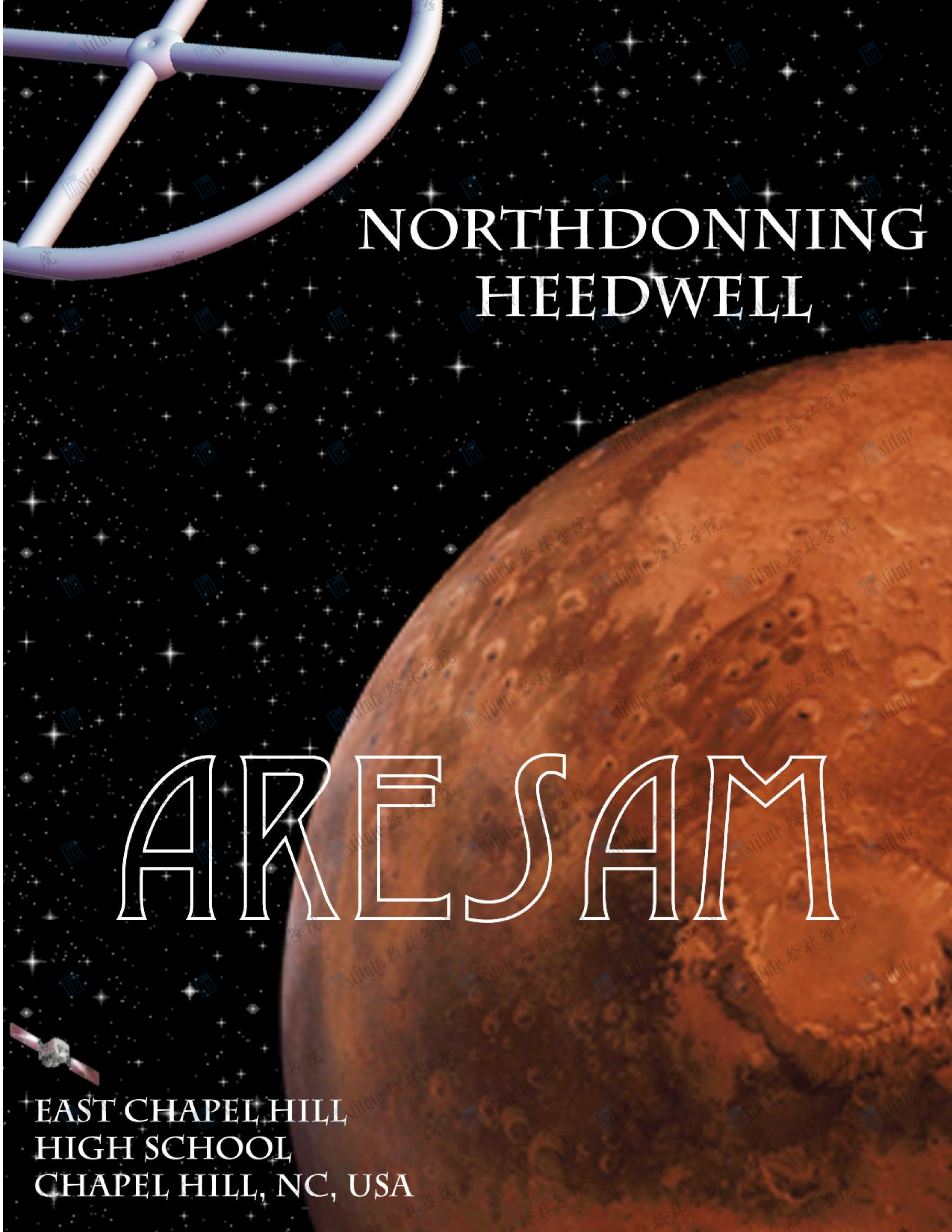

NORTHDONNING HEEDWELL

ARESAM

EAST CHAPEL HILL
HIGH SCHOOL
CHAPEL HILL, NC, USA

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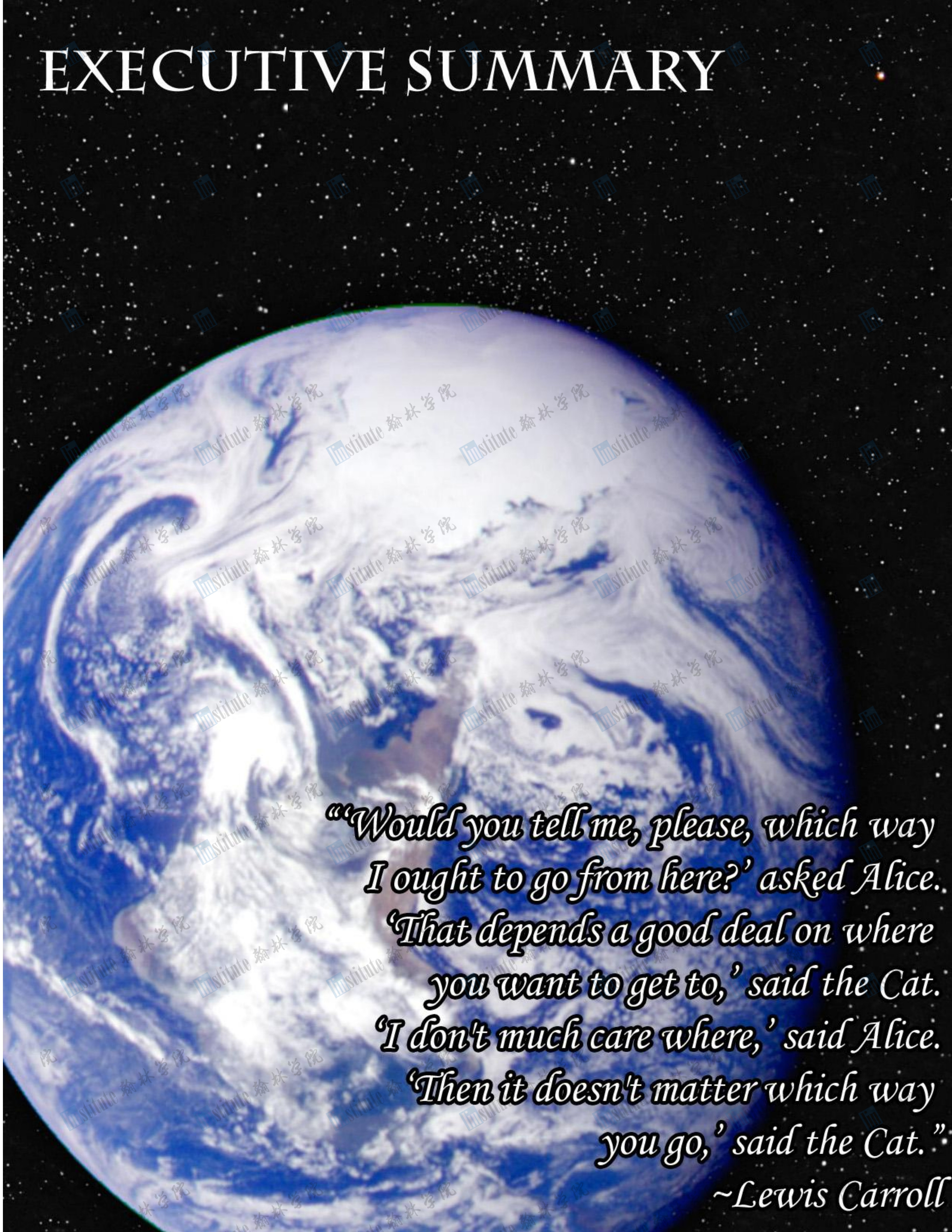
EXECUTIVE SUMMARY



"'Would you tell me, please, which way I ought to go from here?' asked Alice.
'That depends a good deal on where you want to get to,' said the Cat.
'I don't much care where,' said Alice.
'Then it doesn't matter which way you go,' said the Cat."

~Lewis Carroll

1.0 Executive Summary

Aresam will act as a superior gateway to Mars and its future operations. The settlement appears simple, consisting of just three major structures: a large torus surrounding an open central cylinder, and four spokes. Hidden beyond however is an array of unique adaptations and designs that truly fulfill its purpose as the gateway to Mars.

The station was designed with expansion in mind. Almost all parts of Aresam are modular in design, including communities and manufacturing areas. More importantly, a significant percentage of all spaces are initially designated for future expansion, with only basic infrastructure laid out. The docking system is designed uniquely to accommodate vastly different types of ships and consequently allow for near indefinite future development without major changes. All of these combine to ensure the station will have continued potential as the market for extraterrestrial fabrication and manufacturing, specifically Mars-based, increases. The modular capabilities were also present in early construction, with both the spokes and torus consisting of the same dimensions and exterior design and the entire station being covered in the same system of triangular trusses. This not only reduces costs, but makes fast repair possible as almost all exterior parts of the station can be addresses with the same base materials and equipment.

Safety is a primary concern for all designs of the station. Aresam will be located considerably farther away from Earth than any other stations the Foundation Society has previously established, and must have safety procedures and contingency plans for any situation. Features such as the ESSIS, a system which separates the entire station into distinct self-contained and protected segments, or the various safety and quick repair robots make sure that residents and equipment remain safe in any condition.

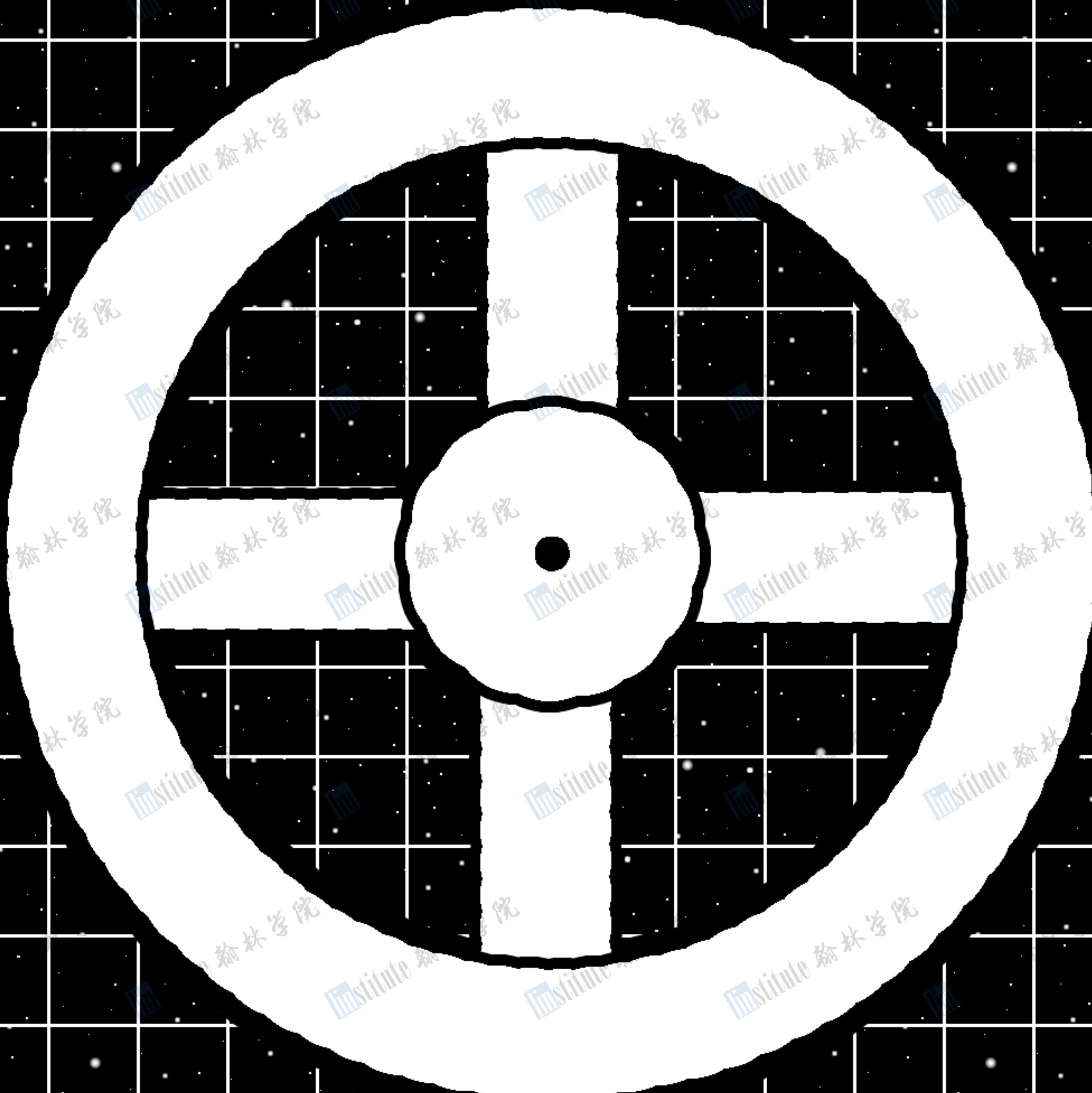
Manufacturing on the station is designed for maximum efficiency as well as productivity. Manufacturing sections associated with Mars Exploration and all transportation are located directly adjacent to the corresponding docking sections. This allows immediate repair and replenishment of any needs for any of these sections. The cargo shipping mechanisms themselves are designed for maximum efficiency and profitability, as all freight is delivered in detachable and combinable containers and crates, which are transported over long-distances by the highly efficient and powerful VASIMR distance as well as a innovative Mars cycler system. Mining operations on Phobos, Deimos, and Mars itself will provide the manufacturing section with a large variety of minerals, which can be processed to accommodate the station itself or be fabricated into various exportable goods. Research stations throughout the community blocks will produce a steady flow of new manufacturing ideas that can be relayed directly to manufacturing sections.

In addition to manufacturing, Mars Exploration is naturally one of the primary interests of the station. The prefabricated base is meticulously designed with function, safety, efficiency, and comfort gaining significant consideration. As with the station, contingency and back-up features are in place to ensure Mars personnel's survival under almost any circumstances. A unique Mars Exploration design to the station is the Mars Exploration Laboratory on one of the spokes. This will feature not only simulated Mars gravity, but also Mars atmospheric conditions and environment, and will consequently allow testing of various Mars equipment and vehicles (including the prefabricated base) as well as acclimation of future Mars explorers.

This design for Aresam includes several other distinguishing innovative features. The spiral hydroponics sections in the spokes are a unique way of designing agricultural processes that require minimal equipment for harvest and can be easily controlled, run and adapted through automated processes. The orbital location has been carefully selected for maximum sunlight and proximity to any potential mining operations. The cross-sectional layout with a park area at the top, combined with the blocked community design and near-Earth atmospheric and ambient conditions, causes residents to feel "right at home" despite being millions and millions of kilometers away from their actual home.

Aresam is the ultimate gateway to Mars and space-based manufacturing center to Earth, incorporating a profusion of unique designs that make it suitable and profitable for the Foundation Society in all aspects of its mission.

STRUCTURAL DESIGN



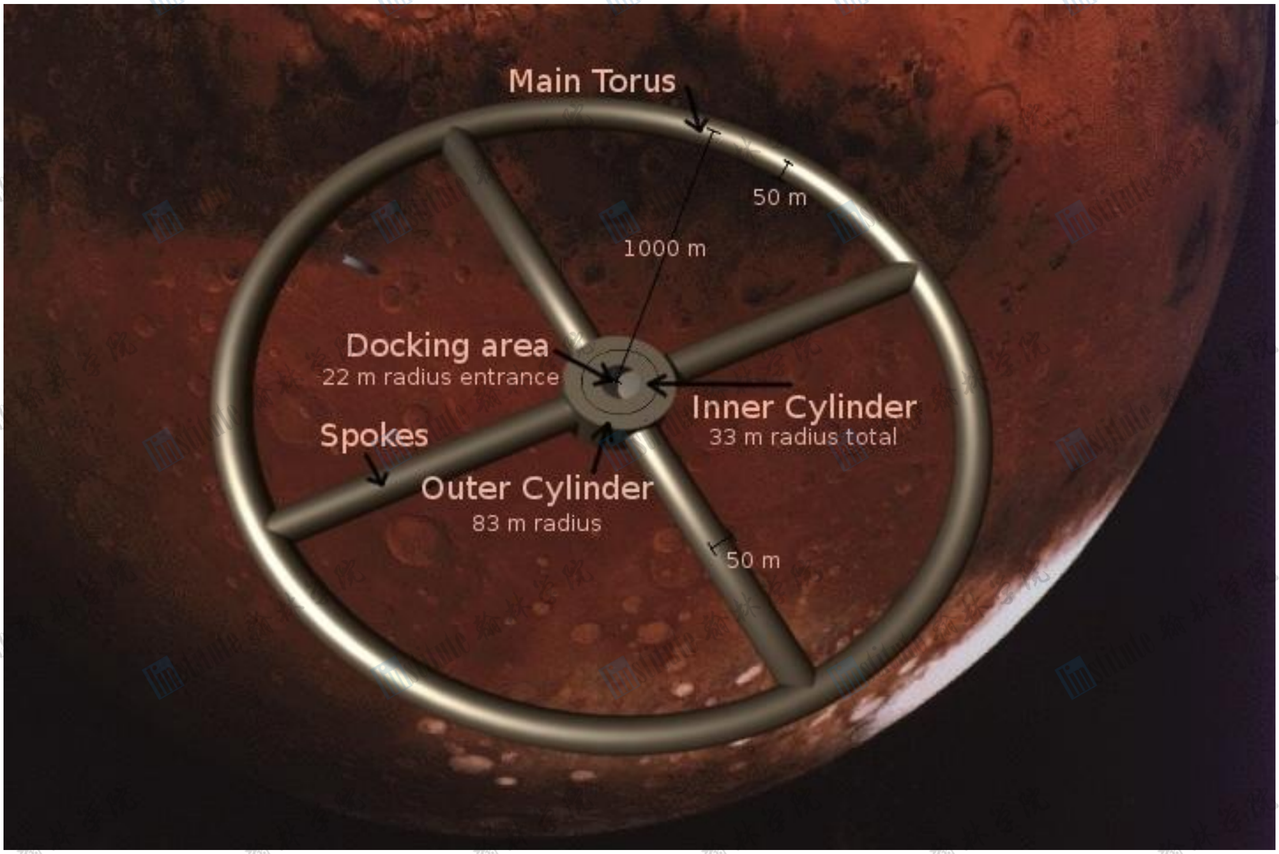
A great building must begin with the unmeasurable, must go through measurable means when it is being designed and in the end must be unmeasurable."

- Louis Kahn

2.0 Structural Design

2.1 External Design

The overall design of the station is a torus, connected to a central cylinder. The torus design efficiently uses construction materials for the greatest inside volume, as well as evenly distributing physical strain from rotation and atmospheric pressure. The torus will be connected to the central cylinder by four spokes. Each spoke will contain an elevator that is able to transport both cargo and personnel from the central docking port to the torus. Having four spokes will minimize the distance required to move manufactured goods to the elevators for shipping. The entire settlement itself will be 1 km in radius, from the central cylinder to the torus.



2.1.1 Artificial Gravity

2.1.1.1 Magnitude

The outer ring of the torus will have the same magnitude of gravity as Earth. Simulating Earth's gravity will ensure that muscle decay and bone density loss should not occur. Different altitudes within the torus will not have noticeable effects on gravity.

Approximately 4/10 of the way from the inner hub to the outer ring, there are Mars Research Laboratories where the gravity is equal to that on Mars. These will contain rooms with similar atmospheric conditions as those on Mars and simulated Mars Environments. These rooms will allow Mars-bound personnel to get acclimated to the gravity and conditions they will experience on the surface of Mars and will allow researchers to test any Mars exploration equipment, vehicles, robots, spacesuits, etc, including the prefabricated base. Due to this process, any equipment or designs used on the surface of Mars will have already undergone ample Mars-like testing and there will be low probability of bad design or failure.

2.1.1.2 Rotation Rate

Studies have been performed that indicate a maximum of two rotations per minute for continuous habitation in most cases. A rate near one rpm has been selected for our station to minimize disorienting effects. The radius of the station is highly dependent on the rotational rate of the station. The radius of the station must be large enough to generate the acceleration without excessive rotation. For a desired acceleration, *a* in m/s^2, and rotational rate ω in rpm the radius is given by: $r = \frac{900a}{\pi^2\omega^2}$, where r is measured in meters. The final rotation rate will be 0.946 rpm and a 1000 m overall radius will be used accordingly to have the same 9.8 m/s^2 gravitational acceleration as on Earth. The difference in acceleration between the head and foot of a human can be considered negligible, as the height of a human is much less than the radius of the station.

2.1.1.3 Means of Initiation

Due to the obvious difficulties posed to construction by a rotating structure, the rotation of the station will be initiated after structural construction is complete. The structure of the station and all major infrastructure such as the plumbing and wiring around the station will be in place before rotation is initiated.
After initial construction is complete, the station will be spun up to its operational rotation. Traditional chemical thrusters will be used due to the large torques needed. A total of 8 thrusters will be evenly spaced around the perimeter of the torus. They will fire their thrusters tangentially and simultaneously. Each chemical rocket will have 1 MN of thrust. The rockets will be fired for 15 minutes daily over a period of one month to bring the station to the desired 0.95 rpm. The thrusters will be retained at their positions around the outer radius of the station to allow for boosts later on to return the station to optimal rotation and orbit in case of deviation.

2.1.2 Volumes

The ring will have a radius of 1000 m as measured from the center of the settlement to the center of the ring. The torus itself will have a 100 m cross sectional diameter. The radiation shielding and debris protection will add another 0.9 m to the outside of the ring. The spokes will also have a radius of 50 m inside and they will have shielding and debris protection added on top. Having the same dimensions and exterior structural designs for the spokes and torus is advantageous in that it greatly simplifies the construction process as the majority of the station uses the same interchangeable and modular exteriors.

2.1.2.1 Material

Material	Purpose	Source	Approximate quantity (metric tons)
Aluminum	Main skin of the station	Mars, earth	720,000
Steel	Structural part of the station	Bellevistat factory, earth; Phobos/Deimos	800,000
Titanium	Debris Protection	Mars	700,000
UHMW polyethylene fiber	Primary cosmic radiation shielding	Half earth, other half Deimos and Phobos	300,000
Water	Secondary cosmic radiation shielding	Primarily from the polar caps of Mars	400,000
Other plastics, organic materials	Various uses in interior of station such as furniture	75% from earth, 25% taken from Deimos and Phobos	200,000

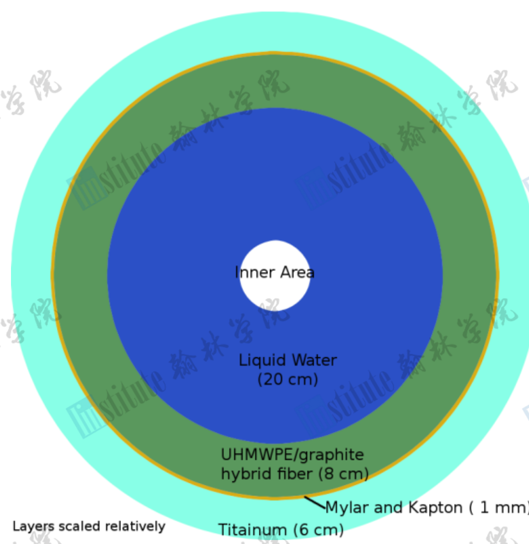
2.1.2.2 Design Features

Feature	Location	Purpose	Volume (m^3)	Gravity Level	Surface Area (m^2)
Main Torus	Outside of the "ring", 1000 m around from center	Residential, commercial, research, livestock agriculture, 1G manufacturing, utilities, free space	4.12 x 10^7	approximately 9.8 m/s^2	1,975,000
Spokes	Between torus and central cylinder, 90° apart	Plant agriculture, utilities, transport from torus to cylinder, Mars exploration research, storage	3.14 x 10^7	Gradient from microgravity to approximately 9.8 m/s^2	1,320,000
Outer Cylinder	Outside of Central Cylinder	Micro-G Manufacturing, storage, shipping/cargo handling, Mars Exploration preparation, departures/arrivals of passengers	2.12 x 10^6	Microgravity	95,000
Inner Cylinder	Inner area of Central Cylinder	Docking, unloading, loading, provisioning and repair of spaceships	5.65 x 10^5	0G and microgravity	

2.1.3 Protection

2.1.3.1 Radiation and Debris

Protection from cosmic radiation will consist of an 8 cm layer of Ultra High Molecular Weight Polyethylene Fibers with graphite (UHMWPE/graphite) for primary radiation protection and structural support. Water is used for secondary radiation protection. The water thickness will be 0.2m. Between the fiber material and titanium there will be a layer of insulating material, consisting of 100 layers of alternating Mylar and Kapton, with a layer of beta cloth every tenth layer for strength. Insulation material is required to keep the liquid water from freezing. The main debris protection for the space station is a 6 cm layer of titanium, which can stop all small objects of size up to 10 cm traveling at 7km/sec.

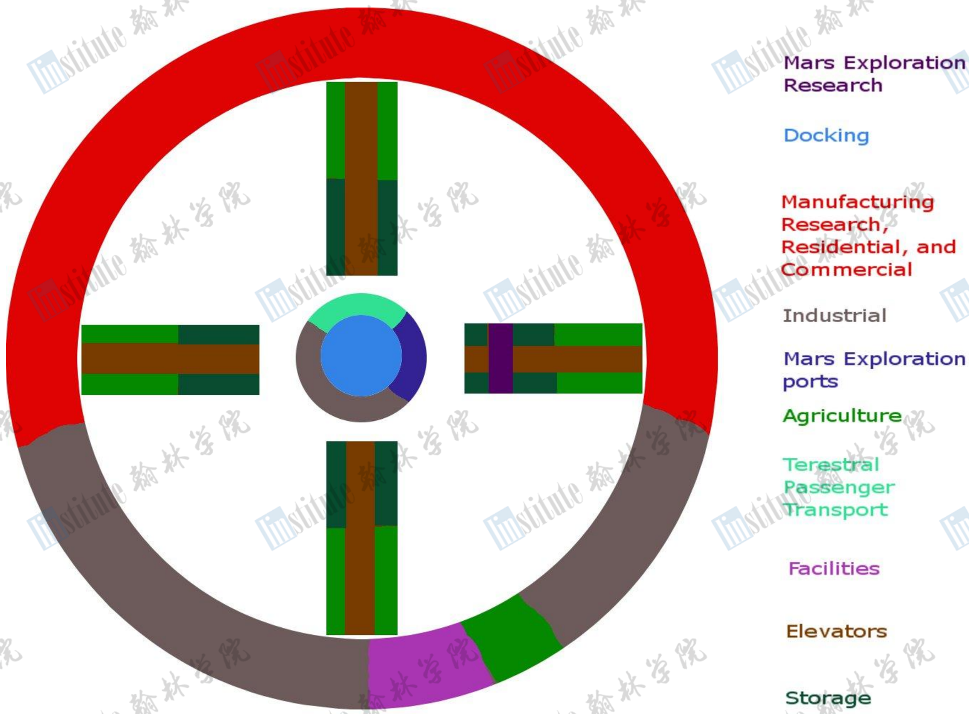


Layer	Purpose	Composition	Thickness
First	Debris protection	Titanium	6 cm
Second	Thermal insulation	Multi-layer insulation, Mylar and Kapton	100 layers of 10 µm, total of 1 mm
Third	Primary radiation protection	UHMWPE/graphite hybrid fiber	8 cm
Fourth	Secondary radiation protection	Liquid Water	0.2 m

2.1.3.2 Isolation

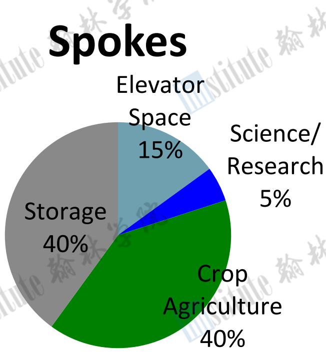
The Emergency Section Shutdown and Isolation System (ESSIS) will consist of inflatable walls that are strategically positioned within the torus equidistant from each other thereby dividing it into 8 sectors. The 4 spokes will also have inflatable walls installed at the end of each spoke thus making each spoke an isolation volume for a total of 12 isolation volumes within the entire space station. The walls are a meter thick when inflated and are composed of Vectran, a material twice as strong as Kevlar, with multi-layer insulation built into it. They are rigid in shape and possess high strength. They are stored in the wall sections of the torus and will be used in the occasion of any contingencies requiring section isolation (see 5.2.3). The walls are strong enough to handle any kind of debris hitting it, well insulated enough not to lose any heat, and precisely designed to be airtight once inflated. A Further measure to prevent leaking air from one isolated volume from entering another is the application of self-expanding foam to the places where the inflatable wall touches with the wall of the torus. The foam, once applied, expands to fill any remaining cracks between surfaces. This will ensure that there is a continuous airtight seal.

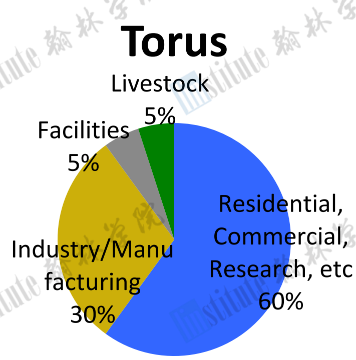
2.2 Interior Spaces

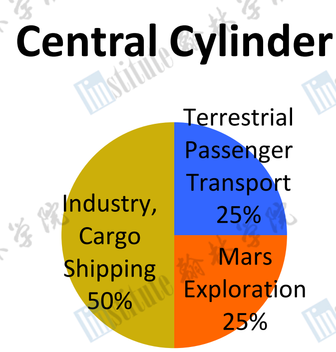


The outer torus makes up the majority of the volume and space on the settlement. It is primarily used for residential, commercial, research and manufacturing. The agricultural area is primarily along the spokes with an additional sector within the torus. The station will have 1.89×10^7 m^3 allocated to residential spaces while 2.10×10^7 m^3 will be allocated to the growing and production of crops for consumption and sustainability. These volumes are based on a projected holding capacity of 23,000 people. A total volume of nearly $4\times10^7 m^3$ will be required. This minimum requirement was used to determine the size of the torus. Additional volume was included in order to accommodate the needed commercial and manufacturing space for the production of goods (see 2.4) and to provide for more open and livable spaces. A large cylinder at the central hub of the station provides a docking port, warehousing, and additional manufacturing area (see 7.1).

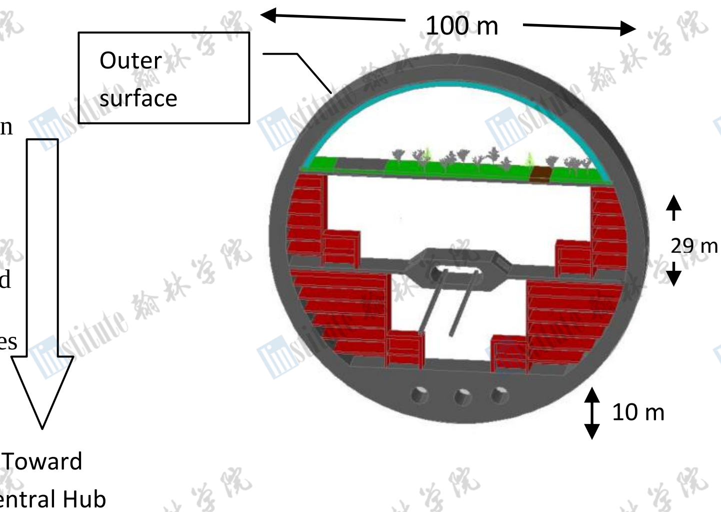
2.2.1 Interior Volumes







2.2.2 Vertical Clearance

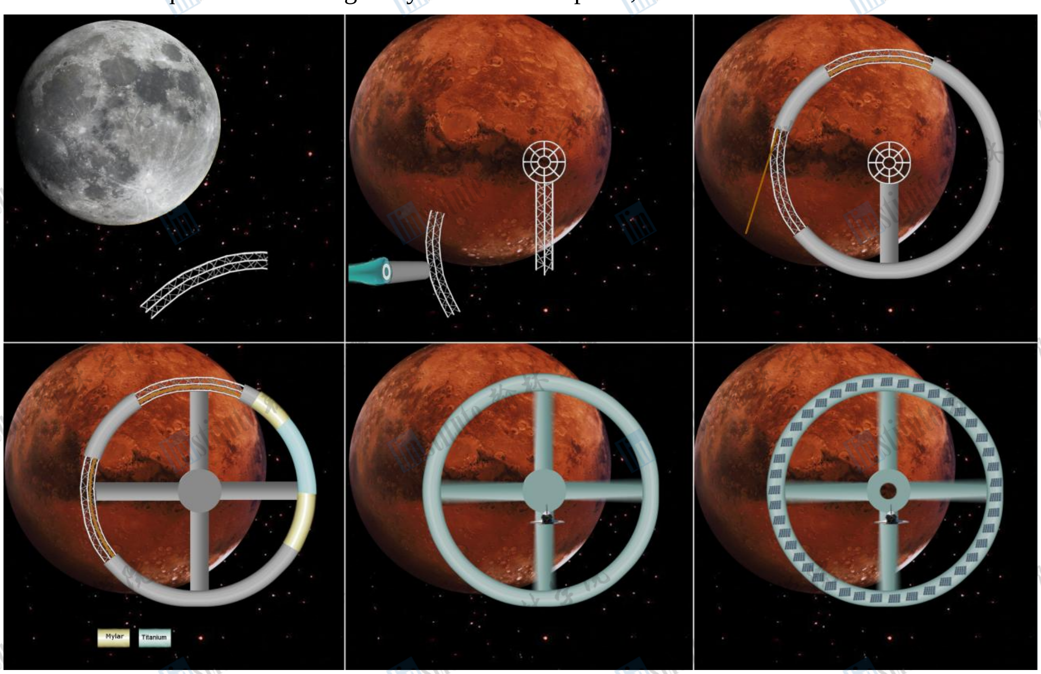


The torus will be divided into 4 levels. The three main levels of the station will have a floor to ceiling clearance of 30 m. The floor-to-floor height is 30 m, which allows for 1 m of piping, air circulation and other systems that need to run between floors. The railway system is sandwiched between the second and third floor of the station. The last level, the utility level, will be 10 meters high and house all utility pipes and routing, temporary storage, etc.

2.3 Construction Process

2.3.1 Exterior

Assembly of the station's 25 different lattice structure sections will start in the limited assembly space available around the automated factory at Bellevistat operated by Northdonning Heedwell. Assembly will start with the one hub section, followed by the four identical spoke sections that connect to the hub, then the four spoke sections that connect to the torus, then the four torus sections that connect to the spokes, and then the twelve identical torus sections that connect to the sections connected to the spokes. Prefabricated living and construction modules will be sent on a long term, low energy journey to Martian orbit. The human workers on the construction phase will be sent on a high speed and high energy journey to meet up with their living modules and tools without enduring unnecessary time in transit. The finished hub structural lattice will be sent when Mars is approaching Earth so that the different lattice sections can arrive sooner together with similar energy level launches. The human and robotic construction crew will receive, assemble, and weld together the geodesic lattice patterned sections starting from the hub, out to the spokes, and then around the torus. While there is nothing covering the geodesic grid of the structural supports, large fixtures and structures will be constructed inside the lattice. While structural sections are still being assembled to form the torus, radiation shielding and the station's shell will be constructed around the already assembled structures. When the radiation shielding and shell are completed, the station will be filled with the gases constituting its atmosphere. After the atmospheric pressure is normalized, construction will continue on interior structures. Solar panels will be installed on the sun facing side of the station. After all interior construction is completed except for that which requires simulated gravity to be fixed in place, the station will fire its chemical thrusters to enter into a .946 rpm rotation to simulate Earth's gravity at the center of the torus (see 2.1.1.3). The final interior construction will then be completed.



2.3.2 Interior

The interior construction of the station will commence before the station is rotated up to full gravity. Large pre-made fixtures will be inserted inside the station before the shielding and shell are in place. This allows for the large fixtures to be placed right where they are needed through the gaps in the truss structure. Structures such as piping for waste management and the structural supports of the main buildings will be included in the pre-gravity and pre-shielding construction. The lack of gravity is also beneficial to the construction of these large structures as they can be fixed in place without the need for a large amount of high-strength scaffolding and cranes, which are necessary for Earth construction. After the outer shell and radiation shield are finished, interior construction of walls, flooring, and other fixtures, will be finished for the buildings. This will allow for humans and robots to continue construction without fear of injury or damage from radiation. After the station is rotated up to its final speed, final construction can be finished for objects and facilities that require gravity for completion. Manufacturing of materials from the Martian moons, Deimos and Phobos, will yield various steel alloys and materials necessary for construction, which can be fabricated into the structural supports of the buildings and flooring.

2.4 Features of Expansion

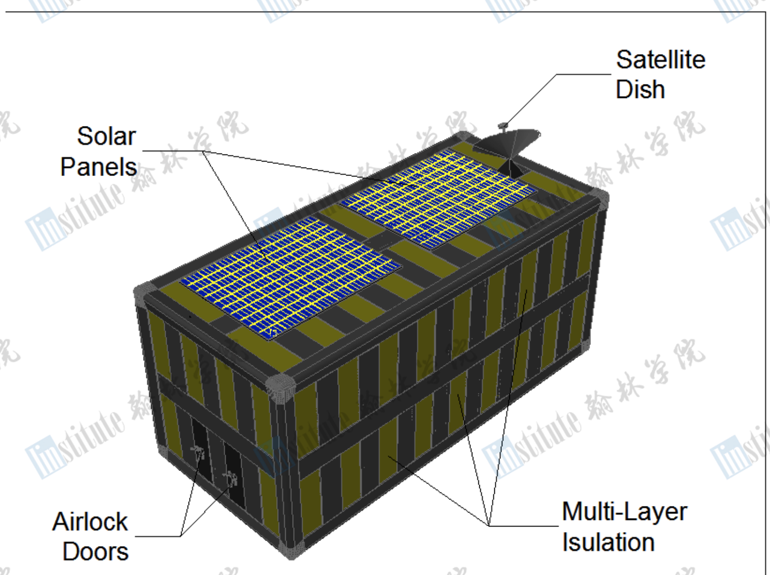
2.4.1 Overall Expansion Features

In order to allow the station to expand, there will be significant extra space from the first completion of the station. Roughly one third of the station, including two of the four central cylinder manufacturing sections (see 7.1) will initially be empty and remain this way until ready to be used. The space will have plumbing, electricity, radiation shielding and similar features pre-installed, making it extremely simple to expand into.

2.4.2 Docking Versatility

The docking port is designed to be very versatile (see 7.1). The only real constraint will be the 22 m diameter opening in the station to allow docking. Ships will not be required to enter any inside docking area or hanger and will instead be accessed by bridges and cranes. Since the bridge will not change its design, as long as all future ships can accommodate the initial design of the bridge, they will be able to dock at the station, irrespective of their other design features. For diagrams showing port modifications to accommodate currently unknowable vehicles, see 7.1

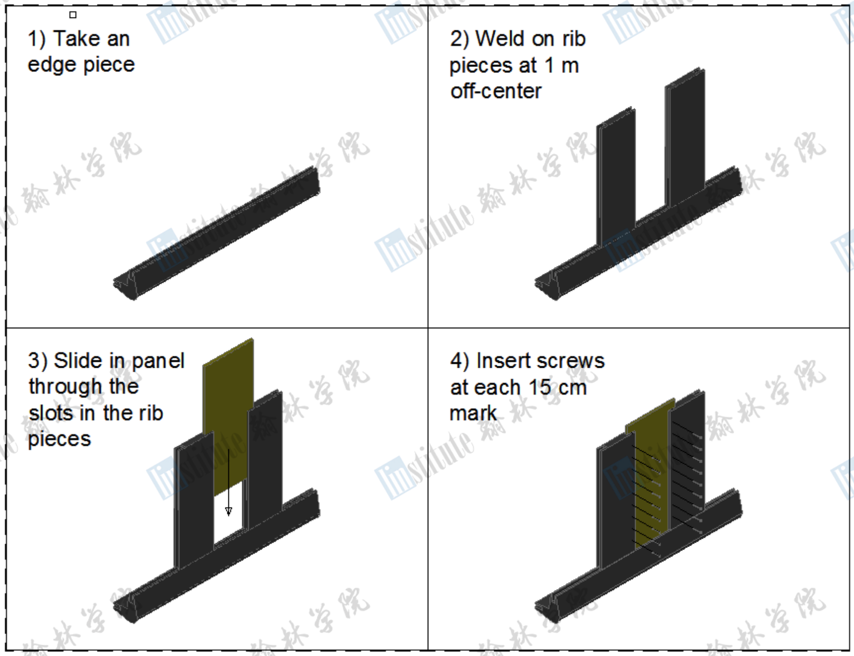
2.5 Mars Surface Deployment

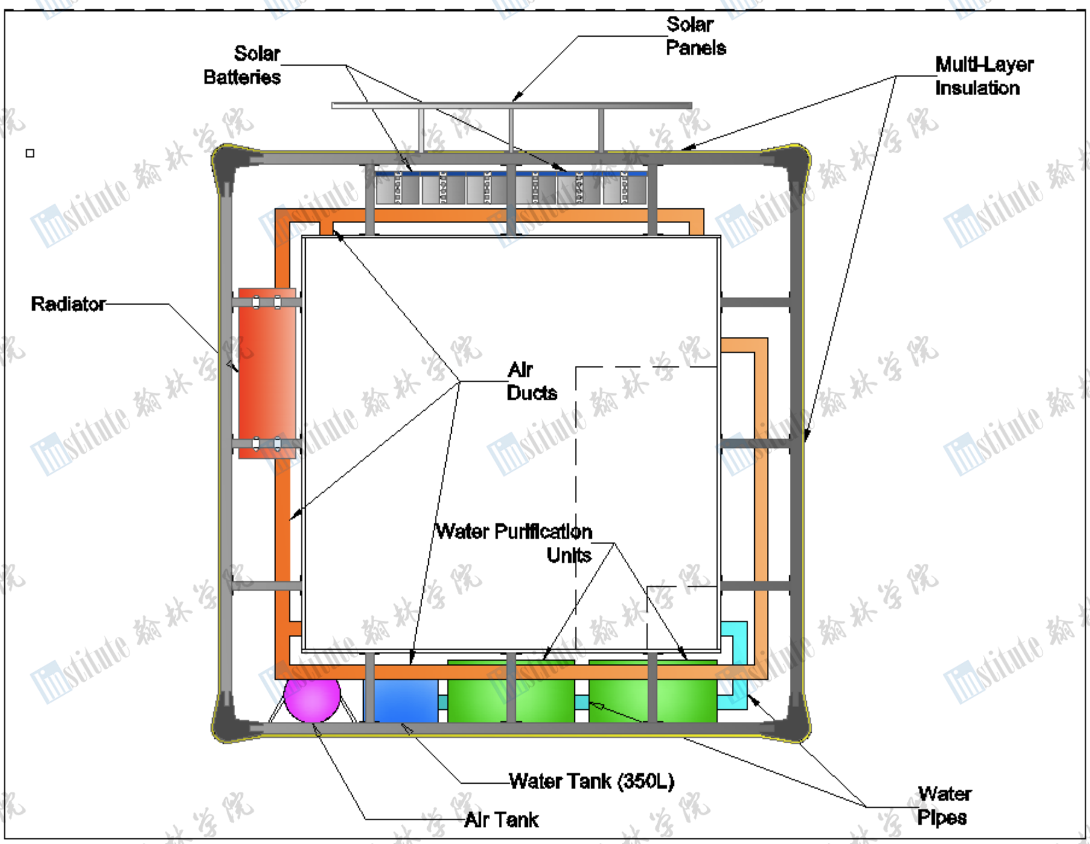


The prefabricated base and all necessary provisions will fit easily within the confines of one 4m x 4m x 9m cargo container and will comfortably accommodate four people for more than 30 days. The base was designed to include all necessary life support features, research equipment, and communication to Aresam, while still being easy and fast to construct (see diagrams).

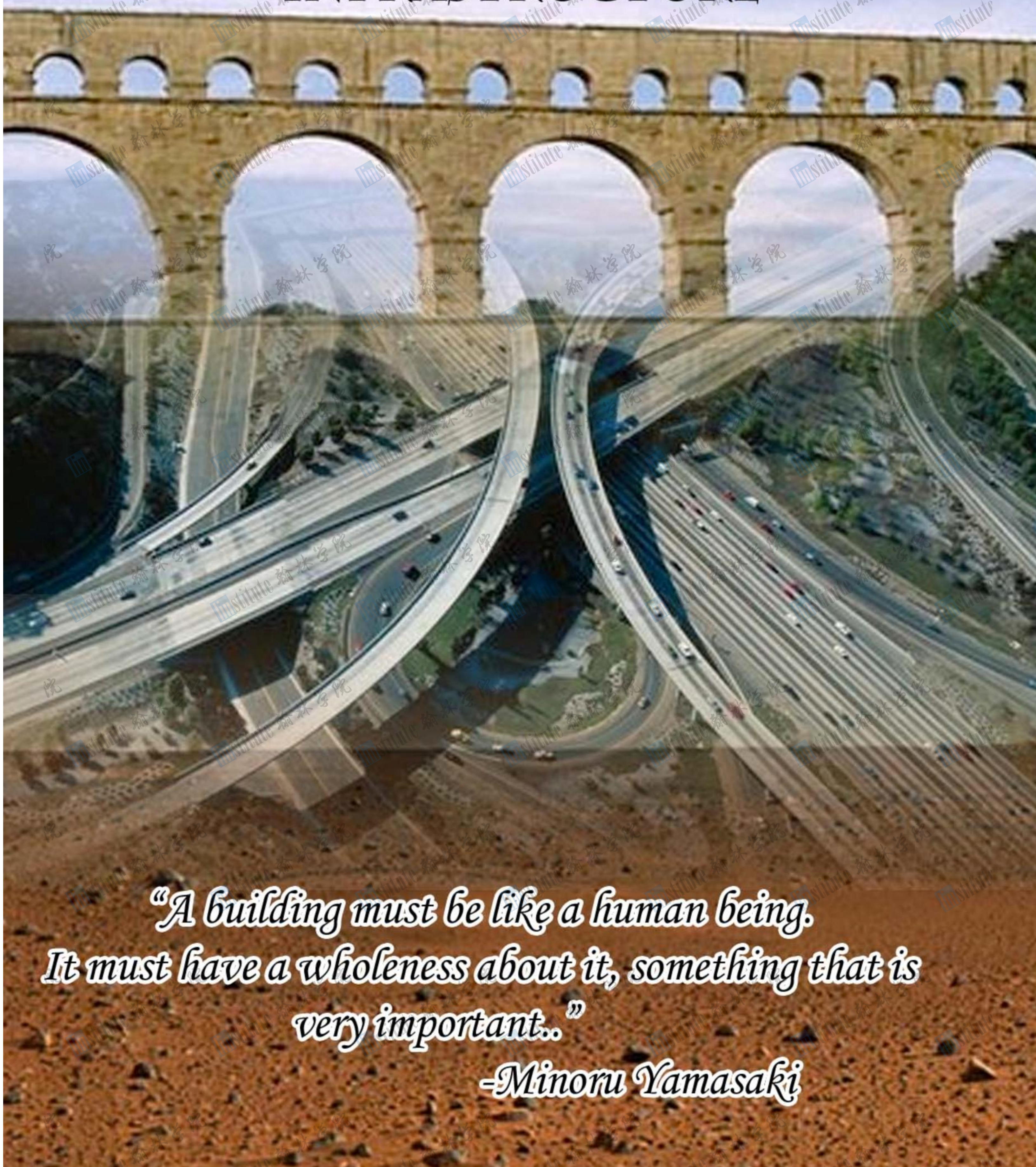
The prefabricated structure that is to be deployed on the surface of Mars has several advances that decrease the time need to construction this structure. Primarily, the prefabricated structure will be created with a simple slot design. Here, the assembly is simple: first, take an edge piece and weld the rib pieces at 10 meters OC (off center); next, slide in the panels through the slots given in the rib and edge pieces; lastly, in order to properly seal the structure (it will be automatically sealed once the interior air pressure is configured), insert screws at 15 centimeters OC. The building process is enhanced since the gravity on Mars is only 38% of that on Earth, allowing the two astronauts building this structure much ease in maneuvering the metal pieces. This simple construction procedure will allow two astronauts to easily construct the entire base in only a few hours, which is essential for all explorers' survival and for maximizing on-surface time spent on research and exploration.

The interior is, once again, of minimalist construction. All there is to the construction are steel supports (6 cm thick, 14 cm at the ends, 50 cm tall) at 1 meter OC holding up a 2 cm thick floor. Not only is this easy to make, it leaves much space for the actual interior room (286 cm x 286 cm x 786 cm) and for the utilities to fit between the floor and the exterior walls. As for insulation, multi-layer insulation, the "gold foil" seen on many satellites, will be used for keeping heat inside the structure, as it is light (just over a centimeter in thickness) and easy to apply.





OPERATIONS AND INFRASTRUCTURE



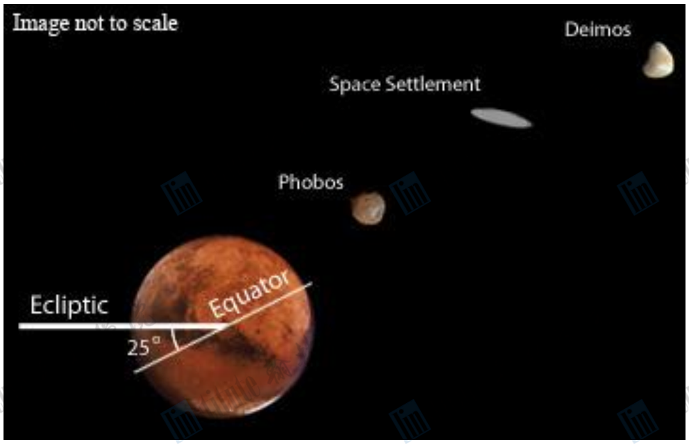
"A building must be like a human being.
It must have a wholeness about it, something that is very important.."

-Minoru Yamasaki

3.0 Operations and Infrastructure

3.1 Construction

3.1.1 Orbital Location



Aresam will orbit between the orbits of Phobos and Deimos, approximately 16,000 km from Mars, at the same inclination of 1 degree from Mars' equator, 26 degrees from the ecliptic, and orbiting in the same direction as the moons. This gives the station easier access to both moons because in the ideal orbital position, where the space station and the moons align, it's closer to both than in any other position. In addition, each moon will be closer to the station for longer continuous periods of time. Finally, since the inclination is large relative to the ecliptic, mars will block less sunlight from reaching the station. The space settlement's orbit has been calculated to be approximately 1.7km/s in tangential velocity with a period of 17 hours.

3.1.2 Materials

The materials that make up a vast majority of the settlement include Aluminum, Steel, UHMW polyethylene fiber, water for shielding, Titanium and plastics. Steel will be used extensively for the main structural parts of the Aresam and much of it can be taken in pre-built form from the Bellevistat factory and be procured through mining operations on Phobos and Deimos, which have significant amounts of Iron and Carbon (the two elements necessary for steel). Aluminum will be used to build the outside of Aresam and for some of the structures inside Aresam. Much of it can be mined from mars but to speed up the building process, approximately half of it will be brought from earth. Since Phobos and Deimos contain a lot of organic material, mining can be used for the UHMWPE fiber and other plastics. However, since UHMWPE can be difficult to manufacture, about half of it will be brought pre-made from earth. Another material that will be needed in large quantities is Titanium, which will be used for debris protection. This will be obtained primarily from Mars, where it is abundant. For specific table identifying types, amounts and sources of construction materials see 2.1.1.2. For equipment (robots) used for construction, see 5.3.1.

3.2 Infrastructure

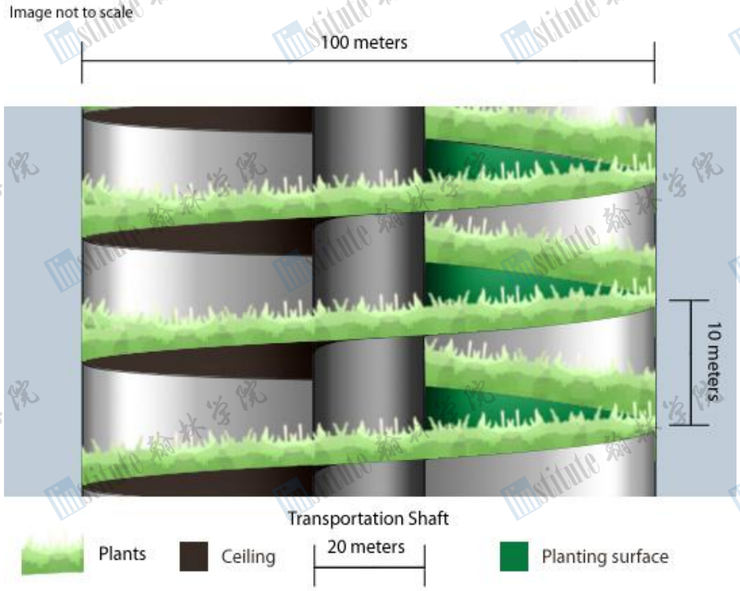
3.2.1 Atmospheric Control

Composition	Volume	Pressure	Humidity
79% N_2, 20.9% O_2, 0.1% CO_2	$7.25x10^7$ m^3	100 kPa	40%

The atmospheric composition of Aresam will be composed of 79% N_2, 20.9% O_2 and 0.1% CO_2. These conditions mimic the atmospheric composition of Earth, without any of the trace gases. Nitrogen gas will serve as an inert gas used to maintain pressure. The primary source of O_2 will be from the agricultural sector of the space settlement, where plants will remove CO_2 from the atmosphere and produce O_2. This oxygen will be collected and then vented into the rest of the settlement. In the event of an emergency, liquid oxygen in pressurized tanks and an oxygen generator that uses the decomposition potassium chlorate ($2KClO_3(s) \rightarrow 3O_2(g) + 2KCl(s)$) with catalytic MnO_2 will provide an immediate source of oxygen, located in the weather module stations. Maintaining the air composition on Aresam also includes the removal of unwanted gases. CO_2 will be removed with zeolite, collected, and then vented into the agriculture chamber. Any pollutants will be removed by being processed through scrubbers and electrostatic precipitators, which form a part of the air circulation system. The atmosphere will have a volume of $7.25x10^7$ m^3 (the total volume of the station) and will be maintained at 100 kPa. The average temperature in the station will be 23°C and the air will be maintained at 40% humidity in order to mimic conditions on Earth. Weather modules stationed every 100m along the torus and the inner spokes will control the temperature and humidity and will create wind at speeds of 5 km/hr to circulate the air.

3.2.2 Food Production

Food will be harvested from both plants and animals in order to maintain a balanced diet for the settlement's residents. The outer 500m of each spoke (the half closer to the torus) will be used for agriculture. The growing area is an extensive spiral that circles the central transportation shaft, providing 3.75×10^5 m^2 of growing area each spoke for a total of 1.5×10^6 m^2 of arable space (see diagram). This design maximizes the available space while minimizing the amount of automation and robots needed to farm the entire area (one per spoke).



The plants will be grown in a continuous-flow hydroponics system where water is treated with a solution of nutrients at the bottom of the shaft, pumped up, and will flow down in a continuous cycle. Hydroponics are advantageous because they have significantly higher yield per area than conventional farming and require less and conserve more resources, which are all essential features for the settlement. The specific mixture of nutrients will depend on the particular crops grown in that spoke. The atmosphere in each shaft will have elevated CO_2 concentrations because it will receive the CO_2 collected from the weather stations found in the torus. They will also be exposed to constant high intensity Sodium lighting at all times to maximize harvests and minimize growth time. A balanced diet will consist of the foods shown in the table below. The wheat, soybeans, and rice will all have one spoke allotted for their growth, and the remaining four vegetables will be grown in the last spoke.

Food	Growing Area	Yield per Cycle
Wheat	3.75×10^5 m^2	3.39×10^5 kg
Soybeans	3.75×10^5 m^2	6.36×10^4 kg
Rice	3.75×10^5 m^2	5.05×10^5 kg
Tomatoes	5.06×10^3 m^2	2.27×10^5 kg
Spinach	1.24×10^5 m^2	2.65×10^5 kg
Lettuce	1.24×10^5 m^2	2.93×10^5 kg
Chinese Cabbage (Bok Choy)	1.24×10^5 m^2	2.51×10^5 kg

In addition to agriculture, animals will be raised for meat and eggs. Although a fully balanced diet can be achieved with plants only, meat will provide a psychological benefit because most humans are accustomed to eating meat. Domesticated pigs and chickens will be raised in the livestock sector in the torus, not the spokes because they would not be accustomed to low gravity. Organic wastes will be retained and used as a natural fertilizer. Meat livestock will be automatically regularly weighed and when passing a certain threshold will undergo health inspection, and continue through an automated slaughtering process, similar to those used on Earth. Most hens will be used for permanent egg production in an automated plant, while most male chicken will be consumed. Select males of both species will be retained for continued reproduction. All plants and animals raised for food will be genetically engineered to maximize harvests and nutritional value and minimize growth time. A portion of each plant harvest will be retained for seeding the next cycle of crops. Small amounts of additional edible plants such as various fruits will be located in park sections throughout the residential to serve as both deluxe food and decoration.

Once grown and harvested, all food will be collected and sent to a processing and packaging area of the torus. There, the food will be sealed into reusable containers, frozen, and stored in the appropriate facility (see 3.2.9). Food will be distributed to a centralized service station in the residential area of the torus, which will be kept stocked from the storage facility.

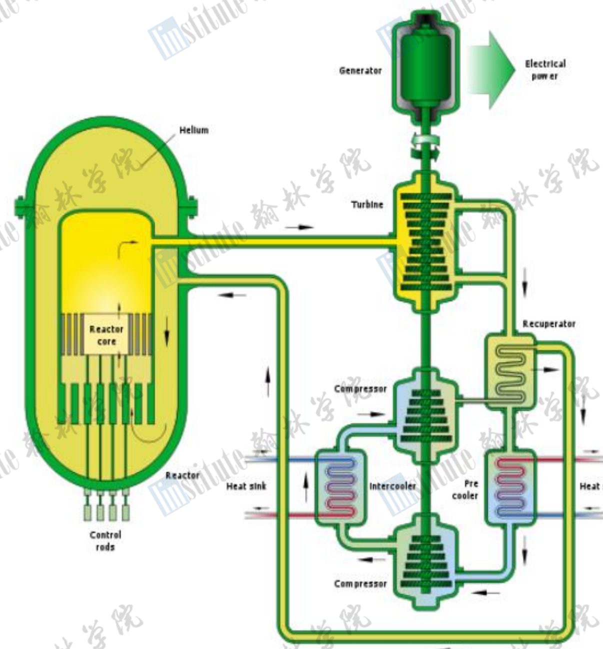
3.2.3 Electrical Generation

Electricity is extremely important for the operation of Aresam, so redundant measures will be taken to ensure that it will be available at all times. As such, the station will have three systems of generating electricity:

System	Maximum Output
Photovoltaic Cells	108 MW_e
Nuclear Fission	300 MW_e
Plasma Arc Gasification	8 MW_e
Total	416 MW_e

Photovoltaics
The system will almost always be exposed to sunlight, so the station will take advantage of this by installing multi-junction solar panels along the exterior of the torus on the half facing the sun. Each solar panel will be 30m x 10m and will be controlled by a computer so that it will maximize the radiation received from the sun at all times. This will give a total surface area of 180,000 m^2 of photovoltaic cells and will produce about 108 MW_e.

Nuclear Fission Reactor
This system will be a helium-cooled fast reactor using thorium as fuel and will be the main source of power for Aresam. It is a proven and reliable technology, which requires minimal maintenance and is very safe. The system starts with a mix of U-235 and thorium, and it breeds its own fuel. It only needs to be refueled minimally (about 3% of initial mass) every 18 months. The advantages of using thorium over uranium or plutonium as the primary fuel include: fission of thorium is more efficient than fission of uranium, a closed fuel cycle, and the fact that thorium is more abundant on Earth. Therefore, it is more economical and environmentally friendly to obtain. Thorium will also burn uranium and plutonium so that the waste will be mostly lighter elements that present a significantly smaller health risk. The reactor type is also advantageous over other fission reactors as, since it uses fast neutrons, does not require liquid coolants or a moderator such as water. This in turn significantly reduces the risk of pressure explosions and other nuclear emergencies. There will be one such reactor located within the Facilities section of the torus.



Plasma Arc Gasification
Plasma Arc Gasification is primarily a method of managing non-recyclable wastes, but will produce some electricity as a by-product. In this process, wastes are heated to temperatures exceeding 4,400°C and are broken down into its basic elements. Electricity can then be produced from the gasses that are released, giving a net gain of electricity.

The redundancy in the systems is intended so that if one of the main systems (1 or 2) fails, the other will be able to power Aresam until the failed one is repaired. The systems will produce as much electricity as is needed, which will usually be well below their maximum possible output. Electricity will run on sinusoidal AC currents with 240 Volt, 50 Hz configurations due to higher efficiency and compatibility with the majority of Earth's electronics. All generated electricity will be pooled at the Facilities section and distributed on a three-phase grid system to any location on Aresam.

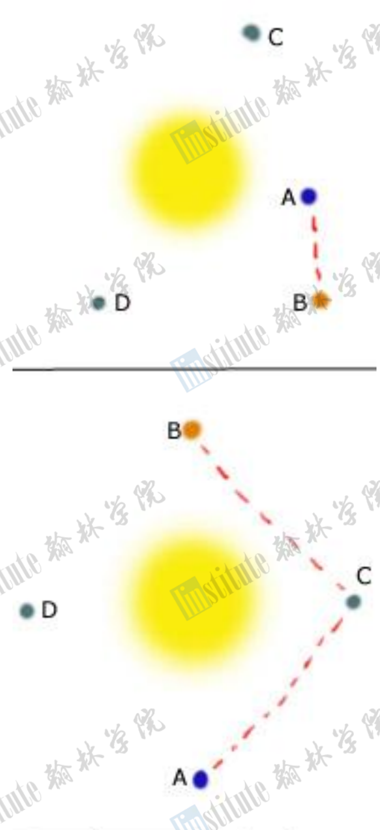
Maximum Output	416 MW_e
Residential, Commercial Use	20 MW
Industrial, Other Facilities Use	80 MW_e

3.2.4 Water Management

As water is one of the most important molecules central to life, a supply of clean water must be readily available to everyone in the settlement. Water can be harvested from ice on Mars' poles and from its two moons, and will also be recycled to the fullest extent to prolong its use. It will be used for agriculture, industry, as well as household consumption. The average American uses about 100 liters of water per day, so in space, with strict conservation, most people would need less than 50 liters of water a day. If people require approximately 50 liters of water per day, then the settlement will need about 1.5×10^6 liters of water. At any time, the settlement should carry enough water to last for 2 – 4 weeks, plus the amount of water needed for industry and/or agriculture. However, it won't need to carry 1.5 million liters daily, since an efficient treatment system will be able to recycle up to 90% of the water used.

3.2.5 Waste Management

The primary method of waste management in Aresam will be by reducing waste. All residents will be educated and regularly reminded of the importance of waste reduction. After that, almost all materials will be reusable or recyclable. These materials will be collected through chutes leading to every household as well as collection system in each community block. All recyclables will be automatically sorted and transported to respective manufacturing and distribution plants for reuse. Biodegradables will be transformed into fertilizer for agriculture. Any non-recyclable materials that are left, including hazardous wastes form the industry sections, will be sent to the Plasma Arc Gasification plant to be broken down. Plasma Arc Gasificaiton is capable of breaking down nearly any material and produces highly desirable syngas and a versatile slag for construction in response. It is also capable of powering itself and any additional energy produced from it will feed into the electrical grid (see 3.2.3).



A= Earth, B= Mars, C= Satelite 1, D= Satelite 2

3.2.6 Communication Systems

3.2.6.1 Internal

For internal communication, a wireless mesh system will be used. There will be dedicated hubs located every 500 meters along the torus. A wireless system is convenient, efficient and cheap and the mesh system will make it possible to have extensive wireless communication with less pre-built infrastructure. The wireless communication will be used for both transferring information and communicating with access devices. Amount and type of internal communications devices are specified in section 5.

In addition, there will be wired connections, similar to Ethernet, which will use high bandwidth digital cables. These will be connected to every laboratory and there will be one per every collection of housing units. They are best for emergency purposes or transferring large amounts of data to different labs.

For emergencies, there will be a PA system in every room in the torus wired with digital audio cables. It will work for every single room or can be directed to specific sections of the torus.

3.2.6.2 External

External communications will use the X-band of radio communications at approximately 8.0GHz. This frequency is ideal in terms of data transmission and signal strength over long distances. Transmitters will be located on opposite sides of the torus in case one side is not in an ideal position. To ensure continuous communication with Earth, there will be two relay satellites orbiting the Sun in the same orbital plane as the station and equidistant from it. When necessary, any communication signals will then be relayed to Earth through either of these two communications satellites (see diagram and 5.4). A laser system will also be employed for high data rate, satellite-to-satellite communications.

3.2.7 Internal Transportation Systems

In order to minimize the risk resulting from personal vehicles, optimize the use and conservation of resources, and allow for a less congested and more mobile movement in the station, public transportation will be used. This will be accomplished with trains that are electrically powered and move around the edges of the station at 60 mph.

The trains will have 5 primary residential stops, 10 industrial area stops, 5 emergency stops, and 10 secondary residential stops.

Line	Location of Stops	Area of Transportation
Residential Line	10 stops will be stationed equally around the residential area	Transportation around the residential area
Labor Line	5 stops will be stationed at the residential area and leave to the central working area where there will be 10 stops	Transportation for people to leave from the residential area to go to work
Emergency Line	5 stops at the stationed at various points around the station will lead directly to a medical center	Transportation from any point in the station to a medical center
Leisure Line	5 stops from the residential area will lead to the most used leisure activities, such as exercise, entertainment, viewing areas	Transportation from the residential area to areas used most often for leisure purposes
Docking Line	A main stop at the docking area will lead to 5 stops in the residential area (from there one could take the residential line)	Transportation for people arriving at the station to reach the residential area

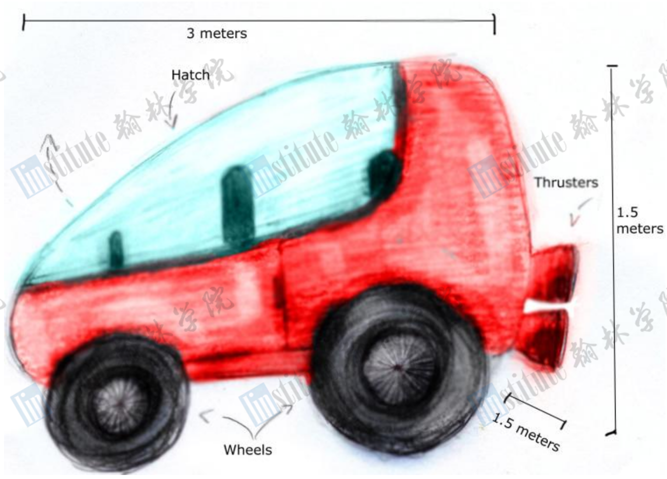
Between buildings, a system of moving walkways and pneumatically powered elevators will be used to move people around (see 4.1.5). The moving walkways will take residents to all points after they leave from mass public transportation, allowing for a faster way to move. The walkways will move at a safe and comfortable speed of 10 mph, and will lead directly to the entrances of all buildings.

Because fuel needs to be conserved for external transportation, electric power is important for an internal transportation vehicle. A brushless DC electric motor is expensive initially, but has a long lifespan, high efficiency, and requires little maintenance, making it preferable for the large amount of use internal transportation vehicles can expect on a space settlement. In order to support loads of varying sizes and shapes, the vehicle will not have walls or a roof, being essentially a mobile platform. A navigation system will be attached to the front for steering purposes, and a driver's seat is attached so that the load can be supervised in case of accidents or emergencies. The steering mechanism will involve electric power steering for efficiency and ease of use, backed up by a rack and pinion in case of component failure.

In order to transport goods to and from the torus, there will be four spokes connecting the torus to the central cylinder. In each spoke, there will be 2 elevators, with one going up and one going down. These elevators will be also used to transport people to the central cylinder, where the docking station, Mars exploration ports, and the terrestrial passenger transports are located.

There will be a primary transportation system to travel around the torus. There will be four train systems that extend completely around the Torus, which will be located in the center floor of the three floors. Two of the train paths will be going in a clockwise direction, while the other two go in a counter-clockwise direction. One in each direction will be solely used for goods and materials, while the other two will be used for human transportation. These two trains will have stops every 200 meters, for the civilians' transportation. In addition, at each of the stops, there will be an elevator to aid the civilians in moving from the middle floor to each of the other two floors in the torus. Both the elevators and the trains systems will be powered by electricity. The other two trains will be used for industrial transportation; they will have stops and vertical distribution centers every 400 meters.

Vehicle Type	Quantity
Electrical Train	4 for passengers and 4 for industrial use
Small car	120 shared by communities

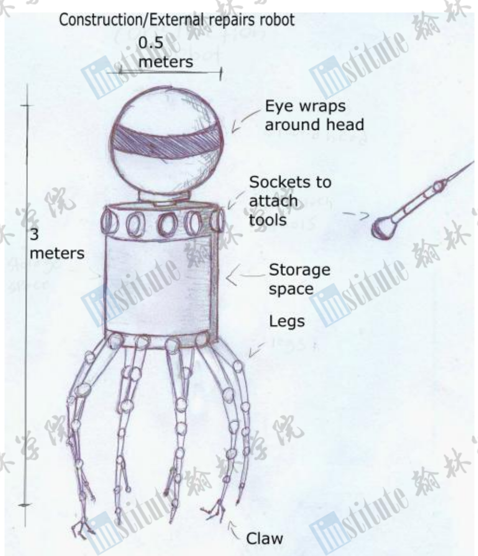


3.2.8 Day/Night Cycle

The main station will run on a constant, consistent 12 hour day and night cycle. Public lights affixed around the station will show this difference by dimming and brightening in accordance to the projected light on Earth. The station will be programmed with the amount of light Earth receives at each hour. A master clock, programmed with Earth's standard time, will project that amount of light, updating and changing it each hour. Only public lights will do this, as this will allow people to be reminded of Earth. Private lights, however, such as lights in residential homes, will not follow this schedule, and will be dimmed and brightened at the resident's leisure. At night, lights will be dimmed to a low dim, only bright enough to allow residents to see in case of emergencies. Through the day, lights will steadily increase in the amount of light they release and steadily decrease through the night, allowing for a close imitation of Earth. The type of lighting will primarily be LED lights affixed throughout the station, advantageous for their low temperatures and high efficiency, but there will also be a sky projection simulating earth environments in the upper level to remind people of their terrestrial home.

3.3 Construction Equipment Design

The overall construction process is described in detail in section 2.3. Nearly all primary exterior and interior construction that constitutes this process can be accomplished using the Hephaestus robots described in 5.3.1. The 1 robot will have modular, interchangeable tools for any purpose that can attach to its sides so it can accomplish any variety of tasks it is faced. The claws at its bottom will allow it to effectively move across and attach to any parts of the in-construction station, but these can also be replaced with wheels, suckers, or magnetic appendages, depending on designated area of use.

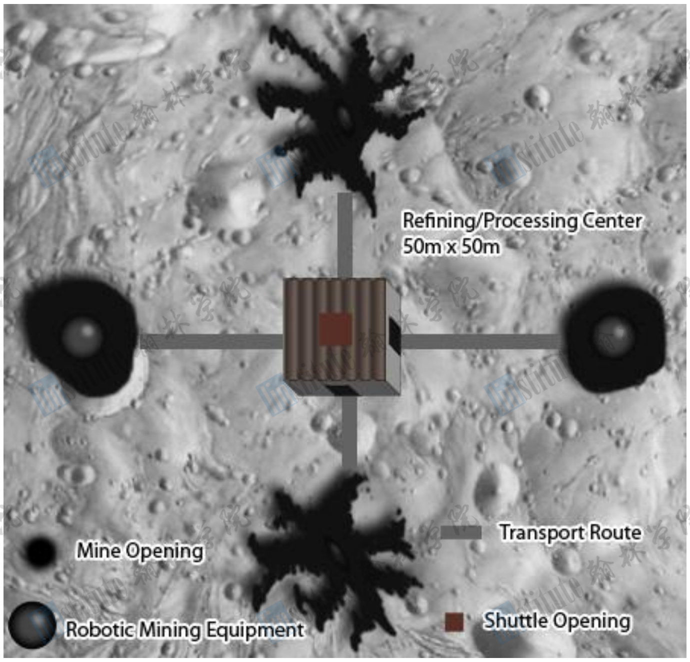


The materials necessary for construction (see 2.1.2.1) will be mined using the Mining Rover (see 5.5) and delivered using the cargo ships described in section 7.1. Various other robot designs, such as transportation robots and internal construction robots (see 5.3.1), will be used throughout the construction phases. Transportation robot will be preprogrammed and unmanned vehicles responsible for loading and unloading materials from and to the major storage to construction site. Assembling robots generally consist of smaller wheels for movement and arms for positioning; arms and wheels can be specialized for specific constructions. For example, pipes for water and gas can be put together by robots with smaller wheels sliding along the pipe line; they would consist of a tube connected to the pipe factory and an arm to place the sections of pipes in the correct position.

Automated conveyor belts connected to lower levels for materials, such as nails or glass panels, will also be installed to facilitate these processes. In the last stage, after a group of buildings is constructed, equipment or furniture is moved into the buildings with transportation robots gliding on the concave rails within the ceiling with or along the down surface by wheels. Drawers and cabinets are moved into labs with prefilled equipment, such as graduated cylinders or test tubes, from the manufacturing site.

The trails are paved by transportation robots with mechanisms that place down pieces of rectangular woods. For gravel trails, similar machines can also be used to trace out the path with gravel. Multi-armed robots will be used to perform tasks with a higher efficiency, eliminating the need for coordinating tasks among several humans or other robots.

3.4 Mining Operations



Phobos and Deimos contain large stores of important minerals, which make them vital in the construction of a space settlement. The equipment necessary to mine the two moons must be compact for ease of transport, and solar powered to conserve energy. Due to the lack of gravity, miners and equipment will need to anchor themselves to the surface, and a large net will be used to catch debris loosened during the mining process. Automated mining equipment will be utilized as much as possible to reduce the danger to workers and increase efficiency. The most effective mining methods to extract desired substances from the moons are strip mining and drilling. Minerals obtained through the mining process can be incorporated into the structure of the settlement. The compounds most accessible on the moons are silicates and metal sulfates. Silicon will be refined for use in electronics and ceramics through reaction with carbon at high temperatures, while the metal sulfates are refined through iron refining processes. These substances will be processed using electrolytic extractive metallurgy, charging the particles so that they can be separated magnetically. The refining and processing processes will be done on the moon and will be completely automated. The base of mining operations will be roughly a cross shape, with a contained structure for automated refining and processing in the center. The mining will take place a safe distance from the central structure, facilitated by rovers to transport minerals from the mines to the processing structure. The processing structure will be arranged to work from the outside towards the center, where processed and refined substances will be deposited into a shuttle for transportation to the settlement.

3.5 Deployment Infrastructure

3.5.1 Waste

As on Aresam, the primary means of waste handling will be reduction and reuse. Most materials brought to the surface will be reusable or recyclable, even over the 30-day period. For the non-reusable wastes that do accumulate, a small incinerator will be placed at one end of the base. Human wastes as well as household wastes will be burned by means of the incinerator. The resulting heat, produced by this incinerator, will be used to heat the base directly.

3.5.2 Water

Since water takes up significant space, only the bare minimum amount of water will be brought onto the base. The main use for this water will be for consumption. However, gray water will be used to wash dishes and take showers. In addition, to minimize the amount of water (excluding drinking water) that needs to be used, a 3 gal/min shower head, wet wipes, rinseless shampoo and edible toothpaste will be used. The average male needs to consume around three liters of water, while the average woman needs to consume around 2.5 liters of water each day. Therefore, around 325 liters of drinking water will need to be brought onto the base.

Similar to the space shuttle Endeavour of NASA, there will be a water distiller and filter that will process and purify the occupants' urine, sweat, and other waste waters. The purifying system is efficient enough to turn this water into fresh drinking water. This distiller and filter is approximately the size of two refrigerators next to each other. This water recycler is thought to be able to cut the need of carried fresh water by about 65% due to its efficient purifying system. It is approximated to be able to purify around 93% of the water it receives into clean drinking water.

3.5.3 Energy

The energy source for the base will be the sun. In order to maximize the amount of energy collected, photovoltaic cells will be placed on the outside of the base during the day when sunlight is available. This sunlight will be directly converted into electricity through the use of solar arrays. This energy will be stored by rechargeable nickel-hydrogen batteries, which are used during the nighttime and recharged each day during the daytime. The heat from the waste incinerator will be collected and used to heat the base. This way, no excess energy will need to be converted into a lower form of work.

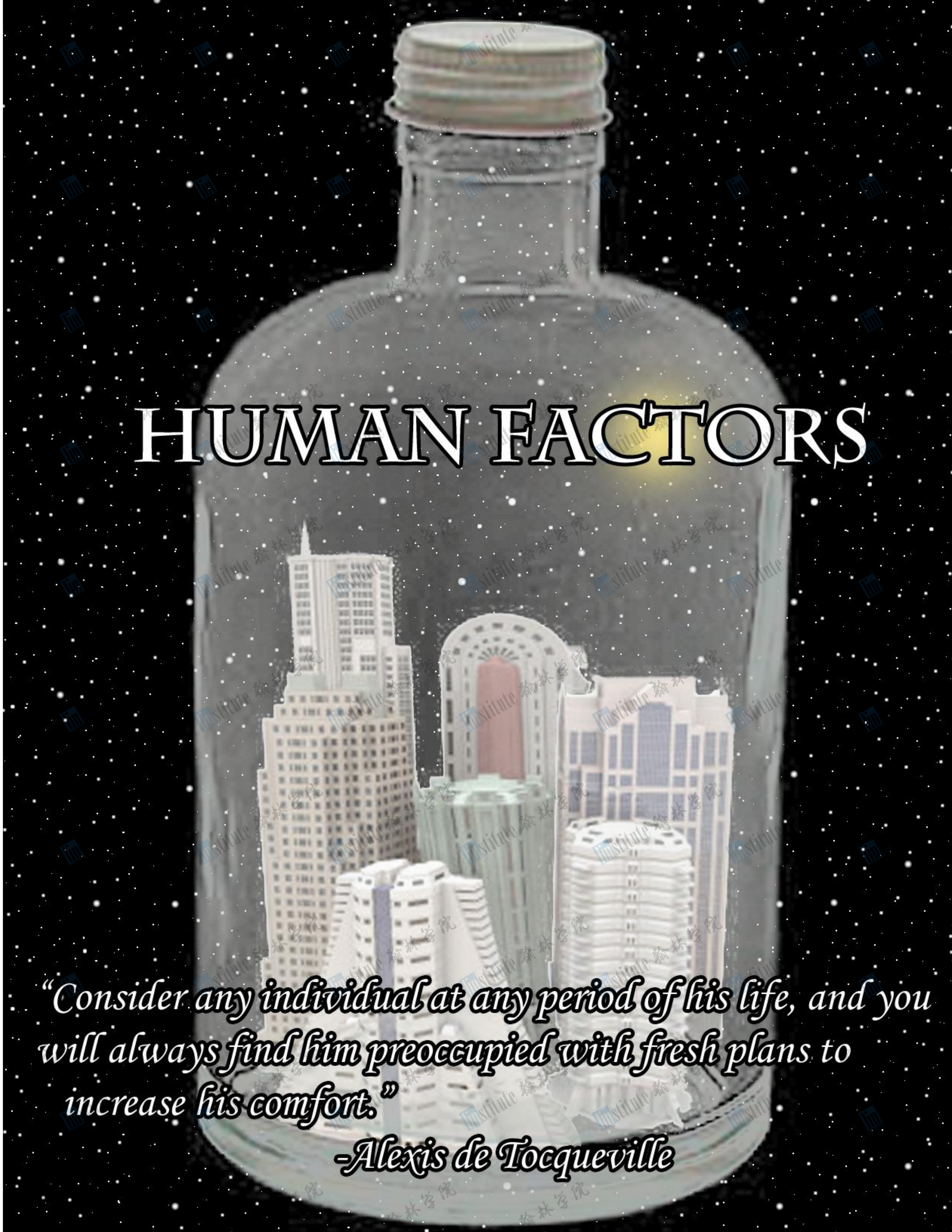
3.5.4 Atmosphere

In the fabricated base, there will be an oxygen producer. This device will split the oxygen and hydrogen molecules present in some waste water, releasing the oxygen into inhalable air. In addition to the oxygen producer, there will also be various tanks of oxygen. These tanks will be filled periodically by means of the oxygen producer. The tanks will be used for expedition onto Mars as well as for emergency purposes in the fabricated base. Additionally, there will be solid $KClO_3$, which will be heated to produce oxygen. The resulting H_2 gas will be contained and used as another form of energy, such as for heating.

3.5.5 Food

The food taken on the fabricated base will consist of packaged food produced on the settlement. Since the average amount of food consumed per person is 2.132 kilograms per day (according to US Department of Agriculture) and there are 4 people on the base for around 30 days, there should be at least 230 kilograms of food. However, in order to ensure the food amount for emergencies, an additional 150 kilograms (around an additional 18 days) will be stored. This food will be vacuum packed in order to minimize the space that it takes in the fabricated base. Such possible foods need to be able to be safely consumable for 30 or more days. Therefore, the majority of the foods will be dried: dried fruit, dried meat, wheat, rice, and dried vegetables.

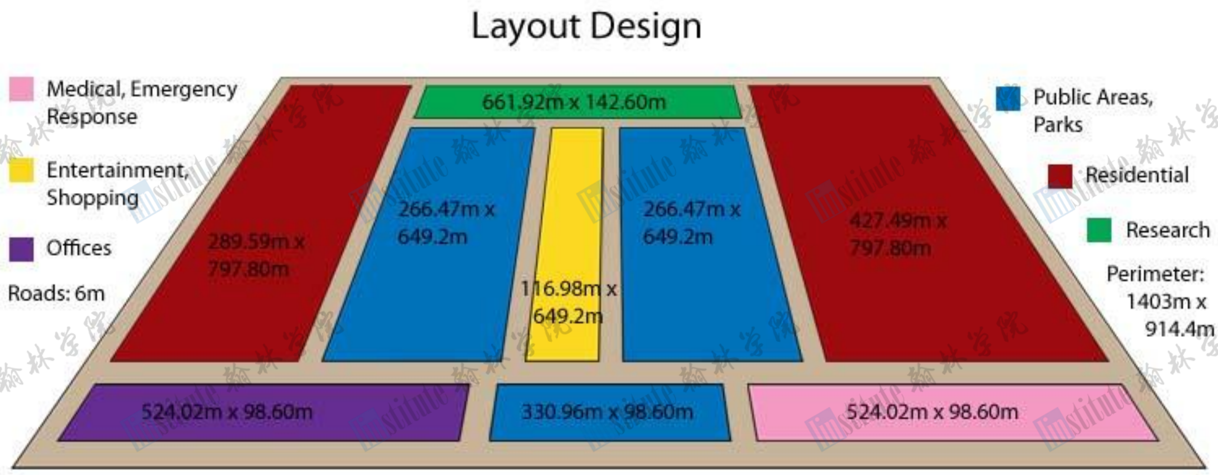
Resources	Quantities
Air	160 m^3 Total
Water	2800 L Total
Food	380 kg Total
Energy	6.5 kW
Waste	6.4 kg/day


HUMAN FACTORS
"Consider any individual at any period of his life, and you will always find him preoccupied with fresh plans to increase his comfort."
-Alexis de Tocqueville

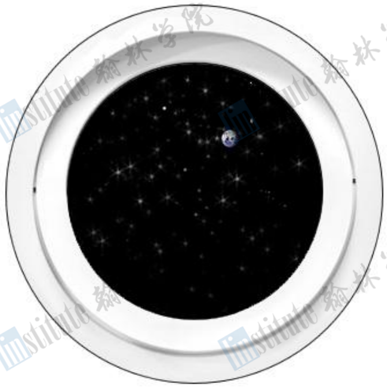
4.0 Human Factors

4.1 Community Design

The design of the community will consist of repeating units of the below diagram. The design of the residential areas on Aresam creates efficient travel between locations as well as a pleasant environment for the residents. The separated blocks of residential areas provide a location for large open spaces such as parks and commercial areas. The placement of the research and office areas also adds to the allusion of an expansive, well spread out community. This community design allows for a residential area that mimics a small town on earth and at the same time is an efficient living space for a work-oriented community. By building the parks in the middle of the community, residents can look out their windows and feel like they are on earth.



4.1.1 Natural Views



Besides living in an earth-like environment, residents will also want to be able to look at the natural views all around them. There will be certain viewing centers at different points in the residential areas where residents can go to view the sun, earth, and space. There will be a viewing center on each level as to provide easy access to all residents. At times that the windows are directly in line with the sun the centers will be closed to residents. This will protect them from potentially harmful UV rays and light exposure. The windows of the viewing centers will be made of fused Silica and Borosilicate glass. The glass will be streamlined with the curve of the station. The windows will also be equipped with shutters to protect it from space debris that might come in contact with the glass.

4.1.2 Entertainment, Activities and Education

Entertainment on the settlement is crucial because it helps stabilize the mental conditions of the residents and provides them with reminders of home. Residents will expect the same level of enjoyment on the station that they would have at home. Entertainment on the settlement will include several different sports complexes and community centers that will allow for physical contact and exertion. Virtual reality will provide for the remaining sources of entertainment. The sports complexes will be located close to low gravity areas in the immediate vicinity of the settlement. These complexes will feature all-purpose fields made of rubber synthetic grass that can support additional types of sports such as tennis, golf, frisbee, and kickball. A community center will be found on each level of the settlement. These centers will emphasize low-stress exercise and gym workouts, whereas the sports complexes will be dedicated mainly to low gravity sports. To ensure the safety of the occupants in the low gravity areas, there will be security handrails and tethers on the insides of the buildings. Bungee cords can be used to strap the person on the workout equipment if necessary. The entertainment on this settlement is meant to give people a more enjoyable and care free environment. To supplement existing facilities, virtual reality will be used for education, exercise, communication, and entertainment. Virtual reality limits the amount of space needed and provides people with a more surreal environment. The user will wear a set of virtual reality headgear, which uses stereoscopic imagery and olfactory enhancers to create the illusion of the environment of their choice. The virtual reality can provide 3D movies, video games, and virtual communication; a form of Internet unique to the settlement. To allow for user safety, spaces will be reserved for safe virtual reality environments. Users will walk around on a surface consisting of freely rotating metal spheres (2m diameter) which will allow more believable actions than if the user were not moving and will provide for their safety. The headgear will be completely wireless, but will need to be recharged nightly when not in use. This technology can be combined with other equipment for exercising to make these activities more entertaining and rewarding. There can be some short-term exercises similar to motion sensory exercise games or other interactive programs. Because virtual reality can cause intense dizziness, eyestrain, and headache, there will be safety devices and precautions, including emergency shut-off controls, in case of emergencies.

4.1.3 Public Areas

Public areas in the settlement will be made up of parks and open spaces in between areas of residential and business. These areas will be places for residents to relax and enjoy an earth-like environment. The parks systems will include a projection of the sky with a circadian light cycle, vegetation, benches, playgrounds, recycled flowing water, and a panoramic view of the settlement. The parks will be open at all times and will be available to people of all ages. Children will be able to play on the playgrounds while adults can listen to the relaxing sound of flowing water, stroll through the park and meet up with other residents. Everyone on the settlement will be able to take advantage of these calming, stress free, earth-like environments.

4.1.4 Medical

In order to minimize the negative effects of space flight on the human body, those travelling to Aresam must undergo a strength training program before the launch date in order to help make up for the bone and muscle loss that will result from the six month flight to Aresam. While travelling to the station, astronauts must eat foods that have been heavily fortified with vitamins to impede the loss of bone and muscle mass. Astronauts will also be required to perform two hours of exercise. This can include attaching oneself to a treadmill with bungee cords and weight training in a Lower Body Negative Pressure system to mimic the pull of gravity.

Upon arrival to Aresam, travelers will be brought to a medical facility for a full medical checkup in order to ensure no detectable pathogens enter the station. Travelers entering Aresam will also need to be given vitamin supplements to aid their bodies in regaining bone and muscle mass lost during the flight. In addition to a continued daily intake of vitamins, they will also be required to participate in at least an hour of physical exercise a day, which can include resistance training if desired. This will ensure that their health is returned to normal after the physically stressful flight.

Two medical doctors and seven nurses per 1000 people on Aresam will ensure that all residents receive quality treatment. Medical facilities feature advanced “smart” equipment to perform basic tasks, as well as robots to assist the doctors and nurses during procedures and rounds (see 5.3.1).

4.1.5 Roads and Paths

Between buildings and levels, a system of pneumatically powered elevators will be used to move people throughout the settlement. These pneumatically powered elevators will take the form of mobile platforms, so as to minimize resource use and maximize the amount of space available. Upon stepping into the center of the elevator, a sensor on the floor of the elevator will activate magnets in the shoes of each resident. The resident will then be magnetically attached to the elevator, allowing them to safely move in an open elevator. At each stop, the elevator will stop, the magnets will disengage, and the resident will be able to travel onwards. Roads and pathways will occupy approximately 5.8% of the space. See 3.2.7 for more internal transportation.

4.1.6 Consumer Goods

Variety	Quantity per year	Distribution Method	Description of Material	Sources
Appliances	125,000 appliances	Sent to depots	Major appliances will be air conditioners, microwaves, televisions, and computers. Other less notable appliances will be available for consumers.	Made at Aresam from raw materials mined and shipped from Earth.
Beverages	16,425,000 kg	Sent via tube system	Beverages will be available in a variety of flavors and types.	Made from liquid recycled on the station with other ingredients shipped from Earth.
Furniture	220,000 pieces of furniture	Sent to depots	Furniture will be available in couches, tables, desks, chairs, stands, shelves, and beds in different styles and designs.	Made at Aresam from raw materials shipped from Earth.
Clothing	100,000 outfits	Sent via tube system	Clothing will be available in different styles, designs, and size.	Made at Aresam from raw materials shipped from Earth.
Toiletries	358,000 kg	Sent via tube system	Toiletries will include sanitary items and cosmetic and grooming items in multiple types and styles.	Made at Aresam from raw materials shipped from Earth.
Food	5,475,000 kg	Sent via tube system	Food will either be delivered in: Meals ready-to-be eaten after being heated, Ingredients ready to make a meal, in accordance to the consumer's wish	Made from food grown at the agricultural section of Aresam,
School and Office Supplies	600,000 kg	Depends on item	Supplies will be objects that are needed in the office workplace or at school in order to conduct business or the school day efficiently and smoothly.	Made at Aresam from raw materials shipped from Earth.
Toys and Games	80,000	Depends on item	The main toy to be played will be a handheld video game player that will able to project and play holographic games	Made at Aresam from raw materials shipped from Earth.

4.1.6.1 Variety and Quantity

The items are the key items that are needed to maintain a stable society. Basic necessities are met, such as food and beverages. Social necessities, such as clothing and toiletries, are also met. Leisurely needs, furniture, appliances, school and office supplies, and toys and games, are met in order to provide the most comfort for consumers. The quantities for the variety of items are listed above. However, in order to ensure consumer satisfaction, there will be a surplus of items available compared to the size of the population in order to be used as replacements and to provide for the growing population. Each year, items will be examined to assess their performance. Items that are deemed to be malfunctioning or damaged will be replaced with items from this surplus. A continuous supply of items will be created and added to the surplus in order to stay at a comfortable limit above the population amount.

4.6.1.2 Distribution Method

Each building in Aresam will be connected to a system of pneumatic tubes called Hermes that stem from 4 main warehouses at each part of the station in order to provide the most convenience and least congestion for the consumers. Whenever a consumer wishes to attain an item, they enter their desired query into their personal computer, which is connected to the station's master network. The master computer will receive these requests, process them, and crosscheck with the rations lists to make sure that the requests fit in those parameters. The master computer will then send the request to one of eight main warehouses spread around the station according to the type of good. Robots at each warehouse will receive the request and select the desired object. After selecting it, the robot will process its size in order to determine what to do with it next. If the object is larger than 28 inches, the diameter of the tubes, the robots will place the item on a supply vehicle which will take the item to one of 50 depots stationed around the station, the depot chosen will be the one closest to the location of the computer which original sent the request. The station's network will then send a message to the computer, which sent the original request, stating that the item has arrived at the depot and what and where the depot is. Items that are less than 28 inches will be able to fit into the tube system and sent from there. The robots will choose the good and package and place into a canister. The canister will then be placed into the Hermes tube system and sent to the location, which sent out the original query. After receiving the item, the consumer will send back the canister after they have removed their desired item.

4.2 Residential Design

4.2.1 Housing

The residential area will be split up into four different kinds of residences, the first will be dorm-style living for single adults, the second will be for married adults with three or less people per family. Because of the small number of people living in each of the small family units, two units will be connected together to make one larger unit. The third unit will be for families with three or more people per family. The final housing-type is another small family arrangement that is more Spartan and work-oriented than the other ones, and consequently cheaper. People living in different types of units will live in the same areas as to create a strong sense of community. The dorm-style houses will support 6 people in two bedrooms with a shared kitchen, two bathrooms, and living space. The spaces for married adults will support two adults with room for one child, and a bathroom, kitchen and small living space. The third level will be designed to support three to six people with two bathrooms, a larger kitchen and a reasonable living area. The idea is that people would mostly not be spending so much time in their houses, and instead be entertained elsewhere in the settlement. All dimensions in this section are given in feet.

Type	Capacity	Area (Sq. Ft.)	Number of Units	People Accommodated
1: 2-Bedroom Dorm	6	843	1,843	11,004
2: 2-Bedroom Small Family	4-6	1270	3,000	6,000-9,000
3: 3-Bedroom Large Family	3-5	834	1,000	3,000-5,000
4: 2-Bedroom Alternate	2-4	812	500	1000-2000
Total			5,834	21,000-27,004

Type of Room	Dorm Style	2-3 people	3-5 people	2-3 people alternate
Bed 1	10x14	10x14	10x12	10x8
Bed 2	10x14	6x14	8x10	14x10
Bed 3	N/A	N/A	10x12	N/A
Bath 1	4x8	6x10	6x6	10x4
Bath 2	4x8	N/A	6x6	N/A
Bath 3	N/A	N/A	4x10	N/A
Living Area	20x22	12x20	12x14	20x14
Kitchen	12x12	12x10	14x14	10x12
Entryway	N/A	4x14	N/A	4x12

4.2.2 Sources of Items in Residences

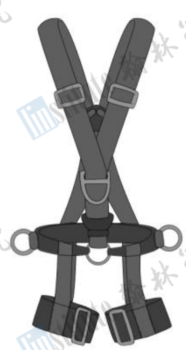
Appliances, furniture, clothing, toiletries, toys and games, and school and office supplies will be made in factories at the Aresam space station. Raw materials will be sent from Earth to the station to be made into distributable goods. Once they reach the station, the raw materials will be processed in factories to make the finished goods.

4.3 Safety in Artificial Gravity

4.3.1 Spacesuit Design

The Bio-Suit will be the spacesuit used for the people on the settlement. The suit provides support through mechanical counter-pressure applied to the body by a skin tight suit. The suit is made up of two layers, an internal spray on suit and an external body suit. Different materials that will be used for the spray on structure of the Bio-Suit are nylon, spandex, and polymer. Those materials help adhere to the person's body to provide great flexibility and comfort with the wearer's body. To connect the outer exo-skeleton layer of this suit, nickel titanium wire laces will be used to hold both layers together. The gas pressurized hard shell helmet will be detached to the suit. There will also be durable shoulder and knee pads attached to the external suit to ensure safety. The rest of the outer suit consists of arm and leg shells that don't connect with the torso shell. These precautions must be used to prevent severe injury from potential falls. The pressurized gas pack is also made with lightweight nickel titanium and attaches to the back of the suit. There will be tubes to connect the oxygen to the inside of the helmet. The internal spray on part of this suit is disposable and must be re-applied every time people go to low gravity areas. The outer part of the suit will be custom made for everyone on the settlement. Bio-Suits will be stored in the pressurized houses of the residents because they will not need to wear these suits in the settlement. They will be checked for damage before and after a person uses them. For a person to don the Bio-Suit, they apply the spray on the inner biodegradable layer of the suit, which helps maintain normal body temperature in low pressure areas. After spraying and wiring everything together, they don the hard torso shell that latches on with the gas pack. The rest of the donning will be putting on the arm, leg, and helmet. For a person to doff the Bio-Suit, it will be the reverse order of donning. The suit can essentially benefit and provide comfort for people of all shapes and sizes.

4.3.2 Safety Infrastructure



Safety in abnormal gravity will comprise of combinations of handrails, tethers, and open cages. Because the docking area will be in 0g, handrails will be required in order to load and unload passengers safely. Fixed handrails will be used along the outer edge of the 0g area to prevent anyone from floating out while movable handrails will be utilized throughout the area to aid workers and to load and unload passengers from ships on Aresam. Workers can mount handrails onto the walls and/or vehicles in the 0g area with tethers in order to maintain a steady position as they work. Also, workers can assemble a crane-like device by tethering an open cage around his/her workspace and then tethering him/her to the cage. This setup can be used if the job at hand requires a steady worker without the floating motion brought about by microgravity.

4.3.3 Airlocks

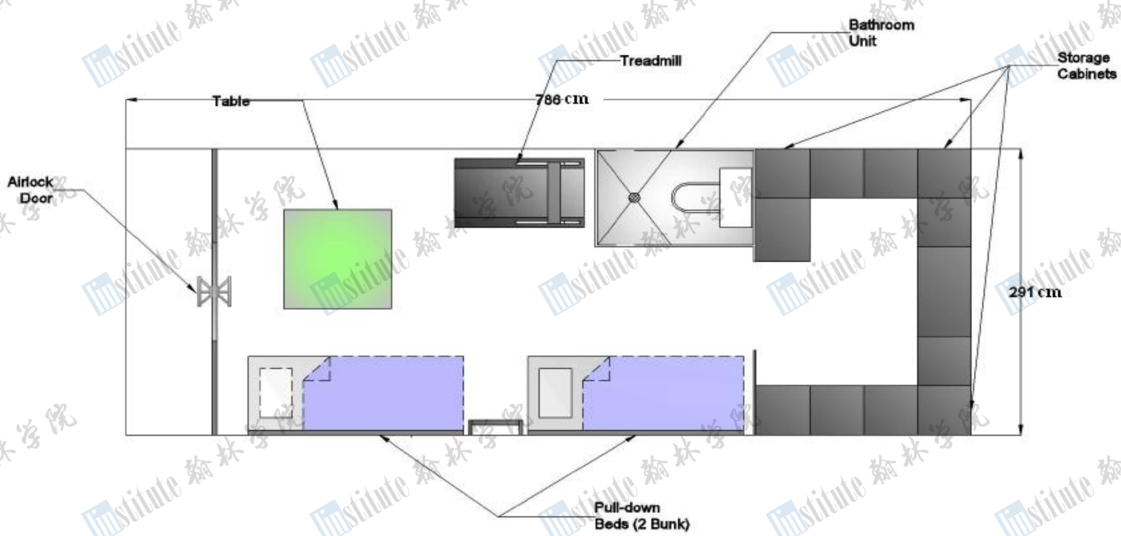
Airlocks will be designed for a person to safely enter and leave areas that are connected to openings leading out into space. Airlocks will be made out of aluminum, for their ability to withstand pressure and tear, and ease and cheapness of obtaining. The most important location of the airlocks will be at the docking entrances of the settlement, where the transport ships arrive into the center of the station. Pre-Pressurized bridges will extend from the station to any ships with passengers, and will form an airtight seal to allow passengers and content to pass safely to the station. Pressurization for cargo-handling areas can be handled simply by closing the airtight cargo doors and adding in gases as needed, since the cargo does not require immediate pressurization to be processed. Full-scale airlocks are consequently unnecessary for this section.

4.4 Population Dynamics

This is the result of population growth if there were to be unlimited resources. However, a population growth to such an extent would be not able to be handled by the space station. In order to minimize the population growth, certain measures must be taken to ensure a stable population. First, immigration to the station will be controlled. Immigrants will only be allowed to enter and live in the station if there is an opening at the station. Secondly, the amount of children that residents will have will be limited. A married couple can have at most 2 children, 2 being the optimal number as those 2 will be able to replace their parents once they have died. Finally, elderly residents will be sent back to Earth once they are unable to perform effectively. After every year, all residents will be mandated to take a physical and health exam. If they fail the exam, and are older than 65 years old, they will be sent back to Earth.

4.5 Deployment Configuration

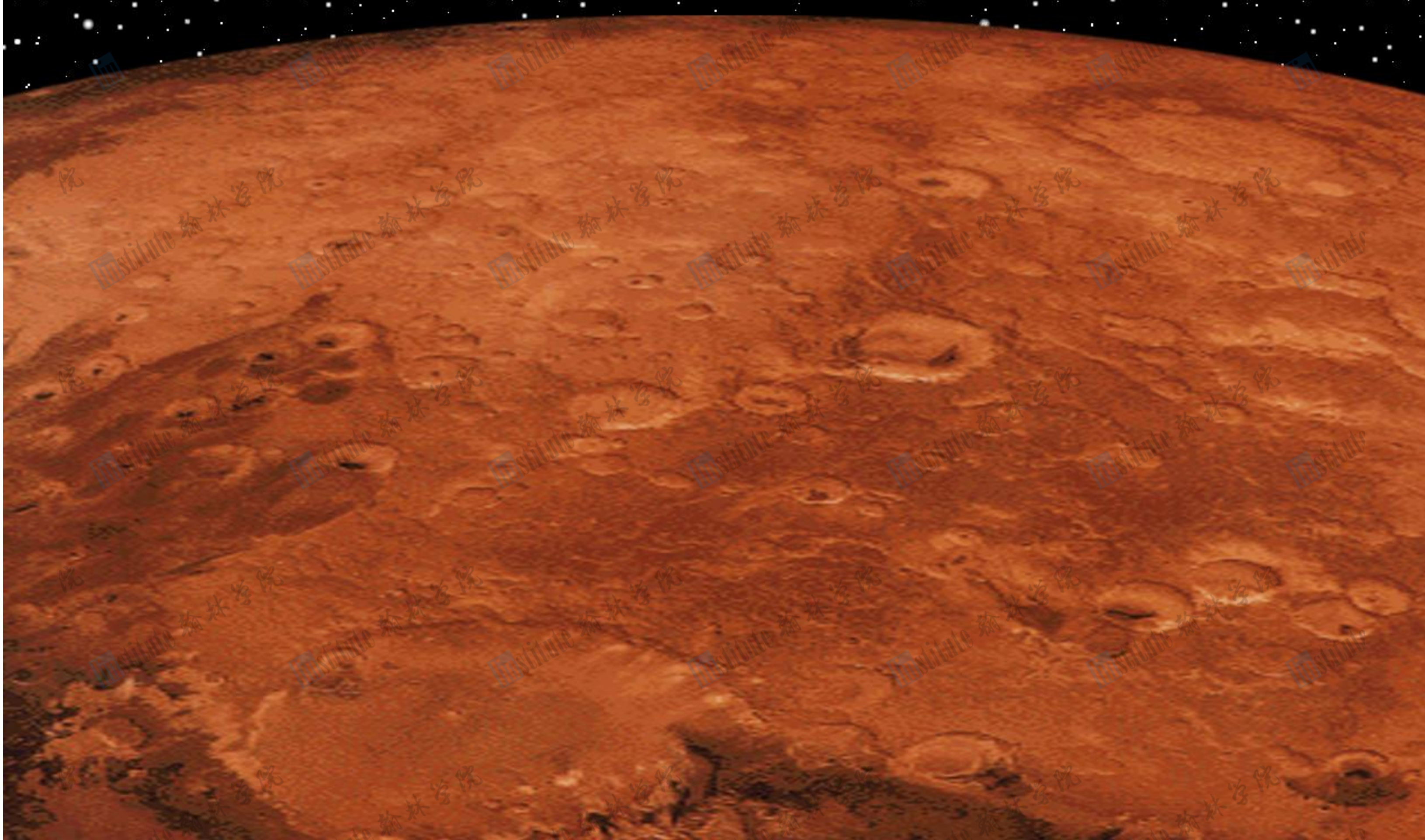
The various consumable/usable supplies that will be needed on the module include food, water, clothing, toiletries, electronic devices, exercise methods, and medical supplies. There will be amenities like sleeping areas and a lavatory. Food has to be compressed and built for pressurized environments. It is freeze dried and packaged without water. However, the food has to also consist of the different varieties of all the nutritious food groups. Water will be recycled by human waste, which is processed through a purification system. There is a limit, by liters, for the water that can be used per day. The amount of usable water must be less than the amount of purified water. A small meter will be located on the water purification system to indicate the amount of water available. Clothing will consist of 12 work shirts, 12 pants, 4 sweaters, 4 pairs of running shoes, 20 pairs of socks, and 40 pairs of underwear. The sweater and running shoes will not be changed over the 30 day period. All the clothing will be lightweight and moisture resistant to maximize comfort during this period. The clothes will also be stored in vacuum bags so the storage space for the clothes becomes very minimal. Toiletries are very important to maintain the overall hygiene of the module.Two bars of soap will also be provided, allowing each person to shower once every four days. Each person will alternate sponge baths between the four-day periods. Electronic devices work as a way for taking notes of the exploration, entertainment, and data collecting. Scientists will utilize the same dual touch screen handheld device used on Aresam, except with more mission-specific software. The electronic device for collecting data and minerals on the Mars terrain will be a movable robot that is similar to a rover. All electronic devices used in this module will be powered by solar panels built on the module. Exercising will be very important towards the bodies of the people in the space. The Alter-G Anti-Gravity Treadmill M310 is the primary exercise machine that will be used in the module. Medical supplies include several first aid kits, medicine, and an automated external defibrillator. The various kinds of medicine include many bottles of painkillers, antibiotics, multi-vitamins, antihistamine, and antiseptic. The bathroom unit on the module will be 146 x 96 cm. The waste materials will be flushed out by a pressurized system and go through the water purification system. The bathroom unit will also be used to take sponge baths. The sleeping areas will be foldable beds sized at 200 x 75 x 10 cm. The materials for the beds will be made of recycled polymer fibers.



AUTOMATION DESIGN AND SERVICES

"Civilization advances by extending the number of important operations which we can perform without thinking of them."

-Alfred North Whitehead



5.0 Automation Design and Services

5.0.1 Computing and information processing

Every person on Aresam over the age of 12 will have a personal computer/phone called the Apollo, which will be one device that functions as both. This device measures 9 by 18 by 1 cm, and consists of two touch screens. One screen can be used as a keyboard when operating as a computer. The device will be capable of projecting the display onto a larger surface. The Apollo devices will be capable of storing certain types of data and performing certain calculations useful to Aresam personnel. To ensure security, a thumbprint-scanning system will be used to turn on each phone.

5.0.2 Security and Access

All residents have biometric data on file, including fingerprints, iris scans and DNA samples. This allows levels of security to be tailored to all residents appropriate for their age and position in the settlement. Access to shared files and common computing resources involves biometric identity confirmation from sensors on all devices. Every permanent resident of Aresam will have a computer chip implanted in his/her arm as a requirement of residency in the settlement. These can be removed with minor non-invasive surgery if people return to earth. The chip will monitor his/her health status by continuous assessment of blood pressure, heart rate, white blood cell count, and other measures of normal physiologic functioning. This also serves to isolate infectious outbreaks immediately and to monitor locations of individuals in emergency situations.

5.1 Automation for construction

In 2051, an international team landed a craft on the surface of the asteroid 16 Psyche, a 200 km diameter body in the main asteroid belt that is composed almost entirely of iron and nickel. The craft blasted a 500,000 metric ton section of the asteroid away from the surface and spent the next 2 years towing this section into the proximity of a Mars orbit. The approach of the Martian and 16 Psyche orbits in 2053 facilitated the placement of this material into a stable Mars orbit, within easy access to the site of the Aresam construction project. This resource therefore is a ready supply of metal ore for processing into settlement structures. A permanent processing facility has been built into the surface of this artificial satellite for the convenient purification and processing of the ore, and this processed material is then ferried to the construction site in robotic transports for a steady supply of construction material.

The interior construction robots would not be doing anything after the initial construction (as opposed to the exterior construction robots, which will continue to operate by doing external repairs), so they can be slightly modified (tentacles can be replaced by wheels, as there will then be gravity) and do the interior finishing. After that is complete, some can be kept for repairs and occasional new construction. The two main types of construction robots are outlined below. See 3.3 for illustrations.

	Description	Purpose	Quantity	Dimensions
Robotic Exterior Construction Device, Hephaestus 1	16 sockets to attach tools. Large storage space. 8 legs for movement, 6 joints each. 2 of 8 legs have permanent grasping devices. Radiation resistant.	Build and maintain exterior surface of settlement	600 units	2 x 0.5 x 0.5m
Robotic Interior Construction Device, Hephaestus 2	16 sockets to attach tools. Large storage space. 8 legs for movement, 6 joints each. 2 of 8 legs have permanent grasping devices.	Build and maintain interior living and working spaces	600 units	2 x 0.5 x 0.5m

5.2 Automation Systems for Settlement Maintenance

5.2.1 Contingency Plans

Hazard	Response
Hull Breach	Dispersal of oxygen masks and immediate evacuation. Residents are notified of emergency through Apollo Devices. The implanted chip system will be used to determine any remaining residents and rescue them as necessary. Particular section is then sealed off using the ESSIS as internal or external repair robots rush in to fix. If necessary, human engineers can also enter area using pressure suits to assess problem.
Major Fire	Dispersal of oxygen masks and immediate evacuation. Residents are notified of emergency through Apollo Devices. The implanted chip system will be used to determine any remaining residents and rescue them as necessary. Particular section is then sealed off using ESSIS and then deprived of oxygen as emergency fire robots come in and disperse fire-retardant foam.
Small Fire	Evacuation of area. Emergency Fire robots rush in and disperse fire-retardant foam or water, depending on type and size of fire. Sprinkler systems are also activated if inside buildings.
Epidemic	Infected individuals will be quarantined at closest medical station immediately. Medical parameters are set up along the emergency sections, and can be sealed off from the rest of the station incase of an outbreak of a major airborne disease. Emergency medical personnel will then proceed to evacuate these sections of uninfected people and treat others.
Water Contamination	If significant water contamination is detected by regularly placed sensors, that sector of the water system will be shut off and all surrounding water rerouted. The contaminated water is routed to the water treatment site through smaller emergency side pipes, where it will be cleaned and reused.
Solar Flare/Storm	All personnel and sensitive electronics on outside of station are immediately evacuated and brought within the confines of the torus. Any approaching ships are immediately docked and evacuated and all docks in central module are shut down. Electronics and people inside the station will be protected by the layers outlined in section 2.1.3.1.
Nuclear Power Failure	The Thorium based gas-cooled fast fission reactor used in the station precludes the possibility of steam explosions and the location of the reactor away from any residential areas allows minimal radiation in the case of catastrophic failure, once the section is isolated using ESSIS. After a shutdown, the solar panels on the exterior of the station will be sufficient to continue powering the station for some time until the reactor is ready for reactivation.

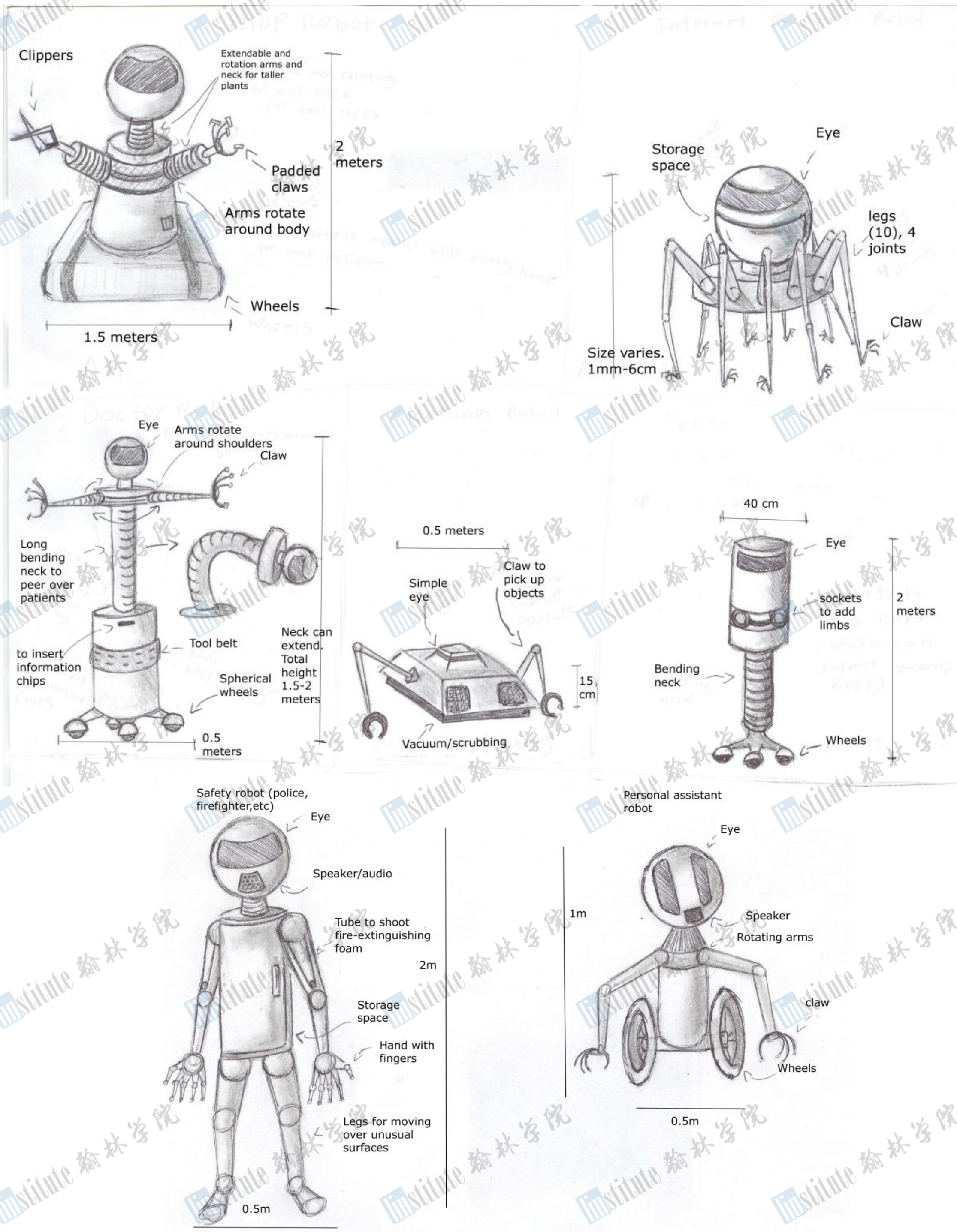
5.3 Automation to Enhance Livability

5.3.1 Robotics

Name	Size	Function	Details
Hestia	Height Range:1.75m-2.25m	Surgeon	• Performs surgery • Bending neck • Has a tool belt • Adjustable height and neck length • Neck extension: 1.5-2m
Hygieia	Height range: 1.75m-2.25m	Doctor	• Adjustable height and neck length • Has a convenient "warm hand" feature for the patient's comfort
Hades	Height:4m Width:3m	Mining	• Mines for materials on moons
Ichnaea	Height:1.25m Width:1m	Exploration	• Collects samples for research
Demeter	Height:2m Width:1.5m	Crop tending	• Has clippers • Has padded claws • Extendable arms
Ares	Height:2m Width:0.5m	Safety robot	• Keeps residents safe • Serves as firefighter, police • Has a humanoid structure
Dionysus	Height:1m Width:0.5m	Personal Assistant robot	• Serve as assistants for any task
Krios	Height:1mm-6cm	Internal Repairs	• Has storage space • 10 legs • 4 joints in each leg • Size varies depending on the size of location where Eddie is working
Hephaestus 2	Height:1m-2m Width:0.5m-1.5m	Interior Construction	
Themis	Height:15cm Width:0.5m	Janitor	• Vacuum, scrubbing, dusting, etc. • Claws for picking up objects
Hephaestus 1	Height:2m-6m	Exterior Construction/repair	• Size varies depending on the task • Uses heat/laser to fuse parts together • Assembles station
Eos	Length:18cm Width: 9cm	Personal Computer/Cell phone	• Functions as a computer and cell phone
Ananke	Height:2m Width:40cm	Factory Robots	• Bending neck • Has multiple sockets so that extra arms can be attached

5.3.2 Robot Design

Below are sample robot designs from various robots listed above:



5.3.3 Privacy of Personal Data,

Access to private personal data will be available using a combination of the security and access features described in 5.0.2 and will be stored on servers across the station.

5.4 Access to Data Repositories on Earth

Internet service from Earth would be very slow in some cases. For normal, non-emergency situations, standard radio waves can be used to communicate. Satellites will be set up in both Earth's and the settlement's orbits. The distance from Earth to Mars varies from about 35 million miles to 340 million miles. Earth and Mars reach their shortest (and longest) separation distance about every 2 years. Communications will take about 5 minutes at the shortest distance and about 20 minutes at the longest one. There will be two satellites in the same orbit as Mars at a 90 degree angle from Mars to the Sun. This will ensure constant relay capabilities to Earth (see diagram in 3.2.6.2). Information retrieved under these normal conditions would be pre-recorded and compressed and sent in groups based on their date and relative importance. All regular adults on the settlement would have their own access code to the radio wave system to communicate with Earth. Docking stations for the spacecrafts would be set up on satellite stations evenly spaced around Mars and Earth for quick access.

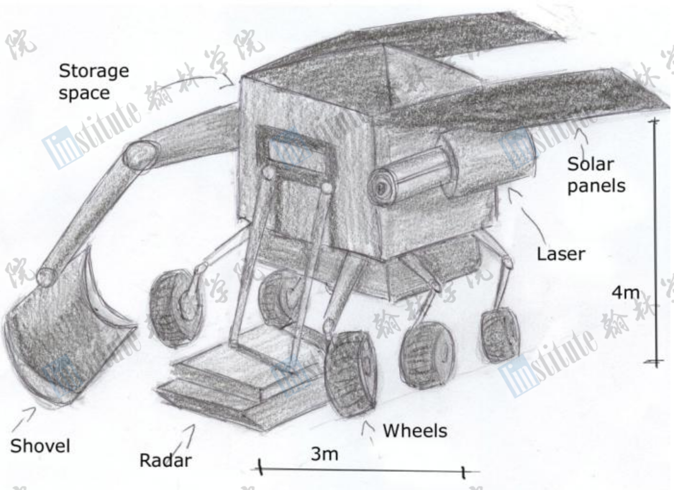
Internet on the settlement

The Internet in the settlement will be separate from that of Earth because of the delay. However, 500 websites (determined by how frequently they are used) will be constantly uploaded from Earth. This way, should a person on the settlement choose to visit one of those websites, it will never be more than 20 minutes out of date. The list of websites will be regularly edited using information from polls (as opposed to keeping track of what websites everyone is going to). All other websites will exist only in the network of the settlement, and they will be used most of the time. An image showing Internet user experience on Aresam is featured to the left.

5.5 Automation of Deployment

On both Phobos and Deimos, five rovers with storage units will survey the terrain of each moon for certain materials. They will not be programmed to find the same amounts/kinds of materials, since each planet's set of five rovers will be placing their materials in different refining pods and therefore creating different parts of the prefabricated base. When a rover determines a suitable location for mining, one of their two robot arms will shoot lasers and separate the desired materials from the moon, while the other lifts it into the storage unit. When the rovers have reached their maximum carrying capacity for materials, they will be emptied into a pod for refining. There is one refining pod per moon. Each refining pod has different sections for refining different materials. The two refining pods will also be used for making the materials into parts ready for assembly. When the materials have been refined they will made into parts in a separate factory area of the pod, in order to be ready for transportation and assembly. Once the materials are refined and made into parts, they will be transported to Mars by shuttle, where they will be assembled into the base by two robots. Each robot will have two arms as well as special equipment (such as screws, drills, etc) to help with the construction of the base. All items such as clothing, toiletries, and personal electronics will be placed in the base by humans after it is assembled.

Phobos/Deimos mining rover



When the base is created, there will be a robot to sample, analyze, and compare the terrain of Mars. It will have a robotic arm that will take samples, and will be solar-powered. When a sample is taken, the robotic arm will place the sample into a small storage vial. The contents of these vials will be analyzed when the robot returns to the base.

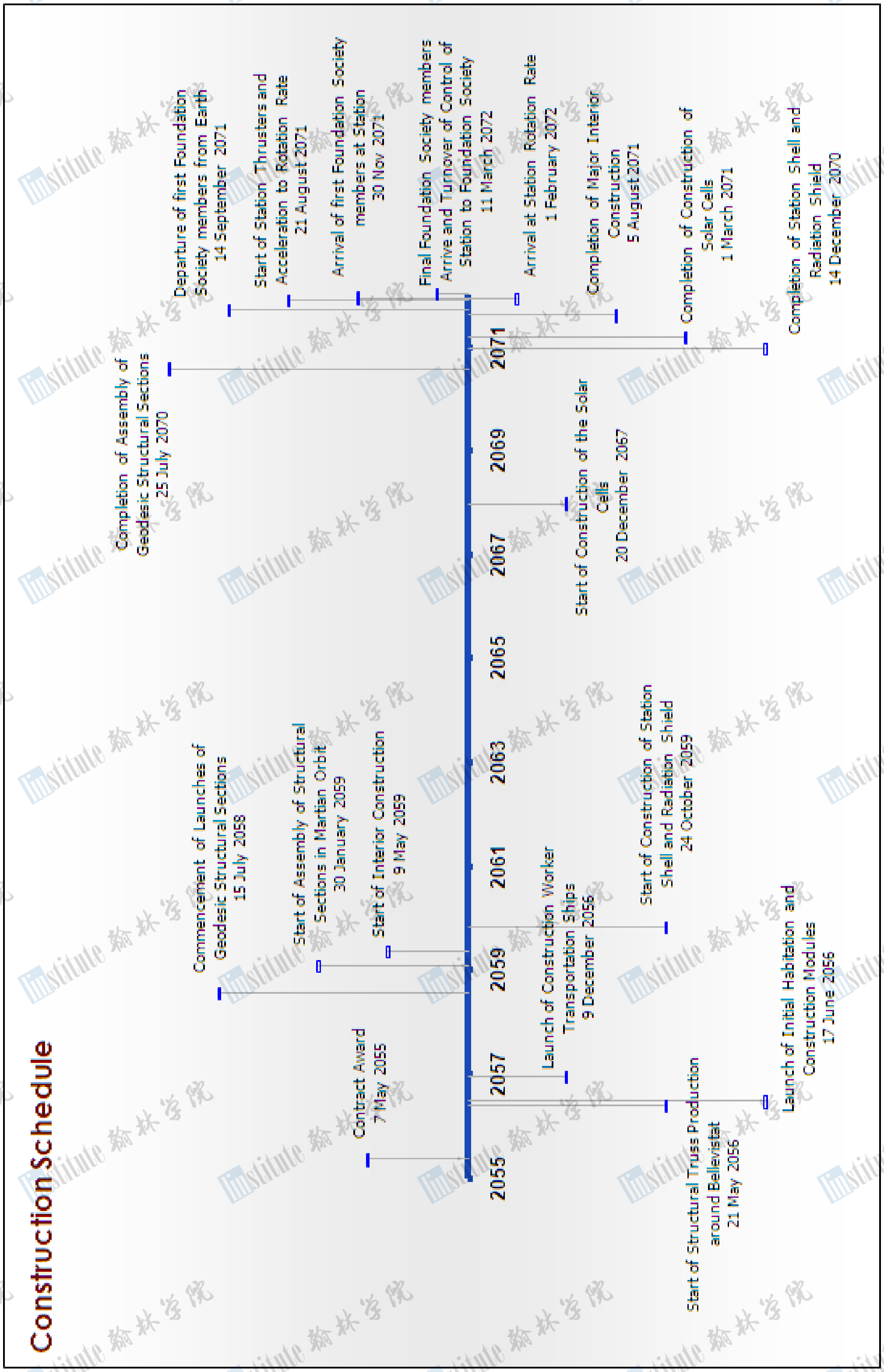
SCHEDULE AND COST

*"A truly good book teaches me better than to read it.
I must soon lay it down, and commence living on its hint.
What I began by reading, I must finish by acting."*

-Henry David Thoreau

6.0 Schedule and Cost

6.1 Schedule



6.2 Cost

6.2.1 Structures

Material	Mass (kg)	Cost/kg	Approximate Total Cost
Steel	2,080,000,000	$41.84	$87,027,200,000
Aluminum	720,000,000	$2.54	$1,828,800,000.00
Titanium	700,000,000	$19.18	$13,426,000,000.00
UHMWPE/graphite	300,000,000	$5.43	$1,630,000,000
Mylar	4,720,000	$22.14	$104,500,800.00
Kapton	4,800,000	$119.37	$572,976,000.00
Vectran	1,760,000	$100.50	$176,880,000.00
Beta Cloth	1,000,000	$150	$150,000,000
Total	**3,812,280,000**		**$104,916,356,800.00**

Phase	Phase Description	Phase Employees	Phase Cost
Ankt	Lattice Sections Constructed around Bellevistat	1700	$87,227,200,000.00
Odin	Assembly of Sections in Martian Orbit	2400	$1,345,300,000.00
Thor	Initial Large-Scale Interior Construction	3000	$28,529,280,000.00
Tyr	Construction of Radiation and Debris Shielding	2000	$15,487,380,800.00
Esus	Solar Panel Placement	1000	$9,380,000,000.00
Hadur	Post-Pressurization Interior Construction	4300	$49,430,000,000

6.2.2 Operations and Infrastructure

Item	Cost
Construction Materials	$20,000,000,000
Initial Atmosphere	$500,000,000
Agriculture Investment	$2,000,000,000
Solar Panels	$300,000,000
Fission Reactor and Fuel	$1,000,000,000
Plasma Arc Gasifier	$350,000,000
Water Treatment System	$100,000,000
Recycling System	$80,000,000
Transport Vehicles	$100,000,000
Communications System	$50,000,000
Prefabricated Base	$500,000,000
Total	**$24,980,000,000**

6.2.3 Human Factors

Small Family Houses	$400,000,000
Large Family Houses	$750,000,000
Dorm Houses	$275,000,000
Alternate Houses	$200,000,000
Community Centers	$2,500,000,000
Sports Complexes	$5,000,000,000
Parks	$900,000,000
Medical Centers	$350,000,000
Pneumatic Tube System	$3,200,000,000
Spacesuits	$1,500,000
Safety Infrastructure	$5,000,000
Airlocks	$8,000,000
Total	**$13,589,500,000**

6.2.4 Automation

Item	Quantity	Cost
Apollo Device	20,000	$200,000
Arm Computer Chips	20,000	$200,000
Hestia	100	$20,000,000
Hygieia	250	$1,500,000
Hades	10	$15,000,000
Ichnaea	1	$100,000
Demeter	500	$5,000,000
Ares	500	$250,000
Dionysus	10,000	$20,000,000
Krios	100	$10,000,000
Hephaestus 2	100	$15,000,000
Themis	1,000	$1,500,000
Hephaestus 1	100	$15,000,000
Eos	20,000	$200,000
Ananke	1,000	$100,000
Mined Material Refining	n/a	$9,000,000
Mined Material Parts Construction	n/a	$20,000,000
Mined Material Transportation	n/a	$1,000,000,000
Mined Material Assemly	n/a	$15,000,000
Total		**$1,148,050,000**

Estimated Total Cost: $ 144,634,000,000

"A business that makes nothing but money is a poor business."

-Henry Ford

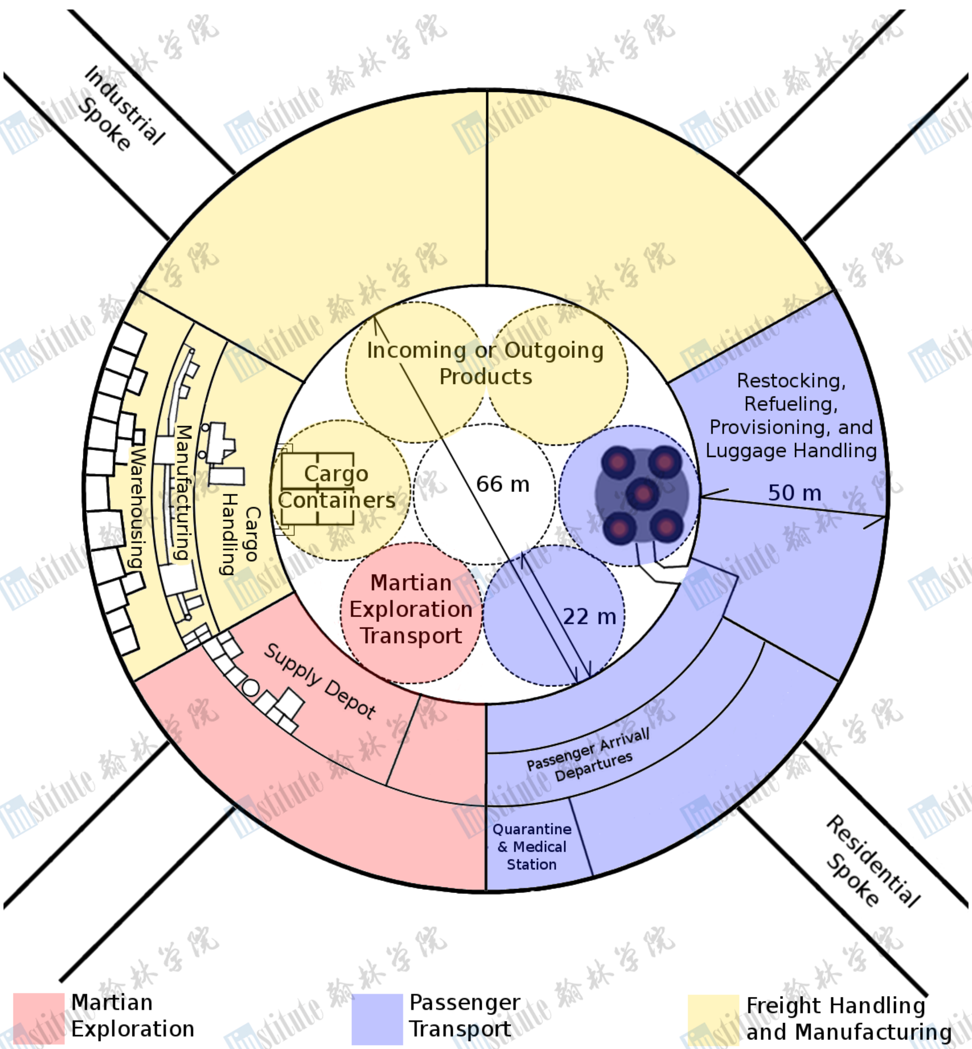
BUSINESS DEVELOPMENT

7.0 Business Development

7.1 Transportation Node and Port

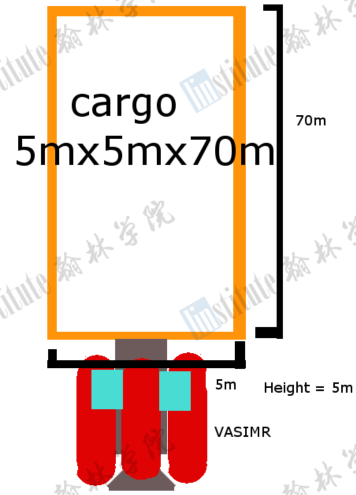
Docking and Port facilities for the three main types of transportation – freight, terrestrial passenger, and Martian exploration – will all be located on the inner-most rings of the central cylindrical module. All ships enter the module through the upper opening, dock and go through refuel and repair procedures, and then proceed to exit out of the other end. This method produces an efficient docking system since one-directional transportation minimizes risks of accidents such as collision and reduces the effect of "traffic". The autopilots and human captains will be in constant contact with both automated and manned control stations located at intervals along the inner rings of the central module, to be guided to their destination. All ships will, after having approached their designated port areas, be guided in and anchored by cranes exuding from the station in order to match up with the rotation of the station, and all people or objects on the ships will be moved to the station with bridges or cranes. This will effectively eliminate the problem of accumulated Martian dust deposited on main vehicles entering the interior of the Aresam station and will also allow substantially larger ships

The areas of the central module will be separated into six main port sections that run along the entire length of the cylinder. Three of these sections, accessed by the two side Spokes and will have the primary purpose of freight handling and manufacturing. Initially, only the outer two of these manufacturing sections will be filled up, with the central one being expanded into as the need for further manufacturing increases depending on how the station expands (see section 2.4). Two other sections, centered around spoke the residential spoke will be used for terrestrial passenger transportation and the last section for Martian exploration (see diagram).



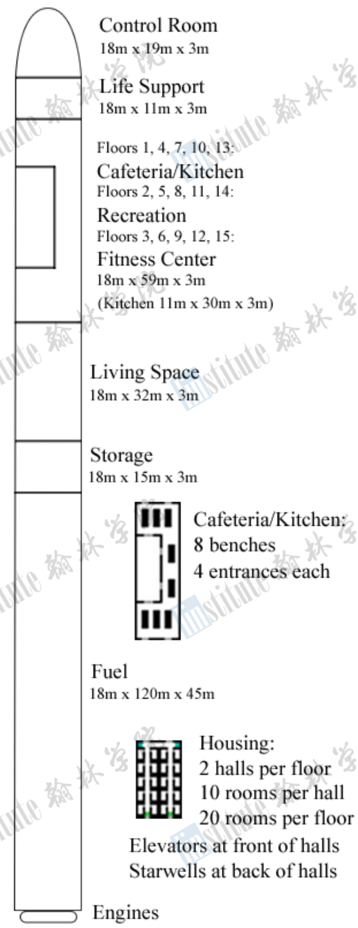
7.1.1 Cargo and Freight

Materials from Martian and Phobos/Deimos mining will be transported in both large freight crates for processed materials and by being surrounded by large mesh nets for any bulk minerals. Attached to each of these will be a transport vessel consisting simply of a fuel tank, a navigation computer, and a Variable Specific Impulse Magneto Plasma Rocket (VASIMR). The VASIMR engine is excellent for long-distance space cargo transportation as, unlike both Ion Thrusters and Chemical Rockets, it has a considerably high specific impulse as well as thrust, and is extremely fuel efficient, with approximately 43,000 MJ of energy per kg of exhaust and because it is considerably less prone to failure or technically complications as it requires little to no moving parts. Since the VASIMR engine produces both significant heat and high magnetic fields, which might negatively affect the inner areas of the central module, as well as lacking the precision necessary to navigate the docking areas, the VASIMR transport vessels will drop off their freight crates near the central module entrance. Small, precise, and relatively low power "tug ships" will then proceed to guide the freight crates into the docking areas. There are VASIMR refueling and repair facilities located at each end of the central cylinder that these transport vessels will then go to. This is also where unused passenger shuttles and tug ships will go to for storage and significant repair. After being pulled in by a crane (See 7.1), the crate is anchored to the side of module and opened as gantry cranes move the cargo into a large holding area inside the module. The fact that neither the transport crates nor vessel enters the station – just the freight inside it – prevents any build up of Martian dust from entering these parts of the station. Once all the freight has been moved inside the holding area in the station, this is closed off and pressurized. Now, the freight is, through an automated process, sorted and placed on different conveyer belts to transport it to respective manufacturing sections. The freight crates anchored to the outside will remain in location or be moved to other sites along the manufacturing sections to be restocked for transport to other locations. Once ready to continue, they will be guided to the exit areas by the tug ship where they will rendezvous with newly refueled and repaired VASIMR transport vessels.



7.1.2 Terrestrial Passenger Traffic

Passenger shuttles (see diagram) arriving from the earth or other space stations will enter the central port area inside the cylinder by themselves and approach their designated port facilities. After shuttles are secured at the port facilities, pressurized bridges extend out to exits to retrieve passengers and cargo. Passengers undergo medical checks and are provided with all necessary equipment for the station, including the implanted chip, IDs, and network access device. Basic quarantine and medical stations will be located in the port areas for immediate access after arrival. Passengers will continue through the port facilities to the residential spoke and be transported to the residential areas from there. All luggage will be delivered directly to passenger's residential locations by means of the Hermes system. After passengers and luggage are unloaded the ships remain in their ports to be refueled, repaired and restocked on site. Food and item restocking and provisioning will be available through direct lines from the central warehousing locations on the station. Once restocked and repaired, the ships are ready for continuing travels and will again be guided out of the hangar and to the exit areas by cranes.



7.1.3 Martian Exploration

The docking procedures of the Martian exploration section will be relatively similar to those of the terrestrial passenger transportation section. Vehicles to and from Mars will also be docked on the outside of the inner rings of the cylinder and the insides accessible by bridges extending from the station, preventing most accumulated dust from entering the inside of the station. As the vehicles are refueled, repaired, and prepared for future missions, robots will also extend from the cranes to robustly sweep and vacuum the exterior and interior of any deposited Martian regolith. Inside the Martian Exploration section will be a hangar serving as a base and depot for various Mars vehicles, specifically for repair and servicing of rovers and prefabricated bases. The location of this section directly adjacent to the manufacturing will allow efficient production and transportation of vehicles and equipment for Mars exploration. The spoke leading to the Martian section provides any other supplies, food, etc necessary for Mars missions.

7.2 Manufacturing

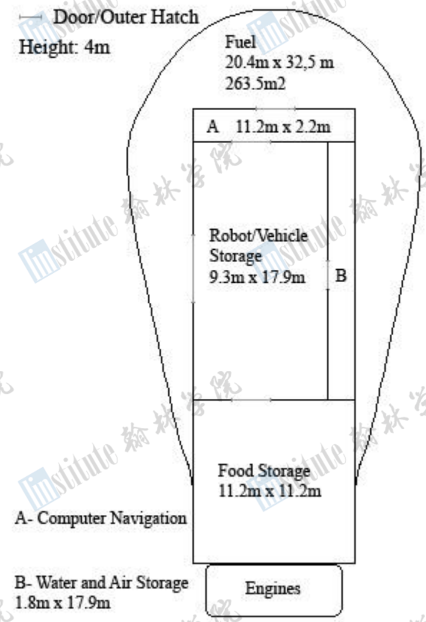
Material	Source	Use on Station	Exports/Products
Iron	Phobos, Deimos, Mars	Steel for station, Prefabricated Base, vehicles, etc	Magnets
Carbon	Phobos, Deimos	Carbon Steel for station, Prefabricated Base, vehicles, etc; Synthetics, Plastics, etc for use inside station, vehicles, Prefab Base	Electronics
Nickel	Phobos, Deimos		Magnets, Batteries
Titanium	Phobos, Deimos	Outside protection of station, Prefabricated Base	
Magnesium	Mars	Refractory material for furnacing	Electronics
Aluminum	Mars	Transportation, Wiring, Construction	
Silicon	Mars	Glass Products, Electronics	Electronics
Sulfur	Mars	Fertilizer	
Calcium	Mars	Alloying agent, cement	
Olivine, Hematite	Mars		Peridot Gemstones, Hematite Gemstones, etc.

7.2.1 Manufacturing Process

There will be two main sections dedicated to manufacturing on the station. One is going to be located near the freight/cargo ports in the central module and another will take up a major part of the torus module. (For reasoning for choice of location see Appendix A).

7.2.2 Transportation of Vehicles, Robots, and Other Commodities

One universal Mars shuttle (see diagrams) will be used to transport prefabricated bases and supplies to Mars surface.



7.3 Research for Commercial Products

7.3.1 Location of Laboratories

As described in section 4.1 laboratory stations will be scattered throughout the residential/commercial sections of the torus. Researchers will be able to brainstorm, research, and design potential exports and applications of materials mined on Phobos, Deimos and Mars surfaces. Mars exploration missions with the prefabricated base will return with samples and precise statistics of Martian minerals and mining operations on Phobos, Deimos, and Mars will send further data.

7.3.2 Capability of Fast Production

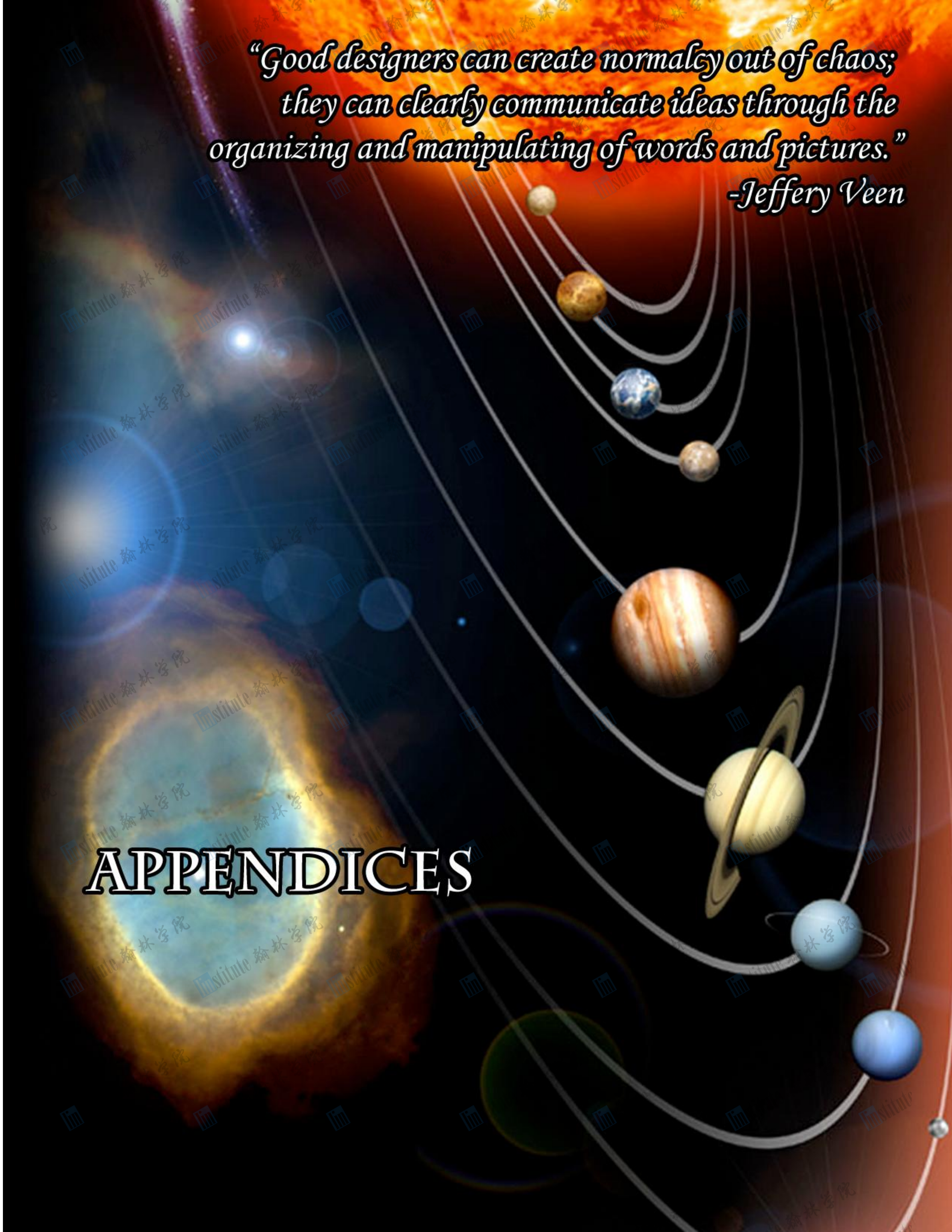
As soon as new products for station operations or with commercial potential are identified and designed, manufacturing sections can quickly be adapted for production. Production lines will be modular in design and, since there is ample expansion space both in the central and toroidal industrial sections, fabrication of new products can be accomplished within short amounts of time.

7.3.3 Cost Criteria for Commercially Viable Products

The cycler and VASIMR cargo transportation system - taking advantage of gravity and using high-efficiency long-distance engines - will allow freight to be transported from Aresam to the Earth at comparatively low cost. Therefore, many products that could be produced on Earth could still be commercially viable for export from Aresam. The significant amount of metals such as Iron, Titanium, Nickel and Aluminum as well as the presence of silicates, Carbon and many other minerals makes production of magnets and electronics on Aresam desirable. Ferromagnetic metals are abundant and easily harnessed on Mars and its moons, more so than on Earth, and this could therefore become a primary export of Aresam. Additionally, the presence of certain minerals such as olivine can be sold at substantial prices on earth in the form of gemstones (Peridot for example), since their extraterrestrial origin would add substantial appeal and value.

7.3.4 Quarantine Capabilities

All labs can be individually sealed using inflatable modules in a similar manner to ESSIS incase materials hazardous to humans are identified. Any researchers exposed to the minerals will be quarantined and continue to receive life support until it is assured that their release will not endanger the station.


"Good designers can create normalcy out of chaos;
they can clearly communicate ideas through the
organizing and manipulating of words and pictures."
-Jeffery Veen
APPENDICES

Appendix A

The locations of all industrial and manufacturing sections in the station were determined precisely based on several factors. All manufacturing stations are interconnected without materials having to go through any residential or commercial areas where residents might be located. Despite minute risks and intrusiveness for most types of manufacturing, residents would still prefer being as far away from heavy industry as possible. This station configuration ensures this is the case and also essentially eliminates any environmental impact on residential and research communities. The placement also ensures that materials and products can also be efficiently and quickly transported throughout industrial sectors due to minimized distances between any processing, fabrication, or packaging. The initial processing and handling of any incoming materials is located directly near the freighter ports (see section 7.1.1) and all other industry will have immediate access to the freighter ports through the industrial torus. This will further streamline the manufacturing process as materials come in from mining stations, move through processing and handling near the ports, to the main manufacturing sights and back to the freighters to be exported in one continuous process. The location of certain types of manufacturing directly adjacent to the Martian Exploration and Terrestrial Passenger ports allows vehicles and systems (shuttles, prefabricated base, etc) to be produced and moved to their desired locations immediately. This way, necessary parts for repair of docked ships or Martian Exploration equipment can be manufactured immediately and brought to the necessary site without delay. Manufacturing of certain products can take advantage of the micro-gravity available in the cylindrical module while other processes require greater gravity for efficient industry; therefore two ranges of gravity are provided. Pressurization of industrial sections will also depend on the type of manufacturing, and will be adapted accordingly. As explained in sections 2.4 and 7.3.2 there will be significant expansion space throughout manufacturing areas to ensure continued innovation and expansion in exported products for a growing station and market. Several types of repair and maintenance robots (see section 5.3) will be constantly available and moving throughout the manufacturing sections to ensure continued production. Since the train-system will run through the manufacturing areas with requestable stops, any human personnel desiring access to manufacturing sections for detailed repair or oversight will have access to their desired locations. Human oversight will also be possible through the automated monitoring of all processes.

Appendix B

http://www.globalspec.com/MyGlobalSpec/NewProfile?forcetok=1&GoToUrl=http://www.globalspec.com/SpecSearch/Suppliers/Material_Handling_Packaging_Equipment/Material_Handling_Equipment/Industrial_Manipulators_Industrial_Lifters%3FsrchItem%3D3%26frmqry%3Dcup%2520robot%2520suctionkqid%3D187601111%26frmsrc%3Dsoe&areaId=4016
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http://www.nasa.gov/vision/space/travelinginspace/future_propulsion.html
http://www.bis-spaceflight.com/sitesia.aspx/page/358/id/1270/l/da

Appendix C