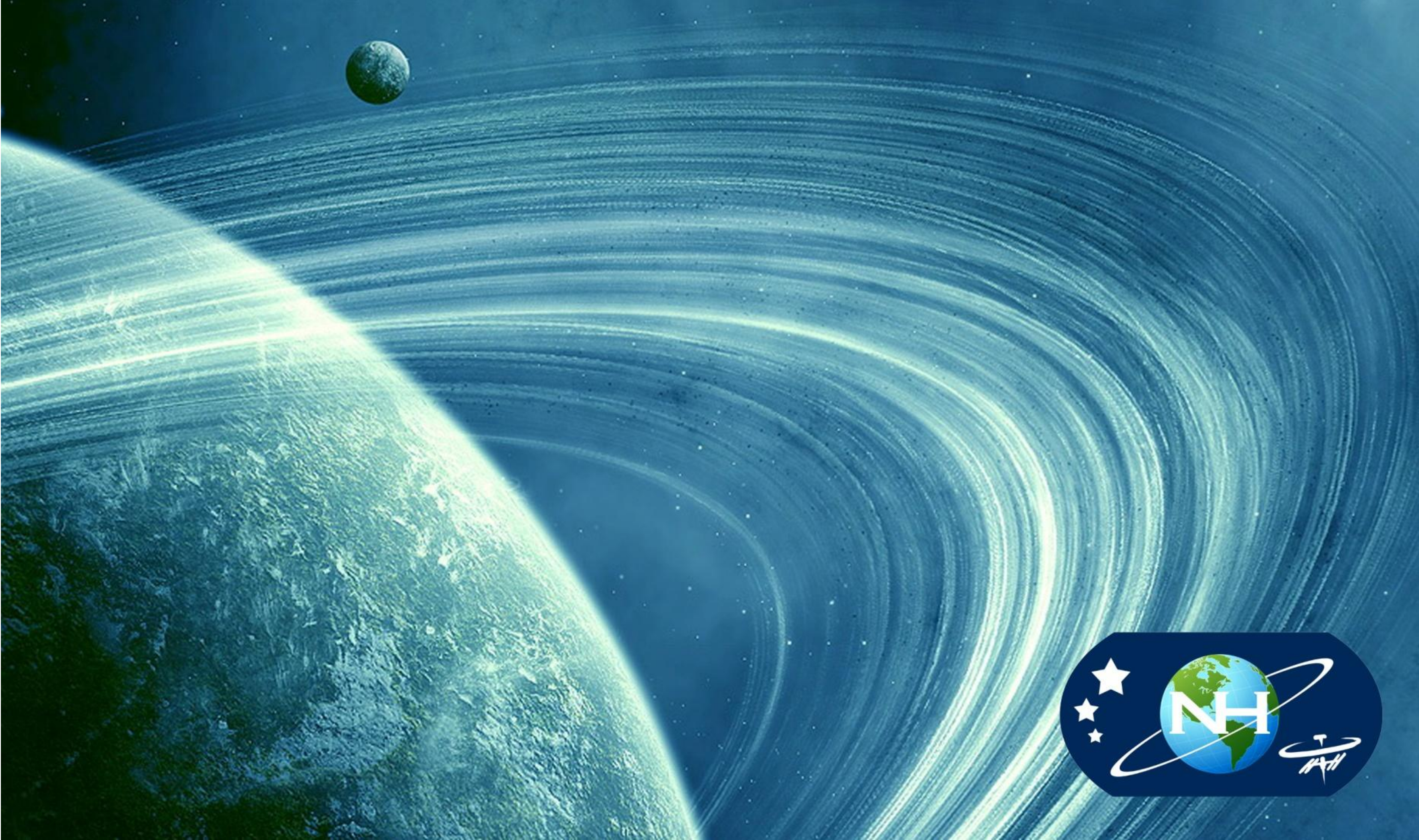
Northdonning Heedwell

ARESAM

Gretchen Whitney High School
Cerritos, California
United States of America



17th Annual International Space Settlement Design Competition
Proposing Team Data 2010

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Names, [grade levels], and (ages) of 12 students currently expecting to attend the Finalist Competition:
(we request that participants be at least 14 years old, and not older than 19)

Allan Wang	[12](18)	Mitchell Kim	[11](17)
Andrew Lee	[12](17)	Emily He	[10](15)
Patcharapon Neranartkomol	[11](16)	Annie Yan	[10](15)
Thaddeus Trinh	[12](18)	Eric Ho	[10](15)
Sattik Ghosh	[11](16)	Sajjad Mirza	[11](16)
Henry Wang	[11](17)	Brandon Liao	[12](17)

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

I understand that if our Team qualifies for the International Space Settlement Design Finalist Competition July 30 - August 3, we will be expected to finance our own travel to / from Nassau Bay, Texas, USA.

Paul F Bender — 3/5/10
Responsible Teacher / Advisor Signature — Date

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1.0 EXECUTIVE SUMMARY

"Mars is there, waiting to be reached." These were the words uttered by Buzz Aldrin, one of the first people to step on the Moon. However, in the early 2000s, a global recession forced President Barack Obama to cut NASA's budget. The Shuttle fleet was being retired, and the plan to reach Mars had been scrapped. The future seemed bleak.

Today in 2055, about fifty years later, we are beyond merely landing humans on Mars. Instead, our goal is even more ambitious: the colonization of the Red Planet. To achieve this dream, we at Northdonning Heedwell have the pleasure of presenting Aresam, *the Gateway to Mars*.

As a lone settlement, the farthest one from our home planet, Aresam will be critical to future operations. Aresam will be responsible for producing the infrastructure, equipment, and vehicles required for settling on Mars. Once full operations on Mars begin, Aresam must handle traffic en route to the Martian surface. If human settlement of Mars is to succeed, Aresam is crucial.

Unfortunately, Aresam's utility as a faraway outpost makes it very vulnerable. The nearest help from the Moon and Earth is months away. Thus, Aresam must surpass its Earth-bound predecessors, Alexandriat, Bellevistat, and Columbiat, in self-sufficiency and durability. Several key design features allow us to address this challenge. Power can be quickly rerouted from the various nuclear reactors and solar panels to compensate for power loss. Our living sectors are separated into nine sectors, allowing for easy quarantine and containment. The hull can withstand abuse by meteorites, able to self-repair most damage. Redundancy ensures the loss of a critical system will not cripple the colony.

However, Aresam is not only a base of operations, but also the home of 20,000 residents. To ease the isolation from Earth, Aresam features weather parks to mimic Earth's seasons. Events such as Open Mic night and talent shows help create a sense of community. Aresam also hosts microgravity sports such as bumper balls. Each house comes equipped with a virtual reality room that immerses the user in a life-like environment, allowing them to play the latest first person shooter or explore the Valles Marineris – all from the comfort of their home. With such a wide variety of activities, we have ensured residents will always have something to do on a Saturday night.

Beyond a safe and entertaining living space, Aresam also incorporates the latest technology to improve efficiency. Wireless transfer of electricity permits mobility of devices within homes. Traveling wave reactors both breed and consume fissionable material, allowing Aresam to be powered on radioactive materials normally considered waste. Electron beam freeform machines craft parts with minimal waste. Evolutionary algorithms allow software to improve itself over time. These technologies combine to push the limits of productivity, and allow Aresam to serve any foreseeable needs.

Upon completion in 2067, Aresam will serve as the Gateway to Mars. However, the robustness and flexibility of our design will extend its utility far past this initial goal. We at Northdonning Heedwell envision a probable future where Aresam will serve as a stepping stone to human settlement of the entire solar system. Aresam will be not just the Gateway for Mars, but rather the *Gateway to the Future*.

STRUCTURAL DESIGN

2.0 STRUCTURAL DESIGN

We at Northdonning Heedwell have envisioned Aresam as the Gateway to Mars. Aresam will act as the base of operations for future developments on the Red Planet. To accommodate these future needs, modularity has been incorporated into the design of Aresam, making it adaptable and versatile.

2.0.1 Permanent Population With over 100,000 square meters of down area dedicated to residential and commercial pursuits, Aresam would serve as the home of 20,000 full-time residents.

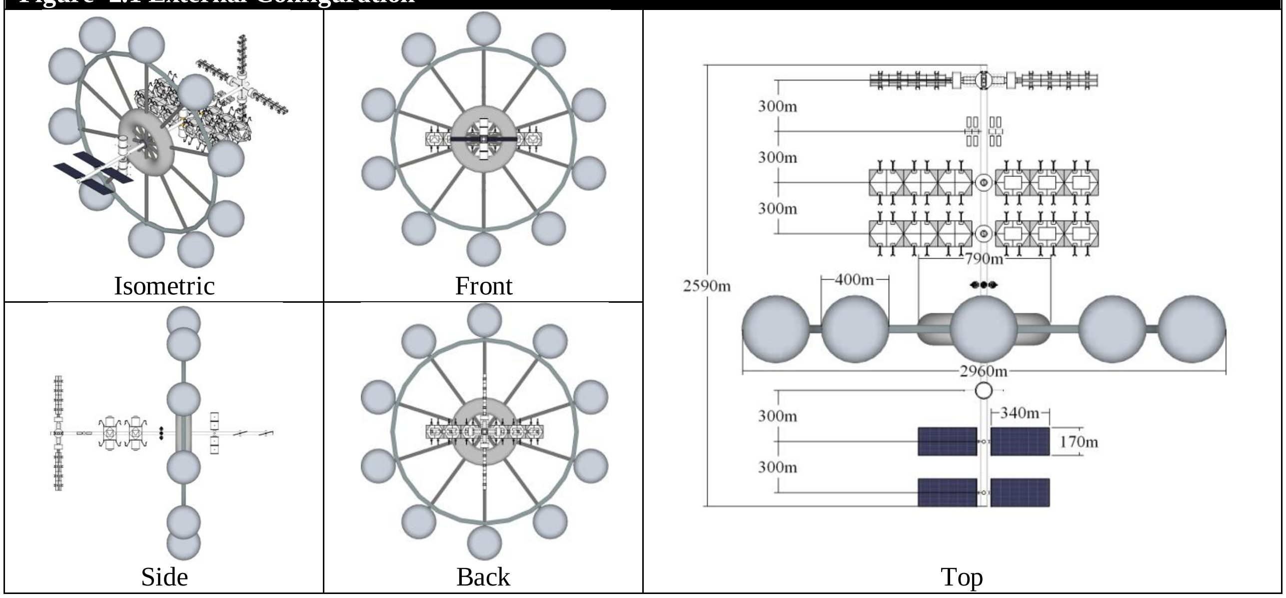
2.0.2 Transient Population As the only large settlement around Mars, Aresam acts as a major transit station for any traffic going to the Martian surface as well as further out in the Solar System. Aresam provides a second home for these travelers in its various hotels. These hotels utilize modular rooms to expand very easily, allowing Aresam to accommodate an increase of over 50 additional visitors every year.

2.1 EXTERNAL CONFIGURATION

2.1.1 External Design

Each of Aresam's large structures has been optimally positioned to increase its efficiency as well as reduce the strain on the colony's structure. Artificial gravity is only applied in areas where humans live for long periods of time, and everything has been kept as close to the center of rotation as possible to reduce weight. These efforts have allowed our design to save on costs and improve safety as well as structural integrity.

Figure 2.1 External Configuration



2.1.1.1 Hestia The residential and commercial spheres, named Hestia after the Greek goddess of home and hearth, house the vast majority of Aresam's population. Placement of Hestia spheres at the furthest distance from the axis of rotation allows residents to experience 1 G gravity, providing an Earth-like environment.

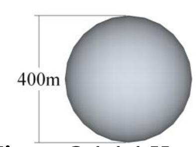


Figure 2.1.1.1 Hestia

2.1.1.2 Demeter An agricultural ring, named Demeter after the Greek goddess of harvest, provides Aresam with a steady, healthy, and delicious food supply. Demeter features two floors filled with aeroponic systems and cultured meat. Because crops only require minimal gravity to grow properly, the ring has been placed close to the axis of rotation, reducing structural loads.

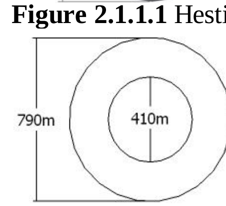


Figure 2.1.1.2 Demeter

2.1.1.3 Hermes A transportation ring serves as an inter-colony highway as well as structural support. The ring is located above the Hestias, and will act as a common marketplace where people can gather to exchange goods, socialize, and work.

2.1.1.4 Atlas The central rod, named Atlas after the Titan who held up the heavens, acts as the backbone of Aresam, holding together the various modules. Four monorails and one Maglev rapidly move cargo and people from each area along Atlas. Atlas provides sets of four universal docking ports, spaced 300 m apart, for various modules. As a result, expansion only consists of attaching additional modules. *For more information about expansion,*

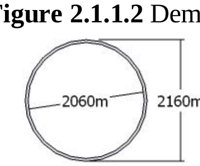


Figure 2.1.1.3 Hermes

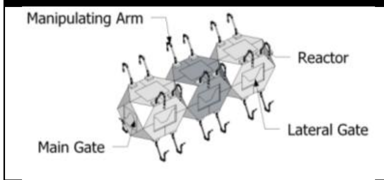
refer to section 2.4.2.

2.1.1.5 Hephaestus Industrial class modules, named Hephaestus after the Greek God of fire and the forge, give Aresam manufacturing capabilities. Hephaestus class modules can be reconfigured to serve various needs such as heavy manufacturing, smelting ores, and research. Location at the center of the colony allows for zero-G construction in space, which gives Aresam unparalleled flexibility in manufacturing capabilities. Furthermore, all Hephaestus class modules are equipped with airlocks which allow access to space as well as a nuclear generator allowing expansion of industrial capabilities without the need for expensive expansions.

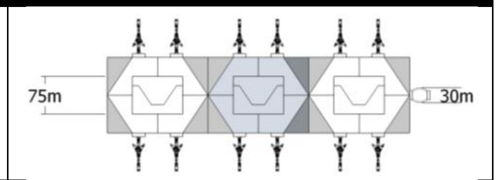
2.1.1.5.1 Heavy Manufacturing Robots in assembly lines churn out manufactured products in large numbers very cheaply. By utilizing versatile robots with several functions, Aresam can put new products onto the production line, reducing the time between R&D to actual products. Furthermore, with the airlock, small components can be assembled into large products such as extra modules and spaceships. Heavy manufacturing modules come with a medium traveling-wave reactor (TWR) which provides 300 MW of power.

Table 2.1.1.5.1 Heavy Manufacturing Module

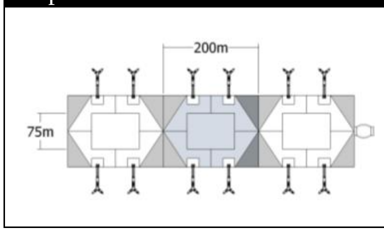
Isometric



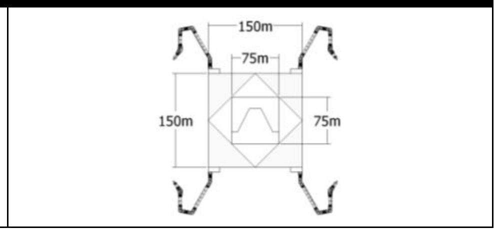
Side view



Top view

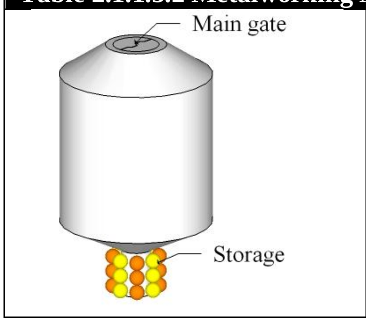


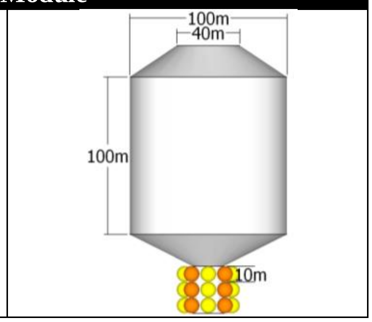
Front View



2.1.1.5.2 Metalworking Aresam will receive raw ores from various sources including Phobos and Deimos, as well as possibly the Asteroid Belt in the future. A large open volume and a 600 MW TWR reactor allow the installation of custom equipment to smelt raw ores or create exotic materials in the microgravity environment. A standard configuration would include a centrifuge to generate artificial gravity in order to separate materials and a furnace to melt ores. Although placing the metalworking module on the rotating structure would generate gravity as well, the gravity generated would be greatly limited by the residents sharing the rotating structure.

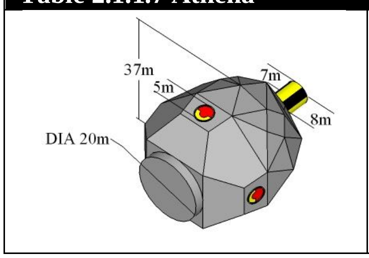
Table 2.1.1.5.2 Metalworking Module

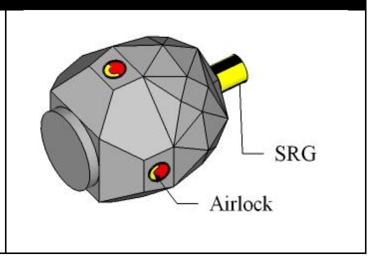




2.1.1.6 Athena Research modules, named Athena after the Greek goddess of wisdom, utilize evolutionary algorithms to develop better products from Martian resources. Evolutionary algorithms start with a design and randomly mutate it in small manners. The mutations that lead to a better design are kept. The cycle repeats, and within a few generations, a much better design is created. Our research modules test designs using physics models and then construct promising prototypes for actual testing. As a result, each research module is equipped with a small smelter to create custom materials, robotic workplaces to construct prototypes, and a testing center to determine the efficacy of various designs. Four airlocks provide access to space and allow additional equipment to be attached. The process is primarily automated with minimal human oversight, eliminating the need to endanger lives inside the research module. A 50 MW Stirling radioisotope generator powers each research module. Placement of the reactor on the outside of the module allows for easy reconfiguration to increase power output. *For more information about Athena, refer to section 7.0.3.*

Table 2.1.1.7 Athena





2.1.1.7 Power Primary power is supplied by solar panels. Four solar panel fields self-orient themselves to face the sun at the optimal angle. Each field measures 170 meters by 340 meters. Placement far away from the ring minimizes the chance that the colony's shadow will decrease the solar arrays' power output.

2.1.1.8 Poseidon The Poseidon class modules, named after the Greek god of commerce and travelers, serve as ports, the vital link between Aresam and the rest of humanity. This class of modules includes three primary forms that accommodate three types of traffic: space tugs, Mars surface landing/launch vehicles, and inter-colony/interplanetary spacecraft. The space tugs help in the construction, maintenance, and expansion of the colony.

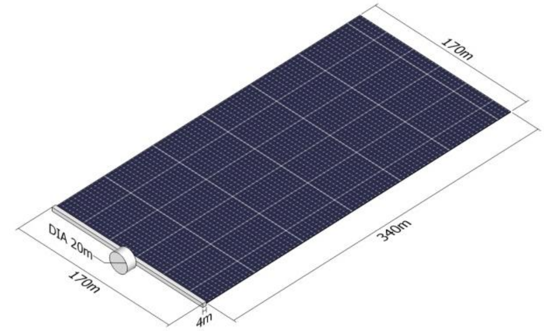
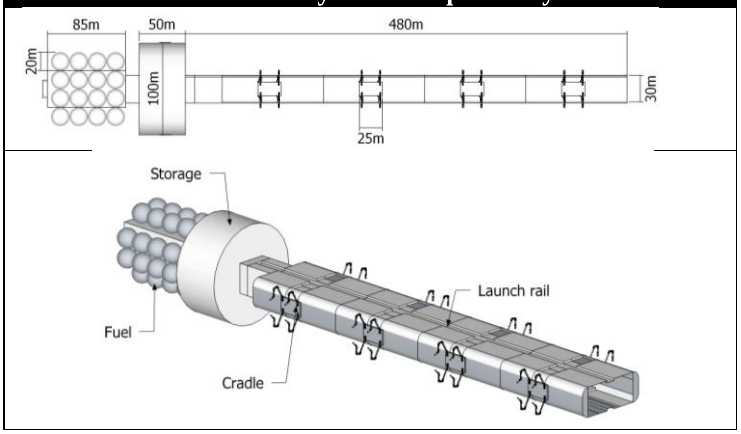


Figure 2.1.1.8 Solar Panel

2.1.1.8.1 Inter-colony and Interplanetary Vehicles Aresam has four passenger/cargo ports, each of which can accommodate 8 vehicles. Each port is 630m in length, allowing ample room for large spacecraft and transport of goods. *For more information on accommodating unknown vehicles, please refer to Section 2.4.3.*

Table 2.1.1.8.1 Inter-colony and Interplanetary Vehicle Port



2.1.1.8.2 Martian Surface Landing/Launch Vehicles The lander station can be rotated to always face Mars so that minimal maneuvering is required after launch, reducing fuel costs. Each Martian surface landing/launch vehicle (MSLLV) is stationed inside a compartment in the lander station. A lock-and-key mechanism uses an anchor rod to secure the MSLLV. The anchor rod once inserted into the craft uses several heavy pins to lock it down. Supplies, fuel, and passengers can be transported via the anchor rod. Vital fuel lines are protected greatly reducing the chance of accident. To launch, the anchor rod is detached and the doors of the compartment open. Electromagnetic rails on the sides of the compartment aim and launch the craft down towards the Martian surface. *Refer to Figure 2.1.1.9.2.*

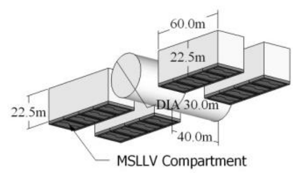


Figure 2.1.1.9.2 MSLLV Port

2.1.1.8.3 Space Tug Port Two ports house Aresam's fleet of 8 space tugs which provide the heavy lifting for Aresam and are used for construction, reconfiguration, expansion, and docking. Each space tug port is fully automated to reduce human error and is equipped to repair and maintain the space tugs.

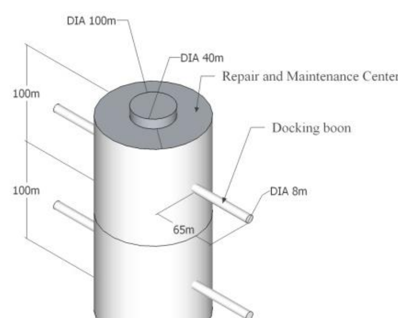


Figure 2.1.1.8.3 Space Tug Port

2.1.2 Debris and Radiation Protection

The Aresam hull utilizes two types of hulls for various degrees of structural strength and protection. Each type utilizes the same layers, but the differences in thickness change their strength and other properties. The primary hull provides structural support in the areas of the colony under great stress due to artificial gravity, and the secondary hull provides structural support in the zero-g portions of the colony. Another key difference is the secondary hull does not have the protective layer of MgO because it is not exposed to moisture nor air.

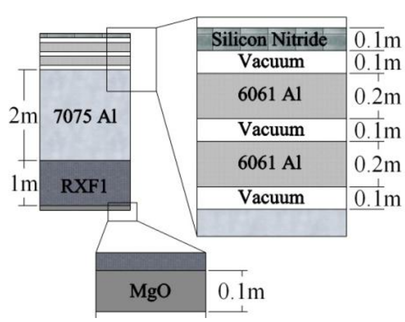


Figure 2.1.2.1 Primary Hull

2.1.2.1 Debris Protection The hull uses multiple layers to stop heavy impacts. The first layer of silicon nitride shocks incoming particles and causes most of them to disintegrate. The heat of impact will melt micrometeorites and for those that do penetrate the first layer, a gap will cause the molten particle to spray across the next layer of Aluminum 6061-T6, dissipating the energy of the impact across a larger area. The vacuum also serves another purpose: a vacuum is the best insulator, so will prevent the colony from overheating. Under these thin layers are panels of Aluminum 7075, a more durable alloy of aluminum than 6061. A self-healing layer of RXF1 polyethylene will repair any small fractures before a small defect cascades into a catastrophic structural failure. Finally the innermost layer of magnesium dioxide protects the hull from possible internal threats such as fire, moisture, and mold. Because all the structural strength comes from the RXF1 and 7075 Aluminum layers, the top few layers can be heavily damaged without any threat to structural stability, greatly reducing maintenance costs and increasing safety.

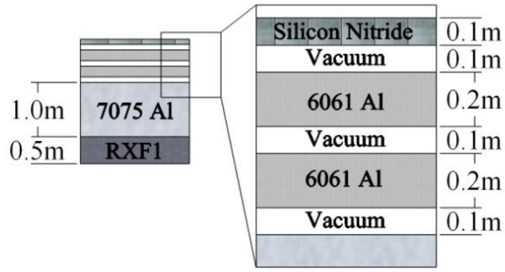


Figure 2.1.2.2 Secondary Hull

2.1.2.2 Radiation protection Aresam's hull protects the settlement against both electromagnetic radiation and ionizing radiation. The numerous layers of aluminum and the thick titanium ensure electromagnetic radiation will not penetrate inside, protecting the electronics within the colony. The RXF1 polyethylene scatters particle radiation, rendering the danger insignificant.

2.1.2.3 Maintenance Sensors embedded within the titanium hull monitor it constantly for signs of fractures, fatigue, and stress, while robots help perform regular inspections of other sections of the hull. Every layer with the exception of the titanium is installed as panels that can be easily replaced. Robots replace defective portions of the hull, greatly reducing the likelihood of a catastrophic structural failure. Replaced hull pieces are melted down and recycled.

Table 2.1 Radiation and Debris Protection Material

Material	Use	Maintenance	Properties
6061–T6 Aluminum	Debris shielding; electromagnetic radiation shielding	Inspected weekly, topmost layer replaced annually	Tensile strength of 290 MPa, yield strength of 241 MPa
7075-T6 Aluminum	Debris protection; structural support; electromagnetic radiation shielding	Inspected weekly	Tensile strength of 572.3 MPa, yield strength of 503.3 MPa
Magnesium oxide wallboard	Corrosion, fire, mildew, and moisture protection	Inspected monthly	Non-combustible, non-toxic, exceptional bonding surface, facial surface hardness of 8.3 MPa, water resistant
Silicon nitride	Debris shielding	Inspected weekly	Yield strength of 8.7 GPa
Self-healing RXF1	Radiation shielding; debris protection; ionizing radiation shielding; structural support	Inspected annually	Compared to aluminum, three times as strong, 50% better at shielding solar flares, and 15% better for cosmic rays

2.1.3 Artificial Gravity Aresam balances structural needs and human needs. Thus, the Hestia spheres have been placed 1280 meters from the axis of rotation, which provides enough clearance for the number of Hestia spheres to double as well as reduces the rotation rate needed to provide 1 G of gravity. The Demeter ring is located 300 meters from the axis of rotation, leaving only a small distance between the edge of the ring and Atlas. The Hestia spheres rotate at 0.836 rpm to generate 1.0 G (9.8 m/s^2) of gravity and the Demeter ring experience .23 G (2.25 m/s^2). With the full 1.0 G gravity in the Hestia spheres, newly arrived residents from Earth can easily adapt to the new environment. Furthermore, although the maximum rotation rate for long-term human habitation is 1.0 rpm, the low rotation rate renders the Coriolis effect unnoticeable. However, the transportation ring, Hestia spheres, the spokes and the Demeter ring are the only sections of the colony that rotate to generate artificial gravity; ports remain stationary to aid in docking procedures, Hephaestus class modules take advantage of the low gravity

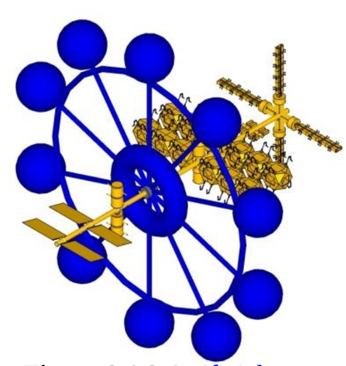


Figure 2.1.3 Artificial Gravity and Microgravity

to boost productivity and produce unique materials, and all other portions of the colony remain at microgravity to reduce the strain on the colony's structure.

2.1.3.1 Initiation and Maintenance of Artificial Gravity Space tugs supply the large amount of torque necessary to accelerate Demeter, Hestia spheres, and the transportation ring. Over time, impacts and minimal friction from the Martian atmosphere slowly causes the colony to decelerate. To maintain the rotation rate and the artificial gravity, space tugs will periodically apply additional torque to compensate for small changes in the rotation rate.

2.1.4 Pressurized Volumes To reduce costs, as much of Aresam has been left unpressurized as possible. The Hestia spheres, Demeter ring, and the transportation ring are the only large components of the colony that are pressurized. The pressure has been maintained at .9 atm in order to reduce the amount of air that must be imported as well as to reduce the structural stress from the air pressure. However, residents will experience minimal side effects from this lower pressure, while the savings will be great. Humans can travel throughout the unpressurized areas via pressurized vehicles or spacesuits.

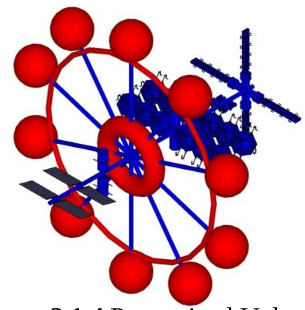


Figure 2.1.4 Pressurized Volumes (red) and Unpressurized Volumes (blue)

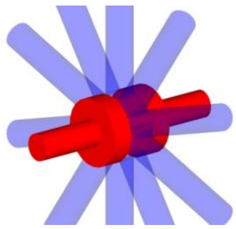


Figure 2.1.5.1 Atlas (red) and Spokes (blue)

2.1.5 Structural Interface Between Rotating and Non-rotating Sections To permit easy travel throughout the colony, a hub eases the transition from Atlas to the rotating portion of the colony. The hub houses the zero-G arena as well as a system of pods to move people and cargo from the non-moving Atlas to the moving spokes. The slow rotation rate allows for easy insertion of the pods into the spokes. Strong electromagnets repel to reduce friction but still maintain the relative position of both sections of the colony.

2.1.6 Contingency The modular nature of Aresam's design aids in the survival and repair of the colony in the event of a disaster.

2.1.6.1 Quarantine During quarantine, each of the ten Hestia sphere can be sealed and self-sufficient. Although airlocks in the elevators already seal off each sphere, large doors within the elevator shaft leading to Atlas can close automatically, providing an additional barrier. If the doors fail to close, residents put on spacesuits to enter the shaft and manually override the system, although the manual process, dependent on human muscle power, takes much longer. Such a system would be used to quarantine an infected region as well as isolate a major hull breach. Furthermore, bulkheads divide the Demeter ring into ten sections, permitting quarantine of one or more area.

2.1.6.2 Hull Breach Deflated ribs hidden inside the hull, which can quickly inflate to become rigid in order to seal off hull breaches as well as to provide additional structural support.

2.1.6.3 Power Failure In the event of a major catastrophe that destroys a large percentage of Aresam's primary power production capabilities, the Hephaestus class modules will scale down operations and start using their nuclear generators as a secondary power source for the rest of the colony.

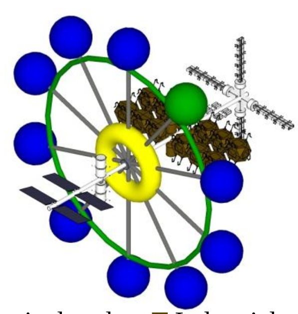
2.1.6.4 Destruction of Ports Essential traffic will be redirected to the Hephaestus class modules where their airlocks will serve as temporary ports, permitting loading and unloading of cargo and people. Although ships would not be able to refuel at these airlocks, this backup system allows Aresam to continue functioning even when its main link with the rest of humanity is severed.

2.2 INTERIOR CONFIGURATION

Aresam is home to a wide variety of activities. Aresam is not only the home of 20,000 people but also the furthest Human outpost, one that will help mankind settle on Mars and beyond. This panoply of purposes can be separated into three broad categories: residential, commercial, and industrial.

2.2.1 Residential The residential area is located in 9 Hestia spheres. Each contains living accommodations, restaurants, supermarkets, clinics, gyms, as well as other facilities to maintain a comfortable and Earth-like environment.

2.2.2 Commercial The commercial region is primarily located in one Hestia sphere, specializing in business pursuits, and the Hermes ring. Office buildings, small factories, banks, and other infrastructure allow Aresam's economy to grow and thrive.



Agricultural Industrial
Commercial Residential

Figure 2.2 Agricultural, Commercial, Industrial, and Residential Areas

2.2.3 Industrial The Hephaestus class modules house and power Aresam's industrial capabilities. These modules, located along Atlas, contain facilities to process raw ores into usable metals and materials and to manufacture almost any imaginable part or machine.

2.2.4 Hestia Hestia provides one level for Aresam's office buildings, hotels, and small factories. Below lie the supporting infrastructure that makes life possible. The living area has 190 meters clearance at the highest point. The top 10 meters is for an observation deck that gives residents and unparalleled view of space and Mars. Below the residential level, 20 meters are reserved for basic infrastructure. Because the lower levels experience greater gravity, the water systems take advantage of the higher gravity to speed up the processes. The volume underneath the infrastructure level is kept hollow to reduce the overall weight on the structure, but can be utilized as future expansion space.

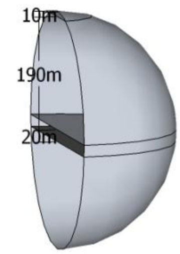


Figure 2.2.4 Hestia

2.2.5 Hermes The ring connects all the residential and commercial areas and thus is the perfect location for commerce. Hermes' top half provide room for commercial activity, while the bottom half houses two levels for transportation, one devoted to cargo and one devoted to passengers.

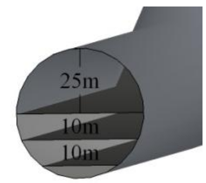


Figure 2.2.5 Hermes

2.2.6 Heavy Manufacturing The internal configuration of each heavy manufacturing module can be customized to fit changing demands. However, to permit this flexibility, each module has vast open spaces to allow the installation of machinery to produces a wide range of products in zero-G.

2.2.7 Metalworking The metalworking modules of Aresam produce refined materials from raw ores. These refined materials are either exported or sent to the heavy manufacturing modules. A large empty internal volume allows the installation of a wide variety of equipment. Because the smelting modules operate in zero-G, any of the walls can be used as a "down" surface.

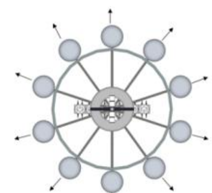


Figure 2.2.8 Orientation of Down Area

2.2.8 Orientation of Down Area Because Aresam's artificial gravity is generated by centripetal acceleration, down is away from the axis of rotation. However, this only applies to Hestia, Hermes, Demeter, and the spokes.

Table 2.2 Areas and Volumes

Component	Down area/ module (m^2)	Total Down Area (m^2)	Down Area %	Volume/ module (m^3)	Total Volume (m^3)	Volume %
Athena	N/A	N/A	N/A	19,058	76,232	0.02%
Atlas	N/A	N/A	N/A	3,254,690	3,254,690	0.70%
Demeter	3,764,173	3,764,173	52.10%	53,443,908	53,443,908	11.56%
Hephaestus	N/A	N/A	N/A	N/A	48,791,768	10.55%
Manufacturing	N/A	N/A	N/A	11,250,000	45,000,000	9.73%
Metalworking	N/A	N/A	N/A	947,942	3,791,768	0.82%
Hermes	840,718.00	840,718.00	11.60%	13,015,541	13,015,541	2.82%
Hestia	262,323	2,623,230	36.30%	33,510,322	335,103,216	72.48%
Poseidon	N/A	N/A	N/A	N/A	8,653,223	1.87%
Interplanetary	N/A	N/A	N/A	1,281,041	5,124,164	1.11%
MSLLV	N/A	N/A	N/A	186,149	372,298	0.08%
Space Tug	N/A	N/A	N/A	1,578,380.50	3,156,761	0.68%
Total	N/A	7,228,121	100%	N/A	519,783,569	100%

2.3 CONSTRUCTION SEQUENCE

The initial construction of Aresam heavily relies on the manufacturing capabilities of Bellevistat; Bellevistat is the only colony in orbit capable of producing Aresam's major modules and structures. However, once the Hephaestus class modules are installed, Aresam will be able to construct its own modules and structures, and large parts will no longer have to be shipped millions of kilometers.

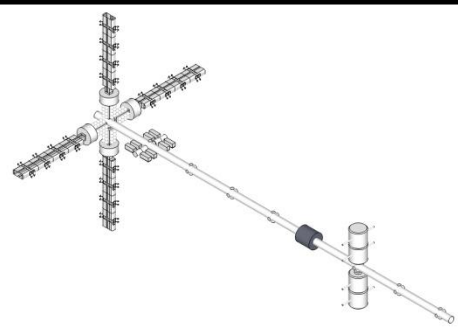
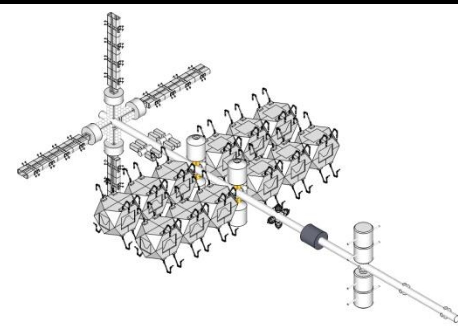
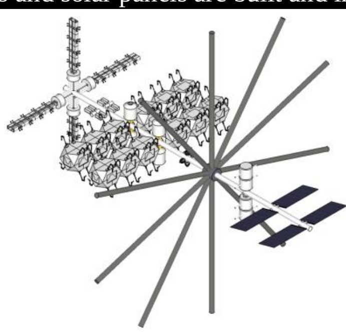
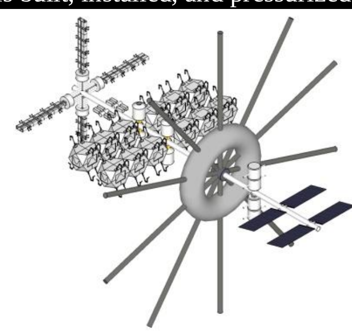
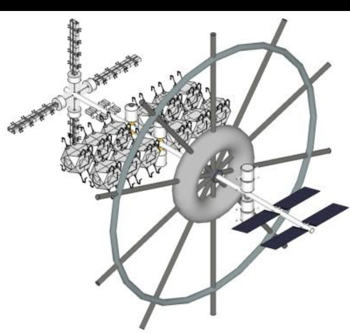
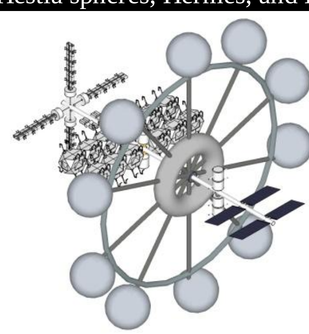
2.3.1 Pre-Construction Before construction of Aresam begins, a mobile headquarter is moved into Martian orbit to house the human supervisors and construction crews. Three robot support ships house and maintain the robotic construction crews. Five tankers supply the fleet with fuel. Mining outposts on Phobos and Deimos provide the raw ores to be processed into finish colony components.

2.3.2 Construction The first and foremost task is to establish a base of operations. Thus Atlas and ports are built first to create an outpost around Mars. The Hephaestus class modules and research modules are installed. At this point, Aresam is operational and can begin generating income, fulfilling its role as a base to explore the Red Planet. Only then are the living quarters and infrastructure for human life aboard Aresam constructed.

2.3.3 After Construction Only after the entire colony is rotating are residents brought in, allowing thorough testing of the colony with little risk to life. Throughout the entire construction sequence, the mobile headquarters supports the construction crew.

2.3.4 On-site Resources Although utilizing Mars as a source of materials is cheaper than importing from Earth, utilizing materials from Phobos and Deimos is even cheaper. One key material on the moons is olivine. By reacting olivine with hydrochloric acid, magnesium chloride is produced. By purifying it, the solution can be electrolyzed to produce pure magnesium metal. This metal can be turned into magnesium oxide to produce magnesium oxide wallboards, a fire, water, and mold-resistant building material.

Table 2.3 Construction Sequence

1. Components of Atlas and ports are transported from Bellevistat and assembled on site. Ports are installed.	2. Hephaestus class modules are installed, allowing Aresam to construct the remaining necessary components. Athena modules are installed.
	
3. The spokes and solar panels are built and installed.	4. Demeter is built, installed, and pressurized.
	
5. Hermes is built and installed.	6. Hestia spheres are built, installed, and pressurized. Space tugs start rotation of spokes, creating artificial gravity in the Hestia spheres, Hermes, and Demeter.
	

2.4 EXPANSION AND FUTURE OPERATIONS

Aresam's design maximizes efficiency and safety. Every effort has been made to reduce the loads on the structure to allow Aresam to expand without extensive renovations. Furthermore, modularity permits easy reconfiguration to adapt to changing demands.

2.4.1 Expansion Procedure for Hestia Each major component of Hestia is prebuilt and assembled near Aresam. To move the module into place, the colony's rotation rate is decreased to aid in installation. Once the colony has been slowed down, space tugs move two Hestia spheres into position. Temporary scaffolding keeps the spheres in position before they are firmly secured to the adjacent Hestia spheres and the transportation ring. Once secure, the entire structure is accelerated back to its original rotation rate. Operations can continue during expansion. The only effect on normal life would be reduced gravity for a few days. During each expansion phase, two spheres are installed opposite of each other in order to maintain balance and stability. The total number of Hestia spheres can double, accommodating twice the original population. By the time expansion is completed, the Hestia spheres will form a beaded torus.

2.4.2 Expansion Procedure for Modules Pre-existing universal docking ports allow modules to attach directly to Atlas. Space tugs maneuver a new module to position. Universal mating joints allow the modules to easily attach to Atlas. To detach the module, the process is reversed.

2.4.2.1 Universal Mating Ports Each universal mating port utilizes three types of connections to integrate each module into the colony: structural, power, and communication. Structural connections secure each module to Atlas, power connections allow each module to connect to the grid, and communication connections allow remote control of various processes inside each module. Each universal mating port on a module has 2 male structural connectors, 2 female structural connectors, 2 male communication connectors, and 2 female power connectors. These connectors slide into its counterpart on Atlas. 4 retractable pins on each male structural connector lock each module in place.

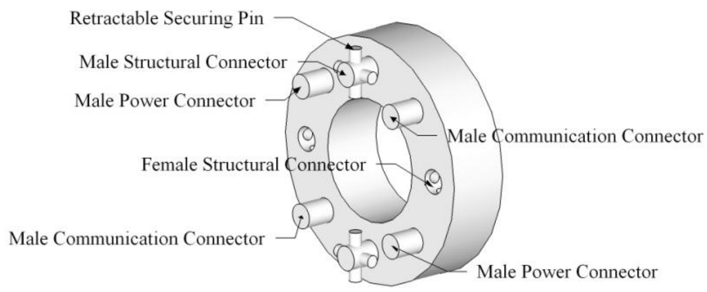


Figure 2.4.2.1 Universal Mating Port on Modules

2.4.3 Port Accommodations for Future Vehicle Designs The configurable robotic arms of the passenger/cargo ports can accommodate vehicles of any plausible shape or size. They also have the capability to exchange apparatuses at the end of them, such as claws, cables, hooks, or any other docking implements.

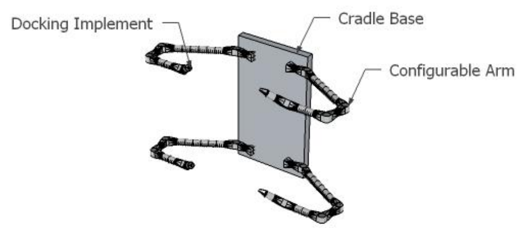


Figure 2.4.3 Port Accommodations for Future Vehicle Designs

2.4.3 Expansion The modular design allows for efficient and unobtrusive expansion; new modules can be attached quickly, minimizing inconvenience. Expansion modules are modeled in the same way as existing modules so standardization and efficiency preserved. Combinations of robots and space tugs are used to attach modules. During module attachment procedures, operation of the Martian Lander and Space Tug ports is unaffected. In the passenger/cargo port, docking and launching are halted for a maximum of 24 hours.

2.4.4 Operations Disruption As the only human settlement around Mars, Aresam will need to wait extended periods of time before aid arrives. As a result, any disruption in Aresam's operation has the potential to become catastrophic and cripple the colony's profitability. Thus, every critical system in Aresam has redundancies. Resources can be redirected where it is necessary; power from the solar panels can be redirected manufacturing, power from the Hephaestus class modules can be rerouted to the Hestia spheres. The manufacturing modules can quickly rebuild any damaged components. In the hull, self-healing RXF1 polyethylene automatically repairs any small fractures before they cause critical failure of structural integrity.

2.5 PREFABRICATED STRUCTURE

Aresam has the capability to construct an easily deployable Mars structure. The structure can self deploy and assemble within 8 hours. The modular nature of these prefabricated structures allows several to be connected to form a large surface base.

2.5.1 External Design Fully deployed, the prefabricated structure measures four meters radius. A heavy base ensures structural stability, and the dome shape provides optimal protection against high Martian winds. Four universal mating joints act as airlocks and can attach additional prefabricated structures to expand an initial base.

2.5.2 Hull Composition High strength polymer tubes filled with Martian regolith protect a dome of carbon steel. The Superadobe provides protection against the high speed Martian winds as well as the radiation going through the thin Martian atmosphere. Because most of Superadobe comes from the local surroundings, volume is saved in the initial landing container. In addition, the carbon steel forms a backbone, providing structural support for the prefabricated base. Although the structures are required to last just 30 days, the customer can choose to reinforce these structures with additional layers of Martian adobe and upgrade lifesupport systems, extending their lifespan far past the initial 30 days.

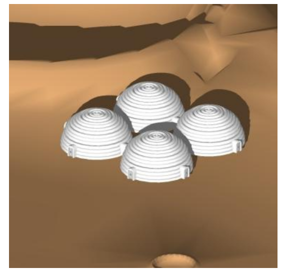
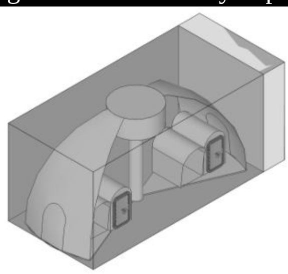
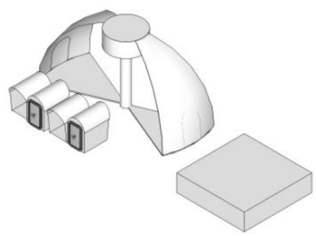
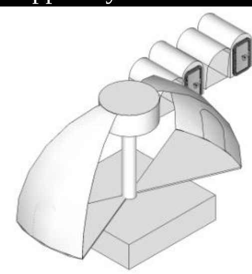
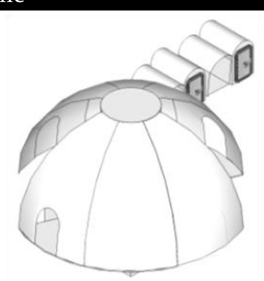
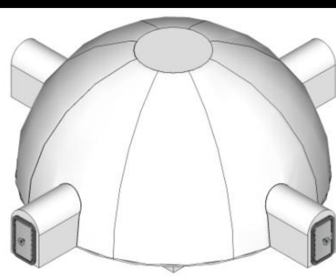
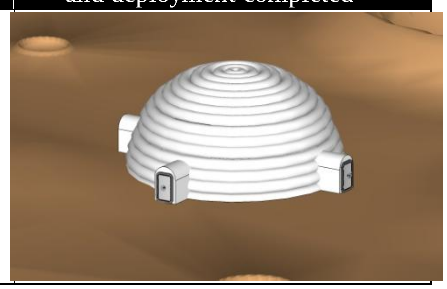


Figure 2.5 Martian Surface Base Composed of Four Structures

2.5.3 Before Deployment To fit inside a standard container 4 meters by 4 meters by 9 meters, 8 panes of the dome are collapsed. Fully collapsed, the structure measures a mere 3 meters wide and 8 meters long.

2.5.4 Deployment Construction of the Martian surface base starts once the cargo container reaches the ground. The construction robot starts excavating a foundation. The excavated Martian soil is used to fill the tubes. After the foundation is fully excavated, life support systems are placed inside the trench to act as a foundation. The collapsed dome is then placed on top. Motors inside the dome then move the panels into place. The universal mating joints are installed and the airlock is attached.

2.5.4 Expansion To expand, additional structures connect directly to the original dome via the universal mating joints found in the airlocks.

Table 2.5.4 Deployment Phase		
1. Container lands on Mars and begins to automatically unpack	2. Trench is dug and life support system is installed	3. Structure is installed on top of life support system
		
4. Panels rotate out to form the dome	5. Panels finish deploying and airlocks added	6. Superadobe tubes are attached and deployment completed
		

OPERATIONS AND INFRASTRUCTURES

3.0 OPERATIONS AND INFRASTRUCTURES

3.1 CONSTRUCTION MATERIAL SOURCES

3.1.1 Aresam Orbital Location Aresam will orbit around Mars at its equator in between the two orbits of Phobos and Deimos. Its orbit will have an altitude of 16,000 km, providing equal access to both of the moons for extensive mining operations. It will orbit at a speed of 0.92 km/sec, following Deimos in its orbital period of 1.26 days, keeping the smaller but slower moon constantly in sight and allowing Aresam to easily expand its focus on material harvesting and research as Aresam develops its reputation as the Gateway to Mars. The much faster orbital speed of Phobos will provide about 5 access time frames during Aresam's orbital period during which communications and transportation between the colony and the moon can be achieved. The colony will have an inclination 5.65^o to the suns equator, providing optimal light exposure with the help of rotating solar panels.

3.1.2.1 Materials and Equipment Logistics Materials and equipment to construct Aresam will come from various sources including Earth and Bellevistat. The majority of materials will be obtained from Mars and its two moons, Phobos and Deimos to most effectively utilize nearby resources. Materials like aluminum, silicon, and iron can be mined from Mars' surface. Manufactured materials come from Bellevistat to save costs of space experimentation and at times, transportation costs. All robot parts will also come from Bellevistat, supplied by the Alliance Automation Division. A selected few materials will come from Earth within the two-month window every two years that Aresam will get to receive materials from Earth. During the beginning stages of construction, raw materials will mined and transported to Bellevistat for processing and manufacturing.

3.1.2.2 Transportation of Materials Our company's fleet of Percheron will provide transport for materials and modular parts of the colony from the origin to the construction site of Aresam. The Percheron space tugs are maintained and service in orbit to greatly reduce transportation cost. Once onsite, material transport robot Convector will unload and deliver them material and equipments to the desired location on site.

Table 3.1.2 Construction Materials and Sources

Materials	Composition	Amount(m^3)	Source
Silicon Nitride	Silica	1,213,297	Phobos and Deimos
	Nitrogen		Martian atmosphere (2.7%)/ Earth
6061 Aluminum	Silicon	4,804,112	Phobos and Deimos.
	Iron		Martian soil; Phobos/Deimos
	Copper		Mars
	Manganese		Martian meteorites can be mined to supply an abundant amount of Manganese.
	Magnesium		Martian mantle/soil.
	Chromium		Martian soil.
	Zinc		Martian soil.
	Titanium		Martian soil.
	Remainder Aluminum		Aluminum can be extracted from aluminum oxide, found on Martian rocks.
7075 Aluminum	Zinc	21,415,062	Martian soil.
	Magnesium		Magnesium can be found on Martian soil as well as deep into Mar's mantle.
	Copper		Martian soil
	Aluminum		Martian soil
	Trace metals: Silicon, Iron, Manganese, Titanium,		Martian soil.
Self-Healing Material	RXF1 plastic	29,060,203	Earth landfills
	Dicyclopentadiene		Earth
	Ruthenium carbine complex		Earth
Magnesium Oxide	Magnesium	881,064	Martial soil
	Oxygen		Martian soil

3.2 COMMUNITY INFRASTRUCTURE

3.2.1 Atmosphere The colony will maintain 0.9 atm constantly with the same atmospheric composition as Earth. The atmosphere is kept at 0.9 atm because nitrogen is extremely expensive to import from Earth, and a lower atmosphere puts less strain against the hull. The 0.1 atm difference is not noticeable for residents all the while saving a large amount of money. There will be no atmosphere in the manufacturing modules, reducing costs and chances for explosions due to the lack of oxygen. Air purification in the colony will be controlled by High Efficiency Particulate Absorbing (HEPA) filters coupled with Photocatalytic Oxidation technology. HEPA filters will remove 99.99% of 0.01 micrometer-molecules using randomly arranged fibers to which air particles adhere to. HEPA filters are crucial in removing allergens and pathogens. The Photocatalytic Oxidation technology will be mounted alongside the HEPA filters to help enhance air filtration by oxidizing organic contaminants. UV light along with magnetic particles in a magnetic field are used to sterilize 99.9% of bacteria and viruses.

Table 3.2.1 Atmosphere Atmospheric Composition (0.9 atm)

Gas	%	Volume m^3
Nitrogen	78%	126628114
Oxygen	21%	34092184
CO2	<1%	1623437

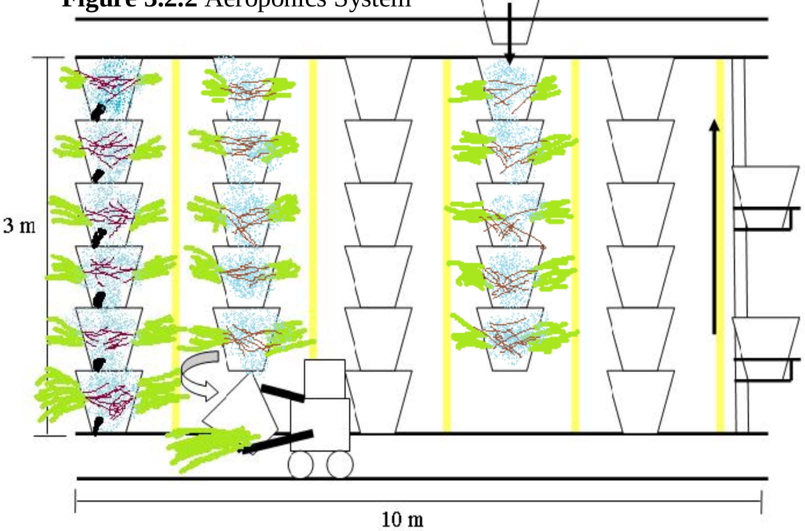
3.2.1.1 Climate A Mediterranean climate of 20 °C to 25 °C and 35% to 40% is constantly maintained throughout the colony. Foam sheets are applied over fiberglass to provide for optimal insulation in residential and commercial buildings. Personal temperature controls are available to residents to satisfy their preferences. In industrial and agricultural sectors where specific temperatures are required, vacuum insulated panels will be applied for optimal insulation and temperature control. Each individual sphere will have its own automated climate system, and vents will exchange carbon dioxide for oxygen from the agricultural ring.

Figure 3.2.1 Weather Park

3.2.1.2 Weather Control Aresam will simulate Earth's weather patterns as closely as possible by installing 5 weather parks in selected residential domes. Weathers such as rain, snow, fog…etc can be simulated and different seasons will be controlled by the atmosphere control system and amount of light allowed into the colony. Water will by recycled closely to ensure efficiency. The parks will also help maintain psychological stability of residents through natural scenery and earthlike conditions.

3.2.2 Agriculture Agriculture on Aresam will be centralized in a low gravity ring Demeter near the central rod. The agricultural torus Demeter has a 95m radius and will supply all the spheres with produce and livestock products. The Demeter torus is divided into 5 levels of growing sectors, each specializing in different types of agriculture to optimize efficiency. Each sector will contain a Processing and Distribution Center. A ring of fresh produce markets will be placed inside the transport ring, ensuring all residents equal and easy access to the freshest produce.

Figure 3.2.2 Aeroponics System

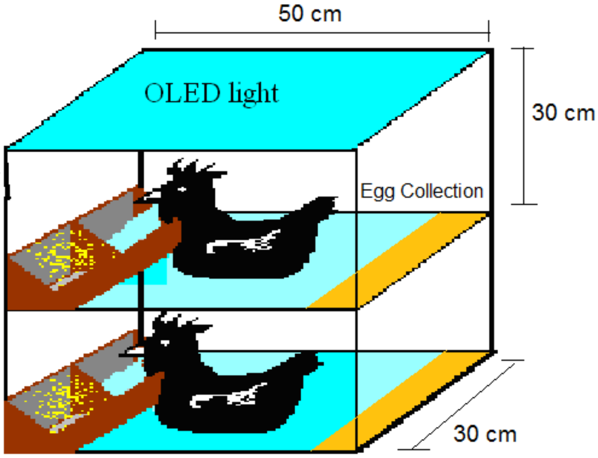


3.2.2.1 Aeroponics Aresam will be using aeroponics as the main system of agricultural growth. Aeroponics offer several essential advantages over hydroponics or traditional soil method that warrants our usage. First of all, aeroponics produces about 30 times more crops than traditional soil methods while still maintaining quality taste. In an aeroponics system, crops can be grown year round and the equipment and nutrients required will be greatly reduced. While soil agriculture requires 200-400 liters of water per plant and hydroponics require 70 liters, aeroponics needs only about 20 liters of water with dissolved nutrients. The system operates on low energy requirements as it uses gravity as the main water and nutrient distribution force. The nutrient and water supply of Aeroponics is constantly and easily monitored Aeroponics is also mush more productive and self-sufficient, recycling all the water used.

3.2.2.2 Growth Our system will operate on the principles of Zero Waste (discussed in 3.2.4), efficiency, as well as self-sufficiency. The aeroponics structure consists of multiple modules of five 3 m long vertical rods on which produce will be grown. The rods are then separated into 6 "vases", each vase supporting an individual plant. The initial seeds are planted into the modules at different time intervals, so the 6th vase (bottom vase) will contain the most mature produce while the top vase contains the youngest seedling. Each vase will contain individual water and nutrient misting nozzles programmed to the needs of specific plants. Artificial lighting will be provided by LED light strips that run vertically alongside the rods. In each sector, 10 of this Aeroponics structure will be stacked on top of each other to maximize volume use, and these stacks will run the length of the torus. This system of rods reduces the already slim possibility of pathogenic water infecting the entire agriculture system and increases sustainability, and the concept of modularity enhances efficiency.

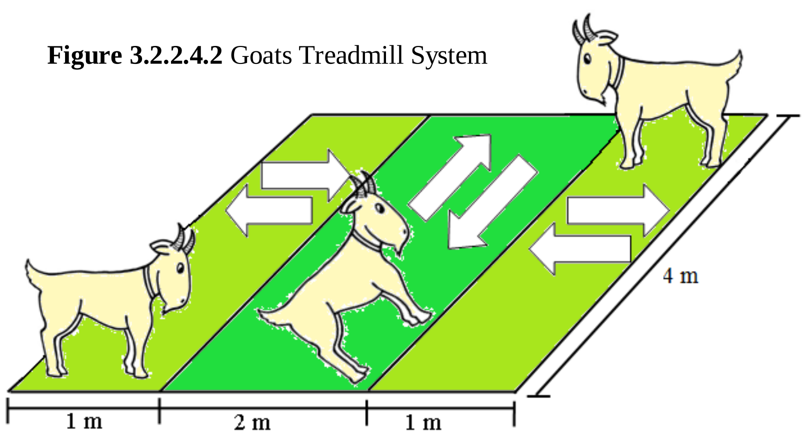
3.2.2.3 Harvest Harvesting robots will roam the base of the structures to collect ready-to-harvest plants. Most plants mature in a 90 day period under system and will be located at the bottom-most vase. The vase is detached and crops are extracted before the empty vase is replaced at the top of the structure, ready to receive another seed. The entire rod then shifts down and the cycle repeats. This system of continuous growth and harvest ensures colonists the freshest produce year-round. Harvesting operations will resume every 15 days as the vases are pushed down.

Figure 3.2.2.4.1 Chicken Housing



3.2.2.4 Livestock Management Meat products on Aresam will be provided by goats, chickens, and tilapia. The chickens will provide white meat and eggs for the colonies. The goats will provide red meat, cheese, milk, and yogurt. The tilapia will provide white meat and an alternate food choice and cultured meat will supply protein source for vegetarians. Each chicken will be contained in 0.3 m x 0.5 m x 0.5 m boxes with a wired ground surface, allowing easy collection of their droppings. Hens will lay eggs into collection gutters and eggs will be collected every four days with one egg from each hen allotted for hatching. Goats will provide the main dairy source on our colony. Cows are too inefficient for management, and goats offer equal, if not more, nutritious products. Goats are contained in 4m x 4m of living area, with the entire floor functioning as a treadmill. The treadmill floor will run in two directions, with one belt operating vertically in the middle and two belts running horizontally next to it. This arrangement conserves an enormous amount of space and provides the same amount of exercise as natural grazing. The floor will detect goat movement and turn on as soon as the goat enters the correct directional range. Goats are milked daily for dairy products Tilapia are chosen as the colony's main fish source for their high protein content, rapid growth and palatability. Tilapias are grown in tanks that supply 4 gallons of water for every fish. The tank is controlled at 25-30°C and they will be fed twice a day on algae. Only male tilapia are grown to sustain a controlled and marketable population as females will cause rapid breeding and interrupt with efficiency of the system.

Figure 3.2.2.4.2 Goats Treadmill System



3.2.2.5 Cultured Meat Cultured meat is grown as a vegetarian replacement for live animals. Cultured meat will be grown on a system of scaffolds that produce layers of tissues grown from animal stem cells. Raised tubes on the surface of the scaffolds will train the muscle cells into developing vessel-like tubes and blood nutrients will be supplied to the meats through the system of blood vessels. Cultured meat can also be altered to increase its nutrition contents to be healthier for the residents.

The agriculture sector will continue to research and perfect the process to simulate real meat and the colony will shift towards a larger incorporation of cultured meat into its diet.

3.2.2.6 Processing/Packaging/Storage

The chickens and goats will be caught by solely automated systems. The chickens will then be swiftly and humanely disposed of while ridding of the excess parts (sent to waste management). The chickens will be stored in cold water between 0-40 degrees Fahrenheit to hinder the growth of bacteria. The chickens will ultimately be packaged in plastic wrap. The tanks for tilapias are connecte to a reception pool inside the processing plant through a regulated opening. The tilapias are then caught and disposed of swiftly. The tilapias will ultimately be packaged using a foam base and plastic wrap (either as whole or as fillet).

3.2.2.7 Distribution/Selling From the Processing and Distribution Centers, the food will be distributed to the markets through the ten spokes to the Hermes transportation ring and then individual residential spheres with the help of transport robot Argo through the third level of Underground Transport System. Some will be allocated for emergency storage inside each sphere.

3.2.3 Electrical Power Generation Solar power remains the most effective and cost-efficient source of power despite the distance of Martian orbit. One of our company's most effective existing technological processes is the production of solar cells in a zero-g environment. Utilizing this well-developed technology, silicate based photovoltaic cells will supply the primary power of the colony. Coats of thin film cells composed of silicon dioxide will be coupled with nanoengineered antireflective coating to ensure maximum light spectrum absorption. The thin film cells are arranged in the form of vertical crystals of silicon, in the way blades of grass are arranged. This arrangement allows the cells to capture sunlight at various angles and the thin-film structures require only 1% of silicon used in traditional silicon wafers, dramatically reducing cost without reducing efficiency.

Table 3.2.3 Electrical Power Generation

Priority	Type	Electric Output	#	Allocation	Location
Primary	Solar	1,200,000 kW	2 solar panel fields	Hestia residential spheres/Hermes transport ring	At the end of Atlas opposite to ports
Secondary	Traveling Wave Nuclear Reactor	1,000,000 kW	Varies according to # of industrial modules	Industrial modules/ agricultural ring	Industrial modules
Backup Storage	Rechargeable Batteries	Varies	12	Throughout colony if needed	Hestia spheres/Ports

Table 3.2.3.2 Estimated Power Allocation/ year

Purpose	Power (kW)
Residential	45,000
Commercial	30,000
Heavy Manufacturing	300,000
Smelting	600,000
Research	50,000
Ports/Spacecraft	200,000
Lighting/Utilities	20,000
Agriculture	200,000
Communications	100,000
Climate Control	15,000
Transportation	200,000
Automations	150,000
Total	**1,910,000**

3.2.3.1 Traveling-Wave Reactor Solar power will provide power to the residential sectors, while the nuclear Traveling-Wave Reactor will provide the massive power requirements of heavy-manufacturing and smelting modules. The Traveling-Wave Reactor is a low-weight reactor that requires only a small amount of enriched U-235 as its core contains mostly of U-238, depleted uranium largely available on Earth. The minimal amount of nuclear waste that is produced will be vitrified and eventually propelled towards the sun. The low maintenance and high energy output capability of the reactor ensures the safest possible nuclear energy source suitable for industrial power generation. One Traveling-wave reactor will be placed in each industrial module and will also serve as secondary power to solar panels in case of emergencies.

3.2.3.2 Power Distribution Aresam will use High Intensity Laser Power Beaming (HILPB) system for wireless power transmission as the primary means to distribute electrical power throughout the colony. Solar energy will be received easily by the lasers and fast neutrons from nuclear reactions in nuclear generators will be utilized in nuclear pumped lasers (NPL). Vertical Multi-junction (VMJ) photovoltaic cells, which converts laser to electrical energy, will be essentially integrated onto the rooftops of buildings so as to maintain a direct line of sight with the master laser generator situated above the colony as needed. Quantum cascade lasers will be implemented to increase the efficiency of laser to better the effectiveness of converting solar/nuclear energy to light. Once the VMJ photovoltaic cells have generated electricity, the power is distributed within the building through the use of witricity. Witricity will provide for a smaller scale wireless power transmission using electromagnetic resonance properties of identical transmittance and receiver metal coils. Witricity offers effective power transmission harmless to humans and non-disruptive to machineries. The HILPB system provides benefits not found in other conventional energy transfer methods including: the capability for the system to operate with zero radio-frequency interference to communications systems, the relative compact size of the photovoltaic cells allow for energy to be distributed on smaller scales if necessary, and the collimated monochromatic wavefront propagation of such technology allows for narrow energy beams to be transferred over larger ranges. As a result, provides a comfortable, wire free environment for citizens living on the colony. Excess electrical power from both the solar panel and Traveling wave reactor will be stored in batteries in case of emergencies.

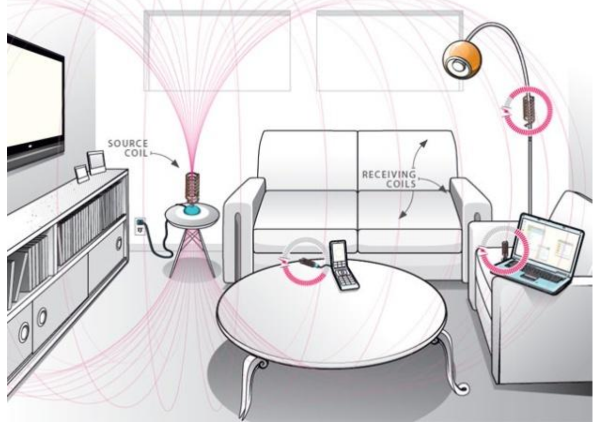
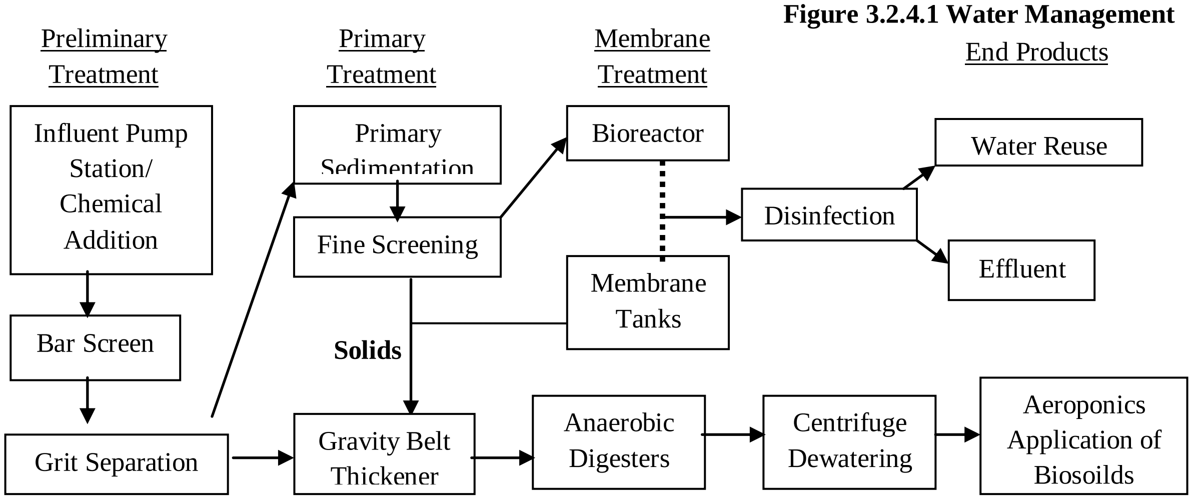


Figure 3.2.3.2 Witricity

3.2.4 Water Management Water on Aresam will mostly be obtained from the Martian polar icecaps. A main water reservoir and water treatment center will be located in each residential sphere, under the surface roads. It will utilize the centrifugal force generated to create water pressure which will simulate systems created on earth. The reservoirs will consume a sphere with a volume of approximately 230,000 gallons each. The water treatment system will run both clockwise and counterclockwise throughout the colony and will supply all the main pipes. Two main pipes will run perpendicular to each spherical subsector, one for an inflow of water and the other handles the used water. The water will follow a circular pattern and with each cycle, will pass through the water treatment system and main reservoir at least once.

3.2.4.1 Water Treatment Water will be monitored throughout the colony with the use of infrared spectrometer, which can easily measure water toxicity, by detecting the colors in the infrared spectrum. All waste water is sent to the Water/Waste Management Center located underground in the Hermes spheres. Influent contaminated water first goes through a series of filters which take out any major solids in the water. The Bar Screen filters big particles when water passes through. The water then goes though a Grit Separation process for flocculation, utilizing a consistent spinning motion to coagulate disturbed larger particles. Next the water travels to the primary Sedimentation Tank in which settled sediments are collected at the bottom of the tank. Fine Screening then filters even smaller particles. Membrane bioreactor (MBR) technology is utilized in the next phase where bioreactors consume remaining miniscule solids and microorganisms and are retained by the membrane tanks so as to not move onto the next phase. MBR implements braided fibers which water passes through, reducing damages to the system thus diminishing the cost for repairing the system. In treating waste water, MBR also eliminates sludging which in the long run would prove to be cost-effective. The filtered particles from each phase is collected and through our Zero Waste policy will be turned into compost and returned back to the colony causing minimal harm to the

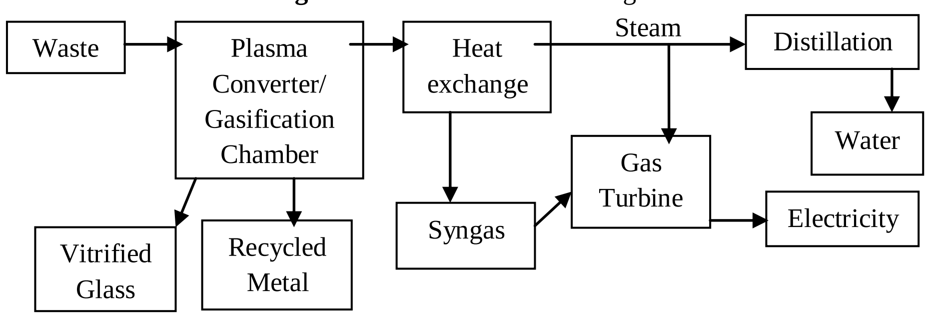
Figure 3.2.4.1 Water Management



environment. Disinfection commences with the implementation of electro dialysis which draws ions out of the water. Also, ozone will be used in further disinfecting the water to get rid of microbes in the water and eliminates radiation as well. With this well-developed water treatment process, we are left with clean effluent water that will prove to be suitable for drinking to people living in the colony. We advocate a water treatment process which would prioritize cost-efficiency as well as promote resource conservation which would also tie in with our zero-waste policy. Our water treatment process would also bear in mind the safety of our residents and thus we refrain from using radiation to eradicate any water waste.

3.2.5 Waste Management We understand that our colony and industrial systems must move away from a primarily linear, one-way industrial system to a cyclical system modeled on nature's successful strategies. Each material must be used as efficiently as possible and must be chosen so that it may either return safely to a cycle within the environment or remain viable in the industrial cycle. As a cost-effective approach towards the issue of wastes, the Zero Waste policy will incorporate aims to establish zero solid waste, zero hazardous waste, zero toxic emissions, zero material waste, zero energy waste and zero waste of human resources ultimately in order to provide the most plausible and effective solution for waste management. The Zero Waste concept emphasizes sustainability beyond reuse and recycling. More importantly, it promotes designs that consider the entire product lifecycle, such as longer product life, reparability, and ease of disassembly. As a result, Zero Waste maximizes recycling, minimizes waste, reduces consumption, and ensures that products are made to be reused, repaired, or recycled back into nature. The Zero Waste strategy addresses the overuse of raw resources, minimizes waste of natural and human resources, and it achieves infinite sustainability by eliminating waste rather than managing it.

Figure 3.2.4.1 PGP Waste Management



3.2.5.1 Household and Industrial Waste Treatment The Plasma Gasification Process (PGP) provides capabilities to the colony to put the Zero Waste Policy into action by converting waste to clean synthetic gas, electricity, fertilizer, construction material, salt and clean water. PGP is a thermal process that utilizes intense heat to process waste materials in a closed, controlled, and oxygen-starved environment. Although similar to incineration, the oxygen deficient environment minimizes burning, and highly energy-efficient syngas is produced. Then from the second product heat, the steam is collected and fed into the electricity generation process, improving its efficiency. The last product is a glass-like reusable solid called "slag" which is durable and nonreactive and can be used for construction materials for roads and buildings. The PGP system can process any waste stream, has no emissions, and produces self sufficient electricity, making it an extremely cost-efficient system in managing waste. In support of the Zero Waste policy, we propose to eliminate household and industrial waste through implementation of reusable and modular packaging. With standardized modular packaging that can be adjusted for different sizes and shapes, waste products from packaging is effectively eliminated.

3.2.6 Internal Communication We will provide internal communications while bearing in mind cost-efficiency as well as safety by means of an OLED system. Flexible OLED sheets will be installed throughout the colony and the visible lights emitted will be specifically amended to be encoded with wireless information for data transmission in addition to its lighting purposes. The primary OLED source will function at the same frequency as the uplink transmitter; which will allow for information to be transferred during the off-cycles of the OLED sheets' frequency. The OLED system is also capable of performing its functions even when the OLED sheets are turned off with the implementation of a light source which operates at an invisible frequency. The OLED system also resolves issues concerning the interference in communications by the obstruction of the signals and OLEDs are relatively cheaper in comparison to LCD technology and plasma displays. Furthermore, OLEDs are characterized by a faster response time than do LCD screens: LCDs generally offer a frame rate of 1,000 Hz while OLED are allegedly able to offer response times of less than 0.01ms which provides refresh rates of 100,000 Hz. The OLED system will sustain a well-connected living environment for the space colonists and allow for efficient transfer of data within the colony. *For more information about network structure, refer to Section 5.3.2.3.*

3.2.6.2 External Communication With rapidly growing requirements for larger bandwidths and power constraints, radio frequency will no longer be suitable for long range communication among Aresam, established colonies, mining sites, and Earth. We propose the use of infrared based free space optical communication to satisfy these growing demands. Optical communications will offer our colony higher link bandwidth and a dramatic decrease in power required. High-gain, photon-counting detectors will be placed at each receiving site for high detection efficiency, stability, and superior in its signal to noise ratio. These photon detectors will effectively convert information embedded in the lasers into electrical signals with high accuracy and efficiency. Satellites will be placed in the Sun-Mars L4 and Sun-Mars L5 points to provide for constant line of sight for relaying the laser communication. The laser communication will follow the DTN protocols and transmit information in bundles to ensure data safety and successful transmission. *For more information about DTN protocols, refer to 5.4.1.*

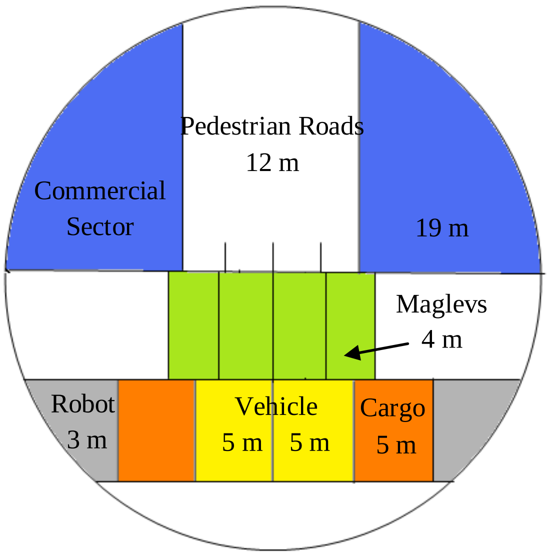


Figure 3.2.7 Hermes Transport Ring Road Division

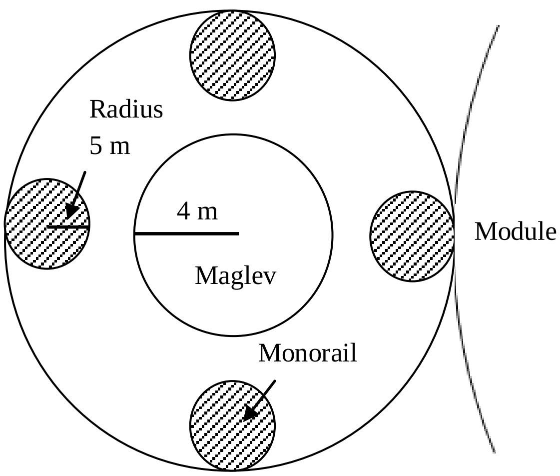


Figure 3.2.7.1 Atlas Configuration

3.2.7 Internal Transportation Residents will mainly walk the 400m diameter of the Hestia residential spheres. Bipods will be provided as well to offer a variation in individual transportation. Mass transit is supported by Maglevs that run through the Hermes transportation ring. The Hermes ring is attached to the residential spheres for easy transit throughout the colony. The ring is divided into 3 levels: the first level is connected to the surface roads of the spheres and will support most of the commerce of the colony as well as pedestrian roads. The second level under that contains the Maglev system that circle the colony. Two lines will run in both directions to ensure the fastest possible transport for colonists, while one specialized line will provide transport within Atlas. The last level will provide transport routes for robots, cargoes, and vehicles. A system of 4 monorail tracks will circulate the entire colony, including the spokes and the central rod; these tracks will provide distribution of agricultural products as well as robot, cargo, and vehicle transport through the Atlas central rod to ports and industrial modules.

3.2.8 Day/Night Cycle Due to a lack of adequate atmosphere, sunlight will not be scattered and consequently a naturally produced "blue" sky is not possible. As a result, OLED technology will be utilized to artificially produce a day-night cycle consisting of 24 hours modeled after Earth's cycles. The OLED panels can also be programmed to adjust to the shorter and longer days characteristic of the seasons on Earth. The OLED panels are easily maintained and require only a slight amount of energy in order to operate a full 24 hours. With the use of the OLED technology, the inhabitants will experience a comfortable and familiar environment. The infrastructure of the dome that shelters the colony will be lined with these OLED panels and the inhabitants will feel more comfortably at home.

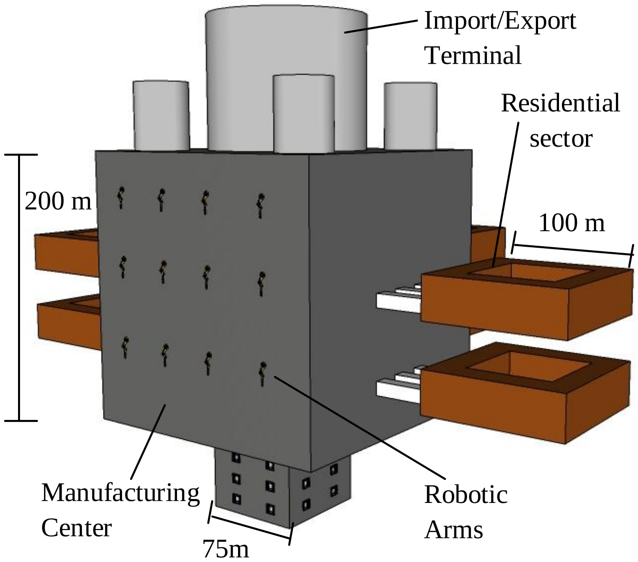
3.2.9 Emergency Storage Facilities

Within the Demeter agricultural ring, there will be a storage facility which will devote a great deal of it's capacity to emergency storage of food, it will allow for the storage of 20,000 m^3 both cryogenically and freeze-dried foods; providing enough emergency provisions for nearly 300 days for all inhabitants of the colony in case of an interruption of supply or a sudden food blight. Furthermore, each home is to have an emergency supply of food and commodities for use onsite in case of the quarantine of an entire sector. These emergency supplies, when properly used, can provide enough sustenance to allow a family of 4 to survive for nearly a month

3.3 CONSTRUCTION MACHINERY

3.3.1 Primary Construction Machines/Equipments Aresam will be an extensively modular colony to satisfy the demand for continuous expansion as well as to streamline the construction process. Modularity will significantly

Figure 3.3.2 Mobile Headquarter



reduce the amount of on-site manufacturing, with the majority of modules constructed at Bellevistat; this not only ensures quality control but also greatly decreases the problem with limited resources of on-site construction.

3.3.2 Mobile Headquarter A mobile headquarter constructed at Bellevistat will be sent into Martian orbit as the first step of construction to oversee and manage the entire construction process of Aresam. The mobile headquarter will contain living quarters for human workers, multiple robotic arms to assemble and disassemble modular parts of the colony, and also a manufacturing center to provide structural changes to the parts when needed, or to construct additional components that are required. Manufacturing will be conducted in a zero-atmosphere environment in the center, and multiple openings will allow import and export modules and materials.

Figure 3.3.2.2 Percheron Space Tug

Residential sectors will be placed on three sides of the headquarter, while robotic arms are placed on the fourth for assembly of modules

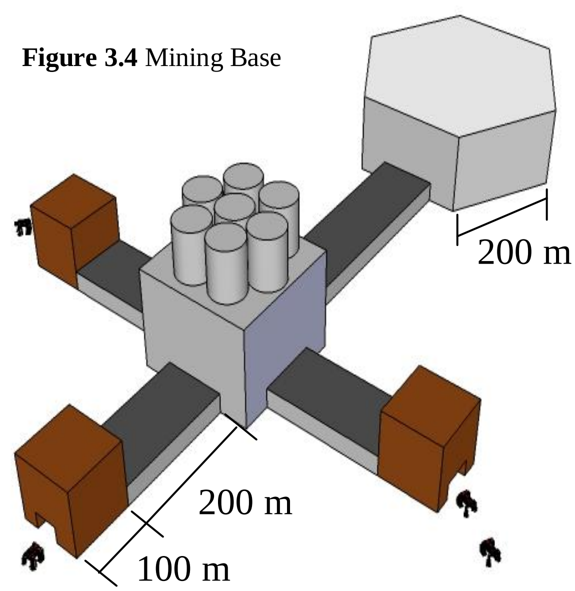
3.3.2.2 Materials and Transport Mining bases on Phobos and Deimos will be immediately deploy along with the headquarter to supply Bellevistat as well as manufacturing center on the mobile headquarter with raw materials required to manufacture individual modules and components. A fleet of 8 space tugs developed from the existing Percheron technology will be constructed to serve as the primary workhorse in the construction process. Modular segments of the central rod, manufacturing and research modules, Hestia domes, and individual segments of the Demeter and Hermes ring will all be tugged into orbit from Bellevistat by the space tugs, while Second-Generation Percheron will transport raw materials from Phobos and Deimos to mobile headquarter and Bellevistat for further processing and manufacturing.

3**.3.2.3 Structural Assembly** Once in orbit, the components will be assembled by three robotic base ships that will attach the modules with the help of its robotic arms and specialized construction robots. Four fuel tankers will constantly resupply the headquarter as well as the robotic base ships. More detailed machinery construction processes and modular attachment processes are shown in Figure

3.4 MATERIAL HARVESTING OPERATIONS ON PHOBOS/DEIMOS

3.4.1 Material Harvesting Logistics Mining bases will be placed on each of the two moons orbiting Mars. Each base is completely unmanned and equipped with its own fleet of mining probes; ore transport robots, storage space for processed ore, a spaceport and loading dock, and an ore refinery. Ore separation, which is dependent on the ore being processed, will take place in the cylindrical substructures on top of the primary structure. Refining processes will take place in the middle sector, and then moved to the pentagonal structure for storage or export from the 3 ports located on the exterior of the structure. Raw materials will be packed into second generation Percherons and

Figure 3.4 Mining Base



launched off the moons on angular tracks to eliminate dust-kickup from chemical rockets.

3.4.2 Material Harvesting Processes

Mining operations consist primarily of simple, proven methods such as simply pulling the desired materials from the surface from strip mining. Refining processes include molten electrolytic separation for aluminum, electromagnetic separation for iron, and acid/microwave leaching for titanium. These processes are chosen over other processes for their cost efficiency and overall simplicity. For example, the acid/microwave leaching extracts titanium more efficiently than other metallurgical processes like treating molten slag with chlorine or sulfuric acid solution. The latter process is not only expensive and complicated to set up, it also produces toxic waste which is costly and time consuming to treat. The acid/microwave leeching process produces none of these wastes, is cheaper to operate and less expensive to set up. Purified ore will then be ready for transport via cargo shuttle to a heavy manufacturing station, where the alloys used for constructing Aresam are formed.

3.5 OPERATION SYSTEMS FOR PREFABRICATED BASE

3.5.1 Operations Logistics Self-sustainability and efficiency will be characterize operation systems on the base; the systems will aim to minimize operational waste and will emphasize reduce and reuse using a connected system that will provide for each other. Operation systems will be packed alongside of the prefabricated base in a 4x4x1m volume. Once arrived on Mars, the systems will be unpacked and provide the foundation for the prefabricated base, again in a 4m x 4m x 1m volume.

3.5.1 Power Generation Power will come from a hydrogen based fuel cell. Liquid hydrogen, amounting to about 4000 liters and liquid oxygen amounting to about 2000 liters will react in an electrolytic reaction to produce electricity sufficient to sustain operations for about 30 days.

3.5.2 Atmospheric Regulation The exothermic reaction of the hydrogen fuel cell and water byproduct will help in sustaining the crewmembers for the duration of their stay by aiding temperature regulation and providing a large source of drinkable water. The interior of the base will be pressurized at .9 ATM, and will be 80% nitrogen and 20% oxygen by composition. About 110 liters of liquid nitrogen and 28.1 liters of liquid oxygen are needed to fill the base with the needed gasses. Dye-sensitized solar cells deployed on the roof of the base will be used in a carbon fixation cycle, in which the products will be disposed of. Not only does this filter the air of carbon dioxide, it also produces a small amount of energy to supplement the power cells. Additional liquid oxygen will be included in case of system failure.

3.5.3 Water and Waste Management Waste will be processed to extract the maximum amount of usable materials and minimize harm to crew members. Waste management will utilize a small scale micro-biodigester system, taking up about 1 cubic meter of space. Water is extracted from waste through distillation and cycled back into the filtration system. By treating human waste with a series of methane producing bacteria, other pathogens are destroyed while the waste is converted into methane gas which can be stored and used as fuel.

3.5.4 Food Food consists of freeze dried, vacuum sealed rations which take up about 1500 liters.

Table 3.5 Operation Systems Amounts

Materials/ Components	Biodigester system	Liquid Oxygen+Liquid Nitrogen	Rations	Dye-sensitized solar cells	Fuel cell components	Liquid Oxygen	Water
Purpose	Waste management	Pressurized Atmosphere	Food	Energy/Oxygen source	Energy/Water source	Oxygen source (emergency)	Water (initial source)
Volume (cubic meters)	1.00	.1281	1.5	7.00	6.00	.100	.100
Total volume used: 15.8281 cubic liters							

HUMAN FACTORS

4.0 HUMAN FACTORS

Aresam, the premier colony at the furthest point of humanity's reaches in the galaxy, has been designed to welcome in booming numbers of immigrants and to allow for efficient research of the Martian surface by incorporating innovative technology that allow for both comfort and convenience.

4.0.1 Natural Sunlight and Views of Space and the Martian Surface Residents of Aresam will have access to observatories where they can spend their spare time gazing out towards space and observing the stars. The observatories will hold special significance because it is the only easily accessible location where residents can have a natural view of the outside.

4.0.1.1 Observatories Each Hestia has an observation level. The outer edge of the observatory is transparent allowing residents to use publicly available telescopes to view the outside. Towards the middle are private rooms where residents can hold parties or social events while enjoying the wonders of space, courtesy of the OLED walls.

4.0.1.2 The "Sky" To help create a more Earth-like environment, the ceiling will be covered with OLEDs to create a simulation of a day-night cycle by showing a sky which will change according to the time of day. To further mimic a natural sky, advanced software allows us to simulate random events such as clouds and meteors.

4.0.2 Expanding Community As the Gateway to Mars, Aresam will experience an influx of new residents hoping to join in the rush to settle Mars. As a result, Aresam has been designed to accommodate increases in population in both its modular hotels and homes. For more information about modular buildings, refer to section

4.0.3 Roads for Pedestrians With much of society's focus on staying healthy and fit, especially into the later years of people's lives, Aresam will encourage citizens to walk around as much as possible by discouraging the use of personal motorized transportation.

Figure 4.0.3.1

4.0.3.1 Alternatives: Bipods However, for the handicapped, individual carts, known as Bipods, will be available. The individual carts can be manually driven within buildings, but on the street must be connected to a railway system and remain in a section of road dedicated to Bipod traffic. *See figure 4.0.3.1*

4.0.4 Mitigation of Coriolis Effect One major problem introduced by living in an environment with artificial gravity is the increase in the Coriolis Effect. Although we have taken measures to reduce the effect by decreasing the rotation rate, the effect is still detectable. In order to minimize both the discomfort and disorientation brought on by the forces, Aresam will implement precautions in the design of the settlement and in the accessories provided to colonists.

4.0.4.1 Neckwear Upon entry of the colony, people will be provided with Noriolis, neckwear that prevents sudden head turns as well as other sudden head movement that greatly increases the Coriolis Effect.

4.0.4.2 Elimination of Unnecessarily Long Lines of Sight In Hestia, long straight streets are eliminated. Because most people will travel on foot, traffic will be not significantly impeded. However, the benefits will be great with long lines of sight will be eliminated, reducing the disorienting effect on residents.

4.1 FACILITIES, SERVICES AND CONSUMABLES

A variety of buildings from the residential and commercial sectors of society will be in place throughout the colony to help maintain an Earth-like environment. *Refer to Table 4.1.1*

4.1.1 Facilities

4.1.1.1 Hermes, the Transportation Ring As the link between all the residential and commercial areas, Hermes is a logical location for a center of commerce— a downtown for the colony. Much of the official governmental activity and business will be run in the area, as well as much of the recreation/entertainment.

4.1.1.1.1 Foundation Society Headquarters, Police Department, Fire Stations The headquarters for the Foundation Society, Police Department, and Fire Stations will be located in the transportation ring. However, smaller extensions of the Police and Fire Stations will be in place in all of the spheres to ensure quicker response times to emergencies.

4.1.1.1.2 Visitor's Center Visitors who have made it all the way to Aresam must first stop by the Visitor's Center to pick up a temporary communications device. From there, they can meet up with Janus helping robots to gain more information about the colony. *For more info on Janus refer to 5.2.3.*

Table Facilities 4.1.1 Buildings/Facilities	Area (m^2)	#	Area (m^2)
Two Story Houses	128	1000	128,000
One Story Houses	99.23	1800	178614
Apartments	75.88	4500	341460
Condos	80.7	3,000	242100
Masera University	1500	1	1,500
Transportation Center	225	10	2,250
K-12 School	3,000	1	3,000
Fine Dining	400	16	6,400
Family Restaurants	289	32	9,248
Fast Food Restaurants	120	48	5,760
Supermarkets	750	10	7,500
Gym	400	11	4,400
Personal Health Center/Luxury Spas	900	2	1,800
Clinics	625	12	10,000
Hospitals	1800	2	7,200
Fire Station	600	2	1,200
Police Department	400	2	800
Libraries	900	1	900
City Hall	625	1	625
Amusement Parks	62500	1	31,750
Large Parks	18750	4	75,000
Sports Complex	22500	2	45,000
Performing Arts Center	10000	1	10,000
Museum/Cultural Enhancement Center	3000	2	6,000
Movie Theater	900	4	3,600
Hotel	4200	1	4,200
Night Clubs	500	2	1000
Pool Halls/Casino	500	2	1000
Malls	2500	2	5,000
Shops	225	20	4,500
Arcade	289	8	2,312
Visitor's Center	169	4	676
Computer/Food Cafes	289	16	4,624
Bank	600	14	8,400
Foundation Society Headquarters	1050	1	1,050
5-Person Office	100	30	3,000
50-Cubicle Office	256	16	4,096
100-Cubicle Office	700	8	5,600
Other office space	1400	4	5,600
Convention Centers	3750	1	3,750
Air Backup Tank	150	10	1,500
Robot Storage	1440	2	2,880
Computer/Robot Repair Shop	400	4	1,600
Computer Storage	2500	2	5,000
Warehouse	2500	2	5,000
Waste/Water Management	2025	2	4,050
Worship Center	400	9	3600
Recycling Center	900	10	9,000
Factory	15000	2	30,000

4.1.1.1.3 Aresam Performing Arts Center In Aresam's attempts to provide all types of entertainment to colonists, the APAC will have a variety of shows playing throughout the year, from classic plays to live musical performances, and even some colonial original acts.

4.1.1.1.4 Education Considering the relatively small number of children present in the colony, Aresam will have only one K-12 school located in the transportation ring. The school will be built with several levels and a few basement floors (all expandable), to account for a constantly growing number of children.

4.1.1.1.4.1 Masera University Masera, the premier and only university on Aresam will serve not only as a center for higher education, but also as a hub for scientific research with its well-equipped labs and access to the Athena research modules. With the University's proximity to the Martian surface, Masera will easily serve as a base for scientists to conduct research, prepare expeditions of the Martian surface, and analyze new data.

4.1.1.1.5 Office Space Companies will have choices between hundred cubicle offices, fifty cubicle offices, and five person offices when trying to lease spaces for their workers.

4.1.1.1.5.1 Entrepreneurship In Hermes, a business center will allow innovative residents to pitch their business plans to investors as well as for inventors to find customers for their new products.

4.1.1.2 Recreational Activities Beyond the advanced home entertainment system, Aresam residents will have access to numerous facilities, including parks, performing arts centers, and even a zero-g arena.

4.1.1.2.1 Zero-G Arena In the hub of the colony, a large area will be set aside for experiment zero gravity games and activities for anyone to try out. There will be rooms for simply floating through the air or rooms with balls, goals, etc. for people to attempt and create their own games.

4.1.1.2.2 Bumper Balls Harkening back to the carnival game of bumper cars, Aresam will provide residents with an unusual twist on the original game by putting it in zero gravity. Players will be placed inside large hamster ball-like spheres with elastic coverings which will effectively bounce— or bump— off other spheres that they collide

Table 4.1.5.1 Consumables per Year		
Food	Per person	Total for Colony
White Potatoes	33.11 kg	66224 kg
Spinach	1.13 kg	22679 kg
Soybeans	10.43 kg	208652 kg
Tomato	41.59 kg	831888 kg
Lemons	3.04 kg	60781 kg
Radishes	.23 kg	4.54 kg
Common Oats	2.95 kg	58967 kg
Wheat, hard white	64.27 kg	1285480 kg
Shitake Mushrooms	1.81 kg	36287 kg
Cod	2.27 kg	45359 kg
Soymilk	60 L	1200000 L
Pasta	8.16 kg	163293 kg
Nanking Cherry	0.82 kg	16329 kg
Tilapia	.52 kg	10341 kg
Goat Milk	23 gal	460000 lbs
Goat	7.26 kg	145150 kg
Goat Cheese	14.06 kg	281227 kg
Roasted Chcken	27.40 kg	547940 kg
Raw tofu firm	12 g	108862 kg
Plain Yogurt	2.27 kg	45359 kg
Eggs	15 kg	296649 kg
Romaine Lettuce	18 kg	362873 kg
Peas	.91 kg	18143 kg
Beans	22.68 kg	453592 kg
Cabbage	3.86 kg	77110 kg
Glutinous Rice	25.4 kg	508023 kg
Garden Onions	9.07 kg	181436 kg
Imperator Carrots	4.72 kg	94347
Idaho Potatoes	57.61 kg	1152124 kg
Sweet Oranges	35.74 kg	714861 kg
Apples	21.82 kg	436355 kg

Figure 4.1.1.2.2 Bumper Balls

with. To ensure safety, seatbelts secure the players while cushioning isolates the center from the shock of impact. To control the ball, players use a simple joystick mechanism, whose movements are translated by a computer into bursts of air from small pressurized canisters in the bottom. After each game, the canisters are refilled and the balls are ready for the next game. Also, residents can choose between several different modes of play, including simple free-for-all style and a capture the flag.

4.1.2 Health and Fitness of Residents With life in space being a relatively new experience for most people, Aresam will keep the monitoring of the health of residents as a top priority. In order to do so, each of the universal communications devices, named PAN (Personal Access to Networking), will also monitor each resident's health.

4.1.2.1 Clinics and Personal Health Centers When the vital signs of a colonist begin to show abnormalities, PAN will suggest that residents visit a local clinic. Additionally, residents will be encouraged to visit Personal Health Centers, where can people relax. The Personal Health Centers will also be able to distribute vitamins. *For more info on the monitoring of the health of residents refer to 5.3.2.2.*

4.1.3 Parks and Open Public Areas Parks will maintain wide open space so that claustrophobic people will have a place to relax out in the open. Each of the public parks will be filled with greenery, small bodies of water, and playgrounds to help complete a wholesome "outdoor" experience.

4.1.3.1 Weather Parks Because seasonal weather cycles for the entire colony would be extremely costly, Aresam will have Weather Parks simulate different kinds of weather. Having the parks will help residents adapt to their new settings by helping ease homesickness. Also, aside from simply showcasing the weather, each of the parks will have a café to allow visitors to lounge around, enjoy some coffee, and listen to live performances by fellow colonists with events like Open Mic Nights, Talent Shows, and other social activities, helping develop a sense of community.

4.1.4 Community Layout About 11% of the area will be used for roads. There will be four of residential sphere one and 5 of residential sphere two. *See Figure 4.1.4.*

4.1.5 Food and Consumables

4.1.5.1 Tilapia Tilapia, a very healthy and nutritious fish, will enhance the health of the residents of Aresam. This type of fish will be a healthy addition to the residents' diet. Not only does Tilapia contain omega-3 fatty acids that are beneficial to the heart, but they also taste very good. These fatty acids reduce blood pressure, the risks of certain cancers, inflammatory conditions. Tilapia also has omega-6 fatty acids, which lower blood cholesterol levels.

4.1.5.2 Nanking Cherry Nanking cherries are a type of cherries that are moderately fast growing. They grow on short shrubs which saves space. This shrub can tolerate dryness and wind. Nanking cherries have a very sweet taste and are ripe when they are a dark red hue.

4.1.5.3 Soymilk Soymilk is a substitute for cow's milk due to its lack of lactose. Soymilk also contains a high concentration of protein. Compared to cow's milk, soymilk has a fiber. Furthermore, it also contains isoflavones, which play an important role in preventing cancers, heart disease, osteoporosis, and diabetes, as well as enhancing eye health.

Figure 4.1.4 Community Layout

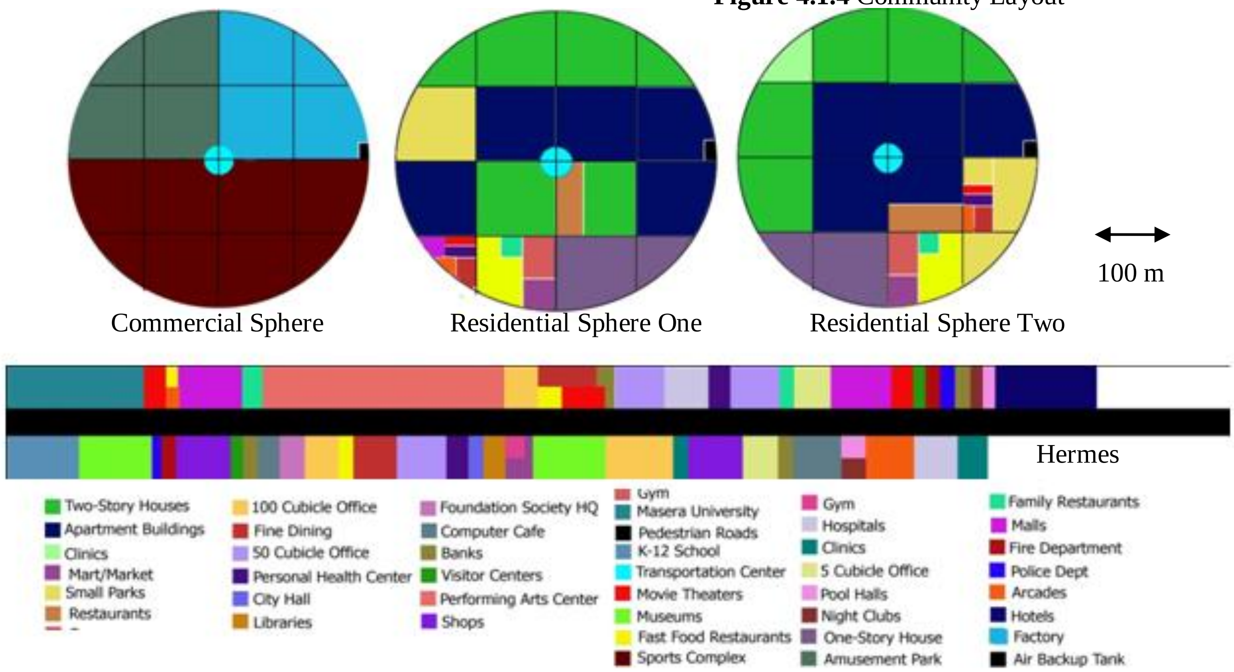


Table 4.1.5.2 Consumption of Water, Paper, and Fabric					
Consumables	**Amount / Capita**	**Amount / Household (family of 4)**	**Amount Per Colony**	**Sources**	**Method of Distribution**
water/day	378.54 L	919.86 L	7570823.57 L	Water will be initally harvested from the Martian ice caps and continuously recycled	Water will be distributed to households via the colony's infrastructural pipelines
water/ year	138167.53 L	335747.10 L	2.7633506 × 109 L		
paper/ day	.73 kg	N/A	14415.53 kg	Aresam will import an initial supply of paper and recycle all waste	Paper, after being produced in the factories will be delivered to convenience stores and supermarkets in each sphere for people to buy
paper/ year	263.08 kg	N/A	526167149 kg		
fabric/year	30 kg	130 kg	760000 kg	Aresam will import an initial supply of fabric and recycle/reuse that supply	Fabric, after being will be sold from to businesses for consumers to buy afterwards

4.2 RESIDENCES, FURNITURE, AND APPLIANCES

Designs of homes and their furnishings will be built with efficiency in mind, while maintaining comfort and style.

4.2.1 Home Designs One story houses, two story houses, apartments and condos will be able to accommodate a wide range of families and individuals.

4.2.1.1 Honeycomb Apartments Keeping efficiency in building and in space saving in mind, Aresam will be using apartments in the shape of honeycombs. Each separate comb will be composed of modular parts that can easily be added on to the main building to make a whole complex. There will be 4500 apartments each with an area equal of 75.88 m^2.

4.2.1.2 One Story Houses Aresam's single story houses will feature an extremely flexible and customizable home setup. The house itself, with a seashell shaped design, will feature a revolving center to save space in eliminating the

Figure 4.2.1 Home Designs

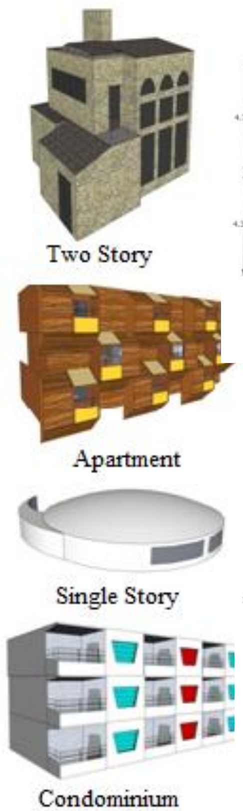
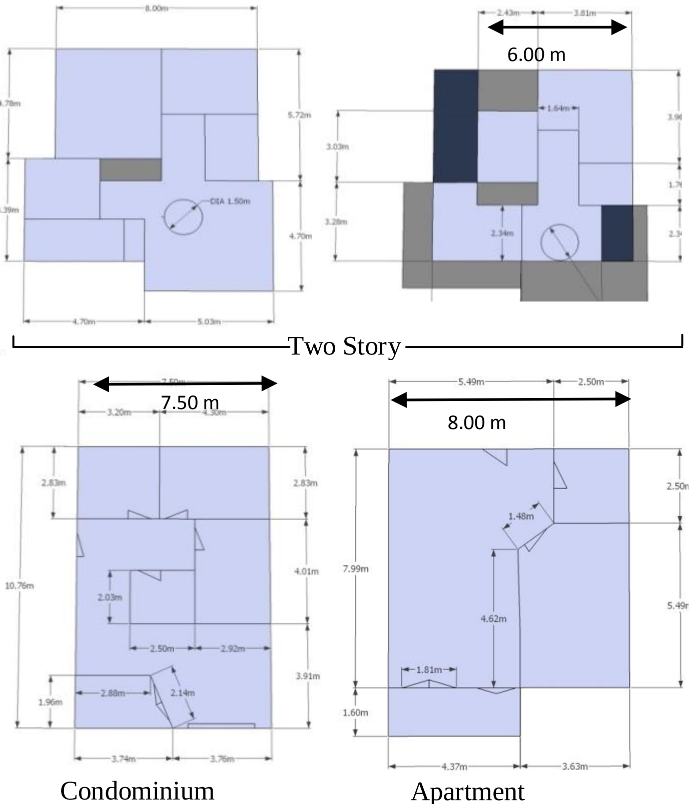


Figure 4.2.1.1 Floor Plans



need for hallways; this will be explained more in 4.4.2. Additionally, walls in the house will be completely mobile, allowing for people to choose the size and amount of the rooms in their house. There will be 1800 single story houses with an area of 99.23 m^2.

4.2.1.3 Two Story Houses The colony's two story houses will follow a more traditional style of housing according to Earth's standards. These houses, despite their older look won't lose out in style or comfort. There will be 1,000 houses each an area equal of 128 m^2.

4.2.1.4 Condominiums For people looking for their own property rather than rentals, condos will be available. There will each with an area of 80.7 be 3000 condos square meters.

4.2.2 Furniture and its Sources Furniture on will be designed with a homely feel in mind while maintaining the colony's theme of using space efficiently. *Refer to Chart 4.2.2 for amounts of furniture.*

Chart 4.2.2 Amount of Furniture per Building

Furniture	1 Story	2 Story	Condo	Apt	5 Person Office	50 Cubicle	100 Cubicle	Total
Auto Roll-out Beds	3	4	2	1	0	0	0	19900
Styrofoam Chairs	2	4	1	1	0	5	10	15260
Bamboo Dining Chairs	4	4	2	2	0	0	0	26200
Cooktop Ventware	1	1	1	0	0	0	0	5800
Minimalist Cooktop	0	0	0	1	0	0	0	4500
Global Mobile Office	0	0	0	0	5	0	0	150
Waterless Urinal	0	0	0	0	2	5	10	210
Cardboard Couch	0	0	1	0	0	2	4	3064
I-Basket Washing Machine	0	0	1	1	0	0	0	7500
Public Washing Sink	0	0	0	0	0	2	2	48
Clam Light/Lamp	2	2	1	1	2	10	20	13480
Eco Shower	2	2	1	1	0	0	0	13100
Sink	2	3	1	1	2	0	0	14160
Dual Flush Toilets	2	2	1	1	2	6	10	13336
Dining Table	1	1	0	0	0	0	0	2800
Multi-Purpose Dining Table	0	0	1	1	0	0	0	7500
Magnetic Refrigerator	1	1	0	0	1	1	2	2862
Food Cabinet	1	1	0	0	0	0	0	2800
Bud Workstation	0	0	0	0	0	50	100	1600
XYZ Computer Desk	1	1	1	1	0	0	0	10300
Sofa	1	1	0	0	0	0	0	2800

4.2.3 Home Entertainment, 3-D Rooms Colonists will not have to travel far for entertainment. With 3-D rooms, residents will be able to experience their own virtual reality in their very own homes. They can play games, watch movies, or simply amuse themselves by walking around in virtual worlds using an omnidirectional treadmill. *Refer to 5.3.3.2*

4.2.4 High Tech Cleaning To help relieve Aresam's citizens of mindless chores and other janitorial duties, cleaning robots, appropriately named WALL-E after a keynote early 21st century movie that helped spur a movement to consume less. Additionally, the walls of each house will be coated with a substance that cleans when exposed to UV light. *For more info on WALL-E refer to 5.3.3.3.*

4.3 SYSTEMS, DEVICES, AND VEHICLES

A wide variety of equipment will be available for use outside of the colony by both colony workers and average colonists. However, Aresam will be designed in such a way to have very few pressurized zero gravity volumes.

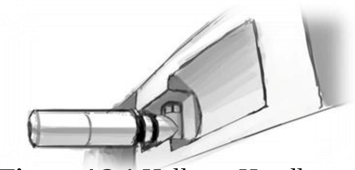


Figure 4.3.1 Hallway Handles

4.3.1 Hallway Handles For times when moving through zero gravity environments becomes too troublesome, dangerous, or disorienting, handrails attached to conveyor belts will line all of the hallways. People traveling through areas of the colony without gravity will be able to grab onto the rails to help guide their path through the air. *Figure 4.3.1*

4.3.2 Magtrain To travel throughout the colony, Aresam residents will use the Magtrain, a Maglev system located in Hermes. The reliability, safety, and silence of the Maglev system made it an obvious choice for our colony's transportation system. To reach the Magtrain from the commercial level of Hermes, people will take an elevator down to the station.

4.3.3 Tether Shots Attached to the arm of each spacesuit will be an extra deployable tether, in addition to the primary tether attached at all times to space suits. This tether can be shot out. A carbon nanotube based adhesive at the end of the tether would stick to the side of the colony, allowing the spacewalker to return to the colony if the primary tether fails.

Figure 4.3.5 Spacesuit

4.3.4 Rocket Pack For spacewalks that require more distance then can be provided by the tether, the spacesuit will be equipped with a rocket pack that permits greater mobility.

4.3.5 Spacesuits While working in space or while just floating around, people will be provided with spacesuits to use whilst outside of the colony. *See figure 4.3.5.*

4.3.5.1 Helmet The helmet will have a clear visor with a heads up display that monitors air pressure levels, radiation levels, view of what is behind the person, and a myriad of other suit functions. There will also be a vent pad to direct oxygen to the helmet and a communications device.

4.3.5.2 Biosuit Layer The Bio Suit layer is made of Shape Memory Alloy that apply counter pressure by expanding at certain temperatures. A gel layer woven in with a quilt pattern regulates the temperature. The bio suit layer can be zipped up with a remote control to distribute the pressure evenly.

4.3.5.3 Hard Torso Shell The shell will consist of lightweight polymers. It seals with couplings at the hips and shoulders and stores sweat in a removable component where it is recycled to help cool the suit.

4.3.5.4 Stowage The hard torso shell will be left attached to the walls and spares will be placed in storage rooms near the airlocks. The biosuit layer will be placed in lockers where colonial workers change.

4.3.5.5 Airlocks Airlocks will be scattered throughout each of the spheres, but mostly next to important infrastructure. Each of the airlocks will consist of two rooms one pressurized to around 0.7 atm and the next room to about 0.2 atm. The hard torso shell of the spacesuit will have a detachable backside for spacefarers to enter/exit from, but in this case the back side will be attached to the wall between the first and second airlock rooms. After the allotted preparation time has been passed for exiting the colony, astronauts will put on the biosuit layer of their space suit and enter the first room. In this room, they will spend some time prepping themselves by breathing pure oxygen for around 50 minutes to avoid decompression sickness, checking their suit functions, and using the lavatory. From there, they will enter their hard torso shell and the airlock crew will attach the back side of the shell while a sliding panel closes over the hole between the first and second rooms. Now that the people are in spacesuits that are completely sealed off at 0.7 atm and the first room is sealed off, the second room's hatch will open after completely depressurizing the second room and then they will exit.

4.3.5.6 Donning In a room attached to the airlock, the persons will stay overnight in a lower pressure room to avoid decompression sickness. The next day, after entering the first room that is at 0.7 atm, the persons will breathe pure oxygen for 50 minutes and they will put on the biosuit retrieved from the lockers the day before. From there, they will enter the hard torso attached to the wall and a crew will seal the back side as the suit functions are checked.

4.3.5.7 Doffing After entering the second room of the air lock, the suits will be attached to the wall while the first room is being depressurized to match the pressure of the suit. Then the backside of the hard torso will be removed as crew helps to get the person out of the suit, all the while the suit is going through shut down procedures. From there, the persons will re-enter the waiting room attached to the airlock to wait as the area is slowly brought back up to normal colony pressure.

Figure 4.4.1 Apartment Module

4.4 DEMOGRAPHICS SHIFTS

With a large amount of expected immigration from both Earth and other colonies, as well as the birth rate of the colony, many procedures have been put in place to help satisfy the demand for housing.

4.4.1 Modular Buildings Both the apartment complex and condos have been created in such a way to ensure quick assembly. Each of the Honeycomb Apartments can easily be stacked both on top of and next to each other to make complexes. The condos are also built in such a way so that rooms can easily be added or removed. *See figure 4.4.1*

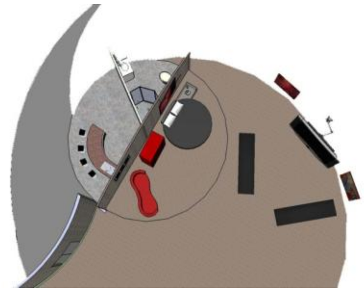
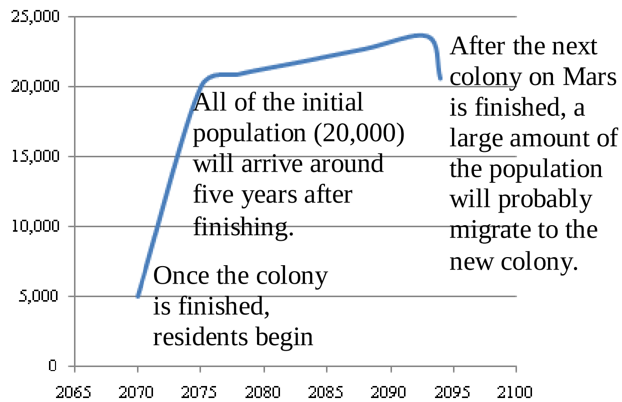
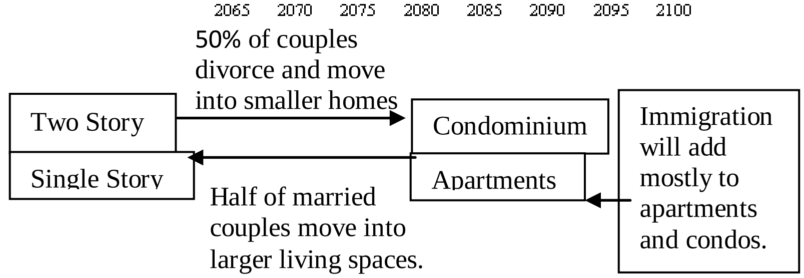


Figure 4.4.2 Rotor Houses

4.4.2 Rotor Houses Single story houses will be implementing a unique design in order to help save space. By using the rotating center piece with rooms attached, more rooms can be fit into a smaller area. The rotations will be controlled by remote and the speed, number of walls, and numbers of doors will all be up to the home owner. Going along with our modularity theme, the center piece is also removable and replaceable so that people can easily customize what rooms they have in their homes. *Refer to figure 4.4.2*

4.4.3 Pod Hotels In order to accommodate the ever increasing transient population Aresam will be using Pod Hotels to help save a great amount of space. The pod hotels will have capsules around the size of 2m x 1m x 1.25 m stacked along the walls for people to stay in. Communal bathrooms, pools, and plenty of other amenities will still be available. Additionally, each capsule will have walls lined with OLED's to provide virtual for virtual entertainment. Alternatively, there will luxury suites for customers who find the small living spaces uncomfortable.





Projected Demographic Changes

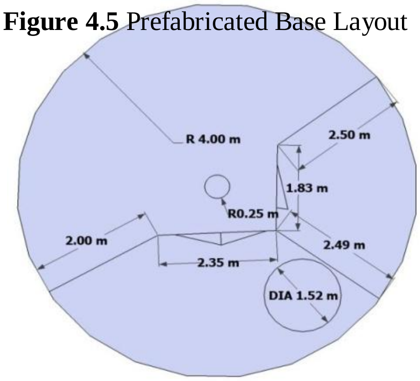
260 marriages	30 Deaths
116 Divorces	24 Births

Figure 4.4.5 Projected Demographic Shifts

4.5 PREFABRICATED BASE OUTPOST

Because space is at a premium inside the prefabricated structure, every effort has been made to save room. Folding beds can serve as a large table when not in use. Two floors allow us to take advantage of the domes height. Most of the life support systems are kept underground. Because we have saved so much space, four people can live in the prefabricated structure in relative comfort.

Figure 4.5 Prefabricated Base Layout



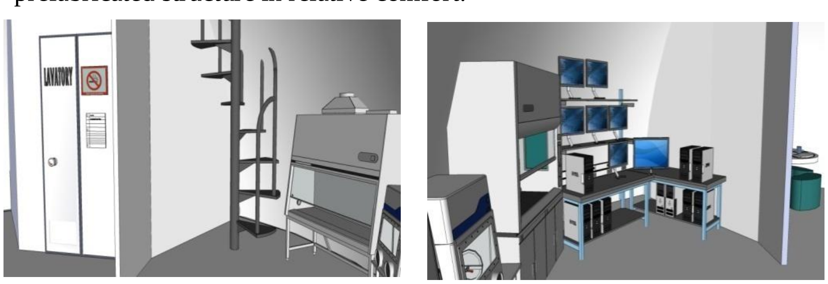


Figure 4.5.1 Prefabricated Base Interior Layout

AUTOMATIONS DESIGN AND SERVICES

5.0 AUTOMATIONS DESIGN AND SERVICES

Automations in Aresam will serve to reduce the need for manual labor and allow the citizens of the colony to focus on tasks that take full advantage of Aresam's unique placement in the solar system. Since Aresam is intended to be the stepping stone of humanity in its colonization of Mars and beyond, Aresam's automated systems and robots must be able to adapt to changing conditions. Therefore, robot design heavily emphasizes the potential for modularity, which adds versatility to robot systems. Software will be evolutionary, improving at its tasks as the colony faces new challenges.

5.0.1 Computer Specifications

5.0.1.1 Hardware Features

5.0.1.1.1 Memory Computer memory will be in the form of non-volatile memristor crossbar latches. The latches will form a universal memory, combining processor cache, random-access memory, and general storage in a single unit. This will virtually eliminate program and file load times because all information is prepared for immediate use, and the non-volatility allows nearly instantaneous boot and shut down procedures, increasing efficiency and productivity. In addition to this, Aresam's servers which must archive large amounts of data will use holographic crystals which have an unparalleled memory storage density. The crystals are read without moving parts, and have incredibly fast access rates allowing servers to both hold vast quantities of information and quickly answer requests.

5.0.1.1.2 Processors Computers throughout Aresam will use multiple-core graphene chips as processors. Graphene transistors can allow processors to achieve up to incredible speeds of 500 GHz. Multi-threaded programming will take full advantage of multi-core capabilities.

5.0.1.1.3 Display User interfaces across Aresam will use electrofluidic (EFD) displays, which will be haptic, allowing for interaction. EFD's water based ink can switch between colors rapidly enough to display high quality video, and additionally EFDs use far less energy than LCDs.

Table 5.0.1 Computers

Name	Amount	Dimensions (L*W*H in meters)	Memory	Purpose
PAN- Personal Access to Networking	Initially 20,500, 50 more per year	0.07*0.04*0.03	500 GB	Communications Device
Ceres	Initially 10,300, 20 more per year	0.3*0.4*0.2	20 TB	Home Computer
R&B- Research and Business	2100	0.4*0.6*0.3	50 TB	Research and Business Computer
Server	850	0.6*0.5*1.0	1 PB	Colony

Figure 5.3.1.1.1 PAN

5.0.1.3 Personal Access to Networking (PAN) Devices All residents, except the few who are too young or unable to use the technology for medical reasons, will be issued their own PAN units; guests will be issued temporary PAN model that resets when their stay ends. PAN consists of a headpiece that fits comfortably beneath the ear, with a small, detachable handheld holographic display. It will connect wirelessly to Aresam's network, enabling the resident to interact at any point with Aresam's internet and multimedia resources. PAN will utilize graphene processers and will be powered by lithium ion batteries with carbon nanotube anodes and recharged through Witricity available in buildings throughout Aresam. PAN can also synch universally with colony computers, allowing users to ubiquitously input and access data through PAN. *For more about PAN, refer to Section 5.3.1.1.*

5.0.1.4 Ceres Home computer systems in Aresam, named Ceres, will integrate with each available component of the home system. All of the appliances will thereby be integrated with Ceres, allowing residents to have complete control over the functions and energy usage of the home. Residents can then issue commands through their PAN units or any manner of command, verbal or physical in nature as Ceres' sensors will detect and monitor the activity of the resident to respond to his or her needs. *For more information about home computer applications, refer to Section 5.3.3.1.*

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

5.0.3 Robot Design Features

5.0.3.1 General Robotic Fabrication Aresam's robots will utilize a monocoque frame design, with their exterior shells providing the main structural support for the units. The shells of the majority of robots encountered on Aresam will consist of 6061 aluminum alloy. For higher strength applications, such as construction, titanium 6Al/4V alloy will be used.

5.0.3.2 Thrusters External robots, Vulcan and Argo, will use High Power Electric Propulsion (HiPEP) xenon ion thrusters to maneuver; the high specific impulse will increase efficiency and precision by allowing small amounts propellant to be ejected at high velocity.

5.0.3.3 Location Robots will pinpoint locations through a combination of multiple onboard laser rangefinding devices and triangulation with other robots and manned craft as well as beacons within the colony. The triangulation data and other communications, such as orders and status reports, will be sent to servers through carbon-nanotube radio devices, which provide wide angles of communication with very low power consumption.

5.0.3.4 Energy Storage Robots will be powered by lithium-ion batteries with $Si/TiSi_2$ heteronanostructure anodes. The nanostructures will be shaped into nanonets that prevent the batteries from losing their charge capacity over time, improving the longevity of the batteries and decreasing the need for replacements.

5.0.3.5 Recharging Mats lined with electric coils will be installed on multiple surfaces along robot corridors underneath the living quarters of Hestia and among uninhabited areas of Aresam to charge robots. Pressure sensors will switch the coils on and off as devices are placed on the mats. A miniscule carbon nanotube radio will communicate with the devices to prevent overcharging.

5.0.3.6 Movement Chassis Certain interior robots will have their upper monocoque body installed upon a lower body chassis consisting of 6 legs with wheels attached to the end. To traverse large distances across Aresam, the chassis will spread the legs apart, lock them, and utilize the wheels for movement. However, when the robots are deployed for occupational use, they will lock the wheels and maneuver upon legs with greater precision. *To see the movement chassis in use, observe Figure 5.1.2.1 for wheeled deployment and Figure 5.2.6.1 for the legged form.*

5.1 AUTOMATION FOR CONSTRUCTION

5.1.1 External Construction A fleet of Vulcans will construct the frame of Aresam. They will be equipped with HiPEP thrusters and two 7-jointed arms with gripping units and electron beam welding devices to allow rapid assembly of the prefabricated hull pieces.

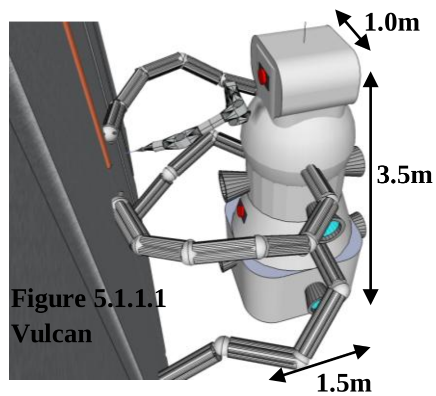


Figure 5.1.1.1 Vulcan

5.1.2 Internal Construction Buildings in Aresam will be constructed by Vesta robots. These robots will construct scaffolding for each planned structure of Aresam. It will then construct the frame of the building by clamping onto the scaffolding.

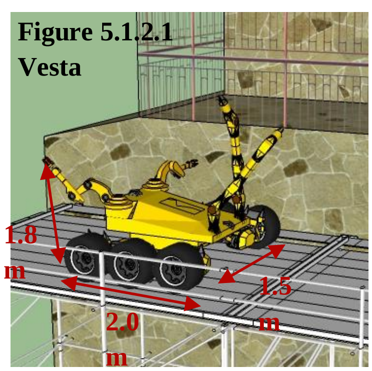


Figure 5.1.2.1 Vesta

5.1.3 Internal Finishing Minerva robots complete the finishing work on the interior of buildings in Aresam. A 7-jointed arm with a modular gripper unit to install tiles and fixtures, plus different modular attachments including sanders, glue dispensers, soldering irons, and applicators for drywall and paint are utilized by each robot according to the design specifications of each resident.

5.1.4 Materials Transportation Transportation of construction materials on the interior of the colony uses the fleet of Convector robots. Each wheeled robot carries either an open cargo bin and loading crane configuration, or a fluid tank and hose configuration. Both are modular and will be swapped depending on what the robot must carry.

5.2 AUTOMATION FOR MAINTENANCE, REPAIR, AND SAFETY FUNCTIONS

Table 5.2 Safety and Repair Robots

Name	Purpose	Name	Dimensions (L*W*H in meters)	Number
Barrex	Law enforcement	Non-lethal heat rays, LRAD, net launcher, sirens & lights, EMP cannon, backscatter X-ray, spherical wheels	1.2*.75*1.0	100
Florian	Extinguish fires	Movement chassis, storage tank, variable nozzles, sirens, lights	1.0*1.3*1.5	130
Bacchus	Internal structure inspection and repair	7 jointed arms, concrete pourer, wire clipper, movement chassis	1.0*1.2*1.0	600
Janus	Provides friendly guidance to residents in need. Subdues minor physical threats.	Self-balancing wheels, 3-D touch screen interface, non-lethal heat ray, net launcher, backscatter X-ray	0.4*0.3*0.75	800
Somnus	Medical treatment	Wheels, stretcher, blood transfusion, defibrillator, vitals monitor, surgical arms, first-aid medicines, conveyor belt for picking up patients, sirens & lights, wheels	2.0*1.5*0.6	400

5.2.1 Settlement Maintenance Procedure A computer system will monitor all anomalies detected by hull sensors as well as potential internal structural weaknesses and prioritize inspection and repair based on potential threat and productivity cost.

5.2.1.1 User Identification In order to verify that each user has the appropriate level of access according to their level of clearance, multiple biometric analyses will be utilized. Facial recognition and gait analysis, which can identify an individual based on the manner in which they walk, can be performed in real time through Aresam's surveillance system. Physical access to select areas of Aresam will be controlled by biometric scanners as well as the measures described above. *See Table 5.3.1.2.1.*

5.2.2 Repair Automations

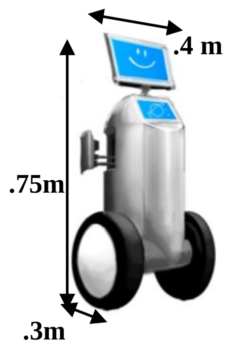
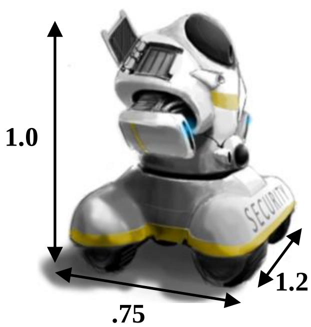


Figure 5.2.4.1 Janus

5.2.2.1 Hull Repair The hull of Aresam will contain a layer of self-healing RXF1 polyethylene embedded with sensors and RFID tags that register any fractures or stresses to the repair computer. In the case that emergency repairs are required, Vulcan will be deployed to fix the hull.

5.2.2.2 Operation in Solar Flares The core circuitry of Vulcans that will be required to operate under solar flare conditions will be protected by faraday cages composed of steel and coated with depleted uranium, providing optimal shielding from electromagnetic radiation and charged particles. In order to prevent the cage from interfering with communications with the robot, the faraday cage will be split apart and thereby deactivated. However, when there is a need for the robot to operate in a solar flare, the faraday cage will be activated, creating an electric field that cancels harmful charged particles.

Figure 5.2.4.2



5.2.2.3 Building Repair Bacchus will be called in to repair damage to buildings in Aresam. In the case of structural damage, should new construction be required, Vesta will respond to the problem. Minor damage to interior furnishings will be repaired with by Minerva.

5.2.3 Security Automation Patrol robots, Janus, will be able to subdue individual criminals through a non-lethal ray gun that induces painful heat sensations in a target's skin. Janus will also respond to residents in need of assistance and provide guidance on a friendly touch screen interface. For large riots or insurrections, a larger unit, Barrex will be deployed, equipped with heat rays and a Long Range Acoustic Device can emit painful sound waves to disperse crowds. Barrex will also utilize an EMP cannon that can deactivate electronics, preventing the use of vehicles against Barrex itself. Both Janus and Barrex will be equipped with backscatter X-ray imaging, which allows them to detect objects through walls in order to track down physical threats. When the suspect has been disabled, Janus and Barrex can subdue them with its net launcher.

5.2.4 Surveillance Systems A system of hidden thermographic and Fine Detail Optical Surveillance cameras will be used in public areas to detect suspicious individuals and create 3-D real time map of the colony, allowing for complete situational awareness for Aresam's protectors. The cameras will also detect dangerous objects and identify them through use of software algorithms that analyze the shape of objects suspects may be carrying. The software will alert a human who can view any portion of the colony through any camera, sensor, or robot. Security robots, Janus or Barrex, can then be sent to confront the threat.

5.2.5 Medical First Aid In the case that a resident is in need of medical treatment, Somnus, automated mobile capsules, each equipped with multiple surgical arms and a variety of first-aid equipment, such as morphine and bandages will be sent to the scene. The arms within the robot will allow a remote surgeon to perform operations even as the patient is transported to better equipped hospital. An automated conveyor belt system will allow the robotic responder to pick up patients without human assistance. Once inside, the environment is pressurized with pure oxygen, the patient is sedated, and automated routines inject blood grown from stem cells if necessary.

5.2.6 Firefighting Automations Florian will be deployed in the case of a fire and is equipped with two different fire extinguishing chemicals. In the case of a small, easily contained fire threatening property, a liquid that rapidly evaporates to gas and prevents further combustion, Halotron (chemical formula: $C_2H_3F_3$), will be utilized. For larger fires, Florian would use a powder based extinguisher consisting of treated potassium bicarbonate and urea. This blend scatters over a large surface area and expands to even greater surface area while preventing combustion.

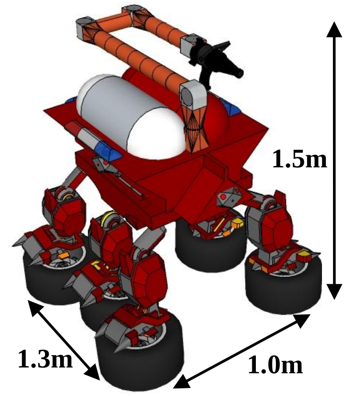


Figure 5.2.6.1 Florian

5.2.7 Emergency Shelter During emergencies, all affected citizens will be informed both through a priority message to their PAN devices, as well as through a colony-wide broadcast and siren system. Janus will also help direct citizens to the nearest shelter, each of which will be visibly marked and contain its own atmosphere and food supplies. Each Hestia sphere will have two airtight shelters underneath the occupied level on opposite sides. The shelters will be constructed out of polyethylene to provide optimal shielding from ionizing radiation.

Table 5.2.1 Contingencies

Contingency	Initial Response	Secondary Response	Time to Complete Initial Response
Biological/ Chemical Leak	Quarantine infected area and evacuate citizens. Somnus treats affected residents.	Fix the source of the leak. Monitor residents for adverse effects.	~15 minutes
Computer Virus	Quarantine affected systems. Identify and eliminate malware.	Replace lost files. Resume normal operations.	~20 milliseconds
Cyber-Security Breach	Quantum cryptography locks out intruder and encryption key changed.	Locate and arrest eavesdropper.	~Instantaneous
External Communications Failure	Switch to backup servers. Reestablish connection.	Diagnose and repair cause of failure. Send automated probe to investigate/repair communications satellites if communications remains down.	~40 seconds
Fire	Evacuate nearby civilians to shelter. Isolate sector. Florian extinguishes fire.	Repair damage caused by fire with Bacchus. Vent contaminated air, restore air quality.	~3 minutes
Minor Hull Breach	Airbags expand to seal the hull breach.	Deploy Vulcan to repair hull.	~1 minute
Major Hull Failure	Tarp is deployed to cover breach. Evacuate citizens to pressurized shelters.	Repair hull with Vulcan.	~3 minutes
Power Failure	Load switches to silver-zinc ion	Analyze and repair power grid.	~20 seconds

	supercapacitors.		
Physical Security Threat	Deploy Janus and/or Barrex. Apprehend threat.	Repair collateral damage.	~5 minutes
Solar Flares	Solar activity reported by satellites. Evacuate citizens to shelters.	Restore normal operations.	~5 minutes

5.3 AUTOMATION FOR PRODUCTIVITY, LIVABILITY, AND CONVENIENCE

Table 5.3 Livability Robots

Name	Purpose	Features	Dimensions (L*W*H in meters)	Number
WALL-E	Janitorial tasks	Spatial recognition and surrounding detectors. Waste compartment, vacuum cleaner, scrubbing brushes, storage tank for cleaning agents, legs	0.3*0.2*0.4	3300
Saturn	Harvest agriculture	Robotic vase gripper arm, two arms with modular claws/clippers, storage compartment, wheels	5.0*3.0*3.5	220
Gorgon	Robotic modularity	Multiple rotating gripping arms, conveyor belt, storage device.	10*8*6	80
Argo	Cargo loading/ unloading	Cargo bay, loading arm, Xenon HiPEP thrusters	12*9*8	200

5.3.1 Personal Communications

5.3.1.1 PAN Residents will control their surroundings through electroencephalography functions in their PAN unit, which allows residents to activate and control lights, music, and other functions simply by thinking about them. Users will also be able to connect to the computer databases and access files and information. Through electromyography PAN can read the nerve signals sent to muscles of the larynx associated with speech and with training, allow users to mimic telepathic abilities by recognizing speech without the user having to physically speak. Additionally, the recognition of speech is only limited to a specific level of intention, requiring some basic training to use, but preventing any background thoughts from being converted into speech. PAN will also utilize bone conduction to allow users to listen without earphones. An acousto-optic light modulator equipped with a tiny ultrasound generator is built into the PAN unit and can be detached and used in synchrony with PAN to display full 3-D holograms that provide sensation when touched.

5.3.2 Intra-Colony Communication

5.3.2.1 Connection Media Communications between PAN and the colonial internet will be fully wireless. Multiple phased arrays will broadcast and receive OLED internet signals, allowing users to access the internet from all locations. Each array will provide enhanced broadcast and reception to users in its direction, and when moving from one array's jurisdiction to another, a soft handover where PAN is connected to both arrays simultaneously will be used. To prevent interference from OLED’s which are commonly used for lighting, transmission within buildings will rely upon radio frequency signals. *For more on communication transmission, refer to 3.2.6.*

5.3.2.2 Integration with Health Monitoring Systems Carbon nanotubes will be embedded in the yarn of residents’ clothing, making the clothing conductive, hence able to be made into circuitry. As a result, residents’ health can be constantly monitored by their clothing, which acts as sensors. Health data is sent from the clothing to PAN units, and residents will be advised to visit a clinic should any illness be detected.

5.3.2.3 Network Structure Servers in Aresam are assigned to different uses. A set of servers will oversee day to day automations. Residents can access their residential server that will handle their processing load. Users with business or research clearance will be given secure access to Commercial and Industrial servers that will provide with extra computing power. All servers across Aresam in their respective sub-networks are interconnected allowing for grid computing, which will boost efficiency by spreading

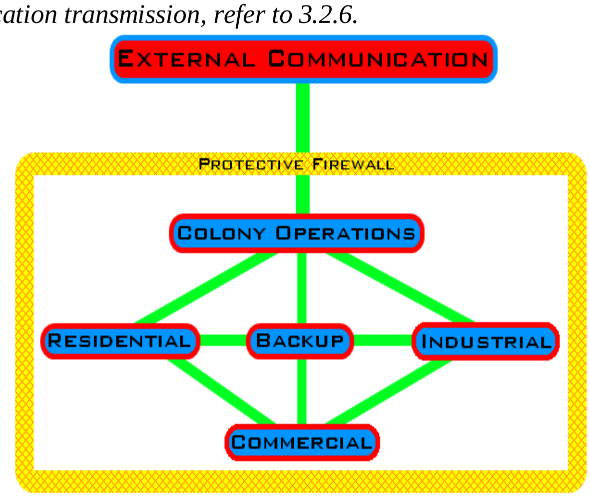


Figure 5.3.2.3.1 Network Diagram

computing load across all servers. Besides being networked within each sub-network, all servers will be connected to backup servers that can help to process information when the workload becomes too great or if certain servers were to fail. *Refer to Figure 5.3.2.3.1.*

5.3.2.4 Data Security To keep communications throughout Aresam safe and private, quantum encryption will be ubiquitously employed.

Table 5.3.1.2.1 User Account Access

User	Access Options	Authentication Measures
Resident	Able to access public computing services, network, and Ceres and able to operate PAN, local and personal computer systems, and work computers	PAN, facial recognition, hand scan, password, voice recognition, and gait analysis
Commercial	Able to access all of the common resident features as well as access business relevant networks, areas, and resources.	PAN, facial recognition, hand scan, password, voice recognition, iris and retina scan, and gait analysis
Researcher	Able to access all of the common resident features as well as access to research facilities and networks.	PAN, facial recognition, hand scan, passwork, voice recognition, iris and retina scan, and gait analysis, vein scans.
Guest	Able to access public computing services, network, and command of temporary living quarters and able to operate PAN and local and personal computer systems.	PAN, facial recognition, voice recognition, password (temporary)
Administrator/ Technician	Complete access to all areas of Aresam	PAN, facial recognition, hand scan, password, voice recognition, iris and retina scan, gait analysis, vein scans, odor detection, and DNA matching

5.3.3 Home Livability Enhancements

5.3.3.1 Smart Integration Residences in Aresam will be equipped universally with RFID tags. Readers spaced throughout residences allow for seamless integration with a computer system. Each home will also be controlled by a computer system, Ceres, which will automatically order the food supplies to be restocked, and provide instruction on any tasks the resident requires aid with. The user will also be able to change not just the thermostat but the colors of the walls and the level of window tint due to electrochromic pigments in the paints and glass. Smart meters and sensors will be connected to each appliance and throughout the home, and they will be able to communicate in real time to Ceres via Ethernet connection. This allows users to regulate device activation and energy use. Should the resident require any assistance, Ceres can immediately call for the appropriate robot to help.

5.3.3.2 Domestic Entertainment Interactive entertainment will be located in a special room within each residence. The walls of this room will be embedded with OLEDs and covered with a rounded layer of transparent concrete, and this will provide a wraparound screen. Several levels of interfacing will be offered: at the most basic and casual level, the user may simply use gestures to take advantage of the 3D motion capture abilities of multiple cameras by enabling them to control an in-game avatar by running on an omnidirectional treadmill while experiencing virtual resistance through ultrasound waves. More intense applications allow a resident to don a full body haptic, force-feedback suit with visual-supplementing helmet that simulates the sense of touch through pneumatic pulses, and allows the user to "fire" a mock weapon with the helmet, which will have a laser attachment. The laser will trigger an electric current in any LED it hits, and thus allow the system to register a shot with lifelike precision. Procedural generation will allow sprawling, detailed scenarios to be compressed into small amounts of data, allowing the room to be used for memory-intensive applications such as virtual tourism.

5.3.3.3 Easy Cleaning of Surfaces Surfaces people will encounter in Aresam will be coated with a diarylethene substance that imitates the micronodules of a lotus leaf. This coating becomes extremezly hydrophobic when exposed to UV light, and causes water to simply roll off, collecting dirt and grime as it leaves. This material allows WALL-E to quickly spray the surface with water and remove any impurities.

5.3.4 WALL-E As homage to a successful 2008 film that inspired conservationism, janitorial robots on Aresam will be named WALL-E. WALL-E will regularly clean areas throughout Aresam that humans will come in contact with. WALL-E will also respond to any calls for immediate cleaning.

5.3.5 Computer Aided Design/Manufacturing On-Demand Advanced computer software will allow residents to enter ideas textually or verbally and receive a detailed design solution from Aresam's computer systems. Businesses and researchers can use the computer software to engineer three dimensional prototypes of any object of up to 5*5*5 meters in size. For a cost, an electron beam will place 5-10 mm layers of material sequentially in order to produce a prototype of the design. This electron beam freeform fabrication machine will be available in Hermes and the business sphere in Hestia.

5.3.6 Agriculture Automation Saturn will harvest crops grown in the aeroponics structures in Demeter. *For agriculture operations, see 3.2.2.* Saturn will remove the bottom vase of the six stacked vases of each vertical rod using its gripper, thus leaving the top five vases dangling. The claws holding the top vase will release the top vase after the sensors directly under the bottom vase sense that the bottom vase has been removed. Saturn will then utilize its smaller arms to harvest the produce and place it inside its storage compartment. The robot will then plant new seeds in the vase. Afterwards, the robot will place the freshly prepared vase under the grasp of the overhead crane of the aeroponics structure that will lift the vase to the top of the stack. Saturn will drop produce off at the processing center of each aeroponics center, where modified Convector models with refrigerated storage will take produce to the agricultural sector of Aresam.

5.3.7 Cargo Loading Argo will carry cargo from docking ships to the monorail which will transport the cargo to other sectors of Aresam.

5.3.8 Modularity Multiple robots that will be used in Aresam will possess modular elements in order to deal effectively with unforeseen challenges. New tools can be designed through a computer aided design process, and the prototype can be produced by an electron beam freeform fabrication process. *See section 5.3.5 for fabrication details*. Gorgon will be used to remove end effectors of each robot's arms and then replace them with new tools through a twist and lock mechanism. The complete toolbox of each robot can also be removed, and new tools can be installed.

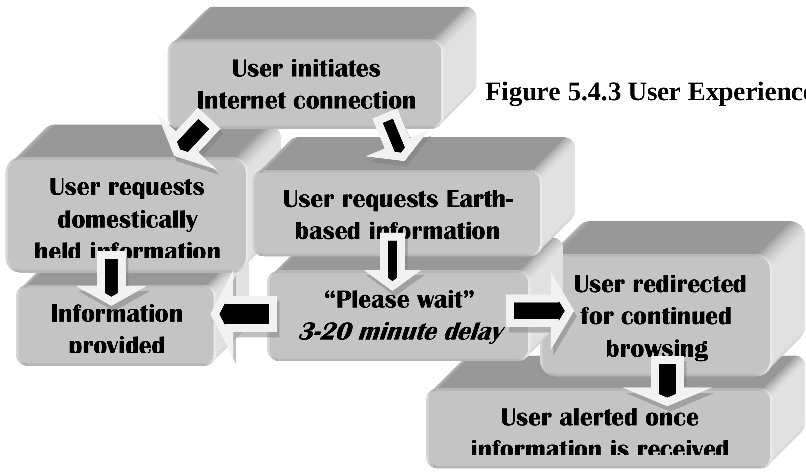


Figure 5.4.3 User Experience

5.4 EARTHBOUND COMMUNICATIONS

5.4.1 Access to Earthbound Data Repositories To allow users on Aresam to access data repositories on Earth, Delay Tolerant Networking will be used to send data using the SCPS set of protocols, which will account for frequently disrupted connections and high latency. To avoid possible blackouts when Earth and Mars are blocked by the Sun, communications will be routed through satellites located at Sun-Earth L4 and L5 points. DTN will hold information until it confirms that it has been received, preventing data loss from jeopardizing data transmission.

5.4.2 Latency TCP acceleration through IP stacks and proxies will reduce latency within Aresam by lessening the number of roundtrips packets have to be sent through. However, natural delay in communications with Earth will occur due to the distance that electromagnetic radiation used to transmit messages must cover and can vary from 3 to 21 minutes one-way depending on the distance between Earth and Mars. Therefore, instant messaging and telephony are impractical, making more e-mail and recorded messages more effective tools for communication.

5.4.2.1 Masking Delay To reduce appearances of the delay, some of the most popular websites and databases will be pre-loaded onto the colony's servers. As the colony grows, the capacity will expand and the average delay will decrease. If a user changes the internet by uploading any data, the change will locally be reflected instantaneously even as the data is transmitted to Earth. Additionally, to reduce the amount of power required for broadcasting, consolidated data techniques will allow receivers to separate messages from electromagnetic noise.

5.5 ROBOTIC ASSISTANTS

Table 5.5.1 Base Deployment and Phobos/Deimos Operations

Name	Purpose	Features	Dimensions (L*W*H in meters)
Diana	Excavate minerals from Phobos and Deimos	Bucket wheel, rotating treads, storage compartment	12.0*8.0*10.0
MAIA- Martian Infrastructure Automation	Support deployment of prefabricated base.	Modular rotating assembly with bucket wheel and forklift attachments, zero-tail counterweight, 7-jointed arm with laser welder and grippers, Superadobe compactor, treads	2.0*.8*1.0
Mithris	Assist process, refining of raw materials at Phobos/Deimos mining bases.	Crucible mount, rotating treads	7.0*6.0*10.0

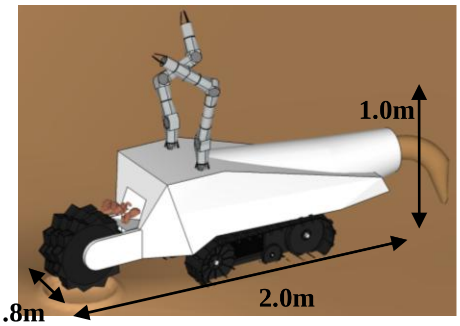
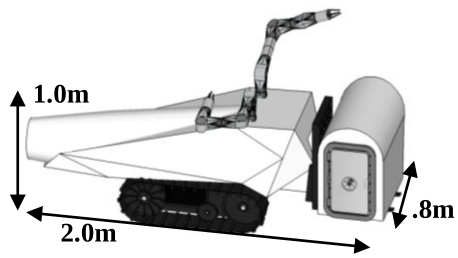


Figure 5.5.1.1 MAIA – Bucket-wheel

Figure 5.5.1.2 MAIA - Forklift



5.5.1 Deployment Robot Assembly of the Martian base requires the aid of a robotic assistant, MAIA, which will be dropped onto the Martian surface inside the prefabricated base. The robotic assistant will be equipped with a modular main assembly as well as 7-jointed arms with a laser welding suite and a gripper unit. The bucket wheel excavation equipment will first be placed onto the modular assembly and used to dig a pit to place the base's foundations while the excavated earth is processed through high strength polymer bags in the robots interior to form Superadobe. Then the forklift attachment will be used will assemble the deployable structure. Finally, the arms will weld supports into place and place the Superadobe to protect the deployable structure.

Figure 5.5.2.1 Diana – Bucket-wheel

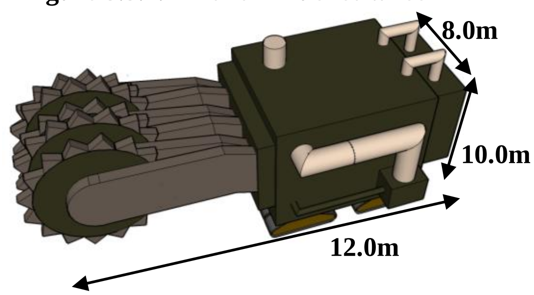
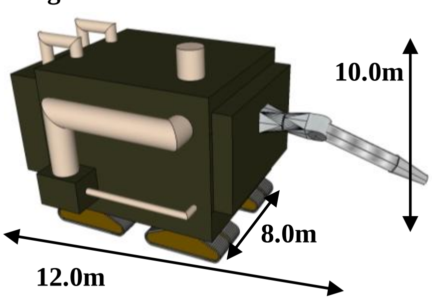
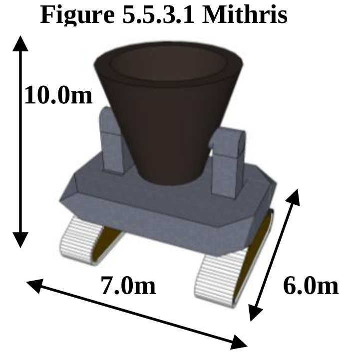


Figure 5.5.2.2 Diana – Drill



5.5.2 Mining Automations Diana will use a bucket-wheel excavation system for mass digging on the lunar surface. The mining assembly is capable of full circle rotation on top of its treaded base. The bucket-wheel configuration allows the robot to continuously remove overburden and ore while moving laterally across the pit instead of moving earth bucket by bucket thus removing a major bottleneck on the excavation process. In order to drill through the solid rock common on Phobos and Deimos, Diana is equipped with a hydrogen flame jet drill that fractures rocks by combusting the hydrogen to form acetylene. The mined ore will be transferred to a storage compartment in the main body of Diana via a conveyor installed in the mining arm.

Figure 5.5.3.1 Mithris



5.5.3 Refining and Processing Raw Materials To aid the operations of mining bases, Mithris is equipped with rotating treads and a tilting crucible mount for a standardized crucible that will hold all ores and molten slag as it is taken from one process to another. *For specific processing procedures, refer to Section 3.4.*

SCHEDULE AND COST

6.0 SCHEDULE AND COST

6.1 Colony Construction Schedule

Table 6.1 Construction Schedule

	Schedule	2055		2056		2057		2058		2059		2060		2061		2062		2063		2064		2065		2066		2067	
	Preparation; Construction 0:																										
M	Mining Facilities construction (15 months)																										
M	Mobile Headquarters and Robotic Supply Ships go to Mars (8 months)																										
M	**Transport of gases for pressurization (138 months)**																										
B	Construction of Atlas components: 2055 (10 months)																										
B	Construction of ports: 56 (8 months)																										
B	Transportation of Atlas components: 56 (16 months)																										
B	Transportation of ports: 56-57 (16 months)																										
	Construction 1:																										
C	Assembly of Atlas: 57 (6 months)																										
C	Attachment of ports: 57 (3 months)																										
B	Construction of manufacturing facilities: 56-57 (12 months)																										
B	Construction of research modules: 57 (5 months)																										
B	Transportation of manufacturing facilities: 57-58 (16 months)																										
B	Transportation of research modules: 58 (16 months)																										
	Construction 2:																										

C	Attachment of manufacturing facilities: 58 (5 months)																										
C	Attachment of research modules: 58 (1 month)																										
	Construction 3:																										
C	Construction of Spokes: 58-59 (10 months)																										
C	Attachment of Spokes: 59 (3 months)																										
C	Construction of Demeter: 59 (6 months)																										
	Construction 4:																										
C	Attachment of Demeter: 60 (4 months)																										
C	Construction of Hermes: 60-61 (9 months)																										
C	Construction of Hestia: 60-65 (60 months)																										
	Construction 5:																										
C	Attachment of Hermes: 61 (6 months)																										
	Construction 6:																										
C	Attachment of Hestia: 65-66 (18 months)																										
C	Pressurization of Hestia: 6 (3 weeks)																										
	Construction 7:																										
C	Centrifugal speed-up: 66 (8 days)																										
C	Interior construction & finishing: 63 (6 months)**																										
C	Position Mobile Headquarters into parking orbit (1 day)																										

M- Construction on Martian Moons **C-** Construction on Colony **B-** Construction done at Bellevistat

6.1.1Schedule Explanation Immediately after the mining facilities are constructed, operations will begin collecting and processing usable resources for exports and future manufacturing of construction materials on-site. After the manufacturing modules are attached, the colony will begin producing some of its own building components to reduce the time and cost of transportation. The settlement will be completely finished by mid-2067, and people may start moving into a fully operational colony at that time.

6.2 Cost of Construction

Table 6.2.1 Cost Labor During Construction					
Jobs	ANNUAL SALARY (In thousands)	Number of Years	People	Construction Phases	Total (In Millions)
Foreman	$180	13	15	0-7	$35.1
Robotic Technicians	$150	13	100	0-7	$195
Electricians	$125	7	300	4-7	$262.5
Pilots	$140-200	13	60	0-7	$156
Asteroid Geologists	$250	3	3	0,1	$2.25
Mining Overseers	$120	10	20	1-7	$24
Construction Engineer	$130	2	240	0	$62.4
Mechanical Engineer	$130	2	270	0	$70.2
Chemical Engineer	$140	2	100	0	$28
Electrical Engineer	$130	2	200	0	$52
Software Engineer	$115	3	250	0,1	$86.3

Subtotal: $973.75 Million

Table 6.2.2 Cost of Operations (During Construction)				
Operation	Cost per year	Number of Missions (Per Year)	Years in Operation	Total Cost
Cargo Transportation	$107,692,000	2	13	$1.4 Billion
Passenger Transportation	$9,923,000	2	13	$129,000,000
Solar Cell Manufacturing Device	$146,000	N/A	120 days	$48,000
R&D	$10,000,000	N/A	5	$50,000,000
Mining	$10,000,000	N/A	11	$110,000,000

Subtotal: $1.69 Billion

Table 6.2.3 Cost of Equipment			
Equipment	Cost per unit	Amount	Total
Solar Cell Manufacturing Device	$40 Million	1	$40 Million
Mobile Headquarters	$57 Billion	1	$57 Billion
Robotic Support Ships	$20 Billion	3	$60 Billion

Subtotal:$117.04 Billion

Table 6.2.4 Cost of Construction Materials			
Materials	Volume(m^3):	Price per unit(m^3):	Total Price
Silicon Nitride	1,213,297	$100,693	$122.17 Billion
6061 Aluminum	4,804,112	$1,556	$7.47 Billion
7075 Aluminum	21,415,062	$4,914	$105 Billion
Self-Healing Material	10,389,872	2000	20.8 Billion
Magnesium Oxide	881,064	$4735	$4.18 Billion

Subtotal:$259.62 Billion

Table 6.2.5 Raw Materials			
Material:	**Unit Cost (per kg):**	**Mass (kg):**	**Total Cost:**
Nitrogen	$0.70	130,491,704	$91.87 Million
Oxygen	$0.20	40,151,293	$8.03 Million
Carbon Dioxide*	-------	2,628,953	-------
Olivine*	-------	10,221,908,670	-------
Calcium	$110.00	455,139	$50.07 Million
Calcium Hypochlorite	$5.95	277,654	$1.65 Million
Carbon*	-------	124,013	-------

Subtotal: $151.62 million

****Materials found on Mars/Phobos/Deimos***

Table 6.2.6 Cost of Robots			
Type	**Cost Per Unit**	**Total Unit**	**Total (in Millions)**
Vesta	$9 million	450	$4,050
Vulcan	$17.5 million	400	$7,000
Minerva	$4 million	600	$2,400
Convector	$3 million	450	$1,350
Barrex	$12.8 million	100	$1,280
Florian	$3.75 million	130	$487.5
Bacchus	$2 million	600	$1,200
Janus	$90 thousand	800	$72
WALL-E	$40 thousand	3300	$132
Saturn	$36.75 million	220	$8,085
Somnus	$1.8 million	499	$720
Gorgon	$62 million	80	$4,960
Argo	$15.75 million	200	$3,150
Diana	$345 million	5	$1,725
MAIA	$5 million	Variable	Variable
Mithris	$90 million	20	$1,800

Subtotal: $40.1 billion

Table 6.2.7 Cost of Computers				
Computers	**Memory**	**Cost per unit**	**Number of Units**	**Total Cost**
PAN	500 GB	$200	20500	$4.1 million
Ceres	20 TB	$4000	10300	$41.2 million
R&B	50 TB	$10,000	2100	$21 million
Server	1 PB	$200,000	850	$170 million

Subtotal: 236.3 million

Table 6.2.8 Income	
Source of Income	**Income**
Deuterium Exports	$1.2Billion
Miscellaneous Mining Exports	$40 Billion
Research and Patents	$1.5 Billion
Tourism	$15 Million

Subtotal: $42.72 Billion

Table 6.2.9 Operating Costs	
Operation	**Cost**
Mining	$20 Million
Consumables	$2 Million
R&D	$10 Million
Maintenance	$6 Million

Subtotal: $38 Million

TOTAL COST OF CONSTRUCTION
$419.8 BILLION

ANNUAL REVENUE
$42.68 BILLION

YEARS TO COVER CONSTRUCTION COSTS
9.8 YEARS

BUSINESS DEVELOPMENT

7.0 BUSINESS DEVELOPMENT

7.0.1 Transportation Node and Port Aresam will initially have four port facilities.

7.0.1.1 Docking, Warehousing, and Cargo Handling

7.0.1.1.1 Docking An incoming vehicle latches onto a cradle at the end of the port. The cradle rotates it 90 degrees to its parking slot on one of the segments. Four arms securely hold a spacecraft in place. Once docked, a retractable bridge comes out to load and offload people and cargo. Passengers and cargo needing to leave Aresam wait in the storage area before departure to minimize the chance of delay moving from the rest of the colony to the ports.

7.0.1.1.2 Launching A departing vehicle is rotated 90 degrees onto the launch rails. The cradle will accelerate the craft to 10 m/s, giving the vehicle a small initial velocity away from the colony, allowing it to ignite its rockets at a safe distance away.

7.0.1.1.3 Oversized Vehicles Large vehicles that cannot fit onto a single cradle can be fitted onto two or even more cradles and occupy two or more parking slots. These vehicles would skip the launch process and would instead be towed away from the port by space tugs.

7.0.1.1.4 Warehousing Storage and fuel areas are kept separate to mitigate accidents. The storage area is cylindrical to provide convenience for storing bulky, solid objects. Fuel is stored in 32 small spheres. The separation of the spheres allows for easier localization and repair of any fuel leakage. The storage cylinder acts as a buffer between the vehicles and the fuel spheres to further prevent accidents.

7.0.1.1.5 Damaged Vehicles Each spacecraft is maintained and small defects are automatically repaired by a fleet of repair robots. However, for spacecraft that have its navigation systems damaged, space tugs move the spacecraft onto a cradle. Severely damaged spacecraft are moved to the manufacturing modules where replacement components can be made. Vehicles that are in danger of explosion are kept at a safe distance from the colony. Shuttles will transport passengers off the craft while robots commence repairs.

7.0.1.2 Terminals Terminals are located within Atlas and service both departing and arriving passengers. The passengers are shuttled to and from ships by high-speed monorail, and pass through airlocks at their destination.

7.0.1.3 Refueling and Provisioning Fuel will be transferred to ships through pipes within the walls of the port. Modules have extendable nozzles which are configured to fit each ship perfectly. Several types of fuel and propellant will be available for sale, including hydrazine, nitrogentetroxide, he3, deuterium, hydrogen and oxygen.

7.0.1.4 Base and Repair Depot for Mars Landers See 2.1.1.8.2

7.0.1.5 Dust Mitigation Robots returning from Phobos, Deimos, or the Martian surface will be contaminated with hazardous dust. In order to prevent this dust from entering Aresam, the port's airlock will be sealed, and the enclosed areas of the colony will be protected by a series of electrodynamic dust curtains, which generate an electric field with alternating current that will repel charged particles. Meanwhile the contaminated vehicles will be treated with an automated electron gun so the dust can be removed by a positive plate before the vehicles enter the colony.

7.0.1.6 Medical and Quarantine Services Sterile Hazmat suits are provided to ailing individuals onboard a vehicle after it docks. They are transported to the port's terminal, which will contain a sterilized medical facility capable of treating 20 people. This procedure serves both to provide quick treatment to the sick and to quarantine them. They are strapped to beds and treated by remote-controlled robotic arms, which are ideal for operation in 0G.

7.0.2 Manufacturing Center There will initially be two Hephaestus-class modular manufacturing facilities attached to Atlas, each composed of three modules. Each module has two lateral gates, with the end module having an additional gate in front. Each gate has two manipulating arms above and below to allow for assembly of structures larger than the facility itself. Expansion of the structure is simple: the gate at the end of the structure is removed, a new module fixed in place, and the gate re-attached to the end opening of the new module. The facility is powered by a 300 MW Traveling Wave Reactor.

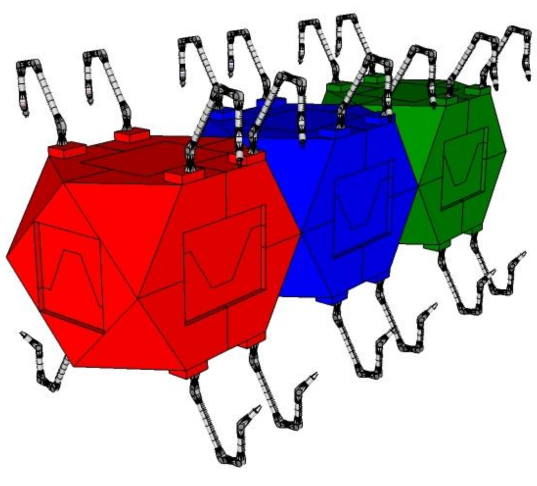


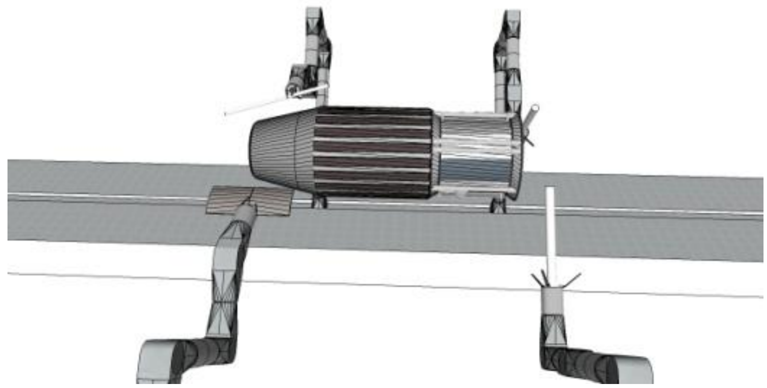
Figure 7.0.2.1 Division by product

7.0.2.1 Division by Product Initially, Manufacturing facilities will be used to construct Aresam itself, but afterwards the individual modules will be each focused towards a particular product: landing and surface vehicles (red), tools and machinery (blue), and robots and surface bases (green).

7.0.2.2 Sources of Materials Due to the abundance of olivine, serpentine, and carbon on Mars as well as on Phobos and Deimos, items containing magnesium, iron, silicon, and carbon (magnesium oxide, steel, carbon nanotubes, etc.) will be produced in the colony itself. Adobe made from Martian moon dirt will also be readily available. Items that require rarer elements such as nitrogen (aramid fibers) will be produced on Earth and transported to Aresam.

7.0.2.3 Manufacturing Processes Within the module are robotic arms equipped with laser welding and electron beam machining and freeform fabrication, as well as gripper units for assembly of individual components. The entire structure works as an assembly line to construct finished products from raw materials.

Figure 7.0.2.4 Assembly Line Production



7.0.2.4 Production Line Production lines consist of robotic arms mounted on tracks running the length of the facility. The arms can move along the tracks, and rotate 360 degrees. The tools are modular, allowing arms to change their capabilities for any product.

7.02.5 Transportation of Surface Vehicles and Robots Shuttles will transport robots and vehicles to and from the Martian surface. They will be two-staged: a first stage of reusable solid-fuel chemical rockets to boost into the atmosphere, and a second stage solid-cored nuclear thermal rocket. The NTR is based around a particle-bed reactor, which will withstand higher temperatures than a standard reactor and allow greater thrust, and uses hydrogen as propellant to attain extremely high exhaust velocities. The payload will be held in standardized intermodal containers and fluid tanks, so that storage capacity and function can be varied to match the specifics of each mission.

7.0.2.6 Transportation of Food and Other Commodities Food, drinking water, and other substances which need only be transported to the surface and not into orbit will be dropped from Aresam in reentry capsules protected by heat shields. The capsules will deploy parachutes to moderate descent in the atmosphere and preserve the cargo. After unloading, the capsules will be returned to Aresam on the next shuttle launch, and will be reused.

7.0.3 Research Center for Development of Commercial Products from Mars Resources

7.0.3.1 Laboratories for Assay and Experimentation Four initial Athena Research Modules will be located on Atlas. They will be geodesic structures shaped like spheres to contain atmospheric pressure, with four clearly marked airlocks for EVA operations, and a set of Stirling radioisotope generators. The SRGs will have a total power output of 50 MW, and will be located outside, on the end of the facility, to keep them away from researchers inside the facility. Internal equipment includes centrifuges and mass spectrometers for separation and identification of material.

7.0.3.2 Products with Commercial Potential Athena modules will be equipped with computers with evolutionary algorithms for design work and electron beam freeform fabrication machines for rapid prototyping, allowing Aresam to immediately exploit the fruits of its research.

7.0.3.3 Cost Criteria High space shipping costs make it uneconomical to export bulk goods to Earth. Instead, Aresam's balance of trade will rely on valuable rare or manufactured goods and research data. Phobos and Deimos will be extensively mined for platinum. Aresam will also tap into Mars's abundant deuterium reserves and become a major force in the coming fusion economy. And the most profitable investment will be in research and development: Aresam will use the capabilities of its Athena modules to sell lucrative data and license patents to foreign manufacturers.

7.0.3.4 Laboratory Quarantine Pressurized volumes of Athena-class facilities will be fitted with ULPA filters for recirculation and decontamination of air. Entrance and exit to the facility requires passage through an airlock, where researchers first clean off in an air shower and then don CBRN protective suits. If seriously threatening materials or organism are detected, the facility's connection to Atlas is sealed and the researchers are ordered to evacuate through the external airlocks, where they can be safely taken to a hospital for decontamination and treatment. The offending sample is isolated and can be either destroyed or kept for remote study.

APPENDIX

8.0 APPENDIX A

Appendix 8.A.1 Efficiency of Moving In-Process Products Metalworking modules produce the components that are assembled into final products in the heavy manufacturing modules. As a result, the heavy manufacturing modules have been paired with the metalworking modules on each set of universal mating ports, greatly reducing time and increasing efficiency. Furthermore, this industrial region has been located near Aresam's inter-colony and interplanetary ports and the MSLLV ports, allowing easy movement of raw materials from outside and export of final products.

Table 8.A.1 Time to Move In-Process Products from Metalworking to Heavy Manufacturing

Location	**Time**
Atlas	15 minutes
Demeter	60 minutes
Hermes	80 minutes
Hestia	90 minutes

Appendix 8.A.2 Gravity and Pressure Environment for In-process Activities

	Zero G	Low-G	1 G	Pressure requirements
TWR	Zero-G provides versatility for machinery in terms of position as well as control.	A Low-G environment provides a little less machinery versatility while also lacking the physical certainty of 1-G gravity, and machineries must be individually adjusted to account for the low gravity.	Earth-like gravity is feasible because all of these manufacturing processes have all been performed on Earth.	Extremely high pressure is required to manufacture a TWR power generator. About 13,000 tonnes pressure is required to continuous apply press forging.
Solar Panels				Solar Panel processes is a relatively light manufacturing process and does not require high pressure
Metal-working				Metalworking processes uses different pressure to distribute distinct metallic fluids. Relatively low pressure is usually applied but higher pressure usually improves the cooling quality.
Ship Manu-facturing				Ships and shuttle manufacturing requires a huge variety of components ranging from processor chips to exterior hulls. Different pressures will be required for the processes
Materials Processing				Raw materials acquired from Mars and Phobos/Deimos will mostly be processed on-site on the mining bases. However several materials will be further processed on the colony using such processes as acid/microwave leeching, requiring high pressure to thoroughly refine the materials.

From trade-study results analyzing different pressure requirements of each in-process activity required on the colony and gravity possibilities, we have concluded that placing manufacturing process in their own modules to provide for greatest versatility for the huge variety of manufacturing processes that will be required of Aresam. A zero-gravity environment is generally beneficial for manufacturing processes, providing a stable and controlled environment, thus our choice to place the modules on the non-rotating central-rod. The different pressure requirements of each process will be accommodated within individual modules.

Appendix 8.A.3 ENVIRONMENTAL IMPACT OF PROCESSES ON COMMUNITIES AND INDIVIDUALS			
Processes	**Commercial Sphere Environmental Impacts**	**Central Rod Environmental Impacts**	**Residential Sphere Environmental Impacts**
Raw Material Processing	Thanks to the design of Aresam's colony, the separation of many different spheres allow for the separation of facilities. With raw material manufacturing being placed in the commercial sphere, people would not be greatly affected because they would not be exposed to the air within that sphere for very long as they would live in a totally separate area.	Also separate from living quarters, the placement of the factory in the central rod would not affect the lives of people since they would not live in the central rod. However, this placement would make the processed materials further away from the transportation ring, adding to the cost of moving the materials.	Placing the processing of raw materials inside a sphere would probably greatly reduce the air quality within residential spheres. Also, this would not be very different from placing it within the commercial sphere.
TWR Manufacturing	An advantage of TWR manufacturing taking place within the Commercial Sphere were that if an accident were to occur, it would be isolated into only one sphere.	TWR manufacturing taking place in the Central Rod could be troublesome considering that if a mishap were to occur, it would damage the central piece of the colony's infrastructure.	Probably the least favorable choice of location would be the residential sphere considering that any failure with the manufacturing system could essentially wipe out a whole sphere's worth of lives.
Manufacturing Solar Panels	Although not as many people would head towards the commercial sphere as often as they do other parts of the colony, it still would probably not be a safe idea to have them potentially exposed to dangerous chemicals. Also, it would require more transportation from here.	The safest place for solar panel manufacturing would probably be in the central rod, as far away from average citizens as possible in order to minimize the chances of exposing dangerous chemicals to citizens. Also, it would require less transportation.	Considering that the manufacturing of solar panels requires toxic metals like lead and mercury, placing the manufacturing of solar panels within residential spheres could be potential dangerous to citizens.
Ship Manufacturing	If ships were to be made within commercial spheres it would not be much of a nuisance to average citizens. However, it would be fairly costly to move such large ships from the sphere to the docking bay.	With ship manufacturing taking place within the Central Rod, it would make the transportation of ships from factories to docks much easier than if it were inside one of the spheres.	Ship manufacturing taking place in a residential sphere would be fairly troublesome for residents as they would have to deal with the annoyances of loud noises and the constant movement of large ships in and out of the spheres.
Metal Working	With metal working taking place within the commercial sphere, it would be far easier to transfer the finished metals to the transportation ring to be sold in its finished form.	Metal working taking place in the Central Rod would not bother colonists very much, however, it would probably be more of a hassle to transport to other parts of the colony than if it were in the commercial sphere.	If metal working took place within residential spheres, residents would probably be annoyed by the constant noise of clashing metal.

Appendix 8.A,4 Access for Maintenance and Repair of Automations Systems		
Systems for Accessing	**Time to Access**	**Cost Efficiency**
Technicians must put on space suits and enter manufacturing centers through non-pressurized airlocks	Technicians will be stationed in different areas of Hermes and Hestia spheres. Therefore, they would have to put on spacesuits and enter through airlocks.	Manufacturing centers will not be pressurized, so the cost of creating an atmosphere will be mitigated.
Pressurize ATLAS with complete atmosphere and allow technicians to travel directly to manufacturing centers	Pressurizing ATLAS will allow technicians who are stationed in Hermes and Hestia to enter ATLAS without putting on a spacesuit and reach the automation systems quicker.	Pressuring ATLAS would require 3.3 billion liters of atmosphere to be imported to Aresam.
Pressurize manufacturing modules and maintain a constant presence of technicians	Technicians can constantly maintain and repair automation systems. However, they would still be required to put on spacesuits in order to enter ATLAS and reach the manufacturing modules.	Pressurizing the manufacturing centers would reduce cost compared to pressurizing ATLAS entirely, but it would also require a larger workforce of technicians in order to maintain a constant human presence over the manufacturing centers.

Manufacturing in Aresam will take place in non-pressurized manufacturing modules, and maintenance crews will need to put on spacesuits in order to reach and operate within heavy manufacturing areas. Although this bottlenecks repair, the money saved in atmosphere and hiring costs is well worth the trade-off of less capability to access, repair, and maintain automated systems.

APPENDIX B Bibliography / References

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8.0 APPENDIX C Compliance matrix

Structural Design

	Requirement	Location in Proposal	Page
2.0	Provide a safe and pleasant living and working environment for 20,0000 full-time residents	2.0.1 Permanent Population	
2.0	Provide a safe and pleasant living and working environment for 500 transiet population at Initial Operational Capability and increasing by 50 per year of operations for 30 years	2.0.2 Transient Population	2
2.1	Identify attributes and uses of large enclosed volumes	2.1.1.1 Hestia; 2.1.1.2 Demeter; 2.1.1.3 Hermes; 2.1.1.4 Atlas; 2.1.1.5 Hephaestus; 2.1.1.6 Athena; 2.1.1.8 Poseidon; 2.1.4 Pressurized Volumes	2,3
2.1	Show dimensions of major hull components	Fig 2.1 External Configuration	2
2.1	Specify volumes where artifical gravity will be suppplied	2.1.3 Artificial Gravity	6
2.1	Specify structural interface(s) between rotating and non-rotating sections	2.1.5 Structural interface between rotating and non-rotation sections	7
2.1	Specify rationale for selected roation rate and artificial gravity magnitude(s)	2.1.3 Artificial Gravity	1
2.1	Specify means of protection from radiation	2.1.2.2 Radiation protection	6
2.1	Specify means of protecting from debris protection	Table 2.1 Radiation and Debris Protection Material	6
2.1	Show capability to isolate any two of at least ten separate volumes in case of emergency	2.1.6.1 Quarantine	7
2.1	**Minimum requirement: overall exterior view of settlement, with major visible features (e.g., solar panels, antennas), showing rotating and non-rotating sections, pressurized, and non-pressurized sections, and indicating functions inside each volume (e.g., port, residential areas, and agriculture)**	Figure 2.1 External Configuration; Figure 2.1.4 Pressurized Volumes and Unpressurized Volumes; Figure 2.1.5.1 Atlas and Spokes; 2.1.1.1 Hestia; 2.1.1.2 Demeter; 2.1.1.3 Hermes; 2.1.1.4 Atlas; 2.1.1.5 Hephaestus; 2.1.1.6 Athena; 2.1.1.8 Poseidon	2-5
2.2	Specify percentage allocation and dimensions of interior "down surfaces", with drawings labeled to show residential, industrial, commercial, agricultural, and other uses	Figure 2.2 Agricultural, Commercial, Industrial, and Residential Areas; Figure 2.2.4 Hestia; Figure 2.2.5 Hermes; Table 2.2 Areas and Volumes	7,8

	Requirement	Location in Proposal	Page
2.2	Show orientation of "down surfaces" with respect to overall settlement design, and vertical clearance in each area	Figure 2.2.8 Orientation of Down Area	8
2.2	**Minimum requirement: overall map or layout of interior land areas, showing usage of those areas**	Figure 2.2 Agricultural, Commercial, Industrial, and Resiential Areas	7
2.3	Describe the process required to construct the settlement, by showing the sequence in which major components will be assembled	2.3.1 Pre-Construction; 2.3.2 Construction; Table 2.3 Construction Sequence	8
2.3	Specify when artificial gravity will be applied	Table 2.3 Construction Sequence	9
2.3	Describe a construction technique for interior structures making use of materials from Phobs and/or Deimos	2.3.4 On-site Resources	9
2.3	**Minimum requirement: drawing(s) showing at least six intermediate steps of settlement assembly, and method of initiating rotation for artifical gravity**	Table 2.3 Construction Sequence	9
2.4	Show design features enabling expansion, emphasizing reduction of initial construction costs and later operations disruption	2.4.3 Expansion; 2.4.4 Operations Disruption	10
2.4	**Minimum requirement: drawing(s)/map(s) showing interface(s) and/or other system(s) enabling future expansion, especially port modifications to accommodate currently unknowable vehicles**	Figure 2.4.2.1 Universal Mating Port on Modules; Figure 2.4.3 Port Accomodations for Future Vehicle Designs	10
2.5	Create a design for a prefabricated structure to be built at Aresam of materials from Phobos and/or Deimos that can be transported to the Martian surface inside one cargo container (interal dimensions 4m x 4m x 9m) and be erected by two spacesuited persons in 10 or fewer hours	2.5.0 Prefabricated Structure; 2.5.1 External Design	10
2.5	The prefabricated structure must be provisioned to accommodate up to 4 people for 30 days	2.5.2 Hull Composition	**11**
2.5	**Minimum requirement: drawings of deployed and undeployed prefabricated base configurations, plus as least one interim configuration illustrating the deployment process**	Table 2.5.4 Deployment Phase	11

Operations and Infrastructures

	Requirement	Location in Proposal	Page
3.0	Facilities and infrastructure necessary for building and operating Aresam space settlement	3.0 Operations and Infrastructures	13
3.1	Mars orbital location and reasons	3.1.1 Aresam Orbital Location	13
3.1	Sources of materials and equipment used in contruction and in settlement operations	3.1.2.1 Materials and Equipment Logistics	13
3.1	Means for transporting those materials to Aresam	3.1.2.2 Transportation of Materials	13
3.1	**Minimim requirement: table identifying types, amounts, and sources of contruction materials**	Table 3.1.2 Construction Materials and Sources	13
3.2	Elements of basic infrastructure	3.2 Community Infrastructure	14
3.2	Atmosphere/climate/weather control	3.2.1 Atmosphere 3.2.1.1 Climate 3.2.1.2 Weather Control	14
3.2	Food production	3.2.2 Agriculture	14
3.2	Growing/Harvesting	3.2.2.1 Aeroponics 3.2.2.2 Growth 3.2.2.3 Harvest	14,15
3.2	Packaging/Storing	3.2.2.6 Processing/Packaging/ Storage	16
3.2	Delivering/Selling	3.2.2.7 Distribution/Selling	16
3.2	Electrical Power generation(kilowatts)	3.2.3 Electrical Power Generation 3.2.3.1 Traveling-Wave Reactor	16
3.2	Electrical power distribution and allocation for use	3.2.3.2 Power Distribution	16
3.2	Water management(quantity)/storage facilities	3.2.4 Water Management 3.2.4.1 Water Treatment	17
3.2	Household/Industrial solid waste management	3.2.5 Waste Management 3.2.5.1 Household and Industrial Waste Treatment	18
3.2	Internal communication systems (devices/central equipments)	3.2.6 Internal Communication	18
3.2	External communication systems (devices/central equipement)	3.2.6.2 External Communication	18,19
3.2	Internal transportation systems (routes, vehicles, dimensions)	3.2.7 Internal Transportation	19
3.2	Day/night cycle provisions	3.2.8 Day/Night Cycle	19
3.2	Emergency storage facilities	3.2.9 Emergency Storage	19

	Requirement	Location in Proposal	Page
		Facilities	
3.2	**Minimum requirement: charts or tables specifying quantities required of air, food, power, water, waste handling, communication devices, and internal transport vehicles**	Table 3.2.1 Atmosphere Table 3.2.3 Electrical Power Generation	19,20
3.3	Conceptual designs of primary machines/equipments used for contruction	3.3.1 Primary Construction Machines/Equipments	20
3.3	Materials/components/subassemblies delivered to machines	3.3.2.2 Materials and Transport	20
3.3	Mechanisms of machines that convert supplies into completed structures	3.3.2.3 Structural Assembly	20
3.3	Minimum requirement: drawings of primary contruction machinery, showing how it shapes and/or manipulates raw materials or structural components into finished form	Figure 3.3.2 Mobile Headquarter Figure 3.3.2.2 Percheron Space Tug	20
3.4	Material harvesting operations on Phobos and Deimos	3.4.1 Material Harvesting Logistics	20
3.4	Refining/processing of Phobos/Deimos resources	3.4.2 Material Harvesting Processes	21
3.4	**Minimum requirement: illustration of Phobos and/or Deimos mining base**	Figure 3.4 Mining Base	20
3.5	Air, food, power, water, and waste systems required for operations of a prefabricated base	3.5.1 Operations Logistics 3.5.1 Power Generation 3.5.2 Atmospheric Regulation 3.5.3 Water and Waste Management 3.5.4 Food	21
3.4	**Minimum requirement: chart of table listing quatities of air, food, power, water, and waste.**	Table 3.5 Operation Systems Amounts	21

Human Factors

	Requirement	Location in Proposal	Page
4.0	**Human Factors**	4.0 Human Factors	23
4.0	Aresam will offer attributes availibile to residents of Earth's small cities in developed countries	4.0 Human Factors	23
4.0	Provide natural sunlight and views of space outside and Mars below for residents	4.0.1 Natural Sunlight and View of the Martian Surface	23
4.0	Include features in design of community facilities (e.g., roads and paths)	4.0.3 Roads for Pedestrians	23
4.0	Include features enabling mobility and access with a practical minimum of motion (e.g., head-turning) that has been found to cause mild discomfort due to coriolis effects	4.0.4 Mitigation of Coriolis Effects	23
4.1	Provide facilities and services that residents expect in comfortable modern communities (e.g., housing, entertainment, medical, parks and recreation)	4.1.1 Facilities, Table 4.1.1 Facilities	23
4.1	Provide residents with a myriad of recreational activities, including large open area parks with long lines of sight, considering both the physical and psychological health of residents	4.1.3 Parks and Recreation	25
4.1	**Minimum Req: maps and/or illustrations depicting community design and locations of amenities, with a distance scale; identify percentage of land area allocated to roads and paths**	4.1.4 Community Layout	25
4.1	List major types of consumables and quantities, including consumer goods. Depict of specify means of distributing conumables to residents	4.1.5 Foods and Consumables	25
		Table 4.1.5.1 Foods and Consumables	25
		Table 4.1.5.2 Distribution of Consumables and Food	25
4.2	Provide designs for typical residences, clearly showing room sizes; home designs will be no smaller than 800 sq. ft. and no larger than 2000 sq. ft.	4.2.1 Home Designs	26,27
4.2	**Minimum Req: external drawing and interior floor plan of at least four home designs, the area (preferably in square feet) for each residence design, and the number required of each design**	4.2.1 Home Designs	27
4.2	Identify sources and/or manufacture of furniture items and appliances	4.2.2 Furniture and its Sources, Table 4.2.2 Amount of Furniture per Building	27
4.3	Designs of systems, devices, and vehicles inteded for use by humans outside of artificial gravity volumes will emphasize safety	4.3 Systems, Devices, and Vehicles	28

	Requirement	Location in Proposal	Page
4.3	Show spacesuit designs, with stowage and donning/doffing procedures, and airlock designs for exiting/entering the settlement from unpressurized volumes	4.3.5 Spacesuits and Airlocks	28
4.3	**Minimum Req: drawings showing examples of handrails, tethers, cages, and/or other systems enabling safe human access to any location on or in low-g settlement areas**		28
4.4	Show exmpales of flexible housing and community design to respond to anticipated changes	4.4.1 Modular Buildings, 4.4.2 Rotor Houses	29
4.4	**Minimum Req: chart or table showing anticipated demographic trends for Aresam**		29
4.5	Show interior configuration of a prefabricated base	4.5 Prefabricated Base Outpost	29
4.5	**Minimum Req: drawings of a base structure interior floor plan and amenities**		29

Automation Design and Services

	Requirement	Location in Proposal	Pg
5.0	Specify numbers and types of computing and information processing devices, multi-function personal electronic tools, servers, network devices, and robots required for Aresam's facility, community, and buisness operations.	Table 5.0.1 Computers 5.0.1 Computer Specifications Table 5.1 Robotic Assistants for Construction Table 5.2 Safety and Repair Robots Table 5.3 Livability Robots Table 5.5.1 Base Deployment and Phobos/Deimos Operations	31
5.0	Describe types and capacities of data storage media, data security, and user access to computer networks.	5.0.1.1.1 Memory 5.3.2.4 Data Security Table 5.3.1.2.1 User Account Access	31
5.0	Show robot designs, clearly indicating their dimensions and illustrating how they perform their tasks	5.0.3 Robot Design Features	32
5.1	Describe use of automation for construction.	5.1 Automation for Construction	32
5.1	Consider automation for transportation and delivery of materials and equipment, assembly of the settlement, and interior finishing	5.1.1 External Construction 5.1.2 Internal Construction 5.1.3 Interior Finishing 5.1.4 Materials Transportation	32
5.1	**Minimum requirement: Drawings showing automated construction and assembly devices--both for exterior and interior applications (e.g., homes)--and illustrating how they operate**	Figure 5.1.1.1 Vulcan Figure 5.1.2.1 Vesta	32
5.2	Specify automation systems for settlement maintenance, repair, and safety functions, including backup systems and contingency plans	5.2 Automation for Maintenance, Repair, and Safety Functions	33
5.2	Robots required for emergency external repairs must survive and accomplish tasks during solar flare activity.	5.2.2.2 Operation in Solar Flares	33
5.2	Describe means for authorized personnel to access critical data and command computing and robot systems; include descriptions of security measures to assure that only authorized personnel have access, and only for authorized purposes.	Table 5.2.1.2 User Identification	33
5.2	**Minimum requirement: chart or table listing anticipated automation requirements for operation of the settlement, and identifying particular systems and robots to meet each automation need.**	Table 5.2 Safety and Repair Robots	33

	Requirement	Location in Proposal	Pg
5.3	Describe automation devices to enhance livability in the community, productivity in work environments, and convenience in residences.	5.3.3 Home Livability Enhancements 5.3.5 Computer Aided Design/Manufacturing On-Demand	36
5.3	Emphasize use of automation to perform maintenance and routine tasks, and reduce requirements for manual labor.	5.3.3.3 Easy Cleaning of Surfaces 5.3.4 WALL-E	36
5.3	Provide for privacy of personal data and control of systems in private spaces.	5.3.3.1 Smart Integration	36
5.3	Describe devices for personal delivery of internal and external communications services, entertainment, information, computing, and robot resources.	5.3.1 Personal Communications 5.3.1.1 PAN 5.3.2 Intra-Colony Communication	35
5.3	**Minimum requirement: drawings of robots and computing systems that people will encounter in Aresam, and diagram(s) of network(s) and bandwidth requirements to enable connectivity.**	Figure 5.3.1.1.1 PAN Figure 5.3.2.3.1 Network Diagram Figure 5.2.4.1 Janus	35
5.4	Access to data repositories on Earth	5.4.1 Access to Earthbound Data Repositories	37
5.4	Describe access processes to Earth-based Internet/website data, both for retrieving and posting information	5.4.2 Latency	37
5.4	**Minimum requirement: table describing or images showing Internet user experiennces on Aresam; include user messages to identify delays, and methods to create appearances of instant access.**	Figure 5.4.3 User Experience 5.4.2.1 Masking Delay	37
5.5	Provide robotic assistants for deployment of prefabricated base design as described in Paragraph 2.5	5.5.1 Deployment Robot	38
5.5	Provide robotic assistants for conducting materials harvesting operations on Phobos and/or Deimos as described in Paragraph 3.4	5.5.2 Mining Automations	38
5.5	Provide robotic assistants for refining/processing of raw materials	5.5.3 Refining and Processing Raw Materials	38
5.5	**Minimum requirement: drawing(s) of robotic base deployment and Phobos/Deimos operations**	Figure 5.5.1.1 MAIA – Bucket Wheel Figure 5.5.1.2 MAIA – Forklift Figure 5.5.2.1 Diana – Bucket-Wheel Figure 5.5.2.2 Diana – Drill Figure 5.5.3.1 Mithris	38

Schedule and Cost

	Requirement	Location In Proposal	Page
6.0	SCHEDULE AND COST	6.0 Schedule and Cost	40
6.1	The schedule must describe contractor tasks from the time of contract award (7 May 2055) until the customer assumes responsibility for operations of the completed settlement. Show schedule dates when Foundation Society members may begin moving into their new homes, and when the entire original population will be established in the community.	6.1.1Schedule Explanation	41
6.1	**Minimum Requirement: Durations and completion dates of major design, construction, and occupation tasks, depicted in a list, chart, or drawing.**	Table 6.1 Construction Schedule	40,41
6.2	Specify costs billed per year of Aresam design through construction in US dollars, without consideration for economic inflation. Estimate numbers of employees working during each phase of design and construction in the justification for contract costs to design and build the settlement.	6.2 Cost Of Construction	42,43
6.2	**Minimum Requirement: chart(s) or table(s) listing separate costs associated with different phases of construction, and clearly showing total costs that will be billed to the Foundation Society.**	Table 6.2.1 Cost Labor During Construction	42
		Table 6.2.2 Cost of Operations (During Construction)	42
		Table 6.2.3 Cost of Equipment	42
		Table 6.2.4 Cost of Construction Materials	43
		Table Table 6.2.5 Raw Materials	43
		Table 6.2.6 Cost of Robots	43
		Table 6.2.7 Cost of Computers	43
		Table 6.2.8 Income	43
		Table 6.2.9 Operating Costs	43

Business Development

	Requirement	Location in Proposal	Page
7.0	Business Development	7.0 Business Development	45
7.0	7.0.1 Transportation Node and Port	7.0.1 Transportation Node and Port	45
7.0	Docking, warehousing, and cargo-handling capability to transfer freight between spacecraft, including cargo associated with large-scale Mars surface development and industrial enterprises planned for Mars and the asteroids	7.0.1.1.1 Docking	45
		7.0.1.1.2 Launching	45
		7.0.1.1.3 Oversized Vehicles	45
		7.0.1.1.4 Warehousing	45
		7.0.1.1.5 Damaged Vehicles	45
7.0	Terminal facilities to handle passenger traffic in transit to and from the Mars surface	7.0.1.2 Terminals	45
7.0	Refueling and provisioning services for visiting ships	7.0.1.3 Refueling and Provisioning	45
7.0	Base and repair depot for a fleet of Mars surface landing / launch vehicles	7.0.1.4 Base and Repair Depot for Mars Landers	45
7.0	Vehicles spending time on the Martian surface and bringing materials from Phobos and/or Deimos will accumulate dust on exterior and interior surfaces; show method(s) for preventing dust from entering enclosed areas in Aresam	7.0.1.5 Dust Mitigation	45
7.0	Medical and quarantine services assure treatment and isolation of serious illnesses	7.0.1.6 Medical and Quarantine Services	45
7.0	Manufacturing center for elements of Mars and Phobos / Deimos infrastructure	7.0.2 Manufacturing Center	45
7.0	Products will include launch/landing and surface vehicles, tools, machinery, robots, and prefabricated transportable bases as described in Paragraph 2.5	7.0.2.1 Division by Product	45
		Figure 7.0.2.1 Division by product	45
7.0	Identify sources of materials for vehicle, robot and prefab base construction	7.0.2.2 Sources of Materials	45,46
7.0	Describe manufacturing processes to be conducted in pressurized, non-pressurized, rotating, and non-rotating volumes of Aresam (see description of	7.0.2.3 Manufacturing Processes	46

	Appendix A)		
7.0	Illustrate a representative scene from a production line	7.0.2.4 Production Line	46
		Figure 7.0.2.4 Assembly Line Production	46
7.0	Show how vehicles and robots intended for surface operations will be transported	7.02.5 Transportation of Surface Vehicles and Robots	46
7.0	Show how food and other commodities will be transported to the surface of Mars	7.0.2.6 Transportation of Food and Other Commodities	46
7.0	Research center for development of commercial products from Mars resources	7.0.3 Research Center for Development of Commercial Products from Mars Resources	46
7.0	Provide laboratory(ies) for assay of and experiments with materials collected on Mars	7.0.3.1 Laboratories for Assay and Experimentation	46
7.0	Provide capability to quickly begin production for products(s) identified as having commercial potential	7.0.3.2 Products with Commercial Potential	46
7.0	Describe cost criteria for selecting commercially viable products: value of products on Earth vs. transportation costs from Mars	7.0.3.3 Cost Criteria	46
7.0	Although surveys have not found life on Mars, more ambitious exploration of the planet may find life; labs must be configured to enable quarantine if materials hazardous to humans are identified	7.0.3.4 Laboratory Quarantine	46