



AYNAH

by Kylin Company

13th International Space Settlement Design Competition

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**Design, Development, Construction, and Operation Proposal for
the First Large Space Settlement Community in the Orbit Around
the Planet Mercury**

Kylin Company

From Chengdu No. 7 High School

Enpei Zhao Dingkun Guo

Qingyuan Zeng Yulun Zhang

Guanghao Ye Ran Luo

Ruopeng Zhou Yuyou Wu

Zehao Huang Xinran Ming

Yifan Mo Yating Zou

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1.0 EXECUTIVE SUMMARY





1.0 EXECUTIVE SUMMARY

As humans slip the leash Earth's gravity and stretch their arms to other planets in the solar system, they yearn for new space colonies for special material production and human settlements.

Kylin, as the leading figure of space exploration, has been focusing on the development of space industry. Entrepôt, a model of space ship industry, is the crystal of Kylin. The most advanced space ship ever in human history, With our 27-year experience and state-of-the-art technology, we have the confidence, as well as the strength, to build such an advanced space station. Aynah will become another majestic milestone along the long journey of space sailing under the persistent and industrious effort of Kylin!

Designed by Kylin Co., Ltd, Aynah, as the combination of the most graceful art, the most state-of-the-art science, and the most enthusiastic spirits of humans, will become the most advanced, multi-functional space settlement ever in human history, providing a well-rounded and secure residential, industrial, agricultural as well as experimental space quarterback.

With the support of a newly discovered metal, Reardonium, an innovative material possessing features such as lightweight, strong, amenable to producing complex shapes, self-lubricating, and providing protection from heat, cold, and radiation, we'll be able to protect the settlement from space radiation and the sun more efficiently. Thus, we can ensure an eminent and secure performance of the settlement with a fair cost.

Safety, as usual, will be our company's priority. In order to minimize human's exposure to the space, we have designed surface vehicles as well as space ships for material transportation and manned space missions. Details will be mentioned in part five. Inevitably, humans have to be involved in certain missions in vacuum; as a result, we have designed a space suit, guaranteeing human's safety in vacuum as well as the exposure to solar radiation. As for residents, we will also provide full surveillance of the settlement, responding to emergencies as quick as possible. Certain areas can only be accessed by members with special authorization. Details will be mentioned in part four.

Providing our clients with comfortable experience has always and will always be one of our most important goals. Structures are refined to provide the most suitable gravity for both children and adults. The design of our operational mechanisms and devices, such as water management, waste management, and air conditioners, are environmentally friendly. Most



renewable materials will be used either as a source of energy or a source of productions. We have also designed departments for the single, the married as well as families. Regardless of his marriage status or physical well-being, one can always find his place in the settlement.

In addition to good service and safety guarantee provided by our company in the 27 years of our young history, **profits also played a vital role in the maintenance of our daily operation as well as scientific research.** In Aynah, as usual, we have also designed a mechanism to gain back our costs in three years.

For thousands of years, human kind have sought so many ways to explore the night sky that we have gazed at on earth. Yes, human would one day go out of the cradle that is the earth to seek better lives. With Aynah, the combination of the most cutting-edge technology, of the dreams that was in the back of our heads all along, we will strive to soar in the sea of science, and look deep into the depth of the universe.



2.0 STRUCTURAL DESIGN

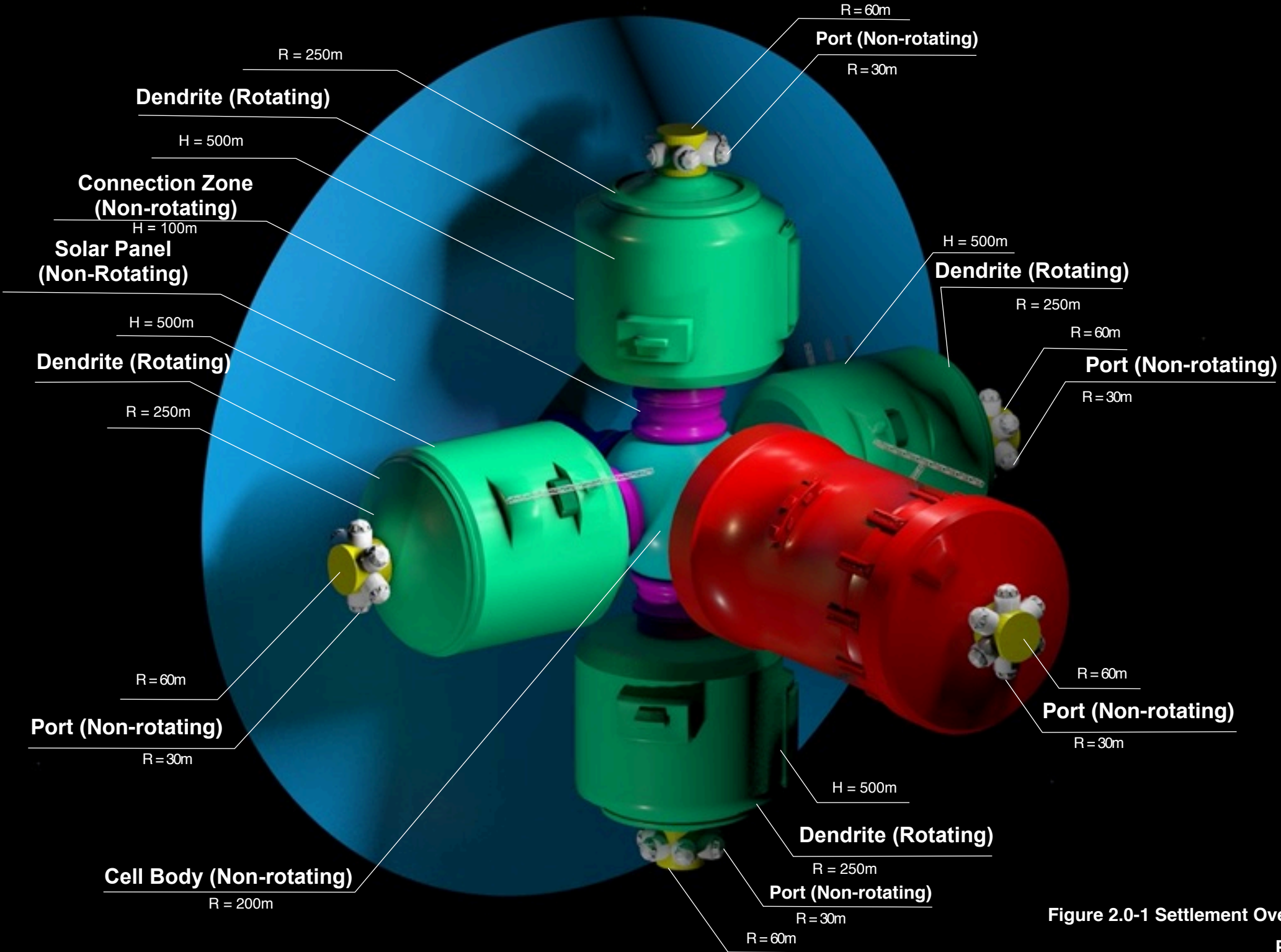


Figure 2.0-1 Settlement Overview

2.0 STRUCTURE DESIGN

Aynah provide all residents with safe and pleasant environment via its structural design.

2.0.1 Residential Demands for Structural Design

14,000 full time residents and 200 visitors will have enough space for their daily routines. Proper rotation will ensure their comfort by providing 0.5g gravitational acceleration. For the growth of the kids, 1.1g zone is provided.

2.0.2 Mercury Natural View

Consisted of silicone fiberglass, twenty oval windows inlaid in the floor of the Residential&Agriculture Dendrites are able to provide natural view of Mercury below for residents passing by the window. These windows are provided in the recreational area of Dendrites.

2.1 External Configuration

Rotating parts: Dendrites of the settlement.

Non-rotating parts: Cell Body of the settlement, ports and the axis.

2.1.1 Main Structure

The main structure shapes like a neuron without axons. The “Cell Body” is the central sphere (radius 100m) that connects to all the functional cylinders—Residential&Agriculture Dendrites (5 in total with separate structure, radius 250m, height 500m, longest exterior structure is perimeter 1570m and 1600m length) and Industrial Dendrites (1 in total, radius 250m, height 936m). Each dendrite is for a certain function (4 for residential and agricultural, 1 for reardonium manufacturing). All the Dendrites rotates at 0.141 rad per second (see details in figure 2.0-1).

2.1.1.1 Hull

The outmost layer of Aynah needs to be heat-insulated as well as radiation-resistant. So we utilize reardonium, a lightweight and strong metal, to construct the hull. The debris and electromagnetic waves will

be blocked via the multi-layer crusts. There are one layers of Reardonium, one layer of Polyethylene material, one vacuum layer and a water layer in order to make the hull strong enough, electromagnetic shielding, and homeothermal (see details in table 2.1.1-1 Hull Arrangement).

Table 2.1.1-1 Hull Arrangement

Reardonium 0.7m
Vacuum 0.4m
Polyethylene Material 0.5m
Water Layer 0.5m

2.1.1.2 Cell Body and Axis

All Dendrites are connected to the Cell Body through the non-rotating axes and tunnels which every Dendrite revolves around.

The axis is stationary so that motionless parts are connected to it while rotating parts is isolated from it.

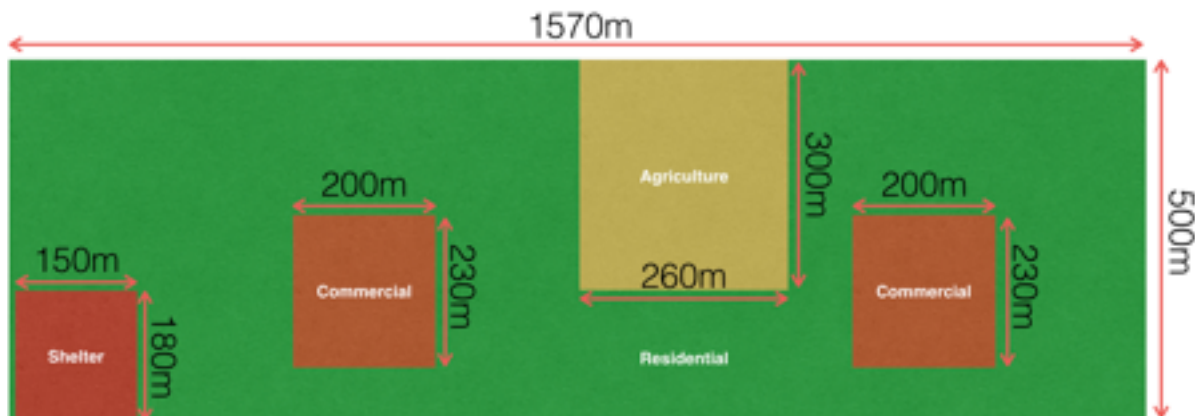


Figure 2.2-1 Internal Arrangement View

In addition, there is an electrical stabilization system, maintaining the distance (along with the silicon buckystructures) between axis and outer sections that don't connect to the axis.

2.1.1.3 Solar Panel

Since the space settlement locates specially near the sun, solar energy is available all the time. The solar panels are on end of the Aynah, facing the sun. This is a non-rotating section, connected to axis on Anyah. Its shape is part of a sphere, and the total area of is 15.61 square kilometers, providing enough energy for industrial production and operation.

2.1.1.4 Porting Section

Each Dendrite has its own port. Each port connected to the residential Dendrite is able to contain 4 spaceships simultaneously and the port connected to the industrial Dendrite is able to contain 6 spaceships simultaneously. The ports are non-pressurized so an

airlocks are set for people and cargoes entering and exiting the settlement.

2.1.2 Volume Specification

Residential&Agricultural Dendrites will be for residents' living, light industry including food production. Industrial Dendrite will be for reardonium manufacturing and heavy industry. Each volume will have food storage and backup power generation system to survive alone if catastrophe happens.

2.1.2.1 Gravity Specification

Dendrites will provide artificial gravity of 0.5g. A relatively rapidly rotating ring will be set around (but still attached to) the Residential&Agricultural Dendrites to provide 1.1g for children.

2.1.2.2 Pressure Specification

Cell Body and Residential&Agriculture Dendrites are all pressurized between 79.6 and 89.7 kpa, Industrial

Table 2.2-1 Allocation of Dendrites

Compartments	Specialization	Allocation (%)	Total Surface Area (10 ³ m ²)
Residential	Residential Building	19.1	1331.0
	Hospitals	1.0	67.0
	Hotels	0.8	59.0
	Commercial Buildings	7.6	527.0
	Recreational Space	12.8	891.0
	Schools	2.5	176.0
	Subtotal	43.9	3051.0
Agriculture	In Vitro Food Production	0.8	59.0
	Plant Growing	12.7	882.0
	Food Processing	1.4	94.0
	Storage	2.0	141.0
	Subtotal	16.9	1176.0
Operational	Essential Storage	5.3	368.0
	Refinement	2.3	161.0
	Transportation	3.3	230.0
	Scientific Research	1.7	115.0
	Waste Management	0.7	46.0
	Subtotal	13.2	919.0
Industrial	Part I	21.7	1508.0
	Part II	8.7	603.2
	Part III	4.3	301.6
	Subtotal	26.0	1809.6
Total		100.0	6955.6

Dendrites is pressurized between vacuum and 137.8 kpa and ports and the solar panel aren't pressurized.

2.2 Internal Arrangement

Aynah comfortably accommodates its 1,4000 full-time residents and 200 short time visitors. Taken each resident's spatial needs based on people's needs living on Earth into account (see table 2.2-1 for details), Aynah was calculated to be ample space to provide a luxurious experience for a city in outer space.

Aynah is divided into 6 major parts— one Industrial Dendrite, four Residential&Agricultural Dendrites and one Cell Body. All the Dendrites have vertical clearance of 150 meters.

2.2.1 Industrial Dendrite

As Aynah is intended to be the settlement built for scientific research and industrial production, we will have a large area planned for industry. The whole Dendrite is designed to concentrate the heavy industry factories so that waste management will be simplified. It contains energy system, ore refining area, reardonium formation parts and heavy industry.

2.2.2 Residential&Agricultural Dendrites

Residential&Agricultural Dendrites are mainly for residents' living, entertainment, light industry, and food production.

2.2.3 Cell Body

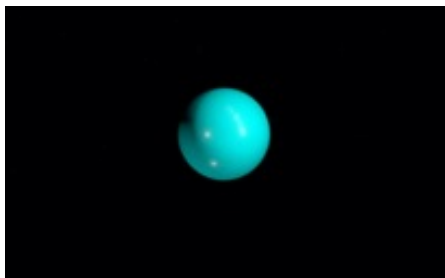
The Cell Body connects to all Dendrites and the solar panel. It will be the inter-dendrite transportation hub and the central automation control.

2.3 Construction Process

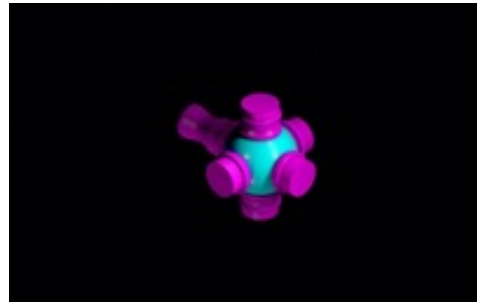
The whole construction process uses a huge number of assemblage components, Deformoes, which are linear and can be assembled together as a 3D net frame, Scopfer, for certain construction purpose. (See details in 3.3)

2.3.1 Construction Steps

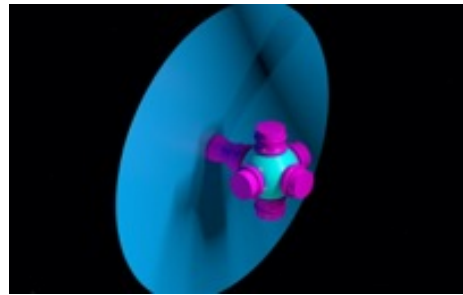
Step 1: Cell Body Construction



Step 2: Connection Zones and Energy Zone Construction

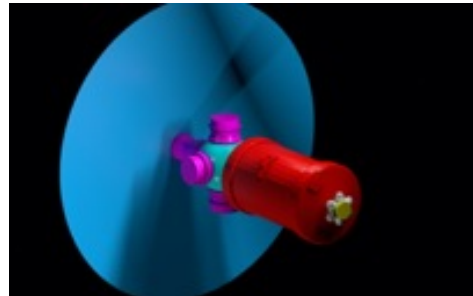


Step 3: Solar Panel Construction and start engender electricity

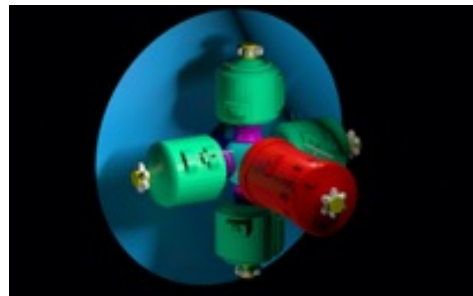


Step 4:

Industrial Zone and first port Construction, starting Rotating, with 20,000 square meters, which enables produce at early stage.



Step 5: Four Residential&Agriculture Zones and remain four Ports Construction



2.3.2 Way to Initiate Rotation

The top size of the Scopfer (see details in 3.3) has a huge rotating circle, Pienek, which will connect to the surface of Rotation part and rotate, leading the part rotate and be able to control the rotational speed.

2.4 Arrangement of Industrial Dendrite

The Industrial Dendrite is divided into three parts.

Part one: the radius from 100-250m is the manufacturing area; to increase the variety of the reardonium products, this area uses the honeycomb structure (shown in figure 2.4-1). Between every manufacture module (length 50m), there is a 5m gap to adjust the acceleration of gravity, and within the gaps there will also be lyings of wire, tubes and supports. Every manufacture module is filled with different amounts of Nitrogen in of operation; the Nitrogen functions as pressure adjuster to apply different pressure range from 0 to 137.8 kpa.

The part two: To increase the manufacture space of 0g, the space settlement also has non-rotating manufacture modules (radius: 50-100m, length: 936.3m) that are directly connected to the axis. Also within the non-rotating areas locates the Industrial Control area in charge of all the manufacturing operations to increase space for the manufacture.

The part three: in the center of the Industrial Zone (radius: 0-50m) is the axis which takes the responsibility of transporting parts and products in and out.

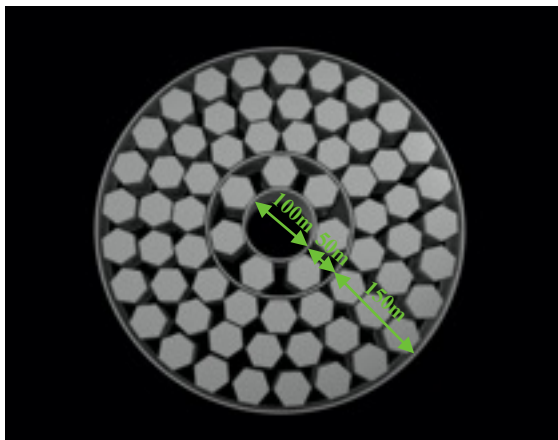


Figure 2.4-1 Internal Layout of Industrial Zone

2.5 Settlement Protection

Aynah is able to protect people inside from intense radiation in the space. As the solar panel is facing the Sun, the settlement can avoid direct sunlight. This solar panel will be able to intercept strong electromagnetic radiation from the sun with a wide range of wavelength, and with the special materials including perovskite, transition-metal sulphide and other materials, it will be able to turn radiation into electricity. In addition, to reduce the possible penetrated radiation, a water layer of 0.5m thick is set.

Also considering the damage caused by the accumulation of large amount of cosmic dust. In order to save residents from this unavoidable cosmic disaster, the surface of Aynah which is facing opposite to the direction of Aynah are all covered with a 0.005m-thick layer of nano-material which can repair itself if it has any damage.

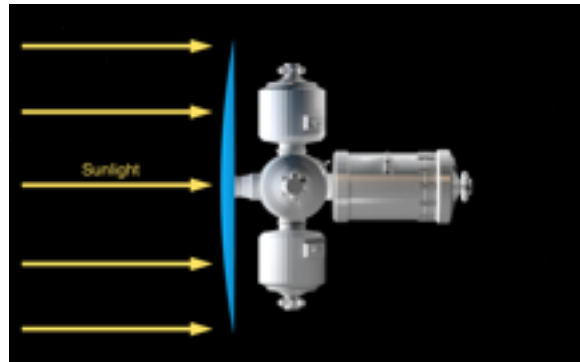


Figure 2.5-1 Settlement Protection



3.0 OPERATIONS AND INFRASTRUCTURE

3.0 OPERATIONS AND INFRASTRUCTURE

Facilities and infrastructures on Aynah mainly include food production and storage facilities, energy supply, environmental systems, water management system, waste management system, communication system, robots, and transportation and storage of cargos.

3.1 Location and Materials

3.1.1 Orbit Recommendation

Aynah will orbit Mercury on a sun-facing polar orbit. Aynah will be able to change its orbital altitude when necessary. The initial altitude of its orbit will be 370 kilometers due to the following reasons.

- 1) Aynah can orbit the Mercury with the speed of 2.89 km/s.
- 2) Transporting materials such as Rerardonium can be the most economical.
- 3) Space shuttles from other space settlements can easily access the settlement.

3.1.2 Materials and Sources

Silicates, sulfides, ice water, iron and nickel can be easily exploited on the surface of Mercury. Rocks and soil can be used to cultivate plants and build inner landscapes of Aynah; Carbon and iron can be exploited to produce steel. Additionally, ice from meteorite pits are essential to support lives. Furthermore, in order to provide air conditions similar to those on earth, Oxygen and Nitrogen have to be transported to Aynah in liquid phase.

Table 3.1-1 Materials and Sources

Material	Composition	Quantity	Source
Water	Water (Ice)	2,967,860kg	soil on Mercury
Steel	Iron, Nickel, Carbon, etc	31,610,500kg	crust on Mercury
Organic Compounds	Agricultural production, experiments, producing organic composite materials	20600kg	Bellevistat
Glass	Silicate	125,700m ²	crust on Mercury
Silicate	Silicon	25,792,670kg	soil on Mercury Chemical industry
Perovskite	CaTiO ₃ , CH ₃ N-H ₃ PbI ₃ , etc	52,765,300kg	Material Industry
Rerardonium	Rerardonium	993,780m ³	Rerardonium Production
Transition-metal	WS ₂ , CuGaS ₂ , etc	661,200m ³	Material industry

3.1.3 Material Storage

Materials will be categorized and then stored in small space storage stations called Entrepôt. In order to maintain the quality of materials, air conditions will be strictly controlled according the category of materials. In addition, exclusion system will protect materials from the harm of space radiation.

3.1.4 Material Transportation

During construction periods, space ships and 3D printers will be the main construction entities. While space ships transfer materials from Entrepôt to the huge 3D printer, Entrepôt serves as a charging base for such space ships.

3.2 Community Infrastructure

3.2.1 Atmosphere/Climate/Weather Control

Aynah provides residents with incredible comfortable and natural experience in atmosphere, climate and weather control, which benefit them in both physical and psychological ways.

3.2.1.1 Atmosphere

The atmosphere situations are monitored and controlled by Air Stations in each zone. See allocation of them in 4.1. The different zone are aerial separated but Air Stations in each volume are connected underground by pipes for circulation of different gases.

3.2.1.1.1 Air Composition

Table 3.2-1 Air Composition

Gas Type	Percentage (%)				Total Quantity (kg)
	Residential	Agriculture	Storage	Industrial (mean)	
Nitrogen	78.0	78.0	85.0	20-85	5.923×10 ⁸
Oxygen	21.0	21.0	1.0	0-40	2.131×10 ⁸
Helium	0.934	/	4.0	0-10	9.187×10 ⁶
Carbon dioxide	0.034	0.2-1.0	10.0	0-3	4.753×10 ⁵
Water vapor	0.02-0.30	0.3	<0.02	0-0.5	8.144×10 ⁵

Shown in the table 3.2.1-1, air composition of Aynah is different in residential, agriculture and industrial

zone. Among them, air composition of residential zone is similar to that of earth; the agriculture zone has low oxygen and higher carbon dioxide for crops to grow faster; the industrial zone has low oxygen and higher nitrogen to increase the stability of air with safety concerns.

3.2.1.1.2 Oxygen Production

Firstly, oxygen are mainly produced by ISS Oxygen Generator System. The process of it is shown in figure 3.2.1-1. O₂ produced by electrolysis is consumed by respiration and burning into CO₂, which will be extracted from air. After that, CO₂ reacts with Hydrogen produced in electrolysis. In the reaction, water is led into Water Management System (see details in 3.2.4) and CH₄ is used for producing heat in further processes.



Figure 3.2.1-1 ISS Oxygen Generator System

Moreover, plants in agriculture zone convert CO₂ into O₂. The redundant O₂ is circulated to use or storage by underground pipes connected to each Air Station. They also transport part of CO₂ into agriculture zone. Lastly, trees and plants in parks also convert CO₂ into O₂.

3.2.1.1.3 Air Purification

HEPA (High efficiency particulate air) filters with ultraviolet ray are applied to purify the atmosphere in Air Stations. In fact, HEPA filters intercept small particles and microorganism in air, and ultraviolet ray kill them, in order to avoid infectious and respiratory tract diseases.

3.2.1.1.4 Air Storage

To maintain the air composition, it is necessary to store some oxygen and other gases in cans to recharge the atmosphere. These cans are laid underground and connected to Air Station. The whole process of air circulation is controlled by Weather Control System (see details in 5.3) in Air Stations.

3.2.1.2 Climate

In order to provide the best living environment for residents, Aynah's atmosphere, climate and weather take that of Kunming (the place with most agreeable

weather in China) and airplane standards as references.

The climate of the four rotating seasons (spring, summer, fall and winter) will be shown in table 3.2.1-2. In Air Stations, the humidifier and dehumidifier maintain an amiable humidity for the residents and air conditioner regulate the temperature in settlement. Pressure is given when air is injected to each zone after purification by Air Stations.

Table 3.2.1-2 Season Succession

Season	Temperature (°C)	Relative Humidity (%)	Pressure (kpa)
Spring	18-21	50	80.5
Summer	23-30	60	79.6
Fall	16-20	45	81.4
Winter	12-18	40	82.7

3.2.1.3 Weather Control

3.2.1.3.1 Day/Night Cycle Provisions

The Principle of cycle of day and night is LED lights. With LED lights to simulate the sky view on earth, Aynah will be able to mimic the cycle of day and night. Through colour and brightness control, the goal of simulating the alternatives between day and night on earth could be achieved. Moreover, by using the low energy cost and easily controlled LED lights suitable for the approximately 628,900 square meters, conditioning the different times for sunrise and sunset according to seasons would be easy.

The day and night are circled according to earth time. During sunrise, the sky becomes a color of red like the that of the morning sun. As the day drags on, the brightness of the simulated sky increases, whereas the color slowly turns white-blue; at about 2 pm, the brightness of the sky would be maximum. After the time passed 2 pm, the brightness slowly decreases, and the yellow color of sunset is shown on the simulated sky. At night, the sky mimics the stars that could be seen on earth, and there could be blurred clouds.

The cycle of day and night in one year would be set according to the data in figure 3.2.1-2.

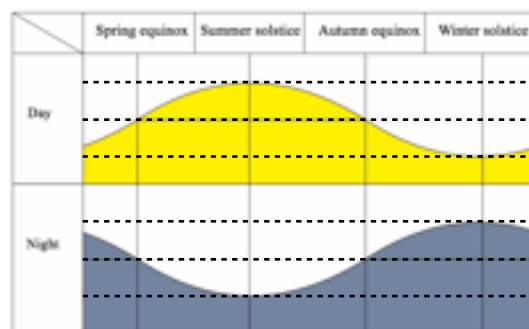


Figure 3.2.1-2 The Cycle of Day And Night In One Year

3.2.1.3.2 Wind Provisions

The Air Stations take in air from low ground and inject air back from high position. Fans are employed to produce ventilation in settlement. The output ratings are automatically controlled according to needs of purification. The velocity of winds is between 0.5m/s and 7m/s.

3.2.2 Food Production

3.2.2.1 Supply Quantity

The total amount of food supply is shown in the table 3.2.2-1.

Table 3.2.2-1 Food Supply

Food	Demands / person/day (g)	Demands / season (10 ³ kg)	Production Aim /season (10 ³ kg)
Grains & Crops	600	777	800
Vegetables	500	648	650
Fruits	200	259	250
Chicken & Eggs	100	130	130
Insects	100	130	130
Total	1500	1,944	1,960

3.2.2.2 Allocation

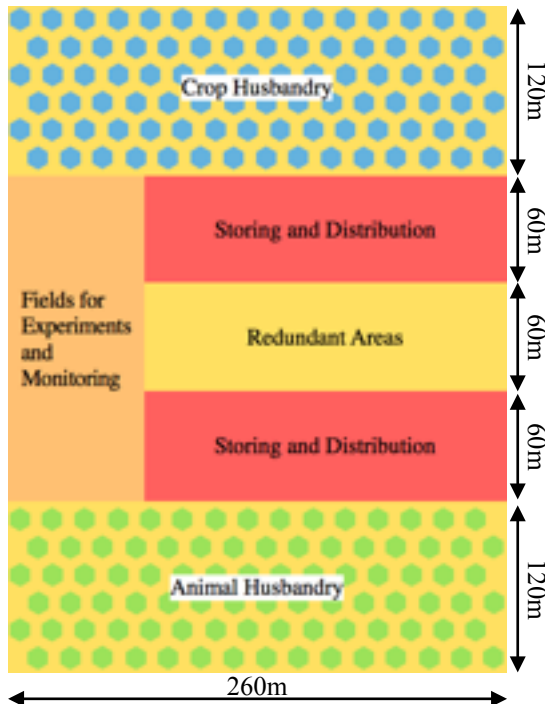


Figure 3.2.2-1 Agriculture Allocation

The areas arrangements are shown in figure 3.2.2-1. Crop and animal husbandry is completed in basic unit of agriculture (named Stereon). The figure 3.2.2-2 is

a explosive view of it. Stereones quadruple the area for husbandry and the united units not only save the costs but also separate areas preventing transmission of pests. Automatic machines decrease the needs for human to enter the toxic areas. Even though, humans need to equip oxygen provider and protective clothing in Stereones.

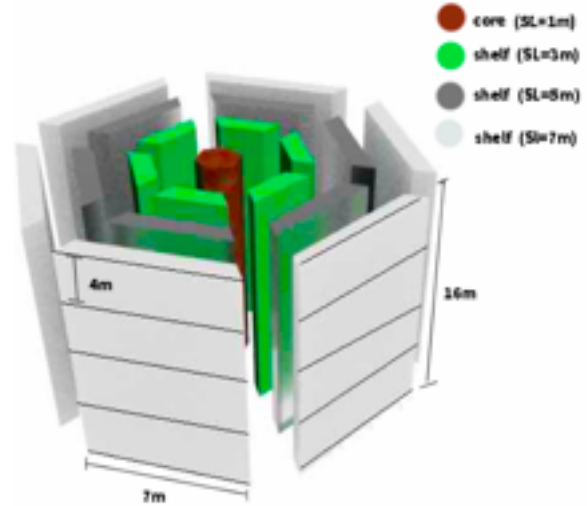


Figure 3.2.2-2 Stereon

3.2.2.3 Crop Husbandry

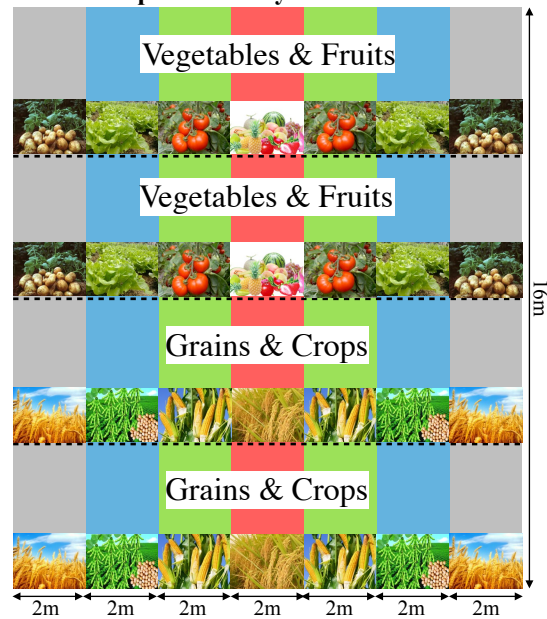


Figure 3.2.2-3 Crop Husbandry Stereon

As for crop husbandry, the whole process, including sowing plowing and fertilizing, will be automatized through machines monitored by human. The soil and hydroponics detectors detect the composition of the soil and liquid, and automatically manure them according to the nutrition the crop needs. Moreover, the harvest process is also completed through the automatically operated machines moving along the hexagon. After being processed by machines, the crops

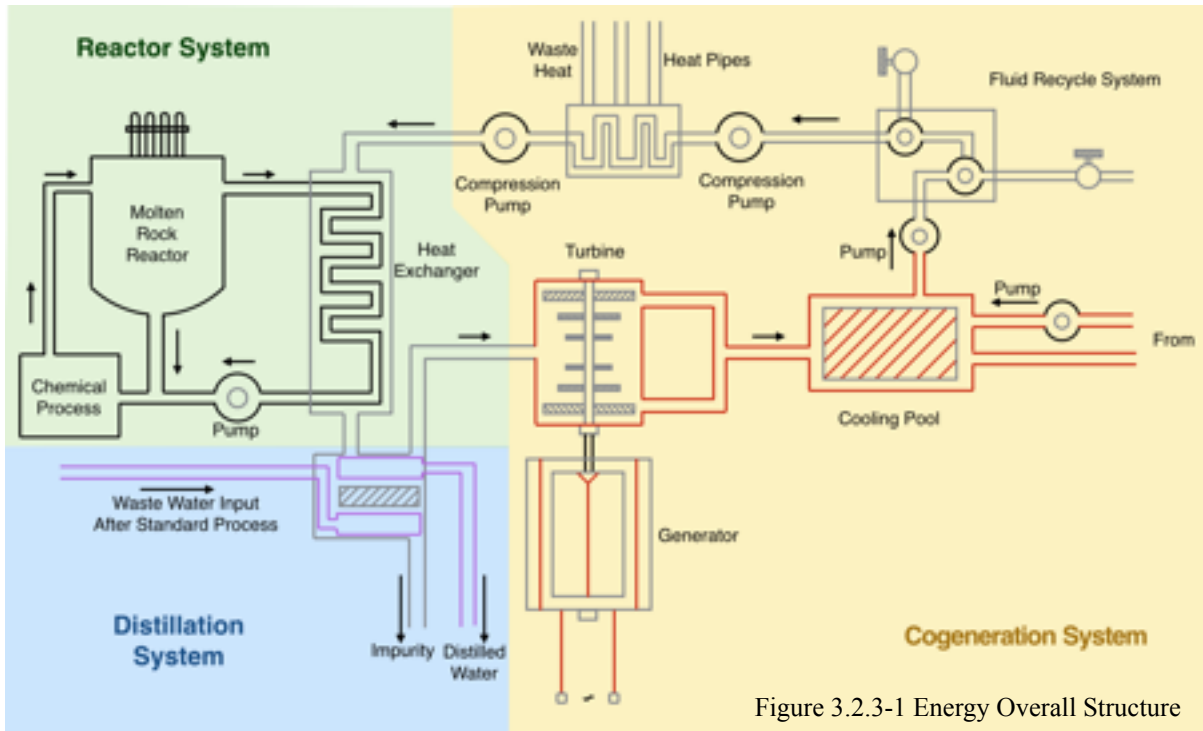


Figure 3.2.3-1 Energy Overall Structure

are delivered to restaurants and supermarket by trucks or sold or stored in places with low temperature and low oxygen. The figure 3.2.2-3 shows the front view of corp husbandry Stereon.

3.2.2.4 Animal Husbandry

As for animal husbandry, the insects like worms and grasshoppers are raised in automatic Stereon and be fed by machines. The eggs will be collected by mechanical arms. The mature chicken are massaged by machines. Then the chicken and eggs are automatically packaged by machines and delivered in trucks to restaurants or supermarkets every day. For all food, there will be people in charge of delivering everyday and delivery is not part of farmers' responsibility for higher efficiency. After delivery, the food are served in restaurants or sold in supermarkets. Moreover, the waste of animals and waste in restaurants will be recycled and processed to be fertilizers for agriculture. The front view of animal husbandry Stereon is similar to that of crop husbandry, and the animal fed in floors from top to bottom are grasshoppers, worms, chicken and chicken.

3.2.2.5 Storing

Basic supply for human, such as water, food and vitamins, are stored in standard containers and automatically managed in multi-storeyed storing warehouse with low temperature and low oxygen. The amount are equal to 3 month's supply for the whole population. Food storage will be replaced by newly produced food every 3 months, and the meat is in vacuum packages.

3.2.3 Energy Supply

In order to provide reliable power for various facilities on space settlement, we designed three different power sources to stabilize the energy supply, including solar cells, a small molten salt nuclear reactor and cogeneration system. We also set up fuel cell backup energy source for emergencies. The reactor and cogeneration system are both installed in the Energy Zone in Cell Body, separated by solar panel. With the use of these techniques, the overall power efficiency of energy can reach approximately 50% while that of reactor and cogeneration systems reach 60%.

Table 3.2.3-1 Energy Distribution

	Residential Sector	Business Sector	Agricultural Sector	Industrial Sector	Gross
Daily consumption (kWh)	320,000	44,000	28,000	960,000	1,352,000
Annual Consumption (mWh)	116,800	16,060	10,220	350,400	493,480

3.2.3.1 Solar Cell System

Solar Cell System contains four-junction cells with concentrator, electrical inverter and voltage stabilizer to provide more than 10 Mega Watt AC electricity with 45 percent efficiency. It was installed on the anti-radiation panel with electrical thermometers and heat pipes to transfer the waste heat. Electrical in-

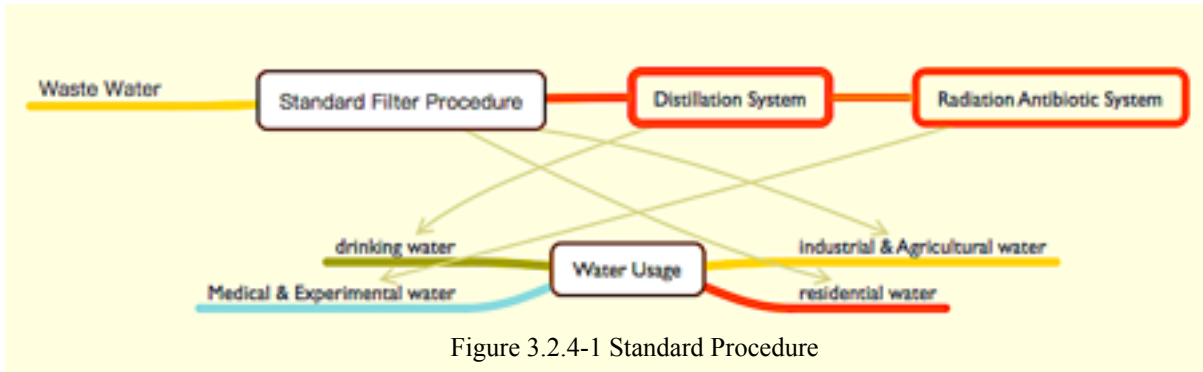


Figure 3.2.4-1 Standard Procedure

verter and voltage stabilizer are also located in Energy Zone near the Cogeneration System.

3.2.3.2 Molten Salt Nuclear Reactor

Molten Salt Nuclear Reactor is a small fission reactor in which the primary coolant and fuel itself are a molten salt mixture. It can run at high temperature that any other reactors and has high thermodynamic efficiency while staying at low vapor pressure. So it can generate nearly 25 Mega Watt electricity safely and efficiently in a very small volume. The anti-radiation containment made by concrete and composite material with high neutron and ray absorption rate can resist more than 500 kPa and 1500 degree.

3.2.3.3 Cogeneration System

Cogeneration System integrates thermal energy sources in different temperatures and media pressures and transforms them to both electricity and specific temperature thermal energy. It can deal waste heat from different facilities transferred by heat pipes and generate useful energy. With the use of supercritical fluid media and two high-efficient turbines, its efficiency can reach 60% and transform more than 30MJ per second with high stability.

Table 3.2.3-2 Energy Sources

Source	Power (kw)	Efficiency	Transformer	Usage
Solar Cells	15,000	40%	Inverter, AC transformer	Most for emergencies and residence
Molten Salt Reactor	60,000	60%	Cogeneration System	Most for industry and flight system
Waste Power	<1,000	60%	Cogeneration System	Waste heat disposal

3.2.4 Water Management

With the consideration of high expenses to transport resources from the earth to the space settlement, the design should maximize its ability to recycle the water resources.

3.2.4.1 Specific Mechanisms and Facilities

Any kinds of water that goes through the Water Processing Center will first experience a standard procedure. The specific process will be illustrated in the figure 3.2.4-1, along with the description of the mechanisms and facilities. After the standard process, water for different usage will go through specific facilities respectively.

3.2.4.1.1 Industrial Water

Due to the fact that quality requirements of industrial water is not as high as drinking water, with the treatment of the quite advanced facilities mentioned above, we can directly pass the water to the industrial areas.

3.2.4.1.2 Drinking, Residential and Agricultural Water

With consideration of the fact that the three kinds of water usage mentioned above are tightly related to human factors, the quality requirement of the water should be quite high. In order to achieve this goal, we will use cogeneration System in 3.2.3 to distill the water by supercritical fluid. We also provide radiation antibiotic system to reach medical water standard which makes water exposed to X-ray radiation from reactor.

3.2.4.2 Backup Water Storage Center

It is not impossible that the main water recycle system faces some problems and has to stop to get repaired; as a result, backup water resources is necessary. We specify the amount of water need by estimating the amount needed to sustain the full-operation of the settlement for five earth days. Water Storage facility is shown on the right.

3.2.4.3 Data Specification

Table 3.2.4-1 Water Quantity

Water Usage	Storage Amount (10 ⁶ liters)	Water Flow (10 ³ liters/hr)
Drinking	0.7	10
Residential	40	160
Agriculture	10	150
Industrial	15	800

Water Usage	Storage Amount (10 ⁶ liters)	Water Flow (10 ³ liters/hr)
Backup	40	\

3.2.5 Solid Management

3.2.5.1 Household Solid Waste Management

For household solid wastes, residents collect and classify them (see specific classification in figure 2.3.5-1) in the houses, and then throw them in corresponding waste containers. The containers in every room are connected to bigger ones in solid waste management center via pipelines; waste management center will collect wastes from containers every six hours.

In particularly, figure 2.3.5-2 shows the operations to incombustibles disposals.

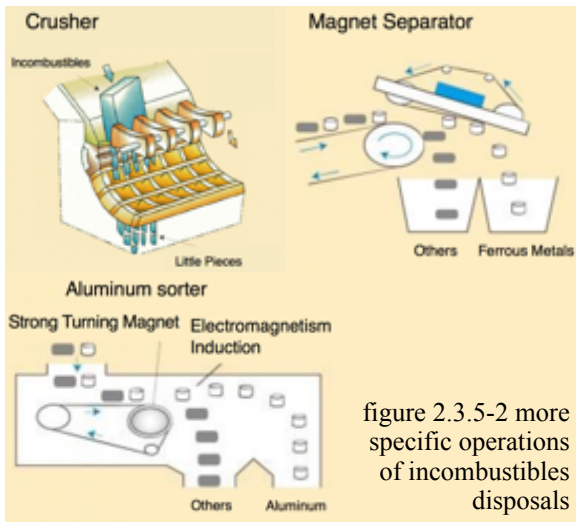


figure 2.3.5-2 more specific operations of incombustibles disposals

3.2.5.2 Industrial Waste Management



Figure 3.2.5.2-1 Industrial Waste Classification and Disposal

Industrial waste will be categorized and the components will be provided by the factory. Shown in figure 3.2.5.2-1. Plastics and glass will be melt down and reformed to become new products; certain substances will be dissolved in certain solvents; most organic wastes will be burned and proper substances such as biological materials will be made into fertilizer. The unworthy wastes will be move to rubbish pool and be gasified by waste heat.

3.2.6 Internal and External Communication Systems

All the communication devices will have access to the central quantum data processor to have immediate information exchanges. And if the quantum system cracks down, the data processors inside the base stations will provide information services as backup.

3.2.6.1 Internal Communication

The internal communication of Aynah will be provided by two main parts: individual accessories and in-

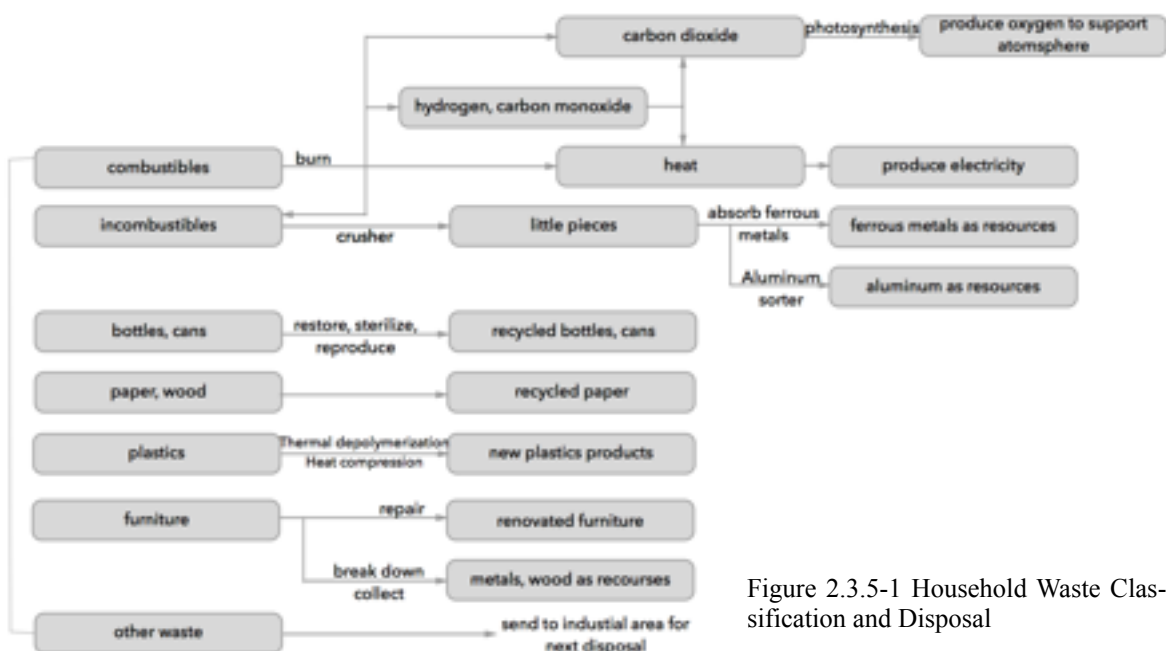


Figure 2.3.5-1 Household Waste Classification and Disposal

side interactive stations. People can communicate with each other and access the Internet via phones, watches, glasses and badges, which display 3D hologram to group well between reality and virtuality. Data will be transmitted into or out of the quantum data processors in the form of photons, and base stations will mainly serve as radio repeaters.

3.2.6.2 External Communication

External communication system is compromised with radio stations, optical senders (lasers) and receivers, and data processors. Radio is used for locating and communicating with objects in the vicinity of settlement, and laser is employed for long distance communication. Space traffic like interstellar travel will use a different wave bond from data transmitted with Earth and other space settlements in order to avoid disturbance.

3.2.7 Internal Transportation Systems

The transportation system of the settlement is designed in three dimensional that enables residents to access conveniently to all the corners of the settlement.

3.2.7.1 Layout Design

The layouts of all the routes of the Residential&Agriculture Dendrites present a cross mesh. A connection zone connects all part of the Aynah, which has 40 elevators connecting to it(each Residential Zone has 10 elevators).

3.2.7.2 Road Design

The Road is divided into three floors from top to bottom. The top floor is for vehicles MFV(described later) and robots to drive and the bottom floor (also the ground, story height: 3 meter) is pavement (0-3 meters high). All the floors have roads of both directions.

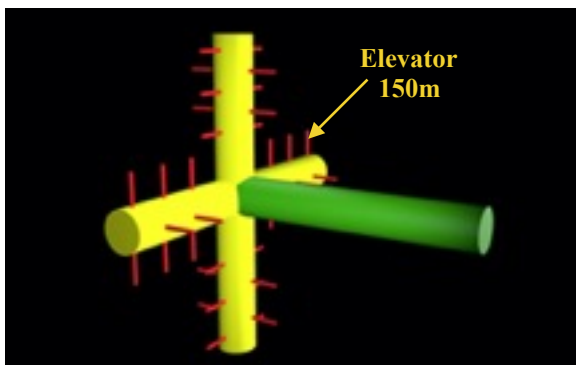


Figure 3.2.7-1 Layout of Transportation System

Platforms and stairs are designed for the switch among different ways of transportation. Also the elevators are the main devices for residents to move between the ground surface and the connection zone, both in normal condition and in emergency situation. Pedestrian elevator has nothing on its floor while vehicle elevator has holder on its inner floor. These

holders make it possible for vehicles to take the elevator without going down on the floor. The size of the both pedestrian elevator and vehicle elevator are: 3 meters long, 3 meters wide and 2.5 meters high, which can hold 35 people or 12 vehicle and lifting at an average speed of 10 meters per second.

3.2.7.3 Multi-functional Vehicle (MFV)

To accommodate the transportation and frequent need for commuting inside the Aynah, private cars are not allowed, and a new kind of universal vehicle is called for—the Multi-functional Vehicle(MFV)—which is used for the every day transportation on the roads and through the elevators to everywhere the residents want to go. The MFV is powered by magnetic force caused by electricity flowing on its bottom.

Each MFV consists of two main parts, power device and functional parts. Functional parts can include parts for human transportation, cargo transportation, human accommodation, internal construction and so on. Residents can choose to combine the power devices with functional parts to create their own vehicles due to their demands.

It is designed like this mainly to reduce the cost, simplify replacement and mending process and meet the increasing demands from the residents.

3.3 Construction Machinery

3.3.1 Internal Construction— Hephaestus

We suppose to use 3D Concreting Machine to build inner construction like buildings, public facilities and so on. In order to maximize the practicability of these machines, we designed modular technology to realize complicated structure efficiently. The main module is shown in figure.

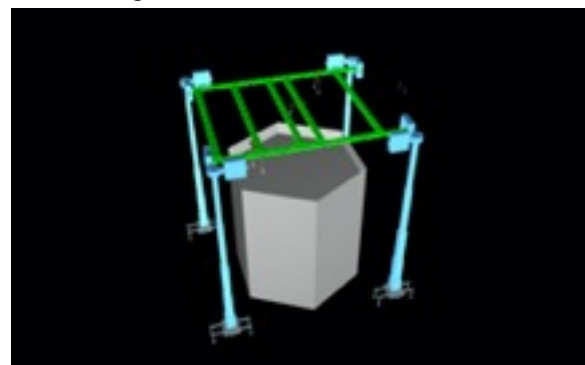


Figure 3.3.1-1 Hephaestus

3.3.1.1 Concreting printer

Starting the construction, structure module controlled by programs fixes the stills and compositions on construction area. With the use of fast concreting technology, this printer module has ability to accurately pour high-quality composition to specific position in buildings' structure. It also can draw tiny structure step by step by the sequence the material was solidified.

3.3.1.2 Modular design

Modular machine can easily adapt any types of buildings. The main module can not only lift the materials but also link itself to other modules' joints which allow it to build an enormous framework for printer to pour the composition. The example is shown in picture.

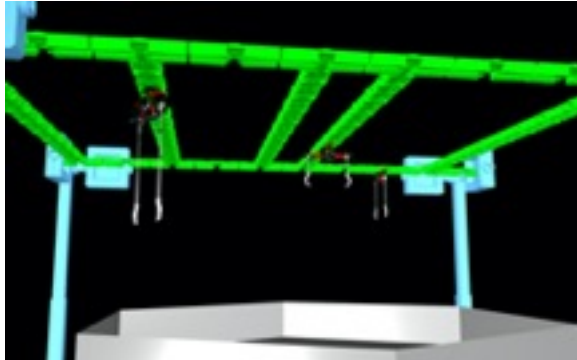


Figure 3.3.1-1 Hephaestus

3.3.2 External Construction—Deformo, Scopfer and Manipulator

The whole construction process uses a huge number of assemblage components, Deformoes, which are linear and can be assembled together as a 3D net frame, Scopfer, for certain construction purpose. The size of each Deformo is 3m long, 1m wide and 0.5m thick. So Deformo is capable of framing any type of Scopfer as required by construction process.

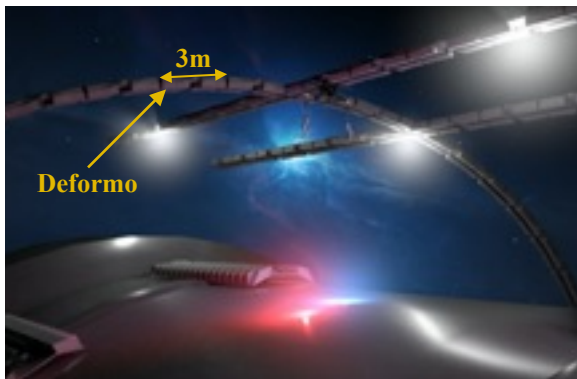


Figure 3.3.1-1 Full View of Hephaestus

The cubic or cuboid Scopfer will enclose the construction site. There are electromagnetic tracks on the both sides of each Deformo, so after Deformoes are assembled as Scopfer, its outer surface and inner surface will have track transportation systems that allow Manipulators to move around the Scopfer and do the construction. Construction Engineers can formulate and supervise the whole construction process through the controller on the Scopfer. After a construction step is finished, the Scopfer will disassemble into Deformoes which will reassemble as the next type of Scopfer for next construction step. And also this kind

of assembling technique can allow engineers formulate different track routes by combining Deformoes in different ways, in an attempt to save energy and enhance efficiency.

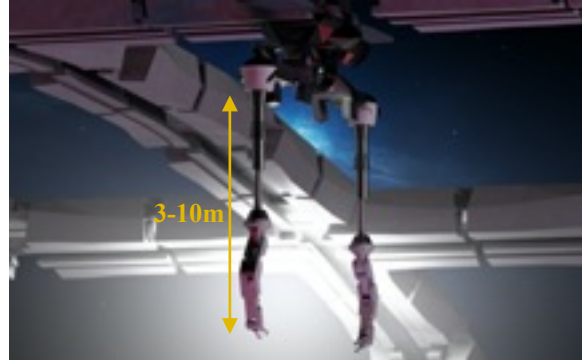


figure 3.3.2-2 Manipulator

The Manipulator has two long arms, each installed a multi-functional machine hand that can do a series of construction work including cutting, transporting and welding of the raw parts. With the ability to move on the two-dimensional tracking systems and move up and down using its machine arms, the Manipulator can construction every part of the structure from inside to outside.

3.4 Solar Panels

The showcase of a single piece of solar panel is illustrated in the figure 3.4-1. The overview of solar panels is also illustrated the figure.

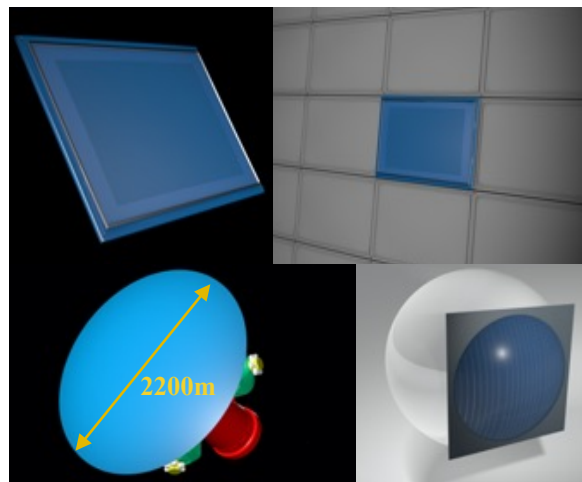


Figure 3.4-1 Partial and Full View of Solar Panel

3.5 Cargo Operation

3.5.1 Ports

3.5.1.1 Allocation

The port locates on the tips of five cylinder zones. Each port has a round of six connection channels

which are 20m long. On the top of each channel is a round platform (diameter: 30m) which has a cargo interface and a series of maintenance machines.

3.5.1.2 Shield

Docking ports with shielding provides landers and spaceships with protection. When the spacecraft lands on the port, the shield immediately covers the ship. The shield could separate the pollution of dust and damage of space rays.

3.5.1.3 Space Care and Maintenance

After covering the shields, the scanners and moveable mechanical arms start to do diagnose and maintenance for landers and spaceships. The maintenance system is compatible to most range of spacecraft models and engineers can also import the parameter manually.

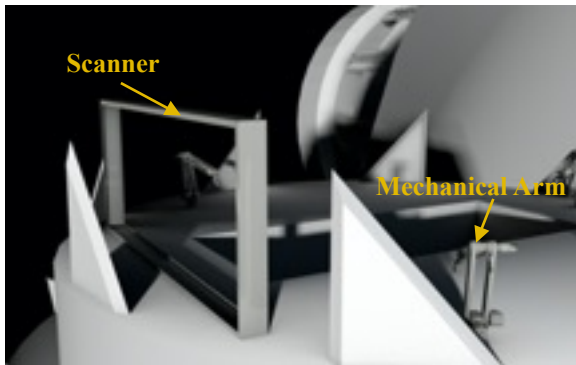


Figure 3.5.1-1 Port

3.5.2 Lander—Manticore

Lander Manticore is responsible for the transporting of reardonium and other construction materials between ports on Aynah and mercury habitat. Manticore has solar panels in order to generate electricity. Manticore provides long-time bedding and food for the crews. Manticore is 45 meters long, 25 meters wide for the widest place, and 13 meters high. Each lander could have 16 passengers on aboard but it can navigate and shuttle to and fro automatically without operation. The internal jigs will get the components loading and unloading from the Manticore and each Manticore only has space for one type-a container or 18 type-b containers.

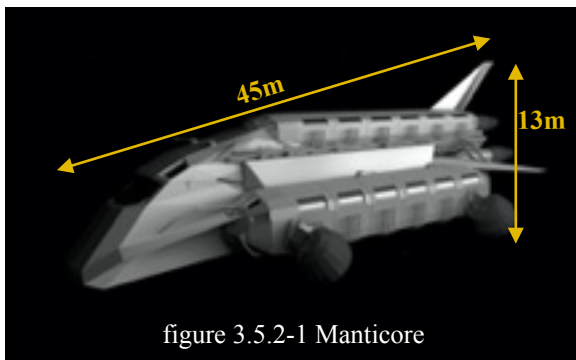


figure 3.5.2-1 Manticore

3.5.3 Cargo Transportation

3.5.3.1 Standard Containers

All reardonium parts are packaged in standard containers with two sizes. Size of Type A is 35×15×10m which have two moveable shelves and all disassembled sides. Type B is much smaller with 10×5×5m size to package some necessities and samples of reardonium.

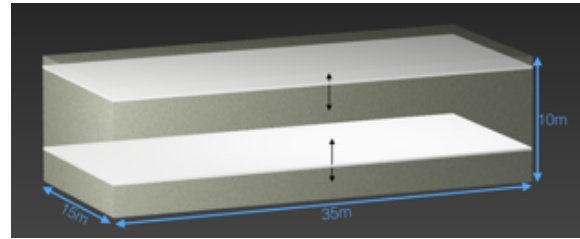


Figure 3.5.3-1 Container Type-A

3.5.3.2 Packaging

After objects are transported by elevators to packing and storing centers, several ways are employed to load and unload them to containers. Firstly, advanced mechanical arms with sucking plates will load and unload cured Reardonium from containers. Secondly, robot Drone, (see details in 5.1 robot system) can load and unload smaller packages like daily necessities. Lastly, all people and cargoes will go through airlock to reducing dust pollution. (see details in 4.3.2)

3.5.3.3 Transportation between Ports and Manufacturing

The elevators are the main parts for cargo transportation. Under the craft opens a hole, enabling the drop of cargos. Then, the cargos are transported by elevator for containers and people can also go to elevators on conveyors underground. The figure 3.5.3-2 is the side view of this cargo transportation system.

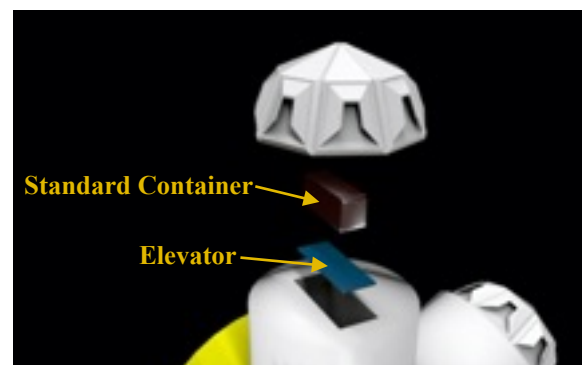


Figure 3.5.3-2 Cargo Transportation

3.5.3.4 Export

Smaller spaceships like Manticore could land on the ports and load the cargo the same way. Larger spaceships (larger than 50×30×15m) have to stop near the space settlement. Manticores is responsible for the necessity and cargo transportation between large spaceships and settlements.



4.0 HUMAN FACTORS AND SAFETY

4.0 HUMAN FACTORS AND SAFETY

Providing our clients with comfortable experience has always and will always be one of our most important goals. Within the scope of security, our design of communities, transportation systems and housings will be accordant to the standard of developed countries and maximize users' convenience.

In order to satisfy the need of natural view from developed country citizens, when designing Aynah, we specially provide a special windows for residents to enjoy the scene of Mercury. Sixteen other oval windows provide views of Mercury (see details in 2.0.2) in recreation area during daytime.

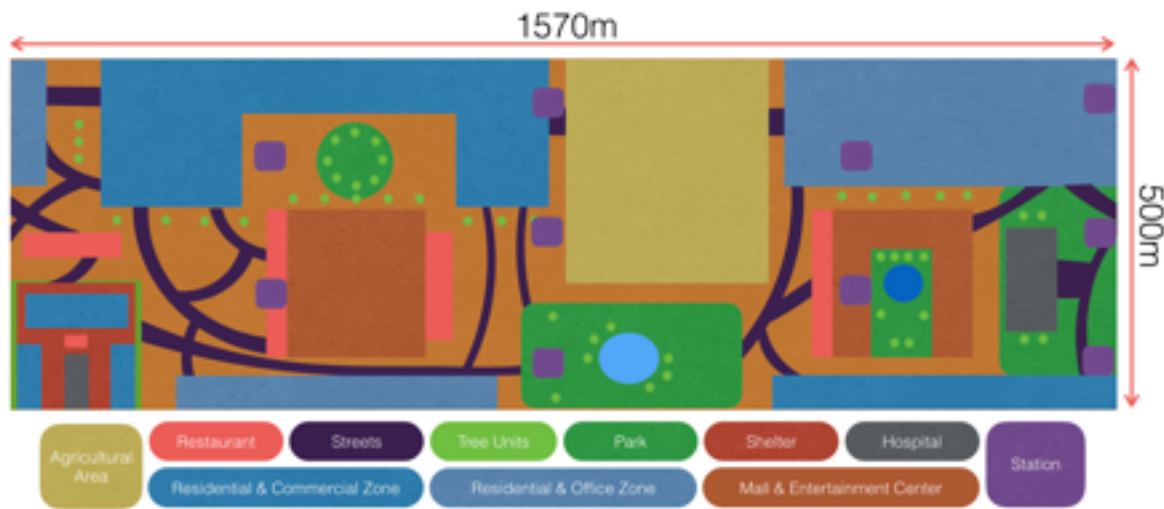


Figure 4.1-1 Layout of Community

4.1 Community Design

4.1.1 Community Allocations

The residential area will be divided into 4 identical districts. Each of the four districts are of circular shape with a radius of 175m. Located on one side of every district is an agricultural area which provides food for residents.

For entertainment, each district will have a nearby mall where residents shop, eat, read, play electronic games, watch movies and do grocery shopping and so on. The restaurants both within the center mall and in other places provide residents with a large variety of foods ranging from Italian food, to Chinese food to fast food. A four-floor entertainment center of every district will be also near residence buildings. One side of the center is the music and theatre hall, at the other side there will be a gym, a playground, and an athlete center that allows residents to play basketball, tennis, ping-pong and other sports for the first two floors, and on the third and fourth floor is the library. There are three parks with lakes or fountains within the residential area in each district. Also, each apartment will be fully furnished, and residents can directly move in after purchasing. Moreover, residents could have long line of sight in parks, where they experience similar environment to earth.

Each district will be equipped with a hospital that at least allows 50 patients to stay and has 2 ambulances, 2 pharmacies that are close to residence buildings. When there are emergencies, such as diseases that are not under control and patients would need to be isolated, there is one shelter for the patients that provides normal living facilities and a hospital of its own. The Shelter area is not only isolated by gates and distance, a ring of trees is planted for double insurance.

4.1.2 Major Consumables

Major consumables can be easily bought in grocery stores except that water and electricity are provided in apartments, and pharmaceuticals are provided in pharmacies. Major consumables are listed as following.

Table 4.1.2 Major Consumables

Consumable	Amount	Source
Food	10,390,128kg/year	Produced in settlement
Water	45,460,200kg/year	Recycled and imported
Hygiene Products	500,800kg/year	Imported
Pharmaceuticals	3,1500kg/year	Imported

Consumable	Amount	Source
Paper	101,200kg/year	Produced in settlement
Clothing	14,000articles/year	Recycled and imported
Shoes	14,000pair/year	Recycled and imported
Electronics	32,500items/year	Imported
Housing Items	72,500items/year	Imported

4.2 Residences

Aynah provides comfortable and spacious living conditions for all residents, including single, married and families.

4.2.1 Demographics Statistics

Table 4.2.1-1 Demographics Statistics

		Aimed	Housed
Single adults		4900	5400
Married adults	Couples	7340	7800
	Parents	1060	1200
	Subtotal	8400	9000
Children	Single Child	400	450
	One sibling	180	200
	Two+ siblings	120	150
	Subtotal	700	800

4.2.2 Types of Houses

There are 4 kinds of house design and floor plans provided for single adults, married adults and family with children named Spes, Amicitia, Fidus and Libertus, these are Latin words for four good qualities that human kind cherish. Each kind of resident are assigned to the houses that are designed for them, but a few may choose to pay for larger houses. Also, there are buildings left of each type for temporary residents. See details in following.

Table 4.2.2-1 Demographics Distribution

Number of People	Number of people housed			
	Children	Married Adults	Single Adults	Total
3	450	900	/	1350
4	200	200	/	400

Number of People		Number of people housed			
		Children	Married Adults	Single Adults	Total
Family House	5+	150	100	/	250
	Sub-total	800	1200	/	2000
Married house	2	/	7800	/	7800
Single house	1	/	/	5400	5400
Total		800	900	5400	15200

Table 4.2.2-2 Type of Houses

Style		Spes Homes	Amicitia Homes	Fidus Homes	Libertus Homes
		4+p	3p	2p	1p
Floor	houses per floor	1	1	4	18
	per building	3	12	9	7
Quantity	houses per building	2	11	32	108
	house	150	450	3,900	5,400
	building	75	41	122	50
Internal area (sq feet)	per house	178.4	157	122.6	83.6
	per building	535.2	1417.2	1,103.7	9029.9
	total	40,410	60,320	134,648	451,495
Dimension	Per house (m)	hexagonal		rectangle	
		side 8.4 height 3.5	side 7.8 height 3.5	12.34 ×10.2 ×3.5	9.3 ×9.3 ×3.5
	Building surface area (sq feet)	712	2,123	3,839	10,191

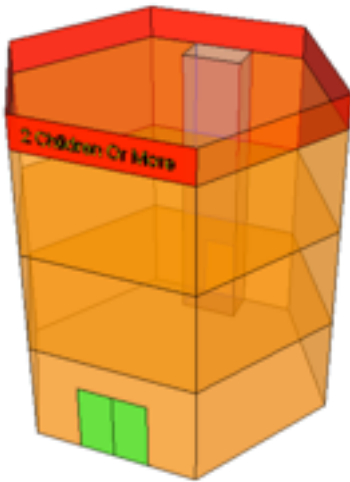
4.2.2.1 Spes Homes

Spes means hope; the Spes homes are named to remind residents never to lose hope, wherever they are.

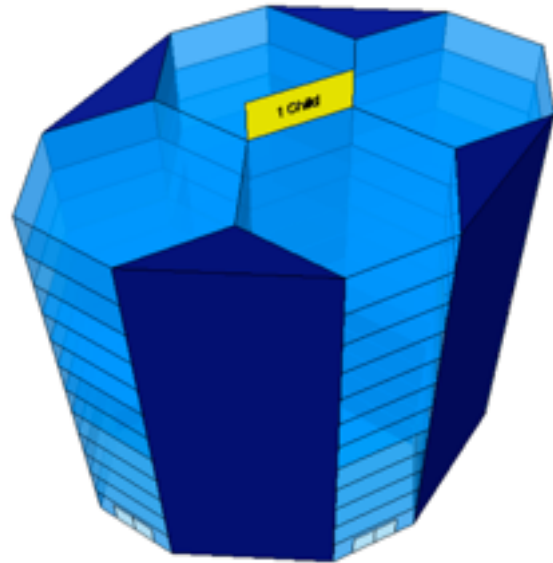
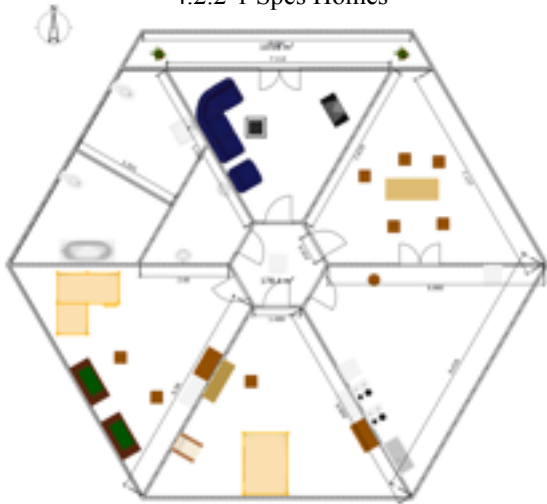
The Spes homes are designed for families with more than one child, or one-child families who could afford the price. Each building is designed for two families to live in. Each has three floors with shops down at the ground floor. For security, the elevators are at the out side of the house, so that the residents would not need to get in the shops to return home. Each of these hexagonal buildings is made totally of one-way glass, with a garden at the top. Therefore, the chil-

dren would feel more comfortable playing with other children and not just within their own families. The one-way glass can change its color according to the amount of light that reaches the glass, providing the residents with a clear and comfortable view outside, while they will not be seen by the people on the streets. At night time, the glass will turn automatically into darker color, to provide better sleep; in the morning, the glass will let more light, along with the soft music that the alarm clock provides, the people could be waked normally and gently.

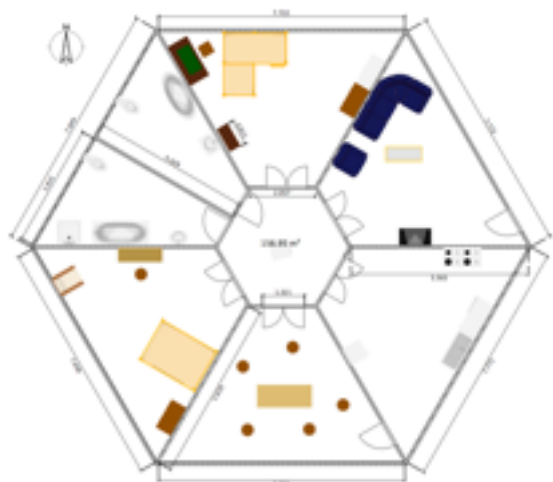
fit for one family to live in, thus also creating a happy community for kids. The mansions will be able to joint together according to the need of companies' offices at the ground floor. However, no more than 4 buildings are allowed to be joint together to make sure enough light is provided to each family. For security, each mansions has its own triangle shaped elevator at the out side. The exterior of Amicitia homes are made totally out of one way glass with the same functions as the Spes homes. (See details in 4.2.2.1)



4.2.2-1 Spes Homes



4.2.2-2 Amicitia Homes



4.2.2.2 Amicitia Homes

Amicitia represents friendship and love; the Amicitia homes are named in the hopes that all residents could be friendly to each other, thus building a loving community.

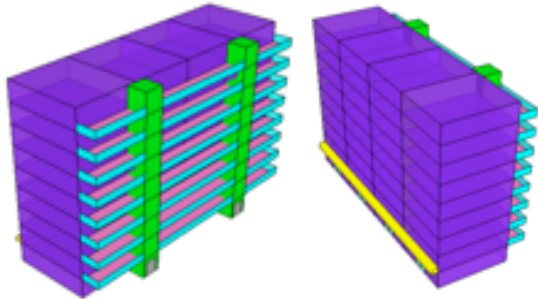
The Amicitia homes are 12 floor mansions with offices at the bottoms and gardens at the top. These are designed for single-child families and couples who can afford the price. These mansions are also hexagonal. Each floor of the building is

4.2.2.3 Fidus Homes

Fidus represents faithfulness and loyalty. The Fidus homes are named to remind the residents that faithfulness is a key to build mutual trust and long lasting love within the society.

The Fidus homes are designed for couples with no children, and also singles who can afford the price. The Fidus house are normal 9 floor apartments made

of stone and glass, with a little veranda garden on one side of the house. The first floor of the Fidus homes are for shops. The elevator is at the outside of the building to maintain security.

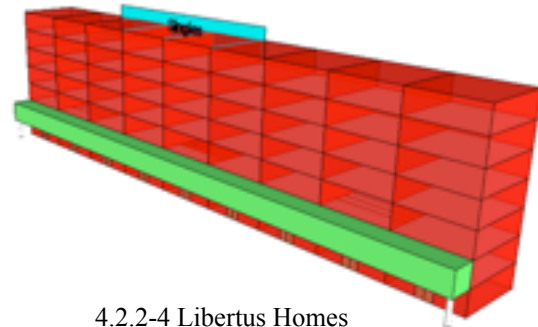


4.2.2-3 Fidus Homes



4.2.2.4 Libertus Homes

Libertus means freedom. The Libertus homes are named to tell the residents to always keep have freedom in their minds and let their imagination soar in the universe.



4.2.2-4 Libertus Homes

The Libertus homes are designed for singles. The inspiration of the Libertus homes comes from houses in Hong Kong. The first floor can be shops or offices. They are nine 7 floor houses jointed together to form one building on a street with a aisle at the second floor. Thus , the first floor can form a commercial street. The residents would need to walk to the second floor from stairs on the one side of the street and after they walked to their homes, they will be able to reach their apartments using elevators. According to every resident's needs, there will be all-women buildings, all-men buildings and mixed buildings. All the

Table 4.2-1 Sources and Quantity of Furniture and Appliances

Item	Sorces		Quantity					Total
			Libertus	Fidus	Amicitia	Spes	office(total)	
Chairs	Plastic	Manufactured	3	3	8	8	20000	85300
Sofas	Fabric	Imported	1	1	1	1	10000	60725
Tables	Plastic	Manufactured	3	3	4	5	10000	79725
beddings	Fabric	Imported	1	1	2	3	/	21525
Television	Glass, Plastic	Manufactured	1	1	1	1	/	20725
Toilets	Ceramics	Manufactured	1	1	2	2	500	21850
Showers	Ceramics	Manufactured	1	1	2	2	/	21350
Sinks	Ceramics	Manufactured	2	2	3	3	500	42575
Cabinets	Plastic	Manufactured	2	2	5	5	80000	115225
Stove	Iron	Manufactured	1	1	1	1	/	20725
Bookcases	Plastic	Manufactured	1	1	1	1	/	20725
Wardrobes	Plastic	Manufactured	1	1	2	2	/	21350
Armchair	Fabric	Imorted	1	1	2	2	/	21350
Bed	Plastic	Manufactured	1	1	2	3	/	21525

beds will be double beds to provide residents a comfortable sleep and happy single life.

4.2.2-5 Libertus Homes



4.2.3 Quantity and Sources of Furniture and Appliance

In concern that the gravity is 0.5g, all the furnitures' corners will be round corners and there will be suction plates on all the feet of the furniture to keep them in place.

4.3 Spacesuit

4.3.1 The design of spacesuit

In order for staff to work in the high-radioactive and extreme high-temperature space near the settlement, spacesuits can resist high temperature and cosmic ray and is able to create an independent living condition.

4.3.1.1 the Helmet of Spacesuit

The mask is made of gold, which can protect astronauts from extremely strong sun light and cosmic rays. Also, the helmet has project device inside which can clearly shows every aspects of the condition of the spacesuit and also the communication information.

4.3.1.2 The suit and gloves of the spacesuit

The material of both is carbon fibre, which is strong, flexible and can bear a broader range of temperature difference. There are knuckles structure and rubber lines imitating human's knuckles and loops on fingers part of the gloves. The lines can increase the friction in case of the slipping when astronaut is grasping things. There are connectors on the surface of the back and waist of the spacesuit which are used for connect the nylon cord. There is an air circulatory device for 6 hours' breath in the back of the spacesuit, which contains a compressed oxygen cylinder and an absorption device full of lithium hydroxide

that absorb carbon dioxide, and also emergent compressed oxygen cylinder contained oxygen for 0.5 hours' breath in the waist of the spacesuit. The waist part of the spacesuit has a device box which contains tools for working out in the space.

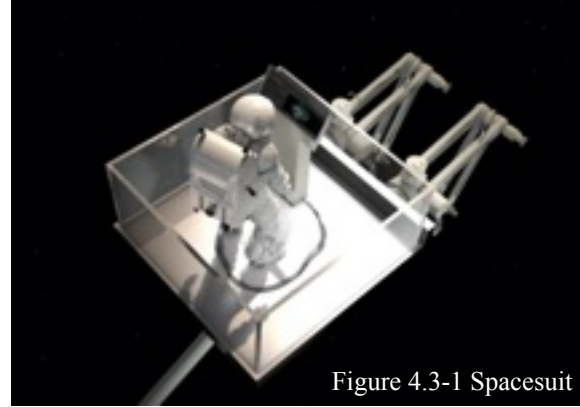


Figure 4.3-1 Spacesuit

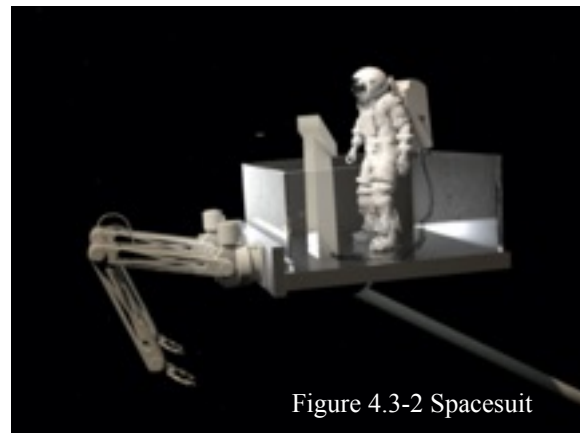


Figure 4.3-2 Spacesuit

4.3.1.3 Other Components of Spacesuit

Boot: The material of the boots is the same as the suit. There are fixators on the bottom used for anchoring the boots on foot restraint of the settlement or basket.

Jetpack: Each jetpack has six nozzles that can inject air to all directions and thus propel the spacesuit. Each jetpack has four connectors that can connect the backpack to the back of spacesuit. Each jetpack weighs 20 kilograms and can propels astronaut to move in a distance of 10 kilometers. The fuel in the jetpack can be filled up after used up.

Rope: The rope used to connect astronauts to settlement is Carbon Fibre Rope.

Basket: There is foot restraint on the inner bottom of basket used for fix the boots. The basket connects a machine arm fixed on the hull of Aynah and also on the spaceships to provide a standing platform for astronauts. The bottom surface of the basket has the size of 3 meters long and 3 meters wide. The height of the handrails is 1 meter.

4.3.2 Airlock and Space Suite Storage

The spacesuits are placed in the wardrobe on the inner walls of the airlocks.

4.3.2.1 Design of Airlocks

In order for astronauts to go outside the pressurized space of Aynah quickly in case of emergencies or in order to work, air-locks are able to pressurize and unpressurize quickly.

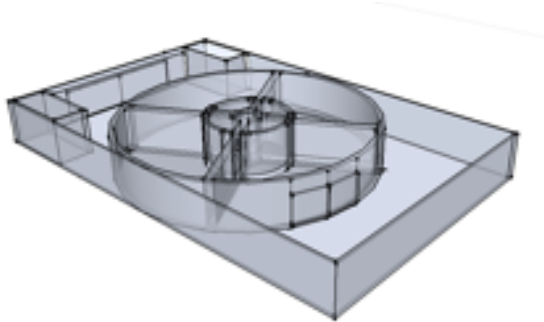


Figure 4.3.2-1 Airlock

4.3.2.2 Procedure

Three astronauts at most will enter the first pressurized airlock and dress spacesuits on. After a complete check of the spacesuit, they will enter the second airlock. Then the second airlock begins to reduce pressure for 10 minutes until it becomes vacuum. Finally the door will open and astronauts will go out. Every person's health going out from the airlock system would have to check in, they would have a tracking device clip attached to their front arms to make sure that they will not be lost forever in space.

4.4 Children

In order to guarantee children's normal growth and health, there is a 1.1g zone arranged for children. where children can experience different gravity living area. The blue ring in the figure 4.4-1 indicates the 1.1 g zone with 20m wide.

4.4.1 1.1g Zone

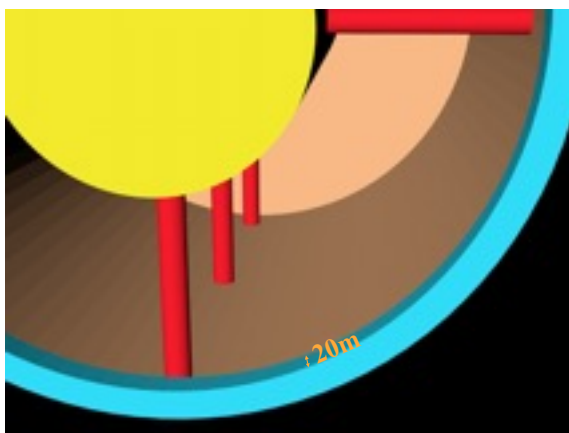


Figure 4.4-1 1.1g Zone

All the children will be required to stay in this zone for at least three hours per day. They can be assigned

to different sports. There, they can choose from a wide variety of sports, such as volleyball, basketball and badminton. Children are required to take at least 1.5 hour of sports. After that, students can go to other extracurriculars in the arts or music department. In the arts department, students can draw, paint or sculpture, where as at the music department, students can learn to play various instruments, such as piano, guitar and violin.

4.4.2 Studying

There will not be schools for children on Aynah, instead, all the children will be homeschooled using a computer. Students under 12 grades will have compulsory classes (literature, art, math, physics, chemistry, space, sociology and so on). Also, they can study in the library located at the entertainment centre.

4.5 Safety Protection

4.5.1 Surface Vehicles for Human Inspection

Cruiser is Mercury surface vehicle for humans to inspect Mercury during both day and night. As for regular patrol missions, our design of Cruiser will be enough for the guarantee of human safety.



4.5.1-1 Cruiser

4.5.1.1 External Design

Because the man-controlled vehicles are used to examine and maintain the mining robots regularly, the shell of the cart is made of Reardonium. This can protect the engineers inside from heat and radiation; also, the Cruiser would be much lighter. Two robot arms are attached to the headstock of the Cruiser, to complete heavy work that space suits cannot bear, such as maintaining the mining machines, or collecting specimens. The design of base plate used the independent suspension system, and can rise and fall, considering both speed and comfort.

4.5.1.2 Power Supply

The power of the Cruisers will be provided by the battery attached on the car; With every recharge, the Cruiser can cover 500 kilometers, with a maximum

speed of 100km per hour. Since the examination places of Cruiser are also the working areas of the Hammer (recounted in section 3.5), the headquarters on Mercury will command Hammer to park on the path of the Cruiser, and the accumulators on Hammers will automatically wirelessly charge the Cruiser in 30 minutes.

4.5.1.3 Internal Design

The Cruisers will be installed with oxygen synthesis machines and temperature-control devices. The Cruiser is divided into two parts. The front part is the cab, within hand operations and examinations can be proceeded. The back part of the Cruiser is the lobby; since the Cruiser is auto-driven or charging, the passengers on board can entertain themselves with the devices on board and take meals.

4.5.1.4 Automation Features

The vehicle-mounted GPS would plan the best route before departure. The Cruiser can drive automatically to decrease the amount of the labor. The vehicle antennae can contact with the base, and thus the emergency situations can be solved.

4.5.1.5 Safety Features

4.5.1.5.1 Nanometer Self-repair Mechanism

Each surface vehicle will have a nanometer self-repair system in its shell. Due to the surface of Mercury is not flat enough, accidental damage to the vehicle surface is inevitable. As soon as such damage is detected, nanometer robots will fix it in a short time, guaranteeing the absolute protection for human inside from space radiation and vacuum.

4.5.1.5.2 Backup Oxygen System

Each Land cruiser will contain 2 backup Oxygen systems. If the vehicle encounters serious damage that the air leaks out, just after the nanometer robots fix the shell, the backup air will be released to maintain the inner air pressure and oxygen density.

4.5.1.5.3 Backup space suits.

The basic features of these suits will be the same as those mentioned in 4.3. Additional safety features will be described below in 4.5.2.

4.5.2 Space Suits for detailed examination

Space suits are specifically designed for human missions under vacuum or conditions such as 0.5 g with 20 psi. Regular designing features of space suits has been specified in 4.3; additional safety guarantee features will be reemphasized here.

4.5.2.1 Nanometer Self-repair mechanism

Each space suit will have a nanometer self-repair system in its shell. Due to the surface of Mercury is not flat enough, accidental damage to space suits is inevitable. As soon as such damage is detected, nanometer robots will fix it in a short time, guaran-

teeing the absolute protection for human inside from space radiation and vacuum.

4.5.2.2 Backup Oxygen System

Each space suit will contain 2 backup Oxygen systems. If the space suit encounters serious damage that the air leaks out, just after the nanometer robots fix the shell, the backup air will be released to maintain the inner air pressure and oxygen density.

4.5.2.3 Double Protection Layer

Each space suit will contain two protection layers in order to keep humans from space radiation. However, if the first layer is damaged, the second layer will be immediately activated. As soon as the first layer is fixed, the first layer will continue to work while the second will be deactivated. However, if the first layer is not activated, the first layer will be immediately abandoned and the second layer will take the place of the first.

4.5.2.4 Life Detection & navigation system

The living conditions will be instantaneously monitored by the central base. If any confirmed abnormal signals appear, the central base will immediately send out rescue vehicles. The exact location of the astronaut will also be instantaneously transmitted to the central base. As a result, the rescue space ship can find the astronaut in quite a short time.

4.5.3 Safety Management and Rules

Each part of the settlement will have different safety rules in order to protect humans in maximum. Safety rules must be obeyed by either residents or staff except under unexpected emergencies. Any one discovered to break such rules will be regarded as a potential threat to the settlement; as a result, such people will be required to leave the settlement for certain period of time according to the rules they break. Under more severe circumstances, they will be required to forever leave the settlement.

Any kind of admissions mentioned in the following rules will be and will only be delivered by APD. Any attempts to produce fake admissions will be regarded as a top-level threat to the settlement.

Anyone in the settlement is able to apply for any kind of admissions mentioned in the following rules.

4.5.3.1 Safety Management Overall Description

In addition, anyone inside the settlement will be assigned a classification. There are three kinds of classification. The first classification, only belonging to APD staff and special guests, will have access to any part of the settlement. The second classification, only belonging to loyalty-level-one residents, will only allow access to fewer districts. The third classification will be given regular visitors who only have access to certain sightseeing areas as well as residential areas.

4.5.3.2 Agriculture Area Safety Rules

- Before entering the area, anyone has to put on a special protection suit. Detailed designing features and parameters will be specified in 3.2.3.
- Due the high density of CO₂, anyone entering this area will be required to wear an oxygen mask to maintain the regular oxygen input in residential areas.
- The whole area will be under 24-7 no-blind-area surveillance.
- Without special permission granted by the APD staff, anyone intentionally affecting the regular operation of the area (including plants cultivation, irrigation and maintenance) will be regarded as a potential threat to the settlement.

4.5.3.3 Residential Area Safety Rules

- Despite members regarded as potential threats to the settlement, any one will have access to the residential area.
- The whole area will be under 24-7 surveillance. Specifically, only public areas will be monitored; however, private areas such individual houses and departments will be under zero surveillance, ensuring the absolute privacy protection in the settlement.
- Each house will have direct access to APD staff so that any potential threat detected can be directly reported to APD staff.
- Without special permission granted by APD staff, anyone intentionally affecting the regular operation of the area (including entertainment, living

and exercising of residents) will be regarded as a potential threat to the settlement.

4.5.3.4 Industrial Area Safety Rules

- Only APD staff and those who possess admissions granted by APD members have access to this area.
- Anyone who tries to break into the area will be regarded as a potential threat to the settlement.
- The area is differentiated into three areas, which are mentioned in 2.3. As a result, admission to each part of the area will also be required.
- Anyone who tries to break into any part of the area will be regarded as a potential threat to the settlement.
- Even with special admission, anyone who interferes, or tries to interfere, the regular operation of the area will be regarded as a potential threat to the settlement.

4.5.3.5 Safety Rules for Space Missions

- Any mission into the space must be granted special admission by APD.
- Anyone attending a space mission must wear the only specially designed space suit designed for Aynah, which is mentioned in 4.3 as well as in 4.5.2.
- Despite in Mercury-Surface missions, there must be a steel rope connecting the astronaut and their space ships or Aynah itself.
- Any action potentially threatening astronauts' lives (including cutting off the connecting steel rope; harming space suits; deviating from default route when driving space ships) will be regarded as a top-level to the space settlement.



5.0 AUTOMATION DESIGN AND SERVICES

5.0 AUTOMATION DESIGN AND SERVICES

Robots is a major part of automation of the space settlement. From construction of the settlement to the maintenance of it, robots play a vital role throughout all processes.

Megatron is responsible for delivery of raw materials. Spider shaped Arachne I &II, eagle shaped Hermes, and ant shaped nano-sized robot Demeter take part in repairing and maintenance of interior and exterior zones of the settlement. They are directed by relevant systems to do their jobs. In addition, during extreme situation, people survive from possible dangers by receiving help from Hades.

Table 5.0.1-1 Robot Quantity

Maintain					Transportation	Construction			
Arachne I	Arachne II	Hermes	Hades	Demeter	Megatron	Hoder	Drone	Hephaestus	Arhat
200	300	500	1000	2meters	100	100	200	3	200

Table 5.0.1-2 Quantity of Network Equipments

Sever	Base Station	Individual Network	Computer
15	24	15000	15000

5.1 Automation of Construction Processes

5.1.1 External Construction

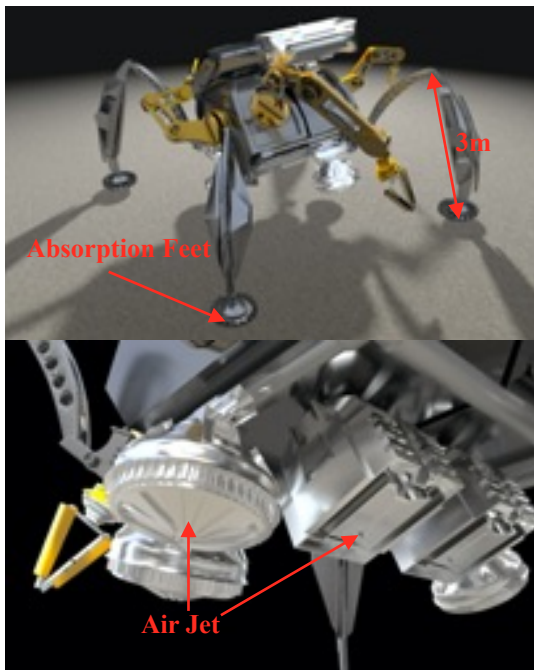


Figure 5.1.1-1 Hoder

In order for the construction process to function smoothly in zero g environment, the cell body will be constructed first, providing trajectories for robots to hold on to. The external skeleton will be constructed using Hephaestus (the 3D printer, see details in 3.3.1). Hoder, a robot made of 8 air jets, 4 absorption

feet, 2 material boxes each with size of 5 meters long, 5 meters wide, and 5 meters high, can transport the raw materials that Hephaestus needed. During the construction process, human will be in the industrial area to monitor these machines with the help of the Damage Detecting and Maintaining System (DDMS), designing blueprints for Hephaestus, sending signals to Hoder when raw materials are needed, and managing these robots when emergency takes place.

5.1.2 Internal Construction

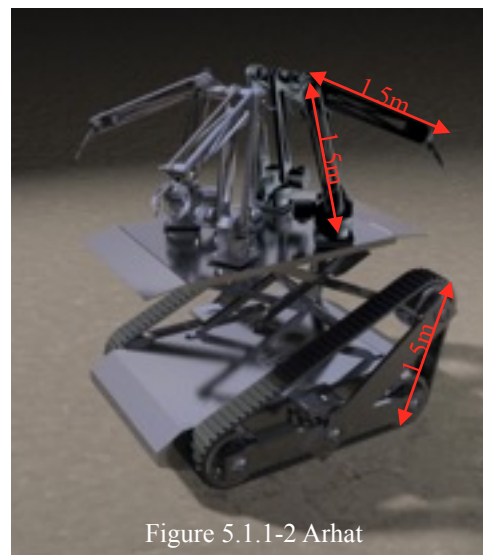


Figure 5.1.1-2 Arhat

Arhat can be used to construct the internal part. Using its artificial intelligence, Arhat is able to receive assignments send by human and then start to construct automatically in the industrial area, using its four stretchable arms with different function. After the construction is complete, Arhat can send them to wherever the item is needed.



When Arhat's power is less than 20 percent, it can detect the nearest power station to recharge itself and leave the power station when its battery is fully charged.

5.2 Automation Facilities

Table 5.2-1 System List

Systems	Sub-Systems	Types
The Central Disaster Detecting, Early Warning and Commanding Headquarter (CDDEC)	DDMS—The Damage Detecting and Maintaining System	Maintenance and Repairing
	SSDS—The Sealing Screen Door System	Safety Function
	MC—The Mediation Centre	Safety Function
	SEWES—The Space Extreme Weather Emergency System	Safety Function
	SOCS—The Space Orbit Control System	Safety Function
	ICGS—The Internet and Communication Guarantee System	Safety Function
Contingency Systems	TMS—Transportation Maintenance System	Safety Function
	Back-up System—Alignment-Based Approach for Durable Data Storage into Living Organisms	Back-up System
	Self-Inspecting, Repairing, and Announcing Software	Contingency Plan of Automation Systems
	Space Station Shelters	Contingency Plan of human safety
	The Escape Pods	Contingency Plan of human safety
	The Anti-Hacking System	Contingency Plan of communication and internet system
	The Air-Pressure Control Center	Contingency Plan of air pressure
	Material Safety Check and Track System	Contingency Plan of human safety
The Fire-Alarm System	Contingency Plan of human safety	
Robotics Centers (RC)		Location of Robots
The Aynah Police Department (APD)		Safety of human
The Space Settlement Identity and Access Control System (SIACS)		Safety of delicate parts of Aynah and automation system

5.2.1 CDDEC

The Central Disaster Detecting, Early-Warning and Commanding Headquarter (CDDEC) contains: the Damage Detecting and Maintaining System (DDMS), the Sealing Screen Door System (SSDS), the Space Extreme Weather Emergency System (SEWES), the Space Orbit Control System (SOCS), the Internet & Communication Guarantee system (ICGS, within the CDDEC) and the Mediation Center (MC, near the CDDEC).

Since there are four dendrites, all of the sub-systems of CDDEC possess four sub-computers. Such design could significantly reduce the damage and venture that Aynah possibly meet.

5.2.1.1 The Damage Detecting and Maintaining System (DDMS)

This system is one part of the CDDEC, and is made up of the Detecting and the Maintaining System.

It is the earliest system to be set up at early stage of construction. Therefore, it is able to inspect all robots and 3D printer responsible for constructing Aynah. Humans can use MR(Mixed Reality) to see through any cameras equipped by robots. If any failure happens, the system would automatically detect and calculate the level of the damage, and send the information to humans. So humans are able to handle the situation by commanding robots or even deal with it themselves if needed.

When the construction is finished, the system would be responsible for detecting and repairing damages Aynah suffers from. If damage appears, the Detecting system would first search for the damage and report the size, location and the emergency level of the damage; the information would be sent to the maintaining system, and auto-maintaining robots controlled by the system would fix the problems. If the damage is too complicated, there will also be human-operated robots to fix the problems.

5.2.1.2 The Sealing Screen Door System (SSDS)

This system lies in the core of the CDDEC. If the damage is too big to fix, and the interior is directly connected to outer space, this system would shut the screen doors automatically, and they will open after the Arachne fixed the damage. If there are humans trapped in the area, the system would first scan for the survivors, and send the report to the CDDEC. Afterwards, the inner damage detecting center would automatically or manually send a rescue team to help the trapped. The screen doors would be shut shortly afterwards.

5.2.1.3 The Mediation Centre (MC)

The mediation center lies near the CDDEC, and is also safe. It has professional doctors and materials, accepting and treating the injured anytime.

5.2.1.4 The Space Extreme Weather Emergency System (SEWES)

This system lies within the CDDEC, mainly to research, detect and warn about the extreme weathers of outer space. It will give precise information about the extreme

weathers, such as meteorite showers or solar storms that can be damaging for the space settlement beforehand.

When it detects the upcoming solar flare, it will send the information to CDDEC and ICGS(5.2.1.6).

5.2.1.5 The Space Orbit Control System(SOCS)

This system lies within the CDDEC. There are chances that the space settlement would meet dangers that the outer shell cannot behold (eg. mega-meteorite collisions). When these situations occur, the space settlement would need to change its orbit. This can be achieved by the SOCS using the information sent from the SEWES.

5.2.1.6 ICGS

The Internet and Communication Guarantee System (ICGS) lies within the CDDEC. If the space settlement meets with strong solar winds or other similar elements, the Internet and communication system of the space station might be damaged severely. If the SEWES successfully detects the solar winds, this system would demand the residents inside the station to shut off the communication means that might be damaged, and the residents will also be informed when they will be able to use these means again.

If the solar winds were not successfully detected, this system would try to find ways to communicate, and the information would be sent to the CDDEC. This situation would continue until the whole communication system is fixed by robots. In addition, it will command all 12 satellites to seal itself into their shells made of Reardonium to overcome the extreme weather.

5.2.1.7 Transportation Maintenance System(TMS)

Because of the complexity nature of the process of manufacturing Reardonium, Aynah need a system to inspect all the robots and equipment taken part in the transportation of Reardonium to guarantee the safety and reliability of every single process of transportation.

The system is consisted of inspection system on Aynah and on Mercury. The one on Aynah is a part of Material Safety Check and Track System. The other on Mercury, which is much more important, is accomplished by a series of satellites launched. The system on Mercury consists of 12 satellites orbiting Mercury. Similar to GPS on earth, the Mercury Transportation System is able to locate any transportation robots or equipment and see if they meet any problems under any situation.

The robots and equipment include HAMMERS, being responsible for excavating ores, Manticore-II, the space cargo ship, all of the conveyers on Aynah, and Megatron-II, used to move Reardonium to curing center. The inspection towards robots on Mercury is accomplished by cameras on robots and satellites launched.

5.2.1.8 Location of CDDEC

The CDDEC lies within one of the safest places in the Space settlement. On regular occasions, the CDDEC will not be (or can be slightly) damaged. If some uncontrollable force destroyed the CDDEC so

severely from the outside that it cannot be repaired, the space station would be scrapped, and could be abandoned. Therefore, it is nearly impossible to thoroughly destroy CDDEC by using external forces. If it is, however, survivors would be transported into a temporary safe space outside the space settlement, later transported to somewhere else, and the space settlement would be abandoned.

5.2.2 Contingency Plan

Under some specific dangerous circumstances, the Central Disaster Detecting, Early-Warning and Commanding Headquarter would be damaged by a great number of human factors or would meet some system failure. Therefore, it is necessary to establish a contingency plan to repair the damage.

5.2.2.1 Back-up System

With alignment-based approach for durable data storage into living organisms, the back-up system is an isolated automatic system in four space shelters, where the safety of it could be guaranteed.

The system is accomplished by a new technology called Alignment-Based Approach for Durable Data Storage into Living Organisms. Duplicated data encoded by different oligonucleotide sequences was inserted redundantly into multiple loci of the *Bacillus subtilis* genome. Multiple alignment of the bit data sequences decoded by *B. subtilis* genome sequences enabled the retrieval of stable and compact data without the need for template DNA, parity checks, or error-correcting algorithms. The DNA containing all back-up systems would be replicated and be placed in all four dendrites. Thus, if one of them meet major failure, all the information could be saved.

Although the cost is relatively high now in 2016, it would be considerably lower more than 70 years later.

5.2.2.2 Self-Inspecting, Repairing, and Announcing Software

This is a software attached to all automation systems. Every hour, it will automatically scan all the systems under its inspection and announce the situation to the human inspector. If there is any problem with automation systems, software or hardware, humans would endeavor to fix the problem by commanding robots or even go fixing mechanical problems by themselves.

5.2.2.3 Space Station Shelters

There are four major shelters in Aynah. They lie in the center of four dendrites, where the safety of the shelters could be guaranteed, because dangers usually come from the outside. When disasters happen, people can go there through self-generated elevators, whose power is supplied by the battery of themselves. Within the shelters, the safety of the people can be guaranteed. They provide enough food and water that can sustain 5000 people to live for a month.

Additionally, the inner part of all dendrites are connected, so even if one of the shelters is destroyed, peo-

ple can go to other shelters directly through the transportation system within the inner parts. The shelter and the mediation center are connected together so it would be very convenient for the injured to be cured.

5.2.2.4 The Escape Pods

The escape pods are in the inner part of all four dendrites. It is a kind of small space shuttle that can contain 100 people. When people are forced to evacuate from Aynah, they can take the pods and the pods will launch from Aynah through the inner parts.

5.2.2.5 The Anti-Hacking System

While the space station is operating, the network firewall might be attacked by the lawbreakers inside the space station or on earth. Such attack may severely damage back-up systems in Aynah. The Anti-Hacking System can pinpoint the hackers in a very small amount of time after the hacking was detected. If the attack is too violent and swift for the system to react, the technist from the Anti-Hacking System would act to repair the system.

5.2.2.6 The Air-Pressure Control Centre

Outer damage might cause decompression. If this happens, then the screen door would automatically shut off the doors, and after the relevant robots have repaired the damage, the air-pressure control center would fix the air pressure of the damaged areas. At

the same time, the air-pressure center would probe the data of the pressure and make adjustments.

5.2.2.7 Material Safety Check and Track System

Any materials that residents bring into the space station would be automatically examined and its danger level(1~10) would be determined. If the level is high(above 6), APD would be informed; if that material is legal, the system would track the material, and if emergencies happen, the APD would be informed. This system is used when tourists come in or weapons/experimental tools are transported into this system to maintain the safety of the space settlement.

5.2.2.8 The Fire-Alarm System

Because of the experiments and the productions, there are possibilities that fire accidents might happen. Like the normal fire-alarm systems, the smoke detectors would detect the smoke, then water would be sprayed from the sprinklers to put out the fire.

5.2.3 Robotics Centers (RC)

There are five robotic centers in total, lying near the outer side of four dendrites and one industrial zones. It is a place where the unused robots are placed, also where robots can be maintained. Because these centers are irrelevant with the robot-control center attached to the damage detecting system, even if the robotics centers are destroyed, the robots can still function normally.

Table 5.2-2 Robot List in Robert Center

Names	Purpose	Design
Arachne I	Emergent repair of internal and external areas of the space city	Its shape is like spider, having six feet. It is powered by electricity. The bottom of the feet exploits bio-technology, which allows spider mouse to stick to the surface of the city. Then they would move to where damages appear and stretch a bunch of mechanical arms to repair the damages. The shell of it is made of Reardonium to survive from fatal solar radiation and during solar flares.
Hermes	Repair of far side of the space city	Intellectual unmanned planes, powered by electricity. For most of the time it would repair damages that spider mouse cannot reach. It could also be manipulated by human inside the city. The number of it does not need to be too large, because the design of the space city has already allowed spider mouse to reach most of the areas. The shell of it is made of Reardonium to survive from fatal solar radiation and during solar flares.
Hades	Assisting people to escape, saving people from extreme situations, and send them to the medical center.	Sphere shape with several arms, powered by electricity. Limps can be stretched out and back. It possesses life tracking equipment, searching survived life. It could survive in the universe and take a number of oxygen masks. Under extreme situation, it can count the surviving rate of different people, and first save those who have the lowest surviving rate. Meanwhile, it can be manipulated by human to choose who to save. The shell of it is made of Reardonium to survive from fatal solar radiation and during solar flares.
Demeter	Assisting spider mouse to repair and maintain the space city, especially small and delicate damages, which spider mouse cannot go into or do not have ability to solve, such as internal damages of nuclear fission engines.	Nano machines, ants' shape. The shell of it is made of Reardonium to survive from fatal solar radiation and during solar flares.

figure 5.2-1 Arachne I

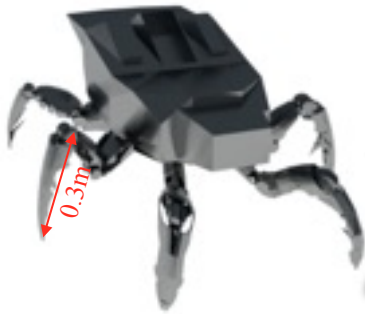
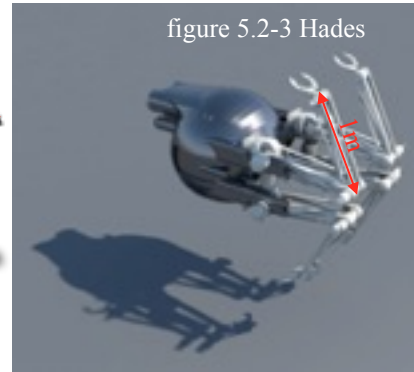


figure 5.2-2 Hermes



figure 5.2-3 Hades



5.2.4 The Aynah Police Department

Cops within the the Aynah Police Department (APD) are always prepared to face with emergencies, also there will be weapons. Cops are responsible for the patrolling in the space station, stopping conflicts between the residents of the space station, stopping space crimes and maintaining order while sightseeing.

5.2.5 SICAS

From the moment they step on the space station, all the human beings are required to sign up their fingerprints and DNA in the The Space Settlement Identity and Access Control System (SIACS). By checking their identities and backgrounds, this method can control the individuals who might go into core or classified areas or automation systems. At the same time, the insiders of the space stations would be given different levels of access, ranging from 1 to 10. Every level has its own information-receiving, walking- area and task-difficulty control. This method can prevent trespassers or the non-professional from damaging delicate parts and critical computer systems inside the space settlement.

5.3 Habitability and Community Automation

5.3.1 Means to Enhance Livability

5.3.1.1 Wearable Device—Selene

Selene, the human computer interaction device in Aynah, is a device with a curved screen closely attached to the wrist. It keeps in touch trough the hight bandwidth Light Fidelity with Aynah’s central server. Selene would all-weatherly tests human health and various indexes. In order to encourage people to exercise, Selene will compute daily ranking of people’s amount of exercise. When the wearer’s health condition is abnormal, the hospital will automatically send a rescue robot to help him or her.

5.3.1.2 Home Entertainment System

Each family will install an entertainment system based on holographic projection. Unlike Selene, this system doesn’t concern too much about people's

physical condition, but focus on the entertainment. People will have a better experience in both entertainment and access to information because of the use of optical fibers and better equipment.

5.3.1.3 Productivity in work environments

Due to the fact that the productivity of automaton is much higher than that of human beings, humans in the production area of the Aynah are not responsible for any production process. The flaws of using automaton in the working process is negligible for the benefits of reduced percentage of error. The productivity in the early year is positive correlated with time, since after the accumulation of primitive resource, more and more automatons is constructed.

5.3.2 Computer System

5.3.2.1 Network Access

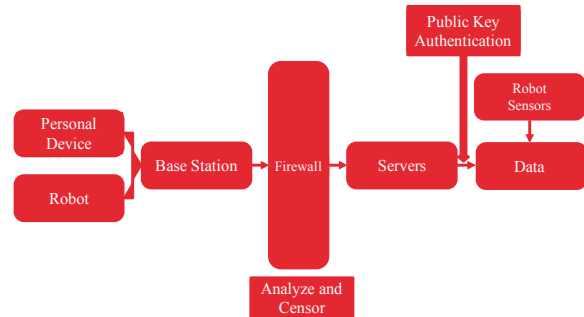


Figure 5.3.2-1 Network System

To ensure the coverage of network access, while reducing the cost, Aynah use both optical fiber and LiFi. The fiber from the data center server connect directly to each family, and then small router in each family will convert optical fiber signal into LiFi signal. To maintain the continuous operation of the industry and reduce the cost of optical fiber maintenance, network access in the industrial area is directly converted into LiFi signal using a high-power router.

5.3.2.2 Data Center

Aynah data center adopts remote multi-live mode and uses data unitary, so that when one of the data center breaks down, the offline can seamlessly switch to

other servers. Since the volume of Aynah is relatively small, the delay problem can be neglected.

5.3.2.3 Encryptions and Access Control

All communication in Aynah is encrypted. Typically, Aynah uses the public-key crypto systems which names AES-256-CFB. Through that encryption and decryption algorithm, server on the Aynah will recognize and distribute to the user certain access control. Just like the Linux file permission system, for a certain user, it will feedback if the user can read, modify or execute the certain file. In this way, both the official documents and personal data can be saved and shared safely.

5.3.2.4 Public Access

The network structure on Aynah has little difference with and the one on earth. However, due to communication with earth's delay, people tend to only communicate with people who also live in Aynah using IM (Instant Message). The rest of the Internet data content exchange between Aynah and earth need to adopt multilayer cache technology, which makes the time of message delay less than 10 minutes, to synchronize with Earth.

5.3.2.5 Base Station & Firewall system

All connection between individual user toward the sever will through the base station with a Firewall system. The base station will use the firewall system to detect all malicious visit and the content of all packet. Firewall system ensures the block of certain individuals and websites.

5.3.2.6 Human Protection

All robots in the Aynah will automatically identify human being around them by detect nearby devices. Through the signal of two different part in the wearable devices, the robot can estimate relative position of the one. Once the position of human is located, the program which coded by hardware will keep the movement away from people at least 2 meters.

5.3.3 Robot Resources

5.3.3.1 Home Delivery System



Figure 5.3.3-1 Delivery Robot—Drone

To reduce the labor requirement of delivery, the whole Delivery system are implemented by drones. All residents are make order online and post a certain code to the delivery system. The system will assign a drone to the warehouse to attach the goods. The map

given by the system will be sent to both drone and costumers, so those customers can know where the goods in the progress.

5.3.3.2 Automatically Performing Maintenance

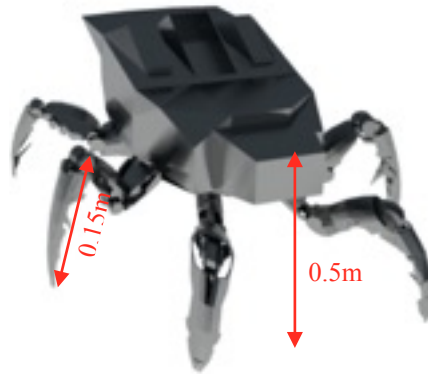


Figure 5.3.3-2 Arachne II

While the drones is delivering the goods to costumers, the drones scan the condition of Aynah. Once drones find potential treat of Aynah, it will send a post to the data center. Then the system will call ArachneII to check it out and fix it if necessary.

5.4 Automation of Reardonium Manufacturing Process

5.4.1 Automation of Unloading Reardonium Ores from Manticore

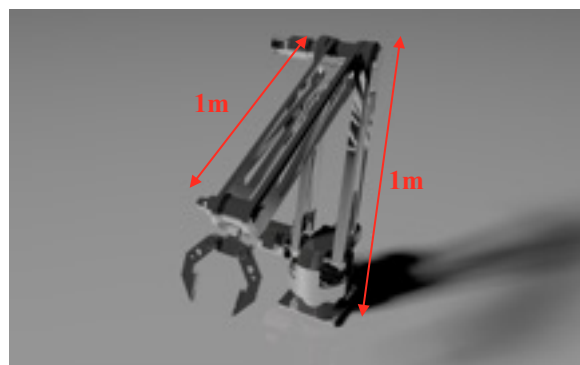


Figure 5.4.1-1 Mechanical Arms

After Manticore, the unmanned cargo ships carrying ores, arrive at the port, the container containing ores would be transported by elevators into Aynah

Then the ores would be carried out by claw-shape mechanical arms (figure 5.4.1-1) and be put on the conveyers which can send ores to the refiners in the industrial modules.

5.4.2. Automation of Refining

The manufacturing modules will provide pipes for multiply kinds of chemical reagents, electric heater

unit and hot air circling type to dehumidification, all parameter needed for chemical reagents and heating will be provided by the central control computer based on the flexible requirement typed in. After the refining process, the waste will be piped away to certain places.

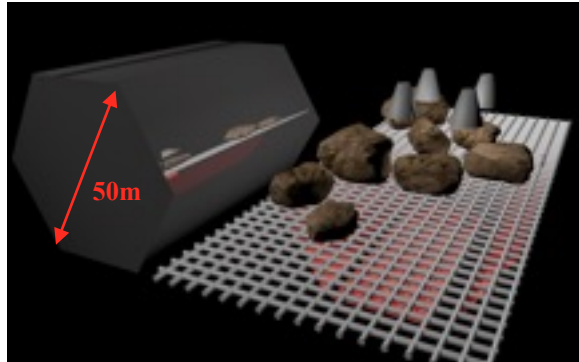


Figure 5.4.2 Refiner

5.4.3 Unloading Refined Reardonium to the Curing centers

When the refining process on Aynah is finished, refined ores would be transported back to Mercury via Manticores. Then transportation robots Megatron (figure 5.4.2.2), equipped with metallic tracks, low-height chassis, a small-power electric motor, and a liftable platform, will move the refined ores to the curing center.

5.4.4 Automation of Curing

The refiner, or the curing center (Figure 5.4.4-1), is an unmovable machine on the Mercury. The metals are laid on the platform according to moving belt. Then they are heated to extremely high temperature via great heat from sunlight.

The robotic arms around platform will turn metals over many times, which make it possible for every piece of metal to be heated adequately. After heating, the metals are cooling down in a short time by using heat pipes to conducting the heat out. This process will be repeated multiple times until the quality of metals meets criteria. The sensors are able to detect data such as temperature and moisture, allowing the computer to adjust the process without human interference.

The second step in the process is hardening. Solid solution strengthening is a type of alloying which adding silicon and manganese to base metals. Plastic deformation of contact materials comes from the movement of dislocations throughout crystalline lattices that comprise each grain. Dislocations can move easily throughout an unalloyed metal. When other elements are dissolved into the metal, they help to increase the friction of dislocations and impede that movement. This imparts extra strength to the material. In addition, it enables metals to maintain constant strength and hardness under high temperature on Mercury.

5.4.5 Safety Configuration

We have to ensure that all devices can operate in extreme conditions. Consequently, the shells of transportation cars and refiners are made of Reardonium as well as other electronic shielding metals. The interlayers include six layers of material with high electronic conductivity as well as magnetic permeability. The cables entering refiner from outside are covered with magnetic rings. In case of solar flare, all openings are closed in order to form an electromagnetic shield. Some of the electromagnetic waves are reflected on the surface. The eddy currents induced also contribute to shielding. The multi-layer design allows high-frequency waves to reflect and refract several times, which protects the devices inside efficiently.

5.5 Robots for Human to Ride for Inspection—Smurf

Smurf is the robot used by human to inspect the refining process inside Aynah. Under the 0g gravitational circumstance, certain movements required by inspection become the main problem.

Therefore, generated by electricity, Smurf has a shape of sliding plate and a symmetrical shape. Human can ride on it, moving easily and swiftly in the 0g condition. Furthermore, it is suitable to apply Smurf in the aisles between hexagonal modules in the industrial zone, because the size of it is greatly small. An automatic position control system is placed inside Smurf, so when people want stay in one position, Smurf can automatically adjust itself via the system.

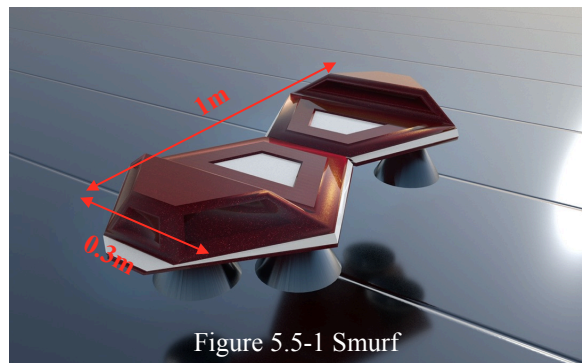


Figure 5.5-1 Smurf



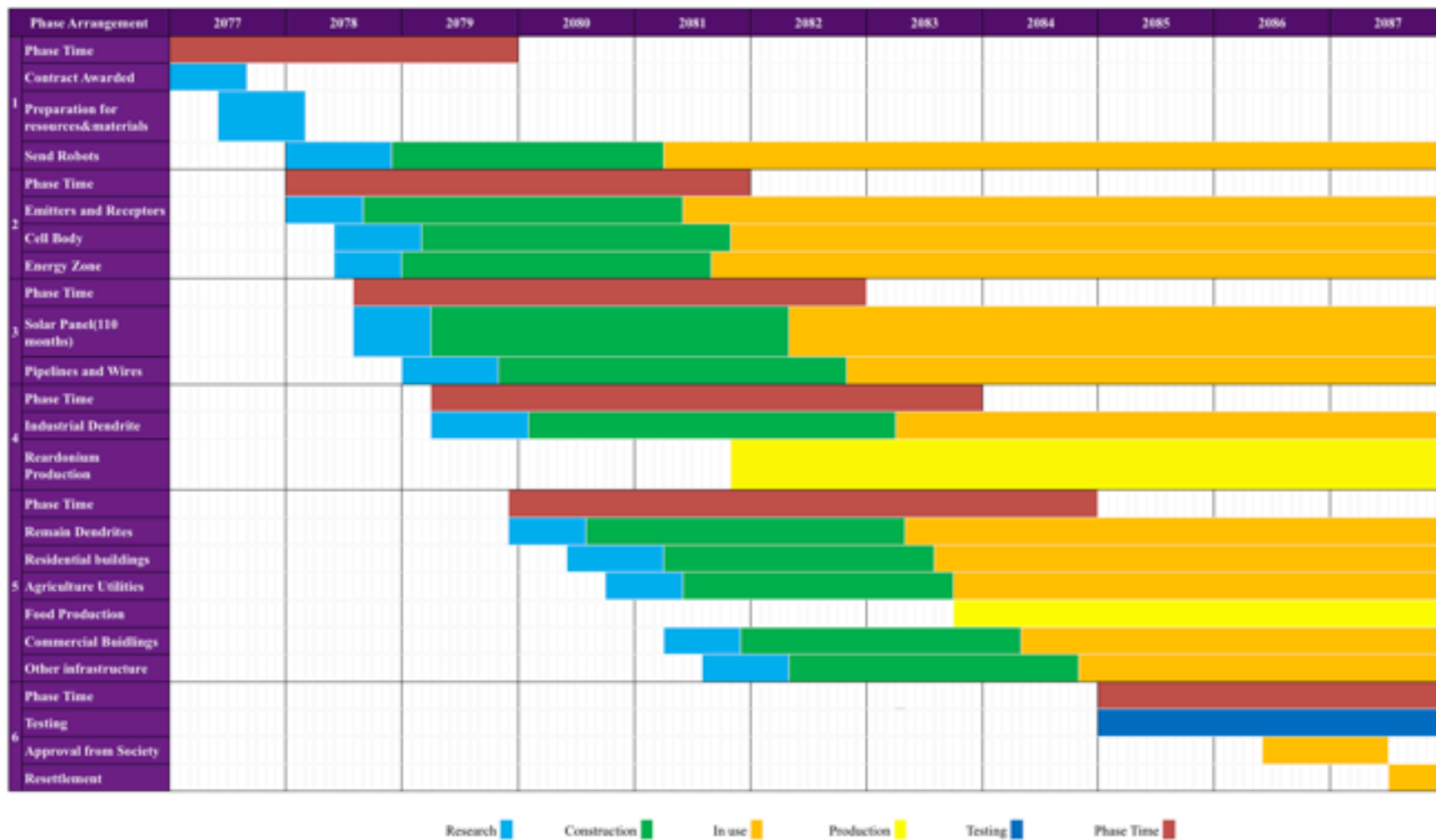


6.0 SCHEDULE AND COST



6.0 SCHEDULE AND COST

6.1 Schedule



6.2 Costs

		Unites	Quantity	Price Per Unite	Total Costs
GAS	Nitrogen	kg	592,300,000	1.23	728,529,000
	Oxygen	kg	213,100,000	1.14	242,934,000
	Helium	kg	9,187,000	6.15	56,500,050
	Carbon Dioxide	kg	475,300	1.07	508,571
	Water Vapor	kg	814,400	1.52	1,237,888
	Subtotal				1,029,709,509
(Raw) Materials	Water	kg	2,967,860	1.52	4,511,147.2
	Steel(kg)	kg	31,610,500	5.23	165,322,915
	Reardonium	m ³	993,780	35,734	35,511,734,520
	Transition-Metal Sulphide(m ³)	m ³	661,200	358.4	236,974,080
	Perovskite(kg)	kg	52,765,300	48.7	2,569,670,110
	Glass	m ²	125,700	101.4	12,745,980
	Solar Panel	m ²	7,373,000	158.9	1,171,569,700
	Silicate	kg	25,792,670	0.45	11,606,701.5
	Subtotal				39,684,135,153.7
Network and Equipments	Sever	\	15	23,870.92	358,063.8
	Base Station	\	24	1740236.95	41765686.8
	Individual Suit	\	15000	7567.54	113513100
	Computer	\	15000	2389	35835000
	Subtotal				191,471,851
Robots	Arachne	\	200	480,000	96,000,000
	Hermes	\	500	320,000	160,000,000
	Hades	\	1000	270,000	270,000,000
	Demeter	\	2 (meter tons)	1,170,000	2,340,000
	Megatron	\	100	300,000	30,000,000
	Hoder	\	100	300,000	30,000,000
	Drone	\	200	200,000	40,000,000
	Hephaestus	\	3	500,000,000	1,500,000,000
	Arhat	\	200	150,000	30,000,000
	Subtotal		2303		2,158,340,000
	Design&Constructi on Engineer	people	180	64,500 (Annual Salaries)	92,880,000
		year	8		
	Mechanical Engineer	people	200	66,890	133,780,000
		year	10		
	Chemical Engineer	people	80	73,100	43,275,200



KYLIN

		Unites	Quantity	Price Per Unite	Total Costs
Jobs		year	7.4		
	Electrical Engineer	people	80	71,100	21,614,400
		year	3.8		
	Civil Engineer	people	130	62,000	30,628,000
		year	3.8		
	Robots Engineer	people	160	81,280	117,043,200
		year	9		
	Software engineer	people	150	79,360	119,040,000
		year	10		
	Geologists	people	5	61,320	613,200
		year	2		
	Electricians	people	220	56,000	123,200,000
		year	10		
	Foreman	people	20	54,700	10,940,000
year		10			
Pilots	people	50	101,400	50,700,000	
	year	10			
	Subtotal	people	1,275		743,714,000
Operation	Cargo Transportation	year	89,473,000	11	984,203,000
	Passenger Transportation	year	6,734,900	6	40,409,400
	Construction	year	6,800,000	5.6	38,080,000
	Assembly	year	5,900,000	3.2	18,880,000
	Food Production	year	947,300	6	5,683,800
	Reardonium Production	year	130,840,000	4.4	575,696,000
	Consumables	year	2,048,800	3	6,146,400
	Network Building	year	463,700	3	1,391,100
		Subtotal			
Income	Reardonium Exports	year	4.4	187,389,300	824,512,920
	Robot Exports	year	2	241,809,725	483,619,450
	Miscellaneous Exports	year	3	222,789,330	668,367,990
	Research and Patents	year	3	129,303,800	387,911,400
	Tourism	year	3	280,030,000	840,090,000
		Subtotal			1,061,322,155
Total					42,273,358,453.3

STRUCTURE

OPERATION

HUMAN FACTOR

AUTOMATION

BUSINESS



6.3 Business Analyses

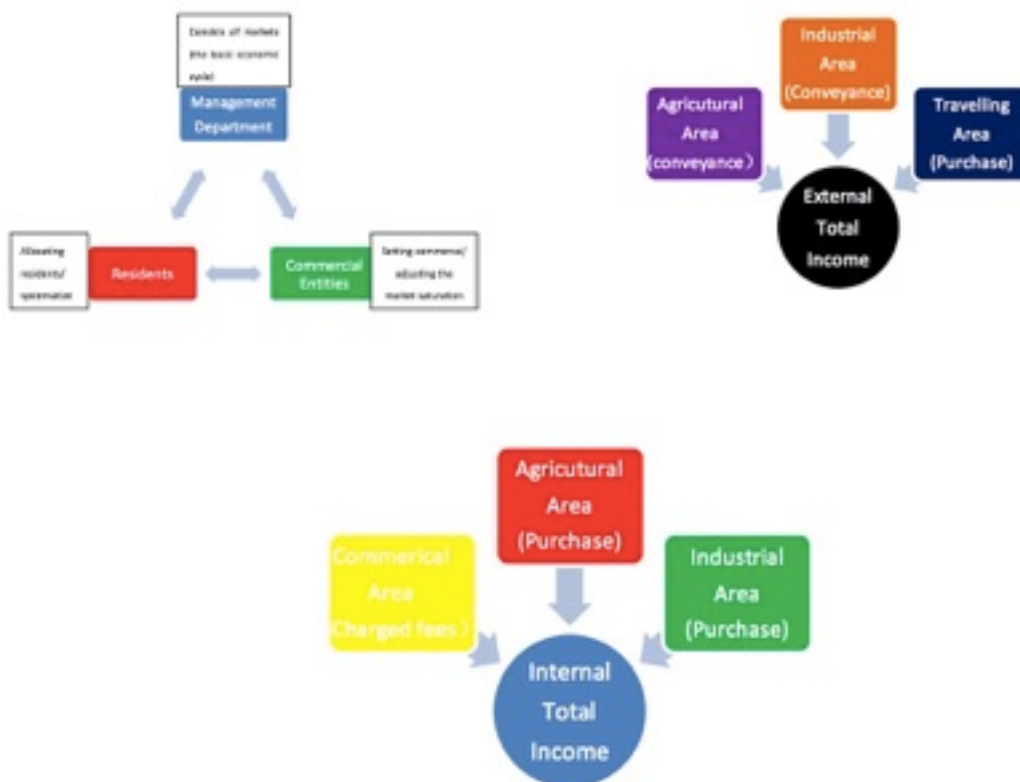
The business components are important factors in Aynah and can't be neglected. It mainly consists of two big sections—the internal management and external operation. Because of these two parts, the investors can get back their money no later than 40 years with the turnover ratio 10%.

Saving money is a large dimension in business field. However, in our engineers delicately designed Aynah, it's not even a problem. The whole operation system won't cost lots of money because with the free natural sunlight, the energy problem could be hugely reduced and maintain a virtuous cycle. Due to the effective sunlight, the agricultural area won't have big issue producing crops. Besides that, the operation systems are mostly in cycle such as the water management, therefore, the whole operation fees won't put any burden on the engineers and investors. While the construction fees could be a problem, we design a profitable business mode on Aynah and can easily tract money back in a fairly short amount of time.

The whole business system relies on the costumers. In the internal management section, the money comes from commercial area, agricultural area and industrial area. In the commercial area, when the immigrants move to the Aynah, they will automatically exchange their money (from Earth currency to the Aynah currency). They can only have debit cards because other cards like credit cards will add complexity to the system on Earth, so as to avoid terrible consequences – inflation. In this system, the residents can and can only use flexible money and debit cards to purchase their necessities and loving products. All finance-related stores (shopping stores, restaurants, entertainment centers, even work place) will be charged money due to the space occupation fees since we agree to privatize each store. Tax sometimes can be a hard and exhausting process, but in Aynah, we use a simple but efficient way to manage. The management department will automatically charge 10% of the benefits that each store gain annually and plus a fixed fee. The income from this part will be approximately 80 stores multiply annually average 30,000 dollars plus profitable tax 80 stores multiply 10% out of annually average income 400 thousand dollars. Such a setting is the most reasonable since the competitiveness in the market is limited due to a small amount of business, the proprieties will be likely hold a large amount of money. Meanwhile, the households should be responsible handing management fees which extracts from the working income or direct money source from relatives on Earth. The total income should be 9,088,000. In the agricultural area, the crops that successfully plant on Aynah can be gained from customers purchasing different food. The food will be divided into excellent quality, good quality and average quality and people will purchase them in different fees but the basic cost 500,000,000 will be covered., In the industrial area, the benefits can raise up when people buy those light industrial products

through the shopping mall and even the ones that are directly bought themselves from the management department.

The external operation mainly contains three parts. One part is agricultural area. To transport the food planted on Aynah to Earth is essentially a simple but great idea. However, the transportation fees need to be addressed. Since the cost of conveyance should be delicately calculated by management, the positive net income can be guaranteed every time they convey the products. For example, if the maximum amount of 1t and the transportation fee is likely to be 100 million, then the basic cost should be covered and add up the needed benefits. The other part is industrial area. Because there are many precious metals and resources on Mercury, transporting them could gain a fair amount of money. The idea of transporting is essentially the same as the one in agricultural area – to accumulate products in order to gain only benefits. Moreover, the travelling gaining also needs attention. The management department can organize the visitors on Earth to take a trip to Aynah with different packages. The first package will contain only visiting; the second package will include experience for 1 day at Aynah; the third package will be a week staying at Aynah. Each package has different requirement and charged money. To sum up, the total estimable annual income should be $5200,000 + 364,635,000 + 100000000 + 60000000 + 4000000 = 533,835,000$ dollars





7.0 BUSINESS DEVELOPMENT

7.0 BUSINESS DEVELOPMENT

7.1 Infrastructure for Refining and Manufacturing Rerardonium

7.1.1 Capability for Handling and Processing Raw Ore

After the Rerardonium collected and manufactured by the methods mentioned in 3.5 and 5.5, it was transported to the industry area. The impurities at the surface of Rerardonium would be separated by using static electricity and acids/bases. The waste produced during this process would be classified, and we could recycle part of the metal and chemical substances. While transporting, the Rerardonium would be placed in completely sealed boxes, and they will be unloaded at the edulcoration areas at the industry district. Therefore, dust and pebbles will not enter the resident district while transporting Rerardonium.

7.1.2 Manufacturing Capability in Various Gravity and Pressure Environments

Since distances between various parts of the workshops in the industry district and the spindle are different, the gravity varies (see 2.4). The workshops have standby artificial spiracles, so robots can detect the pressure inside the workshops and control themselves intellectually.

7.1.3 Separated Hazardous Manufacturing Operations

Hazardous Manufacturing Operations are Separated from Humans Occupying Areas. There is a screen (thickness: 10m) between the industry district and the resident districts. The screen is made of composite materials, the surface is made of Rerardonium, and inside there are acoustic and shock proof panels. This could prevent the noise of the machines from polluting the resident district, also prevent explosions from affecting the residents.

7.1.4 Transportation of Goods

Inside the industry district, transportation of semi-manufactured goods would be achieved by conveyors and mechanical arms. At the same time, the conveyers in the entry port would be directly connected to the process sheet in the industry district, increasing transportation efficiency. The whole manufacture process is automatic. At the outer shell of the industry district there are control centers for

workers to monitor the machines and manage emergencies.

7.2 Receiving and Shipping Rerardonium Parts

7.2.1 Checking and Classifying of Rerardonium

Steps of collecting and processing Rerardonium on the surface of Mercury includes checking the equipment, evaluating the process, and handling problems. After that, the shipping area on the surface of Mercury would be examined again, go through the robot monitoring and analyzing process. Then, Rerardonium would be classified and marked according to its main purity. At last, after the edulcoration inside Aynah is completed, the third examination would be run to determine the method of processing and use of Rerardonium.

7.2.2 Packing and Transporting of Rerardonium

The last products of Rerardonium can be in three forms: clintheriform, H-shaped, and tube shaped. The industry district would pack the products according to the quantity and shape on the order using packing machines. The shell of the containers would be made of Rerardonium. This could prevent the Rerardonium from adverse conditions that would effect the quality of the products. While Rerardonium is being packed, high stretch carbon fibre bandages are used to prevent the collisions between the cargo and the containers when the spaceship is turning.

7.2.3 Automation of the Process

The collecting, checking, transporting, purifying, casting, and packing process would all be managed automatically. Every process has its checking robot which rely on intelligent programs to amend the manufacturing process. When emergencies occur, the controlling centre can also send robots to deal with the problems.

7.3 Port of Entry for Mercury

7.3.1 Radovich

The spaceship Radovich is mainly used for interstellar travels, and is mainly responsible for long-distance trading. The Radovich has a lot of space inside and can complete many orders after the orbit is



planned. The Radovich is equipped with large engines and a hard shell to maintain the cargo's safety and rise the speed of the delivery.

7.3.2 Manticore

The space ship Manticore is used for transportation between Mercury and Aynah. Since the distance is short, it uses plasma engine powered by electricity. The Manticore is auto-piloted and has a passenger cabin (for 10 people) and a medium sized cargo cabin. As the main way to transport people and cargo between Aynah and the surface of Mercury, Manticore takes only three hours to drive from the surface of Mercury to Aynah. At the same time, Manticore can be used to transport materials between the station Entrepôt and Aynah.

7.3.3 Supplement Station

When there are not enough places for the storage or parking areas on Aynah, spaceships can stop at the small supplement station around Aynah to unload. Each small station has a deck named entrepôt. There are stations on the orbits both at inner and outer sides of Aynah, and the radius differ in 1km.

The time needed for traveling between the small station and Aynah is only 10 mins.

7.3.4 Transportation inside the Supplement Station

The transportation between the entrepôt and the storehouse of the station is achieved by conveyers. Every cargo is sealed in the containers inside the entrepôts. When necessary, the cargo would be taken out using the shuttle panels, put on the conveyers, and be transported to the entrepôt. The robots on the entrepôt would put the containers on the corresponding spaceships. For passengers there are special corridors and elevators.

7.3.5 cargo warehousing and inner cargo transporting system

There are channels connecting each interface on the platform of the port to the main channel of Aynah's axial elevator system. There are cargo conveyers and people corridors in the channel, which function to transport the cargo and human from the port to the main body.



APPENDIX A OPERATIONAL SCENARIO



RUOPENG ZHOU/THE AYNAH TIMES

The subtle yellow light projects on all ground, leaving small halos on every individual's face. Here I am - the most majestic and gorgeous construction in space history ever - Aynah. I am still amazed by the internal setting in it. To tell the truth, I can't believe they can really make space another paradise. It's Oct 31st, 2092 now, and I stand on such an unbelievable settlement to report this memorable experience.

Grandiose Space Settlement Ever

Incredible Work of Kylin

11 a.m. Oct 31st, 2092

Aimed building a livable residency for sustainable mining and astronomical exploration, the design of Aynah shows great flexibility in utilizing limited resources. It's self-evident that the construction of Aynah is among the greatest projects of the human history. And I'm honored to be a witness of this never-been achievement, as a visitor, to take a deeper look into the residency and bring back first hand information for the readers.

After an exciting though exhausting journey, at Oct 31st 2092, I was finally able to take a peek at this floating station with strange appearance. A spherical central area was connected to 5 larger

cylinders, and adhered to an enormous disk. When viewing from the space, the I automatically questioned the practicality of the design since it did not have an appearance considered "magnificent" by common aesthetic. But why would the Foundation Society choose this particular contractor, among hundreds or thousands of them, for this epic project? In other words, what are the main focus and novelty of this design?

Driven by curiosity, I started my tour accompanied by an indigent guide, Haha Jiang. Jiang introduced me the function of each section of the fundamental structure: 4 green cylinders were for agriculture and residential base, the red one was for industrial activi-

Enjoy Cozy Life in Aynah

Comfortable, Secure and Scientific

3 p.m. Oct 31st, 2092

After a short break, I jumped up from the soft bed of the visitor's room. The afternoon's schedule excites me a lot. The engineers on Aynah first showed me around the human areas. Walking on the street in the area, I immediately immersed by the vitality it conveys. Then the first construction came to my eyes — the residential and commercial area. Embracing by clusters of trees, the building seemed to stand with majesty. As I walked into it, the unique residences impressed me. Some of the areas are divided into four parts, which mostly support the single family while the division of five areas supports a big family that contains two children or more. Considering the singles' strong need for social activities and make it easier for them to find partners, the kind house designers conceive the singles' apartment blocking which is consisted of six single buildings and whose second floor has a thorough veranda that allows residents to arrive at any other rooms in the same blocking. The divisions of houses were so delicately designed by the engineers that I felt exactly at a both newly developed and warming area. "I had never imagined I would be in space one day but I had never felt as if I left mother Earth," as Sherry, a mother with two children, ventures. The residences in Aynah have the magic to propel people to for-

get the fact they are in space! I stayed for a while and came out of the building. The banners and the slogans suddenly

ference and you know, work. It's basically the same day after day," contended by a man in the office. I then

must be the shopping mall where the costumers cannot only buy the necessities but also lots of space specialties.



intruded into my eyes. There were at least 10 different restaurants that support individuals' diversified flavors. I quickly tasted the offered meal and shocked by its delicacy. The surrounding parking lots, unlike the ones on Earth, provide completely convenience and autonomy.

The sunlight coming down from the sky above, reflecting the blue cloud. This lifelike and high-definition scene is produced by the LED light spot settling on the ceiling board. The office area is the same as the ones on Earth — not too impressive but clearly displays the trait of office area. "It's the same as ones on Earth. I don't sense any dif-

walked along the street and saw a huge acre of agricultural area. This area adopts a special system. Crops are planted on three-dimensional agricultural zones, which has multiple floors of artificial field that transported water, air and fertilizer. "By doing this, we successfully make all use of the limited space in the Aynah." The guider claimed in a confident tune, reflecting a faint smile on his face. He told me that later the raw corn will be processed to be delicate food by automatic cooking machine which can continually update its cookbook and produce food according to customer's personal need. The most impressive place for me

Children won't worry about their studying because the smart engineers have already designed schools with complete systems. Besides the human part, the operation of space guarantees the normal life in space. Most importantly, the hospitals enhance the efficiency of hospitals by providing artificial assistants that can help doctors make disease diagnosis and nurses do nursing. Also the Center for Disease Control and Prevention supervises all the potential disease within the whole settlement.

The atmosphere is strictly controlled by the engineers who clearly states that it is better than the air on the earth,



where the air is polluted for several centuries. People won't feel sick even a little because the designs of convenient spacesuits. Such spacesuits are consisted of carbon fiber. The spacesuit is very safe since there are a thin layer of nanomaterials cover the surface of the spacesuit prevented the spacesuit from accidental damage. Also, the carbon fiber defends the temperature difference when they are out for activities. Beyond that, the whole mechanisms in Aynah provide people with the recyclable and convenient lives. The waste water will go through different system for different usages. The water after standard filter process is for industry and residences area; the water that goes through distillation is for drinking water; and finally, the water processed by Radian Antibiotics system is for medical use. The transportation system is another thing that impresses me a lot. Since residents have to take elevators frequently every day, it is inconvenient to drive private cars or ride bikes. So to integrate the transportation system and keep it in order, engineers design a system in which people use the same type of small maglev carriage powered by magnetic force. This carriage can both drive fast on the road and take the elevators.

ties, and the huge disk was a solar panel for the whole residency's energy supply. In the middle of them was the central part that took the job of transporting no only humans and vehicles but also utility. "What makes our design greatly different from others' is the utilization of special material on the solar panel," Jiang said, "and this kind of material prevents and alleviates the devastating destruction that meteorites and space debris cause when hitting the residency."

"A critical job of this residency is to develop new resources and mine the precious Rardonium," introduced by economist Zhe Zhang, a consultant for the Aynah project, "so exportation is an essential part to the residency's market chain." To make this more convenient, the designers set the port at the top of each cylinder, in the out most area of each zone. When I arrived at the industrial zone in the first place, I was greatly impressed by the prosperity of the industry and how complex it looked. The port was incredibly busy with transporting mine to other places, and the busy manufacturing process still remained orderly.

—The Galaxy News TV, Jane Leon Bowes

STRUCTURE 3-7

Mercury Natural View

Residential&Agriculture Dendrites now provide natural view of Mercury below for residents in the recreational area. PAGE 4

Honeycomb Structure

To increase the variety of the reardonium products, Industrial Dendrite uses the honeycomb structure. Every manufacture module is filled with different amounts of Nitrogen in of operation. PAGE 7

OPERATION 8-16

Agriculture Unites

Stereones are advanced basic unites for agriculture. This year, the government increase their quantity and reap a bumper harvest. PAGE 10

Cogeneration System

Cogeneration System integrates thermal energy sources in different temperatures and media pressures and transforms them to both electricity and specific temperature thermal energy. PAGE 11

HUMAN FACTOR 17-24

Spacesuit

Spacesuits can resist high temperature and cosmic ray and is able to create an independent living condition. PAGE 21

Safety Management Rules

Government sets forth a program of reforms safety rules in order to protect humans in maximum. Safety rules must be obeyed by residents. PAGE 23

AUTOMATION 25-31

SEWES

The Space Extreme Weather Emergency System forecasted a solar storm in 45 days. PAGE 26

DNA Backup

Aynah, for the first time, exploits DNA statistics storage technique, with significantly reduced cost, considerably improved security, and extremely decreased occupying space. PAGE 27

Demeter

Nanobots Demeter, assisting spider mouse to repair and maintain the space city, have repaired a hole with 1.5 meter diameter within two hours. This action save two million dollars for Aynah government. PAGE 28

BUSINESS DEVELOPMENT 32-38

Flexible Workshops

The changeable distances between different industrial works gives motility to different parts and thus is able to produce various of dedicate products. PAGE 37

Quiet Living Condition

The industrial zone is isolated well by special materials from the four residential and agriculture dendrites and so create a quiet environment for residents. PAGE 37

Redundancy Consideration

The ingenious redundancy design in the port loading system gives plenty of places for the storage of redundant cargo, in case of the obstruct jam cause by too many cargo containers. PAGE 37

Thanks for All Teammates!

Enpei Zhao	Yanting Zou
Dingkun Guo	Beier Chen
Guanghao Ye	Xinran Ming
Ruopeng Zhou	Yuyou Wu
Zehao Huang	Qingyuan Zeng
Yulun Zhang	Ran Luo
Yifan Mo	





**APPENDIX B
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APPENDIX B

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APPENDIX C

COMPLIANCE MATRIX



APPENDIX C

COMPLIANCE MATRIX

Requirement		Location in Proposal	Page
1 Executive Summary			
1.0	The contractor will describe the design, development, construction, and operations/maintenance planning for the Aynah space settlement in orbit around Mercury.	1.0 Executive Summary	1-2
2 Structure Design			
2.0	Provide a safe and pleasant environment for 14,000 full time residents and 200 short time visitors	2.0.1 Residential Demands for Structural Design	4
	Enable residents to have natural view of Mercury below	2.0.2 Mercury Natural View	4
2.1	On exterior design drawing(s), identify attributes and use of large enclosed volume	Figure 2.0-1 Settlement Overview	3
	The exterior hull and major load-bearing structures will be manufactured of reardonium.	2.1.1.1 Hull	4
	no load-bearing reardonium exterior structure can have a dimension longer than one mile	2.1.1 Main Structure	4
	silicon buckystructure netting maintains tensile strength	2.1.1.2 Cell Body and Axis	4
	Show dimensions of major hull components and design features	Figure 2.0-1 Settlement Overview	3
	artificial gravity less than 0.75 g and atmospheric pressure less than 12.0 psi	2.1.2.1 Gravity Specification 2.1.2.2 Pressure Specification	5
	Specify volumes where artificial gravity will be supplied	2.1.2.1 Gravity Specification	5
	Specify structural interface between rotating and none rotating sections	Figure 2.0-1 Settlement Overview	3
	Specify rotationable for selected rotation rate and artificial gravity magnitude	2.1.1 Main Structure 2.1.2.1 Gravity Specification	4-5
	Show capability to isolate at minimum ant two separate habitable volumes in case of a depressurization or other emergency	2.1.1 Main Structure	4
	Minimum Requirement: Overall exterior view of settlement, with major visible features(e.g, solar panels, antennas), show rotating and none-rotating sections, pressurized and none pressurized sections, and indicating functions inside each volume(e.g, port, residential areas and agriculture).	Figure 2.0-1 Settlement Overview	3
	Specify percentage allocation and dimensions of interior residential, industrial, commercial, agricultural "down surfaces" with labeled drawings.	Figure 2.2-1 Internal Arrangement View	4-5

Requirement		Location in Proposal	Page
2.2	Show orientation of "down surfaces" with respect to overall settlement design and vertical clearance in each area.	Table 2.2-1 Allocation of Dendrites	4-5
	Minimum Requirement: Overall map or layout of interior land areas, showing usage of those areas	Figure 2.2-1 Internal Arrangement View	4
2.3	Describe the process required to construct the settlement, by showing the major assembly sequence	2.3.1 Construction Steps	6
	Specify when artificial gravity will be applied	2.3.1 Construction Steps Step 4	6
	Existing manufacturing facilities on Mercury can produce reardonium components no larger than 40 by 20 feet.	2.3.1 Construction Steps Step 4	6
	Early manufacturing areas of at least 100,000 square feet with 60 foot ceiling height that enable product of components up to 100 by 40 feet	2.3.1 Construction Steps Step 4	6
	Show standard component configurations for exterior hull	2.3 Construction Process	6
	Describe a construction technique for interior structures making use of minimally refined materials from the Mercury surface	2.3 Construction Process	6
	Minimum Requirement: Drawing(s) showing at least five intermediate steps of settlement assembly, and method of initiating rotation for artificial gravity.	2.3 Construction Process	6
2.4	Minimum Requirement: Show how manufacturing areas will provide required ranges of conditions for reardonium parts production. The process requires varying accelerations from 0 to 0.5g and atmospheric pressure varying from vacuum to 20 psi	2.4 Arrangement of Industrial Dendrite	7
2.5	Residential areas and commercial areas must be on the opposite side of the settlement from the sun	2.5 Settlement Protection	7
	Residential areas and commercial areas must be completely surrounded by a 20-inch layer of water	2.5 Settlement Protection	7
	Minimum Requirement: Configuration drawings that show protection for areas occupied by humans	Figure 2.5-1 Settlement Protection	7
3 Operations and Infrastructure			
3.0	Facilities and infrastructure necessary for building and operating Aynah space settlement	3.0 Operations and Infrastructure	8
3.1	Mercury orbital location and reasons	3.1.1 Settlement Orbital Location	8
	Equipments and sources of materials used in construction and in settlement operations	Table 3.1-1 Materials and Sources	8
	Minimum Requirement: Table identifying types, amounts, and sources of construction materials	Table 3.1-1 Materials and Sources	8
	Identify air composition, pressure and quantity	Table 3.2-1 Air Composition Table 3.2.1-2 Season Succession	8-9

	Requirement	Location in Proposal	Page
3.2	Include growing, harvesting, storing, packaging, delivering, selling of food, emergency storage	3.2.2 Food Production	9
	specify kilowatts distributed to habitable areas	Table 3.2.3-1 Energy Distribution	10
	Specify required water quantity and storage facilities	3.2.4.1 Specific Mechanisms and Facilities 3.2.4.3 Data Specification	11-12
	Specify recycling and/or disposal of household and industrial solid waste	3.2.5 Solid Management	12
	Specify devices and central equipment of internal and external communication systems	3.2.6 Internal and External Communication Systems	12
	Show routes and vehicles, with dimensions of internal transportation systems	3.2.7 Internal Transportation Systems	12
	Minimum Requirement: Provide chart(s) or table(s) specifying quantities required of air, food, power (for residents), water, waste handling, communications devices, and internal transport vehicles	Table 3.2-1 Air Composition Table 3.2.1-2 Season Succession	10-14
3.3	Show conceptual designs of primary machines jigs, and equipment employed for settlement construction, especially for exterior hull and interior buildings assembly.	3.3 Construction Machinery	14-15
	Describe materials, components, and/or subassemblies delivered to the machines, and how the machines convert delivered supplies into completed settlement structures	3.3 Construction Machinery	14-15
	Minimum Requirement: Include drawing(s) of primary construction machinery, showing how it shapes and/or manipulates raw materials or structural components into finished form	Figure 3.3.2-2 Manipulator	14-15
3.4	Using solar panels	3.4 Solar Panels	15
	Minimum Requirement: Show solar panels in drawing(s) depicting Aynah design.	Figure 3.4-1 Partial and Full View of Solar Panel	15
3.5	Aynah port operations require loading and unloading the largest reardonium parts on exterior racks of ships that land on the Mercury surface, and for export.	3.5.1 Ports 3.5.3 Cargo Transportation	16
	drawing(s) of method(s) for moving parts from manufacturing to landers for curing, and from returning landers to ships for export.	Figure 3.5.3-2 Cargo Transportation	16
4 Human Factors and Safety			
4.0	Offer attributes available to residents of Earth's small cities in developed countries	4.0 Human Factors and Safety	17
	Provide natural sunlight and views of Mercury below for residents	4.0 Human Factors and Safety	17
	Provide services in comfortable modern communities	4.1.1 Community Allocations	17

Requirement		Location in Proposal	Page
4.1	Provide variety and quantity of consumer goods	Table 4.1.2 Major Consumables	17-18
	Include public areas with long line of sight	4.1.1 Community Allocations	18
	Designate facilities or parts of facilities with and without interior roofs	4.2 Residences	18
	List major types of consumables and quantities	Table 4.1.2-1 Major Consumables	18
	Depict ways of distributing consumables to residents	4.1.2 Major Consumables	18
	Minimum Requirement: Include maps (including distance scale and percentage of land allocated for roads) of community/ location of amenities	Figure 4.1-1 Layout of Community	17
4.2	Provide designs of typical village residences, with shops and offices on the ground floor and residences above	Table 4.2-1 Sources and Quantity of Furniture and Appliances	18
	Clearly show room sizes; home designs will be no smaller than 900 sq. ft. and no larger than 2000 sq. ft	4.2.2 Types of Houses	19-20
	Identify sources of furniture and appliances	Table 4.2-1 Sources and Quantity of Furniture and Appliances	19-20
	Minimum Requirement: External drawing and interior floor plan of at least 4 home designs, area for each residence design, number required for each design	4.2 Residences	19-20
4.3	Provide designs of systems/devices/vehicles intended for use outside of gravity volumes will emphasize safety	4.3.1 The design of spacesuit	21
	Show spacesuit stowage and airlock designs	4.3.2.1 Design of Airlocks	22
	Minimum Requirement: Provide drawings of handrails, tethers, cages, etc. enabling safe human access to any location on/in low g areas	Figure 4.3-2 Spacesuit	21
4.4	Require children to daily exposure to 1.1g for at least 3 hours per Earthday, including one or more hours of physical play	4.4 School	22
	Minimum Requirement: Drawing means for children to spend time in 1.1g	Figure 4.4-1 1.1g Zone	22
4.5	Humans must personally inspect reardonium refining and parts manufacturing	4.5.1 Surface Vehicles for Human Inspection	22
	Describe safety rules and protection for different environments required for reardonium processing	4.5.3 Safety Management and Rules	22-24
	Minimum Requirement: describe safety accommodations for humans in zero g with vacuum, and 0.5 g with 20 psi	4.5.1 Surface Vehicles for Human Inspection	23
5 Automation Design and Services			
	Specify numbers and types of computing devices, electronic tools, servers, network devices, robots, and community and business operations	Table 5.0.1-1 Robot Quantity Table 5.0.1-2 Quantity of Network Equipments	25

	Requirement	Location in Proposal	Page
5.0	Describe types of data storage media, data security, and user access to computer networks.	Table 5.0.1-2 Quantity of Network Equipments	25
	Show robot designs indicating dimensions and illustrate how they perform tasks.	5.0 Automation Design and Services	25
5.1	Describe use of automation for construction.	5.1 Automation of Construction Processes	25
	Consider automation for transportation, delivery of materials and equipment, assembly of settlement, and interior finishing.	5.1.1 External Construction	25
	Describe how humans monitor automated construction processes and progress, and where/how human interaction is required during construction	5.1.2 Internal Construction	25
	Show how jigs hold robots in position to perform construction tasks in zero g	5.1.1 External Construction	25
	Minimum Requirement: Dimensioned drawings showing automated construction and assembly devices—both for exterior and interior applications (e.g., homes)—and illustrating how they operate.	5.1 Automation of Construction Processes	25
5.2	Specify systems for maintenance, repair, and safety functions, including backup systems and contingency plans for failures of primary automation systems	5.2.1 CDDEC	26
	Describe when and how human contributions to and/or intervention in these functions is required	5.2.1.1 DDMS	26
	Define physical locations of computers and robots for critical functions. Robots required for emergency external repairs must survive and accomplish tasks in extreme solar environments and during solar flare activity	5.2.1.7 Location of CDDEC 5.2.3 RC	27-28
	Describe means for authorized personnel to access critical data and command computing and robot systems	5.2.5 SICAS	28
	Include descriptions of security measures to assure that only authorized personnel have access, and only for authorized purposes	5.2.5 SICAS	28
	Minimum Requirement: Include a chart or table listing anticipated automation requirements for operation of the settlement, and identifying systems and robots to meet each automation need.	Table 5.2-1 System List Table 5.2-2 Robot List in Robert Center	26-28
	Describe devices to enhance livability in the community, productivity in work environments, and convenience in residences.	5.3.1 Means to Enhance Livability	29
	Emphasize use to perform maintenance and routine tasks, and reduce requirements for manual labor.	5.3.1 Means to Enhance Livability	29
	No robot may interact with a human in an authoritarian or threatening manner	5.3.2.6 Human Protection	29



Requirement		Location in Proposal	Page
5.3	Robots encountered in daily community life will be no taller than 4 feet (1.22 meters). If required by their functions to be larger, robots in work environments will be taller than 8 feet (2.44 meters).	5.3.3 Robot Resources	29-30
	Provide for privacy of personal data and control of systems in private spaces	5.3.2.3 Encryptions and Access Control	30
	Describe devices for personal delivery of internal and external communications services, entertainment, information, computing, and robot resources	5.3.2.4 Public Access	30
	Minimum Requirement: Drawings of robots and computing systems and that people will encounter in Aynah, and diagrams of networks and bandwidth requirements to enable connectivity.	Figure 5.3.2-1 Network System Figure 5.3.3-1 Delivery Robot—Drone Figure 5.3.3-2 Arachne II	29-30
5.4	Provide automation for efficiency of reardonium manufacturing processes, including unloading raw ore arriving from Mercury’s surface, moving ore through refining processes, forming and handling parts, and unloading/loading parts sent to Mercury’s surface for curing.	5.4 Automation of Reardonium manufacturing process	30-31
	Minimum Requirement: Provide drawings of robots for reardonium parts manufacturing and handling.	Figure 5.4.1-1 Mechanical Arms	30
5.5	Provide robots that humans ride to conduct inspections of reardonium refining and parts manufacturing processes	5.5 Robots for human to ride for inspection—Smurf	31
	Minimum Requirement: drawing(s) of “riding robot” with human(s) on board.	Figure 5.5-1 Smurf	31
6 Schedule and Cost			
6.1	Describe contractor tasks from the time of contract award (8 May 2077) until the customer assumes responsibility for operations of the completed settlement.	6.1 Schedule	32
	Show schedule dates when Foundation Society members may begin moving into their new homes	6.1 Schedule	32
	Show schedule dates when the entire original population will be established in the community.	6.1 Schedule	32
	Minimum Requirement: Include durations and completion dates of major design, construction, and occupation tasks, depicted in a list, chart, or drawing	6.1 Schedule	32
6.2	Specify costs billed per year of Aynah design through construction in U.S. dollars, without consideration for economic inflation.	6.2 Costs	33
	Estimate numbers of employees working during each phase of design and construction in the justification for contract costs to design and build the settlement.	6.2 Costs	33

Requirement		Location in Proposal	Page
	Minimum Requirement: Provide chart(s) or table(s) listing separate costs associated with different phases of construction, and clearly showing total costs that will be billed to the Foundation Society.	6.2 Costs	33
7 Business Development			
7.1	Capability for handling and processing raw ore from the surface of Mercury, including systems to prevent dust and grit from entering habitable areas	7.1.1 Capability for Handling and Processing Raw Ore	37
	Manufacturing capability in various gravity and pressure environments	7.1.2 Manufacturing Capability in Various Gravity and Pressure Environments	37
	Hazardous manufacturing operations are separated from areas humans occupy (e.g., residential and commercial areas)	7.1.3 Separated Hazardous Manufacturing Operations	37
	Manufacturing areas must be arranged to enable efficient movement of parts through production processes	7.1.4 Transportation of Goods	37
7.2	Perform inspections and quality checks of reardonium parts returning from curing processes on the surface of Mercury	7.2.1 Checking and Classifying of Reardonium	37
	Install completed parts in standard shipping containers or on pallets for delivery to customers throughout the solar system	7.2.2 Packing and Transporting of Reardonium	37
	Automate routine processes	7.2.3 Automation of the Process	37
7.3	Interorbital spaceliners transfer cargo in standard shipping containers and personnel	7.3.1 Radovich	38
	Operate a fleet of landing shuttles (procured through contracts separate from the Aynah acquisition) to transfer personnel and cargo to/from the surface of Mercury	7.3.2 Manticore	38
	Operate a fleet of landing shuttles (procured through contracts separate from the Aynah acquisition) to transfer personnel and cargo to/from the surface of Mercury	7.3.3 Supplement Station	38
	Provide cargo warehousing for customs purposes and storage while waiting for transfer to other ships	7.3.4 Transportation inside the Supplement Station	38
	Provide vehicles/systems for moving cargo containers between ships and warehousing	7.3.5 cargo warehousing and inner cargo transporting system	38