>Total</b>			<b>\$2,098,193,364</b>



### 6.2.2 Operations Costs

Material	Total Units	Source	Cost
Thorium	1 metric ton	Earth	\$150,000
Helium 3	4 metric tons	Alaskol	\$99,892
Sodium	10 metric tons	Earth	\$35,500
Planting Soil	73,103,964 kg	Balderol, Earth	\$57,327,973
LEDs	540 billion		
WristWatch	15,000	Earth	\$3,100,000
Backup Servers	5	Earth	\$500,000
Industrial Comm Server	1	Earth	\$100,000
Main Settlement Server	1	Earth	\$100,000
Residential Comm Server	1	Earth	\$100,000
Logistics Comm Server	1	Earth	\$100,000
Administration Server	1	Earth	\$100,000
Mercury Satellites	5	Earth	\$6,300,000
Aynah Comm Disc	1	Earth	\$240,000
Nitrogen	50,816,000 m <sup>3</sup>	Earth	\$55,081,600
Oxygen	13,508,110 m <sup>3</sup>	Earth	\$100,524,330
Gravity Interface Train Lines	12		\$400,000
Residential Elevators	12		\$96,000
Bikes	14,000		\$40,000
Education Center Train	1		\$120,000
<b>Total</b>			<b>\$224,515,295</b>

### 6.2.3 Human Factors Costs

Expense	Total Units	Source	Cost
Furniture	84,200	Earth	\$24,150,500
Appliances	54,180	Earth	\$26,006,400
Clothing	434,600	Earth	\$18,790,000
Space Suits	8,000	Earth	\$960,000,000
Toiletries	306,630	Earth	\$10,392,660
Food	N/A	Earth	\$59,360,000
Medicine	N/A	Earth	\$2,063,400,000
'Comet' Vehicles	100	Balderol, Aynah	\$120,000,000
<b>Total</b>			<b>\$3,282,099,560</b>



#### 6.2.4 Automation Costs

Most of Aynah’s construction costs will originate from its large robotic fleet and all associated maintenance. Acquisition of required regolith, reardonium, and steel will come primarily from robotic operations on Mercury.

System	Total Units	Cost
Settlement Construction Systems	2,450	\$5,386,800,000
Settlement Operations Systems	10,171	\$870,900,000
Livability Systems	72,016	\$2,993,300,000
Mercury Operations Systems	5,019	\$428,400,000
Industrial Systems	2,400	\$720,000,000
Logistics Systems	660	\$635,400,000
Maintenance Allocation	N/A	\$5,110,860,820
<b>Total</b>		<b>\$16,145,660,820</b>

#### 6.2.5 Total Billing

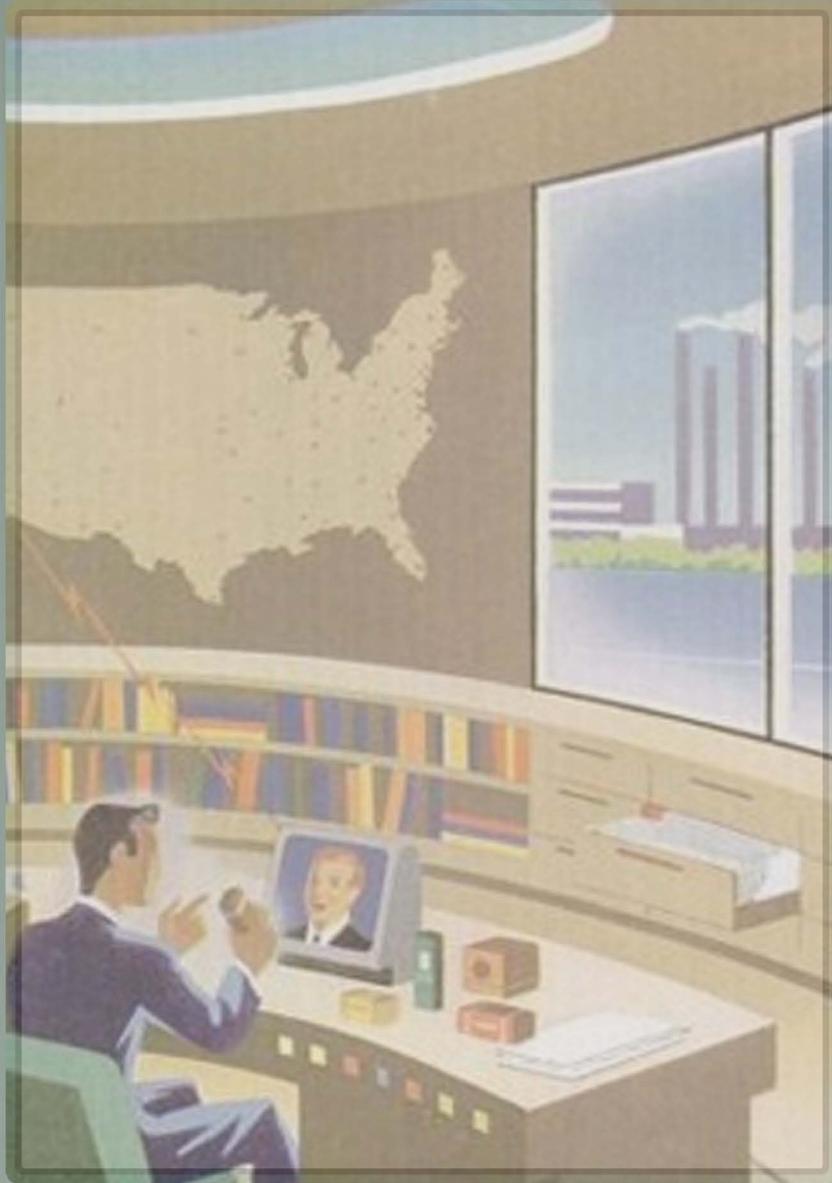
Billing of Aynah will occur by phase.

Phase	Cost	Associated Expenses	Total Employees required
Wells	\$8,331,054,284	Robotics, Docking facility, associated launch costs	1,200
Verne	\$3,135,400,000	Additional robotics costs, structural materials, associated launch costs	400
Asimov	\$426,233,300	Additional robotics costs,	200
Drake	\$1,826,233,300	Gases delivery, industrial infrastructure delivery, associated launch costs	600
Bradbury	\$1,570,200,000	Additional robotics costs, industrial infrastructure delivery, associated launch costs	800
Herbert	\$3,378,700,000	Gases delivery, communications delivery,	1,000
Clark	\$1,244,515,295	Operations infrastructure delivery, associated launch costs	300
Heinlein	\$4,282,099,560	Delivery of human factors related products, Launch costs to Mercury	150
<b>TOTAL</b>	<b>\$24,194,435,739</b>		<b>4,650</b>

**Total Cost to be billed to Foundation Society: \$24,174,435,739**

**Note: This expense includes launch and logistics costs that are not applicable to section costs.**

# BUSINESS DEVELOPMENT



**GO AS FAR AS YOU CAN SEE;  
WHEN YOU GET THERE,  
YOU'LL BE ABLE TO  
SEE FARTHER.**

**-J.P. MORGAN**

## 7.0 Business and Development

### 7.1 Commercial Ventures

On the lower level of the habitation ring, 150,000 m<sup>2</sup> of space will be allotted for all Aynah commercial ventures. In this area are convention centers, plazas, hotels, and recreational space for the sole purpose of establishing Aynah as a major commercial hub. Visitors from other planets will enjoy the luxuries of their trade relationships with Aynah, and the citizens of Aynah, and the Foundation Society, will prosper. This area isn't limited to buyers and sellers of reardonium. Any commercial venture or convention that is hosted on Aynah can be hosted on this expansive area.

### 7.2 Industrial Projects

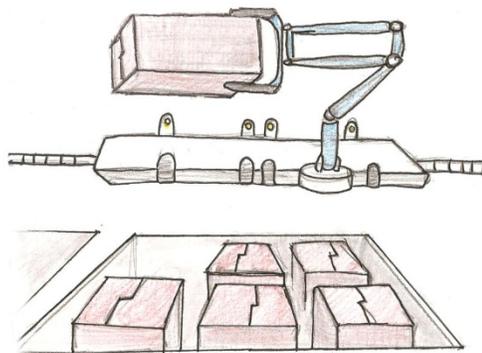
#### 7.2.1 Industrial Complex

The Industrial Complex allows for Aynah to function at its true potential as an industrial and commercial giant. Forty large-scale zero-g facilities within the complex will offer a large space for a variety of tasks, including (but not limited to) zero-g R&D and manufacturing, while 80 smaller volumes will be spinning, creating gravities of up to half Earth's gravity. Each of the 120 industrial volumes in the Industrial Complex will allow for variances in pressure, from vacuum to 20 psi, allowing for a wider range of production environments for reardonium parts.

Each of the discs of the Industrial Complex is still in contact with Aynah's centrifuge, meaning that cargo trains can load and unload cargo with ease. Parts that may need to experience higher gravities may move from a disc with a maximum gravity of 0.2g to a disc with a maximum gravity of 0.5g. This configuration of industrial areas in Aynah means that the movement of parts from docking to any industrial zone and back will be as efficient as possible.

The Industrial Complex itself is located on the opposite side of the settlement from human residential and commercial areas. Humans are able to access the Industrial Complex through both the centrifuge (from which centrifugal trains are moving cargo) and the Industrial Control Deck. This prevents contamination of residential areas from dust and any harmful industrial chemicals. Under normal circumstances, no industrial part or byproduct of industrial operations will ever come in contact with Aynah residents.

Cargo loading/unloading



#### 7.1.1 Industrial Control Deck

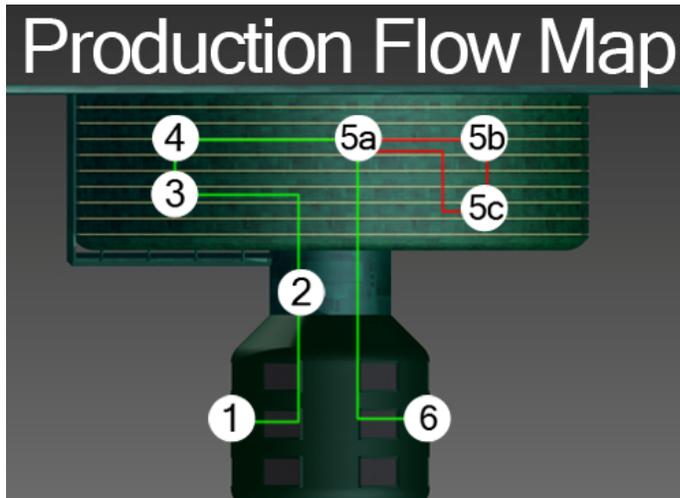
The Industrial Control Deck will be manned and operated by humans as an administrative and observational center to facilitate the oversight of production tasks within the Industrial Complex. This includes the remote inspection and quality testing of reardonium parts returning from Mercury.

Installment and packaging of finished reardonium goods will be completed by Robotic Loading systems, which will interact directly with



centrifugal cargo trains. From the Centrifugal cargo trains, cargo boxes can be loaded into cargo compartments, or onto shuttles or docked ships and sent elsewhere throughout the solar system.

## 7.2.2 Production Flow



Pictured is a production flow chart for parts processing and handling: First (1), materials are loaded to the docking facility from ships. Parts will receive a composition check to determine their makeup and designation (2). Once materials have been scanned, the parts are moved to their designated industrial area (3). Industrial processes occur (4) and parts are subjected to a finished parts quality check (5a). If finished goods are not considered quality, they will be subjected to review (5b), necessary adjustments will be made (5c), and checked again for quality. If parts pass the quality check, they are packaged and sent to storage, where they will be ready for shipment (6).

## 7.3 Port of Entry

Aynah's docking facility, located between Aynah's industrial complex and habitation module, will serve as an entry point for Aynah with an initial docking capacity of 24 ships. The structure of Aynah's docking facility allows for easy entrance and egress of ships, and provides room for expansion beyond the initial 24-ship accommodations.

From Aynah's docking facility, cargo containers are moved from ship cargo holds to trains lining the inner centrifuge. These trains, depending on their cargo makeup, will either go towards the industrial complex or go towards habitation modules, where they will be stored until utilization.

The interior of Aynah's docking facility contains robotic loading systems and airlocks for the movement of ships, cargo, and humans, as well as maintenance bays and storage compartments. Any incoming ship that requires repairs can take advantage of Aynah's extensive array of repair equipment, while cargo that is not scheduled for immediate movement can be stored in honeycombed storage areas. Humans in transit will use passenger trains, also moving along the inner centrifuge, to move to their desired destinations within the station.

### 7.3.1 Orbital Shuttle Fleet

The Cormorant All-Purpose Transport Shuttle will act as an intermediary between large space liners and Aynah, ferrying standard cargo containers to storage and transit lines within the settlement. These shuttles will interface with the docking facility to move cargo containers.



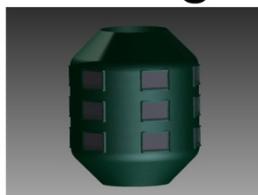
### 7.3.2 Landing Shuttle Fleet

Landing shuttles obtained through separate contracts with Aynah take advantage of Aynah's docking facilities to provide easy access between the surface of Mercury and the settlement. Aynah's robotic loading systems, maintenance facilities, and airlocks will be able to interface with any separately obtained ship easily, maintaining logistical efficiency.

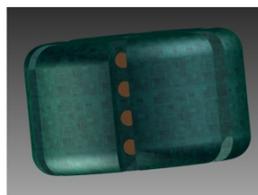
### 7.3.3 Cargo Warehousing

Storage compartments within Aynah's docking facility will initially have space for cargo and ships. Keeping the expansion of Aynah in mind, the structure of the docking facility allows for an ease of growth. Initially, 24 shuttles and visiting ships may dock in Aynah at once, but an expansion of the docking facility by the Foundation Society could allow for any number of additional ships or cargo spaces if and when desired.

## Docking



Initial Docking

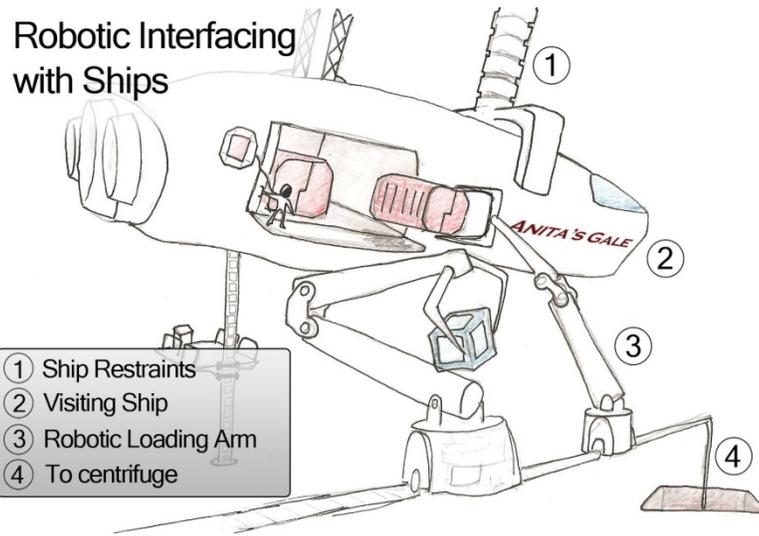


Potential expansion of Docking Facility

### 7.3.4 Systems for loading and unloading

Robotic loading systems will interface with visiting ships and shuttles in order to maintain an easy transfer of goods back and forth. Once cargo is removed from ships, robotic loading systems will store

containers in storage compartments within Aynah's docking facility. Centrifugal cargo trains will take those materials, when required, to their designated locations within the settlement.



# OPERATIONAL SCENARIO



**A MAN CAN SUCCEED  
AT ALMOST ANYTHING  
FOR WHICH HE HAS  
UNLIMITED ENTHUSIASM.  
-CHARLES SCHWAB**



## 8.0 Appendices

### A. Operational Scenario

For the purposes of this scenario, two reardonium parts have been chosen: one 100 foot by 40 foot construction panel, and one reardonium bracelet. The construction panel is scheduled for shipping to Earth for ship hull plating, and the bracelet will be sent to Belvestat for a trade exhibition.

The reardonium parts process begins with the loading of ore into containers by Mercury-based Tortoise vehicles (refer to 5.5.2) and surface personnel in Comet surface vehicles (refer to 4.5). Once ore is packaged and ready for shipment at launch depots, a Cormorant shuttle (refer to 5.5.1) outfitted for ore retrieval will move to the surface and extend retractable arms within its body to secure cargo.

From here, the process branches due to the difference in parts size. Ore slated for large construction plates will move straight to Aynah's docking facility, where the Cormorant shuttle will interface with Robotic Loading Systems (refer to 5.4.2) to deliver ore. Because of the bracelet's much smaller size, ore slated for its assemblage will be dropped off at one of Aynah's Mobile Refineries (refer to 5.4.3).

Robotic Loading Systems in Aynah's docking facility will interface with Centrifugal Cargo Trains (refer to 5.4.1) where the trains will move up Aynah's centrifuge. Before entering Aynah's Industrial Complex (refer to 2.4.1), the packaged ore will be scanned for composition. At the conclusion of scanning, the Centrifugal Cargo trains will continue on; in this instance, ore will be moved to Aynah's tenth disc, closest to the shield. Here, disc gravity and pressure has been modified for production of construction panels. The ore will be loaded off into the tenth disc, where Robotic loading systems will move the ore into centrifugal extractors. In this instance, the centrifugal extractors being used have been stripped from an out-of-service Mobile Refinery and reconfigured for use within the Industrial Complex. Ore will be spun until reardonium metal is separated from refuse. Once separated, the refined metal will be moved through the industrial processes of sheet forming. To ensure that parts production is running smoothly, operators safe aboard the Industrial Control Deck (refer to 2.4.2) keep watch on this project through live feeds. Forming of the reardonium sheet completes, and the part is moved to a parts quality check. If errors are detected on the produced part, operators will be notified and amendments will be made prior to another parts check. In this case, the sheet is perfect and ready for curing. Robotic Loading Systems then load the sheet onto a large Centrifugal Cargo Train, modified specifically for the movement of large reardonium parts. This Train is bound for the docking facility, where another Cormorant, specialized in parts transport, will deliver the sheet to the surface for curing.

Inside the Mobile Refinery, another process is taking place. Transit systems inside the Mobile Refinery will move raw ore into an array of centrifugal extractors. Once all centrifuges have completed extraction, reardonium metal is sent to a 3d printing module aboard the refinery, where a small portion of the newly refined metal is crafted into the first reardonium jewelry piece ever made. Transit systems in the refinery exercise caution when moving and packaging the bracelets, and in this instance, a team of suited observers watch the part being moved from the exterior of the refinery via their HUD contact lenses (refer to 5.3.1.8). The bracelet is packaged in a transparent curing crate for smaller parts, in which it will sit among reardonium drill bits, bolts, and wiring. Once moved to the refinery's export module, the part is ready for curing on the surface. A Cormorant with dedicated cargo space for delicate reardonium parts will pick this case up for delivery to the surface.

Six Earth-months have passed on Mercury's surface since both parts were delivered to be cured, and it is time for their scheduled flipping. A Tortoise flipping vehicle moves first to the large reardonium sheet, which has been sitting on one side for almost a week. Retractable manipulating arms extend from the Tortoise's underbelly, and slowly but surely, the part is flipped. The transparent case for curing delicate parts is located 30 kilometers away, and the tortoise makes its journey to the case in just over an hour. Smaller manipulating arms extend and the Tortoise flips the case. In another six months, both the reardonium bracelet and the reardonium sheet will be scheduled for transfer back to Aynah aboard Cormorant shuttles.

Once back in Aynah's Docking Facility, both parts receive dust-cleaning treatment and packaging. Right on schedule, the Earth-bound ship *'Curiosity'* enters the docking facility and passes through customs. Robotic Loading systems move the parts aboard the *'Curiosity'*, and the parts are on their way; the reardonium bracelet to Belvestat, and the reardonium sheet to Earth. The parts production, curing, and shipping process is complete. This process, for all reardonium parts, will take approximately 14 months to complete.

# BIBLIOGRAPHY



**A HUMAN BEING  
IS NOT ATTAINING  
HIS FULL HEIGHTS  
UNTIL HE IS EDUCATED.  
-HORACE MANN**

## B. Bibliography

### Operations

Unknown. "Breathing Easy on the Space Station." *NASA Science*. NASA, 13 Nov. 2000. Web. 29 Feb. 2012. <[http://science.nasa.gov/science-news/science-at-nasa/2000/ast13nov\\_1/](http://science.nasa.gov/science-news/science-at-nasa/2000/ast13nov_1/)>.

Schmid, Deb. "SwRI-led RAD Measures Radiation from Solar Storm." *Measures of Radiation from Solar Storm*. Southwest Research Institute, 27 Feb. 2012. Web. 18 Feb. 2012. <<http://www.swri.org/9what/releases/2012/rad-solarstorm.htm>>.

Unknown. "Patent Storm." *Method for Processing and Fabricating Metals in Space*. Web. 23 Feb. 2012. <<http://www.patentstorm.us/patents/4480677/description.html>>.

Boyle, Rebecca. "With New Materials, Air Conditioners Can Be Powered By Waste Heat." *Popular Science*. Popular Science, 31 Mar. 2011. Web. 29 Jan. 2012. <<http://www.popsci.com/technology/article/2011-03/new-organic-heat-carriers-could-help-future-air-conditioners-run-heat>>.

Unknown. "Monoethanolamine." *Monoethanolamine*. Huntsman, 26 June 2011. Web. 20 Mar. 2012. <[http://www.huntsman.com/performance\\_products/Media/Monoethanolamine.PDF](http://www.huntsman.com/performance_products/Media/Monoethanolamine.PDF)>

Unknown. "Toxic Chemicals in Everyday Products." *Kid Organics*. Web. 20 Mar. 2012. <<http://www.kidorganics.com/Chemicals%20to%20Avoid.htm>>.

Unknown. "LED Grow Lights - Superled." *LED Grow Lights*. Super LED. Web. 11 Jan. 2012. <<http://www.superled.net/>>.

Unknown. "The Beginner's Guide To Diet, Nutrition & Healthy Eating." *A Calorie Counter*. Web. 22 Jan. 2012. <<http://www.acaloriecounter.com/diet-guide.php>>.

Pimentel, David. "FOOD, LAND, POPULATION and the U.S. ECONOMY" *FOOD, LAND, POPULATION and the U.S. ECONOMY*. 21 Nov. 1994. Web. 23 Jan. 2012. <<http://dieoff.org/page40.htm>>.

Unknown. "Vertical Farming." *Wikipedia*. Wikimedia Foundation, 28 Mar. 2012. Web. 29 Mar. 2012. <[http://en.wikipedia.org/wiki/Vertical\\_farming](http://en.wikipedia.org/wiki/Vertical_farming)>.

Unknown. "Crop Yield Verification." *Crop Yield Verification*. Gardens of Eden. Web. 20 Jan. 2012. <<http://www.gardensofeden.org/04%20Crop%20Yield%20Verification.htm>>.

Unknown. "No Food = No Problem!" *Hydroponics Gives 100 times Field Yields*. Android World. Web. 21 Jan. 2012. <<http://www.androidworld.com/prod26.htm>>.

Jones, Jonathan D.G. "Why Genetically Modified Crops?" *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*. Royal Society Publishing, 2011. Web. 19 Jan. 2012. <<http://rsta.royalsocietypublishing.org/content/369/1942/1807.abstract>>.

Helmenstine, Anne M. "What Is Activated Charcoal and How Does It Work?" *About.com Chemistry*. About.com. Web. 29 Mar. 2012. <<http://chemistry.about.com/od/chemistryfaqs/f/charcoal.htm>>.

Kershner, Kate. "How Reverse Osmosis Works." *How Stuff Works*. How Stuff Works, 8 Mar. 2008. Web. 20 Mar. 2012. <<http://science.howstuffworks.com/reverse-osmosis.htm>>.

King, Tom. "How Does UV Light Kill Bacteria?" *EHow*. Demand Media, 17 July 2009. Web. 19 Feb. 2012. <[http://www.ehow.com/how-does\\_5188035\\_uv-light-kill-bacteria\\_.html](http://www.ehow.com/how-does_5188035_uv-light-kill-bacteria_.html)>.

"Methane Digesters, Anaerobic Digestion, Fertilizer, Cogeneration, Interconnection." *Valley Air 2020*. Valley Air 2020. Web. 17 Feb. 2012. <<http://www.valleyairsolutions.com/methanedigesters.htm>>.

Unknown. "Plasma Gasification Process Description Overview." *Plasma Gasification Overview*. Recovered Energy. Web. 24 Feb. 2012. <<http://www.recoveredenergy.com/overview.html>>.

Unknown. "Hydrochloric Acid Manufacture." *Hydrochloric Acid*. 18 Nov. 2011. Web. 12 Feb. 2012. <<http://www.hydrochloric-acid.co.uk/hydrochloric-acid-manufacture>>.

Unknown. "10 Futuristic Cell Phone Concepts." *Design Ideas and Tech Concepts*. Toxel.com, 7 Jan. 2010. Web. 3 Mar. 2012. <<http://www.toxel.com/tech/2010/01/07/10-futuristic-cell-phone-concepts/>>.

Tetlow, Karin. "Escalator Basics Today: How to Plan, Design and Update." *Continuing Education*. KONE Inc., Oct. 2008. Web. 15 Mar. 2012. <<http://continuingeducation.construction.com/article.php?L=14&C=455&P=4>>.

Unknown. "PatentStorm." *Method for Processing and Fabricating Metals in Space*. Web. 25 Mar. 2012. <<http://www.patentstorm.us/patents/4480677/description.html>>.

Morgan, John W., and Edward Anders. "Chemical Composition of Earth, Venus, and Mercury." *Pnas.org*. Pnas.org. Web. 14 Feb. 2012. <<http://www.pnas.org/content/77/12/6973.full.pdf>>.

*Home Server Icon*. 2011. Photograph. Icon Archive. *Iconarchive.com*. IconArchive, 28 July 2011. Web. 30 Mar. 2012. <<http://www.iconarchive.com/show/vista-hardware-devices-icons-by-icons-land/Home-Server-icon.html>>.

*Satellite Icon*. 2009. Photograph. Icon Archive. *Iconarchive.com*. IconArchive, 25 June 2009. Web. 30 Mar. 2012. <<http://www.iconarchive.com/show/gis-gps-map-icons-by-icons-land/Satellite-icon.html>>.

*Satellite Icon*. Photograph. GettyImages. *Gettyicons.com*. GettyIcons. Web. 30 Mar. 2012. <<http://www.gettyicons.com/free-icon/102/network-icon-set/free-satellite-icon-png/>>.

*Network Router Symbol*. 2008. Photograph. *Www.clker.com*. clker, 26 Mar. 2008. Web. 29 Mar. 2012. <<http://www.clker.com/clipart-16348.html>>.

*User Group Icon*. 2008. Photograph. Icon Archive. *Iconarchive.com*. IconArchive, 26 Mar. 2008. Web. 30 Mar. 2012. <<http://www.iconarchive.com/show/people-icons-by-aha-soft/user-group-icon.html>>.

*Globe Icon*. Photograph. *Ladyantebellum.com*. Lady Antebellum. Web. 30 Mar. 2012. <<http://ladyantebellum.com/sites/ladyantebellum.com/files/globe-icon.jpg>>.

*Firewall Icon*. Photograph. *Www.iconarchive.com*. Iconarchive. Web. 29 Mar. 2012. <<http://www.iconarchive.com/show/junior-icons-by-treetog/firewall-icon.html>>.

*Network Switch Clip Art*. 2007. Photograph. *Clker.com*. Clker.com, 18 Nov. 2007. Web. 30 Mar. 2012. <<http://www.clker.com/clipart-10034.html>>.

*Male Client Icon*. Photograph. *Gettyimages.com*. Gettyimages. Web. 29 Mar. 2012. <<http://www.gettyicons.com/free-icon/108/office-icon-set/free-male-client-icon-png/>>.

## Human Factors

Choi, Charles Q. "Virtual Reality Contact Lenses Offer 3D Panorama." *Discovery News*. Discovery, 3 Feb. 2012. Web. 29 Feb. 2012. <<http://news.discovery.com/tech/augmented-reality-contact-lenses-120203.html>>.

Boyle, Rob, Barbara Romig, Charles Allton, Peggy Guirgis, and Mike Gernhardt. "Extravehicular Activity Technology Development- Suit Port Technologies." *Nasa.gov*. NASA, 27 Nov. 2009. Web. 16 Feb. 2011. <<http://research.jsc.nasa.gov/BiennialResearchReport/2011/49-2011-Biennial.pdf>>.

Unknown. "Greek Revival Home Plans at Dream Home Source | Elegant Floor Plans." *House Plans and Home Plans*. Hanley Wood, LLC, 2011. Web. 10 Mar. 2012. <<http://www.dreamhomesource.com/house-plans/dhs/styles/neoclassical-house-plans/greek-revival-house-plans.html>>.

Manaugh, Geoff. "State of Play: The World's Most Amazing Playgrounds." *Popsci*. Popular Science, 6 Feb. 2012. Web. 10 Feb. 2012. <<http://www.popsci.com/technology/article/2012-01/state-play-playgrounds-tomorrow>>.

*The City Lights*. Photograph. *Portwallpaper.com*. Web. 20 Mar. 2012. <<http://img.portwallpaper.com/imgwal/the-city-night-lights.jpg>>.

*A Futuristic City*. Photograph. *Ifimages.com*. If Images. Web. 30 Mar. 2012. <<http://www.ifimages.com/public/image/758227/view.html>>.

*Playing at a Super Cool Playground*. 2009. Photograph. Photos through the Years. *Cheninfo.com*. Cheninfo, 20 Mar. 2009. Web. 30 Mar. 2012. <<http://www.cheninfo.com/photos/v/Years/2009+Photos/March+2009+Photos/Family+Vacation/Day+7/PIaying+at+a+super+cool+playground.jpg.html>>.

## Automation

Jjstout. "AnSCO Expands Automated Machinery for Large Part Turning and CNC Machining." *Article RICH*. Web. 18 Feb. 2012. <<http://www.articlerich.com/Article/AnSCO-Expands-Automated-Machinery-for-Large-Part-Turning-and-CNC-Machining/1923787>>.

Thomas, Edwin. "How to Refine Metal." *EHow*. Demand Media, 26 Aug. 2008. Web. 15 Mar. 2012. <[http://www.ehow.com/how\\_4492496\\_refine-metal.html](http://www.ehow.com/how_4492496_refine-metal.html)>.

Unknown. "Laser Cleaning and Surface Preparation Technology." *Laser Cleaning and Surface Preparation Technology*. 2007. Web. 17 Jan. 2012. <<http://lasercleanall.com/index.html>>.

Micheletto, Ruggero. "Letter to Professor Hara." - *RIKEN People*. Web. 18 Mar. 2012. <<http://www.rikenresearch.riken.jp/eng/riken-people/5652>>.

Unknown. (1996, April 01). *Recommended levels of Gypsum*. Web. 20 Mar. 2012. <<http://nationalgypsum.com/resources/pdf/GA-214-10e-webversion.pdf>>.

Dillow, Clay. "Ring of Laser Light Can Count Individual Viruses and Nanoparticles." *Popsci*. Popular Science, 11 June 2011. Web. 18 Mar. 2012. <<http://www.popsci.com/science/article/2011-06/new-micro-laser-sensor-can-detect-and-count-individual-viruses-and-nanoparticles>>.

Strickland, Jonathan. "How Does the Internet Work?" *HowStuffWorks*. How Stuff Works. Web. 19 Mar. 2012. <<http://computer.howstuffworks.com/internet/basics/internet.htm>>.

Strickland, Jonathan. "How Cloud Computing Works." *HowStuffWorks*. How Stuff Works. Web. 26 Mar. 2012. <<http://computer.howstuffworks.com/cloud-computing/cloud-computing1.htm>>.

## Business Developments

Simmons, Steve. "Illustrations." *Illustrations*. 2006. Web. 30 Mar. 2012. <<http://www.airworksart.com/illustrations3.htm>>.

---

## Cover Art

“Industry in 2030,” by E McKnight Kauffer, for FE Smith’s book, *The World in 2030*(pub. 1930).

<http://debbiegaines.hautetfort.com/media/02/02/1530378347.jpeg>

By Yuly Schvetz, 1972

<http://lh4.googleusercontent.com/-9u0DTd7n3Xg/TjCigax2oMI/AAAAAABgNo/Bc20VHgLCFQ/s800/45ywegerrgr.jpg>  
art by Zdenek Burian)

<http://blogs.artcenter.edu/dottedline/wp-content/uploads/2012/03/L.A-300x229.jpg>  
“L.A. 2013” (1988) by Syd Mead.

Operations artwork by Ralph Mcquarrie

Schedule and Costs artwork by Syn Mead

Art for business development

<http://justc.de/2010/08/sie-wussten-damals-zu-viel-teil-2/>

Art for Structures

[http://www.hale-yeah.net/wp-content/uploads/2012/01/Hotel\\_Edison-Postcard.jpg](http://www.hale-yeah.net/wp-content/uploads/2012/01/Hotel_Edison-Postcard.jpg)

Art for Operational Scenario by Klaus Bürgle

Bibliography art by Eberhard Binder-Staßfurt

# COMPLIANCE MATRIX



**MEN LOVE TO WONDER,  
AND THAT IS  
THE SEED OF SCIENCE.**

**-RALPH W. EMERSON**



### C. Compliance Matrix

Point	Title	Brief summary of the section
1.0	<b>Executive Summary</b>	Aynah will be the first large settlement orbiting Mercury.
2.0	<b>Structures</b>	Aynah's design will provide a pleasant and productive environment for its community of 14,000.
2.1	External Views	Major components of Aynah include Communications Array, Residential Torus, Docking Facility, Industrial Complex, and Shield.
2.1.1	Hull Composition	Hull will consist of reardonium, steel, water and regolith.
2.1.2	Enclosed Volumes	The four main volumes are the Centrifuge (storage, zero-G needs, etc), Docking Facility (port, docking), Residential Torus (homes, entertainment, life support systems) and Industrial Ring (industrial processes).
2.1.3	Artificial Gravity	Residential Torus spins at 0.8G, industrial complex varies from 0G to 0.5G. Gravity interface rails separate areas of different artificial gravities.
2.1.4	Isolation of Volumes	There are four main volumes: Centrifuge, Docking, Industrial Ring, Residential Torus. There are five isolatable volumes in the habitation ring.
2.2	Down Surfaces	Down surfaces of Aynah's habitation ring will be in two floors, each with a storage floor below them.
2.2.1	Allocation of Down Surfaces	Upper Residential Level is mainly residential space. Lower Residential Level is mainly trade and business space.
2.2.2	Vertical Clearance	20 meters in most areas with a 45 meter opening.
2.3	Construction Sequence	The events and methods in building Aynah.
2.3.1	Phases of Construction	There are eight steps to the construction of Aynah.
2.3.2	Method of Rotation	Rotation will be performed by fusion thrusters.
2.3.3	Interior Construction	Interior construction will be completed by the re-purposed mobile refineries.
2.4	Reardonium Manufacturing Facilities	Aynah will have adequate reardonium manufacturing facilities with room for expansion if necessary.
2.4.1	Industrial Complex	To provide varying gravities for reardonium manufacturing, ten discs in the industrial complex will spin at different rates and have different atmospheric pressures.
2.4.2	Industrial Control Deck	Provides for the needs of humans working in the industrial complex. Trams allow for travel between discs.
2.5	Radiation Mitigation	Aynah will provide radiation mitigation via multiple means.
2.5.1	Shield	Sun-facing shield equipped with solar panels creates a barrier from

		the sun.
2.5.2	Human Occupied Areas	Human inhabited areas are surrounded by 0.5 m of water.
3.0	<b>Operations</b>	Aynah will provide the infrastructure and facilities needed for residents and station operations.
3.1	Location and Construction	Aynah will face the sun and be in polar orbit around Mercury. The settlement will be built of mostly reardonium as available.
3.1.1	Location	Aynah will face the sun and be in polar orbit around Mercury.
3.1.2	Material Sources	Material sources of Aynah will include: helium-3, regolith, steel, reardonium, thorium, sodium, polyvinylidene chloride, and LEDs.
3.1.3	Equipment	Initial equipment will be shipped from Earth to Aynah.
3.2	Community Infrastructure	Station operations will utilize efficient processes for life support functions to create a safe and healthy environment for residents.
3.2.1	Atmosphere	The air pressure on Aynah will be kept at 1 atm. Temperature will vary seasonally.
3.2.2	Food Production	Aynah will utilize dynaponics and bio-printing to provide food for its residents.
3.2.3	Electricity	Power will be supplied mainly by a hybrid thermal/solar collector on the surface of the shield. The waste system will provide power as well.
3.2.3.1	Main Power	Main power is supplied using a hybrid thermal/solar collector system.
3.2.3.2	Auxiliary Power	The waste system on Aynah will provide auxiliary power.
3.2.4	Water Management	Water on Aynah will be available in reservoirs on every floor. Residential water will be separate from industrial and agricultural water. All water will go through a filtering process to purify completely.
3.2.5	Solid Waste Management	Waste will be separated into industrial, medical, and residential classifications until it can be processed. Waste will provide auxiliary power.
3.2.6	Communications	Satellites facilitate external communication. Wristwatches will be used internally.
3.2.7	Transportation	Transportation on Aynah will be provided via gravity interface trains, metro elevators, bikes, and a school train.
3.2.8	Day/Night Cycle	The day/night cycle will be synchronized to Earth Greenwich Mean Time. Ambient lighting and OLED displays will provide an illusion of the Earth sky, in addition to views of Mercury.
3.3	Construction Mechanics and Procedure	Aynah's construction process will be fully automated using bots such as welding and construction bots.



3.3.1	Exterior Construction	Exterior assembly bots and welding bots will work in tandem to assemble Aynah's reardonium exterior.
3.3.2	Interior Construction	Once Aynah's exterior structure is complete, mobile refineries will be reallocated to the production of interior infrastructure.
3.4	Solar Panels	10 solar panel arrays will be implemented to facilitate reardonium production and to provide optimal exposure to sunlight.
3.5	'Tortoise' Curing Vehicle	The 'Tortoise' curing vehicle will be used to transport reardonium over the surface of Mercury.
4.0	<b>Human Factors</b>	Through an urban-metropolis inspired society, residents will have a fulfilling and captivating life in space.
4.0.1	Natural Views	OLED screens along the side and roof of the residential torus will simulate day/night cycles by transitioning between projected sunlight and real-time camera views of Mercury.
4.0.2	Paragon Grid Community	With the diamond grid community layout the Coriolis effect can be minimized.
4.1	Community Design	Communities will be designed to provide a convenient and luxurious environment.
4.1.1	Community Layout	The Messenger Stadium and other recreational facilities will be placed with residential convenience in mind. Roads and pathways will account for 8.5% of the surface area on Aynah.
4.1.2	Entertainment, fine dining and recreation	The Messenger Stadium will serve as a multipurpose venue for entertainment, as well as the base of the new sport Coriolis Cart, unique to Aynah. Other attractions and businesses will also be scattered around communities.
4.1.3	Consumer Goods	Aynah will be stocked with a variety of goods to ensure that residents will have everything they require.
4.1.4	Distribution	All consumables will be easily ordered through the Pneumatic Delivery System from the residents' personal WristWatches or purchased in markets.
4.2	Residential Design	Homes in Aynah are designed to accommodate all types of residents and lifestyles.
4.2.1	Housing	With four customizable home designs, each resident can find a home that tailors to their lifestyle and needs.
4.2.2	Amenities	Homes and communities will be designed with healthy sustainability in mind. Homes will also have a variety of automated systems and devices to aid residents in their everyday life.



4.3	Low-G Accommodations	It will be ensured that every low-G area is entered and operated in as safely as possible.
4.3.1	Zero-G Safety	Airlocks, in addition to all low-g areas, will be equipped with handrails and other safety devices meant to prevent accidents in the spacesuit donning and doffing process. Monitoring systems within the spacesuits will ensure health and safety is maintained at all times.
4.3.2	Systems and Devices for Low-G safety	Devices for low-g safety will include heads-up display contact lenses and the WristWatch.
4.4	Gravitational Therapy	With the negative health effects of space in mind, residential gravity therapy and exercise is crucial.
4.4.1	Children	Aynah's school will be located on a train moving around the residential torus. The additional velocity given to the train will create a 1g environment for children.
4.4.2	Adults	Adults will exercise daily as a result of the community bike rental program. They will also be encouraged with weekly goals and reward systems. Exercise-focused activities will be spread throughout the communities.
4.5	'Comet' Surface Vehicles	The Comet will be used to transport humans across the surface of Mercury, primarily for inspection jobs. It can also be used in emergency evacuation situations.
5.0	<b>Automation</b>	Robots and automated systems will be used in all areas of Aynah to fulfill their needs safely and efficiently.
5.1	Construction	Robots purposed for tasks such as welding and general construction will be used so construction can be done as safely as possible.
5.1.1	Welding Bot	Welding bots weld aligned pieces into place.
5.1.2	Exterior Construction Bot	Transport and manipulate station components in space.
5.1.3	Thruster Control & Monitoring System	Regulates rotational rates of Industrial Complex discs and Residential Torus
5.1.4	Interior Construction Bot	Construct Residential Torus and Industrial Control Deck.
5.2	Settlement Maintenance & Operation	Settlement and operational bots will be used to aid food storage, communication, weather, data, and reardonium processes.
5.2.1	Operations Robotics	Robots used for infrastructure and internal systems.

5.2.2	Security Protocol	Protocol allows for flexible human-computer interfacing depending on user role.
5.2.3	Contingency Plans	Plans are in place in the event of hull breach, water and air contamination, depressurization, fire, epidemic and medical emergency.
5.3	Livability Bots	Bots within residential and commercial areas of Aynah will be used to aid in the creation of a convenient and fulfilling lifestyle for residents.
5.3.1	Human Factors Robotic Systems	Systems that will directly aid the lives of residents.
5.3.1.1	Stadium and Assembly Bot	Utilizes repurposed Interior Construction Bots
5.3.1.2	Illusionist	Augmented reality system for Coriolis Cart.
5.3.1.3	Monsieur Gallant	Server, cook and cashier in restaurants.
5.3.1.4	Pneumatic Delivery System	Delivers food, medical supplies and toiletries.
5.3.1.5	Triage	Assesses the health of the resident at home.
5.3.1.6	The WristWatch	The WristWatch is Aynah's main communication and community interface device.
5.3.1.7	Social Media & Entertainment Center	Provides many entertainment options and interactive activities for residents.
5.3.1.8	HUD Contact Lenses	HUD Lenses will be used for pilots and logistics/industrial personnel.
5.3.1.9	Oracle Ground Penetrating Radar	Subterranean mapping system by ground penetrating radar equipped on the Comet.
5.3.1.10	Comet Shield System	A shielded human inspection vehicle.
5.3.1.11	Comet Repair and Survival Unit	Repairs the Comet if necessary.
5.3.2	Networking	Data will go through a series of servers, switches and firewalls before reaching the client.



5.4	Manufacturing Bots	Manufacturing bots will provide automation in the process involving the production of reardonium and moving parts and metals on Mercury's surface.
5.4.1	Centrifugal Cargo Train	Centrifugal cargo trains will provide transportation within the centrifuge on Aynah and will be equipped to pick up and move any cargo needed.
5.4.2	Robotic Loading System	Robotic Loading systems will interface with all docked ships and shuttles to load/unload cargo.
5.4.3	Mobile Refinery	Aynah will contain two mobile refineries for the construction of parts in orbit.
5.5	Reardonium Tending Bots	Reardonium tending bots will be used in the process of raw ore into reardonium on the surface of Mercury.
5.5.1	Cormorant Shuttle	The Cormorant shuttle will be used for transportation of reardonium parts, cargo, and comets from Aynah to the surface of Mercury.
5.5.2	'Tortoise' Reardonium Curing and Flipping Vehicle	The 'Tortoise' reardonium curving and flipping vehicle will be used to transport material in the reardonium production process and to flip parts in order to complete the reardonium process more efficiently.
6.0	<b>Schedule and Cost</b>	Most of Aynah's construction costs are in its automation.
6.1	Schedule of Contractor Tasks	Aynah will take 33 years to build from award of contract.
6.2	Costs by Phase of Construction	Aynah total cost: \$24,174,435,739
7.0	<b>Business Development</b>	Aynah's design allows it to be the materials production capital of the solar system.
7.1	Commercial Ventures	150,000m2 of space will be allocated for trade conference centers, events, etc.
7.2	Industrial Projects	80 factory sectors are available in Aynah's industrial complex for use.
7.3	Docking Facility	Aynah's docking facility initially has room for 24 ships, with room for expansion
7.4	Port of Entry	interior material movement and storage will allow for an efficient production flow.