

Northdonning Heedwell

Astoria

The Foundation Society

Durango High School
Durango Colorado USA

18th Annual International Space Settlement Design Competition

Proposing Team Data 2011

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

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I understand that if our Team qualifies for the International Space Settlement Design Finalist Competition July 29 - August 1, we will be expected to finance our own travel to / from Nassau Bay, Texas, USA.

Daniel Garner

3/1/2011

Responsible Teacher

Date



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1.0 EXECUTIVE SUMMARY



1.0 Executive Summary

Like any community perched in history on the cusp of the frontier, Astoria and its communities have the energy borne of those who explore and innovate. We are keenly aware of the dangers of our remote location; as such, we have designed Astoria to look both outward and inward. While we face unprecedented challenges, our design reflects the innovation and vision necessary to ensure the enduring success of the Foundation Society.

In utilizing the asteroid, Ceres 1, Northdonning Heedwell is taking advantage of one of the most economically promising locations in the solar system. Catering to the booming liquid hydrogen and oxygen markets, we recognize our role as a hub to support mining endeavors and expansion into the outer reaches of the solar system for generations to come.

Astoria revolutionizes the concept of an orbiting settlement through several key innovations:

- Unparalleled advances in structural design include the elimination of a center conduit and centrally located infrastructure. This dramatically reduces vulnerable surface area, preserving the long-term integrity of the settlement.
- Our Matriarch, a single self-contained refining, manufacturing and construction unit balances initial construction costs with refining and manufacturing services. This allows us to simultaneously produce our own construction materials while offering anticipated localized services to existing asteroid belt operations.
- Mining automations transported within the Matriarch extract over 96% of construction materials directly from Ceres 1, virtually eliminating importation costs.

- Advanced micrometeoroid protection and evasion technologies ensure the constant safety of our residents.
- In the unforgiving environment of the asteroid belt, safety is paramount. Thus, Astoria's operations and infrastructure are both extremely redundant and diverse, greatly diminishing the possibility of catastrophic failure.

We at Northdonning Heedwell realize in an endeavor like Astoria, rewards must greatly outweigh risks. We are convinced that this seemingly inhospitable environment contains an untapped opportunity for mankind, yet opportunity is and has always been only for those who have a vision to mitigate the dangers and conscientiously innovate on each success. Astoria, as we envision it, has not merely balanced reward against risk. We have tipped the balance in your favor, to remain poised and ready on the edge of new markets, new discoveries and a new, inspired concept of human capabilities.



2.0 STRUCTURAL DESIGN



2.0 Structural Design

Northdonning Heedwell's Astoria maximizes efficiency and safety by eliminating the central conduit and spokes, found on traditional torus models, thus eliminating 40% of vulnerable surface area and ensuring constant movement readiness. Our structure offers unparalleled strength and protection with six solid structural rings, all-encompassing micrometeriod shields, and a residential torus sheltered by the Enveloping Concentric Operations Ring (ECOR), a critical feature in an environment as structurally taxing as the asteroid belt. In order to provide variable gravity levels to accommodate for residents and processes that thrive in 1G, we have designed six spokes emanating out from the main circumference of the residential torus. These areas descend from our residential "ground level", and are designed to be the structural inner sanctum of Astoria, safe for vital power and computing systems, safe for educational purposes, and safe as a port of entry for transient populations, and emergency contingency measures. As an added bonus, no spokes impede into the residents' view of space from their communities, greatly reducing the disorientation brought on by the Coriolis effect.

2.1 External Configuration

Structural stress and maintenance costs are greatly reduced at an artificial gravity level of less than 0.9g. Thus, we have designed Astoria with the majority of the rotating volumes providing a gravity level between 0.83g and 0.86g, with only 32% of the rotating volumes located at a higher gravity level. The ECOR's safety-enhancing hull composition shelters the operations volumes as well as shielding the residential torus and interior spokes to protect Astoria's residents and the Foundation Society's investment. Interior spokes provide full-gravity for healthy child development without disrupting the terrain and long lines of sight in the residential torus. Our shuttle system facilitates a gentle transition between the rotating residential torus and interior spokes and the non-rotating ECOR.

Interior spokes are attached to the outer edge of the residential torus (See Figure 2.1.2). These interior spokes provide full gravity areas as well as facilitating evacuation measures and transportation between the torus and the ECOR. Minor spokes attached to the outer hull of the ECOR arc out around the torus.

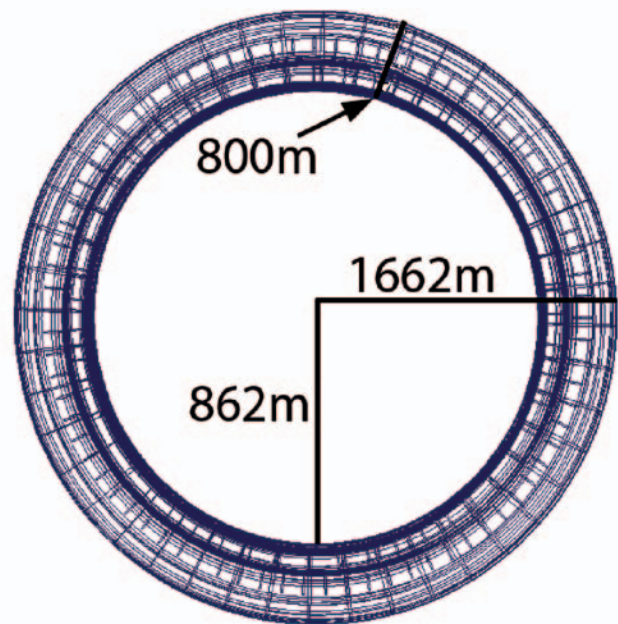
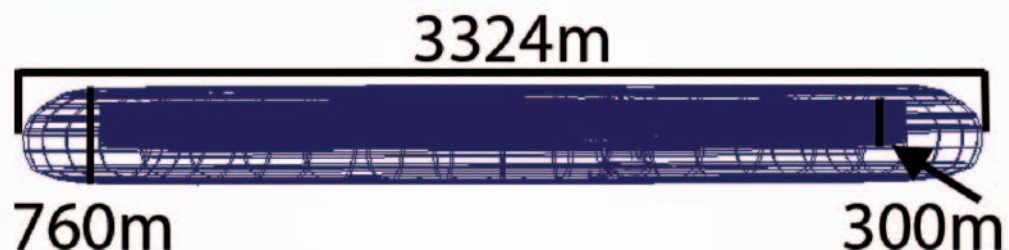


Figure 2.1.1 Astoria's sans-spoke design decreases vulnerable surface area while our enveloping concentric operations ring shields the residential volumes.



Structure	Surface Area	Volume
ECOR	70905312m ²	1163046715m ³
Residential Torus	11938052m ²	126782113m ³
Interior Spokes	4365880m ²	60053027m ³
Total	87209244m ²	1349881855m ³

Table 2.1.1 We provide ample space for industrial pursuits with room for expansion.

Micrometeriod shields (see 2.4) move along these minor spokes to protect the torus from impacts. These minor spokes arc out to provide a 10-meter cushion of open space between the spokes and the ceiling of the torus (see Figure 2.4.1).

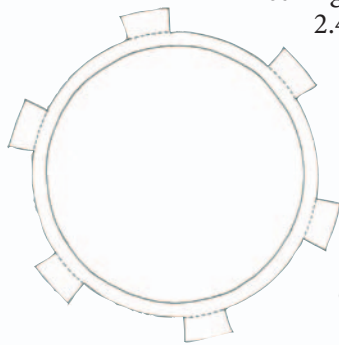


Figure 2.1.2 Rotating volumes provide varying gravity levels for resident comfort.

2.1.1 Volume Allocation

Other mining ventures in the asteroid belt require rapid and efficient refining and manufacturing services which Astoria provides with its strategic volume allocation

(See Figure 2.1.3). Our layout allows ore to move seamlessly from docking through the refining and manufacturing areas, providing quicker refining turnover and maximizing

profit. Next, automated transportation

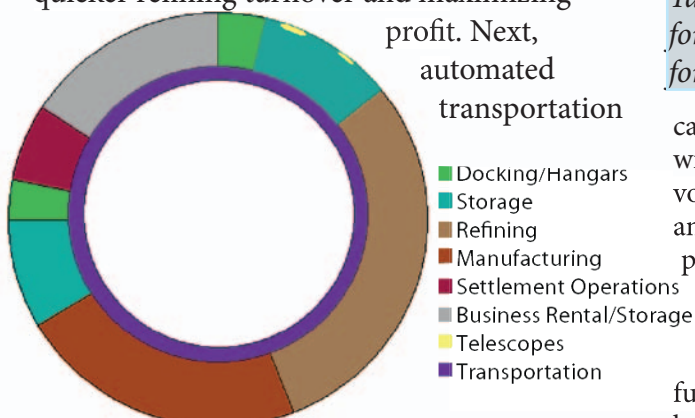


Figure 2.1.3 Astoria's ECOR allocation caters to the needs of a mining settlement with its large refining and manufacturing volumes.

rails provide an efficient means of movement back into storage without affecting the heavy industrial processes taking place. Situated within microgravity areas, business rentals augment Astoria's income, maximizing the Foundation Society's profit. Due to Astoria's focus on refining and manufacturing, we designed the settlement with 30% of the ECOR allocated for refining (See Table 2.1.2). This accommodates refining needs for both Astoria and other enterprises, provides room for future expansion, and allows for rapid refining turnover, reducing necessary storage areas.

As the ECOR houses refining, manufacturing, storage, docking, operations, and business rental, each with unique facility needs, Astoria offers a variety of pressurization levels. We pressurize approximately half of all refining, manufacturing, operations, and storage areas any given time. However, Astoria does possess the

Purpose	Percentage of ECOR	Volume
Docking/Hangars	6%	45622711m ³
Storage	21%	159679490m ³
Refining	30%	228113556m ³
Manufacturing	21%	159679489m ³
Settlement Operations	6%	45622711m ³
Business	16%	121660563m ³

Table 2.1.2 Our ECOR allocation provides room for industrial processes while setting aside plenty for business ventures and expansion.

capability to pressurize up to 75% of the ECOR with the use of atmosphere storage. All residential volumes, business areas within the ECOR, and the full-service repair depot maintain full pressurization. A second set of structural rings within the ECOR provide opportunities for future expansion, envisioning the addition of a second residential torus at some point in the future when demand for Astoria's services increases beyond the current capacity of the settlement.

2.1.2 Hull Composition

Northdonning Heedwell is aware of the highly taxing environment of the asteroid belt, and engineered Astoria's hull with the debris and solar radiation in mind (See Figure 2.1.4). Additionally, Astoria's hull composition makes use of the plentiful resources on our target asteroid, Ceres 1, greatly reducing construction costs. Nextel Aerospace Fabric stretched taut over a matrix of Kevlar poles coated in Aeropoxy 458 enables maximum shock absorption, causing much less fracturing than a standard concrete hull as the empty space below the fabric allows it to bend and stretch to absorb the impact (See Table 2.1.3). Beneath this, a silicon carbide matrix filled with self-healing carbon nanotube-reinforced

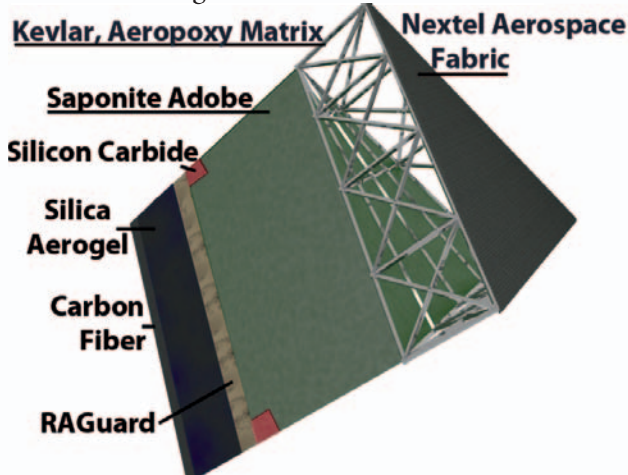


Figure 2.1.4 Our specially engineered hull provides maximum protection from micrometeoroid impacts.

Material	Purpose
Nextel Aerospace Fabric	Hull, micrometeoroid shields
Kevlar	Matrix in hull, micrometeoroid shields
Aeropoxy	Matrix in hull, micrometeoroid shields
Saponite Adobe	Hull, micrometeoroid shields
Silicon Carbide	Latticework in hull, micrometeoroid shields
Carbon Fiber	Hull Interior
RAGuard	Radiation Protection
Silica Aerogel	Insulation
Sapphire Glass	Windows
Amorphous Iron	Structural rings, minor spokes

Table 2.1.3 Astoria's hull composition protects all volumes from the inhospitable environment of space.

Saponite adobe found on Ceres 1 acts as further solid shielding to provide residents with maximum safety from micrometeoroid impacts. Next, a thin layer of RAGuard acts as radiation protection, and a thin layer of silica aerogel insulates residents from the extreme temperatures in space. Finally, a layer of carbon fiber lines the innermost portion of the hull to finish of the surface. A clear ceiling in the residential torus utilizes two panes of strong, scratch-resistant sapphire glass with a layer of RAGuard in between, the combination of which allows for exceptional views of space while maintaining a safe living environment. Also between these layers lie OLED lights to provide for day and night cycles (see 3.2.8).

2.1.3 Artificial Gravity

A magnetic propulsion system located between each pair of corresponding

structural rings (on the ECOR and the interior spokes) initiates and maintains rotation. This system also acts as a buffer for times when the settlement must move to avoid an impact (see 3.4).

A rotation period of 67.07 seconds

greatly reduces the Coriolis Effect in comparison to more rapid rotation speeds, providing a comfortable environment for residents (See Table 2.1.4).

Radius	Gravity	Velocity
932m	.83g	87.36 m/s
950m	.85g	89.01 m/s
967m	.86g	96.76 m/s
1117.5m	1.0g	104.7m/s

Table 2.1.4 Varying gravity levels accommodate comfortable living for adults and healthy development for children.

2.1.4 Structural Interface

We specifically engineered Astoria's structural interface to provide a gentle, safe transition to and from gravity to alleviate the effects of varying gravity on physical health. Set between the ECOR and the interior spokes, a reliable system of shuttles provides gradual transitions between microgravity and a 1 g environment (See Figure 2.1.6). We have designed a transportation network that moves residents, visitors, and goods in the safety found within the operations and residential rings (see Figure 2.1.5). Four types of

shuttles accommodate a wide range of needs (see 4.5). Commuter shuttles transport residents to and from work in the ECOR, accelerating or decelerating at an average rate of 0.116 m/s/s , allowing for a comfortable yet quick trip of only 15 minutes. Acclimation pods allow for much more gradual transitions for passengers who have been subjected to microgravity for long periods of time.

Those new to Astoria and daily commuters, enjoy a sophisticated, comfortable transfer between the ECOR and our home-like environment in the residential torus. Shuttles dock with the ECOR using the Lockwell system (see 7.3) where passengers load from a pressurized transfer depot. Once loaded, a blast shield seals the entrance to the ECOR, maintaining pressure and stable conditions within the ECOR when the shuttle moves out to the vacuum of space. The shuttle disconnects from the ECOR, leaving it connected via a fob to a magnetic propulsion track on the ECOR side. The shuttle then accelerates to the speed of the residential torus, slowly for commuter and acclimation shuttles but more rapidly for cargo. Propelled by a magnetic propulsion track, once up to torus speed the shuttles change tracks, disengaging with the ECOR track while fully interfaced with, and stationary in respects to the residential torus. A robotic arm then grips each shuttle and moves it into a specified docking area located beneath one of the interior spokes where another Lockwell system creates an airlock portal through which passengers and cargo disembark. To maximize efficiency during the unloading process, we have separate docking terminals to meet the needs of each shuttle: commuter to one spoke, acclimation to another, cargo to another, etc. This allows cargo to move through the more industrial spokes while keeping residents in more aesthetically designed areas.

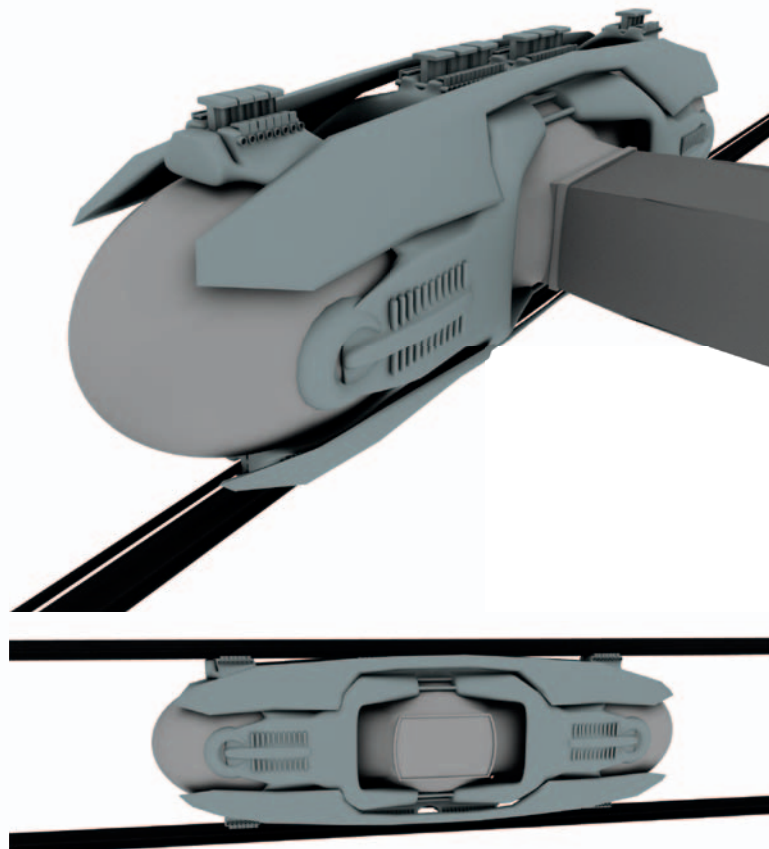
Northdonning Heedwell designed Astoria to be functional in



Figure 2.1.5 Our diverse set of shuttles run between the residential volumes and the ECOR.

every situation. With safety and versatility at the forefront of our design, we equipped the transportation volume with four emergency rails dispersed between the shuttle rails. These rails assure redundant accessibility to every shuttle. If sectioning off the residential torus is necessary, transportation capabilities are available in the lower levels of every interior spoke. In the event that docking is impossible, passengers transfer to emergency shuttles. Additionally, should it become necessary to evacuate residents from the residential torus and interior spokes, all shuttles may act as emergency vehicles. The shuttles can sustain passengers for two days.

Figure 2.1.6 Our shuttle system provides a gentle transition to and from gravity.



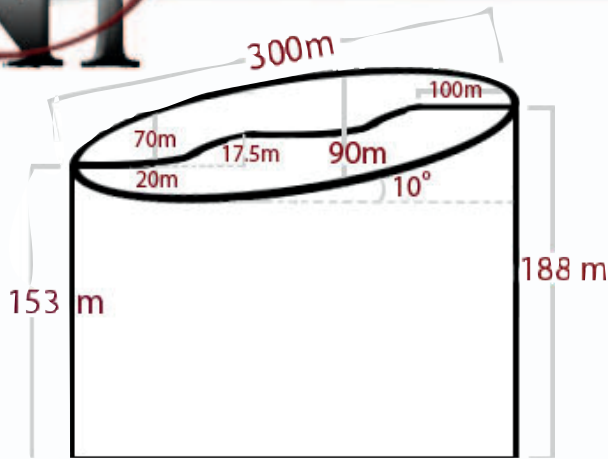


Figure 2.2.1 Terracing in the residential torus provides views of space long lines of sight.

2.1.5 Insolation Capabilities

In the event of damage to the torus or interior spokes, a hydraulic system propels blast shields up from the walls of each interior spoke. Upon meeting with partial blast shields stored within the outer edges of the residential torus, polymeric actuating gel (see 7.3) creates an airtight seal. The residential torus can divide into 12 separate volumes, six of which contain the interior spokes. If the situation requires evacuation, residents in the six spoke and torus sections evacuate through the spokes, and residents in the

Operations	12%	256591m ²
Transportation	4.3%	94027m ²
Full G Recreation	1%	23423m ²
Schools	1%	20133m ²
Life Support	17%	370236m ²
Computing	2.3%	49087m ²
Commercial Storage	10%	223313m ²
Storage	6%	125138m ²
Distribution	7%	147262m ²
Recreation	24.4%	534430m ²
Quarantine	2%	38025m ²
Personal Storage	12%	256591m ²
Total	59396m ² /level/spoke	2138256m ²

Table 2.2.1 Allocated down area in the interior spokes to maximize functionality.

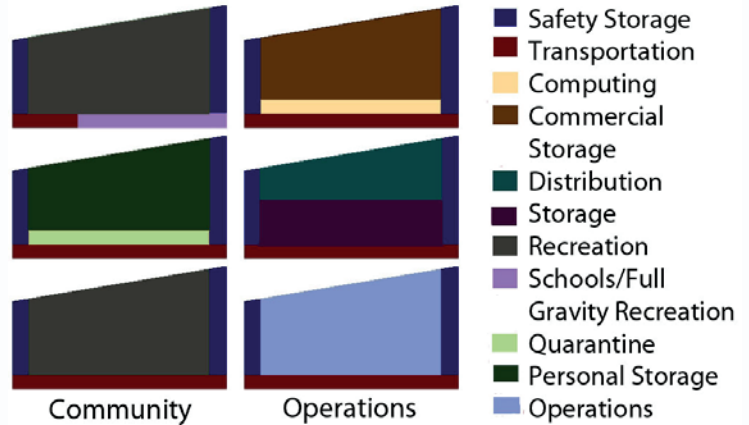


Figure 2.2.2 Interior spokes facilitate operations at a variety of gravity levels.

other six torus sections evacuate to the area beneath the terraces and proceed through airlock systems into the spokes. In this way, each spoke may also be sectioned off from damaged portions of the torus. Each volume contains its own life support systems such as climate control, water and waste processing, automations controls, medical facilities, and food storage, allowing Astoria to remain on-line and productive 100% of the time.

Figure 2.2.3 Our torus weaves residential, commercial, and recreational areas together for an Earth-like living environment.

2.2 Interior Configuration

Our well-protected torus is an embodiment of our community ideals: how and where we live must reflect the culture that makes us a successful business. Interwoven residential, commercial, and parks and recreational areas reduce travel time and provide an Earth-like atmosphere with a gradually blending landscape to accommodate diverse lifestyles.



Residential	35%	626748m ²
Commercial	35%	626748m ²
Parks/Open Space	24%	429770m ²
Agriculture	6%	107442m ²
Total	100%	1790708m ²

Table 2.2.2 Torus allocation promotes psychological comfort.

our torus features a landscape that weaves together residential, commercial, and parks and recreational areas (see Figure 2.2.3.). This layout allows a gradual shift from rural to urban residential options to appeal to a variety of customers while reducing travel time. Parks and recreational areas separate neighborhoods and commercial campuses into aesthetically themed communities, promoting unity of vision and an atmosphere of solidarity in the otherwise inhospitable locale of the asteroid belt. Agricultural areas lay on the upper terrace in the parks and recreational areas. Gray areas in the image show the location of blast shields for sectioning off the living volumes (see 2.1.5). The interior spokes are separated into six levels, each with roughly 28m of vertical clearance (See Figure 2.2.2).

2.3 Construction Sequence

What makes Northdonning Heedwell's Astoria a safe, hospitable and dynamic presence in the Asteroid belt begins well before the first residents arrive. In constructing the ECOR early in the construction process, we have equipped Astoria to begin generating revenue for the Foundation Society very quickly by setting up trade agreements (see 7.1) to refine materials for other mining ventures in the asteroid belt. Additionally, early movement capabilities protect the Foundation Society's valuable investment. The creation of Astoria begins at Bellevistat with the construction of our two-part Matriarch containing the initial mining infrastructure and the initial settlement infrastructure (See Figure 2.3.1). When the Matriarch reaches Ceres 1 in 2077, the mining portion separates to land on the surface of the asteroid and immediately begins mining

operations. The mining portion of the matriarch contains assaying and surveying robots (see 5.1) that assess Ceres 1 for optimal mining locations before mining begins. These mining facilities utilize a rail gun to transport mined ore to refining and manufacturing centers located on the main portion of the matriarch.



Figure 2.3.1 Matriarch is constructed at Bellevistat.

The first hull components to be constructed are the six main structural rings (See Figure 2.3.2). When Astoria is complete, these rings lie in pairs on either side of the transportation terminal within the ECOR, and two are located along the outer edges of the interior spokes. Because of the danger inherent in exposing a central core and spokes to the constant bombardment of asteroidal objects, we have placed the integrity of our structure within the confines of the operations and residential volumes.



Figure 2.3.2 Structural rings are crafted from amorphous iron.

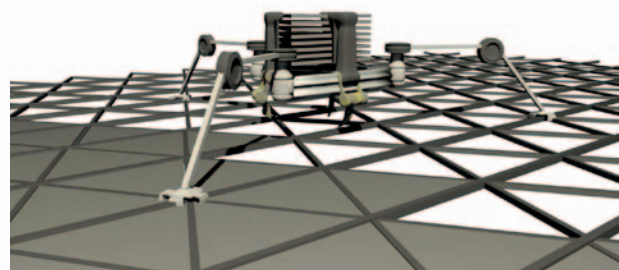


Figure 2.3.3 Tile-laying robot constructs outer hull of ECOR.



Made of amorphous iron, these structural rings provide a skeleton around which the remainder of the settlement is constructed.

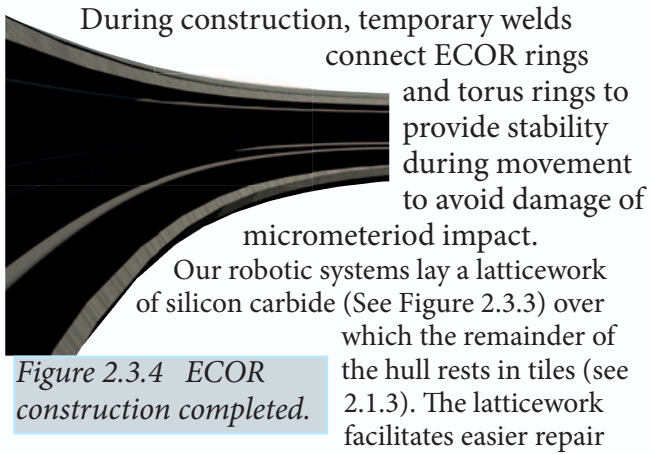


Figure 2.3.4 ECOR construction completed.

During construction, temporary welds connect ECOR rings and torus rings to provide stability during movement to avoid damage of micrometeoroid impact. Our robotic systems lay a latticework of silicon carbide (See Figure 2.3.3) over which the remainder of the hull rests in tiles (see 2.1.3). The latticework facilitates easier repair of damaged hull tiles during station operation. In this stage, micrometeoroid detection and protection are installed simultaneously with the construction of the minor spokes and propulsion systems. The minor spokes, made amorphous iron and coated with carbon nanotubes, provide a skeleton for the micrometeoroid shields (see 2.4) to move along. A full 92% of the materials used to construct Astoria are mined from Ceres 1. Using these materials, contour crafters build interior infrastructure

Our construction sequence increases the Foundation Society's profit by generating revenue early in the process.

(see 3.3). A short three years into construction, Astoria is capable of moving to avoid impacts from asteroids and micrometeoroids, protecting your investment from damage in the crucial early stages of development. A gas-cooled thorium reactor transported aboard the matriarch powers all construction up to this point, when a larger thorium reactor constructed within the ECOR fulfills the growing power requirements of the settlement. Part way through the construction of the ECOR, Astoria begins creating revenue on site for the Foundation Society as its refining and

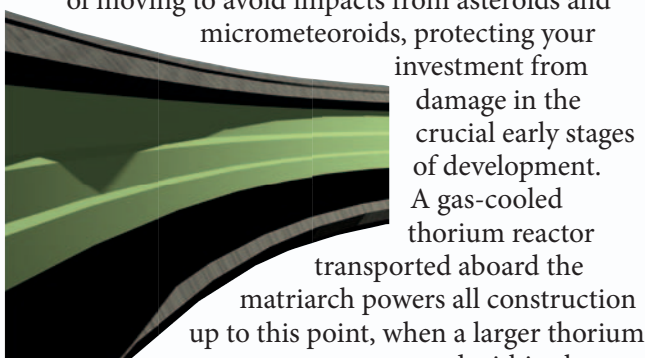


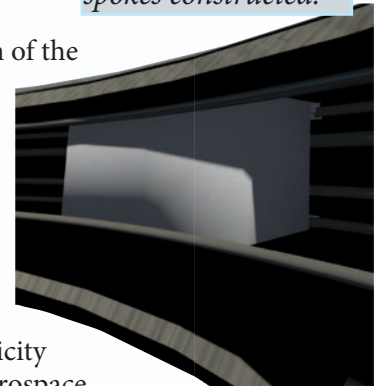
Figure 2.3.6 Residential torus constructed.

the Foundation Society as its refining and

manufacturing centers process ore from other locations. Additionally, Astoria sets up trade contracts with other ventures in the area very early in construction (see 7.1).

Figure 2.3.5 Interior spokes constructed.

As the construction of the ECOR is completed, the construction of the interior spokes begins (See Figure 2.3.5). Construction machines lay a framework of carbon fiber over which tile-laying robots (see 5.1) construct the spokes using our adobe, high-elasticity carbon fiber, and Nextel Aerospace Fabric system (see 2.1.3). Once the interior spokes are completed to the level of the residential torus, automated systems assemble and weld together the structurally triangular matrix into which tiles are laid. Sapphire glass (see 2.1.3) comprises the majority of the windows, along with RAGuard for radiation protection (See Figure 2.3.6). A thin layer of lead lines the walls of the computing areas to protect these vital systems (see 5.2.5). As one full g of artificial gravity poses additional structural stress on the interior spokes, the hull matrices and internal infrastructure



are thicker to provide additional stability.

At this point, robotic systems remove the temporary welds between structural rings, and a magnetic propulsion system (see 2.1.4) initiates rotation (See Figure 2.3.7).

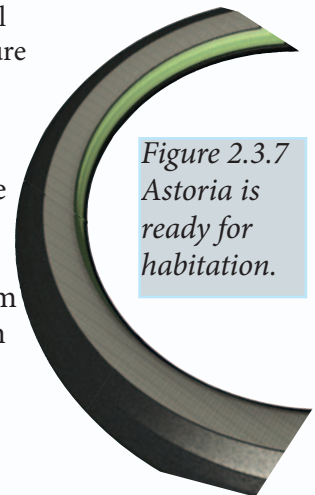


Figure 2.3.7 Astoria is ready for habitation.

Northdonning Heedwell next conducts a wide array of safety checks over a period of six months to ensure all volumes are safe for the future residents. Agricultural and climate control systems run for three months to provide a fully functional environment to residents upon their arrival. Final construction of internal infrastructure is completed. After a remarkably speedy 13-year construction sequence, the settlement is ready for habitation.

2.4 Micrometeriod Protection

Northdonning Heedwell specifically engineered Astoria's hull and micrometeriod shields to provide maximum impact protection with the high elasticity and shatter resistance of the outer layers and ensure the safety of her residents. We designed the base of the shields and minor spokes with a carbon nanotube coating. As carbon nanotubes reflect only negligible amounts of light, this coating minimizes disruptions to daily life, comfort, and productivity.



Astoria's specially engineered hull acts as micrometeriod protection to withstand constant peppering of dust and other small particles.

However, when faced with a larger threat (between 5mm and 11mm), micrometeriod shields stored over the ECOR move along the minor spokes (See Figure 2.4.1) using a magnetic propulsion system to interlock around and completely protect the residential torus. The use of a magnetic propulsion system eliminates friction between the minor spokes and micrometeriod shields, increasing the life of the system and reducing maintenance costs. These shields consist of the same materials and repair systems (see 5.2) as the hull, without the silica aerogel (see 2.1.3). An additional layer of

Figure 2.4.1 Micrometeriod shields protect the residential torus when impact threatens.

RAGuard lies beneath the latticework (see 2.1.3), allowing the shields to act as extra protection during periods of dangerously high solar activity. Blacking out the base of the micrometeriod shields and minor spokes with layers of carbon nanotubes greatly reduces the visual effects of rapid rotation. With no light reflection or emission, the sense of objects moving overhead at great speeds is negligible, allowing the settlement and its residents to function normally during times of shield deployment.

In addition to the passive protection systems of the micrometeriod shields and minor spokes, active systems dissipate the energy before the object strikes the settlement (see 5.2.7).

Astoria's unique design eliminates central infrastructure, greatly reducing the risk of damage to the settlement by decreasing vulnerable surface area. Furthermore, with a conventional central conduit and spoke design, the structural interface is confined to a small area. Astoria's unique design provides a larger structural interface area, eliminating torque and stress that would ordinarily fall on central spokes. Northdonning Heedwell's magnetic propulsion system lines the entire outer edge of the interior spokes and residential torus, greatly increasing structural integrity during movement.

2.5 Mining Camp Infrastructure

Northdonning Heedwell's portable drilling and pumping installation on Ceres 1 maximizes productivity in mining LH2 and LOX by allowing the installation to move whenever the valuable resources at a particular site are depleted, increasing the efficiency of the Foundation Society's major market in the asteroid belt.

A multi-directional drill allows the installment to mine water and other resources while retaining the integrity of the asteroid immediately beneath the installation. The installment contains mining equipment and repair services to ensure long-term functionality. Construction begins with the separation of the matriarch. The mining portion contains drilling and pumping machinery. A small gas-cooled thorium reactor provides power to the entire installation. Power is stored in individual pods after the integration of residential areas or may be used by mining equipment. Two Radioisotope Thermoelectric Generators (RTG's) handle peak loads and act as redundancy power.

The structure of the installation consists of high-strength metal composites including composites of iron and aluminum, which can withstand constant peppering from micrometeoroids as well as minor impacts. However, an exceptionally strong geodesic structure is deployed when the threat of a significant impact presents itself. The outermost portion of the installation hull is composed of tiles of Nextel Aerospace Fabric stretched taut over a carbon fiber matrix with a considerable buffer between this system and the remainder of the hull to protect the more vulnerable inner infrastructure in case of micrometeoroid impact. Automated systems replace any damaged tiles. As well as these passive shielding systems, the drilling and pumping installation employs the same active protection systems as Astoria (see 5.2.7). In the event of impact, the matrix (see 2.1.3) facilitates easy repair.

Three residential pods capable of completely sustaining five people each are transported aboard the mining portion of

the matriarch. As the installment grows, pod production continues at Astoria. Automated systems transport completed pods down to the surface of Ceres 1 where new pods integrate into the structure of the installation. Humans interact in the direct repair of machinery, the monitoring of automated systems, and the facilitation of remote repairs of more specialized robotics. Once the community size is large enough, the versatile pod design can be modified to allow for centralized storage areas, entertainment centers, etc. These pods are located beneath the installment infrastructure, protected from outside threats by the hull of the installation (See Figure 2.5.1).

The installation mainly extracts and packages frozen water, but is also a center for raw material mining. The raw

material mining allows most of the materials necessary for Astoria's construction to come directly from Ceres 1, greatly reducing initial costs (see 6.2). Northdonning Heedwell utilizes a system of glass paving techniques to cut down on airborne dust, but also provides an attachable surface for mining robots (see 5.4). The primary material harvested from Ceres is the rich frozen clay beneath the surface of a dusty outer layer.

Automated systems harvest frozen blocks of clay and transport it back the drilling and pumping station for launch to Astoria (see 5.4). Northdonning Heedwell takes advantage of

the highly lucrative mining of the asteroid belt by harvesting the valuable and profitable materials of Ceres 1, thus ensuring the Foundation Society receives a maximum return on investment.

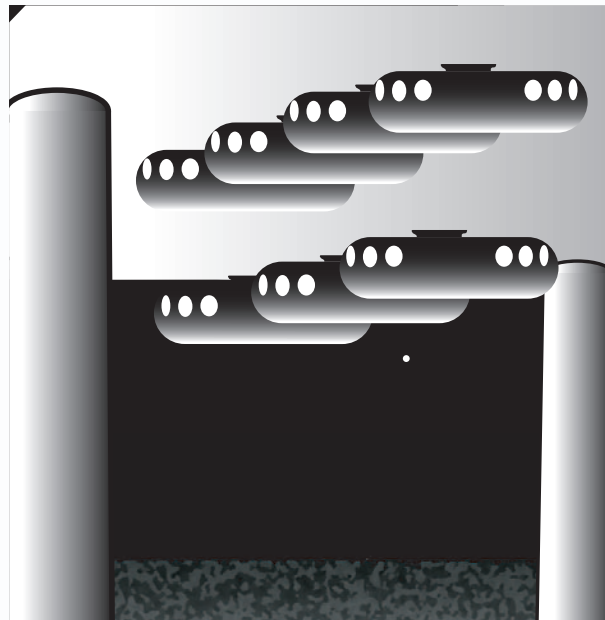


Figure 2.5.1 Residential pods beneath the installation afford exceptional protection.



3.0 OPERATIONS AND INFRASTRUCTURE





3.0 Operations and Infrastructure

By seamlessly integrating state of the art technologies with basic human needs, Astoria optimizes its operations while minimizing disruptions of normal flow. From an effective micrometeoroid evasion system to a comprehensive system of basic infrastructure, Northdonning Heedwell emphasizes maximum efficiency and productivity. Capitalizing on redundancy and diversity, Astoria ensures the safety and wellbeing of our residents and your investments.

3.1 Settlement Location and Sources

Located in the heart of the asteroid belt, Astoria capitalizes on in-situ mining, extracting a vast majority of construction materials directly from our target asteroid. Northdonning Heedwell recognizes the need for Astoria to serve not only as a lucrative mining center, but also as a hub to support future materials refining throughout the asteroid belt.

3.1.1 Orbital Location

Northdonning Heedwell strongly suggests the asteroid Ceres 1 as the focal point of both Astoria's orbit and mining operations.

Located approximately 2.7663 AU (413,832,587 km) from the sun, Ceres 1 offers the optimal blend of size and composition necessary to maintain lucrative mining endeavors for decades. As the largest object in the belt, Ceres 1 features unique structural differentiation, including a carbon and iron-rich crust, an icy mantle, and a rocky core. Vast water resources allow extensive production of liquid hydrogen and oxygen, a vital and lucrative fuel resource marketable to space operations in Earth orbit, Mars, the asteroid belt and beyond.

Material	Purpose	Source	Amount (mTon)
CO2	Cellulose, Nuclear Coolant	Ceres 1	2288460
N2	Atmosphere	Ceres 1	208722.8
O2	Atmosphere	Ceres 1	642471.2
H2O	Water Supply, Liquid Hydrogen, Liquid Oxygen	Ceres 1	1068703.6
Bamboo	Interior structures and consumables, cellulose	Aeroponically grown	Variable
Nextel Aerospace Fabric 312	Hull, micrometeoroid shields	Ceres 1	247782
Kevlar (poly-paraphenylene terephthalamide)	Matrix in hull, micrometeoroid shields	Ceres 1	576740.1
Aeropoxy 458	Matrix in hull, micrometeoroid shields	Aresam (Mars)	4415.1
Saponite Adobe	Hull, micrometeoroid shields	Ceres 1	465505200
Silica Carbide	Latticework in hull, micrometeoroid shields	Ceres 1	392878.5
Carbon Fiber	Hull interior layer	Ceres 1	21325557.7
RAGuard	Radiation shielding	Aresam (Mars)	21802311m ³
Silica	Aerogel, Optical Fibers	Ceres 1	194976.6
Sapphire Glass	Windows	Ceres 1	66079782
Amorphous Iron	Structural rings, minor spokes	Ceres 1 (Saponite Clay)	57476022000

Table 3.1.1 By harvesting 96% of our materials form Ceres I, we dramatically reduce costs.



3.1.2 Sources of Materials

We harvest a majority of construction material directly from Ceres 1, dramatically reducing importation costs and diminishing your initial investment. Responsible for initiating mining operations, the matriarch contains all required facilities and automations necessary for settlement construction. Manufactured at Belvestat, the matriarch comprises of two gas-cooled thorium nuclear reactors, basic mining equipment and automations, a refining and manufacturing facilities, and a rail-gun ore transportation system. Propelled by ion thrusters, the matriarch rendezvouses with Ceres when its orbit achieves a maximum 3 degrees of axial tilt. This minimizes the distance traveled from Belvestat, as well as the likelihood of micrometeoroid impact during initial construction stages. The matriarch eventually fully integrates itself into the ECOR. The use of a matriarch consolidates the Foundation Society's investment into a central craft, capable of almost complete self-sufficiency.

3.2 Basic Infrastructure

Astoria'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

Akin to an altitude of 7,000 feet, an ideal pressure of 568 torr (11 PSI) ensures maximum residential comfort, while reduced oxygen levels significantly decrease the risk of fire. Activated Carbon filters – in conjunction with agricultural volumes - remove excess carbon dioxide from the atmosphere, while water reservoirs and humidifiers preserve a relative humidity of 35% - 45%. Pressurized storage areas have only trace amounts of humidity in order to maintain the integrity of stored products. Compressed air tanks contained within the spokes and ECOR provide an entirely redundant source of atmosphere, should the pressurized volumes be compromised.

A honeycomb matrix of ammonia-filled pipes integrated within the hull allows for

ambient temperatures of 20°-25° C. Excess heat siphoned from the nuclear power generators in the residential torus and ECOR warms high-purity ammonia running through the piping system, providing in-floor heating throughout both the ECOR and Residential torus. Likewise, the system draws heat from the nuclear power cooling system by enveloping the main coolant pipeline with an ammonia-cooled heatsink. This process dramatically reduces energy required for temperature control.

3.2.2 Food Production

Northdonning Heedwell revolutionizes food production systems through an innovative combination of aeroponics, cultured meat, and livestock. Integrated throughout the residential torus, aeroponics systems arranged in a space efficient three-dimensional grid facilitate the growth of all crops. Requiring no pesticides and recycling up to 98% of water, aeroponic trays triple crop yield through increased nutrient uptake, compared to traditional hydroponics and soil-based systems. Soy and rice crops provide a multi-faceted resource, offering various alternatives to traditional cow milk and cheeses; removing large livestock from food production dramatically reduces upkeep costs and supplies. A wide variety of essential

Gas	Percentage	Amount in Air (kg)	Amount in Storage (kg)
Nitrogen	77.97%	417445699.8	208722849.9
Oxygen	21%	128494251	64247125.8
CO2	.0286%	240620.8	120310.4 (Coolant)
H2O Vapor	1%	3441810.31	1720905.2

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

vitamins and minerals enrich the foods, limiting nutritional deficiencies. Versatile aeroponic trays also allow for community gardens and fruits trees interspersed throughout residential areas; the additional plant life enhances aesthetic appeal, while utilizing valuable space. All plants are either self-pollinating, or are pollinated artificially.



Cultured, or “in-vitro” meat provides an extremely efficient and cost-effective alternative to large livestock. With nearly identical taste and texture to traditional meat, cultured meat conserves space and resources, while featuring an elevated nutrient content. Through culturing tissue cells from almost any animal, in-vitro systems provide a nearly infinite variety of meats to suit all tastes and are considered entirely vegetarian. In conjunction with other protein sources, such as tofu and eggs, meat production systems help sustain all nutritional needs.

Automated harvesting systems within agricultural volumes (See 5.3.4) minimize human labor, providing a safer and more efficient collection process. Once collected, all food is packaged using a unique combination of compostable bamboo and Mater-B bioplastics, easily manufactured from resources grown on Astoria. Packaged food is delivered to processing and distribution centers (located conveniently beside agricultural areas) through a series of pneumatic tube lines. Distribution centers then supply urban businesses and residential homes, employing a similar series of pneumatic lines integrated throughout the settlement.

In the event of blight, Astoria maintains a multitude of storage facilities within each sectionable area of the torus. Maintaining a drier, cooler climate, specialized storage areas preserve food integrity and are capable of sustaining residents for over 18 months in the event of a crisis. Similarly, a central seed bank serves as a storage area for a variety of cultivars capable of completely replenishing Astoria’s crops as well as resupplying outgoing ships. A temperature of -18° C and a reduced oxygen

	g/person/day	kg/11,000/day	Allocation of Space m ³	
Sorghum	317	3487	14.9%	14426.16
Wheat	225	2475	10.59%	10253.2
Rice	125	1375	5.88%	5693.01
Soybeans	470	51700	22.1%	21397.2
Corn	50	550	2.35%	2275.3
Vegetables	687	7557	32.3%	31272.8
Fruit	250	2750	11.77%	11395.7
Total	2124	23364	100%	96819.85

Table 3.2.2 Astoria’s comprehensive food system provides a wide variety of foods to accommodate every taste.

environment delay metabolic processes within the seeds, thus drastically slowing aging and deterioration. The seed bank also provides a valuable research tool, allowing for an investigation of crops better suited to microgravity and space environments. This allows Astoria to continually improve its food production systems, maximizing the comfort and health of our residents and serving as an agricultural resource for further solar system expansion.

3.2.3 Power Generation

A series of state of the art nuclear reactors accommodate base load power consumption throughout Astoria. The six primary ECOR nuclear reactors utilize an innovative combination of CO₂ gas coolant and Thorium fuel pellets, optimizing operation in microgravity. In contrast, a CO₂-cooled, gravity dependent Pebble Bed Thorium reactor is utilized in the Residential volumes, providing both redundancy and diversity. Each reactor employs passive safety systems, embracing vital negative-feedback systems and reinforced containment facilities.

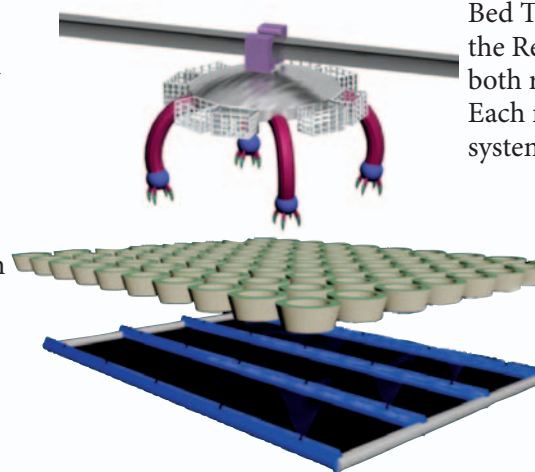


Figure 3.2.1 Aeroponic systems recycle up to 98% of water and triple yield over traditional methods.



System	Location	Number	Size (Total)	Rate/Unit
Nuclear	-	-	-	-
<i>Pebble Bed</i>	Torus	1	6cm pebble 14,158 m ³	50 MW
<i>CO2 Cooled Thorium</i>	ECOR	4	56632 m ³	125 MW
<i>RTG</i>	Torus	24	1056 m ³	
Hydrogen Fuel Cell	Devices	40,000	Dependant on use	1-5 kW
Piezoelectric	Micrometeriod Shields	24		Up to 30 kW
Flow Batteries	Torus/ECOR	20	9259 tonnes	54 W-h/kg
Radiators	Outer ECOR		3,000,000 m ²	30m ² surface area per m ² panel

Table 3.2.3 A multifaceted system of power generation and energy recapture maximizes resources.

The reactors are supplemented by a multifaceted system of energy recapture technologies. Piezoelectric systems are incorporated into the panels of micrometeriod shields, capturing impact energies; nanogenerators and hydropower takes advantage of water drawn “downward” by artificial gravity, recouping energy used in pumps. Compact hydrogen fuel cells power small devices far more efficiently than traditional batteries. Radioisotope Thermoelectric Generators (RTGs) integrated into each section of the spoke provide a redundant source of power capable of sustaining life support and transport systems in the event of an emergency.

3.2.4/3.2.5 Water and Waste Management

Astoria employs a state of the art water purification system to ensure a safe, clean supply for all of our residents. Thirteen treatment centers and storage facilities supply water to the Residential Torus, allowing each section of the torus complete self-sufficiency in the event of isolation. The incorporation of cutting edge waste management technologies, such as cotton nano-silver filters and brocadia anamoxidan bacteria revolutionize the process, maximizing efficiency. Capable of processing 300,000 L/ hour, the plants completely process water for human consumption in just 24 hours. Four primary water

treatment centers and reservoirs within the ECOR accommodate daily operations and resupply of incoming vessels and asteroid mining operations. Within each center, water undergoes either grey water or traditional water processing, depending on future allocation.

This allows Astoria to maximize its water resources while minimizing power consumption. Once a week, ORC's (5.3.4) gather household waste, all of which is highly recyclable. Solid waste is composed primarily of bamboo, silicates, cellulose, and other organic compounds. Recyclable materials are reprocessed, and organic materials are transferred to the biomass gasification plants, producing syngas and nutrients for both agricultural volumes and residents. Industrial solid wastes comprise of organic and inorganic compounds, and undergo appropriate recycling, reprocessing, or disposal.

Allocation	Storage Location	Amount Stored (L)	Water Processed/ Month
Residential	Sub-Terraces; Spokes	2219500	66585000
Agriculture	Sub-Terraces; Spokes	9641115	38564460
Operations	ECOR	350,000	Up to 350,000
Ship Resupply	ECOR	200000	Up to 200000
LOX/LH ₂ Production	ECOR	2000000	Up to 2000000

Table 3.2.4 Water storage areas ensure constant access to clean supplies.

3.2.6 Internal and External Communications

Fiber optic cables crafted from durable silicon oxide (SiO₂) provide high-speed internal communications. 25 terabit lines accommodate all residential communication needs; optical fibers greatly diminish maintenance costs and increase distance, resistance to electromagnetic noise, and bandwidth over traditional copper wires. To maximize data transfer and efficiency, wavelength dimensional multiplexing allows all station computers to transmit and receive data on 160 channels per fiber optic line.

Device	Bandwidth	Quantity
Atlas	7 GBps	11,000
Personal Computers	1 Tbps	16,000
Station Transmitter	250 Tbps	1
Wireless Hubs	10 Tbps	18

Table 3.2.5 High speed communication systems accommodate all communication needs.

Routers capable of broadcasting 60 GHz support the RCN (See 5.3.6), allowing residents access from any point in the settlement. Wireless connection is streamed from numerous transmitters and receivers from residential to ECOR, using a continuous band located strategically within the moving-to-nonmoving interface.

External communications are facilitated by a combination of lasers and radio waves. Capable of transmitting vast amounts of information, laser communications are supported by a series of strategically placed communication satellites located around Astoria, around the asteroid, and at various Lagrange points between the settlement and Earth. In the event of interruption, the system is also capable of transmit providing not only redundancy but also differentiation. Within the mining settlement, communications consist of fiber optics and radio waves.

3.2.7 Internal Transportation Systems

Astoria's internal transportation systems revolve around the innovative Züg pods. As one of the most efficient and quietest forms of transportation, the Zügs embody the essence of green travel. Human powered, the system requires less energy from its occupants than walking, yet is capable of attaining speeds of 20-70 kph due to minimal friction and an extremely aerodynamic, streamlined design. For those residents who require additional assistance, small motors can be attached. Completely automated control and guidance systems integrated within the track remove the possibility of human error, while allowing residents autonomy in their daily travel. A unique buffering system between Züg pods eliminates the possibility of collisions; rather, pods gently decelerate or accelerate upon contact with each other with no noticeable effects of whiplash. Suspended several meters above the terraces, the Züg system also eliminates the possibility of pedestrian injury. Homes,

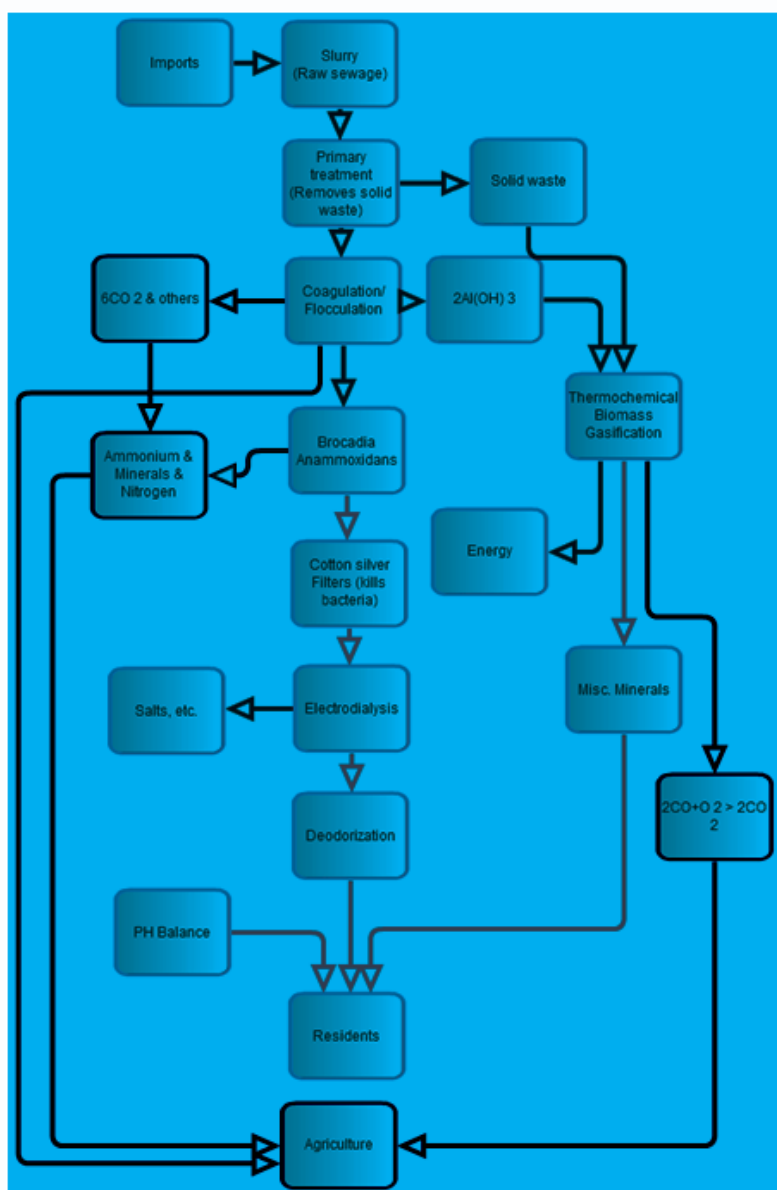


Figure 3.2.2 Astoria's comprehensive water and waste management system provides the safest and cleanest source of water.



Figure 3.2.3 Embodying the essence of green travel Züg provide a safe and clean alternative to train systems.

buildings, and various areas throughout residential volumes are equipped with elevated parking areas to accommodate the pods.

Each resident or family is allocated a Züg, tailored to fit individual circumstances. Capable of holding one to six occupants, Zügs are available in myriad sizes and customizable configurations. Automated Zügs facilitate First Responder Robot (FRR) and disabled persons transportation, working in conjunction with various automations to ensure absolute safety and access to emergency services for our residents. In the event of a malfunction within the Zügs, pods from behind can easily assist the stranded vehicle, pushing it to the nearest parking area with minimal effort.

Simple elevator systems facilitate transportation through the spokes. Capable of interfacing with the Züg rails, the elevators transfer both pedestrians and Züg occupants to various

levels of the spoke. Within non-residential spoke areas, the elevators are responsible for the transfer of goods and cargo throughout the spoke and into the residential torus.

3.2.8 Day and Night Cycle

A matrix of Organic Light-Emitting Diodes (OLEDs) panels integrated throughout the residential torus produces unparalleled ambient lighting. Capable of mimicking sun tones, the lights augment limited natural sunlight resources, realistically adjusting in brightness as the day progresses. Clear, paper-thin, and requiring less energy than even traditional LED's, the controlled lighting environment offers unparalleled nighttime views of space.

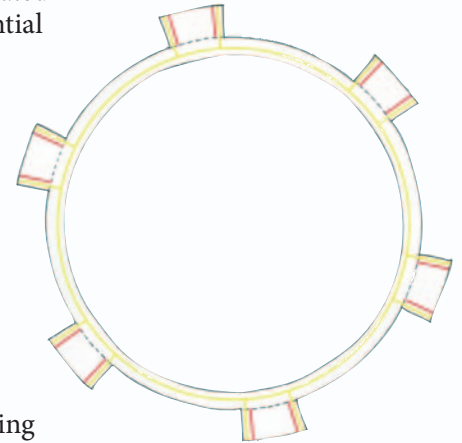


Figure 3.2.4 Extensive transportation routes provide convenient access to any location on the settlement.

	Quantity	Dimensions LxWxH (m)	Max Speed	Max Occupancy	Max Transit Time	Location
Zügs	9100	3.5x	25 kph	1-6	Arbitrary	Torus/Spokes
Elevators	48		15 kph	1-12	40 sec	Spokes
Commuter Pods	2 lines 12 pods	16x5x6	378 kph	72	15 min	Interface
Cargo Pods	3 lines 18 pods	40x40x6 25x25x6	378 kph	150	15 min	Interface
Acclimation Pods	2 lines 4 pods	40x15x6	378 kph	100	15 min	Interface
Emergency	4 lines 8 pods	16x20x6 16x10x6 16x4x6	378 kph	72	15 min	Interface
ECOR Pods			45 kph		9 min	ECOR
Conveyor Belt	Continuous System	--	Arbitrary	--	--	ECOR

Table 3.2.6 A simple but effective transport system facilitates travel to any location.



Glass layered with electrochromatic ion solutions filters light, providing clear, tinted, or opaque windows throughout residential areas. Occupants control all in-house illumination, maximizing their autonomy and comfort. Day-night cycles shift relative to seasons, catering to the unique circadian cycles of the residents throughout the year. In the event of an emergency, all systems are easily overridden to provide optimal lighting conditions.

3.3 Construction Machinery

Every aspect of our construction equipment capitalizes not only on efficiency, but also adaptability in the strenuous space environment. A standardized robotic chassis allows for a multitude of attachment configurations, tailored to the specific task at hand. Prefabricated refining and processing centers greatly expedite construction processes, allowing for the fastest initiation\of construction possible.

Exterior construction begins upon arrival of the matriarch (Structure 2.3; Operations 3.1). Mining operations on Ceres initiate immediately, expedited by prefabricated mining equipment contained within the matriarch. Rail guns located on the surface of the asteroid efficiently transport refined ore directly to processing centers within the matriarch. Eventually integrated into the ECOR, the main portion of matriarch serves as the central hub for initial construction operations.

Primary structural rings within the hull are crafted from amorphous iron, a variation of liquid metal proven to be more elastic and three times stronger than traditional steel. The beams are extruded within the matriarch; they are then floated into position and welded in place by universal assembly robots.

Unique adobe clay tiles reinforced by

carbon nanotubes form the bulk of hull (Structure 2.1); pressed, dried, and bound, these tiles are then set into a carbon fiber framework. Sapphire glass made from aluminum oxide is produced within glass manufacturing units. Cut into triangular prisms, the glass is arranged in geodesic patterns to form the ceiling of the residential torus.

Within the residential torus, a fleet of contour crafters constructs interior buildings from various materials such as modified clay from the

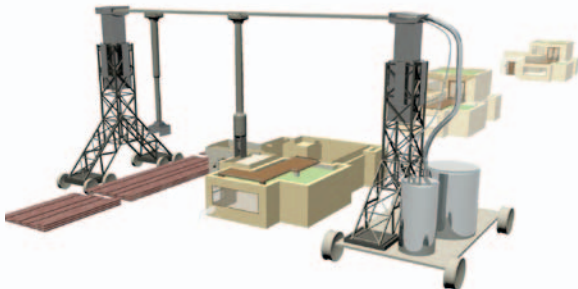


Figure 3.3.1 Contour crafters revolutionize interior construction, able to fabricate two homes per day.

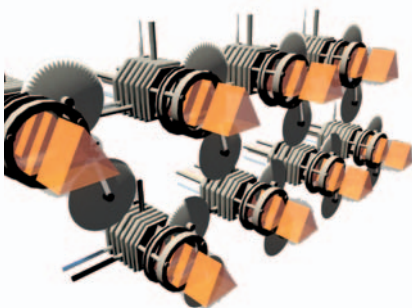


Figure 3.3.2 Glass manufacturing units quickly produce sapphire glass panels, expediting construction.

asteroid, cement composites, plastics, cellulose, and bamboo. Made from simple nozzles powered and moved by hydraulic systems, contour crafters provide a remarkably inexpensive system capable of building nearly two homes every 24 hours. IFR (see 5.1.2) then embellish contour crafted homes

3.4 Propulsion Systems

Northdonning Heedwell is fully equipped to respond to myriad threats presented by Astoria's rugged environment. Located strategically around the ECOR, a powerful series of fully articulated VASIMR engines is capable of moving the entire settlement over a mile in any direction in just 36 hours. In conjunction with cutting edge micrometeriod shields, the engines ensure the integrity of the hull and preserve your investment.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hours Daylight	9:50	10:30	11:24	12:33	13:35	14:20	14:30	13:56	12:57	11:51	10:46	10:00
Sunrise (am)	7:00	6:50	6:22	6:40	6:00	5:38	5:40	6:00	6:23	6:45	7:12	6:40
Sunset (pm)	4:50	5:18	5:52	7:12	7:36	8:00	8:10	7:56	7:23	6:37	5:58	4:40

Table 3.2.7 A seasonal day night cycle adds variety and maintains circadian rhythms of our residents.

In the event of a micrometeoroid impact warning, Astoria retains the capability to move over one mile in 36 hours, allowing ample time to evade all major threats. Through the use of VASIMR VX-200 engines positioned strategically around the exterior surface of the ECOR, the residential torus is completely isolated from unnecessary vibrations. Unlike engines placed on narrow center conduits - in which torque threatens to overwhelm the design's structural integrity - mechanical stress imposed on the ECOR is dramatically alleviated by the balanced distribution of thrusters. Additionally, the thrusters can be used to gently counteract movement of the ECOR caused by the rotating residential torus within.

Easily accessible hydrogen gas serves as the primary engine propellant; however the engines are versatile enough to accommodate a large variety of fuels with little reconfiguration. Heated hydrogen, expelled as plasma, is non-radioactive and the vacuum, oxygen-free environment eliminates the slight chance of hydrogen combustion. Multiple, small cartridges of hydrogen provide passive isolation in the unlikely event of combustion, and double as reusable fuel containment units. This, along with an abundance of hydrogen fuel, greatly facilitates simple refueling at any time.

Each of the six engines is fixed on a fully articulated, pivoting mount, allowing for movement in any direction at any angle. The start-up time of each engine is .6 seconds, with a success rate of over 99%, a far faster alternative to nuclear or chemical rockets. Putting out 5.7 Newtons of thrust at 72% efficiency, the engines coordinate a gentle acceleration and a constant velocity of .05 kph for 36 hours. Buffered by magnetic rotation systems between the ECOR and residential torus, the settlement experiences little to no noticeable

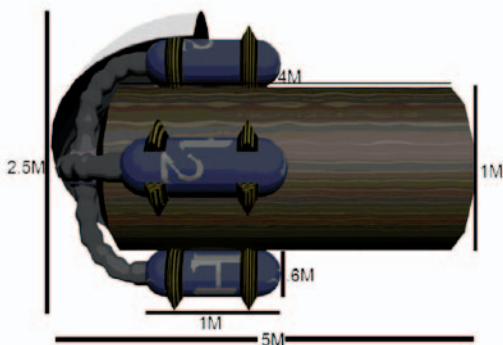


Figure 3.4.1 Able to move a mile in 36 hours, the VASIMR engines revolutionize micrometeoroid evasion.

changes in artificial gravity or vibrations upon movement. As an extra precaution, residents undergo a brief "lockdown" period during acceleration and deceleration, until a constant velocity is achieved. Very little fuel is consumed throughout the process, averaging only 200 mg/s per thruster at 200 kW - the maximum power output of one engine. VASIMR VX-200 engines are extremely conservative, expending only a fraction of the fuel traditional rockets consume.

Engines draw power from the central ECOR nuclear reactor, but are equipped with back-up generators in the event of a loss of power. The thrusters generate no direct waste, eliminating disposal risks of potentially radioactive or otherwise harmful by-products. Working in conjunction with micrometeoroid blast shields (See 2.4), the engines allow superior adaptability in any situation, ultimately maximizing the safety of your residents and material investments.

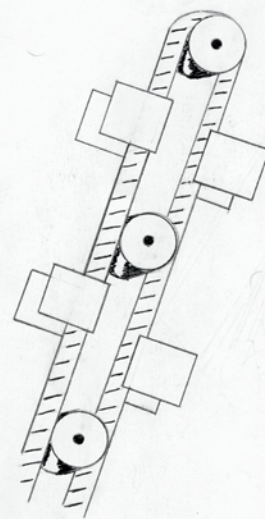


Figure 3.5.1 Our zero- G conveyor belt system allows Astoria to accept ore from multiple sources.

3.5 Port Facilities

Astoria's superior refining and processing facilities capitalize on efficiency and productivity. Capable of accepting ore from any source, Astoria sustains lucrative mining endeavors throughout the asteroid belt, thus pioneering new economical fronts in the pristine asteroid belt.

Upon arrival in the docking facilities, articulated robotic arms transfer ore packages from the cargo bay of the vessel to a unique microgravity conveyor belt system. Cargo packages are outfitted with a series of adjustable clamps and then mounted on the conveyor belt, accommodating packages of nearly any size; through the use of microchips embedded within each piece, the clamps monitor both the location and progress of cargo. Integrated throughout the ECOR, the conveyor belt system optimizes transportation to the refining facilities. Automated tracking systems in conjunction with chemical markers imprinted on each ore unit monitor the progress of ore through the refining process, allowing customers to oversee the processing of their shipments. This minimizes system errors, ensuring complete ore packages and maximum profit for our customers.



4.0 HUMAN FACTORS



4.0 Human Factors

Northdonning Heedwell emphasizes an acute sense of comfort and security for our residents. Views of space greet every resident from their doorstep while natural sunlight streaks across terraced gardens. Ours is a personalized, customizable community that makes for close-knit neighborhoods and culture-driven businesses flavored by the rugged individuals who choose to make their homes here.

4.1 Community Layout

Occupants thrive in the tight-knit community, formed through the incorporation of features that create a safe, earth-like atmosphere on our settlement. Our innovative and meticulously designed community, has been fabricated to allow residents to live a life style capitalizing on comfort and security.

4.1.1 Neighborhood Layout

Northdonning Heedwell provides residents with state of the art accommodations, offering neighborhoods with a multitude of housing options to suit our diverse population (See 4.2). Astoria's residential torus features a terraced design, which provides expansive views of space and long lines of sight; six interior spokes provide additional recreational and educational area in a full gravity environment (See 2.1). Environmentally conscious transport systems ensure a pleasant and efficient traveling experience. (See 3.2.7). Pathways, approximately 2% of the residential area, meander throughout the torus and spokes, connecting Astoria's park systems and offering a convenient option for short commutes, exercise, and community events like fun runs, parades, and socializing.

Green space includes sprawling parks and fields distributed throughout the settlement. Integrated throughout the station, plant life such as hypoallergenic trees and bamboo (See 3.2.2) create a botanical park-like environment. An expansive 24% of Astoria's residential area is dedicated to parks, promoting a connection to the natural world so vital to psychological health while innately advocating an active, low stress lifestyle.

4.1.2 Medical

Northdonning Heedwell prides itself on cutting edge medical facilities located strategically throughout the settlement. Twelve clinics and a quarantine area within each section of the residential volume supplement two medical facilities in the ECOR; the proximity of medical facilities offers the fastest emergency response and travel times from any location. Basic care facilities are dispersed throughout the mining installation; those suffering from acute conditions receive treatment and urgent care procedures either through a remote, physician-controlled IBMS procedure (See 5.3.4) or they may be immediately transported to Astoria's comprehensive healthcare centers. On Astoria, to prevent the spread of disease, each resident undergoes an initial quarantine process, followed by regular vaccinations and yearly checkups. Vital health surveying and feedback in the form of micromedical sensors (See 5.3.1) monitor daily health. In the case of medical emergency, residents may choose between being treated by a First Responder Robot (See 5.2.4) or waiting for human assistance.

4.1.3 Education

We recognize the need for a comprehensive education tailored to the settlement's unique environment. Located within a community spoke, school facilities offer a comprehensive education comparable to the finest Earth schools. Capitalizing on flexibility and adaptability, the curriculum allows each child the freedom to progress through lessons at their own rate under the guidance of qualified



Figure 4.1.1 The integration of amenities and residencies create an earth-like community.

teachers. Additionally, schools and surrounding recreational facilities double as a means of providing a full gravity environment for health development of children (See 4.4). A University located in the upper echelons of the spoke offers full bachelors and graduate degrees, with a focus on astronomy, mining, and other relevant fields.

4.1.4 Unallocated Property

A majority of unoccupied housing on Astoria serves both as storage for unused furniture and as instant move-in space for transient residents (See 4.5). In the event of an emergency and evacuation of one or more parts of the torus, unallocated houses can be easily redistributed amongst displaced residents. Astoria also offers unallocated land lots should you wish to install civil or spiritual service buildings.

4.1.5 Entertainment

Within the unforgiving space environment, entertainment is vital to the psychological wellbeing of our residents. As such, Astoria caters to a diverse range of activities and interests. A unique collection of urban amenities such as shopping areas, movie theaters, restaurants, and clubs supplement a vigorous array of recreational opportunities in both full and microgravity environments. A multifaceted assortment of galleries and theaters support artistic and musical pursuits; the most notable of these is the Astor Theater, named after prominent businessman and patron of culture, John Jacob Astor. Inclusive holographic systems allow residents to engage in exciting virtual games.

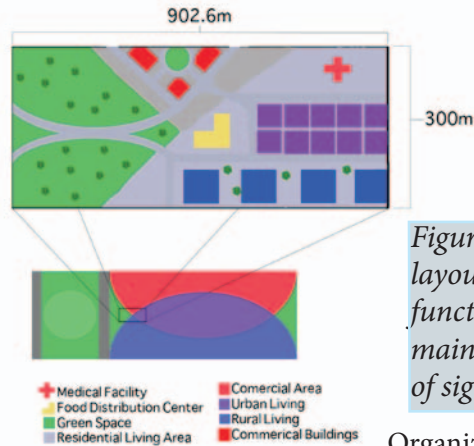


Figure 4.1.2 Astoria's layout provides functionality while maintaining long lines of sight.

Organized sports leagues, fields, parks, and gyms offer regular recreational activities for adults and children alike; additional space within the ECOR provides an exclusive opportunity for zero G activities and games, taking full advantage of the unique space environment (See 7.3).

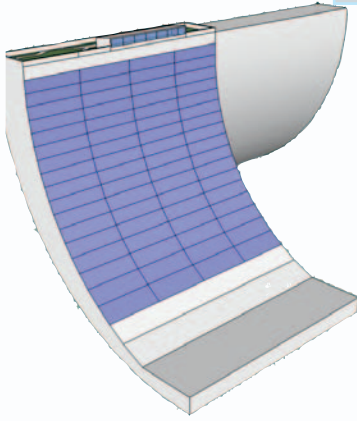
4.1.6 Distribution & Consumables

We pride ourselves on our ability to harvest a vast majority of our materials and consumables directly from our settlement and mining operations. Using a vast digital archive of schematics purchased from other locations, along with a constantly growing design library originating on our settlement, Astoria's contour crafters and other equipment facilitate a majority of consumable manufacturing, eliminating the need for regular supply lines. Consumables are easily transported from manufacturing areas through cargo shuttles and an integrated system of pneumatic tube lines, which deliver goods directly to distribution centers located beneath urban shopping areas.

Consumables	Replenishment	Production	Distribution
Food	362,520 kg/6000 people	Meat: 100% Cultured Produce: 100% grown through aeroponics	Pneumatic tube lines to distribution centers
Cloth	Bamboo and cotton supplies replenished according to need on a monthly basis	100% grown through aeroponics	Cargo shuttles and pneumatic tube lines to distribution centers
Toiletries	Replenished according to need on a monthly basis	Contour crafters utilize biodegradable materials grown aeroponically	Cargo shuttles and pneumatic tube lines to distribution centers
Paper	Replenished on monthly basis	Bamboo fibers grown aeroponically	Cargo shuttles and pneumatic tube lines to distribution centers

Table 4.1.1 A variety of distribution systems eases access to consumables, alleviating wasted time.

Figure 4.2.1 Large Modern - Earthy brick facades and open floor plans embody a sense of unity throughout the large modern home.



The distribution system includes grocery stores, large department stores and local businesses. Residents that own open space on their property may use this space to produce their own food and bamboo for either profit or consumption. Pneumatic Tube Lines are the main source of transportation for products going in and out of the Ops Core.

Figure 4.2.2 Modern Apartment - Affordable apartments promote comfort and flexibility for single residents through sharp, modern designs and customizable floor plans.



Dominated by five architectural styles at inception, housing options include apartments, single-family flats, large and small family homes, and duplexes. Each resident can choose to customize the

interior furniture, colors, and layout of their homes prior to arrival on Astoria. A number of pre-furnished homes allow instant move-in for short-term transient residents who elect not to customize their homes' interior. In the event of an emergency, a total of 1724 overflow residencies are available within the ECOR and torus to accommodate evacuees.

Figure 4.2.3 Rustic Italian - Capable of adapting to shifting demographics with a modular design, the Rustic Italian house accommodates any size family in a cozy, yet tasteful space.

4.2 Housing Designs

With just under 12,200 residencies in the residential torus, Astoria offers myriad customizable housing options, allowing residents the freedom to customize homes to suit any taste.

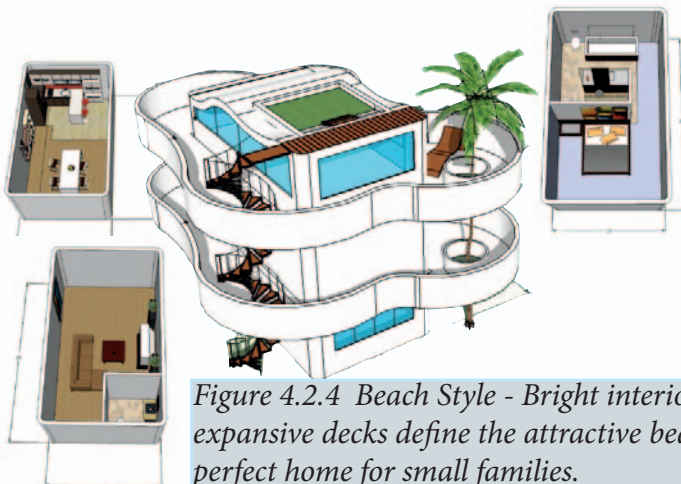
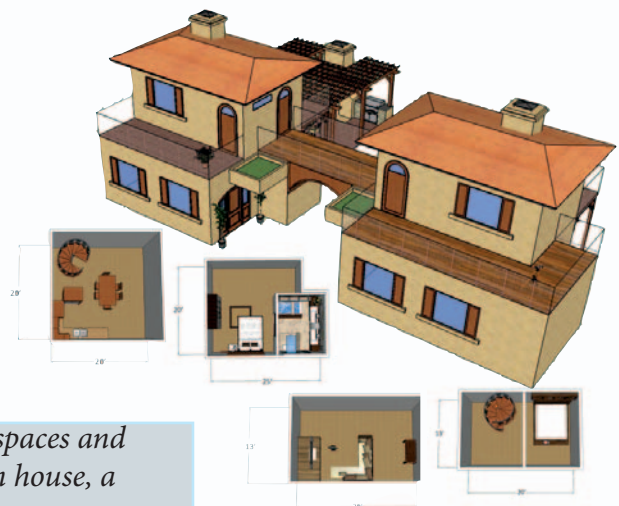


Figure 4.2.4 Beach Style - Bright interior spaces and expansive decks define the attractive beach house, a perfect home for small families.





On Astoria, all housing and appliances are manufactured from materials found on Ceres 1, to provide high quality products to our residents while, providing low costs to manufactures and consumers. Astoria's goods market place is unique in that residents no longer purchase material items, but rather download blueprints and instructions, which are then used to actually produce a material with the use of a couture crafter.

4.3 Safe Access

Northdonning Heedwell's diverse range of systems allows residents safe access within pressurized and unpressurized microgravity environments, minimizing transition times and emphasizing absolute safety in all endeavors.

4.3.1 Biosuit

The innovative biosuit improves comfort over traditional suits, allowing a full range of motion and increased productivity in unpressurized environments. Utilizing a series of small air bladders along the thighs, lower torso, arms, and lower back, the suit maintains a comfortable atmospheric pressure of 4.3 PSI. Lithium hydroxide canisters efficiently filter air, providing over 8 hours of oxygen and eliminating cumbersome tanks.

Residencies	Quantity
Modern Apartment	2312
Multi-Family Living Complex	3348
Italian Style Houses	3445
Beach Style House	1141
Large Modern House	205
Housing Style	
Modern Apartment Building	17
Multi-Family Living Complex	837
Italian Style Houses	3445
Beach Style House	1141
Large Modern House	205

Table 4.2.2 Housing variety provides means by which residents can live in a any lifestyle.

	Long-term residents (6000)	Semi-term occupants (5000)
Married adults 30%	1800	1500
Single Men 37%	2220	1850
Single women 27%	1620	1350
Children(under 18) 6%	360	300

Table 4.2.1 Astoria sustains a wide population of individualism while providing means by which residents have the flexibility to adhere to their own agendas.

	Area (ft ²)
Modern Apartment	900
Multi-Family Living Complex	1200
Beach Style House	1350
Rustic Italian Style House	1000/1500/2000
Large Modern Style House	1700

Table 4.2.3 Diverse housing options accommodate current and future demographic shifts.

To enable the wearer to work in comfort, the suit features strategic joints in the arms, hips, knees, and ankles to enhance movement. A large viewing window crafted of tough polycarbonates reduces glare and fog, increasing visibility. A series of lights embedded into the helmet and gloves allow the user to see what they're doing in low light conditions. Voice activated heads-up display controls vital systems and communications, keeping hands free for use. Compressed nitrogen propellant allows for speeds up to 2.7 m/s in any direction. A primary battery and secondary battery, each with an eight-hour lifetime, power all systems. The suits are constructed from durable layers of Mylar, Kevlar, and Nextel Aerospace Fibers - in conjunction with interior padding - to protect from radiation and micrometeoroids. Liquid glass coats minimize dust contamination, prolonging suit life.

Donning of the suit begins with 30 minutes of pre breathing 100% oxygen to ease the transition. The first layer to be added is an undergarment made from wool and polyester blended for warmth, next comes the air packs followed by pants, boots, a hard torso, arm sleeves, gloves, battery packs and finally the helmet. Doffing consists of a simple reversal of these procedures.

For more demanding situations, Northdonning Heedwell provides an armored space suit design. Based on the normal space suit, this

design features a strong outer shell made of Nitinol, an alloy of nickel and titanium that holds its shape in cold temperatures but becomes workable when warmed, creating suits that better fit the wearer.

Powerful hydraulics are integrated into the limbs of the suit, permitting the wearer to control loads of up to three tons and allowing them to conduct heavy repairs on the outside of the settlement. Despite their strength, high tech sensor technologies let the limbs react naturally to the wearer's movements, increasing productivity and human oversight in situations normally too harsh for human interaction. We are currently working on the addition of assaying and sampling tools to our armored suit at the behest of current mining operations in the asteroid belt and foresee such a complimentary mix of capabilities to revolutionize the current market in human-led asteroid mining endeavors.



Figure 4.3.1 Our bio suit integrates many innovative features that allow residents to remain safe in extreme situations.

4.3.2 Airlock System

Entrance and exit of the settlement is facilitated through the airlock system located on the outer edge of the ECOR. Dust mitigation (see 5.?) occurs during the pressurization and depressurization process, reducing donning and doffing time (see 4.3.1). Air lock systems consist of a revolving capsule that is pressurized and unpressurized when entering and exiting that maximizes safety and efficiency. On Ceres 1, personnel use the same revolving capsule air lock. However, due to the preponderance of dust, bio and armored suits are attached to the

interior of the capsule, making it so that the suits and their dust are kept in an isolated volume outside pressurized living and working quarters.

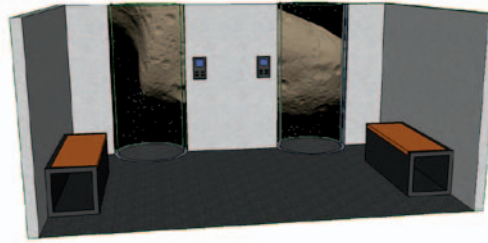


Figure 4.3.2 Astoria's revolving airlock allows residents to enter and exit the settlement with ease.

4.3.3 Tethering Systems

To provide safe access in zero g situations, either on the surface of our target-mining asteroid, Ceres 1, or on the exterior of the settlement, Northdonning Heedwell suits are capable of tethering to a modified ORC (see 5.1.1). An ORC fitted with passenger capabilities can transport one or two residents safely

along the surface of the asteroid or settlement. Each microgravity volume is also equipped with handholds and illuminated arrows set into surfaces to minimize disorientation and facilitate easy travel.

4.4 Full Gravity Accommodations for Children

Northdonning Heedwell, creates a safe and developmentally stable setting for resident's children through the integration of an innovative interior spoke design that creates a full gravity environment.

The safety and wellbeing of our residents are Northdonning Heedwell's chief priorities. As such, we have provided for a unique 1G environment in the safety of our interior spokes to ensure the healthy growth and development of our children. Full gravity environments encourage optimal bone density, immune system health, and the general well being of growing children while ensuring their safety.

Each residential spoke comprises myriad educational and recreational facilities, tailored to provide a full gravity environment for at least three hours of every day. Progressive, technologically oriented schools accommodate all children, age preschool through University grade levels. Daycare facilities care for infant through toddler-aged kids, the full gravity setting encouraging healthy development in a stimulating environment. Up until the age of 25, young people spend three hours or more within the spokes, thus maximizing developmental benefits.

Full-sized sports fields and courts within the spokes offer multifaceted options for exercise and recreational activity. Various shopping centers and family entertainment venues, such as theaters, restaurants, and parks, supplement school-time while providing convenient access to amenities for parents and other adults. Schools, in conjunction with other forms of entertainment, provide up to twelve hours daily of full gravity activities for children throughout Astoria. The facilities also integrate with Residential to ECOR interfaces, offering a convenient access to both jobs and schools for parents.

4.5 Transient Populations

As our settlement is one that naturally lends its self to movement, Astoria is designed to seamlessly integrate semi-term occupants in to communities. We realize that human acclimation from zero to full gravity can be an uncomfortable, and the subsequent integration into an established population can be a psychologically and physically taxing process. As such, our goal is to ease this physical transition by providing comfortable and efficient living areas for transient populations during acclimation and throughout their stay on Astoria.

4.5.1 Acclimation

Astoria's acclimation shuttles are equipped with all the necessities for a safe, comfortable, and efficient transfer between zero-g environments and the comfort of our residential torus. The shuttle service integrates the use of a highly innovative system of convertible rooms, which allow the passengers, to endure the process of acclimation while retaining the accessibility and feel of a larger living area. Provided in each living quarters, for entertainment, is a compact exercise center and a media entertainment center. Living quarters in our pods integrate the use of a moving wall system that allows passengers to rearrange their rooms to conform to varied purposes. Living areas contain small

kitchens, sleeping areas, an entertainment complex and a bathroom. While the acceleration of the pod system acclimates residents physically, the layout and earthly feel of the shuttles help reacclimatize residents mentally to the concept of living in gravity after their long zero-g space transit.



Figure 4.4.1 Promoting creativity and ingenuity, the school and spoke infrastructure melds seamlessly with a sprawling artificial tree.



Figure 4.4.2 Crowning the top of a community spoke, the outdoor Astor Theater serves as a center of culture and arts.

During the acclimation process, medical personnel visit each acclimation shuttle on a regular basis to monitor passenger health.

4.5.2 Transient Housing

Short-term occupants of Astoria are seamlessly integrated into the living communities in the residential torus. Transient populations are provided with all the same housing options as long-term residents on Astoria (see 4.2). Prior to arrival on Astoria, transient populations select their home style, neighbor hood, and interior design. Allowing semi-term residents to have the ability to instantaneously move in is a service we provide to pre-create a feel of ownership, a touch we feel goes a long way of welcoming new residents to Astoria.

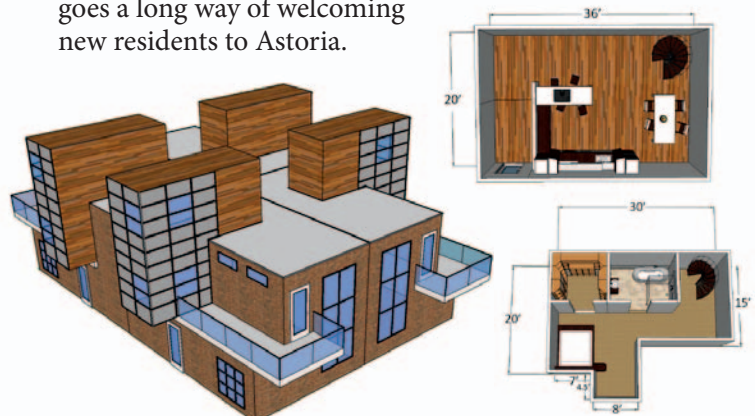


Figure 4.5.1 New residents are able to purchase homes pre-furnished for rapid integration into the settlement.



5.0 AUTOMATED DESIGN AND SERVICES



5.0 Automated Design and Services

The asteroid belt offers us vast reserves of untapped resources, but the great access to materials is hindered by an unforgiving environment. Deep dust, low gravity, high radiation and micrometeorites accompany such a promising arena, so we test and build our automated construction and mining designs to keep working under the most trying circumstances. While our machines prove their durability while extracting and assembling, the same attention to functionality applies to our internal safety and privacy systems. The result: unparalleled convenience and peace of mind in community, businesses, and homes.

5.1 Automation for Construction

Northdonning Heedwell has designed a revolutionary automated system for the construction of Astoria with the emphasis on efficiency, safety and cost effectiveness. With the use of an Omni-function Robotic Chassis we have created a system by which robots are cheaper and more efficient with the utilization of interchangeable parts, and universal systems, thus cutting down on cost and streamlining the operation of Astoria.

5.1.1 Automation for Exterior Construction

Northdonning Heedwell has revolutionized the construction process of Astoria, ensuring a timely and cost efficient completion of the settlement. Before the matriarch arrives, a series of satellites assays the area surrounding Ceres to establish the optimal location for the settlement.

These satellites also determine the ultimate location for mining based on mineral compositions of the asteroid. This ensures an on time construction of the settlement upon arrival. External construction of the

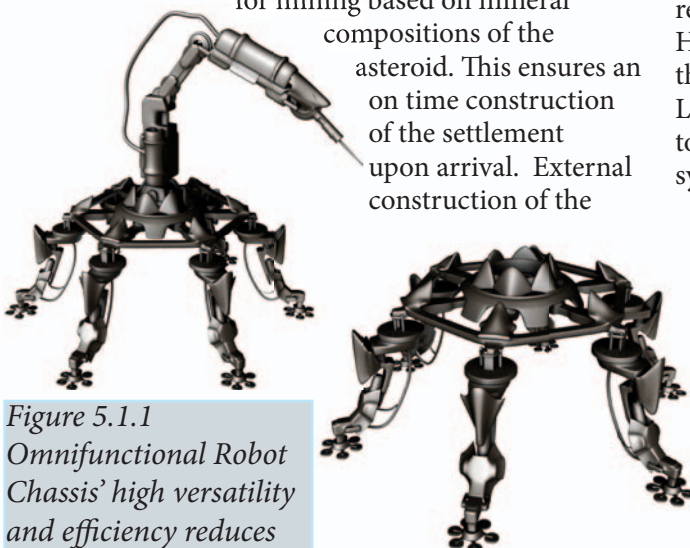


Figure 5.1.1
Omnifunctional Robot Chassis' high versatility and efficiency reduces cost.

settlement is facilitated by Omni-Functional Robotic Chassis (ORCs). The ORCs utilize a universal chassis enabling an extensive array of attachable arms. ORCs include attachments to complete welding, riveting, alignments of materials, and electromagnetic claws. Additionally, synthetic nano-pressure adhesives allow these robots limitless connection to all surfaces during construction.

ORCs work through every process of the construction sequence, thus cutting down on robotic costs, and streamlining the assembly of Astoria due to the limitless range of interchangeable parts and universal maintenance and repair. Northdonning Heedwell employs the use of Tile Laying Robots to provide an expedient and highly efficient system of installing hull tiles.

TLRs have tile shaped bodies in order to install, and transport tiles, for use on the matrix of the settlement. They align themselves over panel locations, drop the panel in to place, and arc weld it to the framework. The use of Omni-Functional Chassis and Tile Laying Robots guarantees the exterior construction of Astoria be completed in record time, saving time and money.

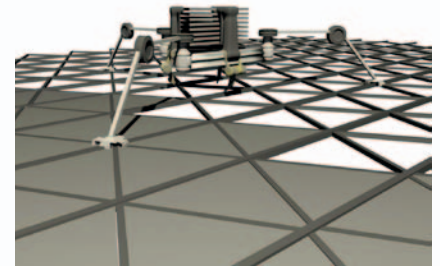


Figure 5.1.2 The shape of Tile Laying Robots increases precision and decreases construction time.



5.1.2 Automation For Interior Construction

Interior Finishing of Astoria includes state of the art automated systems including, ORCs, Interior Finishing Robots, (IFRs) Utility Laying Robots, and Contour Crafters. ORCs are re-equipped with attachments to construct terraces and the interior layout of the settlement. Refitted ORCs are used as Utility Laying Robots, running infrastructure lines and wiring throughout the terraces, and into homes. Northdonning Heedwell constructs homes utilizing Contour Crafters (see 3.3) to ensure an expedient and systematic finishing of the settlement.

Contour Crafters move throughout the settlement constructing homes and buildings at a rate of two per day. These contour crafters employ the use of pressure molding and materials layering in order to provide the quickest, cheapest, and most efficient method of interior finishing. Directly proceeding the contour crafters Interior Finishing Robots operate in small, constricted spaces such as within homes and buildings, where it completes all final construction tasks. IFRs paint walls, move furniture, install electronic systems, and install appliances in homes and businesses.

Robot	Function	Storage	Dimensions	Quantity
Omni-Functional Robotic Chassis (ORC)	Multifunctional Robotic Chassis with six legs, synthetic nano-pressure adhesives to adhere to any surface. Multifunctional attachments to assemble framework of ECOR, interior spokes, and residential torus.	ECOR, Residential Torus	3m x 3m x 2m	400
Tile Laying Robot (TLR)	Installs tiles for the exterior structural framework. Chassis in shape of tiles for easy placement and installation, includes arc welder to secure tiles.	ECOR	2m x 2m x 4m	200
Assaying and Reconnaissance Satellites	Satellites arrive on construction site, and survey the asteroid for optimal location of settlement. Communicates with Matriarch to provide detailed reports regarding exact composition of Ceres.	ECOR	.5m x .5m x .5m	12
Interior Finishing Robot (IFR)	Small, compact robot with attachments to complete interior finishings. Completes tasks including painting, aligning furniture, and maneuvering objects about the interior of small spaces.	ECOR, Residential Torus	.5m x .5m x 1m	200
Refitted ORCs , serving as Utility Laying Robots	Lays wires and fiber-optic cables as well as all tubing, ducts, plumbing, and infrastructure lines.	ECOR, Residential Torus	3m x 3m x 2m	150
Transport Rails	Transports materials throughout the station during construction of the settlement. Includes a rail system to efficiently transport cargo.	Adapted for use within ECOR for industrial purposes.	Encircles Astoria	1
Contour Crafters	Utilizes a combination of pressure molding, materials layering, and appliqué to construct and place all homes and buildings within the residential torus.	ECOR, Residential Torus	20m x 20m x 10m	50

Table 5.1.1 Astoria's automations systems for construction emphasize safety and productivity.

5.1.3 Automation For Construction Transportation

Northdonning Heedwell utilizes an automated transport rail to distribute materials across the settlement easily and efficiently. This rail encircles the ECOR, as well as traveling throughout the interior spokes, to provide a maximum distribution of materials. Carts travel along the rail carrying; secured materials, pre-manufactured parts, and smaller robotic systems. The Omni-Functional Robotic Chassis load and unload these carts at their respective locations. This transport system ensures Astoria is completed in the most efficient and cost effective way. After its completion, Astoria utilizes these transport rails within the ECOR to transport raw ore and materials (see 5.5, 3.5). The construction of Astoria is streamlined and accelerated, ensuring the Foundation Society saves money and time.

5.2 Automation for Maintenance, Emergency Repair, and Security Systems

Once Astoria is operational we implement a wide range of automated systems for the maintenance and repair of the settlement, security of critical data, computing needs, and protection from hazardous external constraints.

Northdonning Heedwell values the safety and protection of residents with the utmost of importance, and thus we have designed state of the art systems for protecting residents, and providing critical assistance during emergencies.

5.2.1 Automation For Maintenance and Repair

Northdonning Heedwell proudly utilizes the All Purpose Aerial Robot, a state of the art new design in robotics. Integrated throughout the interior of the settlement are the APARs, with 360-degree camera vision to allow supreme

assessment of the entire settlement. The APARs are constantly flying throughout the structure scanning the settlement for problems, and likewise receive commands from the Central Robotic Command Center. The APARs monitor atmospheric conditions, scan for gas leaks, and monitor pressure levels. The APARs fly to areas in need of repair, upon arrival the APAR fixes broken items with the use of several multipurpose arms. For repairs and maintenance of internal infrastructure lines, Astoria utilizes refitted IFRs, because of their small, compact size. The IFRs pass throughout infrastructure lines ensuring integrity of Astoria's substructure. Exterior Maintenance and repair is facilitated by refitted ORCs. The ORCs travel about the exterior of the settlement, by use of their synthetic nano-adhesives, scanning the structure for deficiencies and problems. They are equipped with tiling to replace and repair damaged tiles on the exterior. RAGuard coatings and high strength liquid metals protect the robots on the exterior of Astoria from harmful solar flares and micrometeorites. Astoria includes a fleet of repair robotics, maximizing efficiency, and ensuring the safety and maintenance of The Foundation Society's investment.

5.2.2 Automation For Security and Access of Critical Data

Northdonning Heedwell uses various security measures to ensure Astoria's matrix of critical data is safe. Upon arrival on to the station, every resident is issued a personal account on the

Residential Computing Network (RCN) (see 5.3.1). Each resident has a predetermined level of access capabilities, based upon professional qualifications and certifications. We rely solely on the extremely successful combination of an iris scanner and a facial vein-mapping system. Residents use these scanners to gain access to personal computers and files, work stations, and home networking systems, and for those qualified, secure and restricted areas, housing settlement operations systems, and The Central Robotic Command Center.

Since every single person has a different iris and vein pattern, security protocols are unassailable.



Figure 5.2.1 All Purpose Aerial Robots fly through Astoria, scanning every facet of the settlement.



The vein and iris patterns of people with access to the most critical data, or control areas are the only patterns programmed into scanners, thus ensuring maximum safety and security. In the rare event the resident is denied access or a scanner malfunctions, access is granted via medical sensor identification. Medical sensors also assure the person is not being forced against their will, or that another person is using their body for access, through a process of reading stress levels and vital signs.

5.2.3 Automation For Backup and Contingency Plans

Astoria utilizes various contingency systems to ensure the safety of residents and personnel throughout all facets of Astoria's operation. In the case of major problems such as hull breaches, infrastructure malfunctions, and micrometeoroid impacts on the settlement, our APARs fly to the respective locations requiring assistance. That area is immediately isolated, thus ensuring the fastest method of safety. In the event of a hull breach or micrometeoroid impact the APARs fly to the location and rapidly apply an instant cure epoxy foam to all layers of the hull. Simultaneously, and in constant communication, exterior robots, ORCs, respond to the hull breach to provide exterior repairs. When the breach is no longer venting atmosphere the ORC replaces exterior tiles and completes necessary repairs, while the APAR completes internal repairs.

5.2.4 Automation For Safety of Residences and Personnel

Northdonning Heedwell values the safety of residents and personnel, and therefore utilizes a multitude of security and medical automations. The All Purpose Aerial Robot (APAR)(see 5.2.1), flies throughout the settlement constantly scanning and monitoring situations. To handle security threats the APAR is equipped with two tranquilizer guns that fire small capsules containing a potent tranquilizer to seduce obstreperous persons. The health of residents aboard Astoria is of utmost importance, Northdonning Heedwell employs state of the art medical automations to help residents live

productive and healthy lives. To monitor the health of residents, micro-medical sensors (see 5.3.1) are ingested in order to assess internal health threats, and similarly notify authorities when appropriate. In the event a resident becomes injured, or encounters a medical emergency a team of robots respond immediately to stabilize residents and begin exercising medical attention. Astoria utilizes First Responder Robots (FRRs), located throughout the settlement, to respond to medical emergencies in less than 60 seconds, while human doctors and paramedics respond to the situation as fast as possible. These robots are equipped with a multitude of medical devices and sensors such as defibrillators, pulse monitors, IV lines, and medicines that are meant to treat and/or stabilize patients. If further advanced medical assistance is needed, Medical Transportation Robots transport patients to the nearest hospital via the Züg transportation network. Astoria's three-tiered method of medical services ensures that all residents remain healthy and productive.

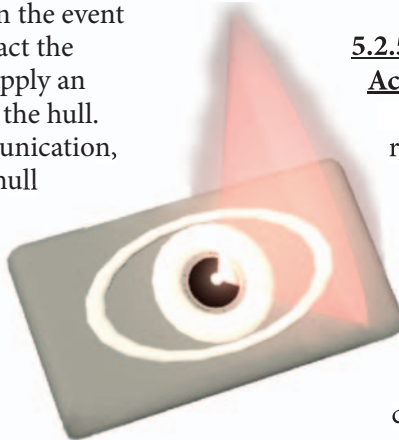


Figure 5.2.2 Security scanners through Astoria ensure protection of critical data.

5.2.5 Protection From Solar Flare Activity

To protect the external robotics employed on Astoria, an array of shielding and protection techniques are used in order to protect these valuable assets. All computing, sensory and communication devices are compressed into a smaller, more easily protected central area an interior spoke.

For radiation shielding, a layered blanket composed of RAGaurd, polyethylene sheeting, and a thin layer of lead surrounds the central processing center protecting it from harmful solar flare radiation. External robots also utilize RAGuard materials and lead coatings. In the case that external robots operate in heavy solar flare activity, some robots are equipped with systems that create magnetic force fields around these robots (see 5.4). This mitigates harmful solar radiation around robotics, and thus allows them to work efficiently at all times.

5.2.6 Automation For Settlement Operation and Computing

Astoria maximizes computational efficiency and power with the use of a Quantum Computing Mainframe (QCM). The QCM uses a distributed network to codify all automations and operations of the station, including medical, residential, security, and maintenance functions. This system standardizes the information transfer between all facets of Astoria, providing a coherent computing system. The QCM is a matrix of four interfacing server arrays, which process all computational demands of Astoria. Each server array is strategically located in the settlement, two in separate interior spokes, and two in the ECOR. In case of emergency, various sections of the settlement can be controlled independently by one quantum computer, which maintains life support and other critical computation functions.

Astoria's use of the QCM provides a comprehensive, fast, and highly efficient system of computing to ensure the operations of Astoria remains stable.

5.2.7 Automation For Settlement Dust Mitigation and Micrometeoroid Protection

Due to the harmful effects on airlocks, moving parts, and the health of residents Northdonning Heedwell has streamlined the process by which dust is both removed, and prevented from entering the settlement. This process begins with a multi-phase docking system. Arriving ships and residents pass through multiple stages, which provides a successive method of dust removal. These docking facilities include a vast array of mitigation techniques to ensure the settlement is dust free. Techniques include pneumatics, acoustic levitation, electromagnetic brushes and wands, liquid glass coatings, embedded vibrating actuators, and electrodynamic dust shields. These extensive measures ensure absolutely no harmful dust enters the settlement,

and thus allows Astoria to operate seamlessly. Every ship entering into the docking facilities of Astoria also experiences these extensive dust removal techniques. Exterior dust removal is facilitated by refitted ORCs, with an elaborate array of attachments these robots remove all dust on exterior surfaces. The multiplex of magnetic infrastructure on the exterior of the settlement

attracts considerable amounts of dust. These areas are equipped with charged electrodynamic dust shield fibers, which collect dust on moving objects of the magnetic infrastructure.

Northdonning Heedwell utilizes an extensive array of dust mitigation techniques, ensuring The Foundation Society's investment is a dust free settlement.

We provide the highest level of micrometeoroid protection on Astoria with the use of micrometeoroid shields (see 2.4), a system of moving the settlement (see 3.4), and an active robotic repulsion technique. Several ORCs

are refitted with elastic projectiles to act as energy absorbers.

When launched at incoming micrometeoroids these projectiles help to dampen and reduce the energy of impact, through dissipation and deceleration of the object, and thus ensure the minimal damage on the settlement. Northdonning Heedwell provides an incredibly vast array of micrometeoroid protection techniques to ensure Astoria operates safely at all times.

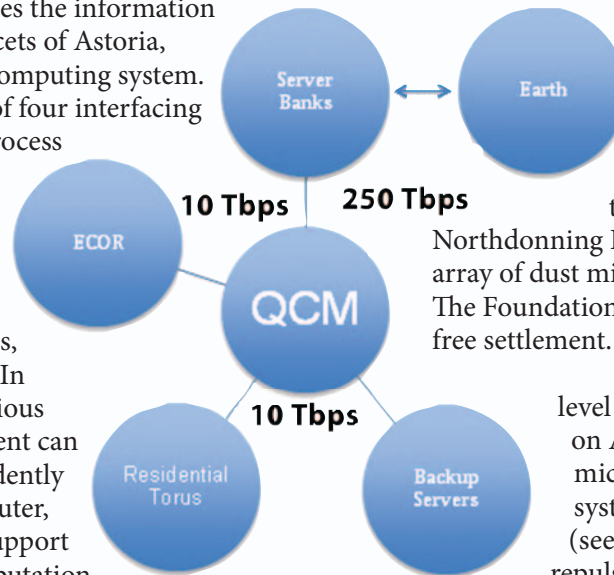


Table 5.2.3 Astoria's high speed bandwidth lines provide the maximum level of communications.

5.3 Automation for Enhanced Livability and Productivity

Astoria includes a vast range of innovative community automations to ensure residents of the settlement experience the highest level of enhanced livability and productivity. Northdonning Heedwell values the importance of a thriving social framework and distinct culture aboard Astoria, and we thus achieve this goal with the maximum level of attention on automations and design services.

Robot	Function	Storage	Dimensions	Quantity
All Purpose Aerial Robot's (APARs)	All Purpose Aerial Robotic Mainframe, flies throughout the settlement scanning all operations with a 360-degree camera. Also refitted for contingency and repair procedures. Equipped with multiple arms for a variety of safety functions. Handles security and emergency management.	Residential Torus	1m x 3m x 3m	250
Refitted IFRs	Refitted IFR's, compact size allows them to pass throughout the internal infrastructure scanning and repairing deficiencies when needed.	Residential Torus ECOR	.5m x .5m x 1m	75
Refitted ORCs	Operates on the exterior of the settlement providing external repair services.	ECOR	3m x 3m x 2m	100
First Responder Robots (FRRs)	Performs medical assistance, and emergency services throughout the settlement.	Residential Torus	1m x 1m x .5m	100
Medical Transportation Robots	Provides medical transportation to the Züg transportation network.	Residential Torus	2m x 2m x 2.5m	75
Quantum Computing Mainframe	Handles all settlement computing and data transfer.	Residential Torus	N/A	4

Table 5.2.1 Automations for enhanced livability ensure residents a comfortable, productive life.

5.3.1 Automation For Livability In The Community

Northdonning Heedwell has created a universal networking system to fuse together every aspect of the resident's lifestyles. The Resident Computing Network facilitates this process, and connects directly to the Quantum Computing Mainframe. Upon arrival all residents create a profile on the RCN (see 5.2.2), and receive an Atlas computing device (see 5.3.2) so they can control all facets of their daily lives. Residents can control an array of appliances using the Atlas computer and RCN network, including dishwashers, home lighting, refrigerators, home electronics, stoves, microwaves, etc. Residents also have the capability to schedule tasks such as food preparation, laundering, vacuuming, and light toggling, and can schedule these tasks via any terminal.

In such a closed environment such as Astoria, we recognize the vital importance of our residents' continued quality of health. The health of residents is of utmost importance at Northdonning Heedwell, and therefore, on a monthly basis, residents are required to ingest a micro-medical pill containing millions of microscopic medical sensors that

disperse throughout the bloodstream, and monitor bodily functions. When the sensors detect a health issue they notify the host resident, so they can decide what further medical attention is needed. At the end of every month these sensors are flushed naturally from the body, diminishing their affects on the immune system.

The educational system aboard Astoria is cutting edge, resident's encounter streamlined automations to provide ease of use in the educational environment.



Figure 5.3.1 First Responder Robots provide initial primary care to residents, maintaining the highest health standards.

Teachers have the capability of posting anything from lectures, class notes, and homework assignments on the RCN, making them easily accessible to all students at all times. Students can complete homework assignments, quizzes, and tests on any computer terminal, and turn them in for grading via the RCN. These methods help augment the teaching process of Astoria, and the exceptional educational standards of Northdonning Heedwell.

Astoria includes a new, and state of the art activity for the residents of Astoria with a robot combat game. Residents design and construct small robots for a weekly competition with other residents. Once a week, a tournament takes place in a safe and designated region of the residential torus, in which the goal of the game is to terminate all other robots, while preserving the operational capacity of their own robot. Northdonning Heedwell transforms the leisure activities available to residents with this fun and interactive activity.

5.3.2 Automation For Productivity In The Work Place

Astoria includes a thriving scientific and technical community, and thus provides multiple workplace conveniences. All residents receive an Atlas computing device when they enter the settlement. The Atlas is a small holographic computer, and it can be placed on any object the user wishes. It projects a touchable holographic display, which can be edited by the user for the desired dimensions and layout. This compact and interactive computing device connects wirelessly to the RCN network to provide Internet connectivity and access to other useful tools and entertainment. The Atlas also includes voice recognition and speech software allowing residents communication throughout all of the settlement.

For Astoria's large and prosperous working community a Business and Entertainment network or BEN, provides access to useful job and entertainment tools. This network allows residents to work anywhere in the settlement, as it is connected to

the QCM. Residents can collaborate in real time, or schedule times in which they can meet. The BEN is connected to the large Internet Databanks available on Astoria providing a limitless access to information and entertainment. The BEN network provides unthinkable flexibility when it comes to working and living on Astoria. The Integrated Biomechanical Suit (IBMS), outfitted with millions of microscopic sensors, allows the wearer to remotely control repair robots. This allows for human intervention in repairs, while greatly minimizing exposure to environmental dangers.

5.3.3 Automation for Convenience in Residences

Northdonning Heedwell provides an automated in home control system to ensure these environments are as luxurious and comfortable as possible. Residents can control anything from cooking meals, to washing dishes, to vacuuming, to cleaning clothes, etc. All of these typically menial tasks are completed via the RCN network allowing residents control of their homes and residences from anywhere in the settlement. Residents schedule these tasks to be completed automatically at desirable times, and similarly residents can manually control these functions by easily disabling the in house control system. The in home control system also monitors all critical functions of the home, including plumbing, lighting, heating, and other critical necessities. The system notifies the resident, as well as the proper authorities when there is a problem, at which point the resident can fix the problem themselves or request further automated assistance. If a part or tool is needed to

fix the home, the system contacts small contour crafters to manufacture the desired parts. The in home control system also acts as a fire suppression system during home fires. Homes are equipped with a network of high expansion fire suppression foam jets to quickly suppress fires, and additionally assist the residents with

an instantaneous and safe evacuation. Astoria includes these facets to make residences entirely customizable, and distinctly convenient.



Figure 5.3.2 The Atlas, a customizable computing device, provides universal access to the RCN.

5.3.4 Automation For Maintenance and Routine Tasks

Northdonning Heedwell provides a multitude of maintenance and repair automations as described in section 5.2.1. Included in these tasks are janitorial and cleaning services. The All Purpose Aerial Robots (section 5.11) fly throughout the settlement scanning for areas in need of services. The Central Robotic Command Center controls these robots and identifies when, and where janitorial tasks be completed. Astoria utilizes repurposed ORCs to serve as janitorial robots throughout the settlement. The cleaning and maintenance of the settlement is completed during the night so residents are not exposed to these automations. Northdonning Heedwell values a clean and sanitary environment aboard Astoria at all times, and fulfills this through fully automated services.

Agri-bots harvest food grown in the agricultural sections of Astoria. These robots are equipped with multiple articulating arms and collection bins. Agri-bots travel along aeroponics grids harvesting fruits and vegetables for settlement consumption.

These Agri-bots are entirely automated and therefore remove the need for human labor, providing the safest and most expedient food harvesting method possible. Agri-bots are also entirely sanitary, and are disinfected every few hours allowing them to monitor crops for disease, fungi, or any other deficiencies, ensuring Astoria has a consistent, and safe food supply.

5.3.5 Automation For Personal Privacy and System Control

The privacy of residents aboard Astoria is a high priority for Northdonning Heedwell, and therefore includes an array system control techniques. Access to all files and secure areas is granted through iris and vein scanners located on every computer terminal in the settlement (see 5.2.2). Every computing device is equipped with these scanners for the purpose of granting secure access. This extensive system ensures that all personal files and data

is secure, and that only qualified personnel have access to secure areas, thereby assuring the integrity of Astoria's control systems.

5.3.6 Automation For Settlement Computing and Communications

Northdonning Heedwell provides state of the art communications and data transfer techniques to ensure all residents have the full capacity for communication needs. In order to provide for Earth-based systems connectivity on Astoria, links with the Earth based Internet and data banks are kept open and updating at all times. Astoria utilizes a 250-terabit bandwidth, and the entirety of the Internet is obtained from Earth. Residents may access any websites or documents they please via the RCN network. All pages are only as old as the time lag between Earth and Astoria, and are constantly updating to provide maximum speed and efficiency. During breaks in communication due to solar flare activity or other malfunctions, user messages detailing the problem, and estimating the time until connectivity is re-established are sent to all inhabitants requesting access to the Internet via the RCN.

Northdonning Heedwell has chosen Astoria as the premier location for the research and development of quantum entanglement communications. Northdonning Heedwell in no way relies on this technology as means of communication. However, with considerable successful earth based research around this technology we have chosen Astoria as the focal point for the development of quantum entanglement communications. Just as John

Jacob Astor pioneered unsurpassed growth with his marketing and trade investments, we believe that Astoria sits on the edge of a momentous real time communications breakthrough, a breakthrough we want to provide to the Foundation Society.

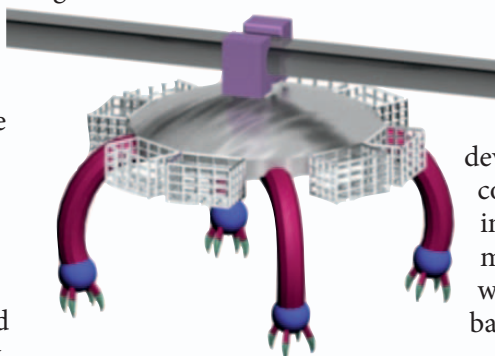


Figure 5.3.3 Agri-bots increase harvesting productivity while ensuring sanitation.

5.4 Automation for Zero-g Mining

Due to the immensely lucrative profit margin of mining in the asteroid belt, Northdonning Heedwell mines the asteroid Ceres with a system of fully automated mining procedures. Due to the high demand of liquid hydrogen and liquid oxygen the frozen water composition of Ceres is quintessential for our business pursuits.

5.4.1 Automation for Mining Operations

Northdonning Heedwell utilizes a new standard in zero-g asteroid material extraction with a network of drilling and pumping stations. Upon arrival at Ceres, we deploy one main drilling and pumping station to the surface, while an array of surveying and assaying units travel about the asteroid. These units evaluate the asteroid for the optimal locations for future mining areas and settlements, and thus allow Astoria to mine Ceres in the most profitable and accessible locations. The main drilling and pumping station harvests frozen water and ice beneath the surface of Ceres. A multidirectional drill mines below the infrastructure in multiple directions, so as to not jeopardize the integrity of the structure. Our heated drilling mechanism melts the frozen water and pumps it to the surface, where the slurry is filtered to remove unwanted impurities. The purified water is then pumped into containers in which the water re-freezes, ready for launch to Astoria.

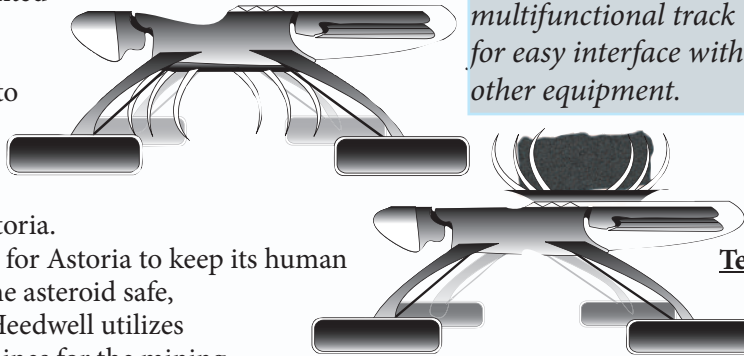
In order for Astoria to keep its human population on the asteroid safe, Northdonning Heedwell utilizes automated machines for the mining processes. The robots have universal chassis with various attachments, and modifications, thereby allowing an endless amount of zero-g robotic functions. With a universal chassis, it allows replacing parts on the robots much easier and uses fewer materials, thus streamlining zero-g automations. The surface extraction robot uses a shoveling attachment on the bottom side of the chassis. The shoveling attachment is comprised of a six-armed articulating grabbing hook. The grabbing hook extracts frozen blocks of clay underneath the dust layer of Ceres. After extracting a block of frozen clay it relocates the block above the robot, at which point it is picked up by an automated transport rail, delivering it back to the main mining outpost. This device also removes and fractures the paved glass layer around the desired mining locations. Paved roads made from heated glass provide for stable ground transportation, as robots are equipped with nano-adhesives to attach themselves to the paved glass surfaces. Ore buckets circulate along the transport rail capturing

the necessary ore blocks deposited by surface extraction robots.

5.4.2 Dust Mitigation

As robots return to the mining settlement on a daily basis, a wide range of dust removal and protection techniques are utilized to provide the highest level mitigation. Northdonning Heedwell coats all robots in liquid glass to maximize efficiency and effectiveness when removing dust. Electromagnetic arms capture the dust off the robots and dispose of it elsewhere, vibrating actuators embedded in the surface of the glass divert the dust off the coating, and electrodynamic dust shields provide additional assistance in removing dust. These processes maximize the mitigation of dust, therefore alleviating complications from dangerous dust particles.

Figure 5.4.1 The surface extraction robot utilizes a multifunctional track for easy interface with other equipment.



5.4.3 Automation for Zero-g Mining Techniques

Northdonning Heedwell employs only one drilling and pumping station for the initial operational years of Astoria, as well as one surface reclamation operation. This cuts down on costs, and ensures The Foundation Society takes maximum advantage of Ceres once the optimal mining locations have been established. Northdonning Heedwell does provide a wide array of zero-g robotic systems, both for sale and for future use on Astoria. Northdonning Heedwell provides a system of clay reclamation with the use of the surface reclamation robot, and glass paved surfaces to provide nano-adhesive connections (see 5.4.1). Additionally, Northdonning Heedwell sells a separate system for surface mining on any zero-g asteroid surface. This system utilizes a lightweight carbon fabric tent above the desired mining location, so as to ensure all materials tossed about via surface mining be captured within the tent. A surface mining robot works inside this tent, and stays on the surface with the use of liquid hydrogen propulsion systems.



If a client requests other mining robotics, or Astoria needs a new adaptation, multiple multifunctional chassis are equipped with propulsion systems to provide limitless opportunities with zero-g mining.

5.4.4 Protection from Micrometeorites and Solar Flares

Micrometeorites are a major concern when it comes to damage to robotic mining systems in the Asteroid belt. To protect and maintain operations and productivity of our fleet, we construct our machines out of ultra high strength amorphous aluminum, and carbon composites. When it comes to protecting our main extraction rig, Northdonning Heedwell employs a high strength, safe, and efficient magnetic field to protect from solar flare radiation. Directing the harmful particles from the flare around the force field, in addition to RAGuard hull components, makes this the most effective way to protect against radiation. For robots operating remotely, and out of reach from the magnetic field, an ultra high strength layer of RAGuard is applied.

5.5 Automation for Cargo Handling and Resupply

Astoria includes a highly efficient system of receiving, and transporting ore to refineries, as we believe this is the focal point for the successful industrial operation of Astoria. We include a method of ore transportation, and identification to provide the highest quality refining of ore received from various asteroid mining installations.

5.5.1 Automation for Unloading of Ore

Northdonning Heedwell has developed, as a solution for receiving ore, a compartmentalized storage container. This container has an integrated computer system for the labeling and processing of incoming ore depending on the majority of materials in that specific selection of ore, and the location from which the ore extraction occurred. This allows for expedient sorting and handling of incoming ore. As a self-propelled unit, the

onboard computer serves as a remote control for safe, easy guiding into docking range of the ECOR. Each compartment of this storage unit is temperature, and pressure regulated for safe and precise transportation of various cargos. Robotic arms magnetically attach to the storage unit and stabilize it in a zero-g environment, while hydraulic floor panels empty the cargo providing Astoria with a swift and efficient unloading of ore. Articulating robotic arms then sort ore containers onto correct transportation conveyor belts, leading to refineries (see 3.5).

Northdonning Heedwell is prepared to accept both ore in bulk, and container ore from other mining installations. A monitoring system automatically identifies and processes

incoming cargo by way of an integrated computing system.

Once identified and traceable, articulating arms load various cargo onto conveyor belts for transportation to refineries. The conveyor belt

handles ore in a zero-g environment with the use of universal securing technique (see 3.5).

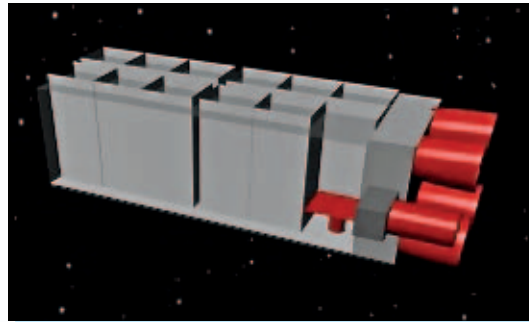


Figure 5.1.1 Astoria's cargo handling techniques allow handling of large amounts of business and trade products.

5.5.2 Automation for Refueling

As the focal point of the asteroid belt, Astoria provides the highest quality of refueling services. We provide an automated system to ensure precision, functionality, and efficiency for vehicles requiring refueling services. All docking areas are equipped with a series of articulating arms for the purpose of resupplying ships with valuable fuels. We understand the need for a variety of adaptations for refueling ships, including varying apertures, diverse pressure requirements, and multiple seals, as we expect numerous differentiated ship designs arriving at Astoria. The use of these articulating arms, and adaptations provides the highest quality in resupply services.



6.0 SCHEDULE AND COST



6.0 Schedule and Cost

Northdonning Heedwell recognizes that a project as immense as constructing Astoria weighs on both wallet and planner; therefore, we designed the station with cost reduction in mind. \$10 billion are saved by refining a majority of construction materials, and the return-on-investment is lowered to 18 years by jumpstarting business ventures through early sales of liquid fuels and property on the settlement.

6.1 Schedule

	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087
Contract Awarded																	
R&D																	
Matriarch																	
Construction at Bellivistat																	
Arrival and Split																	
Construction of Station																	
Initial mining																	
Structural Rings																	
ECOR																	
Propulsion Systems																	
Interior Spokes																	
Minor Spokes																	
Residential Torus																	
Rotation Initiated																	
Interior Finishing																	
Station Ready for Habitation																	
Shake Down Period																	
Population Fully Established																	



6.2 Cost

Phase	Items	Cost of Items	# Employed During Phase	Employees On Site
R&D	N/A	70,000,000,000		3,500
Matriarch	Large gas cooled thorium reactor	250,000,000	1,200	
	Small gas cooled thorium reactor	175,000,000		
	Basic mining equipment and automations	14,000,000		
	Basic refining and manufacturing facilities	10,000,000		
	Railgun ore transportation system	15,000,000		
	6 Structural Rings	4,144,000		
	Transportation	980,000,000		
	Cost of Phase: 71,448,144,000			
ECOR	Hull	120,000,000,000	1,800	
	Micrometeriod Shields	57,000,000,000		
	Minor Spokes	3,000,000,000		
	Propulsion Systems	667,000,000		
	Infrastructure	582,000,000		
	Refining and Manufacturing Facilities	487,000,000		
	Cost of Phase: 181,736,000,000			
Interior Spokes	Hull	17,000,000,000	1,300	
	Shuttle System	26,000,000		
	Infrastructure	50,000,000		
	Cost of Phase: 17,076,000,000			
Residential Torus	Hull	38,000,000,000	2,000	
	Blast Shields	10,000,000		
	Infrastructure	560,000,000		
	Cost of Phase: 38,570,000,000			
Interior Finishing	Automation	440,000,000	1,800	600
	Transportation Systems	301,000,000		
	Water/Waste Systems	112,670,000		
	Buildings and Homes	570,000,000		
	Atmosphere Systems	430,000,000		
	Communication Systems	592,000,000		
Totals	Cost of Phase: 2,445,670,000		Employees	12200
Total	Cost	311,275,814,000	Employees	12200



2.0 BUSINESS DEVELOPMENT



7.0 Business Development

Cognizant of Astoria's future as the central hub of the asteroid belt, Northdonning Heedwell designed the settlement with a strong, flexible marketplace in mind. Building from a solid base in mining, refining, and manufacturing, Astoria's aggressive business plan responds to emerging markets while maintaining dedication to mutually beneficial partnerships in the community of the asteroid belt. All of this is possible because of the success of Astoria's experimental communications systems, early detection and assaying systems and the safety inherent in the strength of its structural design.

7.1 Business Plan

A revenue stream begins the minute the contract is awarded with the early development of Astoria's real estate market. We provide incentives for future residents to pre-purchase property on Astoria by initially providing discounts and allowing completely customized house designs to be integrated into the settlement during construction. In order to lower the barrier to entry into the refining and manufacturing market of the asteroid belt, we send out a preliminary prospectus of our business capabilities to mining outpost, allowing aggressive entry into the market. Drawing business to the significantly lower prices offered by our asteroid belt based supply and service hub.

The sale of liquid fuels forms the next stream of revenue. During construction, materials and services are purchased from nearby small-scale operations on a limited basis. By offering fuel production services, Astoria sets herself up as a central resupply hub, predicting profit of nearly 25 billion dollars per year.

Once construction is complete, the full flow of revenue begins. Astoria serves as the home base to numerous smaller mining operations, providing them with supplies necessary to life that can't be easily produced on every asteroid; fuels, food, and atmosphere. Astoria provides significantly

lower costs than importation of these goods from LEO, providing a substantial source of solid profit. Multi beneficial trade agreements are established with frequent business partners, for example, our reserves of LOX and LH2 could prove to be a significant bargaining chip for rare materials like titanium. This creates an atmosphere of mutual

support. Also catering to the concentration of mining activity, smaller operations can purchase refining, manufacturing, and storage facilities along with highly specialized repair services. Astoria develops technology specifically designed for use in the asteroid belt and integrates it into all mining equipment, increasing durability, dexterity, and lifespan.

Within the settlement, business storage and operation areas provide opportunity for any entrepreneurial pursuits,

including softer ventures like entertainment, research and development, and laboratory pursuits pertaining to understanding the origins of carbon-based life forms. The variety of the business market drops the ROI to 18 years and caters to the individualistic mining culture prevalent here, without compromising the necessary cultural family fabric of Astoria.

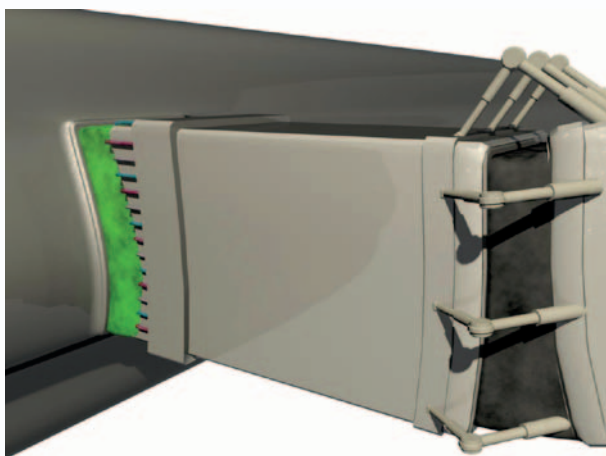


Figure 7.3.1 Astoria's Lockwell docking system bypasses typical airlocks, saving time and money.

7.2 Mining and Refining

As the main hub of the asteroid belt, Astoria capitalizes on self-sufficiency and its role as the central hub of the asteroid belt, providing life-sustaining supplies to private contractors in the area. Our primary commodity is LOX and LH2 fuels. 42,000 cubic feet of LOX and 115,500 cubic feet of LH2, replenished monthly, are stored in the form of frozen water and converted into separated fuel types as required (see Figure 7.2), both saving large amounts of energy and greatly reducing risk associated with storage of liquid fuels. Furthermore, we are able to store vast quantities of ice in case of sudden spike in demand. Visiting spacecraft can have fuels piped directly into their fuel tanks or purchase fuels in a variety of sizes of tanks either for immediate use or for use on a mining site. Once separated from water, Hydrogen storage tanks maintain a constant pressure of 10-5 pascals and temperature of -250 Celsius and oxygen storage tanks maintain a constant pressure of 10-5 pascals and temperature of -200° Celsius. Companies that return tanks after use receive a discount on their next purchase. Astoria produces mining equipment both for use its own use and for lease and sale to private contractors

in complement with refining, manufacturing, and storage facilities. Simultaneously, we provide the Foundation Society with a solid stream of revenue through the exportation of agricultural products, new mining technology, asteroid belt data, and raw materials. We realize that our successes here mean market opportunity elsewhere, and we aim to harness emerging markets to provide a solid stream of revenue now and in the future.

7.3 Astoria's Docking Services

All ships docking with Astoria go through a mandatory dust mitigation process. For frequent visitors, we provide receive a dust-repulsive liquid glass coating which greatly reduces time and cost of future mitigation. Uncoated ships can purchase the coating after going through similar yet more intensive procedures (see 5.2.7). Vessels then proceed to the unloading bays: one specifically for ore, and the other a multifunctional ore and passenger bay. Two unloading gates in each passenger bay allow passengers and cargo to disembark while securing ships into place. Each unloading gate seals around the hatch of the ship using a double layer of polymeric actuating gel

intersected with rubber. The gel expands with the application of electricity, creating an airtight seal with side of any vessel. This dual version of the Lockwell system bypasses costly and time-consuming airlocks. Although we have great trust in the Lockwell system, we also provide a more standard international airlock that does not depend on electricity to seal. Once unloaded, a unique automated system guides vessels into a storage area.

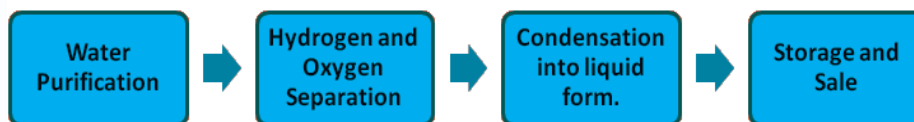
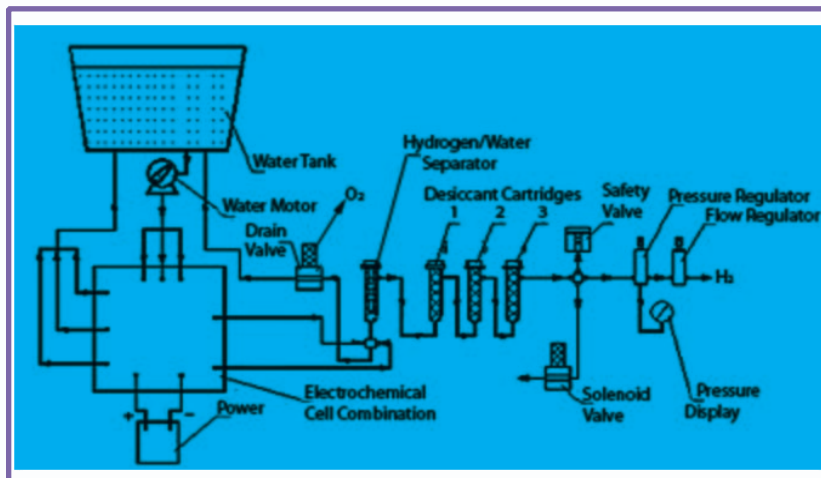


Figure 7.2.1 LOX and LH2 production processes provide vital revenue (photo adapted from hgenerators.com).



Astoria's docking fee includes a plethora of services beginning with fully automated storage utilizing the zero-g conveyer belt (see 3.5) for any cargo, followed by standardized mechanical inspection. Pressurized full service repair depots with a combination of the ORC (see 5.1) and human involvement are available for major repair of both ships and mining equipment. Basic repairs are conducted in storage areas, to eliminate extraneous infrastructure. Upon departure, pre-ordered fuels (see 7.1), atmosphere, food, and water are loaded onto the vessel. These amenities are stored near the docking facilities and undergo inspection and restocking every other week to ensure freshness. They are transported to ships via the rail system (see 5.1.3). We stock enough food and water to sustain 1000 people; this ensures a sufficient supply for visiting spacecraft and deep space missions, as well as a substantial store in case of emergency. Vessels may also purchase small aeroponic and meat culturing units to produce food during missions.

Two acclimation options facilitate rapid entry into the settlement. Passengers subjected to microgravity for greater than three weeks go through a three day reintroduction to gravity in an acclimation shuttle (see 4.5.1 and 2.1.5) before a four day stay in a comfortable resort like quarantine in our welcoming acclimation spoke (see 4.5). We provide top-notch medical staff to monitor and rebuild immune systems. New residents' health monitoring will continue for 12 months. Passengers subjected to microgravity for fewer than three weeks enter the residential torus via a commuter shuttle, disembarking in the designated commuter spoke. All amenities on Astoria are open to visitors: hotels, downtown areas, recreational activities (4.1), and tours of Astoria's manufacturing facilities. Northdonning Heedwell recognizes the importance of spacecraft crews and thus has catered facilities for their wants and needs. A lounge area offering massages and pedicures is located near a bar arcade combination offering a holographic flight simulator based on historical earth airplanes and aviation history trivia among other games. Workout areas and spacious, gourmet restaurants add to the experience created by Astoria, because we

care about creating an inclusive community feel in the harsh expanse of space, especially for our flight crews, who mostly care to hear each other talk.

Figure 7.3.2 A typical invoice for a ship docking at Astoria displays the wide range of docking services.

Astoria Docking Services #5280774				
Service	Quantity	Price	Notes	Total
Docking Fee	1	\$4300		\$4300
Minor Repairs	1	\$770	liquid glass coating	\$770
Pressurized Repairs	none			
Fuel				
LOX	13650 ft ³	\$8/ft ³		\$109,200
LH2	35700 ft ³	\$12/ft ³		\$428,400
LOX Storage Tanks				
Large (5000 ft ³)	2	\$2,500	2 returned	\$0
Medium (1000 ft ³)	7	\$2,000	5 returned	\$4,000
Small (500 ft ³)	5	\$1,500	3 returned	\$3,000
LH2 Storage Tanks				
Large (5000 ft ³)	8	\$3,000	6 returned	\$6,000
Medium (1000 ft ³)	9	\$2,500	7 returned	\$5,000
Small (500 ft ³)	4	\$2,000	4 returned	\$0
Cargo Storage*	100 m ³			-\$468
Short Term				
Pressurized	20 m ³	\$32/m		\$640
Unpressurized	50 m ³	20/m		\$1,000
Long Term				
Pressurized	20 m ³	54/m ³		\$1,080
Unpressurized	10 m ³	40/m ³		\$400
Food	473kg	\$5/kg		\$2,365
Water	9000L	\$0.08/L		\$720
Total				\$566,407

*15% discount for storage rentals above 80m³

7.4 Rescue Capabilities

Astoria sustains the Foundation Society's endeavors in the asteroid belt by providing assistance and rescue to disabled spacecraft. For vessels requiring minor assistance, a Space Tug service is on hand. The Space Tug consists of six small, powerful, unmanned thruster units that attach to strategic locations around a vessel via synthetic nano fiber adhesives. The ability of each rescue ship to propel itself independently allows for extreme maneuverability that accommodates any vessel.

In the event of major problems on an asteroid, Astoria's docking area features two rescue vessels ready to deploy in a mere 24 hours. Each vessel contains enough provisions to sustain 200 people for a full year. Water processing and minor food production facilities augment the stores of nonperishable food items, ensuring complete nutrition and health of crew members. Each vessel features a small versatile sub ship, which serves to explore and retrieve supplies in inhospitable environments. Its compact 10 by 10 meter frame enters areas too small for the larger rescue vessel allowing vast versatility and ultimately saving time and money.

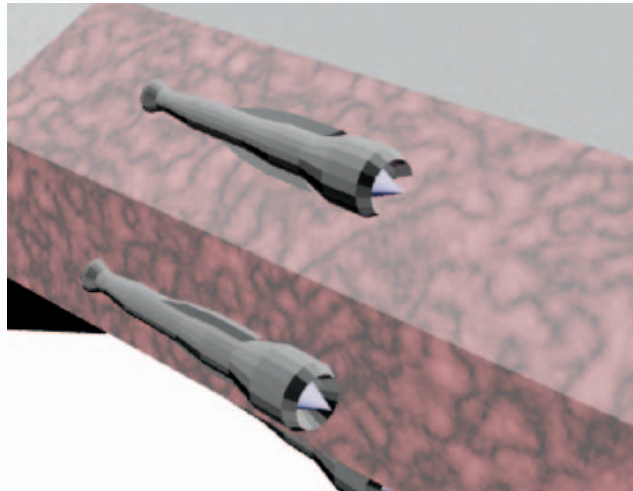


Figure 7.4.1 Space tug units adhere to the outsides of ships, creating maneuverability and compatibility.

through dangerous areas. Educational and entertainment services also utilize images of space.

Due to the nature of living in the asteroid belt, Northdonning Heedwell equips Astoria with the capability to sense impact objects anywhere from a few hours to a few days in advance, allowing the settlement sufficient time to move out of the way of impending impacts.

Northdonning Heedwell provides high quality structural isolation for these crucial systems by locating them above the low-vibration storage area of the ECOR and separating the hull and the telescopes with an acutely sensitive buffer layer that can adjust to the amount of vibrations received. This layer consists of a thermo set polyurethane material developed by Sorbothane Inc. covered

by Nextel aerospace fabric, which reduces vibrations more effectively than conventional methods, providing clearer images and increased data accuracy.

State-of-the-art data processing (see 5.3) and communications are a critical part of Astoria; laser communications, aided by a series of satellites in strategic locations

including Lagrange points, enable effortless communication with Earth and a greater capacity and reliability than other methods, keeping the heart of the Foundation Society close to the vast frontiers of space.

7.5 Sensing and Imaging Research

Northdonning Heedwell equips Astoria with advanced sensing, imaging, and communication capabilities, featuring an optical telescope with a seven-meter dish and a radio telescope with a 160 meter dish, as well as imaging modules integrated into rescue missions and initial assaying satellites (see 5.1). These features survey the asteroid belt: finding potential mining sites, conducting research on the station and Earth, and assisting ships with navigation



APPENDIX A: OPERATIONAL SCENARIO





Operational Scenario

A Day in the Life of Astoria

7:30 AM The Palladine's Rustic Italian Home

"Emily Ava Palladine!"

Milk gushed from the overturned carton, running in steady rivulets from the table's edge. From beneath a mop of curly brown hair, the girl giggled at her mother's exasperation. A quick series of beeps summoned a compact cleaning robot¹, buzzing furiously as it scrubbed the floor to a pristine shine. With a sigh, the woman looked away from her Atlas bracelet².

"Ava, honey, you're four years old – you're a big girl now, you know better." Eyes wide, the girl nodded, apparently chastised. Five minutes from now, her mother knew, the girl would forget completely.

With a stomp of boots, a young boy stormed into the rustic italian kitchen³. "Mom," he whined, "the pipes in the bathroom are still broken."

"Go tell your father. He was supposed to fix that days ago."

"He tried already. If Ava hadn't cut her stupid doll's hair in the sink it wouldn't be leaking at all."

"Jacob, be nice to your sister. Todd!" she screeched, turning towards the hallway beyond.

"Charlotte?" a voice echoed in return.

"Fix the sink!"

"I already ordered the part!" came the distracted reply.

"It's not here yet?"

A pause, a flurry of faint beeps, and then the hurried reply: "It's coming!" The whirring of the contour crafter⁴ suddenly emanated from the next room, the machine quickly fabricating Todd's belated request. Charlotte smirked; her husband was notorious for his procrastination.

After a few moments the sound stopped suddenly, and she rose from her seat, clutching her coffee mug and shuffling slipper-covered feet. The new part – a strange, u-shaped pipe – gleamed from within the machine, ready for installation.

Grabbing the part, Charlotte called out, "Todd?" Silence. "Todd?" she called again, louder. "To- Oh there you are." He leaned against the door frame, eyeing her with a resigned stare. Charlotte tossed him the part, a little harder than absolutely necessary.



"I'll install it before I go to work," he said, catching the pipe easily in one hand.

"Good," she sighed, slightly mollified. "I'll take the kids to school on my way to work. Can you pick up Jacob's present today?"

"Sure." A crash resounded from the kitchen, and Ava's excited squeal mingled with the sound of clattering utensils.

"Mom, I think Ava broke something! And we're going to be late!" Jacob's irritated voice rang from the next room.

"Pick up some more milk on your way home," Charlotte added as an afterthought before turning back towards the kitchen and her errant daughter.

* * *

8:00 A.M.

They shuffled into the family-sized Züg⁵, cramming backpacks under seats and settling easily into the reclined seats. Jacob sat eagerly beside her, his ten-year-old legs stretching to reach the pedals. Charlotte entered their destinations into her Atlas, which then quickly interfaced with the Züg's navigation system: school, then transportation terminal. Too young to operate the vehicle, Ava sat in the back seat, giggling as the Züg picked up speed.

It was easily Charlotte's favorite part of the day. Fast, silent, effortless - pedaling the Züg hardly constituted as exercise. Beneath her, the terraces rolled gently, sprawling and curving into the false horizon. Neighborhoods stirred, residents shedding the last vestiges of sleep; lush fields and parks meandered through the terrain. Traffic on the Züg lines intensified as they drew nearer to the spoke; however, as always, buffers kept the vehicles moving smoothly, the combined effort of a stream of pods carrying them ever faster. Within moments they had reached the spoke, automatically transferred rails, and descended down the elevator system. Scarcely ten minutes after they left home, the Züg slid to a silent stop before the pre-school entrance.

The schools⁶ themselves were a marvel situated in the roots of a magnificent tree⁷, all open architecture and inviting green spaces. The brick and concrete blocks of her childhood on Earth seemed obsolete amidst the arching glass and bamboo of the space-age school. Separate buildings arranged around a central courtyard housed children of all ages. Zügs swarmed around the perimeter, children pouring from their depths.

"Have a good day, sweetie," Charlotte said, wrapping her daughter in a one-armed hug. Clutching her beloved, mangled doll in one hand, Ava hefted her small fuchsia bag onto her shoulder and ran into the school.

"I can walk from here too, Mom," Jacob mumbled, already stumbling out of the Züg.



Smiling, she blew him a kiss and called out, “Have a good day at school and Happy Birthday, Jake!” He raised one hand in absent acknowledgement, already focused on finding his friends amidst the mass of children thronging in the courtyard.

* * *

8:05 AM

If they had a cat, Todd would have said it looked like a hairball. The mess of wet doll hair he had extracted from the sink clumped, ragged and discolored, on the floor. Another stringy, stubborn wad made its way out of the drain, and Todd flung it unceremoniously to the floor. The section of pipe he had to replace – shining and hair-free – had rested on the counter, momentarily forgotten. He picked it up now, holding it in front of the old piece to judge the resemblance. It seemed an exact match. But while he had managed to pull hard enough to make the old piece come out, the same tactic couldn’t quite manage to get the new one in.

His Atlas beeped, the promise of house-repair tutorials and step-by-step holographic directions⁸ tempting. If the problem was really bad, he could always call for a repair robot to effortlessly fix the pipe for him.

But no, he couldn’t bring himself to do that. This had become a matter of personal pride. He would fix the sink himself, one way or another. His Atlas beeped again – a more urgent tone – and he sighed resignedly. The sink would have to wait – if he didn’t leave now, he’d be late for work.

8:10 AM

Todd walked briskly down the path, one hand in a pocket and his briefcase bumping gently against his side. The cool grass of the park stretched out to either side, punctuated by the occasional swing or bench. Occasional Zügs zipped above his head, unnoticeable save for the light rush of air that accompanied their passing. For his own part, he preferred the short morning walk to his urban office⁹, scarcely a quarter of a mile from his home.

“Todd!” came a hurried voice from behind. A hand caught his arm, and he turned to find the grinning face of John Walldorf scarcely inches from his own.

“John,” he greeted in turn.

“Jakie’s birthday today, right?”

“Yeah. He’s turning eleven tonight,” Todd said with a small smile. “I’m supposed to pick up his present this afternoon, but I’m not sure what we’re getting him yet.”

“Actually I wanted to talk to you about that – we just got a new design shipment¹⁰ from Aresam. Those new RoboRaptors came in yesterday and they’ll be stocked by noon today. Can’t think of a better present for little Jakie.”

Todd smiled. “Sounds perfect. I’ll swing by after work and pick one up,” Todd gave a small parting wave and continued down the path.



“He’s going to love it, I promise!” John called after him.

Above, the sky slowly lightened¹¹, the inky expanse of stars giving way to a soft, daytime glow. He quickly reached the end of the park, skipping down a flight of stairs and descending to the lower terrace. Within moments, he was immersed in the “urban” areas, the low, tasteful buildings lending a comforting, small-town feel.

His own office perched on the second story of a modern-looking structure, the outside an elegant combination of floor to ceiling etched glass and rustic adobe bricks. The cantilevered door swung inward on silent hinges, the cool interior a welcome reprieve after his brisk walk. Bustling with activity, the air sang with the soft whir of holograms, the quick beeps of computers, the hurried flashes of personal Atlas’s. He passed rows of desks and doors, responding to the occasional “Good morning, Todd,” with a quick nod. Escaping up a small flight of stairs, he reached his office, opened the glass door, and set his briefcase down with a sigh.

8:22 AM

With a few easy pushes, the Züg parked smoothly near the transportation terminal¹², falling into place on a secondary rail. Charlotte stepped out - grabbing her briefcase in one hand - and entered the terminal.

She tapped her Atlas bracelet and the time flashed: 8:25 am. As if on cue, a low hiss of air signaled the arrival of the shuttle¹³. A small crowd of nightshift workers exited the pod, a larger dayshift throng quickly replacing them. The airlock doors closed behind her with a rush of air, and she settled easily into her seat, fastening her seatbelt. Another tap, and the latest news alerts flashed on her Atlas, the crystalline holographic images depicting stories of Earth and space alike. Pictures of Earth seemed surreal after five years on Astoria, yet she missed little of her old home. What she had found on Astoria rivaled nearly every amenity she had enjoyed on Earth, and what the little settlement lacked, her work more than made up for.

A familiar form took the seat beside her, breaking her from her thoughts with the usual, “Good morning, Charlotte.”

“Morning, John.”

“I saw Todd this morning on his way to work – gave him some good tips for Jakie’s birthday present.”

Everyone seemed to know everyone else, she noted with a small smile, an inevitable side effect of her small community. Yet it did have its uses at times. John worked in packaging and distribution, resulting in a plethora of “insider information” as he called it. If her husband took John’s advice, Jacob would likely have the newest toy Astoria could offer, a fact her ten-year old son would relish.

“Hmm... thank you, it was nice of you to remember,” she finally replied. The rest of the trip was spent in silence – on her part at least. John chatted animatedly, carrying on his typical one-sided conversation. A slight jar and a faint clunk signaled the car had changed tracks. The anticipated loss of gravity hit as the shuttle decelerated slowly¹⁴, her stomach swooping uneasily as she became weightless. The feeling passed quickly, accustomed as she was to working in the microgravity of the ECOR.



As they came to a full stop, Lockwell seals¹⁵ anchored the shuttle; the exit opened with a low hiss. She walked – or rather swam - towards the door, pulling herself gently along with handholds¹⁶ and following luminescent arrows inset into the walls¹⁷. Charlotte mumbled a goodbye to John as he disappeared outside and into an adjacent pod¹⁸; she, in turn, boarded a similar pod en route to the automations sector.

Robotic repair was her specialty, a fact she prided herself on. Machines, mangled and disabled by the harsh mining environment, emerged renewed and ready for work after her ministrations. It was a uniquely gratifying experience. The development of a remotely controlled repair system¹⁹ had allowed her to stay within the settlement, conducting repairs from the comfort of her office rather than commuting weekly to Ceres. Occasionally, a robot sustained enough damage that it returned to Astoria for repair or recycling. She handled these as well, triaging and salvaging what she could.

Her “office” consisted primarily of a semi-automated worktable for physical repairs alongside a simple holographic projector surface. Her IBMS²⁰ lay, folded neatly into a drawer of the worktable. Charlotte waited for a moment as her Atlas interfaced with the automation systems. Almost immediately, her first assignment sprang into existence on the hologram, the image an exact replica of a robot stranded hundreds of kilometers away on the Ceres surface. She quickly donned her suit, thousands of sensory nodes along the surface activating simultaneously.

Carefully manipulating the hologram, she scrutinized the surface of the robot before her, murmuring commands under her breath. Diagnostics sprang to the forefront, detailing a history of corroded circuits and sporadic power loss over the past few days. A repair robot on the surface of Ceres below mirrored her every movement, providing live feedback as she progressed. With a final twist, the robot sputtered to life, joints twisting and bending experimentally. Diagnostic tests returned negative, and the hologram of the robot flashed away.

Another assignment sprang into existence, and she bent over her work with a small smile.

* * *

8:30 AM

Todd settled into his chair, turning on the computer integrated into his desk surface with a quick voice command. So routine was the task that he scarcely noticed the iris and vein scanners²¹ confirming his identity. A welcoming tone sounded and his account homepage slid into view. As his Atlas interfaced with his office-RCN²² - loading the latest updates and schedules - Todd skimmed the digital messages collecting on his desktop. Memos, dates, meetings... the most current data from the newly updated optical telescope²³ caught his attention.

“Finally,” he muttered, opening the files with a quick tap of his fingers.

A slew of images and numbers came into view, a seemingly impossible code to anyone unfamiliar with his work. Asteroids – transmuted into three-dimensional holograms colored with spectrometry data – floated evenly across the surface of his desk. Choosing one arbitrarily, he manipulated it with his hands, expanding the image and scanning the latest data.



The asteroid looked distinctly unpromising, its density suggesting it was only the barest collection of dust. He flipped to the next: too small and porous to prove lucrative. Next.

Eunomia 15... S-Type...

Interesting, he mused. Eunomia 15 had garnered plenty of attention over the last few decades, promising a lucrative array of materials because of its size. It was immense, comprising nearly 1% of the asteroid belt.

Todd archived the asteroid with a quick flick of his fingers, prioritizing it for further study.

* * *

8:37 AM

Colors swirled; reds, blues, greens, yellows turning the surface an unpleasant shade of brown. The girl giggled at the disarray, rubbing her hands across the finger-painting mess with renewed vigor.

“Ava, honey, don’t you want to try and use just one color at a time?” Her preschool teacher’s strained smile belied a growing frustration.

“No,” Ava shook her head adamantly, tapping the paper²⁴ and adding few defiant streaks of red.

“Alright,” the teacher – Ms. Chanler – gave her a comforting pat on the shoulder, “It’s time to clean up anyways. Recess time,” the teacher addressed those last words to the small class.

“Yay!” Rolling up her masterpiece – with considerably more care than she had exercised while creating it – Ava ran to join the throng of children queuing at the door.

Freeze tag dominated the majority of their time, the outside courtyard reduced to swarming, squealing mass of children. None quite understood the rules, but they were more than happy to make them up as they went. When the final whistle sounded, Ava – disheveled and exhilarated – shuffled back into her classroom with the others.

After a few laughs, a few words, and an incident involving a boy gnawing on a scrap of e-paper, the preschool class settled on the floor, a low hologram projector dominating the center of their circle. Images leapt to the surface, suspended fragments of landscapes, people, and places hanging in the air, then forming the easily identifiable shape of Earth.

“This is Earth,” Ms. Chanler pointed out unnecessarily. “Now, let’s see how smart you guys are. Does anyone know how big it is?”

“Like this –” a pair of small arms stretched out to either side “-big.”

“Close, but it’s a little bigger than that Michael.”

“As big as the ash-ter-roid?” the small boy stumbled on the word, doubtful.



“It’s as big as two asteroids,” Ava replied matter-of-factly.

“No it’s not!” Michael retorted.

“Actually,” the teacher interjected, “Neither of you are right. Earth is as big as one hundred and fifty asteroids like Ceres.” Ms. Chanler waited for the fact to sink in, but was met only with blank stares.

“Yeah, right,” Ava said at last. For her – born and raised on Astoria – the concept of anything that big was unfathomable. Ceres – occasionally visible from the outside windows – embodied her definition of a “big rock.” That something could exceed it was impossible.

“Look, Ava,” the picture on the hologram was replaced by a small, scaled image of Ceres against Earth’s formidable bulk. Ava leaned forward, scrutinizing the image – for what, she couldn’t say. Ceres looked like scarcely more than a small marble.

“Whoa,” she whispered.

“‘Whoa’ is right. Now, can anyone tell me how big the Sun is?”

“A kazillion-billion asteroids?” another voice – Austin – spoke up.

“It’s about the size of 300 Earths. So a kazillion-billion asteroids is pretty close...”

The lesson continued for over half an hour, Ms. Chanler regaling the small class with impossible facts and stories about the Earth, the Solar System, and everything in between. The lesson, coupled with a few number games and a messy sloppy joe lunch quickly brought the day to a close.

Noon signaled the arrival of parents and Zügs alike. The “big kids” – like her brother, Jacob - had longer school days, a fact Ava did not envy. Collecting her battered doll and fuchsia bag filled with miscellaneous accessories, she sprinted out the doors.

* * *

12:07 PM

The half-day of work was a nice reprieve for Charlotte. Tonight was a welcoming night for the new settlers in her neighborhood, an event always treated as a virtual holiday. The flexibility of her job allowed her the time off for both Jacob’s birthday and the coming festivities. As Ava chatted animatedly in the back seat of the Züg, Charlotte ran through a mental checklist.

“Dancing shoes...” she mused. It had been a long time since she had indulged in a new pair, and the party seemed the perfect opportunity. “Ava, I think you need a dress too. We’re meeting the new neighbors tonight.” Ava only smiled.

“Oh I almost forgot!” If Charlotte had been driving her old Earth car, she would have slammed on the brakes. As it was, the Züg slowed only marginally before she started peddling again. “We need to pick up your vaccines before we get home. You’re overdue.”



“Aw mom...” Ava whined, “Those things taste bad.”

“It’s better than getting sick,” she retorted, and Ava fell silent. Charlotte stopped peddling entirely as their destination came into view and the Züg slowed, gently changing to a secondary parking rail. “But your dress first... Can you help me pick out some new shoes too?” Vaccines utterly forgotten, Ava nodded enthusiastically.

Leaving the Züg parked unobtrusively at the far end of the street, they descended a small flight of stairs before emerging into the bustling main street. Trees shadowed the buildings in every direction, springing from neat aeroponic planters in the paved ground. Storefronts gleamed, shimmering windows hosting inviting displays. Tantalizing smells wafted from a corner café, and the patio of a nearby restaurant bustled with patrons.

Charlotte wasted no time, heading straight for a bright little store nestled between offices and an ice cream parlor.

12:15 PM

The Shoestring Theory bustled with personnel restocking the tester shoes and aiding shoppers with their customized orders. Charlotte maneuvered through the small crowd with Ava in tow, heading towards the dancing section. An associate approached her asking, “M’am, do you need any assistance today?” Describing her need for a new pair of low-heeled swing shoes, Charlotte watched as the associate quickly glanced through the options and pulled down two tester pairs of swing shoes. After wandering in each pair and trying a dance move or two, Charlotte had chosen.

Linking her Atlas to the store’s network, she scanned the shoe’s barcode. An exact replica appeared in her Atlas’s hologram feed, allowing Charlotte to change the color, pattern, and sizing to match what she desired²⁵. Submitting her shoe to The Shoestring’s database, Charlotte received a message informing her it would be a twenty-minute wait until the shoes were processed and created in a contour crafter.

Looking down at Ava, Charlotte asked “Are you ready to go get your dress?” Ava’s eyes lit up, and she tugged Charlotte out the door saying, “Mommy, can we go to Silk Sparrow?”

“Sure honey,” Charlotte replied.

12:28 PM

Inside Silk Sparrow, Ava turned to her mom pleading, “Can I have my own pretty dress?” Knowing Ava really meant a customized dress, Charlotte answered, “Sorry sweetie, customizing is for special items that you’ll use for a long time.”

Ava pouted for a bit, then grinned mischievously. Before Charlotte knew what had occurred, Ava stood in front of her with an armful of dresses; Charlotte resigned herself to a longer shopping trip than intended and found an empty dressing room.



1:00 PM

Ava finally found herself the “perfect princess dress” – a mass of bright yellow ruffles and velvet trim - allowing Charlotte to return to The Shoestring Theory and pick up her shoes at the counter. Charlotte confirmed her order on her Atlas, swiped it across the scanner, and left with shoes, dress, and daughter in hand.

1:15 PM

Leaving downtown behind, Charlotte and Ava hopped into their Züg and headed to their neighborhood medical clinic. The Palladine’s pediatrician Dr. Selena Apergy²⁶, greeted them and ushered them into an examination room.

“Hello Charlotte, hi Ava! Where’s the rest of the family?”

Charlotte laughed, “Todd’s at work still and Jakie’s in school. So it’s just Ava and I today. We’re here for Ava’s vaccinations.”

“Okay then,” Dr. Apergy smiled, “Go ahead and take a seat. I’ll pull up your records.”

Ava squirmed in her chair, “Mom, are we almost done?” she whined petulantly. Charlotte nodded, shushing the girl with one finger.

After turning to her screen and studying the information there, Dr. Apergy spun around, “Well, looks like you need two vaccinations Ava, so you stay healthy.” Aside to Charlotte, the doctor muttered, “Never know what folks bring to Astoria. That last batch from Alaskol... Yeesh!. They’re still in quarantine!”

Ava grimaced suddenly, until Dr. Apergy handed her two gummy bears²⁷ saying, “Here are your vaccinations, just gobble them up and you’re good to go!” Ava giggled and swallowed her medicine.

Thanking the Doctor, Charlotte and Ava headed home.

* * *

9:00 AM

How many countries are on the African continent?

52? Jacob typed the number into a small computer tablet responsible for his schoolwork. In this case, “school work” meant an Earth geography test. Should he pass it, he would advance to the next science lesson²⁸ about asteroid formation - a change he would appreciate.

Which major country borders Spain’s western side?

Portegul? Portugal? He hoped spelling wouldn’t count. Having lived the majority of his life in space, Earth politics and countries seemed a foreign concept. The last few questions flashed on the tablet, and the test was over, the screen turning green for a moment.



He breathed a sigh of relief; he had passed on his first try, something that didn't often occur, especially with morning tests.

Jacob raised his hand "Mr. Langhorne, I finished my Human History test."

"Nicely done Jake! Take a break then go ahead and pick your next subject, either Science or Math for you!"

"Umm...I worked on my science project yesterday. I researched the Apollo missions! They're next in my space exploration timeline. I guess I'll do some math today instead of researching more," Jacob decided.

Mr. Langhorne nodded and moved across the room to assist another student.

Solve for x: $(5^3)/5=x$ $64=2^x$ $x \cdot 7^2=147$

Ok, this he could do.

12:00 PM

Jacob was focused on his work when lunch bell tolled; he wondered who'd been chosen to pull the ropes in the bell tower today...it was the coolest job, and only the good students were awarded the privilege of going out just before lunch and yanking on the ropes to make the bells chime.

Wandering outside to the lunch tables, Jacob snatched a seat then opened his holographic Superman lunchbox to find a peanut butter and jelly sandwich, water bottle, and carrots.

1:00 PM

The lunch bell sounded again, reminding the students their afternoon classes would soon begin. Jacob raced back inside the tree school. It was Tuesday! That meant music class instead of P.E.!!!

Stampeding into the airy and welcoming classroom, Jacob sat down at his station, eager to learn more piano songs. As the rest of the students arrived, Ms. Marshall's voice sang out, "Now class, before we continue learning piano, we must sing to Jake! It's his birthday today!" In a cacophony of sound, the class burst into "Happy Birthday," with Ms. Marshall accompanying on her grand piano as Jake's cheeks flushed pink.

2:00 PM

Walking to the BookNook – the language arts and composition class, Jacob daydreamed about what crazy story Mr. Schermer would read today. They'd finished *The Big Friendly Giant* by Roald Dahl last week.

Standing in front of the class, Mr. Schermer clapped his hands, "Settle down everyone! Today we're beginning a new book, one that's more challenging than the last, *The Diary of Anne Frank*. Has anyone heard of it? No? Well, it takes place in 1942, during the Second World War on Earth, when the Nazi party from Germany was anti-Semitic or anti-Jewish..."



* * *

2:30 PM

Todd whistled to himself as he ambled down the sidewalk to Discovery Kid, only “the most awesome toy store ever Dad!” as Jacob would say. Searching the shelves for RoboRaptor, Todd dodged hazardous remote control cars, vicious teddy bears, and lethal flying robots. Something white caught his eye behind a display of dolls, there it was! Todd quickly snatched a raptor, had it wrapped up, and paid with his ATLAS. Next stop, grocery store for milk, then school for Jakie.

2:43 PM

Powering through the grocery store, Todd collected milk and shook his head in wonder as he parsed the ingredient label. Vitamin D enriched soymilk hadn’t changed that much in the last few decades. Rushing past the new vegetables and fruits, he spoke a reminder into his Atlas to buy some later in the week, as he dashed through the checkout.

Just as he hit the sidewalk, Todd’s Atlas alerted him. “Finally!” he exclaimed, and he made a beeline for the Mackinac Book Company across the street. As he entered, the man behind the counter said “Morning Todd. I knew I’d see you soon, but this is some kind of record.” Todd eagerly approached the counter as the man put on cotton gloves and handed over a book – old-fashioned paper, antique binding, the works. “Hazards Due to Comets and Asteroids, First Edition. Edited by Gehrels, and signed by Gene Shoemaker himself... just came in from Aresam last night” said the bookseller. “If I were a more emotional man, I’d weep with joy...” Todd said, as he stared at the vintage book in his hands.

Another Atlas notification alerted Todd as he turned for the door. “Ooops... I’ve gotta go get Jake. Thanks a bunch!”

Less than ten minutes later, Todd was at the school. Greeting Jacob outside, Todd handed him the milk to carry as they walked home, and asked, “So, what’d you learn today?”

“In language arts we started a new book! It’s called The Diary of Anne Frank...”

* * *

3:00 PM

With a final flourish, Charlotte finished tossing the salad. Delicately picking up a piece of vinaigrette-laden farfalle, she sampled the pasta. She frowned, considering the taste. An extra dash of cheese rounded off the flavor, and she set the bowl down with a satisfied smile. While she could have ordered a premade meal, real cooking had always proven relaxing and rewarding. The fact that the settlement had no lack of fresh produce only amplified her love of good, homemade food.

Pasta salad for potluck tonight- check, Ava- check, Jacob and Todd... Jacob and Todd- where are those clowns?

“Hey mom, we’re home!” shouted Jacob. Whew! Jacob and Todd- check.



As they came into the kitchen, Ava jumped up and latched onto Todd with a screech of “Daddy!” completely forgetting about her dolls.

“Hi Sweetie, how was your day?” Charlotte asked, giving Jake a hug. “Are you ready to open your present?”

Todd whipped out the wrapped RoboRaptor from his briefcase, bestowing it upon Jacob. Ripping and tearing at the paper, Jacob yelled, “Thanks Mom and Dad! This is awesome!!!” He raced out of the kitchen with Ava at his heels, trailing wrapping paper.

“Don’t forget to be ready to go by 5:30, we have the neighborhood potluck tonight!” Charlotte called after them, before turning and giving Todd a kiss.

“Daddy- I have a question,” Ava announced importantly.

“What is it, princess?”

“Is the sun really as big as a kazillion-billion asteroids? ‘Cuz Ms. Chanler said it was but I don’t believe her. It looks really little. When I put my hand up I can’t see it. How can it be ginormous and still be smaller than my hand?”

“Well, sweetheart, it really is that big. Sometimes things look little when they’re really far away like the sun.”

“How about Earth? Ms. Chanler said that was big too but I can’t even see it.”

“The Earth is huge. Why, I remember when we lived there it was so big that we didn’t ever visit most of the different parts. But one time when I was little, grandma and grandpa took me on a trip...”

Sensing the potential length of the ensuing story, Charlotte sighed and called her neighbor, Jennie. “I have a feeling we’re going to be a little bit late tonight.”

* * *

5:34 PM

They were late, but not for the reason she had anticipated.

“Would you please just ask for directions?” Charlotte sighed irritably, crossing her arms.

“I know what I’m doing,” Todd retorted, equally incensed.

She let out a muffled snort. “Obviously not. You can analyze asteroids ten million miles away but you can’t fix a sink!”



A muffled bump sounded as Todd hit his head on the underside of the counter, letting out an irritated slew of inaudible words.

“Todd, please,” she massaged her temples with one hand, brow furrowed. “Everyone’s already heading over to the theater, we’re going to be late. You’ve got five minutes, and then we’re leaving.” Charlotte turned and walked briskly out of the room, leaving Todd alone under the leaking pipes.

He looked around cautiously, checking to make sure his wife hadn’t returned before he whipped out his Atlas. A few taps, and the step-by-step instructions sprang into view; he skimmed them furtively, the process simple once he realized the problem. He popped the new section of pipe into place and flipped off his Atlas just as Charlotte walked back into the room.

“Ready?” she asked, glancing surreptitiously at the sink beside him.

“It’s fixed,” he said in answer to her unspoken query, wiping his wet hands against a kitchen towel. “I told you I knew how to do it.”

* * *

6:00 PM

The outdoor Astor Theater²⁹ was a wonder to behold aptly named after a patron of culture and the arts. The enormous structure spanned nearly the entire expanse of a spoke below, levels arching gracefully from terrace to terrace. Seating interspersed throughout the perimeter formed a natural amphitheater, melding seamlessly with suspended pavilions and spiraling staircases. The roof consisted only of a pleasant swoop of woven bamboo and carbon fiber that imparted a distinct elegance to the structure.

At one end of the theater, tables were laden with food and drink; at the other, a glossy bamboo dance floor shimmered in the evening light. Already, crowds of people had begun to trickle in, enticed by the tantalizing smell of food and the warm glow of company.

The transient population – timid and uncomfortable only minutes ago – had already started to blend with other established residents, mingling and laughing effortlessly. It was, after all, the point of the evening. Incoming residents – some trapped for months on traveling vessels – were welcomed with open arms into Astoria’s tight-knit community. Save for the slight thinness typical of muscle atrophy, the new residents looked remarkably revitalized by the acclimation process, their bodily systems quickly returning to normal.

The Palladines slowly wound through the crowd, traveling towards the refreshments. Charlotte set their contribution - a pasta salad - down in one of the few empty spaces left; the plethora of homemade food had combined into a single, mouthwatering aroma hanging heavily in the air.

From the small, elevated stage, a local band began to play, ushering idlers from the dance floor. Twirling her new dress, Ava ran into the midst of the crowd, dragging Charlotte by the hand. “Dance, dance!” she laughed, running faster and forcing her mother into an awkward crouch to keep up.

Standing beside a row of empty tables, Todd chatted amicably with a new couple - a pair of analysts who would likely be joining his office in the coming weeks. Jacob took the opportunity to slip away with a group of friends, retreating to the far end of the pavilion to play with his new fighting RoboRaptor. The flying robot buzzed above the crowd, bumping and nudging the occasional head as the boys laughed from afar.

As the music slowly picked up, people thronged to the dance floor. Carbon fiber guitars and keyboards glimmered in the light, the sound resonating throughout the theater. The musicians played expertly, their fingers flying effortlessly over every note. Ava's yellow dress flashed in time with the music, the ruffled rim bouncing incessantly. She caught her mother's other hand, and the two twirled together, Charlotte's low-heeled dance shoes clapping softly on the floor with each step. Somewhere along the way, Ava had lost her shoes, comfortable in just her bare feet. Charlotte sighed inwardly: she'd have to find those before the night was out.

The food tables opened as the last of the latecomers were just trailing in. Piling plates high with steaming entrees and side dishes, the crowd quickly abandoned the dance floor and retreated to the rows of tables erected in the back.

* * *

Epilogue 8:00 PM

As the music filled the amphitheatre, a feeling of ease, like a gentle breeze, meandered through the crowd. Above, night was settling in ever so slowly, and as Ava and her friends whirled about the dance floor, occasionally rubbing their eyes against their spirits' own volition, Todd Palladine found himself in conversation with another new resident to Astoria. "...researching mainly, cold fusion. Still think we're about a decade out."

After a pause in which the newcomer looked approvingly at the gorgeous theatre, and above, the slightest twinkling of stars overhead, he continued, "Say, you've been here a few years. What's your impression of life on Astoria?" Todd, flirtily nudged by Charlotte, replied, "Actually, there's no place else I'd rather be. We've got front row seats to the show, everyday. It's like we're on the edge of our seats as the curtain draws back and new discoveries come filtering in. I know it sounds cliché, but... we love it."





Operational Scenario Footnotes:

1. *Compact cleaning robot*: a reference to automated home maintenance services found in Automations 5.3.1, 5.3.3
2. *Atlas bracelet*: Automations Figure 5.3.2
3. *Rustic Italian kitchen*: an architectural style found in Humans 4.2
4. *Contour Crafter*: Automations 5.3.3
5. *Züg*: Operations 3.2.7
6. *Schools*: Humans 4.1.3
7. *Magnificent Tree*: a reference to the unique architectural style of the schools, built in the base of an artificial tree as specified in Humans Figure 4.4.1
8. *House-repair tutorials and step-by-step holographic directions*: Automations 5.3.3
9. *Short morning walk to his urban office*: Pathways comprise 2% of the residential torus, as specified in Humans 4.1.1
10. *New Design Shipment*: Humans 4.1.6
11. *Sky slowly lightened*: a reference to the day/night cycle in Operations 3.2.8
12. *Transportation Terminals*: Structure 2.1.4
13. *Shuttle*: Structure 2.1.4
14. *Shuttle decelerated slowly*: Structure 2.1.4
15. *Lockwell Seals*: Business 7.3
16. *Handholds*: Humans 4.3
17. *Luminescent arrows*: Humans 4.3
18. *Adjacent pod*: a reference to ECOR transportation pods, Operations 3.2.7
19. *Remotely controlled repair system*: 5.3.4
20. *IBMS*: 5.3.2
21. *Iris and vein scanners*: Automations 5.2.2
22. *Atlas interfaced with his office RCN*: Automations 5.3.1
23. *Optical Telescope*: Business 7.5
24. *Paper*: paper is manufactured using bamboo fibers, as specified in Operations 3.2.2 and Humans 4.1.7
25. *Change... to match what she desired*: Humans 4.1.6
26. *Apergy*: a reference to a fictional artificial gravity system used by John Jacob Astor IV in his novel *A Journey in Other Worlds*.
27. *Two gummy bears*: vaccinations administered as specified in Humans 4.1.2
28. *Science lesson*: a reference to the innovative self-paced school system specified in Humans 4.1.3
29. *Astor Theater*: a community building named after patron of the arts, John Jacob Astor. Humans 4.1.5

Note: All names used in this scenario were derived from people, places, and concepts connected to the Astor family.



APPENDIX B: BIBLIOGRAPHY





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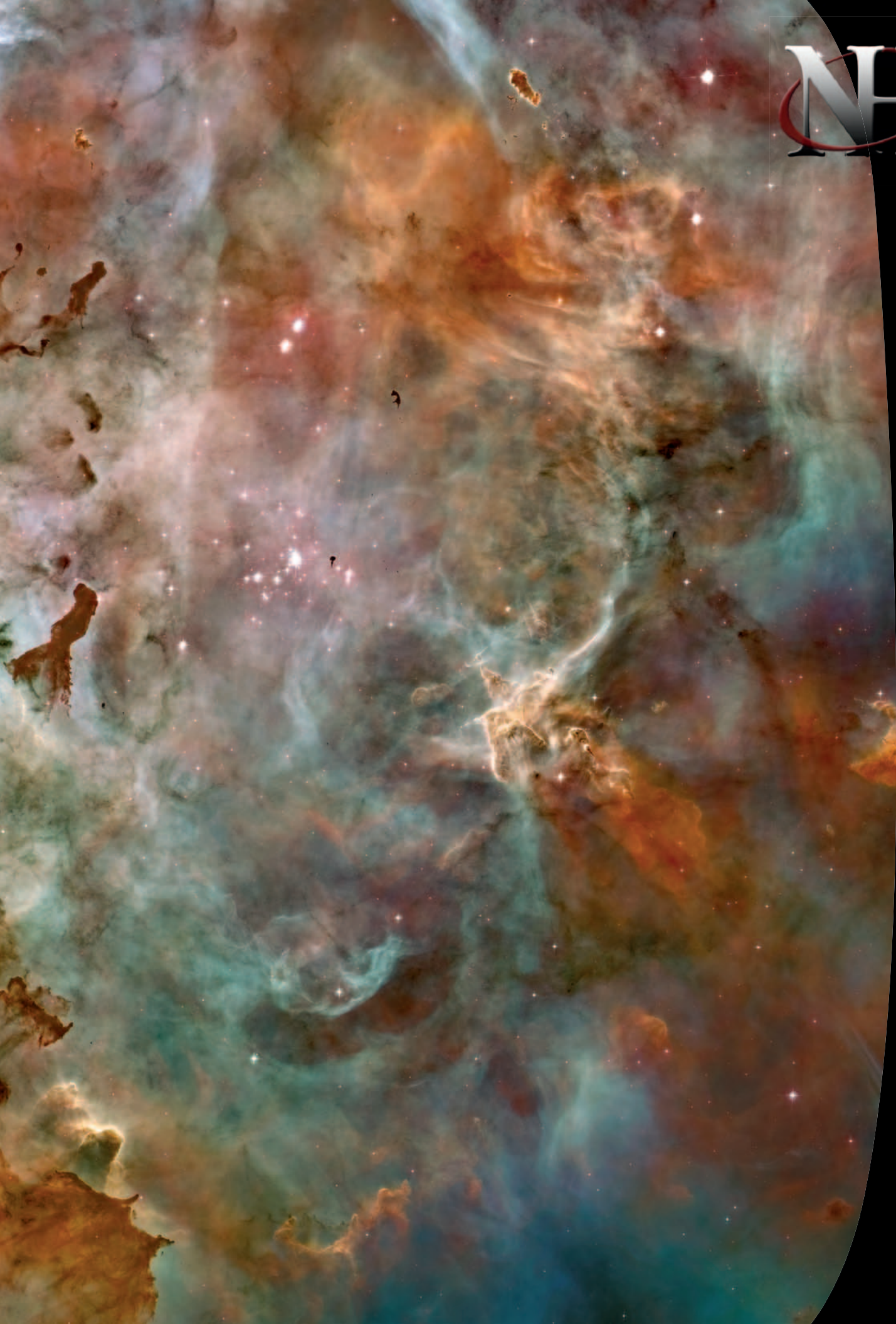
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APPENDIX C: COMPLIANCE MATRIX





Compliance Matrix

Requirement	Where Addressed	Page #
1.0 Basic Requirements: The contractor will describe the design, development, construction, and operations/ maintenance planning for the Astoria space settlement in the asteroid belt.	Executive Summary	1
2.0 Safe and pleasant living and working environment for 6000 long-term residents, 5000 semi-term occupant, and up to 500 short-term visitors	2.0 Structure	2
2.0 Natural views of space	Figure 2.2.1 Terracing	6
2.1 Identify attributes and uses of large enclosed volumes	Figure 2.1.3, Table 2.1.2 ECOR allocation	3
2.1 Show dimensions of major hull components and design features	Figure 2.1.1 Wire frame top and side view	2
2.1 Specify construction materials for major hull components and design features	Figure 2.1.4, Table 2.1.3	4
2.1 Specify volumes where artificial gravity will be supplied	Figure 2.1.2, Section 2.1.3	4
2.1 Specify structural interface(s) between rotating and non-rotating sections	Section 2.1.4, Figure 2.1.5, Figure 2.1.6	4-5
2.1 Specify rationale for selected rotation rate and artificial gravity magnitude(s)	Section 2.1.3, Table 2.1.4	4
2.1 Experience with existing Foundation Society space settlements shows that structural maintenance costs are significantly reduced with artificial gravity less than 0.9 g and atmospheric pressure less than 13.5 psi	Section 2.1.3, Section 3.2.1	4 12
2.1 Specify means of protecting from radiation and debris penetration	Section 2.1.2, Figure 2.1.4, Table 2.1.3	4
2.1 Show capability to isolate at minimum any two separate volumes in case of emergency	Section 2.1.5	4
2.1 Minimum Requirements		
Overall exterior view of the settlement with major visible features	Figure 2.1.1	2



Show rotating and non-rotating sections	Figure 2.1.2	3
Show pressurized and non-pressurized sections	Section 2.1.1, Figure 2.1.2	3
Indicate functions inside each volume	Figure 2.1.3, Table 2.1.2	3
2.2 Specify percentage allocation of interior “down surfaces”	Table 2.2.1, Table 2.2.2	3, 7
2.2 Specify dimensions of interior “down surfaces”	Figure 2.2.1	7
2.2 Drawings labeled to show residential, industrial, commercial, agricultural, and other uses	Figure 2.2.2, Figure 2.2.3	6
2.2 Show orientation of “down surfaces” with respect to overall settlement design	Figure 2.2.2, Figure 2.2.3	6
2.2 Show vertical clearance in each area	Figure 2.2.1	6
2.2 Minimum Requirements		
Overall map or layout of interior land areas, showing usage of those areas	Figure 2.2.2, Figure 2.2.3	6
2.3 Describe the process required to construct the settlement	Section 2.3	7
2.3 Show the sequence in which major components will be assembled	Figures 2.3.1-2.3.7	7, 8
2.3 Specify when artificial gravity will be applied	Section 2.3, Figure 2.3.6	8
2.3 Describe a construction technique for interior structures making use of materials from asteroids	Section 2.3	7, 8
2.3 Minimum Requirements		
Drawing(s) showing at least five intermediate steps of settlement assembly	Figures 2.3.1-2.3.7	7,8
Show method of initiating rotation for artificial gravity	Section 2.3, Section 2.1.4, Figure 2.3.6	8
2.4 Show details of shielding and damage repair methods for frequent impact by small particles	Section 2.4, Section 2.1.2, Figure 2.1.4, Table 2.1.3	9



2.4 Show means for reducing damage due to larger items that can only be detected hours in advance	Section 2.4, Figure 2.4.1, Table 2.1.3	9
2.4 Minimum Requirements		
Illustrations of shielding and damage repair systems	Figure 2.4.1	9
2.5 Show “mining camp” infrastructure on target asteroid	Section 2.5, Figure 2.5.1	9, 10
2.5 Minimum Requirements		
Drawing(s) of human habitation at asteroid mining location	Figure 2.5.1	10
<i>3.0 Describe facilities and infrastructure necessary for building and operating the Astoria space settlement and its communities</i>		11
3.1 Recommend an orbital location and justify its selection	3.1.1 Orbital Location	11
3.1 Specify as the mining target either a known asteroid or preferred small asteroid size, shape, and orbit.	3.1.1 Orbital Location	11
3.1 Identify sources of materials and equipment to be used in settlement operations after construction is complete	3.1.2 Materials Table	11
3.1 Use as much material as possible from asteroid	3.1.2 Materials Table	11
3.1 Identify means of transporting materials to Astoria location	3.1.2 Rail guns	11
3.1 Identify sources of materials and equipment to be used in construction.	3.1.2 Matriarch	11
3.1 Minimum Requirements		
Table identifying types, amounts, and sources of construction materials	Section 3.1 Table 3.1.1	11
3.2 Identify air composition, pressure, and quantity for atmosphere/climate/weather control	3.2.1 Atmosphere and climate	12
3.2 Describe food production including growing, harvesting, storing, packaging, delivering, and selling	3.2.2 Food Distribution Table 3.3.3	12
3.2 Describe electrical power generation, distribution, and allocation for specific uses	3.2.3 Power Generation	12

3.2 Specify kilowatts for electrical power generation	Table 3.2.2	14
3.2 Describe water management, specifying required water quantity and storage facilities	Figure 3.2.4 Table 3.2.4	14
3.2 Specify recycling and/or disposal for household and industrial solid waste management	3.2.4 Water and Waste	14
3.2 Specify devices and central equipment for internal and external communication systems	Section 3.2.6 Table 3.2.6	15
3.2 Show routes and vehicles, with dimensions, for internal transportation systems	Sections 3.2.7	16
3.2 Specify schedule and mechanisms/operations for day/night cycle provisions	Section 3.2.8 Table 3.2.8	16, 17
3.2 Describe storage facilities required to protect against interruption in production of food or commodities needed for daily life (supply lines for imports may be interrupted for ten months)	Section 3.2.2	13, 14
3.3 Show conceptual designs of primary machines and equipment employed for constructing the settlement especially for assembling exterior hull and interior buildings/structures.	Section 3.3 Figure 3.2.1 Figure 3.3.2	17
3.3 Describe materials components, and/or subassemblies delivered to the machines	Section 3.3	17
3.3 Describe how the machines convert delivered supplies into completed settlement structures	Section 3.3	17
3.4 Define requirements for a propulsion system to move Astoria when threatened with impact of a large object.	Section 3.4	17, 18
3.4 The settlement must be clear of the object's path by one mile (1.6 km)	Section 3.4	18
3.4 The settlement must be capable of accomplishing such maneuvers at least once per (Earth) month	Section 3.4	18
3.5 Provide an option for accepting raw ore to refine from other locations	Section 3.5	18
Illustration of port facilities and ore handling processes	Figure 3.5	18
<i>4.0 Astoria will offer attributes available to residents of Earth's small cities in developed countries.</i>		
<i>4.0 Provide natural sunlight and views of space outside for residents.</i>		
<i>4.0 Include features in design of community facilities (e.g., roads and paths) and residences, enabling mobility and access with a practical minimum of motion (e.g., head-turning) that has been found on existing space settlements to cause mild discomfort due to Coriolis effects.</i>	4.0, 4.1.1	19



4.1 Astoria will provide services that residents expect in comfortable modern communities (e.g., housing, entertainment, medical, parks and recreation)	F4.1.1, 4.1.3, 4.1.5	19-20
4.1 Astoria will provide a variety and quantity of consumer goods	4.1.6	20
4.1 Astoria will provide public areas designed with long lines of sight	4.0 4.1.1	19
4.1 List major types of consumables, and quantities	4.1.6	20
4.1 Depict or specify means of distributing consumables (including food) to Astoria residents	4.1.6 Figure 4.1.2	20
4.1 Minimum Requirements		
Map(s) and/or illustration(s) depicting community design and locations of amenity, with a distance scale	Figure 4.1.2	20
Identify percentage of land area allocated to roads and paths	4.1.1	19
4.2 Provide designs of typical residences, clearly showing room sizes	4.2.1	21
4.2 Home designs will be no smaller than 900 sq. ft. and no larger than 2000 sq. ft.	4.2.1	21
4.2 Identify source(s) and/or manufacture of furniture items and appliances	4.2.1	21
4.2 Minimum Requirements		
External drawing and interior floor plan of at least four home designs	4.2.1	21
Area in square feet for each residence design	4.2.1	22
Number required of each design		22
4.3 Designs of systems, devices, and vehicles intended for use by humans outside of artificial gravity volumes will emphasize safety	4.3	22
4.3 Show spacesuit designs with stowage and donning/doffing procedures	Figure 4.3.1	22
4.3 Show airlock designs for exiting/entering the settlement from unpressurized volumes	Figure 4.3.2	22
4.3 Minimum Requirements		
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	Figure 4.3.1	22

4.4 Provide less than 1 g of gravity for accommodating adult living preferences	4.4	22
4.4 Provide children with daily exposure to 1 g for at least 3 hours per (Earth) day to accommodate acceptable development of children through their growing years	4.4	22
4.4 Minimum Requirements		
Drawing(s) of means for children to spend time in 1 g	4.4	22
4.5 Show how semi-term occupants can integrate into Astoria society when only settling down for 6 to 36 months	4.5.1	23
4.5 Minimum Requirements		
Drawing(s) of “instant move-in” designs	Figure 4.5.1	23
5.0 Show robot designs, clearly indicating their dimensions and illustrating how they perform tasks.	5.0 Automation Design and Services Table 5.1.1	25-34
5.0 Specify numbers and types of computing and information processing devices, multifunctional personal electronic tools, servers, network devices, and robots required for Astoria.	5.0-Automation Design and Services	25-34
5.1 Describe use of automation for construction.	5.1-Automation for Construction. 5.1.1-ORCs 5.1.1-TLRs 5.1.2-Contour Crafters	25-26
5.1 Automations for transportation and delivery of materials and equipment	5.1.1-Cargo Transport Rails	26
5.1 Automations for assembly of the settlement and interior finishing.	5.1.2-Countour Crafters 5.1.2-IFRs	26
5.1 Minimum Requirements		
Drawings showing automated construction and assembly devices--both for exterior and interior applications--and illustrating how they operate	Figure 5.1.1-ORCs Figure 5.1.2-TLRs Table 5.1.1	25-26
5.2 Specify automation systems for settlement maintenance, repair, and safety functions, including backup systems and contingency plans.	5.2.1-APARs 5.2.1-Reffitted IFRs 5.2.1-Reffitted ORCs 5.2.3-APARs, Contingency Plans	27-28



5.2 Robots required for emergency external repairs must survive and accomplish tasks during solar flare activity.	5.2.5-Solar Flare Protection 5.2.1-Reffitted ORCs	28
5.2 Describe means for authorized personnel to access critical data and command computing and robot systems.	5.2.2- Iris and Vein Scanners	28
5.2 Include descriptions of security measures to assure that only authorized personnel have access, and for authorized reasons.	5.2.2-Iris and Vein Scanners	28
5.2 Minimum Requirements		
Chart or table listing anticipated automation requirements for operation of the settlement, and identifying particular systems and robots to meet each automation need.	Table-5.2.1 Table-5.2.3-QCM	29
5.3 Describe automation devices to enhance livability in the community, productivity in work environments, and convenience in residences.	5.3.1-RCN 5.3.2-BEN Network 5.3.3-In Home Control System	29-31
5.3 Emphasize use of automation to perform maintenance and routine tasks, and reduce requirements for manual labor.	5.3.4-APAR 5.3.4-Central Robotic Command Center	30-31
5.3 Provide for privacy of personal data and control systems in private spaces.	5.3.5-Iris and Vein Scanners	32
5.3 Describe devices for personnel delivery of internal and external communications services, entertainment, information, computing, and robot resources.	5.3.6-RCN 5.3.2-Atlas Computer	32
5.3 Minimum Requirements		
Drawings of robots and computing systems that residents will encounter in Astoria	Figure 5.3.1-FRR Figure 5.3.2-Atlas Figure 5.3.3-Agri-bots Table-5.2.3-QCM	29-31
Diagrams of networks and bandwidth requirements to enable connectivity	Table 5.2.3-QCM	29
5.4 Show robot design adaptations for low to nonexistent gravity and deep layers of dust	5.4.1-Drilling and Pumping Station 5.4.1-Surface Extraction Robot 5.4.3-Glass Paving and Jet Propulsion Systems	32-34
5.4 Minimum Requirements		



Appendix C

Drawings of robot components enabling drilling, shoveling, loading, transporting, and other tasks on near zero-g surfaces	Figure 5.4.1-Surface Extraction Robot Figure 5.4.2-Drilling and Pumping Station	33-34
5.5 Provide automated systems for unloading ore delivered by ships from other mining installations.	5.5.1-Articulating Cargo Arms 5.5.1-Zero-G Conveyor Belt	34
Drawings of automated unloading systems, clearly showing how ore moves from ship to refinery.	Figure 5.5.1-Cargo Handling	35
6.0 The proposal will include a schedule for complete and occupation of Astoria, and costs through construction phases of the schedule.	6.1 Schedule	35
6.1 The schedule must describe contractor tasks from the tie of contract awarded (8 May 2071) until the customer assumes responsibility for operations of the completed settlement.	6.1 Schedule	35
6.1 Show schedule dates when Foundation Society members may begin moving into their new homes	6.1 Schedule	35
6.1 Show when the entire original population will be established in the community.	6.1 Schedule	35
6.1 Minimum Requirements		
Durations and completion dates of major design, construction, and occupation tasks depicted in a list, chart or drawing	6.1 Schedule	35
6.2 Specify costs billed per year of Astoria's design through construction in U.S. dollars, without consideration for economic inflation	6.2 Cost	36
6.2 Estimate numbers of employees working during each phase of design and construction in the justification for contract costs to design and build the settlement	6.1 Schedule	35
6.2 Minimum Requirements		
Chart(s) or table(s) listing separate costs associated with different phases of construction, and clearly showing total costs that will be billed to the Foundation Society	6.2 Cost	36
7.0 Astoria will host various commercial and industrial ventures, which may change with time.	7.1 Business Plan	37
7.0 The basic design must be sufficiently flexible to add compatible business types with little configuration change.	7.1 Business Plan	37
Show infrastructure for conduction major asteroid materials harvesting and processing operations	7.3 Docking Services	38



Astoria will either build, or import and then deploy, equipment required to conduct asteroid harvesting operations	7.2 Mining and Refining	38
The settlement will provide capability for refining or otherwise processing asteroid materials to enable as much self-sufficiency as possible.	7.2 Mining and Refining	38
The settlement will create commodities and products for export and trade.	7.2 Mining and Refining	38
Port facilities must enable receiving incoming raw materials.	7.3 Docking Services	38
Port facilities must enable warehousing import and export products.	7.3 Docking Services	38
Port facilities must enable shipping of commodities and other products.	7.3 Docking Services	38
Vehicles spending time on asteroids will accumulate dust on exterior and interior surfaces; show method(s) for preventing dust from entering enclosed areas in Astoria.	7.3 Docking Services	38
Describe services for remote asteroid mining operations and outer planet expeditions	7.3 Docking Services	38
Excess agricultural production, storage, and processing capability (beyond the needs of settlement residents) will service provisioning needs of visiting spacecraft.	7.3 Docking Services	38
Provide suitable facilities for visiting spacecraft crews “rest & recreation” (R & R)	7.3 Docking Services	38
Provide a full-service repair depot for major maintenance and repair of space vessels	7.3 Docking Services	38
Provide fueling services for spacecraft traffic using port facilities	7.3 Docking Services	38
Show fuel production and storage facilities for at least 40,000 cubic feet of LOX and 110,000 cubic feet of LH2, replenished monthly	7.2 Mining and Refining	38
“Space Tug” services will be available to assist disabled vessels	7.5 Rescue Capabilities	40
Capability to send rescue operations for asteroid miners requires at least one ship full provisioned for a mission up to ten months long, ready to leave in 24 hours	7.5 Rescue Capabilities	40



Appendix C

Provide for sensing and imaging research appropriate to Astoria's outer solar system location	7.5 Sensing and Imaging Research	40
Radio telescope with dish diameter of at least 500 feet (150 meters)	7.5 Sensing and Imaging Research	40
Optical telescope with mirror diameter of at least 20 feet (6 meters)	7.5 Sensing and Imaging Research	40
Structural Isolation from vibration-causing activities on Astoria	7.5 Sensing and Imaging Research	40
Data processing and communications capability to return data to Earth in real time	7.5 Sensing and Imaging Research	40
8.0 Operational Scenario		
Describe all four family members' activities on a typical day of work, school, and play.	7:30 AM – 8:00 PM. Follows Todd, Charlotte, Ava, Jacob	41-42
Deascribe how features of Astoria design and operations apply to the family's daily life.	Footnotes and References	55
Describe travel time and distance between destinations.	8:00 AM – Züg travel 8:10 AM – Paths and Walkways 8:25 AM - Shuttle	42-44
Describe transportation routes and methods of travel.	8:00 AM Züg; 8:10 AM – Paths; 8:25 AM - Shuttle	42-44
Describe buildings/facilities visited.	7:30 AM; 8:00 AM, 8:10 AM; 8:22 AM; 12:07 PM; 12:15 PM; 1:15 PM; 2:30 PM; 2:43 PM; 5:34 PM	41-52
Describe interactions with other people.	7:30 AM – 8:00 PM	41-55
Describe duration of each activity.	Time signatures preceding each section	41-55
Describe tools/computers/robots used.	7:30 AM – 8:00 PM	41-55
Describe meal preparation.	3:00 PM	51
Describe the repair of a leak under a sink in the family home.	5:34 PM	51



Describe reviewing the daily news.	8:22 AM	44
Describe 2 hours of family entertainment in the evening.	6:00 PM – 8:00 PM	53-54
Describe shopping for milk	2:43 PM	51
Describe shopping for a book for the man	2:43 PM	51
Describe shopping for shoes for the woman	12:15 PM	48
Describe shopping for a birthday present for the boy	2:30 PM	50
Describe shopping for medicine for the girl	1:15 PM	48



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