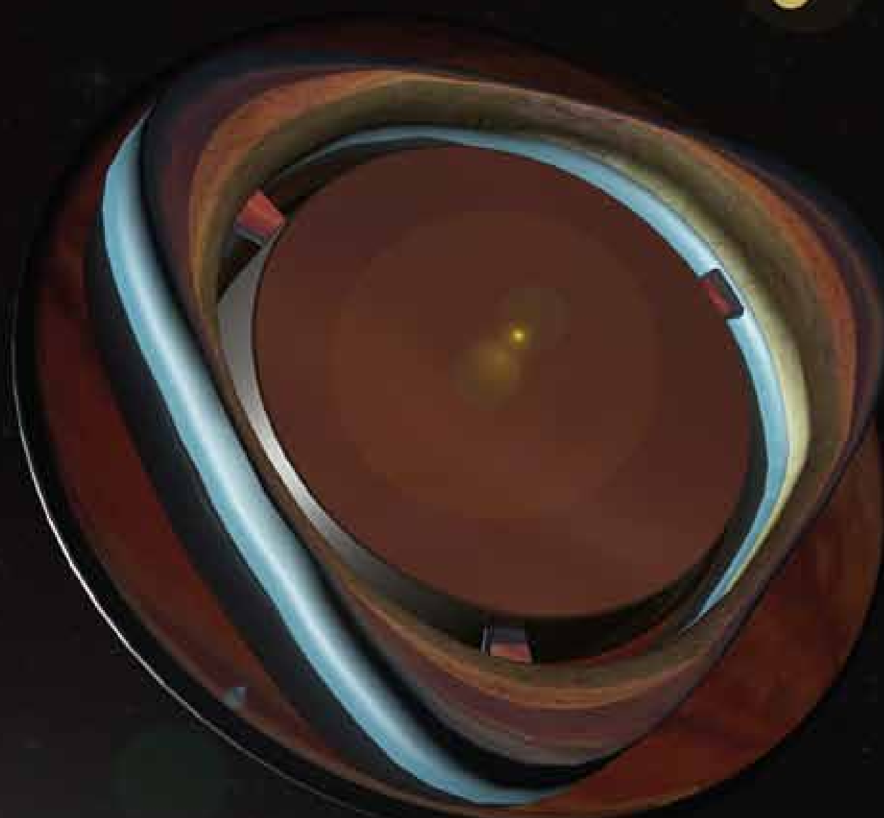
NORTHDONNING HEEDWELL

Aynah

The Foundation Society



Durango High School
Durango, CO, U.S.A.

19th Annual Internatioal Space Settlement Design Competition
Proposing Team Data 2012

Name of responsible teacher/advisor: Daniel Garner
School (or other Group Name): Durango High School
School Address: 2390 Main Ave
School Address (2nd line):
School City, State, ZIP or Postal Code: Durango, Colorado, 81301
Country: USA
Daytime Telephone at School: (970) 259-1630
Message Telephone: (970) 759-8860
Fax Number: (970) 385-1493
e-mail address: dgarner@durango.k12.co.us
Last day of school before Summer 2012: June 1st, 2012

Contact information for responsible teacher/advisor when school is not in session:
Name if different from above:
Address: 230 E Park Ave
Address (2nd line):
City, State, ZIP or Postal Code: Durango, Colorado, 81301
Country: USA
Telephone (also evenings / weekends): (970) 759-8860
e-mail address: dgarner@durango.k12.co.us

Name of alternate contact person (may be a student): Katy Schneider
Telephone x day x eve x weekend: (970) 799-7567
e-mail address: schneiderk94@gmail.com

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

Katie Dudley [11] (17)	Haakon Sigurslid [10] (16)
Chris Walton [11] (16)	Jacob Skeath [9] (15)
Mariah Dorsey[10] (15)	Jeese Rubenstein [10] (15)
Emma Greenberg [10] (16)	Colin Mummery [12] (18)
Izzy Riley [9] (14)	Katy Schneider [12] (17)
James Triola [12] (18)	Will Counley [12] (18)
Jared Engelken [10] (15)	River Weiss [9] (14)

Names of two adult advisors currently expecting to attend the Finalist Competition:
Daniel Garner — Steve Powell

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

Daniel Garner — 3/19/12
Responsible Teacher/Advisor Signature — Date

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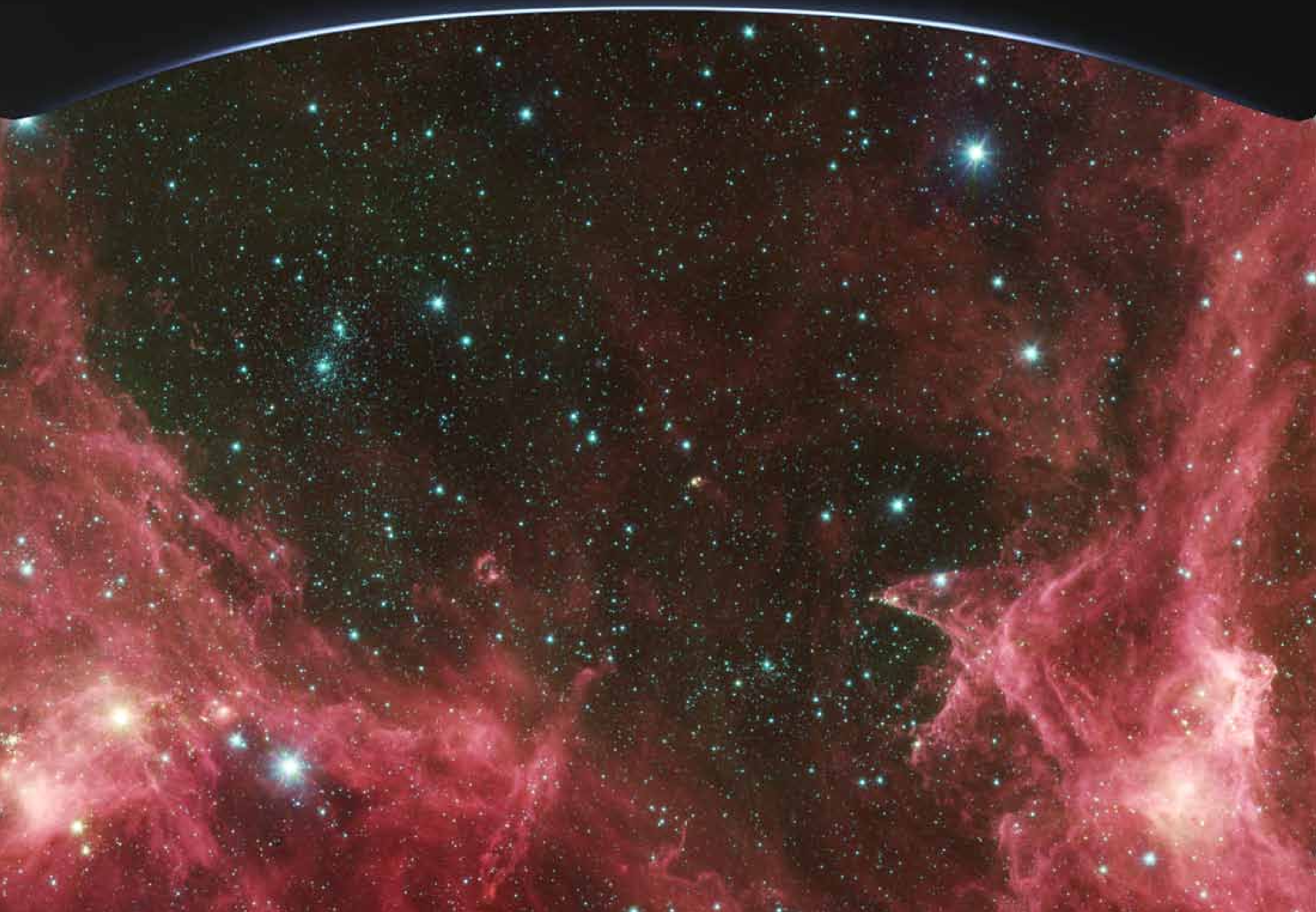
1.0 Executive Summary



1.0 Executive Summary

Aynah's foundation is based on innovation and prudent boldness- innovation to explore a new market and boldness to tackle a formidable location with careful planning. We, Northdonning Heedwell, envision Aynah as a settlement in orbit around Mercury capitalizing on the emerging reardonium market, built with full knowledge that the dangers inherent in such an environment can be balanced by careful engineering and visionary innovation. Our primary goals are to maximize safety with redundant and diverse systems, and to create a stable base to allow flexibility.

Several key innovations comprise the unique attributes of Aynah:

- Due to its close proximity to the sun, Aynah is inundated with solar radiation. Thus, our operations ring doubles as a constant shield. Furthermore, a water shield, reardonium microlattice, and polyethylene work in tandem with reardonium's protective properties to compose our hull.
- Our isolation demands staunch autonomy. To that end, our Isentropic Gravel batteries, charged by the heat captured by hundreds of solar arrays, have gas-cooled nuclear backup, ensuring you constant operations productivity, and no maintenance downtime.
- Remote does not have to mean 'perilous' or 'uncomfortable'. An Example-style community layout, in addition to a forward-thinking range of housing, educational and health monitoring options, redefines 'remote' to mean sophisticated and luxurious.
- We have made bold strides in settlement construction. Our three Settlement Construction Robots replace 'swarm robotics' used in previous projects, cutting maintenance costs by millions, while our automations' power system diversity and function adaptability perform consistently in unforgiving environments.
- We feature two main reardonium products: versatile construction panels and tough universal joints. We keep our cost basis low to ensure you a faster return on investment.

"An inventor is a man who asks 'Why?' of the universe and lets nothing stand between the answer and his mind"- Ayn Rand

We recognize that many question our choice to move with you into Mercury's frontiers due to its hazards. To us, the question seems shortsighted. Mercury has astounding untapped potential as a base for the reardonium market, and we are excited to embark on this journey with you to overcome the location's challenges. In considering the difficulties associated with Mercury, we continuously keep an open mind and ask "How?" rather than "Why?" because we truly believe that nothing other than our own preconceptions can hold us back from the solution.

2.0 Structural Design

2.0 Structural Design

Northdonning Heedwell recognizes the extreme hazards of a Mercury polar orbit and has designed Aynah to compensate for them, transforming our location into a profitable bonus rather than a danger. The operations ring shields all residential volumes from any direct sunlight, thereby significantly decreasing exposure to solar radiation. Tapered Elevated Gravity Regions minimize wasted down area while their parabolic shape increases stability, thus preserving the integrity of the Foundation Society's investment. In addition to reardonium's protective features, Aynah's hull contains innovative measures such as microlattice and vacuum regions, which provide further insulation without adding significant weight. The water shield encapsulating the residential torus provides residents the full benefits of water's radiation protection qualities.

2.1 External Configuration

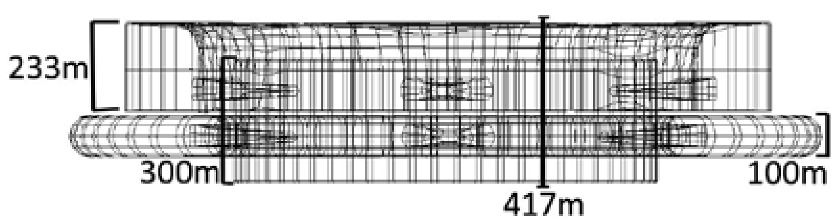
Aynah's structure allows for maximum space usage within a stable and safe environment that has room for flexibility and future expansion to provide a reardonium manufacturing installation that responds optimally to market shifts. Business expansion volumes in the operations ring and manufacturing core provide areas for research and entrepreneurial ventures. Elevated Gravity Regions create down area at levels optimal for childhood development and agricultural growth.

2.1.1 Settlement Design

Aynah's three major volumes, the operations ring, manufacturing core, and residential torus, allow for separation of major processes (see Figure 2.1.1). In order to keep our residents safe from dangerous industrial processes, we separate residential areas from the manufacturing core with the residential spokes. These residential spokes minimize unnecessary down area and volume at .6g (see Table 2.1.1). The heart of our reardonium processing and manufacturing extends outward from the center of the residential torus at the 0.5g level. Its multiple gravitational and variable pressure levels provide ample space for production growth. Meanwhile, our non-rotating operations ring provides an optimal space for 0g pursuits, including refining, docking, and storage. Located between the residential torus and the sun, this reardonium-clad ring also acts as a shield, protecting the residential torus from direct infrared and ultraviolet solar radiation. A set of three spokes protrude from the interior of the operations ring to interface with the manufacturing core.

	Volume (m^3)	Surface Area (m^2)
Residential Torus	235,923,000	4,968,000
Residential Spokes	5,490,000	154,000
Manufacturing Core	202,099,000	1,547,000
Operations Ring	166,152,000	4,244,000
Operations Spokes	8,200,000	239,000

Table 2.1.1 We ample volume to accommodate Aynah's future needs, with additional room in anticipation of future expansion.



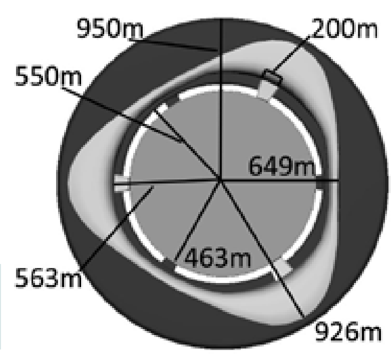


Figure 2.1.1 Our torus width lengthens lines of sight; its radius delivers a rotational period meant to minimize the Coriolis Effect.

Gravity Level	Single Arc Length (0.8-1g) or Circumference (0.1-0.7g)	Torus Width	Tangential Velocity (m/s)
1g	107m	233m	9.53
0.9g	550m	233m	19.06
0.8g	840m	233m	28.59
0.7g	4070m	233m	38.13
0.6g	*spokes*	117m	47.66
0.5g	2910m	300m	57.19
0.4g	2330m	300m	66.72
0.3g	1750m	300m	76.25
0.2g	1160m	300m	85.79
0.1g	582m	300m	95.13

Table 2.1.2 Aynah's manufacturing core is set off from the residential torus to avoid obstructing views of Mercury.

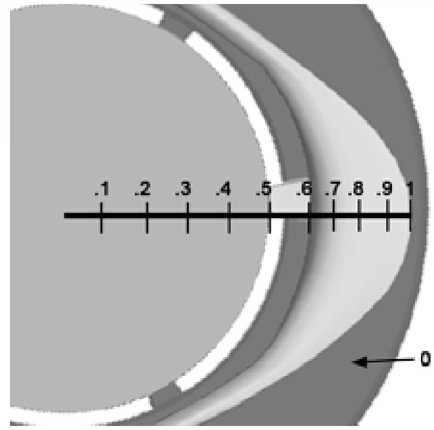
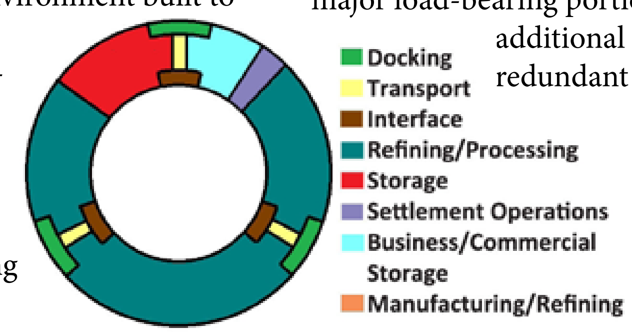


Figure 2.1.2 Gravity levels between zero and one full g accommodate environments beneficial for both resident health and reardonium production.

We pressurize only our residential torus and the portions of the operations ring and manufacturing core dedicated to residential and business use. All other areas of the operations ring and the manufacturing core are unpressurized to save material costs and reduce structural stress, with specific rooms and ORCs (see 5.1.1) providing pressurized areas.

Our 61.05-second residential torus rotational period serves myriad purposes (see Table 2.1.2). The period of rotation minimizes the radius of the settlement, widens our torus, and increases lines of sight, which greatly reduces the Coriolis Effect. The result is an expansive, comfortable environment built to increase workability and livability without compromising space efficiency. Long lines of sight increase comfort for Aynah residents by reducing the Coriolis Effect and creating a spacious environment. Balanced evenly around the torus, three Elevated Gravity Regions (EGRs) extend from the major residential level at 0.7g out to a larger radius, which provides 1g. Parabolic tapers on the EGRs reduce unnecessary down area by 71% when compared to a disc-shaped torus. Still, these regions allow ample space for children to experience the full gravity required for proper development (see 4.4) while reducing surface area by 85,000 square meters and consequently cutting material costs. Radiators channel excess heat from industrial processes and settlement operations into the water shield (see 2.5) to prevent water from freezing.



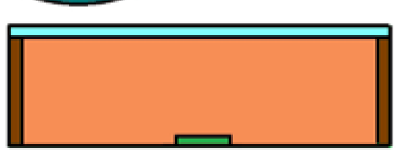
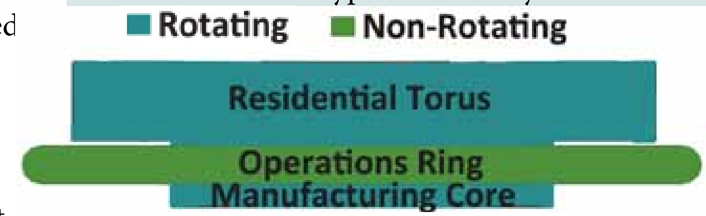


Figure 2.1.3Aynah's volume allocation allows distinct transportation shafts for human and industrial shipping.

2.1.2 Hull Composition

Whereas reardonium composes the major load-bearing portion of Aynah's hull, additional materials serve as redundant and diverse compliments to reardonium's radiation-blocking and thermally insulating properties. In addition to being an excellent insulator, our version of metallic microlattice manufactured of reardonium provides compressibility to absorb the force from a rare micrometeoroid impact. Leaded laminated acrylic glass combined with a vacuum layer provides excellent clear radiation protection and thermal insulation without compromising natural views of space and Mercury. Throughout the first stages of construction, Northdonning Heedwell has ongoing research and development studies (see 6.0) to verify that these materials truly do provide the utmost in radiation and heat protection and refine their design to specialize them for the unique environment provided by a Mercury orbit (see Figure 2.1.4).

Figure 2.1.5 Our combination of rotating and stationary areas provides a diverse set of environments catered to all types of industry.



2.1.3 Rotating/Non-Rotating Interface

To eliminate friction and other issues associated with a structural interface involving physical contact, Northdonning Heedwell employs electromagnets surrounding both the non-rotating and rotating rings of the torus. Embedded vibrating actuators placed within the magnetic rings remove any dust that comes into contact with the electromagnets. After removal from the electromagnets on the interface, the collected dust moves to the main docking areas in the operations ring where it is processed to reclaim valuable materials such as metals useful for reardonium manufacturing.

Three ion drives located on the outer edge of the operations ring stabilize it and counteract the force from the structural interface, thus preventing it from rotating.

Because the settlement runs on constant battery power (see 3.2.3), the electromagnets never have an issue with power interruption. However, the interface does have its own set of batteries so it operates independently of other settlement operations.

To transport personnel and cargo between the rotating and non-rotating rings, Northdonning Heedwell employs a rail system that completely circles around the manufacturing core and the operations ring, allowing a train-like vehicle to travel between these volumes. By accelerating to match the velocity of the other volume, the train becomes stationary relative to the adjacent volume, allowing it to transfer over and dock to move personnel and cargo safely and efficiently.

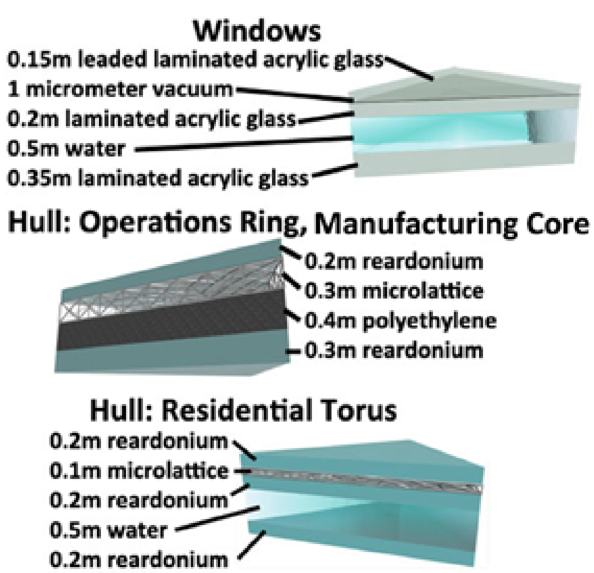


Figure 2.1.4 Reardonium, microlattice, polyethylene, and other materials provide redundant thermal insulation and radiation protection.

2.1.4 Emergency Isolation Capabilities

In the event of an emergency, large hydraulic bulkhead doors lined with polymeric gel actuators can completely seal off up to six different sections of the residential torus containing levels of gravity between 0.7g and 1g with an airtight seal. Moving these doors hydraulically increases strength - ensuring a

Figure 2.1.8 The majority of the manufacturing core is unpressurized to minimize material costs.

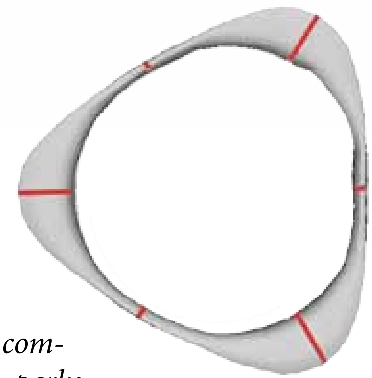


Figure 2.1.7 Each section of the torus contains all gravity levels so they can maintain normal operation even in an emergency.

tighter seal - and decreases the frequency of necessary repairs compared to a pneumatic system. To further minimize damage, each different gravity level of each section can be isolated by closing off transport shafts. Each level of each section contians emergency supplies stored beneath the floor capable of sustaining up to 1800 residents for one week (see Figure 2.1.7). Two separate control panels can operate each door: one near the door and one on a master control panel. Emergency shuttles are located on the outside of all levels of all regions to allow residents in the affected area to safely evacuate. These shuttles may then re-enter the settlement into the operations ring, allowing residents to move through the structural interface and back into the safe regions of the residential torus.

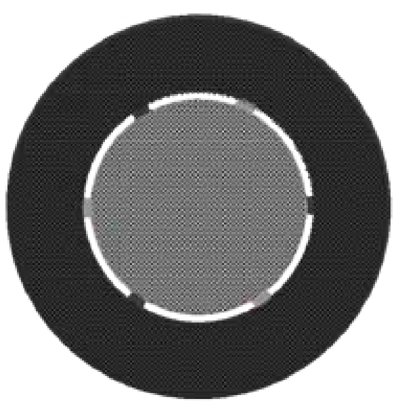


Figure 2.1.6 Lining all sun-facing surface area with solar power systems transforms a potential danger into a beneficial resource.

2.2 Internal Allocation

Aynah strategically combines agricultural, commercial, industrial, parks and recreation, and miscellaneous infrastructure areas to provide a cohesive design that is spacious and psychologically pleasing to its residents and visitors while ensuring no unused space.

Aynah provides an extensive 18 square meters per person of parks, recreational area, and open space by utilizing all down area not allocated to residential, commercial, and agricultural needs. This down area acts as potential space for future business or residential expansion, fluidly accommodating for Aynah's anticipated growth. In dispersing these areas throughout the residential torus, we provide residents easy access to a variety of recreational facilities. Varied combinations of residential, commercial, and recreational areas create diverse community atmospheres, allowing residents to choose the neighborhood that best suits their lifestyle (see 4.2). Allocating all residential areas to 0.7g creates a cohesive community (see Figure 2.2.1). The organic blending of commercial, parks, and miscellaneous infrastructure areas in with residential areas provides opportunities for varied living environments and optimal overall use of

Level	Diagonal Line of Sight (m)
0.7g	665
0.8g	709
1g	256

Table 2.1.3 Aynah's 80m vertical clearance allows for long lines of sight within all residential areas.

Use	% of Down area	Down Area(m^2)
Industrial	56%	2,618,000
Residential	15%	696,000
Agriculture	10%	453,000
Parks/Recreation	5%	255,000
Miscellaneous Infrastructure*	1%	25,000
Transportation	4%	208,000
Commercial	2%	104,000
Personal Storage	2%	71,000
Expansion/Research/ Business Pursuits	5%	242,000
Total	100%	4,672,000

*includes hospital, assembly, parks, and rec.

Table 2.2.1 Aynah provides a balance between residential and commercial areas and green space to preserve our residents' psychological health.

0.7 and 0.8g areas (see Table 2.2.1).

The isolation of agricultural areas to 0.8g provides safety in the rare case of agricultural disaster (see 3.2.2). Six separate and self-sufficient agricultural volumes placed in the EGR's allow each volume complete autonomy in the event of quarantine or other emergency. The 0.9g level consists of meat culturing and bamboo growing, as well as some research and all personal storage. It also contains room for future expansion in anticipation of future growth. Extensive water treatment and power storage facilities, as well as other life support systems such as atmospheric filtering, lie below the floor of the 0.7g level. Placing these systems close to the areas they serve streamlines life support systems for enhanced reliability. Aynah provides 80m of vertical clearance throughout the residential torus for a comfortable, open atmosphere (see Figure 2.2.2).

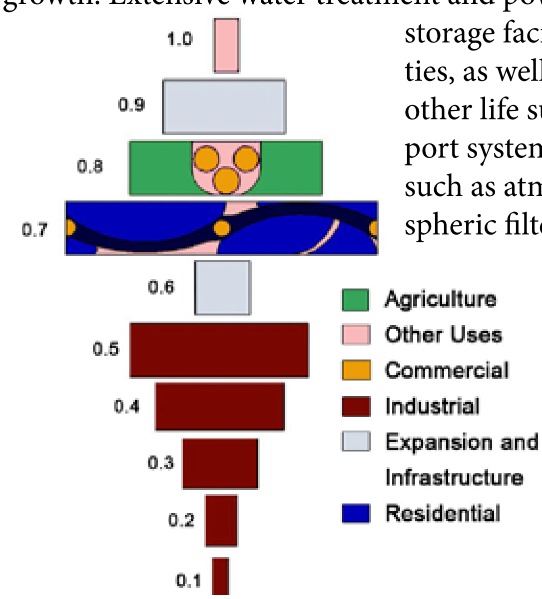


Figure 2.2.1 Aynah's residential torus integrates commercial areas, open space, and residential down area to provide varied neighborhood environments.

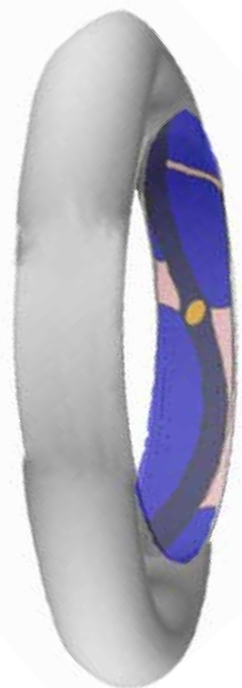


Figure 2.2.2 Aynah's Elevated Gravity Regions place processes at their optimal gravity levels.

2.3 Construction Sequence

Aynah's construction sequence uses Settlement Construction Robots and contour crafters working simultaneously to cut construction time without compromising stability.

An initial vehicle, the matriarch constructed at Bellevistat, travels to the surface of Mercury. This vehicle carries a nuclear reactor to provide power for the construction process until solar power systems are functional. It also brings a Settlement Construction Robots (SCR) (see 5.1) and three Percheron vehicles (see Appendix A) to transport hull components into orbit for Aynah construction. SCR's add an additional 100,000 square feet facility to existing reardonium manufacturing and curing facilities on the surface of Mercury (see Figure 2.3.1). This new facility benefits from Mercury's stable foundation and existing infrastructure, and allows for manufacture of large reardonium hull panels before settlement construction begins in orbit. Use of large components decreases overall construction time and increases structural stability by reducing potential points of failure at junctions. Aynah construction begins with the sun-side of the manufacturing core (see Figure 2.3.2). In constructing the hull of this volume, SCRs first extrude a rail system with a fixed radius to facilitate their movement during construction and serve as a skeleton for the remainder of the hull. After laying the inner layers of the hull, robotics place hull plates in tile form to ease efficiency of handling these construction panels and to facilitate simpler repairs or maintenance later on. Once the hull is complete, SCRs place infrastructure for Asters and Poppies (see 3.2.3) as well as deploying solar power satellites (see 3.4) to generate solar power as soon as possible. The construction of all other hull components uses this same method, but only areas in direct sunlight have solar power systems.

After constructing the manufacturing core, Settlement Construction Robots construct the operations spokes and attach them to the manufacturing core with temporary welds to be removed later when electromagnetic systems initiate rotation (see Figure 2.3.3). Next, SCRs construct the operations ring (see Figure 2.3.4). Constructing the operations ring before beginning on the residential torus protects the residential torus from radiation even from the start of its construction. Therefore, residential torus materials experience minimal exposure to damaging radiation, ensuring a safe and protective environment for our residents. While a team of SCRs works on the operations ring, contour-crafters (see 3.3) construct the interior infrastructure for the manufacturing core. Using silicate materials as well as aluminum mined from the Mercury surface to construct internal infrastructure minimizes construction costs. Throughout Aynah's construction, multiple teams of robotics working in conjunction construction time.

Residential torus construction begins with the spokes attaching to the manufacturing core and then radiating out to complete the hull of the torus itself (see Figure 2.3.5). SCRs construct

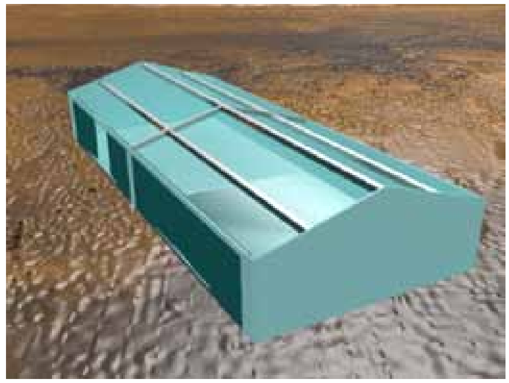


Figure 2.3.1 Expanding manufacturing facilities on the surface of Mercury cuts overall construction time.

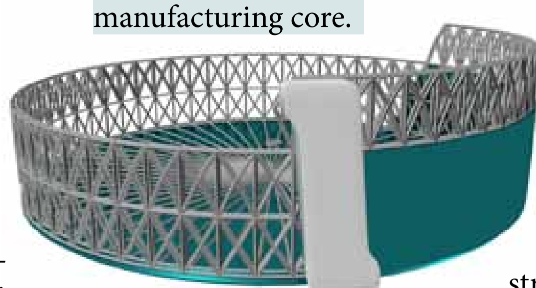


Figure 2.3.2 SCRs begin constructing Aynah at the sun-facing end of the manufacturing core.

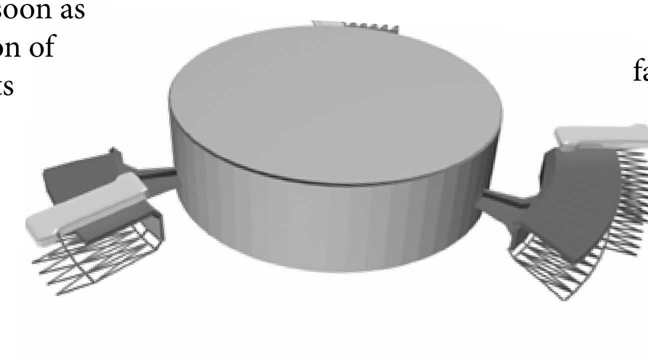


Figure 2.3.3 Temporary welds connect the operations spokes and manufacturing core during construction.

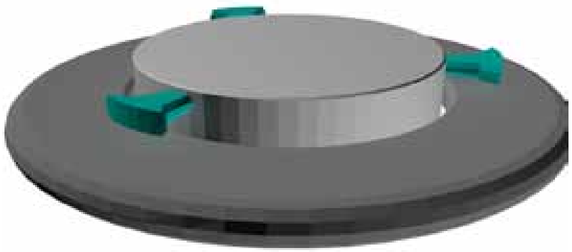


Figure 2.3.4 The hull of the Residential torus hull and internal infrastructure are complete

the reardonium hull and laminated acrylic windows with the same support structure used in the manufacturing core. To increase stability of the water shield (see 2.5), the two panels on either side of the shield have braces placed to support the two panels and hold them in place relative to each other. Then the remainder of the hull is constructed so that sufficient thermal insulation is in place to prevent the water shield from freezing. Only once these systems are in place do the construction robotics fill the water shield. After the outer hull of the residential torus is constructed, the Multifunctional Robotic Spheres or MRSs (see 5.2.1) removes the temporary welds (see Figure 2.3.6). Then the electromagnetic interface between the manufacturing core and the operations ring initiates rotation, with ion drives working on the outside of the operations ring to stabilize it and counteract the reactive force. Construction finishes with the completion of interior infrastructure within the residential torus.

Figure 2.3.5 SCRs construct the operations ring before the residential torus to shield it from radiation.

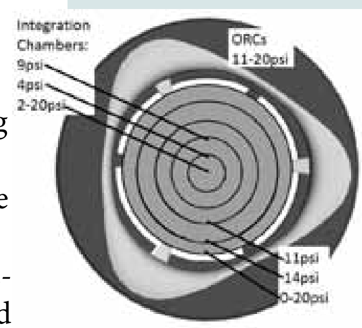
Figure 2.3.6 As electromagnets initiate rotation, ion drives ensure a stable 0g area by firing to prevent the operations ring from rotating.

2.4 Manufacturing Environments

Aynah's design efficiently provides varying gravity levels for reardonium refining and manufacturing.

Northdonning Heedwell engineered Aynah to differentiate gravity levels for reardonium manufacturing. The manufacturing core extends as a cylindrical volume out from the 0.5g level of the center of the residential torus to provide down area at all gravity levels between 0.1g and 0.5g. Aynah's interior design has been made to be as efficient as possible for the refining and manufacturing process. Ore Refining Containers (ORCs) contain all refining processes and have three main sizes for refining differing quantities of elements (see Appendix A). Separate ORCs refine all alloy materials simultaneously. Additionally, each ORC batch matches to a tracking number to assist in quality control. The ORCs allow for great temperature changes, specifically temperature increases to melt ore. In addition, they provide pressures from vacuum to 20psi using argon gas. Temperature tolerance and pressurization capacity allow for the melting and draining of impurities and undesired elements. ORCs move along rail systems to navigate the gravity levels and to move between gravity levels within the manufacturing core.

Figure 2.4.1 We employ a range of pressure and acceleration levels to develop reardonium's remarkable properties.



Integration chambers suspended in the middle of the manufacturing core provide 0g area for alloying and element mixing and are capable of argon pressurization. Casting occurs at the 0.4g and

0.5g levels, with laser machining at 0.3g. Casting and machining take place within rooms at each level that provide necessary pressure (see Figure 2.4.1).

2.5 Water Shielding

With its sun-synchronous polar orbit, the operations ring protects the residential torus from radiation. The continuous water shield surrounds the residential torus to further protect residents.

2.5.1 Water Shield

Aynah orbits the poles of Mercury while rotating along the same plane as its orbit; therefore the manufacturing core faces the sun at all times. With the operations ring acting as a shield, all volumes of the residential torus are away from the sun and are on the opposite side of the operations ring at all times. Aynah's water shield surrounds the residential torus, running from the ceiling of the 0.7g level to beneath the 1g level and protecting residents from solar radiation (see Figure 2.5.2). Acrylic windows allow for containment of the water shield. The water shield is continuous, with support poles interspersed to increase structural stability. Continuity preserves views of space. However, should an emergency arise with a weakened panel, the paneling system eases repair. To handle this with minimal water loss, small robots located in the water shield quickly respond. A robot moves into the damaged panel and disrupts the water flow between the damaged panel and all other panels around it. The robot accomplishes this by placing reardonium plates against the lattice support structure. Then, going to the middle of the damaged panel it uses turnbuckles to pull the plates inwards, sealing the panel off from the rest of the water shield (see Figure 2.5.3). The next step is to replace the damaged acrylic panel. Casting liquid acrylic into the small gap between the existing panels and the new panel fuses them together for a watertight seal.

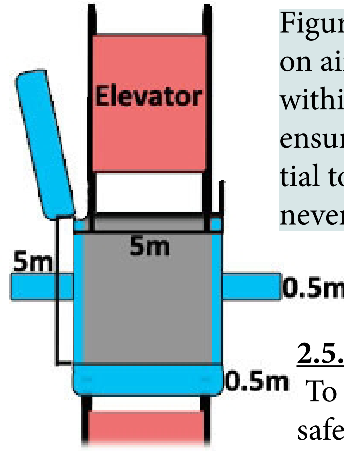


Figure 2.5.1 Water caps on airlocks located within the water shield ensure that the residential torus protection is never interrupted.

2.5.2 Airlock Design

To provide maximum safety while traveling through the water shield in the residential torus, we incorporate permanent airlocks into the residential water shield (see Figure 2.5.1). The connecting elevators lock onto the housing of protective hatch doors containing 0.5 meters of water each. The hatch doors connect to a pod where cargo rests waiting for the hatch door to completely shut. Providing both a pressurized and non-pressurized chamber in-between the water locks, Northdonning Heedwell assures each passenger a safe transition period through our main water shield. Elevators from the 0.7g level dock to the bottom of this airlock, and elevators from the 0.6g spokes dock to the top of this airlock.

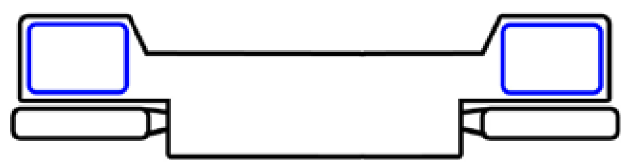


Figure 2.5.2 A water shield envelops the residential torus, blocking solar radiation.

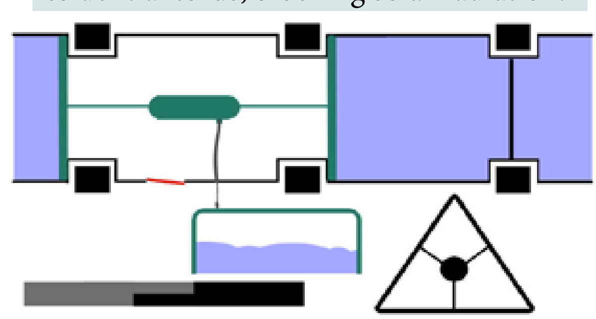


Figure 2.5.3 Our tiling system facilitates easy window repair without compromising the water shield.

3.0 Operations and Infrastructure

3.0 Operations and Infrastructure

By seamlessly integrating state-of-the-art technologies with basic human needs, Aynah optimizes its operations while minimizing disruptions of the normal flow of life on the settlement. Through a comprehensive system of basic infrastructure, Northdonning Heedwell emphasizes maximum efficiency and productivity while ensuring individualism for residents. Capitalizing on redundancy and diversity, Aynah ensures the safety and well-being of our residents and your investments.

3.1 Settlement Location and Materials

Located in Mercury's polar orbit, Aynah capitalizes on in-situ mining, extracting a vast majority of construction materials directly from Mercury. Northdonning Heedwell recognizes the need for Aynah to serve not only as a lucrative mining and refining center, but also as a hub to support future materials curing.

3.1.1 Orbital Location

We have designed Aynah to use the best of materials from Mercury while designating a safe orbital altitude to provide our residents and investors a dynamic base of operations. A sun-synchronous orbit with an altitude of 500km places Aynah within the magnetic field of Mercury. Aynah orbits at a speed of 2.74km/sec providing a constant, safe orbit. Aynah has VASIMR drives to maintain consistent orbital corrections of 4 degrees every 24 hours that compensate for Mercury's precession, ensuring a fixed local time orbit. We conduct studies upon arrival at Mercury during construction to examine solar sails as an alternative measure for orbital correction (see 6.0). Since ordinary solar sails do not have sufficient structural integrity to reliably precess Aynah's orbit, we send a spool of reardonium thread to Alexandriat, where they can manufacture a solar sail out of reardonium to fit our needs.

3.1.2 Sources of Materials and Equipment

Mines on Mercury provide the majority of Aynah's necessary materials, while imports from the Earth, Luna, and Mars provide other essential resources including lead and argon. These materials create a settlement in which residents and corporations may live and work safely, efficiently, and independently. Initial construction equipment, consisting of an SCR (see 5.1), a nuclear reactor, and three Percheron vehicles (see Appendix A), are manufactured at Bellevistat and transported via the matriarch (see 2.3).

3.2 Community Infrastructure

Aynah's infrastructure redefines diversity and safety through innovative, redundant systems that ensure constant operation. Simple, yet extremely reliable processes save the Foundation Society the hassle and revenue loss incumbent upon systems malfunction.

3.2.1 Atmosphere

We consider the comfort and safety of our residents to be a top priority. A humidity of 36% allows for maximum

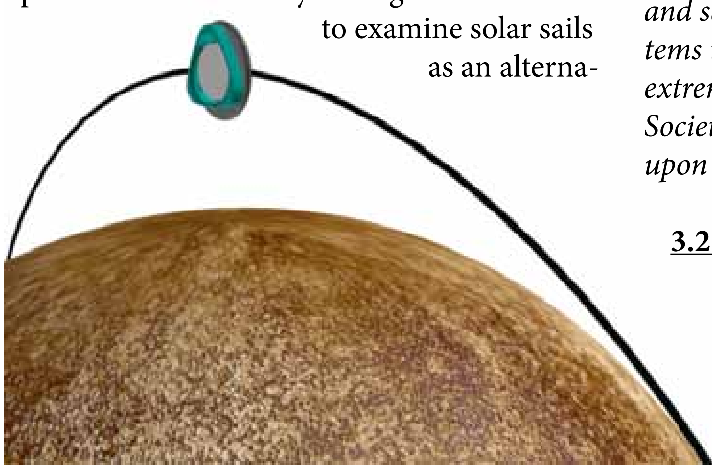


Figure 3.1.1 Aynah's orbirtal altitude cuts transit time to Mercury's surface.

Material	Manufacturing Location	Quantity for Construction	Material	Manufacturing Location	Quantity for Construction
Polyethylene	Manufactured on Mercury	2,061,000 m^3	**Aluminum**	Mined on Mercury	546,000 m^3
Water	Shipped in, mined	2,484,000 m^3	**Reardonium**	Manufactured on Anyah	4,855,000 m^3
Nickel	Mined on Mercury	20,876,000 m^3	**Laminated acrylic**	Manufactured on Aynah	881,000 m^3
Helium	Collected on Mercury	1,230,000 m^3	**Argon**	Imported from Earth	16,672,000 m^3
Steel	Made on Aynah	209,000 m^3	**Cobalt**	Mined on Mercury	2,913,000 m^3
Carbon	Extracted from Iron Ore	413,000 m^3	**Titanium**	Mined on Mercury	291300.018 m^3
Sulfur	Mined on Mercury	24,000 m^3	**Copper**	Mined on Mercury	2,428,000 m^3
Lead	Imported from Luna	536,000m^3	**Aluminum**	Mined on Mercury	583,000 m^3
Calcium	Mined on Mercury	146,000m^3	**Iron**	Mined on Mercury	16,507,000 m^3
Nitrogen	Collected on Mercury	626,169,000 kg	**Oxygen**	Collected on Mercury	192,741,000 kg
Magnesium	Mined on Mercury	3,884,000m^3	**Thorium**	Mined on Mercury	873,000 m^3

Table 3.1.1We construct Ayanh largely from Materials originating on Mercury.

comfort as well as optimal air conditions, which prevent bacterial growth while maintaining healthy conditions for residents within habitable areas on Aynah. Humidity remains constant throughout our precisely controlled mild seasonal changes. Super hydrophilic collectors, located every 100 meters, collect and disperse water through misters that line the ceiling of the settlement. Humidity detectors control the quantity of mist dispensed. Seasons occur within the settlement using OLED panels that change images using a randomizing matrix generator specified per season, as well as a temperature range of 21 to 24 degrees Celsius. Simulating seasonal shifts similar to those of Earth's more moderate climates introduces a sense of security and familiarity in the otherwise hostile environment of Mercury's

Table 3.2.1 The Earth-like atmospheric composition and reduced oxygen mitigate the risk of fire.

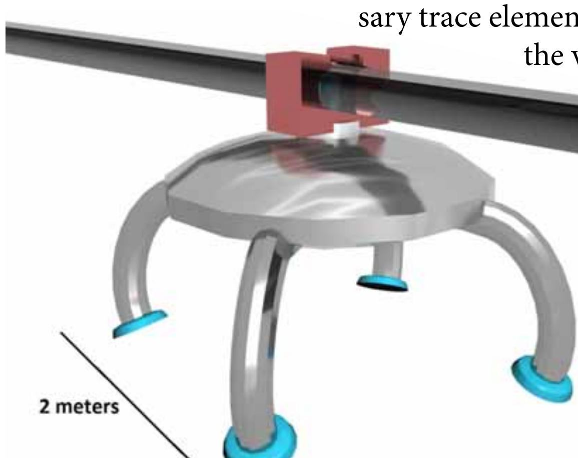
Gas	Percentage	Amount in Air (kg)	Amount in Storage (kg)
Nitrogen	77%	429,117,000	214,558,000
Oxygen	21%	117,032,000	58,516,000
Argon	0.97%	5,406,000	2,703,000
Carbon Dioxide	0.03%	167,000	84,000
H20 Vapor	1%	5,573,000	2,786,000
Totals	100%	557,296,000	278,647,000

	g/person/day	kg/14,200/day	Space Allocation
Wheat	225	3,195	10.6%
Rice	125	1,775	5.9%
Sorghum	317	4,501	14.9%
Soybeans	470	6,674	22.2%
Corn	50	710	2.4%
Vegetables	687	9,756	32.3%
Fruit	250	3,550	11.7%
Total	2,124	30,161	100%

3.2.2 Aynah provides a diverse diet that balances nutrition and variety.

orbit. Circulating our atmosphere through Freon-lined tubes located along walls and ceilings in habitable areas and fans controls temperature changes and overall temperature stability within the settlement. This system requires less space than traditional air-conditioning methods.

Our atmospheric pressure of 13psi reduces structural stress compared to standard Earth sea level pressures. The gases that make up our atmosphere disperse throughout the settlement when connecting with the cooling systems.



3.2.1 The Agbot gently collects all products.

Three filtration systems manage the air in residential and industrial areas. The first system manages the air in habitable areas, while removing carbon dioxide and harmful trace gases, and circulating oxygen from the tanks throughout the settlement. The second filtration system cleanses the air in manufacturing areas to ensure maximum safety. To prevent contamination, the last filter cleanses the air before it enters the agricultural center. The agricultural volumes have a unique environment to promote healthy plant growth. The humidity is 40-45% and the temperature is 13-21 degrees Celsius depending on seasonal variations for different crops. To minimize the risk of contamination or infection of food products, the exposure of food to human contagions remains minimal. Having several types of filtration systems ensures that the air remains clean in all ways possible.

3.2.2 Food Production

Columns of space-efficient aeroponics grids, located in 0.8g level, facilitate the growth of all crops while capitalizing on available down area. Recycling up to 98% of water, aeroponics trays triple crop yield compared to more traditional hydroponics and soil-based systems through increased nutrient uptake and year-round growing capabilities. Fixed nitrogen from urea and other necessary trace elements/minerals are added to the vapor solution to maintain plant integrity. Soy and rice crops offer a variety of substitutes to traditional bovine milk and cheeses, and a wide array of dietary supplements, including minerals, vitamins, powdered spirulina, chlorella and trace elements promote health in our residents and limit nutritional deficiencies. Versatile aeroponics trays provide an opportunity for community gardens, home planting systems, and fruit trees, visually softening our residential areas. All plants within residential areas self-pollinate or subsist by artificial pollination. We also offer a multitude of spices, sweeteners and seasonings to enhance flavor. Augmenting an already protein-rich soy-based diet, bio-printers within agricultural areas provide a cost-effective and innovative alternative to livestock. These printers produce cultured meat with nearly identical taste and texture to traditional meat while providing an elevated nutrient content. The bio-printers produce a nearly infinite array of meat to suit all tastes. Automated harvesting robots, running on rails through the grid system minimize human labor in agricultural volumes, providing a collection process that reduces the likelihood of blight. Once collected, all food products move to large containment facilities for processing and storage prior to distribution. Optimal temperatures of 13-21 degrees Celsius maintain plant growth throughout the year while in short term storage; temperatures of 4.2-5.5 degrees Celsius aid nutrient retention before distribution. A unique combination of recyclable bamboo and soy plastic serves as airtight food packaging. After packaging, food moves to processing and distribution facilities within the agricultural volume. A system of pneumatic pipelines throughout the settlement facilitates on-demand food distribution.

In the event of blight or emergency, our six food production areas can be easily sectioned off from the rest of the settlement and each other: a problem in one section would not hinder production in any other sections of the agricultural volumes. We also offer a multitude of storage facilities throughout the residential torus. Maintaining a cooler, drier climate, these storage units preserve food integrity and can sustain residents for up to 18 months in the event of a crisis. Similarly, a central seed bank serves as a storage facility for a variety of cultivars capable of completely replenishing Aynah's crops while offering invaluable bio-medical research opportunities. A temperature of -18 degrees Celsius and low oxygen levels delay metabolic processes in the seeds, thus drastically slowing aging and deterioration.

Person/Day	125kWh
Person/Year	45,625kWh
Settlement/Day	1,775,000kWh
Settlement/Year	647,875,000kWh

Table 3.2.3 Residential power is supplied by Asters and Poppies for simpler energy transfer.

3.2.3 Power Generation

Aynah's proximity to the sun makes solar power the most practical and efficient form of energy. Aynah employs Asters in order to fill its residential power needs, because they are more efficient than traditional solar panels. Asters reflect solar rays into a center point using six petals in a parabolic shape to collect solar heat. Stirling engines in the center of the Aster convert the heat to mechanical energy that turns a motor and creates electrical energy. Thin sheets of reardonium coated in reflective aluminum constitute the Asters' petals, providing them with a heat-resistant surface that directs the sun's ray into a central point. Reardonium makes up the body of the Aster because of its ability to withstand high temperatures. Carbon nanotubes lining the centerpoint maximize the efficiency of the device. The placement of Asters along the rotating manufacturing core allows for maximum sunlight capture.

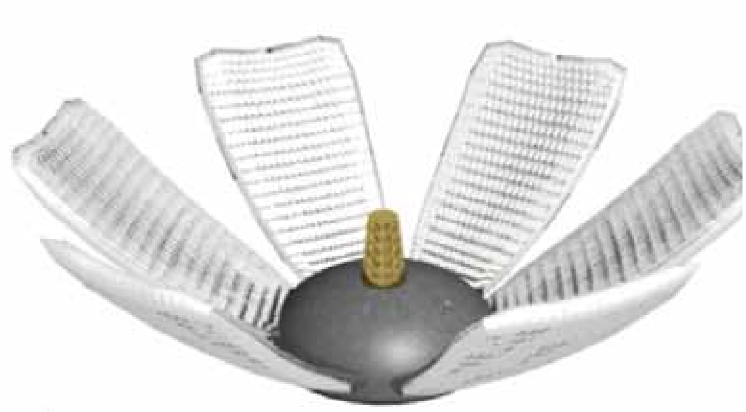
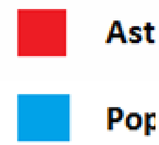
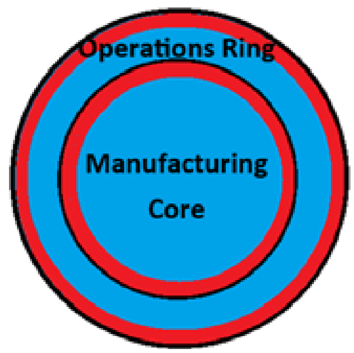


Figure 3.2.2 Aster's unique design provides optimum energy-collection for all rotating surfaces.

Built in nearly the same manner as Asters, Poppies are parabolic devices that lack petals but instead have a semi-sphere as the reflector; they employ the same central point reflectivity. We install Poppies upon the non-rotating operations ring, as the reflector dish cannot rotate. 300 Asters and 200 Poppies support our population with surplus energy should some of the units fail. The sheer number of Asters and Poppies reduces the risk of a power shortage through redundancy and diversity.

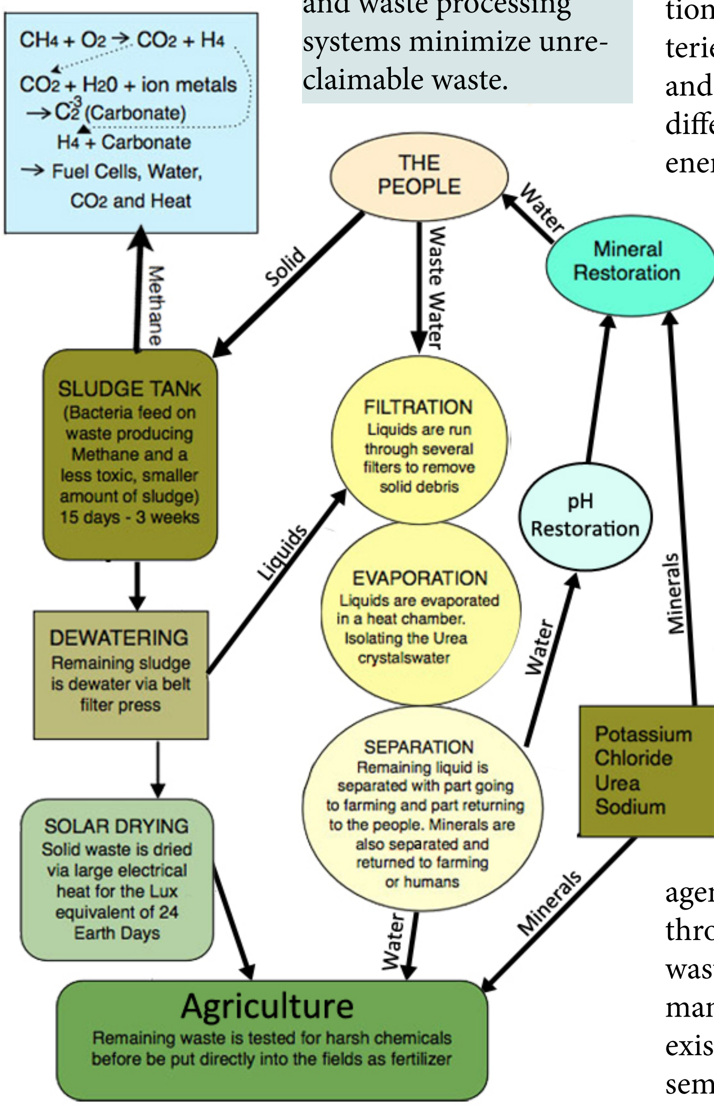
Figure 3.2.3 For maximum energy collection, Asters and Poppies exist on the sun-facing section of the settlement.





Industrial-sized Isentropic Gravel batteries power all settlement operations. Asters and Poppies charge these batteries, but the settlement draws power only from battery banks, never directly from produced power. This ensures that Aynah never has an interruption in power supply. The Isentropic Gravel batteries use two large tanks of gravel, argon gas, and a heat pump, employing the temperature difference between the tanks as an inexpensive energy storage and retrieval mechanism. Six batteries (11.5m by 11.5m by 10m high) power the residential torus and ensure that each section of the torus is self-sufficient with electricity (see 2.1.4). For industrial use, 34 batteries (14.8m by 14.8m by 10m high) power manufacturing and refining with 17 located in the operations ring and 17 dispersed throughout the levels of the manufacturing core. This provides two additional batteries in each industrial volume to act as backups and larger-than-required batteries in the residential volume so other batteries can power residential systems should one fail.

Figure 3.2.4 Our water and waste processing systems minimize unreclaimable waste.



3.2.4 Water and Waste Management

A single system aboard Aynah accommodates both water and waste management. These systems occupy six spaces throughout Aynah for redundancy. Water and waste systems go below the floor at 0.7g; basic management systems, in case of emergencies, exist below the floor at 1g and 0.8g. All solid or semi-solid waste enters a chamber filled with anaerobic archaebacteria. The waste undergoes

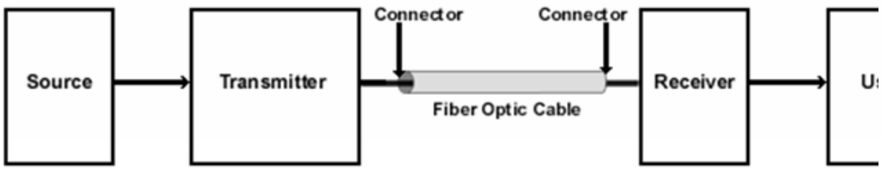


Table 3.2.5 Fiber-optic five you instantaneous connectivity for a multitude of uses.

mesophilic digestion for around two weeks, releasing methane as a by-product. After coming out of mesophilic digestion, the sludge moves through a de-watering process using belt filter presses, which creates a liquid waste that flows to a liquid processing stage and a drier solid waste that continues its journey towards cleanliness. After the de-watering, the more solid waste sits under a heater for a week in order to kill any remaining harmful bacteria and to reduce odor. Now a mix of fiber and minerals,the waste flows directly to the aeroponics system. At any time 9 million gallons of water run in this cycle. An extra 9 million gallons are always on hold, in case of system failure. We have designed all durable goods and construction waste to be 96% repurposeabl. We bury the meager mount of non-recyclable materials in defunct Mercury mine shafts. Northdonning Heedwell allots every person 190 gallons per day, which includes the growing of their food, personal hygiene, and consumption.

Device	Bandwidth	Quantity
OPIC	250 Tbps	14200
Dragen Transmitters	7 GBps	4735

Table 3.2.4 High-speed communication systems accommodate all communication needs.

The liquid waste flows through a series of filters for larger organic particles before it mixes with household water waste and is directed into an evaporation chamber. The evaporation chamber heats slowly until the water evaporates, and leaves a coating of urea, sodium, chloride, and potassium crystals lining the bottom of the chamber, ammonia gas in the open airspace of the chamber, and purified water in a separate containment unit. This purified water travels through a pH balancer, which consists of calcium carbonate, and then toward a mineral restoration chamber, in which the chloride, sodium, and potassium crystals extracted from the evaporation chamber earlier in the process re-enter the water in controlled amounts to make it drinkable by humans. The water then returns to community as purified water.

The gaseous ammonia and crystallized urea go to the agricultural areas as a fertilizer within the aeroponics chambers.

Fifteen tanks capable of handling two tons of waste compose the majority of the waste system, along with heated dryers that circulate air and work with the equivalent of two tons of waste per day.

3.2.5 Internal and External Communication

A system of fiber optics and wireless media allows for internal communication within Aynah, and wireless nodes that connect to each Dragen (part of the voice-automated guidance system) and to the OPIC (see 5.3.6) accomplish person-to-person communication. A fiber optic network modeling Earth's computer communication system constitutes Aynah's communication system. Modified laser modulators establish external communications. To communicate over the large expanses of space, radio waves are used. Radio waves are superior to laser pulses because of the ease with which lasers are disrupted.

3.2.6 Internal Transportation Routes

Aynah's internal transportation system consists of man-powered monorails called Dragens. These clear pods can contain up to five people, arranged in a single row. Wide turns reduce the risk of residents experiencing the Coriolis Effect. In order to help residents unable to propel their own vehicles Aynah has

	Quantity	Dimensions LxWxH (m)	Max Speed	Max Occupancy	Location
Dragen	4.735	4 x 0.6 x 1.5 to 10 x 0.6 x 1.5	70 kph	5	Residential Torus
Commuter Pods	6	16 x 5 x 6	378 kph	72	Interface
Bikes	1,600	1.8 x 8	24 kph	1	Residential Torus

Table 3.2.5 A simple but effective transport system facilitates travel to any location.

made small motors available for assistance. Dragens can travel at speeds up to 70kph. The Dragens are superior in efficiency and convenience to traditional Earth vehicles. They are an opportunity for fun and exercise in the daily lives of Aynah's residents.

Guidance and voice automated control systems mitigate user error and maximize convenience for the rider. Upon the front and rear of each Dragen is a shock absorbing pad that absorbs the energy and slowly releases it, causing a slow deceleration if two Dragens collide. At each intersection, the guidance system chooses the correct path according to the automated passenger commanded, or emergency button ordered, destination. At each residential stop, an elevator transports the Dragens throughout living areas.

With an eye toward ease of transportation, no resident will have to walk more than 500m to hop in a Dragen; each station is only 1km from the next. In mind of cardiovascular health, we also provide walking trails throughout the entire settlement, which allows one to

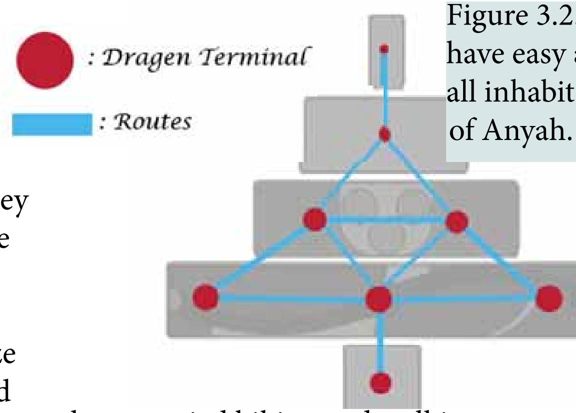


Figure 3.2.6 Citizens have easy access to all inhabitable levels of Anyah.

have myriad biking and walking opportunities (see 4.1.1). The Dragen terminals automatically store a total of 4,735 Dragens when not in use and retrieve them when a person wants to go somewhere. The automatic storage reduces required infrastructure and the time it takes to get a Dragen.

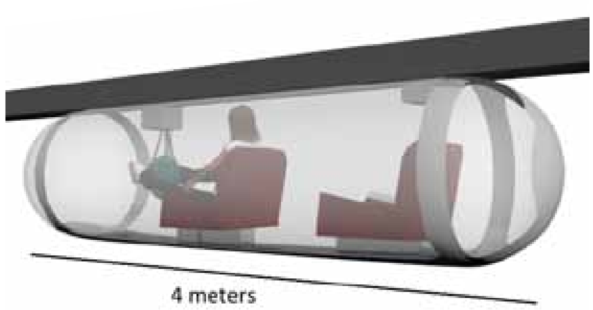


Figure 3.2.7 Dragens provide citizens with comfortable transport along with exercise.

3.2.7 Day and Night Cycle Provisions

An automated computer algorithm operates all the day and night cycles aboard Aynah. The day portion of the cycle includes OLED flexible panels lining the ceilings of the torus levels(see 4.1.6). These panels provide both illumination and a calming Earth-like sky environment. Each of the four seasons has a different database of cloud patterns, which run through a randomizing algorithm at the beginning of each month, determining the simulated weather display for each day in no specific pattern. These cloud patterns become illuminated on the OLED screens. The sunrise and sunset become different each day depending on the prevalent cloud conditions, but there is always a change of coloring in both the morning and afternoon. At night, the OLED's become transparent, leaving residents with splendid views of Mercury and open space. An algebraic equation also determines times for sunrise and sunset by modulating daylight lengths between 9.5 and 14.5 hours of sunlight throughout each Earth year, similar to the daylight fluctuation in the southwestern United States, to meet vital circadian rhythms.

Figure 3.2.8 Providing a sky rather than stars during the day promotes an Earth-like feeling.

3.3 Construction Machinery

Every aspect of our construction equipment capitalizes on not only efficiency, but also adaptability in the strenuous space environment. Contour-crafters allow for rapid building, providing the fastest construction process possible.

To provide radiation protection and power, Northdonning Heedwell constructs the manufacturing core first using machinery sent from Earth, Luna, and Mars using the matriarch (see 2.3). The construction of the operations ring follows, along with the construction of our residential torus (see 2.1). After being cured on Mercury's surface the components move via Percheron to our orbital construction site; the Settlement Construction Robot (SCR) stores these materials. Percheron vehicles transport ore and components between Aynah and the surface of Mercury. When constructing Aynah, we use reardonium beams for the major load-bearing structures; the SCR places these as it spirals across the construction location. It then lays the hull, and Asters and Poppies for initial power. The residential torus has more radiation protection than the hull of the operations ring (see 2.1.2). For the interior construction of the residential torus, Northdonning Heedwell uses 3-D printers called contour-crafters that can print any structure up to 50m using a variety of cheap and safe materials, including silicates on Mercury's surface and bamboo pulp grown in Aynah. Contour-crafters can print up to three buildings in an Earth-day (varying with complexity and height). Contour-crafters offer the best, most cost-effective method of interior construction. The buildings and structures do not lose any structural integrity in this method even though it is significantly faster than an average building crew.

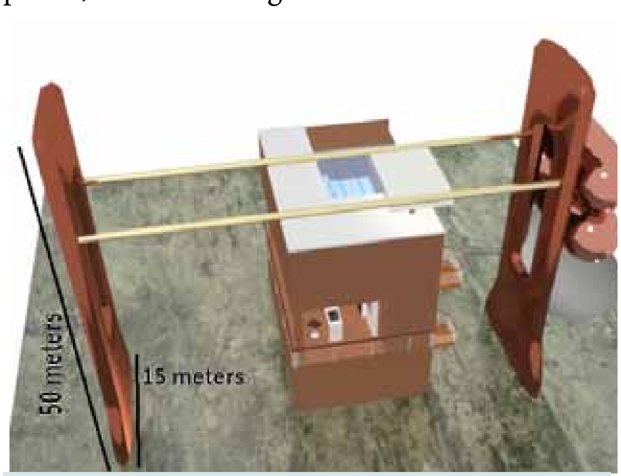


Figure 3.3.1 Contour-crafters allow Northdonning Heedwell to construct all interior objects with ease and efficiency.

3.4 Solar Power Systems

Large arrays of solar panels on solar power satellites charge Isentropic Gravel batteries to provide a reliable source of energy for refining and manufacturing. Powering refining and manufacturing with a separate system from residential power reduces risk of power interruption.

We surpass the power capabilities of solar panels using multijunction cells, which can use a broader range of wavelengths than just the visible spectrum. In addition, they focus the sunlight to increase efficiency. In 2007, multijunction cells overcame the theoretical 37% efficiency maximum, and have continued to progress since then to become 52% efficient- 3 times as efficient as traditional solar panels. Because of this innovation, we only require 1.33 square miles of solar panel surface area to power manufacturing. However, we build five solar power satellites each with 0.35 square miles of multijunction panels to ensure the full power production continues during satellite maintenance or in case one satellite were to malfunction. As with all settlement power, Isentropic Gravel batteries (see 3.2.3) charged through microwave transfer of the collected solar energy power manufacturing. Our solar power satellites produce 17,750,000kWh per day. As emergency backup, we rely on our nuclear generators repurposed from our Settlement Construction Robots (see 5.1.1). Asters and Poppies located on Aynah provide all residential power. (see Figure 2.1.6)

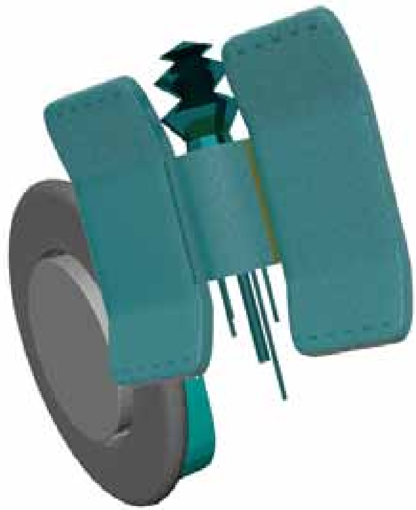


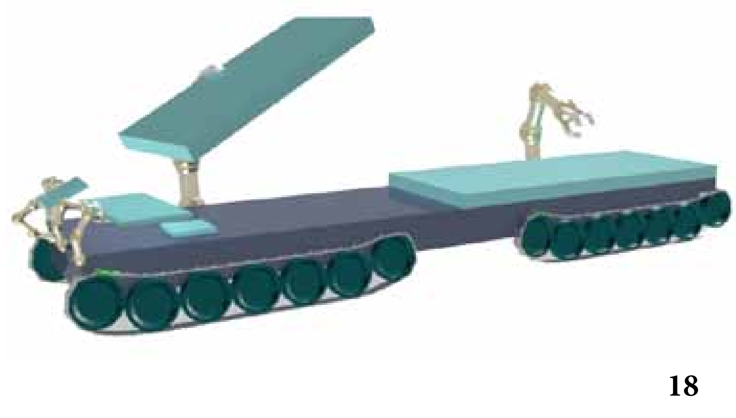
Figure 3.4.1Multijunction solar power satellites decrease the materials necessary to power reardonium manufacturing .

3.5 Reardonium Curing Vehicle

Aynah wisely uses the turn of Mercury with resources we have to create products that demonstrate ideal traits of reardonium.

Careful curing allows for the achievement of reardonium's unique characteristics. All reardonium curing starts at the docking port that lies in the light at the time of a given part's final manufacturing. Parts are placed on the Large Scale Curing Robot (LSCR) and the Small Curing and Transport Robot (SCTR) (see 5.5.1). To reduce infrastructure, parts are transported on the LSCR's and SCTRs. Parts move from ports in order to either remain in the sun-side of Mercury or the dark side depending on the part. The variation of sun-side and dark-side cycles enables Aynah to produce reardonium products with an incredibly wide variety of qualities acquired through these variations of cycles. No matter what the part, each cures for 12 cycles, totaling to one full Earth-year. Sensors searching for impurities, correct temperatures, pressures and radiation levels monitor the entirety of these processes (see Appendix A).

Figure 3.5.1 The Large Scale Curing Robot transports components along Mercury's surface for an even cure.



4.0 Human Factors

4.0 Human Factors

Northdonning Heedwell capitalizes on safety and comfort for all Aynah personnel through our innovative adaptation of the Eixample, Barcelona street layout and advancement of accurate health monitoring systems. Residents luxuriate in the diverse and tranquil environment of public parks and abundant natural foliage that flows throughout our residential torus. For a more dynamic working and playing experience, our Virtual Immersion Block provides every resident with unparalleled entertainment and offers vast opportunities for educational and professional growth. Our diverse housing selection is stylish and comfortable. Northdonning Heedwell's chief concern is the safety of every resident: our customizable space suits maximum security in Aynah's tranquil environment as well as the incredibly hostile area surrounding our settlement. Fitness and child education in 1g volumes assures full, sustained bone and muscle growth for the entire population of Aynah. Northdonning Heedwell also provides an innovative vehicle for human inspection of reardonium, and emphasizes safety and comfort while still focusing on efficiency for each human-occupied vehicle.

4.1 Community Layout

Throughout the design process, Northdonning Heedwell has engineered Aynah's community layout to minimize the discomfort of the Coriolis Effect and encourage social interaction as well as privacy for our residents. We pride ourselves on the flexibility and diversity of our communities, comfortable living areas, and system redundancy.

4.1.1 Diamond Grid Pattern

Deriving our community layout from the 1855 conceptual Eixample street design, Northdonning Heedwell incorporates straight diagonal crossroads into a basic diamond-grid pattern. Allotting 4% of down area to paths, we also integrate foliage and diverse plant life into the daily life on Aynah. Along with benefits of greenery, our community design provides fast and easy access to all commercial and residential areas.

4.1.2 Medical

Ten doctors' offices and one hospital offer medical services to the entire population. A combination of doctors, nurses, and automated services provide care to the residents.

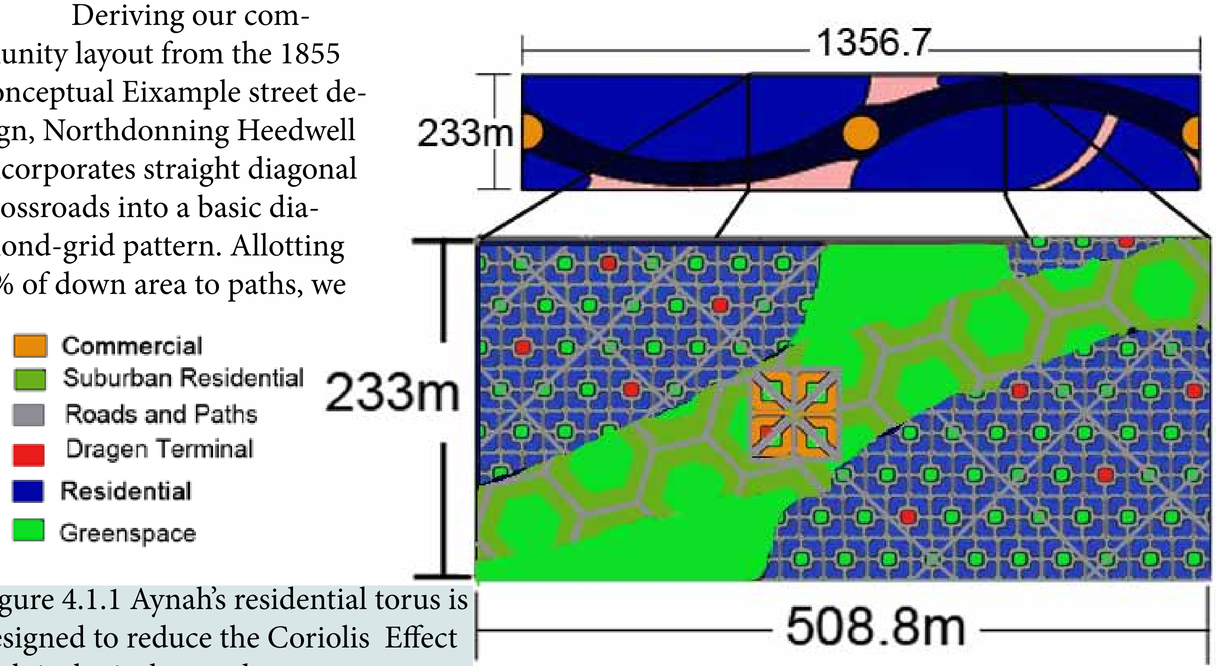


Figure 4.1.1 Aynah's residential torus is designed to reduce the Coriolis Effect with its logical street layout.

Our medical robotic system increases precision in surgical procedures, enabling faster recovery times, while human doctors give the personal feeling necessary during times of ill health. To eradicate all foreign disease, Northdonning Heedwell requires a short-term quarantine for visitors before we permit them to fully integrate into the community on Aynah. Health screening takes place prior to departure from other settlements, but our quarantine ensures safety. The quarantine takes place in the 0.6g residential spokes.

Unlike other methods of health monitoring, Northdonning Heedwell's use of noninvasive monitoring systems, such as saliva sampling, allows Aynah to oversee the health of its residents while reducing the impact that health care has on resident's day-to-day lives. To provide current medical information, all saliva sampling data is wirelessly synced with each individual's OPIC (see 5.3.6) to ensure proper, accurate health alerts and instant feedback from medical staff. Every morning we request that residents use a toothpick-like metal stick to collect saliva and insert it into their saliva assessment system. Saliva samples allow easy monitoring of the residents' health.

Figure 4.1.2 Our VIB personalizes and advances visual entertainment and education, while using fewer resources than modern methods.

4.1.3 Consumables

To reduce the risk of infections spreading through grocery store settings, residents use their OPICs to order food from a digital inventory in a convenient fashion. Pneumatic pipelines then deliver the food directly to each household. The purchase and delivery of non-food items occurs in the same way or through traditional, community-based stores; this system promotes a feeling of community and social interaction between residents.

Item Category	Product Available/Day/Item	Replacement Frequency
Hygiene	5,000	Every Week
Food	42,600 meals	3 per day
Appliances/Technology	1000	Every 3 months
Clothing	3000	Every 6 months
Medicine	750	Every 2 months
Personal Upkeep	250	Every 2 months
Luxury	600	Optional

Table 4.1.1 Each and every consumable material is accurately calculated to sustain a healthy population on Aynah.

4.1.4 Entertainment

Coming from the leading edge in visual technologies, the Virtual Immersion Block or VIB immerses users in a 3D environment that provides endless possibilities for optimal entertainment and educational purposes for all ages. Six high-definition screens create a room that responds to the main user's every move. As the user, connected to the ceiling by means of a retractable cord, travels through the space, the cord tightens when a user nears a screen. Due to lesser gravity on the settlement, users can articulate movements that full Earth gravity would render impossible; this presents a unique and exhilarating experience and offers a fun opportunity for vital exercise. The VIB provides residents with thousands of options for entertainment, exercise, and education with one small space instead of many large, costly activity centers.

4.1.5 Recreation and Parks/Public Areas

Gymnasiums and weight rooms supply the population with hundreds of fun, healthy activities. Exercise rooms equipped with electrochromatic glass give users the option to electronically change the outer enclosure's opacity. This provides the users with a choice of views of the surrounding community and nature or a more private exercise area. Users may check smaller equipment out from the central desk clerk, and personnel help in retrieving larger equipment stored below gyms. We utilize largely spaced foliage clusters to support long lines of sight. This method of spacing replicates Earth tendencies in plant diversity and plant grouping. Furthermore, wide avenues and square blocks with chamfered corners compose our street layout in an Eixample style. This layout gives long lines of sight even in urban settings. For rural settings, Northdonning Heedwell integrates parks and public areas like ribbons throughout the residential torus.

Housing Style	Quantity	Residences
Communal Ring	208	1,664
Spacious Open-air	107	428
Octagonal	536	4,288
Expansive Multilevel	5,467	5,467

Table 4.2.1 Various housing styles give each individual an increased amount of choice and expression at our settlement.

4.1.6 Natural Sunlight/Views of Mercury

Organic Light Emitting Diodes or OLEDs are our gateway to providing natural views of Mercury. An OLED is a light-emitting diode with a film of organic compounds in an electroluminescent layer. Two electrodes surround this layer of organic semiconductors. The OLEDs can use either a passive-matrix or active-matrix addressing schemes. In our system of design for Aynah, both sides of these panels are able to change from translucent to transparent on demand. This configuration allows residents to gaze at the open sky during the night and experience normal Earth weather patterns during the day when the OLEDs are active.

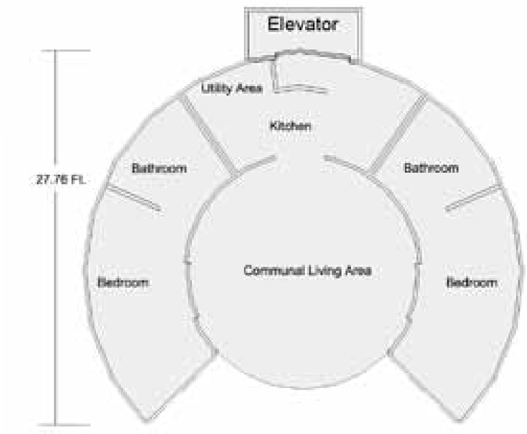
4.2 Housing Designs

Northdonning Heedwell designed Aynah's residential housing to accommodate a plethora of lifestyles, maximizing versatility and privacy, while creating warm, inviting living spaces that people are happy to call home. All houses come equipped with electrochromatic glass that provides privacy in all necessary spaces, while also creating surfaces that can function as electronic displays for a variety of purposes. Each style of house includes privatized green spaces that create an open natural feeling to each residence, which often becomes lost in an enclosed environment such as a space settlement. Aynah's housing selection compliments the diverse lifestyles of our settlement's residents to accommodate any living arrangement. To comply with a lower amount of gravity, we produce our housing with heightened ceilings for maximum comfort.

Furniture

Northdonning Heedwell produces furniture by contour-crafting a frame of bamboo. Next, biofiberous materials surround the frame to support a sturdy shape. For comfortable cushions, we genetically modify sponge material to grow at the desired density for the perfect cushion and then we line the sponge with the same biofiberous material. With robotic assembly and manufacturing for our appliances, Northdonning Heedwell ensures precision and satisfaction in all housing materials

Figure 4.2.1 Communal Ring Housing creates an economical and comfortable living area.



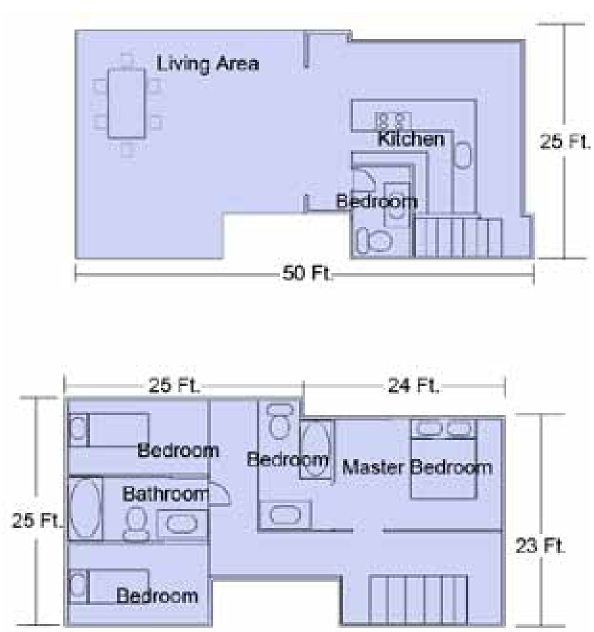
Communal Ring Apartments

With 2,000 square feet of total living area per double-occupancy level, the communal ring apartments provide isolated living areas with shared amenities. Separate living quarters create an efficient and low-cost residence. An open circular living area provides residents a versatile outdoor living area, with a relaxing natural atmosphere. This housing design is for singles looking for an economically priced, youthful residence. Although this style of housing is circular, the flowing layout of the residence, and the linear orientation of the exterior elements reduces the Coriolis Effect.

Spacious Open-air Housing

Our largest house, with 2,116 square feet of living area, the spacious open-air housing offers residents with larger living groups a two-story home that features a spacious flowing layout, designed to unify the indoors and outdoors. Two stories and three different rooms make this house perfect for families or larger living groups. To provide a versatile living area, sliding doors along the outer wall of the upper story of each residence open up to create a flowing feel between interior and exterior spaces.

Figure 4.2.2 Spacious Open-air housing incorporates spacious flow between interior and exterior areas.



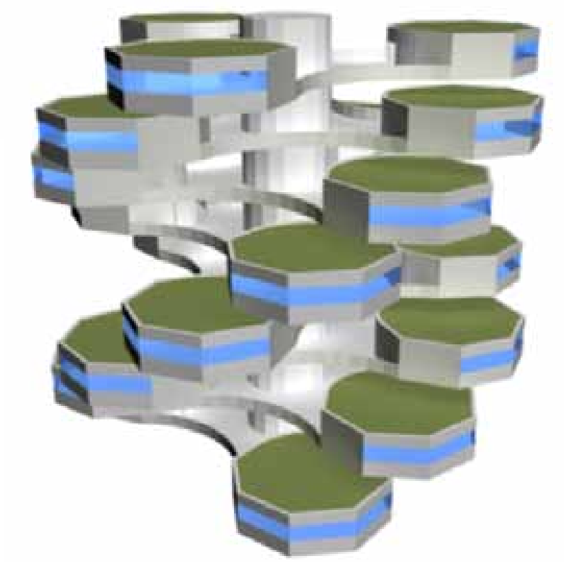


Figure 4.2.3 Octagonal Housing expresses Aynah's youth in multiple ways including open space, communal green space, and minimalist walls.

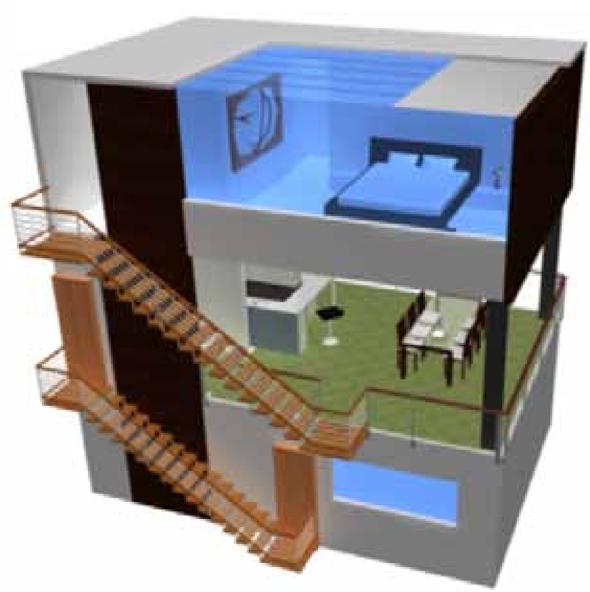
Octagonal Apartments

Each octagonal apartment features an open, flowing design and communal green space. The octagonal design of the apartment provides the resident with panoramic views, while minimizing the Coriolis Effect with its long straight edges. This housing design contains 1,500 square feet of living area, designed to reduce the amount of necessary turning and rotation. A lack of weather on the settlement allows this house to feature large open areas. By minimizing walls, this house gives the impression of having a greater square footage. Electrochromatic glass allows residents to vary the amount of privacy throughout the house.

Expansive Multilevel Housing

Optimized for youthful couples, we designed this 1,800 square foot residence with open living and dining areas to increase feelings of community. The removal of walls in the dining area features expansive views of Aynah as well as a feeling of increased area within the house.

Figure 4.2.4 Expansive Multilevel Housing is a dream design for married adults to incorporate individual as well as communal growth into their lives.



4.3 Safe Access

Northdonning Heedwell's redundant and diverse range of systems allows residents safe access to pressurized and unpressurized volumes of microgravity zones and allows the individual to flourish.

4.3.1 Donning and Doffing

Northdonning Heedwell implements various safety devices for humans operating in the interior and exterior of the settlement. Every airlock stores spacesuits on the wall of a sealed-off region on the back of the airlock. Each user must enter the Extended Mission Suit (EMS) via a rear mounting system. Every EMS attaches to the wall, and the rear of the suit has the donning and doffing apparatus already attached. The user simply climbs into the rear of the suit and an automated system activates the sealing and locking of the suit following the attachment of the life support pack. Personnel then pass through the airlock and exit into the external regions of the settlement. Upon exit a tether attaches to the rear of the spacesuit, and operates independently, automatically retracting and extending to provide efficient movement of the spacesuit. Many microgravity areas necessitating human interaction contain handholds or caged walkways ensure safety.

Figure 4.3.1 Pods provide safe, comfortable access outside habitable areas.

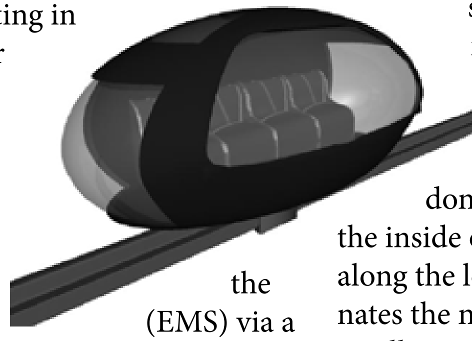


Figure 4.3.2 Our airlocks ensure safety for personnel operating in different pressurization volumes.

4.3.2 Spacesuit Designs

Safety of personnel and residents is Northdonning Heedwell's chief concern. This is why we put safety first in the design of our spacesuits. We offer two types of spacesuits to accommodate various situations on the settlement. The first spacesuit is the Extended Mission Suit (EMS). Northdonning Heedwell purposely designs the EMS for missions lasting up to 10 hours for Aynah personnel. Several layers of Gortex, Nomex, and Kevlar comprise the outer shell to provide maximum flexibility and strength. To protect the suit from radiation, we then apply a flexible reardonium coating. We produce this flexible reardonium coating through weaving threads of reardonium in a cross section pattern. Along the inside of the suit are "pockets" of air placed along the lower torso of the suit. This eliminates the need for an external oxygen pack. A small, nitrogen-propelled pack attaches to the back of the suit. Personnel or residents control the pack by using a joystick. Inside the suit is a series of tubes that contain water to cool or warm the occupant. Temperature change activates via vocal commands using the Heads Up Display or HUD. The suit also includes basic necessities such as a waste absorption sack, CO_2 scrubbers, anti-fog lens, emergency air supply, water distribution tube, and the integrated helmet communications system. The Short Mission/ Recreation Suit (SMRS). This spacesuit has all the features of the EMS, except the hard

Figure 4.3.3 The SMRS is the definition of comfort and manueverability.

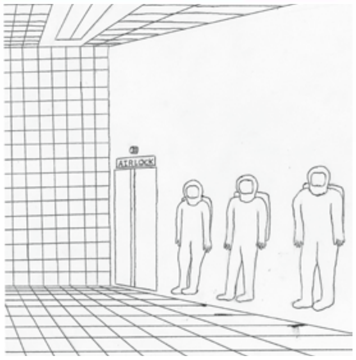


Figure 4.3.4 Spacesuits are stored conveniently close to donning and doffing areas.

torso, and is more form fitting and flexible. Mission time is approximately two hours.

4.3.3 Spacesuit Storage

When stowing an EMS, the wearer locks into his/her individual suitport and exits through the rear of the suit. After stowage, each suit is covered by a retractable panel which protects them from radiation, dust, and accidental impact. When stowing an SMRS, the wearer enters a standard-sized airlock (2m by 1.5m by 4m high). Once through the process of the airlock, they stow the suit in a designated stowage area. The standard airlock for humans consists of one pressurized chamber where two EMS wearers can enter. In the multiple person airlock four SMRS wearers can enter at one time, reducing the number of times the airlock has to be pressurized and depressurized. Inside the airlock are handrails and lights to allow for an easier entering and exiting procedure. In case of an outer door failure, a second door will automatically seal off the airlock.

4.3.4 Additional Saftey Features

When outside of artificial gravity areas, a pod system runs on rails to ensure personnel safe transportation (see Figure 4.3.1). While these pods are pressurized for safety, personnel are required to wear the EMS as a further safety measure. Handrails located along the rails allow personnel to exit the pod and move about to perform maintenance or inspection tasks.

4.4 Full Gravity Accommodations for Children

We, Northdonning Heedwell, sustain proper and beneficial methods of building and sustaining bone mass for all residents, especially children. Also, we provide myriad entertainment and enrichment opportunities in a 1g environment.

To ensure proper development, children under 18 must spend three hours per day in full gravity, though we also advocate for everyone under 25 to spend time at this level. Education takes place in 1g, meeting the requirement on weekdays. During weekends and holidays, children delight in spending time in full gravity sports areas, parks and playgrounds. Arcades, study areas and lounges diversify activities to ensure all ages enjoy their time. Running trails, leisure sports, and adult fitness centers encourage the 18 to 25 age group to visit the EGRs (see 2.1.1) for healthy growth. Through these many options, Northdonning Heedwell ensures that each resident has an enjoyable opportunity to experience full gravity.

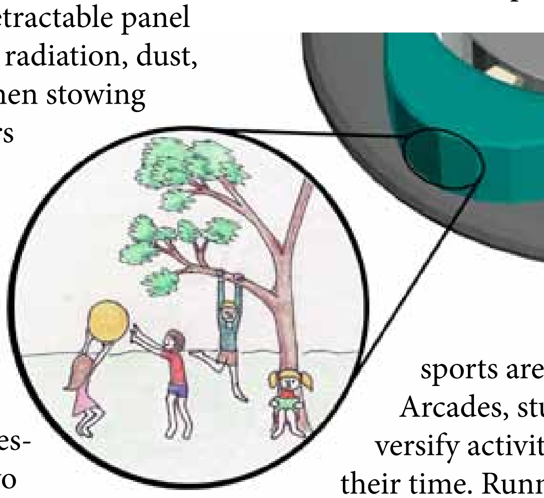


Figure 4.4.1 Fun and stimulating 1g areas give individuals room to sustain bone and muscle mass.

4.5 Human Monitoring of the Curing Process

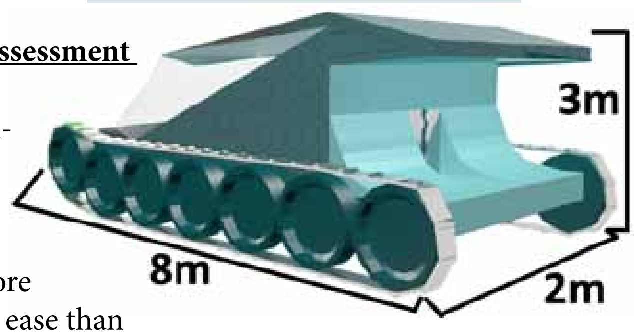
Northdonning Heedwell provides an innovative vehicle for human inspection of reardonium and emphasizes safety and comfort while still focusing on efficiency for each human-occupied vehicle.

4.5.1 Day Curing Assessment Vehicle

Our DCAV uses a 250-horsepower equivalent motor (368.25 kWh) for propulsion. 1225 square feet of solar collectors simultaneously propel a vehicle and charge its solid-state batteries. This type of propulsion provides clean, renewable, and reliable energy all the time since the (DCAV) will always be on the sun side of Mercury's surface.

Reardonium, powdered titanium dioxide to absorb radiation, and high-density polyethylene comprise the hull of our vehicles; our DCAV includes an inflatable sun shield that provides enough shade for extravehicular activity.

Figure 4.5.1 Our vehicles utilize safety measures to overcome the harsh environment of Mercury.



4.5.2 Night Curing Assessment Vehicle

Electricity coming from our charged solid-state batteries propels the NCAVs. Solid-state batteries store electricity with greater ease than other kinds of batteries. Because DCAV solar collectors produce more energy than they use, each DCAV charges extra solid-state batteries and drops them off at one of the four main ports, for the NCAVs to pick up and refresh their electricity stores.

4.5.3 Safety and Climate Control

The vehicles use super-cooled Freon tubes (see 5.3.1) and circulation fans inside to provide climate control. When heating is necessary, the circulating air bypasses the Freon tubes and moves onto an electric heating element. Carbon and oxygen filters maintain atmospheric composition.Vehicles contain sleeping quarters, food, and a sufficient amount of atmosphere comes stored to support four passengers for 10 days.

Tethers, handles, and high ceilings provide comfortable maneuvering options. We have standard radio communications in all assessment vehicles.

4.5.4 Dust mitigation

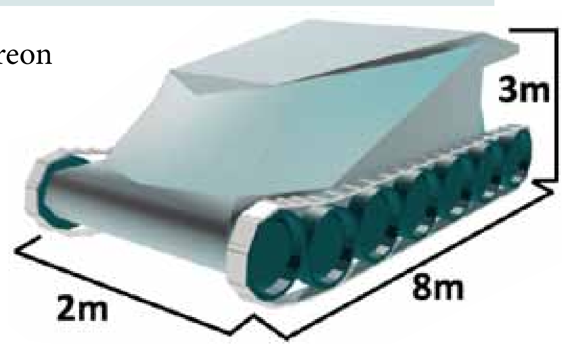
Both vehicles have full spacesuit docking to control dust intake, similar to that on Aynah (4.3.3). To minimize an accident in atmospheric contamination, we have an additional airlock into the operational area of the vehicle.

The tracks are made of reardonium plates providing protection against radiation and dust. Coats of liquid glass cover the hulls of both vehicles to aid in dust mitigation. Electrostatic materials line the interior of the reardonium to attract dust onto the liquid glass surface and repel the dust. During stowage, an electromagnetic wand sweeps the vehicle, capturing all the dust onto the wand.

4.5.5 Emergency Procedures

A radioisotope thermoelectric generator (RTG) powers every vehicle in case battery power runs out. In the case of a solar flare, the electric motor shuts off and the extra battery power directs the current to two copper poles at opposite ends of the vehicle, which provides an electromagnetic shield.

Figure 4.5.2 The NCAV's reardonium hull protects inspection personnel from the extreme cold of Mercury's night.



5.0 Automation Design and Services

5.0 Automation Design and Services

Mercury offers many innovative and untapped resources. To capitalize on these abundant resources, the Alliance Automation Division of Northdonning Heedwell employs a wide variety of automations to insure predictability, reliability, and reusability. We place supreme confidence in our automations: we put them to the test every day to ensure that they are running at maximum efficiency. Northdonning Heedwell equips all of our automated systems with a diverse array of programs to ensure minimum human intervention for surface operations, thereby decreasing the time your personnel have to spend in the harsh Mercury environment. We redundantly back up all systems and programs in not only power but also computing, and all systems have adaptability for any purposes. While our systems focus on forming reardonium parts, we focus as much, if not more, on the safety of the settlement, thereby ensuring maximum comfort for each resident.

Automations Standards

All robotic systems derive their power from solar collectors located on the robotic mainframes, and electric energy is stored in solid-state lithium carbon batteries. Robotic platforms working within the interior of the settlement are equipped with the lithium carbon batteries, which are regularly recharged. Power redundancy is accomplished using smaller lithium carbon batteries with enough potential to provide power for several hours. The intense heat surrounding the Mercury environment is harvested and converted into electrical energy with alkali thermoelectric converters.

To limit overheating of robotic platforms, Northdonning Heedwell utilizes woven Freon cooling lattices. The Freon circulates through the cooling lattices embedded in the robotic systems to provide a lower temperature for more practical robotic operations and ensures reliable operation. These lattices cool robots by radiating heat.

5.1 Automation for Construction

Northdonning Heedwell's Alliance Automation Division re-imagines orbital construction with our revolutionary Settlement Construction Robot. Our automated processes provide for a more efficient construction of the settlement and thus save time. Our state-of-the-art utilization of the assembly line process and systematic transportation of materials on Aynah results in a timely construction sequence.

5.1.1 Construction

We apply a variety of automations to create a novel yet safe method for the construction of Aynah. Beginning from the manufacturing core, Settlement Construction Robots (SCRs) construct the skeleton, inner hull, and exterior hull all in one pass. With the ability to produce items of varying radii the SCR can assemble these items in a circular form enabling precise torus construction. The double-bayed interior of SCR consists of a series of robotic arms equipped with tools to

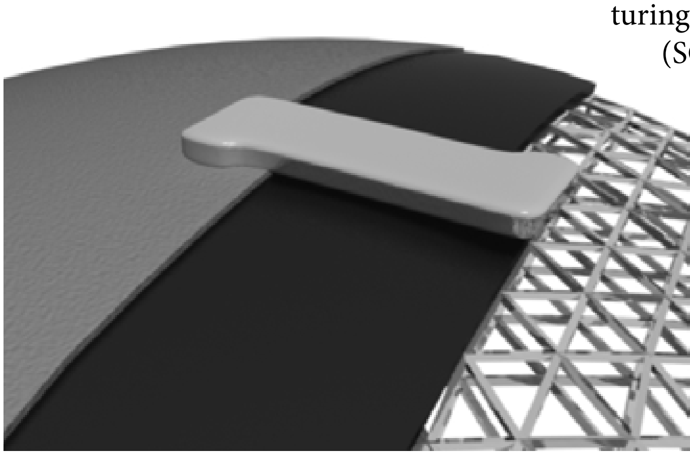


Figure 5.1.1 SCRs have revolutionized Aynah's construction process.

weld and secure pieces of the hull in place. SCR's have storage compartments located on the top side of the robot, allocated for manufactured items built in the settlement. Using an assembly line system, each of the 100 robotic arms only do one specific job until the settlement is complete. In the first line of the SCRs, robotic arms lay down the skeletal framework for the hull. They also lay inner hull layers. These layers include insulation and radiation protection. The second assembly line lays tiles of reardonium on the exterior of the hull. By laying the entire hull in one pass with SCRs, there are few margins for error, and it greatly expedites the construction process. The SCR lays all hull components at the same time allowing for rapid construction. The SCR greatly reduces cost compared to former robotic construction methods that use many robots, which cost more to repair, maintain, and power.

5.1.2 Transportation during Construction

We employ a cost-effective system of materials transport during the construction process. The SCR places a rail system in with the rest of the hull. The SCR has an electromagnetic system, located in its center that clamps around the underside of the rails. Crates with the same electromagnetic system move along the rails providing materials to the SCRs. Northdonning Heedwell uses a Percheron to ship materials from Mercury to Aynah.

Table 5.1.1 The robots operating on Aynah and Mercury minimize mecessary human interference as to keep our residents safe.

Robot System	Uses	Dimensions	Amount
SCR (Settlement Construction Robot)	Constructs the exterior, and interior floors of Aynnah	200m x 300m x 50m	3
MRS (Multifunctional Robotic Sphere)	Maintenance, minor interior finishing,	0.5m x 0.5m x 0.5m (sphere)	450
ORC (Ore Refining Container)	Move Ore through manufacturing	Length of 0g core area out to .5 gravity	1
LSCR (Large Scale Curing Robot)	Automates reardonium curing process for large parts	10m x 35m x 100m	25
SCTR (Small-scale Curing and Transport Robot)	Automates reardonium curing process for small parts	10m x 30m x 50m	25
FER (Filth Elimination Robot)	Cleaning	5cm x 20cm x 20cm	750
OPIC (Optical Personal Interface for Computing)	Personal Computing	0.3m x 0.3m x .03m	14,000
Computing Pod	Computing area	3m x 3m x 4m	5000

5.1.3 Housing Construction

Northdonning Heedwell provides a housing construction system that is easily compatible with the variety of designs provided. Interior finishing of Aynah works in two steps. The SCR has a removable outer layer, in order to build the floors and other interior configuration. It builds in the same manner as before only it constructs in smaller spirals. Once the SCR finishes laying all the floors, we deploy the contour crafters. These swiftly construct all buildings in Aynah; building layer-by-layer, contour crafters adapt to any building designs.

When the residents arrive, they can style the inside of their new homes by inputting a set of commands into their Optical Personal Interface for Computing (OPIC). From the OPIC, the commands are sent to the Multifunctional Robotic Spheres or MRSs via radio wave, allowing for ease of communication between robotics and humans.

MRSs also finish the inside of office and other commercial and public buildings, ensuring buildings are ready for residents.

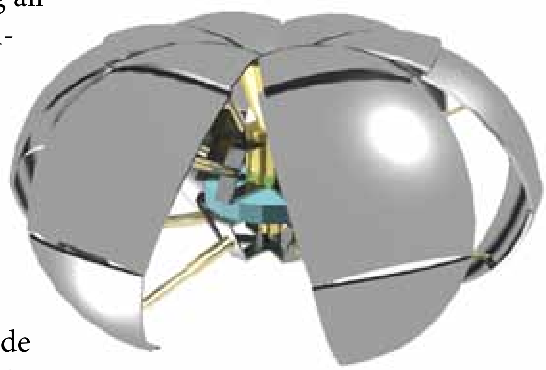


Figure 5.1.2 Our Multifunctional Robotic Sphere and its many attachments perform most routine tasks on Aynah.

Figure 5.1.3 Contour crafters utilize a diverse set of materials to create all buildings on Aynah.

5.2 Settlement Mainenance, Repair, and Safety

Once Aynah is operational, we deploy a wide variety of automations for maintenance and repair on the interior and exterior of the settlement. With our range of robotics, Northdonning Heedwell is confident our robotic systems ensure the safety and protection of residents on Aynah through redundancy and diversity.

5.2.1 Maintenance and Repair

Northdonning Heedwell proudly applies a variety of systems that neutralize all maintenance and repair problems including everyday maintenance tasks, logistical problems, and settlement cleaning. Spherical robots equipped with multiple arms, each with a different tool or function, perform maintenance tasks. Different shells, which fit on the exterior of the Multifunctional Robotic Sphere (MRS), accomplish a multitude of different tasks through variable programming. The MRS's can be quickly and easily re-purposed by a software update, as well as the addition of different appendages. To perform tasks our MRS's utilize their pre-programmed software, instructions sent by a controller, or their advanced Artificial Intelligence, or AI, capabilities to solve problems.

For repair and maintenance inside the water shield (see 2.5), we have a fleet of adapted MRSs with flagellum-like appendages to help them maneuver. These robots, equipped with turnbuckles and reardonium plates, section off damaged panels

Level of Security	Methods of security
1. Personal computers, workstations, home networking systems, housing robots, and maintenance robotics	Finger print scanners and finger vein mappers
2. Housing settlement operation systems and certain restricted areas	Finger scanning and vein-mapping technology, with voice recognition
3. Critical restricted areas, and the central robotic command center and mainframe computer	Facial vein mappers, body heat level readers, stress level readers, and DNA readers via saliva.

Table 5.2.1 At each level, we tighten security to ensure that critical data is safe.

of the hull to replace the hull panel without losing the water in the water shield (see 2.5).

Our solar power systems power all of our settlement (see 3.2.3, 3.4), and keeping them running at maximum productivity is a major concern. An array of sensors that monitor the output from each Aster, Poppy, and solar power satellite ensures that all systems are performing at maximum productivity. If one system develops an error, a repair robot replaces the damaged unit.

5.2.2 Safety

Aynah employs a set of contingency plans for unlikely system failures. In the event of a hull breach, MRSs rush to the scene of the breach and quickly swap the damaged reardonium tiles with new tiles. While we replace tiles, we lock down doors to seal off the area of the breach to prevent atmosphere loss in the rest of the settlement (see 2.1.4). We place all major computing systems, such as the Automations Command Center, in rooms reinforced with extra polyethylene and lead to ensure all communications and computations remain running and viable. Additionally, Northdonning Heedwell plans to take advantage of Aynah's location by researching solar flare detection techniques and thus continually developing advanced warning systems.

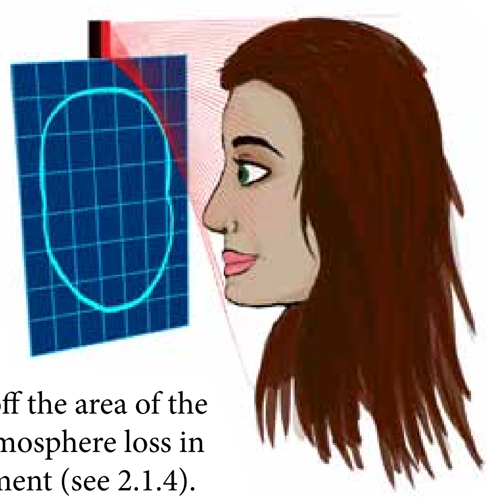


Figure 5.2.1 One of our devices involved in security is the Facial Vein Mapper, which is impossible to bypass.

5.2.3 Critical Access

Residents of Aynah can have full confidence in Northdonning Heedwell to ensure that only authorized personnel have access for authorized purposes. Upon arrival, every resident acquires a personal account on the Computational Analysis Network (CAN). Each resident has a predetermined level of access according to previous experience, professional qualifications, and certifications. We use finger print scanners and finger vein mappers to allow access to things such as personal computers, workstations, home networking systems, housing robots, and maintenance robotics. At the second level of security, we utilize the same finger scanning and vein-mapping technology, with voice recognition added on to compensate for the added critical systems and information. The second level of security allows personal to access housing settlement operation systems and certain restricted areas. The final level of security employs the previous technologies with added body heat level readers, stress level readers, facial vein mappers, and DNA readers via saliva. Both heat and stress level readers prevent forced entry.Facial vein mapping and DNA are impossible to replicate, making our security systems superior to other systems.

5.3 Automation for Enhanced Livability and Productivity

Aynah employs a wide variety of automation innovations to inform all residents of real time levels of metabolic productivity without inconveniencing them or impinging on individual liberties. A range of devices that provide an informative and intuitive interface with users attain this level of productivity.

Figure 5.3.1 The computing pod provides the most interactive workstation yet, helping workers be more productive.

5.3.1 Enhance Livability in the Community

To enhance livability within the community, our settlement includes easy and free personal transportation in the form of Dragens (see 3.2.6), as well as robotic cleaning of the settlement in the form of the FER (Filth Elimination Robot). The FERs are small cylindrical robots that have omni-functional capabilities including vacuuming, dusting, voice activation and direction, and pathogen sterilization. Since Aynah is a closed-loop environment, it is imperative that we monitor our residents' health on the settlement. Every morning before residents brush their teeth they place a toothpick-sized metal rod into their mouths and then place the reusable pick into a sensor system. The sensor system monitors residents' general health through a meticulous, multi-variable longitudinal interpretation of DNA and other metabolic indicators in saliva.

5.3.2 Enhance Productivity at Work

Computing devices that bond user and machine enhance productivity at work by providing an interface that is intuitive and informative. For private workstations, a pod that the worker enters provides an interactive environment through a projector suspended above the worker's head, projecting a display surrounding the worker. Multiple infrared depth sensors capture all of the user's movements so that the individual can use gestures to interface with the pod. The pod also interprets all voice commands and responds to the user using advanced AI. For mobile workers, the augmented reality display, a display mounted within a visor or in wraparound glasses, functions as a real world to computer interface. The display is transparent, yet the user can have the computer overlay information such as the correct route, spacesuit information, pressure and oxygen levels, monitoring information, and parts that are malfunctioning. All of these computing devices make it easier for workers to be more productive in their tasks.

5.3.3 Convenience in Residences, Maintenance and Routine Tasks

To enhance convenience and perform routine tasks in residences, we use an automated merchandise delivery system and automated cleaning devices in the form of cleaning robots.

A transfer system going to every residence delivers consumables, pre-cooked food, and any other items of importance. A host of cleaning devices such as an automated floor-cleansing robot, an automated dishwashing unit, and an automatic laundry-cleaning unit cleans residences.

5.3.4 Reduce Need for Manual Labor

Automating many processes such as self-healing electronics, product assembly, loading and unloading of shipments, and shipment delivery reduces the need for manual labor in the settlement. All product movement within Aynah is completely automated and performed by a subsystem of rails that transport goods to residences and businesses. All of these systems greatly reduce need for manual labor within the settlement.

5.3.5 Privacy of Personal Data and Systems in Private Spaces

Fingerprint and finger vein scanners provide privacy of systems in private spaces (see 5.2.3). This system is superior to any other, as it is fast, hard to compromise, and of trivial size.

5.3.6 Automation for Settlement Computing and Communications

Northdonning Heedwell provides each resident with state-of-the-art communication and data transfer systems to ensure that each resident has the full capacity for any communication needs. A 250-terabyte bandwidth provides the bandwidth necessary for each resident to maintain access to Earth- and Aynah-generated web pages at all times. Earth-based web pages are cached. However, residents who desire real-time communication with Earth may pay OrbitLink Communications to use their fiber-optic link on Aynah. Radio waves are the superior method of communication and data transfer for the settlement. Because Aynah is largely protected from radiation, a radio reception area on the exterior of the settlement to ensures all radio waves are accurately received and relayed to the computing center. The computing center provides all communication capabilities and collects all data. Located within the computing center is the Automations Command Center. The ACC is equipped with a supercomputer server that functions as the backbone for the control of all automated processes. The ACC provides the bridge between automated systems and human oversight, thus ensuring safety and maximum efficiency. Complex algorithms monitor every robot to detect any errors.

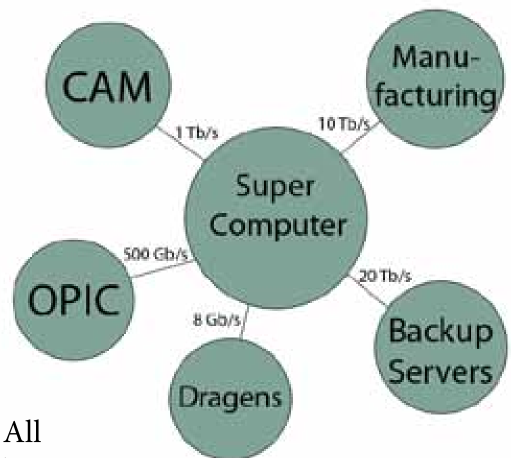


Figure 5.3.2 Aynah's computer network centralizes data storage and computing in the ACC to simplify data transfer.

The harsh environment in which Aynah is located brings about significant challenges for computing stability. Due to radiation, quantum-computing mainframes are simply not feasible. Our incredibly powerful supercomputer system uses both physical and logic-based radiation protection techniques. Instead of using traditional semiconductor wafers, we implement insulated, hardened chips composed of silicon oxide and sapphire. These chips operate safely and efficiently in environments that would otherwise result in ionized data loss. Magnetoresistive RAM also provides radiation-resistant memory in every aspect of the settlement. In addition to physical protection, all systems utilize logic protection methods. In the rare event that data becomes corrupted, we have redundant scrubbing processors that continually scan for corrupted or malfunctioning data. Multiple microprocessors replace corrupted data detected via the scrubbing process as well as run all the same calculations as main processors thus ensuring accuracy.

Our OPIC devices enhance productivity and communication within the settlement. The OPIC uses optical processing, which is faster and more powerful than conventional processing. Additionally, optical processing is more easily maintained and cheaper than quantum computing. OPIC also features a 3D holographic display mode in which the OPIC either projects a display on any solid object, or connects with the user's augmented reality display. The OPIC's processing core is located on flexible and foldable e-paper which creates an interface that can be used as an independent touch paper or as a keyboard and a mouse. These diverse factors work together to make the OPIC superior to any other computing option.

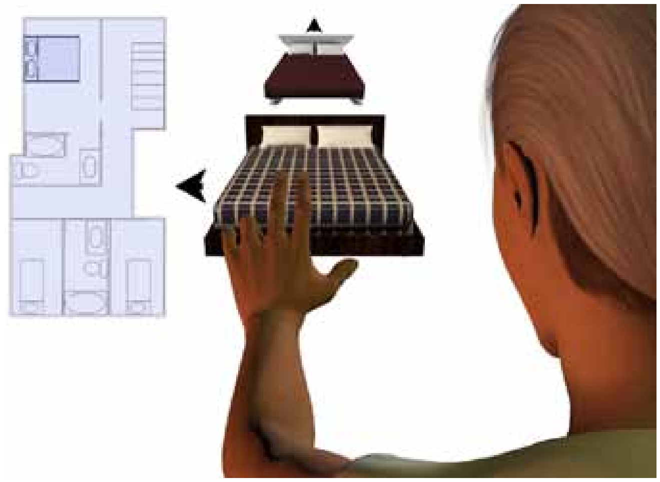


Figure 5.3.3 Residents have the ability to do anything and everything they need from their OPIC.

5.4 Reardonium Production

Our refining and manufacturing process combines state-of-the-art technology with safe and reliable equipment to provide a system that is powerful yet dependable. Dust mitigation, ore and dust containment, and renewable resources make this power and dependability possible, all while lowering cost and ensuring safety.

5.4.1 Unloading Raw Ore

Northdonning Heedwell employs a cargo delivery system that transfers raw ore from Mercury in the standard shipping containers into Ore Refining Containers, or ORCs. When ore arrives in shipping containers on the Percheron surface-settlement transport vehicle, the shipping containers form a metal-to-metal seal with polymeric actuating gel to prevent dust contamination in the docking area. A pneumatic piston pushes the ore out of the shipping container and directly into an ORC. ORCs travel along a rail system from storage to 0g refining and then through the structural interface and onward to the manufacturing core where ORCs interface with the integration chamber. We tag all cargo with a serial number identifying the cargo by type (ore, metal, formed metal or finished reardonium products), its destination, and where it has been. This enables efficient sorting and directing of cargo shipments.

5.4.2 Refining Ore

A plethora of processes such as electric arc heating, oxygen acceptance by pure carbon, and slag separation refine the ore. Within the refining process, a power line transfers electric current through the electrodes embedded within the ORC to heat the ore slowly up to 4000K. This heating melts the ore to ease refining. For instance, when refining iron ore, this heat causes the metal to loosen its bonds from the oxygen, to the point that the vaporized carbon and caldium carbonate produced by the incinerated biomass of algae (Pleurochrysis Carterae) can bond with it and suspend it in slag form. Then the slag drains out of the ORC when the containers enter the structural interface to be accelerated around, separating the element and the slag according to density.

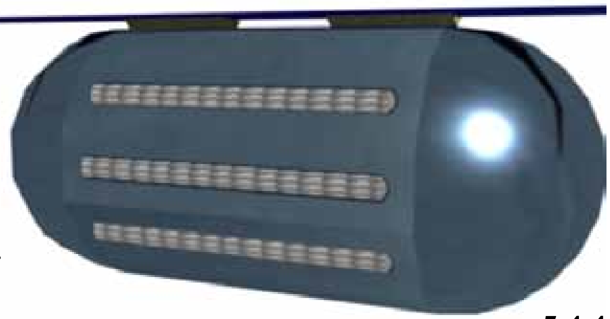


Figure 5.4.1 ORCs transport and refine ore.

ORCs are specialized to the particular refining process they perform, as ores for different elements require different refining processes. Still, all ORCs have the capacity for pressurization, heating, and slag removal. We also refine in all of the different gravity levels from 0 to 0.5 g to provide diversity (see Appendix A). This refining system is superior to any traditional refining method because of its modular, mobile nature which is cleaner than a more static and messier process. With waste, our recycler sends excess products such as CO2 back to the algae, turning it into needed resources.

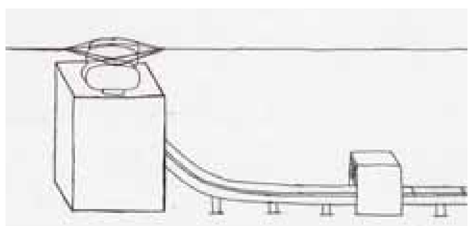


Figure 5.4.2 Multiple ORCs docked to continuous casters prevent any breaks in construction panel production.

5.4.3 Forming

To form the construction panels, we use a standard continuous casting method. Four of the largest ORCs (16m by 5m by 10m) dock to the continuous caster at once with a metal-to-metal connection secured by polymeric actuating gel. Each ORC contains enough molten galtium (uncured reardonium, see Appendix A) to cast seven construction panels (100ft by 40ft by 1ft), so having four ORC docking areas allows for an uninterrupted flow of galtium.

For manufacturing the universal joints and other small components, we use injection casting into movable molds. For both the continuous caster and the injection caster, ORCs dock to the machinery and a pneumatic press pushes molten ore into the caster.

5.4.4 Handling, Loading and Unloading

Once the components cool enough to transport, robotic arms load them onto pallets and secure them with straps. These pallets move along the same rail system as the ORCs to transport the panels to the other gravity levels for cooling. After parts have cooled completely, robotic arms load small components into shipping containers and stack construction panels on shipping pallets for transport down to Mercury for curing. Components are then unloaded by robotic arms onto curing vehicles (see 5.5.1).

5.5 Automation for Curing

Through a highly efficient system of mining and curing robots, Northdonning Heedwell streamlines this process even further. An array of mining and curing robots minimize dust contamination and other normal wear and tear issues and ensure that human intervention is kept to a minimum, thereby increasing safety.

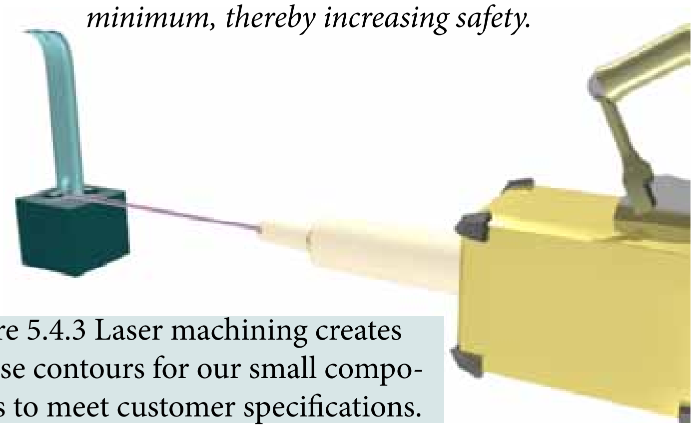


Figure 5.4.3 Laser machining creates precise contours for our small components to meet customer specifications.

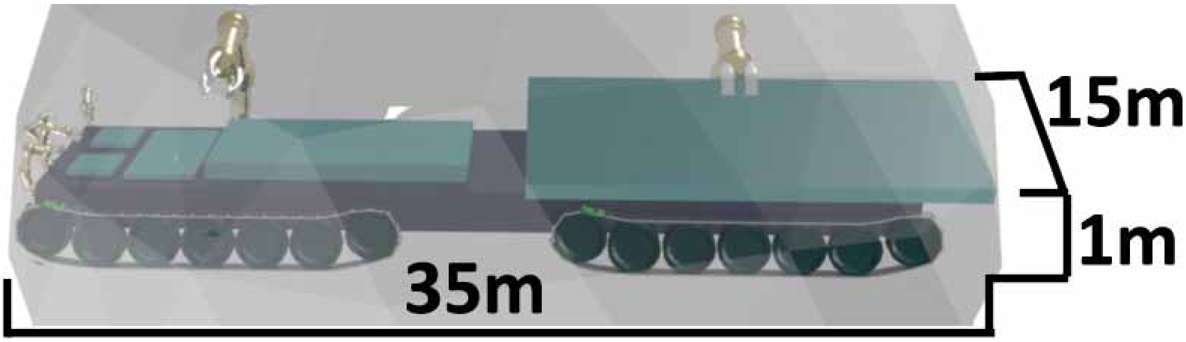
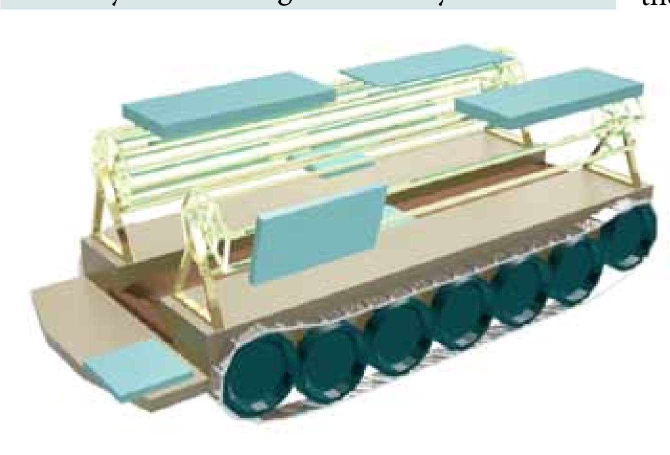


Figure 5.5.1 As reardonium production is the largest focus on Aynah, we have designed a LSCR to create a maximum cure.

5.5.1 Curing of Parts

Northdonning Heedwell has streamlined automated systems by which reardonium parts are cured with the highest level of accuracy. The reardonium curing is accomplished via two robotic platforms, one for larger reardonium components and one for smaller components. The Large Scale Curing and Transport Robots (LSCR) aid in larger reardonium curing processes and are equipped with several multi-directional arms for unparalleled lifting capabilities. The LSCRs are composed almost entirely of reardonium. The LSCRs are designed with multiple dust mitigation techniques including liquid glass coatings, lotus coatings, and embedded vibrating actuators to compliment the dust-pitting resistance of reardonium. The LSCRs are capable of lifting and rotating reardonium pieces of up to 100 feet by 40 feet due to an incredibly innovative robotic arm system. The LSCRs extend a hydraulic high-strength pivot arm on the lateral ends of the robot to allow the reardonium section to rotate via a central axis point for stability. A vehicle similar to the LSCR called the Small Curing and Transport Robot (SCTR) manipulates smaller reardonium components. Holding the small pieces in place is a set of clamps that are on a rotating wheel so full curing can occur from all sides for each part. A conveyor belt system carries the cured reardonium parts to an unloading area at the rear of the SCTR. Other transport systems take the parts needed from the back of the robot for shipping to Aynah.

Figure 5.5.2 Small-scale Curing and Transport Robots handle smaller reardonium components efficiently while curing on Mercury.



5.5.2 Solar Flares

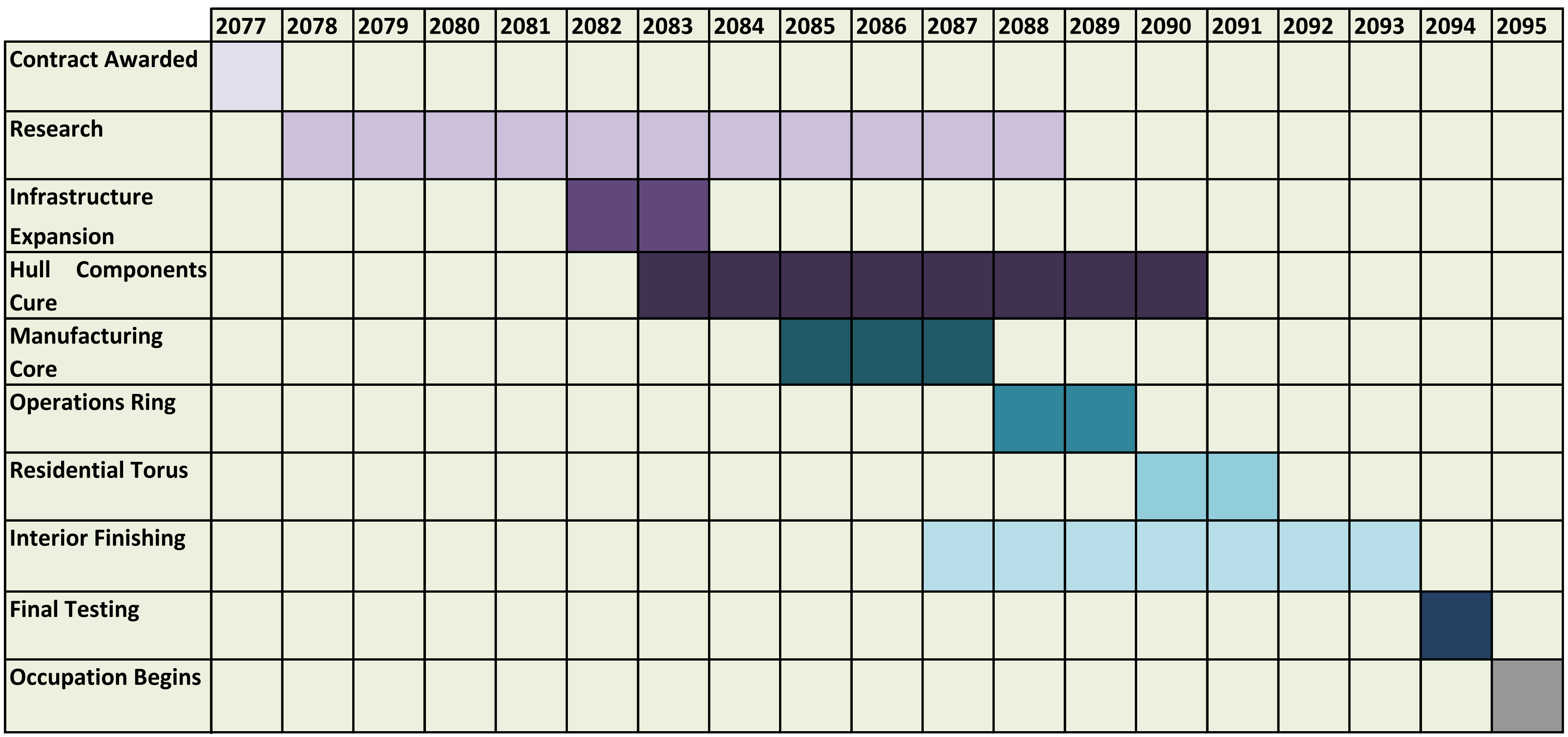
Each LSCR and SCTR has its own battery-powered light source for night use. In the case of a solar flare, both the reardonium transport and the curing robot temporarily shut down and deploy three-inch reardonium shields with a one-inch polyethylene interior layer over the track and solar panels. The curing vehicles then harness a substantial amount of energy to deploy an electromagnetic field to deflect the radiation particles. This combination is enough to provide full radiation protection. Electric motors deploy the protective panels once a solar flare is detected.

6.0 Schedule and Cost

6.0 Schedule and Cost

Aynah is fully functioning 18 years after the contract is awarded. Six years into the process reardonium production begins, allowing for the early sale of parts and thereby a revenue flow before the settlement is even constructed. Pre-sale of real estate, both residential and commercial as well as the transport research items around Mercury, also contributes to this revenue flow. These base market revenues combined with strategically constructing Aynah from materials on Mercury reduces the return on investment to 20 years.

6.1 Schedule



6.2 Cost

Phase	Items	Cost of Item	Employees
Research	NA	60,000,000,000	3,500
	Cost of phase	**60,000,000,000**	
Matriarch	Transport Unit	13,000,000	600
	1 SCRs	1,000,000	
	Nuclear Reactor	238,000,000	
	3 Percheron Vehicles	50,000,000	
	Cost of phase	302,000,000	
Expand Mercury's Infrastructure	NA	15,000,000,000	1,500
	Cost of phase	**15,000,000,000**	
Manufacturing Core	Hull Components	1,489,000,000	1,300
	Basic Infrastructure	9,500,000,000	
	Initial Rails	850,000,000	
	Solar Panels	6,000,000,000	
	Docking Systems	840,000,000	
	Solar Sattelites	**800,000,000**	
	Cost of phase	**17,990,000,000**	
Operations Ring	Hull Components	408,600,000	1,300
	Basic Infrastructure	1,000,000,000	
	Structural interface	250,000,000,000	
	Docking Systems	1,620,000,000	
	Solar Panels	8,000,000,000	
	Cost of phase	**261,028,600,000**	
Residential Torus	Hull Components	4,784,000,000	1,300
	Basic Infrastructure	4,600,000,000	
	Laminated Acrylic Glass	5,991,400,000	
	Water	2,000,000,000	
	Ion Drives	450,000,000	
	Cost of phase	**17,825,400,000**	
Interior Finishing	Contour Crafters	90,000,000	1,500
	Transport Systems	275,000,000	
	Buildings and Homes	570,000,000	
	Life Support Systems	770,000,000	
	Communication Systems	580,000,000	
	Automation	850,000,000	
	Cost of phase	**3,135,000,000**	
	Total Cost	**376,170,000,000**	

7.0 Business Development

7.0 Business Development

Building Aynah establishes a port of entry to Mercury, giving the Foundation Society first access to its reardonium and research opportunities. We aim to define the metal production market and shape its course for decades. By utilizing the vast potential of Mercury's unique environment, we create an entrepreneurial experience catered to up-and-coming industries and business-minded individuals.

Infrastructure for Refining and Manufacturing Reardonium Parts

Throughout the entire refining and manufacturing process, Northdonning Heedwell takes the utmost care in containing dust, grit, and any other contaminants. Upon entering the settlement, ore is transferred directly into ORCs (see 5.4.1) to minimize chances of contamination and provide diverse refining and manufacturing environments (see 2.4). Cured parts undergo dust mitigation via electromagnetic wands of different polarities and acoustic levitation both before leaving the surface of Mercury and after entering Aynah.

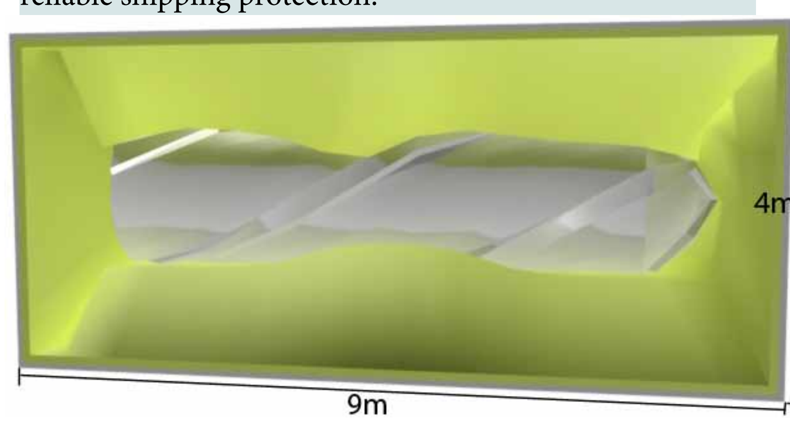
Test	Acceptable Range
Molecular Composition	98-100%
Tensile Strength	1.900-2.200 MPa
Thermal Conductivity	1-10 W/m-k

Table 7.1 Northdonning Heedwell ensures its customers receive high grade products by performing rigorous quality assessments.

Ore starts its journey in the operations ring and uses the transport through the structural rail interface as part of the refining process, minimizing processing time to increase production. Once in the manufacturing core, ore moves out to the 0.5g level and then back to 0.3g in a streamlined path. We ship manufactured reardonium parts ready for curing out of a docking station on the end of the manufacturing core. This cuts transport time that would have otherwise been used moving back through the structural interface and out the operations ring, allowing for simpler, smoother overall process.

The structure of the station separates hazardous materials from humans, with all possible contaminants contained within the manufacturing core and the operations ring. Residential spokes isolate these areas from the residential torus. When passing through residential spokes, all cargo goes through a complete sweep, and residents pass through a double airlock system. Sensors continuously monitor atmosphere within this area for any gaseous or particulate contaminants from the manufacturing core. Humans and cargo also dock in different locations to ensure maximum separation (see 2.1).

Figure 7.1 An inflatable lining provides cost-effective and reliable shipping protection.



Receiving and Shipping

Automated systems remove 5% of each integration chamber's reardonium batch for quality assessments (see Table 7.1). All parts pass through a visual scanner to check for compliance with customer specifications. A magnetic arm installs approved parts in one of eight sizes of polyolefin component containers. A pump inflates the container's Elastic Stretch Film lining to form to the part's contours for maximum vibration isolation and safety throughout the entire shipping process. Another magnetic arm arranges component containers into shipping container' or places large parts on pallets. Companies who reuse shipping containers and pallets to deliver products to Aynah receive credit towards their next purchase.

All pallets and shipping containers possess a tracking chip that holds information about the container's contents. Scanners mark the chips as packages enter/exit warehousing and docking areas, allowing customers to track their packages through all stages of the shipping and handling process. The information collected by the chip allows for automatic and extremely accurate billing.

Interorbital Shuttles

Northdonning Heedwell's fleet of interorbital shuttles provides a safe, relaxed experience for passengers while transporting significant amounts of cargo. A dual-level design maximizes internal space usage on the shuttle. The lower level holds 60 standard shipping containers or one to two large components. Cargo is loaded via a rail system compatible with the one on Aynah.

Up to 50 passengers can travel in the upper level's plush seating and enjoy an interactive 3D holographic display and a variety of refreshments. The majority of the flight is automated, but a technical assistant aids in docking and a flight attendant that ensures the psychological and pysical comfort of our passengers.

Two of our three shuttles operate at any given time with the third acting as backup or extra transport capability during times of peak activity. Despite continuous monitoring by sensors in the hulls, every six months of flight time the shuttles undergo routine inspection and maintenance, which includes refreshing the liquid glass coating and assuring correct functioning of radiation protection. This guarantees the passengers' safety and the longevity of the craft.

Figure 7.2 A dual-level design provides for optimal transport of both personnel and cargo.

Landing Shuttles

Aynah operates a fleet of eight Percheron landing shuttles ,six of which run at any given time. The four-hour flight is completely automated aside from the presence of a technical aid. Cargo and maintenance occur in the same way as on interorbital shuttles.

Warehousing

We provide cargo warehousing in close proximity to shipping stations to ease transit. Cargo uses the same rail transport system that facilitates refining processes. Ships native to Aynah interface directly with this system and a robotic arm is used to unload other cargo bays. The collective volume of all cargo warehouses comes to 6,134,400cubic meters.

An X-Ray scanner at the entrance of the warehousing tags cargo with tracking chips (see 7.2). Depending on the intended storage time and desired environment (pressurized versus unpressurized), rails direct cargo to the correct warehouse. The chip is marked again at the warehouse entrance, and a robotic arm situates the cargo.

Revenue

The discovery of reardonium reveals the vast market potential of Mercury's surface. Aynah has seized this opportunity and acts as a financial starting point for new industries, each one providing revenue and expanding the markets of the Foundation Society's lucrative point of entry to Mercury.

The new and growing industries are a large source of revenue, but Aynah's markets can flourish on her stable base in reardonium production. Our proximity to Mercury allows products we design to be readily tested and improved. Our primary markets are universal joints, industrial drill bits, and construction panels, but Northdonning Heedwell designed Aynah's refining and manufacturing areas to be able to handle the creation of nearly any item. We have recently observed increases in the industry of replacement human joints made of reardonium, this market is significantly more customized and delicate than the production of construction panels, illustratating the flexibility and thereby potential of reardonium as a business market.

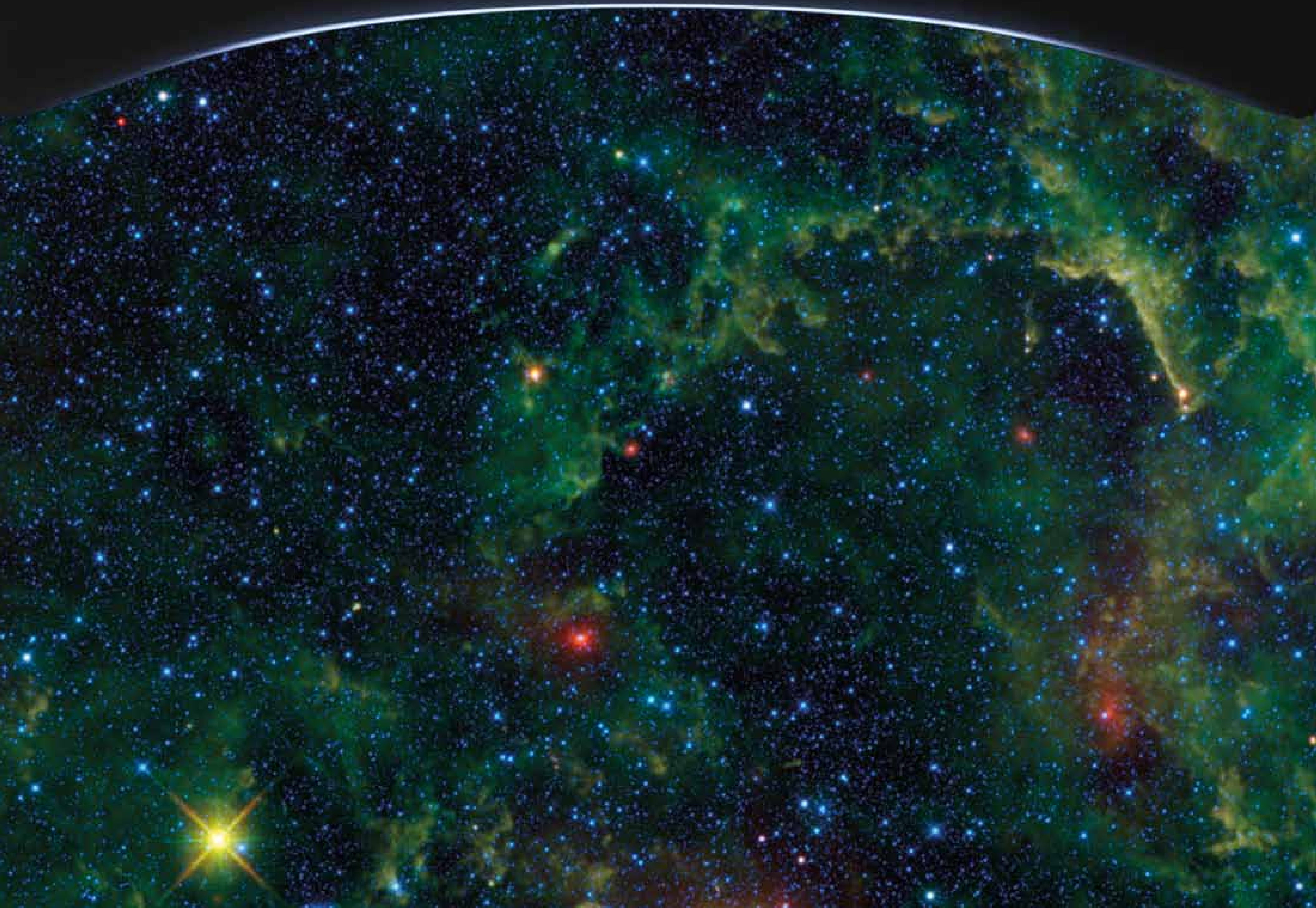
Markets

Marketing specialists project that a strong market for reardonium spacecraft hulls will emerge in the next 2-4 years. Northdonnign Heedwell studies have found that pitting and scarring due to dust, even in superalloys such as Inconel, rapidly compromises hulls and parts on transport and landing crafts, leading to immense repair costs and user uncertainty. Reardonium's exceptional strength causes it to last nearly ten times as long before requiring replacement. For this reason alone, reardonium hulls and parts will revolutionize the spacecraft industry, and its lightweight properties will save on fuel costs. We anticipate that the retrofitting business, if we enter it soon enough, will prove the basis of long-term investment. Another projected market is safety linings for solar flare activity. This problem arose during the development of the space industry and has never been fully resolved. Reardonium is nontoxic as well as requiring a smaller amount to provide superior protection and therefore better suited to the raduatuib protection job than lead, currently the only known option.

Table 7.2 Reardonium is such a new, unexplored product that it can revolutionize the aerospace industry. Its incredible properties will establish reardonium as a cornerstone of life in the future.

Currently Significant Markets	**Up and Coming Markets**	**Projected Markets**
Construction Panels	Replacement Human Joints	Surgical Tools
Universal Joints	Robotic Cases	Long-Term Storage Containers
Drill Bits	Spacecraft Hulls	Circuit Board Components
Thermal Insulation	Electronic Cases	Solar Flare Protection
Radiation Protection	Engine Components	Rail Gun Tracks
Spacesuit Joints	Super Durable Fabrics	Solar Sails

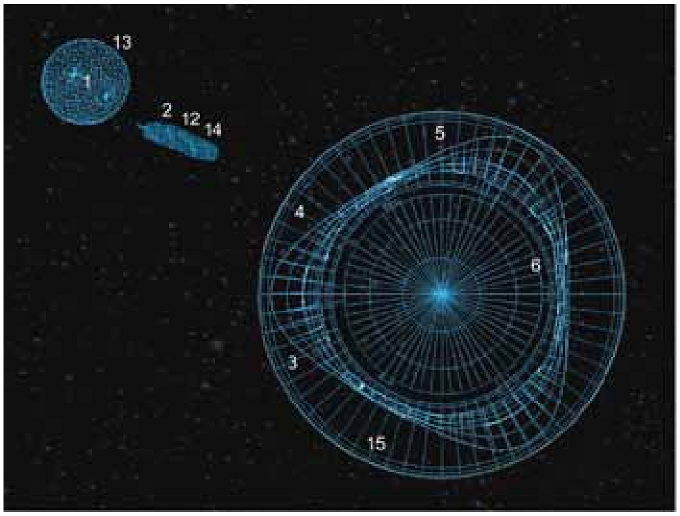
Appendix A Operational Scenario

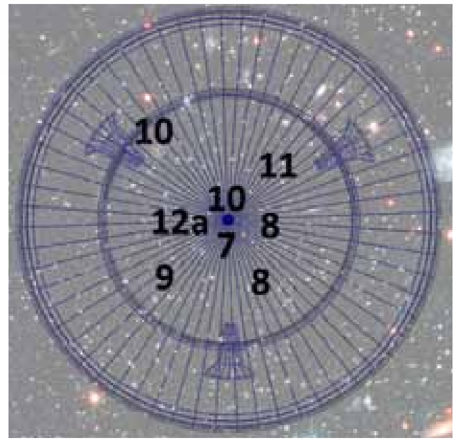


Appendix A

Reardonium is today what aluminum was in the early 20th century. As soon as word of its properties and capabilities spreads, demand will skyrocket. The staggering number of application for reardonium belie the difficulty of its creation. Yet there is no corporation with more orbital refining experience than Northdonning Heedwell. Drawing from the orbital, automated zero-gravity manufacturing expertise gleaned from our Alliance Automation Division, we are poised to revolutionize the superalloy market. Yet we are not resting on our past. Instead, we have streamlined refining with our Ore Refining Container, a mobile refining unit capable of temperature range modulation up to 4000 Kelvin. From a highly progressive combination of standard refining technologies to a fluid multi-gravitational and variable pressure zones, our phenomenally clean, responsive system produces a wide array of reardonium products. Once the Foundation Society possesses our manufacturing system, the barrier of entry into the reardonium market for any other manufacturing entities will become prohibitively difficult to surmount.

Steps	Facility Requirement	Machinery	Human Interaction	Time
Transport of Ore to Aynah	Port facility on Mercury surface, Aynah docking facility	Upgraded Percheron, electromagnetic locking conveyor belt, VASIMR, RTGs	Tracking	4 hours
Transport of Ore to Refinery	Aynah docking facility	ORCs, electromagnetic rail system	Remote shuttle monitoring	30 minutes
Refining	0g Operations Ring, structural interface	ORCs	Inspections, sensor monitoring	25 hours
Manufacturing	Manufacturing core center, suspended integration chamber	ORCs, electromagnetic plates, robotic mixers	Inspections, sensor monitoring	35 hours
Transport of Parts for Curing	Port facility on Mercury surface, Aynah docking facility	Percheron, loading robots	Tracking	3 hours
Curing	n/a	Reardonium transportation vehicles	Inspection, sensor monitoring	1 earth year
Transport of Cured Parts to Aynah	Port facility on Mercury surface,	Dust Removing robots, Percheron	tracking	3 hours
Shipping Completed Parts to Customers	Storage facilities, Aynah docking facility, packaging facility	Electromagnetic conveyor belts, pneumatic actuators, dust removing robots, visual scanners, quality inspections robots, pneumatic cleaner, loading robots, interorbital shuttles	Inspection, customer satisfaction assurance	unknown (depending on location of customer)





1) Galtium ore is mined and extracted on Mercury.

2) The extracted galtium ore is transported to Aynah by a Percheron. Percherons are also used for the delivery of all cargo between the surface of Mercury and Aynah.

3) Upon arrival, the galtium ore is transferred into awaiting ORCs which are then moved to refining or are put in the Operations Ring for storage until later usage.

4) Refining begins by raising the pressures in the ORCs to 20 psi as well as increasing the temperature to 4,000 K which liquefies the gasses. The impurities are then drained away with the liquefied gasses.

5) Once the impurities are drained away the pressure is lowered to 11 psi and the temperature is increased again to melt away more impurities.

6) The temperature and pressure steadily increase as the ORCs move through the structural interface. The structural interface holds a constant velocity for 5 hours at each gravity level, which allows materials to separate and impurities to drain out.

7) The ORCs move to the center of the manufacturing core at 0 G where various elements are melted at different pressures and temperatures before being mixed together.

8) Thorough mixing is started at .1 G and completed at .2 G preparing it for the next steps.

9) The ORCs are then brought to .4 G where the mixtures are put into the casting and molding phase.

10) The mixtures are then allowed to rest and cool at . 5 G and are later moved to 0 G, allowing them to set properly.

11) The joint casts are moved to .3 G where they are laser cut into the appropriate shapes.

12a) Joints and panels are stacked and packaged in containers or layered and secured on pallets before being moved to the export station in the Operations Ring.

12) The manufactured parts are sent to Mercury for curing.

13) All curing occurs on mercury in cycles which are influenced by the type of the parts.

14) The cured reardonium parts are sent back to Aynah for shipping.

15) The reardonium parts are shipped with tracking chips to the customers' locations.

Delivery of Ore to Aynah

We begin our reardonium process by taking advantage of in-situ Mercury resources while continuing with what made us successful so long ago: surface to settlement transport. Our modified Percherons function as a highly specialized ore and product transport vehicle. The Percheron, refitted with reardonium inside and out, services our Surface to Settlement Transport route for delivery of cargo to and from Aynah. Standard-size shipping containers (4 by 4 by 9 meters) load onto 10 electromagnetic, locking conveyor belts that act like shelves and facilitate loading and unloading (10 shelves: 50 meters wide, 50 meters long, and 100 meters high). Once the Percheron is loaded, the large air lock latch closes and everything is secured in the cargo area. A VASIMR rocket propels the Percheron back and forth between Mercury and Aynah with hydrogen. Separate Radioisotope Thermoelectric Generators (RTGs) provide power for the electromagnets of the VASIMR engine. After a speedy transit time of 4 hours, the Percheron docks with Aynah at the stationary operations ring at one of three raw materials ports.

Transport Ore to the Refining Area

Argon pressurization within cargo containers transfers ore from the containers into awaiting ORCs (see 5.4). Because we are keenly aware of the dangers of dust contamination during this process, we have retrofitted our polymeric gel actuating device to form a seal around a metal-to-metal interface between the ORC and cargo containers. To ensure complete unloading, an ejection plate, accompanied by a vibrating actuator sweeps the containers clean. Three different sizes of ORCs allow for refining of different material volumes (dimensions 4 by 5 by 10, 8 by 5 by 10, and 16 by 5 by 10 meters). Galtium, the uncured reardonium alloy, is very complex , so varied ORC sizes allow us to efficiently refine only the amount of a certain element necessary to create each batch without the added costs associated with storing molten material or re-melting refined material.

An electromagnetic rail system then moves the newly filled ORC throughout the settlement, either to raw materials storage or directly into the refining facility. Any excess ore is stored in specified volumes within the Operations Ring. Everything in the Operations Ring is melted later in the ORCs.

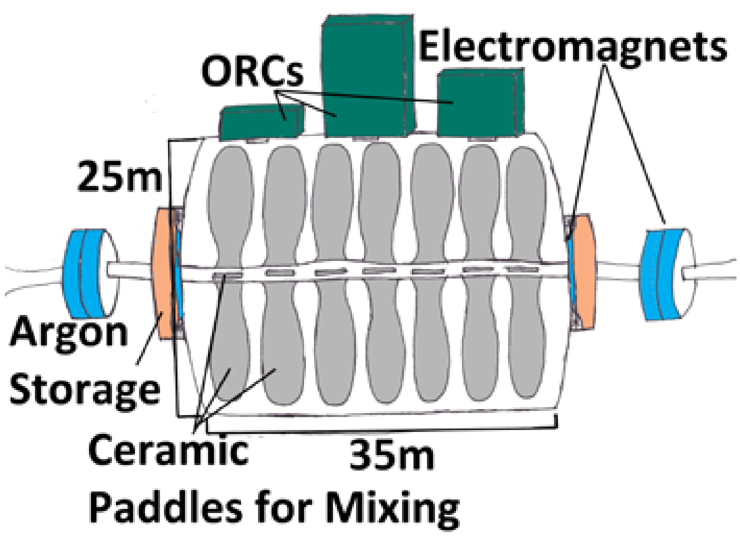


Figure A1 Integration Chambers using electromagnets to avoid rotating in the center of the manufacturing core mix all of our refined elements in 0g for complete homogenization.

Step	Time Required	Gravity	Pressure	Temperature
1 Liquefy Gases	5 Hours	0g	0-20psi	100-900K
2 Impurity Removal	20 Hours	0-0.5g	11psi	100-4000K

Table A1 Multi-stage refining purifies ore so we can achieve our precise galtium composition without contaminants.

Refining

The steps for refining begin with initially raising the pressure within the ORCs to 20psi as well as raising the temperature until the gasses liquefy. The liquefied gasses are then drained and the pressure is brought back down to 11psi and the temperature is again increased to melt away more impurities. These, now liquid, impurities are also drained away. Following this, the pressure and temperature are steadily increased as the ORCs move through the structural interface. The structural interface maintains a constant velocity for 5 hours at each of the various gravity levels, to allow materials of different densities time to separate. This eases the refining process by having the g-forces caused by the centripetal acceleration of the interface transport system to separate out impurities. Impurities are drained into special holding areas on either side of the ORCs, so even this material can be reprocessed to reclaim other valuable ore or useful materials for regular settlement operations. With two trains for transportation running per industrial track and six industrial tracks, all components of galtium, uncured reardonium, can be refined at once.

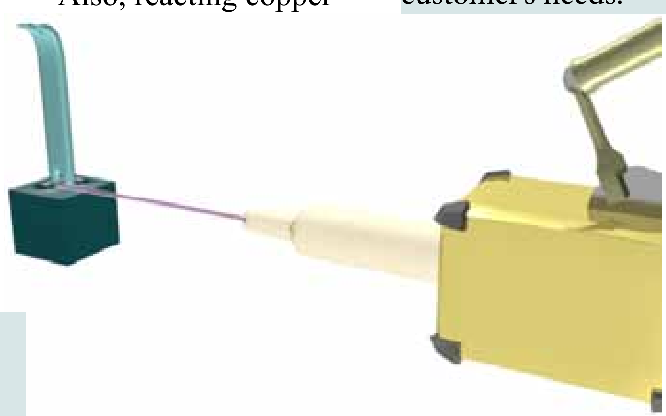
	Percentage Composition by Mass
S	0.05
Cu	5
Al	1.2
Fe	34
C	0.85
Ti	2.6
Ni	43
Co	4
Ca	0.3
Si	1
Mg	8

Table A2 Galtium's composition mimics that of other superalloys with innovations to use materials readily available on Mercury.

Maufacturing Refined Reardonium into Desired Shapes and Parts

Once the material being worked on moves through the structural interface refining process, it moves to the center of the manufacturing core where the suspended integration chamber mixes the various elements into galtium. First, nickel is added to iron (Iron's higher melting point requires that nickel is added to it to avoid any unwanted solidification). Then carbon is integrated into this mixture at a pressure of 0 psi, the low pressure increases the temperature necessary for carbon to dissolve in iron, thus reducing carbide formation. Following that step, silicon, cobalt, and titanium are mixed together and then integrated with the mixture. Next calcium, magnesium, and aluminum are mixed together and then integrated. Then the reactants copper and sulfur are reacted to form copper II sulfide which is then melted and incorporated into the mixture. Materials are mixed according to their melting points to avoid issues from high temperature differences. Also, reacting copper

Figure A2 Laser machining smooths components and specializes them for each customer's needs.



Step	Time Required	Gravity	Pressure
Nickel added to Iron	30 minutes	0g	0psi
Integrate Carbon	45 minutes	0g	0psi
Silicon Cobalt and Titanium are mixed in	30 minutes	0g	0psi
Calcium Magnesium and Aluminum added	45 minutes	0g	0psi
Copper II Sulfide added	45 minutes	0g	0psi
Mixing	4 hours	0.1g	2-4psi
More Mixing	3 hours	0.2g	8psi
Casting and Molding	1.5 hours	0.4g	14psi
Resting and Cooling	7 hours	0.5g	20psi
Cooling Completed	12 hours	0g	14psi then to 0psi
Solution Treatments/Quenching	1.5 hours	0.3g	10psi
Laser Machining/ Cutting	3 hours	0.3g	11psi

Table A3 Our wide range of temperature, pressure, and gravity level modulations allow us to precisely achieve reardonium's desirable properties.

and sulfur prevents the issues associated with boiling elemental sulfur. All mixing occurs at 0psi to ensure a consistent material density and thorough mix.

All the mixing is done in microgravity for easy manipulation and the integration chamber is operated at varying pressure levels. For aid, two electromagnetic plates at each end of the chamber rapidly change magnetic polarity causing the iron to be tugged back and forth so that everything else is dispersed throughout the mixture. Ceramic paddles also help homogenize the alloy. Each batch has a serial number that contains information on all ORC batches which contributed to it. Later when the finished products are tested, all products can be identified as a part of their batch of origin.

Once materials are mixed, the integration chamber moves to 0.1g to finish mixing at 2 psi then at 4 psi. Further mixing at 0.2g and 8 psi continuing to 0.4g for casting and molding at 14 psi and finally at 0.5g the mixture is allowed to rest and properly cool completely at 20 psi. Then cooling is completed in 0g to allow galtium to set up in a uniform manner and prevent the mixture from stratify-

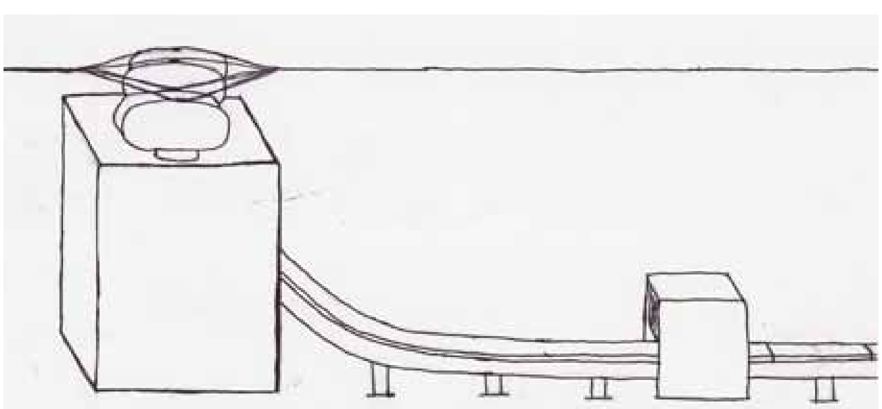


Figure A3 Continuous casting prevents manufacturing interruptions and messes for a more fluid and cost-effective process.

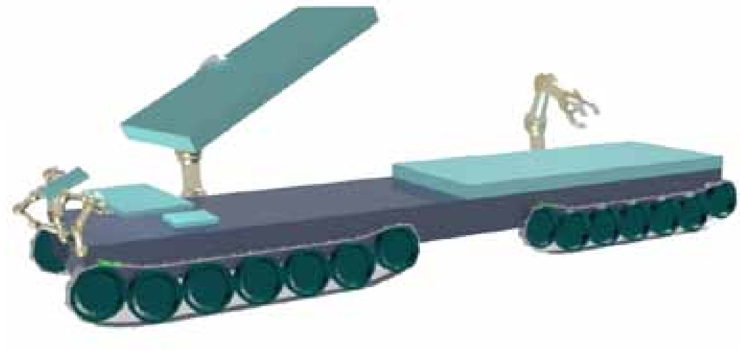


Figure A4 The LSCR's ability to work with large components allows us to reliably cure products such as the construction panel.

ing due to different component densities. This 0g cooling occurs in the center of the manufacturing core using the same electromagnetic suspension system as employed by the integration chambers. In order to cool the construction panel completely, we selected a thinner panel dimension: 100 feet by 40 feet by 1 foot. Having the panel be only one foot thick makes it the maximum thickness possible to cool reliably without being so thin as to compromise integrity.

After mixing and cooling, each component must undergo solution treatments and quenching to ensure the desired strength and other properties. Then, universal joints move to 0.3g for laser machining and cutting at 11 psi. We use this same laser machining process for all other small components requiring small and precise contours. Construction panels and machined joints then move out a docking port located at the sun-facing end of the manufacturing core for shipping to Mercury's surface for curing.

Transporting Manufactured Parts to Mercury for Curing

We rely on our stout fleet of Percherons to transfer manufactured parts from Aynah for curing by delivering the parts to one of four ports on Mercury. These are the same four ports that are used when ore is sent up to Aynah. Curing always begins at a sun facing port.

Curing

Curing requires flipping products three times during their curing period (meaning each side is facing up two times). There are a total of 12 cycles during the curing process, six Mercury days and six Mercury nights. Both components spend the majority of their time curing moving back and forth between the Mercury night and day as the planet rotates, with two or three movements adjusting the curing process to achieve the optimal characteristics of each part.

In designing our construction panel, we aim to increase strength and decrease thermal conductivity. To accomplish this, the curing process for these panels places the panel in equally long heat and cold soaks at either end of their cycle. Two movements accomplish this- one keeping the panel in the Mercury day for a second cycle and one keeping the panel in the Mercury night for a second cycle. Heat fuses the alloy components , while the cold soak at the end thermally stabilizes the panel's composition. Although none of the components of galtium are natively protective against radiation, through the curing process with extended exposure to extreme temperatures and high levels of solar radiation, reardonium sets up a unique crystalline structure that prevents radiation from passing through.

Design of the universal joint curing process strives to decrease weight, increase self-lubrication and create the ultimate, dust-abrasion resistant part to date. Universal joints manufactured of reardonium provide superior strength when compared to those created from a metal alloy like Inconel. Reardonium joints last up to 3 times as long because they are impervious to dust-pitting and are therefore ideal for high-dust applications like robotic operating on the surface of Mercury. Because these characteristics are especially difficult to achieve, the panel is moved three times- twice to keep it in the Mercury night for three cycles and once at the end to keep it in the Mercury day for two cycles. The cool cycles ensure that the reardonium has cooled completely to ensure that it is fully stable and lasts without replacements. The heat soak at the end causes reardonium to expand, thereby decreasing its density. All joints are originally cast smaller than the final product dimensions in anticipation of this thermal expansion which decreases the relative weight of the joint when compared to other products which are simply cast at full density. The rapid cooling of bringing the joints out of the Mercury day and into shielded docking facilities to prepare for transport ensures that this low density and larger size is not lost. The heat soak also helps with self-lubrication, which requires a supremely smooth surface with a low coefficient of friction.

Transporting Cured Parts Back to Aynah

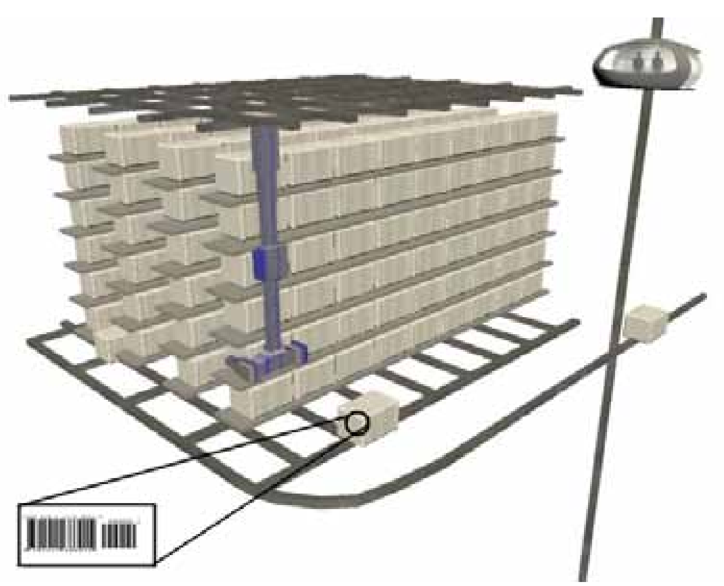
The cured reardonium parts are then brought back to one of the four ports. Dust is then removed from the parts using acoustic levitation and electromagnetic wands which are operated by robotic arms.

Shipping Parts to Customers

When the completed parts arrive on Aynah via Percheron, electromagnetic conveyor belts slide the standardized shipping containers into staging areas where the smaller parts, still arrayed and secured on form-fitting pallets are taken out for dust containment. For larger products such as the panels, a pneumatic actuator gently pushes them out of the Percheron onto another conveyor belt that moves the cured parts to a pressurized room for more dust mitigation. Upon entry into dust mitigation, a set of buffer wheels fringed with fine diamond grit and reardonium fines revolve around both the panels and univeral joint, removing remaining die tags and surface anomalies. Once this final finishing stage is complete, acoustic levitation occurs with the aide of electromagnetic wands to knock off and collect all of the dust. The parts then move along the conveyor belt through the other side of the room. Parts are then run through a visual scanner to check for physical consistency with the customers' specifications.

After visual inspections we pull five percent of products from each batch for quality assessments. Those parts are tested for molecular composition, tensile strength, compressive strength, shear strength, and thermal strength. Products that pass the tests continue on and the parts that fail are melted back down and are sent back to manufacturing. Moreover, when products fail these quality tests, we use their identifying serial numbers to locate

Figure A5 Our organized storage system allows us to locate any product rapidly to serve our customers in a timely manner.



other components from the faulty batch for reprocessing. Following the structural quality checks, the parts are cleaned and any die tags and rough seams are buffed away

To protect the smaller products, in this case, a universal joint, we pack them in stretch film-lined boxes and then load them into cargo containers. The larger parts are loaded and secured onto cargo pallets. All cargo containers and pallets are tagged with tracking chips and when they are delivered by a rail system to the docking area the chips are scanned and become ready for tracking while en route to the customer. Robotic arms load the boxes while rail systems guide the large pallet cargo onto the interorbital shuttles. The rail system can also continue on to storage areas. If the parts are not to be shipped right away, a robotic arm places the cargo in an allocated position according to the length of the storage needed. When the freight is needed to be shipped the robotic arm places the cargo back onto the rails to continue on to the docking area for shipment.

Process Monitoring

All portions of the refining, manufacturing, and curing process are monitored by sensors. For refining, sensors detect levels of known potential impurities as well as temperature and pressure. Sensors in manufacturing monitor alloy composition, carbide formation, oxidation, temperature, pressure, and grain size. Curing sensors monitor temperature and radiation levels. Multivariate statistical process control computer software systems continuously analyze the data collected by the sensors in real time. This analysis compares measured levels of all variables against predetermined acceptable levels, permitting authorized personnel to identify outlier batches or abnormalities in time to adjust for the variance.

Ending Statement

Reardonium offers us a solution to two great thorns in the side of the space exploration and mining industry: radiation and dust abrasion. Our two main products, a construction panel made to customer specifications and a universal joint, mark a re-thinking of exploration and extraction materials. With further studies, we are confident we can manufacture stronger, lighter crafts with greater radiation protection for both electronics and human elements. This is no small progress: once fleet managers grasp the benefits of upgrading their vehicles with reardonium skins, we envision a significant reduction in radiation-caused down time for electronic systems.

With our reardonium universal joints, we triple the lifespan of robotic systems in high-dust applications. Especially in mining applications and surface transportation applications, costs presently incurred for maintenance and personnel down time will see a dramatic drop. Even though our reardonium parts are fairly costly at first glance, a full upgrade of universal joints yields a return on expenditure within a year both in financial gains and systems reliability.

NORTHDONNING HEEDWELL

	Insulation	Machinable	Lightweight	Strong	Hard
S	yes	yes			
Cu					
Al			yes		
Fe		yes		yes	
C					
Ti			yes	yes	
Ni				yes	yes
Co					
Ca					
Si					
Mg		yes		yes	

Table A4 Each element we incorporate into our galtium contributes to specific qualities in the final cured reardonium. Should a customer require enhancement of a particular quality, our flexible refining and manufacturing process allows us to modify the composition to their needs. However, our standard composition maximizes all of reardonium's remarkable qualities for the vast majority of applications.

	Self-Lubricating	Corrosion Resistance	Tough	Impact Strength	Tensile Strength
S	yes				
Cu		yes			
Al			yes		
Fe					
C					yes
Ti			yes		
Ni		yes	yes	yes	
Co					
Ca					
Si					
Mg				yes	

	Carbide Resistance	Oxidation Resistance	Little Thermal Expansion	Electrical Resistance	Grain Growth control
S					
Cu					
Al		yes			yes
Fe					
C					
Ti					yes
Ni	yes		yes	yes	
Co			yes		
Ca		yes			
Si		yes			
Mg					

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Appendix B Bibliography

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Appendix C Compliance Matrix

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Requirement	***Where Requirement Met***	***Page Numbers***
Structure 2.0: safe and pleasant living and working environment for 14,000 people and 200 short term visitors	Section 2.2, Figure 2.2.1, Table 2.1.3	5, 6
2.0 enable natural views of Mercury	Figure 2.1.4	4
2.1 identify the attributes and uses of large enclosed volumes	Figure 2.1.3	3
2.1 external hull and all major load-bearing structures manufactured of reardonium	Section 2.1.2, Figure 2.1.4	3, 4
2.1 show dimensions of major hull components and design features	Figure 2.1.1	2
2.1 specify volumes where artificial gravity will be supplied	Section 2.1.1, Figure 2.1.5	2, 3, 4
2.1 structural interface(s) between rotation and non-rotating section	Section 2.1.3, Figure 2.1.5, Figure 2.3.6	4, 8
2.1 rationale for selected rotation rate and artificial gravity magnitude(s)	Section 2.1.1, Figure 2.1.2, Table 2.1.2	3
2.1 capability to isolate at minimum any two separate habitable volumes in case of depressurization or other emergency	Section 2.1.4, Figure 2.1.7	4, 5
Minimum Requirements: 2.1 overall exterior view of settlement with major visible features	**Figure 2.1.1, Figure 2.1.6**	**2, 5**
2.1 show rotating and non-rotating sections	**Figure 2.1.5**	**4**
2.1 show pressurized and non-pressurized sections	**Figure 2.1.8**	**5**
2.1 indicate functions inside each volume	**Figure 2.1.3**	**3**
2.2 specify percentage allocation and dimensions of interior “down surfaces”	Table 2.2.1	6
2.2 drawing labeled to residential, industrial, commercial, agricultural, and other uses	Figure 2.2.1	6
2.2 show orientation of “down surfaces” with respect to overall settlement design	Figure 2.2.2	6
2.2 show vertical clearance in each area	Section 2.2	6
Minimum Requirement: 2.2 overall map or layout of interior land areas, showing usage of those areas	**Figure 2.2.1**	**6**

Requirement	***Where Requirement Met***	***Page Numbers***
2.3 describe the process required to construct the settlement, by showing the sequence in which major components will be assembled	Section 2.3	6
2.3 specify when artificial gravity will be applied	Section 2.3, Figure 2.3.6	8
2.3 expand manufacturing areas- at least 100,000 square feet	Section 2.3, Figure 2.3.1	7
2.3 describe a construction technique for interior structures making use of minimally refined materials from Mercury's surface	Section 2.3	6, 7, 8
Minimum Requirement: 2.3 drawing(s) showing at least five intermediate steps of settlement assembly	**Figures 2.3.1-2.3.5**	**7, 8**
2.3 show method of initiating rotation for artificial gravity	**Figure 2.3.6**	**8**
2.4 reardonium part production will require refining and manufacture capability in varying accelerations from 0 to 0.5g	Section 2.4, Figure 2.4.1	8
2.4 reardonium part production will require refining and manufacture capability in atmospheric pressures varying from vacuum to 20 psi.	Section 2.4, Figure 2.4.1	8
Minimum Requirement: 2.4 show how manufacturing areas will provide required ranges of conditions	**Figure 2.4.1**	**8**
2.5 residential and commercial areas must be on the opposite side of the settlement from the sun	Section 2.5.1, Section 2.1.1	2, 9
2.5 residential and commercial areas must be completely surrounded by a 20-inch layer of water	Section 2.5.1, Figure 2.5.1-2.5.3	9
Minimum Requirement: 2.5 configuration drawings show protection for areas occupied by humans	**Figure 2.5.2**	**9**
3.0 describe facilities and infrastructure necessary for building and operating the Aynah space settlement and its communities	Section 3.1-3.5	10-18
3.1 settlement operates in a sun-facing polar orbit	Section 3.1.1	10
3.1 materials other than reardonium for construction	Section 3.1.2, Table 3.1.1	10, 11
3.1 recommend an orbital altitude for Aynah and the reasons for its selection	Section 3.1.1	10
3.1 amounts of construction materials	Table 3.1.1	11
3.1 sources for materials	Table 3.1.1	11

Requirement	*Where Requirement Met*	*Page Numbers*
3.1 identify equipment to be used in construction then in settlement operations after construction is complete	Section 3.1.2	10
Minimum Requirement: 3.1 table identifying types, amounts, and sources of construction materials	**Table 3.1.1**	**11**
3.2 atmosphere/climate/weather control- identify air composition, pressure, and quantity	Section 3.2.1, Table 3.2.1	10, 11
3.2 food production- including growing, harvest-ing, storing, packaging, delivering, selling	Section 3.2.2, Figure 3.2.1, Table 3.2.2	12
3.2 electrical power generation-specify kilowatts distributed to habitable areas	Section 3.2.3, Figure 3.2.2-3.2.3, Table 3.2.3	13, 14
3.2 water management- specify required water quantity and storage facilities	Section 3.2.4	14, 15
3.2 home and industrial solid waste management- specify recycling and/or disposal	Section 3.2.4, Figure 3.2.4	14, 15
3.2 internal and external communications sys-tems- specify devices and central equipment	Section 3.2.5, Figure 3.2.5, Table 3.2.4	15
3.2 internal transportation systems- show routes and vehicles, with dimensions	Section 3.2.6, Figure 3.2.6-3.2.7, Table 3.2.5	15, 16
3.2 day/night cycle provisions- specify schedule and mechanisms/operations for providing it	Section 3.2.7, Figure 3.2.8	16, 17
3.2 food storage in case of blight or supply inter-ruptions for up to 1 month	Section 3.2.2	13
Minimum Requirement: 3.2 chart(s) or table(s) specifying quantities required of air, food, power (for residents), water, waste handling, communi-cations devices, and internal transport vehicles	**Figure 3.2.6, Figure 3.2.4, Tables 3.2.1-3.2.5**	**11, 12, 13, 16**
3.3 designs of equipment used to construct settle-ment, especially for assembling exterior hull and interior buildings/structures	Section 3.3, Figure 3.3.1	17
3.3 describe materials, components, etc. deliv-ered to the machines	Section 3.3	17
3.3 describe machines converting supplies into settlement structures	Section 3.3	17
Minimum Requirement: 3.3 drawings of primary construction machinery, showing how it shapes and/or manipulates raw materials or structural components into finished form	**Figure 3.3.1**	**17**
3.4 reardonium production power provided by solar panels	Section 3.4, Figure 3.4	18

Requirement	*Where Requirement Met*	*Page Numbers*
3.4 equivalent of 4 square miles of solar panels in addition to power required for operation of the settlement	Section 3.4, Figure 3.4.1	18
Minimum Requirement: 3.4 show solar panels in drawing(s) depicting Aynah design	**Figure 2.1.6, Figure 3.4.1**	**5, 18**
3.5 vehicle for transporting reardonium on Mercury	Section 3.5, Section 5.5, Figure 3.5.1	18, 35
3.5 each part moved on average 2.5 times during curing	Section 3.5, Appendix A	18, 46, 47
Minimum Requirement: 3.5 drawings of vehicles for moving reardonium parts on Mercury surface	**Section 3.5.1**	**18**
4.0 offer attributes available to residents of Earth's small cities in developed countries	Section 4.1.2, 4.1.4, 4.1.5, 4.2	19-23
4.0 establish roads and paths in a diamond-grid pattern, enabling access throughout residential and commercial areas with a practical minimum of motion	Section 4.1.1, Figure 4.1.1	19
4.0 arrange building to allow route selection that will minimize the need to round acute corners	Section 4.1.1, Figure 4.1.1	19
4.1 provide housing, entertainment, medical, parks, and recreation	Section 4.1.2, 4.1.4, 4.1.5, Figure 4.1.2	19, 20, 21
4.1 variety and quantity of consumables	Table 4.1.1	20
4.1 depict or specify means of distributing consumables	Section 4.1.3	20
Minimum Requirements: 4.1 map(s) or illustration(s) depicting community design and locations of amenities, with a distance scale	**Figure 4.1.1**	**19**
4.1 identify percentage of land area allocated to roads and paths	**Section 4.1.1**	**19**
4.2 provide designs of typical townhouse residences, clearly showing room sizes	Section 4.2, Figure 4.2.1-4.2.4	21, 22, 23
4.2 home designs larger than 1000sq. ft., but smaller than 2500sq. ft.	Section 4.2	21, 23
4.2 identify sources and manufactures of furniture and appliances	Section 4.2	21
Minimum Requirement: 4.2 external drawing and interior floor plan of at least four home designs, the area for each residence design, and the number required of each design	**Section 4.2, Figure 4.2.1-4.2.4, Table 4.2.1**	**21, 22, 23**
4.3 Designs of systems, devices, and vehicles intended for use outside artificial gravity	Section 4.3.1-4.3.2, Figure 4.3.1	24

Requirement	*Where Requirement Met*	*Page Numbers*
4.3 Show spacesuit storage	Section 4.3.3, Figure 4.3.4	24, 25
4.3 Airlock designs for entrance/exit of unpressur-ized volumes	Figure 4.3.2	24
Minimum Requirement: 4.3 drawing(s) showing examples of handrails, tethers, cages, and/or other systems enabling safe human access to any location on or in low-g settlement areas	**Figures 4.3.1-4.3.4**	**24, 25**
4.4 Living conditions at 0.7 g to 0.8g	Section 2.2	5, 6
4.4 daily exposure for children to 1g for at least 3 hours per day during growing years	Section 4.4	25
Minimum Requirement: 4.4 drawing(s) of means for children to spend time in 1g	**Figure 4.4.1**	**25**
4.5 Human Monitoring of Curing Process each month	Section 4.5	25
4.5 Provide Surface Vehicles for human inspection missions during Mercury night and day	Section 4.5.1-4.5.2	26
Minimum Requirement: 4.5 drawing(s) for sur-face vehicles for humans on Mercury	**Figure 4.5.1-4.5.2**	**26**
5.0 specify numbers and types of computing and information processing devices, multi-function personal electronic tools, servers, network devic-es, and robots required for Aynah's facility, com-munity, and business operations	Table 5.1.1	28
5.0 describe types and capacities of data storage media, data security, and user access to computer networks	Section 5.2.3, Figure 5.2.1, Table 5.2.1	30, 31
5.0 show robot designs, clearly indicating their dimensions and illustrating how they perform their tasks	Sections 5.1.3, 5.2.1, figure 5.1.2, 5.1.3, Table 5.1.1	28, 29
5.1 Automation for construction	Section 5.1.1, Figure 5.1.1	27, 28
5.1 Transportation and delivery of materials and equipment	Section 5.1.2	28
5.1 Assembly of the settlement	Section 5.1.1, Figure 5.1.1	27, 28
5.1 Interior finishing	Section 5.1.3, Figure 5.1.3	29
Minimum Requirement: 5.1 drawings showing automated construction and assembly devices-both for exterior and interior applications, and illustrating how they operate	**Figure 5.1.1, Figure 5.1.3**	**27, 29**
5.2 Specify automation systems for settlement maintenance, repair, and safety functions, includ-ing backup systems and contingency plans	Section 5.2.1, Section 5.2.2, Figure 5.1.2	29, 30

Requirement	*Where Requirement Met*	*Page Numbers*
5.2 Robots required for emergency external repairs must survive and accomplish tasks in extreme solar environments and during solar flare activity	Section 5.2.1	29, 30
5.2 describe means for authorized personnel to access critical data and command computing and robot systems	Section 5.2.3, Figure 5.2.1, Table 5.2.1	30, 31
5.2 include descriptions of security measures to assure that only authorized personnel have access, and only for authorized purposes	Section 5.2.3, Figure 5.2.1, Table 5.2.1	30, 31
Minimum Requirement: 5.2 chart or table listing anticipated automation requirements for operation of the settlement, and identifying particular systems and robots to meet each automation need	**Table 5.1.1, Table 5.2.1**	**28, 30**
5.3 describe automation devices to enhance livability in the community, productivity in work environments, and convenience in residences	Section 5.3.1-5.3.3, Figures 5.3.1, 5.3.3	31, 32, 33
5.3 emphasize use of automation to perform maintenance and routine tasks, and reduce manual labor	Section 5.3.3, Section 5.3.4	31, 32
5.3 Provide for privacy of personal data and control of systems in private spaces	Section 5.3.5	32
5.3 Describe devices for personal delivery of internal and external communications services, entertainment, information, computing, and robot resources	Section 5.3.6	32
Minimum Requirement: 5.3 drawings of robots and computing systems that people will encounter in Aynah	**Figure 5.3.1, 5.3.3, 5.1.2**	**29, 31, 33**
5.3 diagram(s) of network(s) and bandwidth requirements to enable connectivity	**Figure 5.3.2**	**32**
5.4 efficient reardonium manufacturing including unloading raw ore arriving from Mercury and moving it through the refining process , forming and handling parts, and loading/unloading parts sent to Mercury's surface for curing	Section 5.4.1-5.4.4, Figure 5.4.1-5.4.3	33, 34
Minimum Requirement: 5.4 drawings of robots for reardonium parts manufacturing and handling	**Figure 5.4.1-5.4.3**	**34**
5.5 robots for operations on the surface of Mercury to handle reardonium parts, including getting a better material cure	Section 5.5.1-5.5.2, Figure 5.5.1-5.5.2	34, 35

Requirement	***Where Requirement Met***	***Page Numbers***
5.5 loading and unloading parts on vehicles (3.5)	Section 5.5.1	35
5.5 robots must be able to operate day and night	Section 5.5.1	35
5.5 robots must assume a “safe” configuration during solar flare events	Section 5.5.2	35
Minimum Requirement: 5.5 drawing(s) of surface robots, showing how they manipulate parts on the surface, and depicting “safe” configuration	**Figure 5.5.1-5.5.2**	**35**
6.0 include a schedule for completion and occupation of Aynah, and costs for design through construction phases of the schedule	Section 6.1, Section 6.2, Table 6.1, Table 6.2	36, 37
6.1 schedule must show tasks from start (5/8/2077) to costumer control point	Section 6.1, Table 6.1	36
6.1 show dates of when people can move in and when settlement will have full population	Section 6.1, Table 6.1	36
6.1 durations and completion dates of major designs, construction, and occupation tasks	Section 6.1, Table 6.1	36
Minimum Requirement: 6.1 durations and completion dates of major design, construction, and occupation tasks depicted in a list, chart, or drawing	**Section 6.1, Table 6.1**	**36**
6.2 cost per year of Aynah construction	Section 6.2, Table 6.2	37
6.2 estimate numbers of employees for each stage of construction	Section 6.2, Table 6.2	37
Minimum Requirement: 6.2 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	**Section 6.2, Table 6.2**	**37**
7.0 various commercial and industrial ventures, which may change with time- design must be sufficiently flexible to add compatible business types with little configuration change	Table 7.2	40
7.0 capability for handling and processing raw ore from the surface of Mercury	Refining and Manufacturing Infrastructure	38
7.0 systems to prevent dust and grit from entering habitable areas	Refining and Manufacturing Infrastructure	38
7.0 manufacturing capability in various gravitational and pressure environments	Refining and Manufacturing Infrastructure	38
7.0 hazardous manufacturing areas are separated from areas humans occupy	Refining and Manufacturing Infrastructure	38

Requirement	*Where Requirement Met*	*Page Numbers*
7.0 manufacturing areas must be arranged to enable efficient movement of reardonium parts through the productions process	Refining and Manufacturing Infrastructure	38
7.0 perform inspections and quality checks of reardonium parts returning from curing process	Refining and Manufacturing Infrastructure, Table 7.1	38
7.0 install complete parts in standard shipping containers or on pallets for delivery	Receiving and Shipping	39
7.0 automate routine processes	Figure 7.2	39
7.0 operate a fleet of interorbital shuttles to transfer personnel and cargo in standard shipping containers to/from interplanetary space liners	Interorbital shuttles, Figure 7.2	39
7.0 operate a fleet of landing shuttles to Mercury	Landing Shuttles	39
7.0 provide cargo warehousing for customs purposes and storage while waiting for transfer to other ships	Warehousing	39, 40
7.0 provide vehicles or systems for moving cargo between ships and warehouses	Warehousing	39, 40

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Structure:
Katie Dudley
Chris Walton

Operations:
Emma Greenberg
Mariah Dorsey
Izzy Riley

Automations:
Jesse Rubenstein
Colin Mummery
River Weiss

Humans:
Haakon Sigurslid
James Triola
Jacob Skeath

Schedule and Cost/Business:
Katy Schneider
Jared Engleken

Images:
Will Counley