

FOUNDATION SOCIETY

COLUMBIAT

NORTHDONNING HEEDWELL



DURANGO HIGH SCHOOL
DURANGO COLORADO USA





TABLE OF CONTENTS



Table of Contents

1.0 Executive Summary

2.0 Structural Design

2.1 External Configuration.....9

2.1.1 External Structures.....9

2.1.2 Construction Materials.....10

2.1.3 Connection Joint Between Rotating and Non-rotating Sections.....11

Section 2.2 Internal Arrangement.....11

2.2.1 Residential Torus.....11

2.2.2 Major Spokes.....12

2.2.3 Operations Core.....13

2.3 Construction Sequence.....13

2.4 Docking Configuration.....14

2.4.1 Passenger Bay.....14

2.4.2 Business Bays.....14

2.4.3 Auxiliary Bay.....15

2.4.4 Emergency Bays.....15

Section 2.5 Varied Gravity Areas.....15

2.5.1 Half and Three Quarter Gravity Environments.....15

2.5.2 Acclimation Process.....15

3.0 Operations and Infrastructure

3.1 Construction Material Sources.....17

3.1.1 Orbital Location.....17

3.1.2 Space Elevator.....17

3.1.3 Origin of Materials.....17

3.2 Community Infrastructure.....17

3.2.1 Atmosphere and Climate Control.....17

3.2.2 Food Production.....18

3.2.3 Power Generation.....19

3.2.4 Water/Waste Management.....19

3.2.5 Communications.....20



3.2.6 Internal Transportation.....	20
3.2.7 Day-Night Cycles.....	21
3.2.8 Terminals for Future Expansion	21
3.2.9 Emergency Protocol.....	21
3.2.10 Fueling Systems.....	22
3.3 Space Infrastructure.....	22
3.3.1 Space Infrastructure.....	22
3.3.2 Space Vehicles.....	22
3.4 Propulsion Systems.....	24
3.4.1 Engine Design.....	24
3.4.2 Propellant.....	24
3.4.3 Orbital Corrections and Artificial Gravity Volumes.....	24
3.5 Docking Services.....	25
3.5.2 Food and Commodity Replenishment.....	25
3.5.3 Vehicle Maintenance and Fueling.....	25
4.0 Human Factors	
4.1 Community Design.....	27
4.1.1 Commercial Space.....	27
4.1.2 Housing.....	27
4.1.3 Undeveloped Property.....	28
4.1.4 Parks and Recreation.....	28
4.1.5 Entertainment.....	28
4.1.6 Education.....	28
4.1.7 Medical Services.....	29
4.1.8 Reduced Gravity Accommodations	29
4.1.9 Consumables.....	29
4.2 Residential Designs.....	29
4.2.1 Housing Designs.....	29
4.2.2 Demographics.....	31
4.2.3 Furniture.....	31
4.3 Safe Access in Micro-Gravity.....	31
4.3.1 Means of Safe Access in Non-Pressurized Areas.....	31



4.3.2 Means of Safe Access in Pressurized Areas	32
4.4 Spacesuit Design	33
4.4.1 Airlocks	33
4.4.2 Spacesuit Composition	33
4.4.3 Donning Procedure	34
4.4.4 Doffing Procedure	34
4.5 Visitor Accommodations	34
4.5.1 Medical Quarantine	34
4.5.2 Education About Life on the Station	34
4.5.3 Hotel Design	35
4.5.4 Security	35
5.0 Automation Design and Services	
5.1 Automation for Construction	37
5.1.1 Transportation for Construction	37
5.1.2 Automation for Construction	37
5.1.3 Automation for Interior Finishing	38
5.2 Facility Automations	39
5.2.1 Quantum Processing Mainframe	39
5.2.2 Automations for maintenance, repair, and safety functions; backup and contingency plans	39
5.2.3 Personnel Access; Security Measures	40
5.2.4 Physical Locations of Computers and Robots	40
5.2.5 Robot Survivability in Solar Flare Activity	41
5.3 Automation for Enhanced Livability	41
5.3.1 Automation for Livability in the Community	41
5.3.2 Automation for Productivity in Work Environments	41
5.3.3 Automation for Convenience in Residences	42
5.3.4 Automation for Maintenance and Routine Tasks	42
5.3.5 Automation for Personal Privacy and System Control	43
5.3.6 Access to Community Computing and Robot Resources	43
5.4 Cargo Handling	43
5.4.1 Cargo Tracking	43



5.4.2 Cargo Handling System	43
5.4.3 Cargo Warehousing	43
5.5 Robot Maintenance	44
5.5.1 Maintenance and Overhaul	44
5.5.2 Dust Decontamination	44
6.1 Schedule	46
6.2 Cost	47
7.0 Business Development	
7.1 Business Plan	49
7.2 Hard Businesses	49
7.2.1 Commerce	49
7.2.2 Transportation Node & Port/ Provisioning	50
7.2.3 Real Estate Market	51
7.3 Soft Businesses	51
7.3.1 Tourism & Customer Service Industries	51
7.3.2 Custom Commodities	51
7.3.3 Small Business Development & Economic Integration	52
7.3.4 R&D, Materials and Research	52
7.4 Conclusion and R.O.I	52

8.0 Compliance Matrix

Bibliography

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1.0 EXECUTIVE SUMMARY



1.0 EXECUTIVE SUMMARY

Northdonning Heedwell is pleased to present Columbiat, an economically synergistic settlement designed and constructed to place the Foundation Society at the nucleus of space-based finance and transportation. Combining a multitude of technological marvels with the untamed spirit of mankind, Columbiat brings opportunity to Earth's doorstep, seamlessly integrating humanity with our final frontier. As the pinnacle of the Foundation Society's domain, Columbiat will undoubtedly be labeled in history books as the forefront platform for universal expansion.

In order to best serve the Foundation Society, our design staff has been guided by three major objectives:

1. To reinforce the Foundation Society's current investments in the space settlements of Alexandriat, Bellevistat, and Alaskol.
2. To increase the Foundation Society's influence in space expansion and further your final goal of establishing settlements of your members in space.
3. To provide the Foundation Society with a generous and secure foothold in the financial and transportation networks of the new space age.

With these goals in mind, Northdonning Heedwell has designed Columbiat to be unique, efficient, and most of all functional. Innovation, balance, and creativity in our design has yielded a cornucopia of company-specific ideas, making Northdonning Heedwell's proposal an airtight fit to the Foundation Society's goals. These are several examples:

- A flowing organic landscape and community design in the residential area sets Columbiat apart as the most hospitable space settlement ever built, providing the perfect location not only for trade and finance, but also for the future Foundation Society Headquarters.
- The versatile commercial and industrial properties on the settlement created through our innovative use of partial and zero gravity spaces encourage all manners of dynamic business pursuits, expanding the influence of the Foundation Society in space-age business.
- Flawless integration of the automation systems through the use of the Quantum Processing Mainframe enables streamlined station construction and operation that ensures the durability of the Foundation Society's investment.
- A plethora of financial pursuits, from

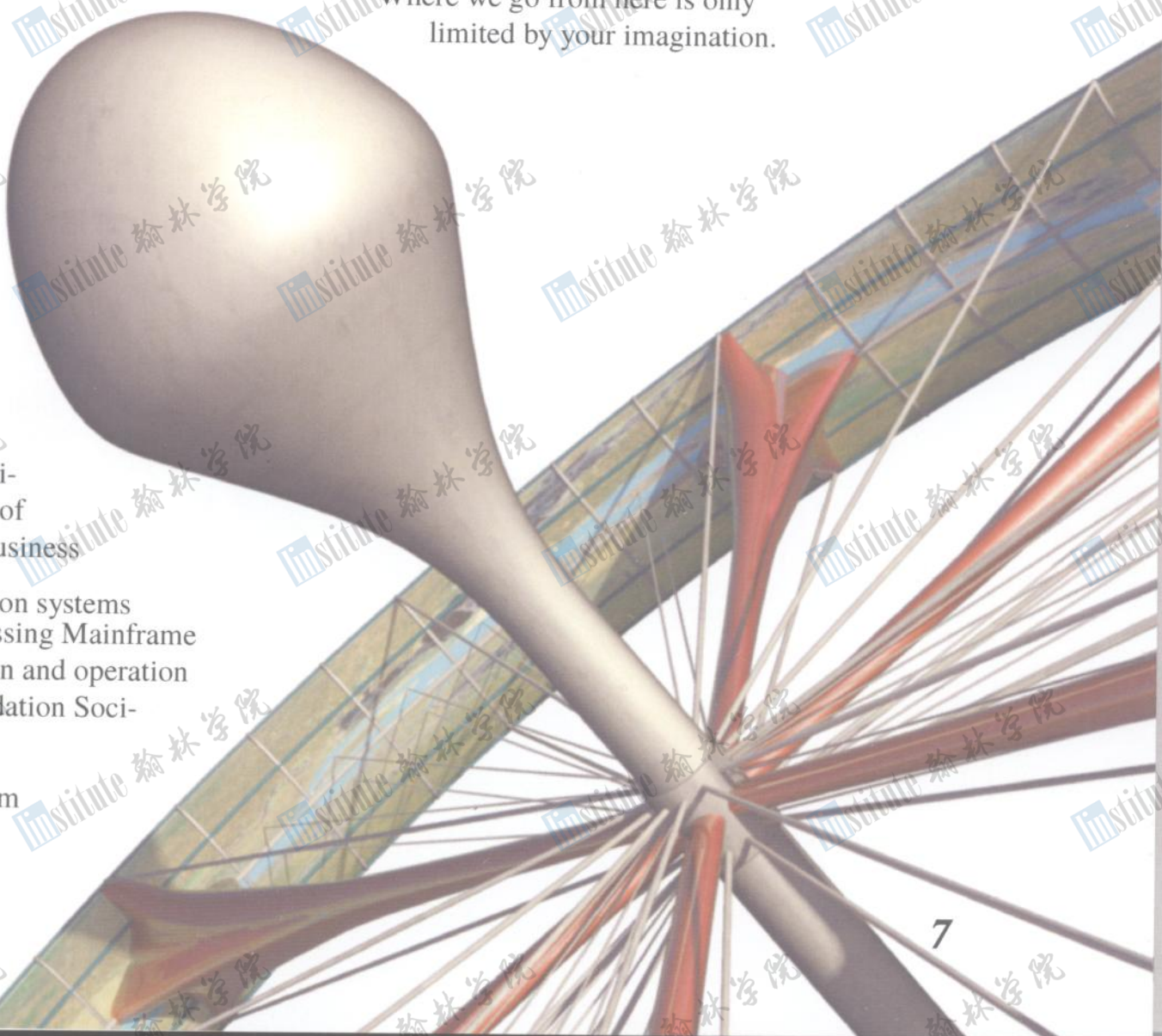
large-scale lucrative real estate sales to the full integration of small businesses in the settlement economy provide the Foundation Society with an early and sustainable revenue stream.

- Thorough yet resourceful infrastructure and operational systems such as the comparatively inexpensive solar power system and the efficient use and reuse of space vehicles places Columbiat in the Foundation Society hands at a very reasonable price without sacrificing quality and safety.

The Foundation Society headquarters preside over the most thriving, highly efficient and comfortable settlement built to date, reflecting your desire to welcome your members to space.

Alexandriat. Bellevistat. Alaskol. Their strengths are our beginnings. Columbiat has sprung from their proud accomplishments to act as the greatest of human endeavors.

Where we go from here is only limited by your imagination.





2.0 STRUCTURAL DESIGN



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The structural design of Columbiat features the best and most effective construction materials to provide safety natural views of space, Earth, and beyond from anywhere in the Residential Torus or Major Spokes. An organic interior design weaves together residential, recreational, and commercial environments seamlessly providing a comfortable, familiar environment. A rapid construction process reduces the return time on investment for the Foundation Society. To accommodate for the countless cargo and vehicle traffic on Columbiat, the docking design maintains and organizes all docking transactions. Finally, a luxurious acclimation process enhances visitors experience on Columbiat prompting return.

2.1 EXTERNAL CONFIGURATION

Northdonning Heedwell's Columbiat combines a comprehensive structural design featuring revolutionary construction materials such as RXFI and Thermal Micrometeoroid Garment, highly efficient utilization of space and atmosphere, and an effortless integration between rotating and non-rotating sections. These features thoroughly provide the Foundation Society with the safety, functionality and innovation required to stimulate and benefit the expansion of space-based

business and cargo transfer networks.

2.1.1 EXTERNAL STRUCTURES

Columbiat is composed of three major sections, the Residential Torus, the Major Spokes, and the Operations Core (Figure 2.1.1). The Residential Torus (Section 2.2.1) is pressurized and rotates at 125 m/s to create a 1g atmosphere providing a comfortable living, working, and vacation environment for all residents and transient population. The advantage of this one torus design is its guaranteed structural stability even with the pressure differential between the interior and outer space. The structural

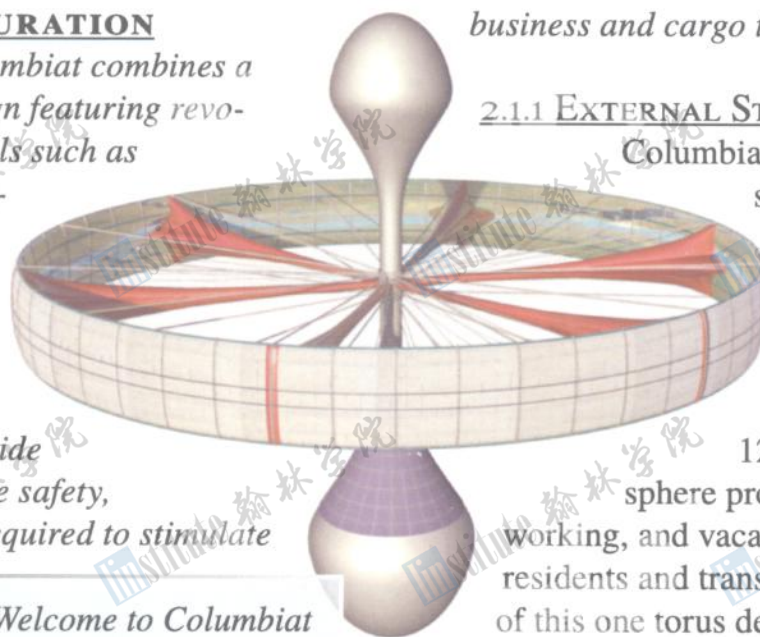
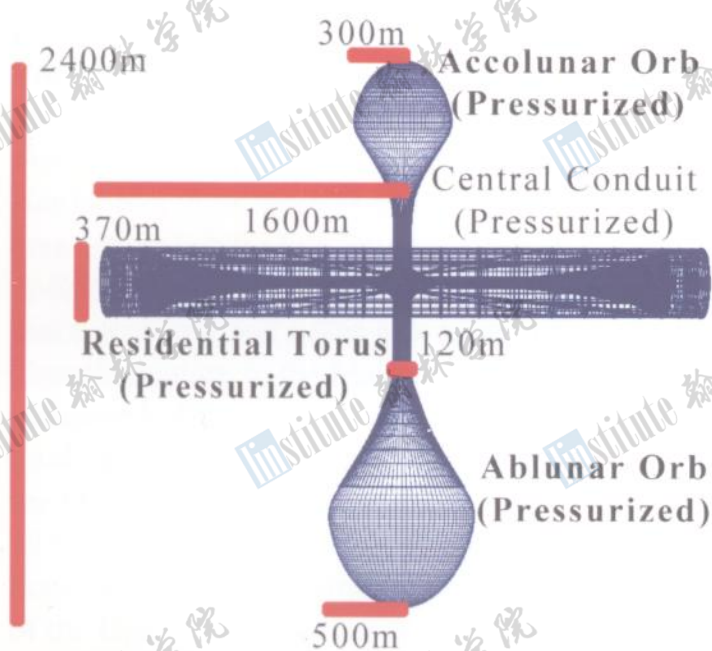
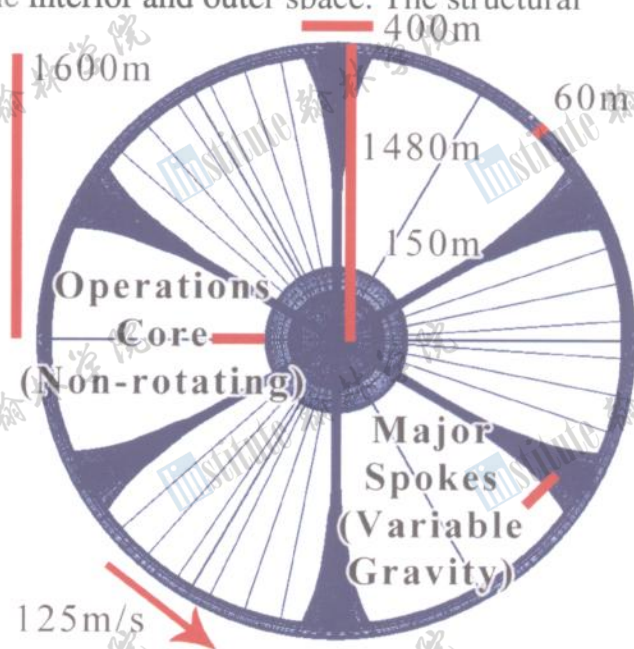


Figure 2.1.1 - Welcome to Columbiat



Figures 2.1.3-2.1.4 show dimensions, rotation rates and pressurization levels of areas of the settlement.



Structure	Radius (m)	Height (m)	Volume (m3)	Down Area (m2)
Residential Torus	1600	60	55,794,000	3,720,000
Major Spoke	1480	75	26,141,000	1,238,000
Operations Core	NA	2400	640,089,000	NA
-Accolunar Orb	300	600	113,040,000	NA
-Ablunar Orb	500	1000	523,333,000	NA
-Central Conduit	60	800	9,043,000	NA

Figure 2.1.2 - Table of settlement dimensions, down areas, and volumes



Material	Location	Width	Amount (m3)	Purpose
Titanium alloy	Geodesic Lattice Structure and Hull	1m & 3m	33,274,000	Structural skeleton providing base for insertion of primary materials. Also used for Base structural support for hull.
Thermal micrometeoroid garment (TMG)	Hull and Windows	.05m	666,000	Protection from penetration of meteoroids using its unique combination of materials
RAGuard	Hull and Windows	.2m	2,664,000	Protection from Gamma and X-ray radiation
RXF1	Hull and Windows	.03m	399,600	Protection from solar flares and galactic cosmic radiation
Silicon Aerogel	Windows	.1m	554,000	Station insulation to combat space temperature fluctuation
Hybrid Multifoil Aerogel Thermal Insulation	Hull	.4m	3,327,000	Primary station insulation and protection from Infra-red radiation
Diamondoid fibers	Windows	.02m	266,400	Structural strength and impact resistance
Transparent Aluminum	Windows	1m & 3m	22,171,000	Structural reinforcement for windows

design of the torus magnifies livability and resident comfort while on Columbiat. Connecting the Operations Core to the Residential Torus are 6 Major Spokes (Section 2.2.2). The Major Spokes provide structural support; food production area; office space and residential locations; and rapid transportation of infrastructure, cargo, equipment, and transient/static populations between the Operations Core and the Residential Torus. The Major Spokes are an innovative method of meeting the Foundation Society's need for variable gravity environments (Section 2.5). In addition, they use a design similar to a skyscraper to offer a profitable development area and accommodate for expansion and businesses desiring less intense gravity, in turn expanding Columbiat's economy and status as a center of commerce. Complementary to the Major Spokes, 120 Minor Spokes composed of titanium alloy provide additional structural support. As the nucleus of settlement operations, the Operations Core (Section 2.2.3) accommodates all infrastructure, recycling, refining, docking, and manufacturing transpiring on Columbiat. The functions of the Operations Core are differentiated into three separate sections. The "orb" that is closer to the moon - Accolunar Orb - is slightly smaller than the Ablunar Orb, which consequently is further from the moon. In addition, the Central Conduit connecting the two orbs transfers infrastructure, personnel, and cargo. The unique figure of the Operations Core maximizes storage space, providing the Foundation Society with the most effective integration of a state of the art manufacturing and infrastructure center, and a separation of docking

Figure 2.1.5 - Construction Materials

bays into a corporate Ablunar and guest oriented Accolunar simplifying docking procedure (Section 2.4).

2.1.2 CONSTRUCTION MATERIALS

In order to reduce the cost of Columbiat, Northdonning Heedwell is utilizing the abundant resources that the moon has to offer. Alaskol is subcontracted to mine titanium for the titanium alloy and multifoil, silicon for the aerogel, and aluminum for the transparent aluminum and titanium alloy. Alaskol refines these materials before they are shipped to Columbiat's construction location. Bellevistat's refining center is subcontracted to produce the RAGuard, RXF1, Diamondoid Fibers, and Thermal micrometeoroid garment (TMG). Once all materials arrive at Columbiat's construction location they are fused into the hexagonal geodesic panels that fill in the frame. The ceiling of the Residential Torus and the Major Spokes are constructed out of entirely transparent materials (Figure 2.1.6). These easily obtainable materials when combined, ensure natural views of space to all residents at any point in the Residential Torus or Major Spokes without sacrificing any safety.

The dangers of radiation and debris penetration are two of the largest threats to space colonization. Columbiat's material combination provides far more than adequate protection granting peace of mind to the residents. In order to combat the radiation threat, Columbiat utilizes a variety of materials (Figure 2.1.5). Protection during solar flare activity is especially important in order for the station to remain fully opera-



tional at all times. To shield the settlement from micro debris penetration Thermal micrometeoroid garment (TMG) uses aluminized PET film, non woven dacron, polyamide Kapton film, beta cloth marquisette laminate, and Teflon coated filament in order to halt the momentum of any projectile with enough force to penetrate the hull of the settlement. If that wasn't enough the TMG is assisted by diamondoid fibers and backed by the transparent aluminum and titanium alloy for a structural base layer designed to stop any threats. If the need arises for even more intense shielding, padded carbon fiber reinforced polymer bands attached to the geodesic lattice structure can be controlled robotically to move to the threatened location before impact (Section 5.2.2). These bands double as a seal in the event of a hull breach while repairs take place without further incident. Columbiat is capable of avoiding the path of any threat larger than the hull can handle.

TRANSPARENT ALUMINUM (1M/3M)	
TITANIUM ALLOY (1M/3M)	
THERMAL MICROMETEOROID GARMENT (.05M)	
RAGUARD (.2M)	
RXF1 (.03M)	
AEROGEL (.1M)	
MULTIFOIL AEROGEL (.1M)	
DIAMONDROID FIBERS (.02M)	

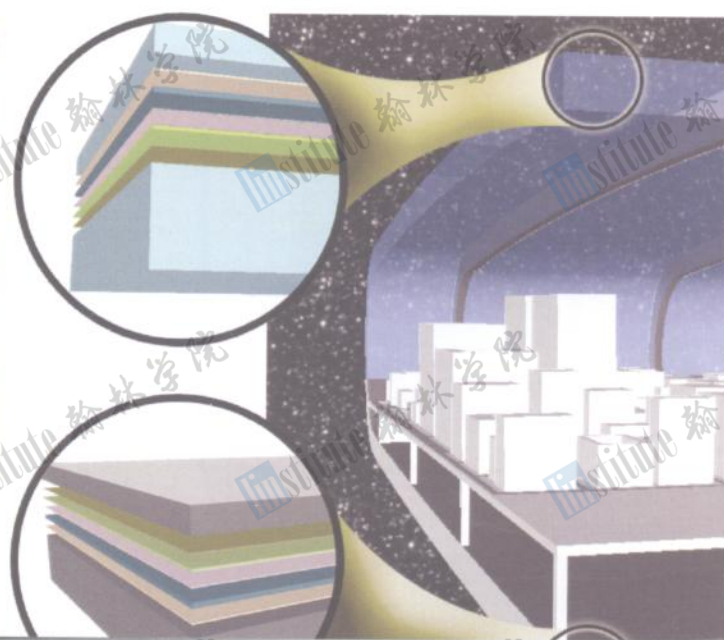


Figure 2.1.6 Demonstrates the arrangement of the construction materials to guarantee residents natural views of space from anywhere in the torus

the value of The Foundation Society's investment.

2.1.3 CONNECTION JOINT BETWEEN ROTATING AND NON-ROTATING SECTIONS

Friction is a substantial obstacle when it comes to maintaining the Residential Torus rotating around a stationary Operations Core. In order to minimize the energy expenditure necessary to keep these sections with their respective gravities, an almost frictionless joint separates the two, lowering operational costs and unnecessary expenses. The joint (Figure 2.1.7) that connects the rotating and non-rotating volumes of Columbiat is a series of ducts, each inside another. The ducts are used to transport materials, people, and infrastructure from the Operations Core to the Major Spokes and beyond. The joint rotates as the interior slides along greased bearings. The bearings are positively charged along with the joint to repel and further reduce friction levels. The smooth integration minimizes friction and therefore energy consumption, allowing for effortless transfer of infrastructure, people, and materials to and from rotating parts.

Figure 2.1.7 - Rotating Joint



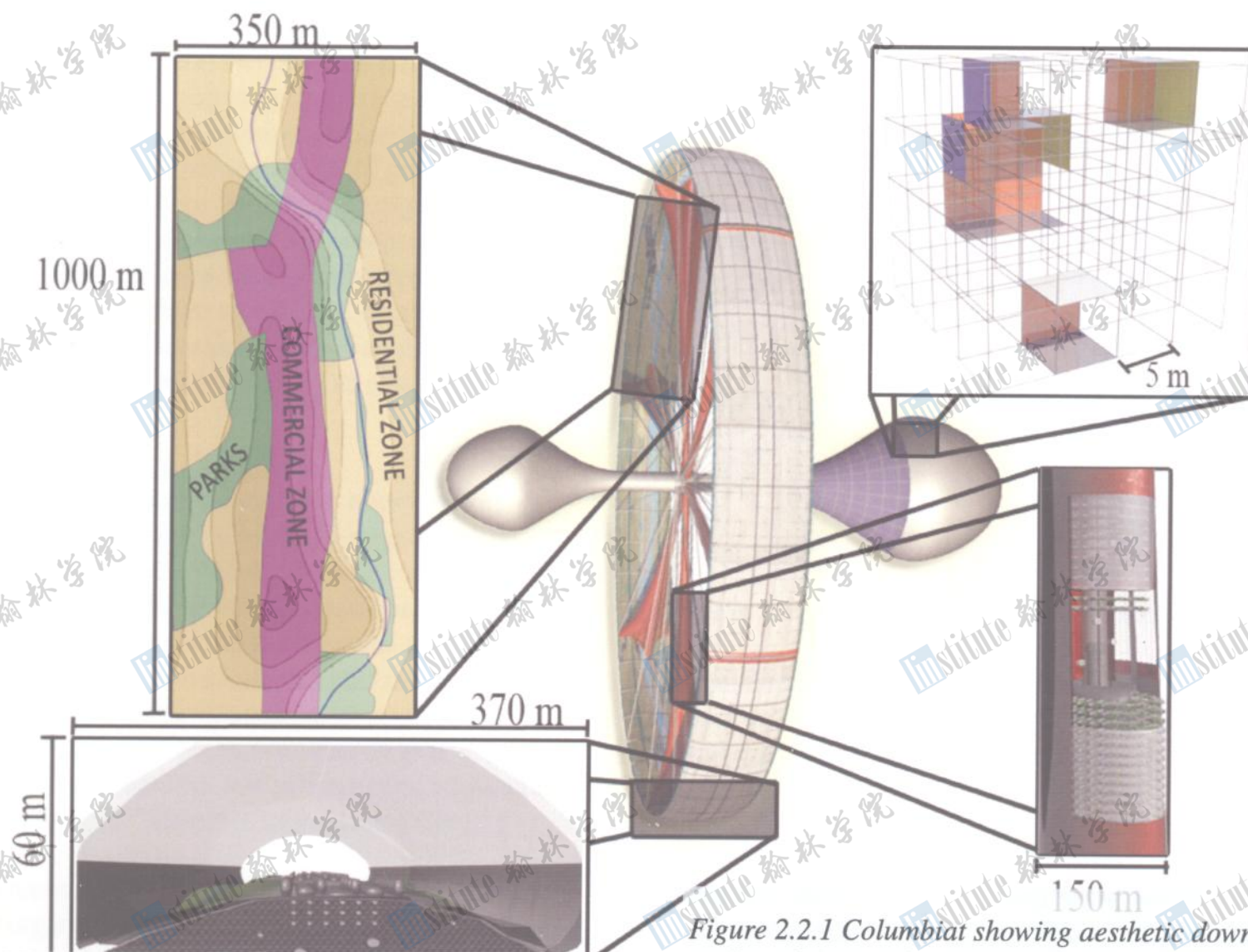
2.2.1 RESIDENTIAL TORUS

As the leading trade and commerce facility in space, Columbiat sets itself apart from all other settlements not only in functionality, but in aesthetics as well. We have strayed away from the standard geometric design of settlement residential areas, and instead created a tasteful, flowing, organic design for the interior of the Residential Torus. This "Hilly Metropolis" emulates earthlike conditions by flowing seamlessly between a city skyline and a hilly landscape. A "main street" style central commercial district runs the length of the torus atop a beautiful gently sloping hillside. On either side of the hilltop commercial district the recreational and residential areas blend flawlessly. This interior organization differentiates the residential neighborhoods while creating the most aesthetically pleasing home or vacation destination that anyone could desire. With the earthlike conditions, all residents on Columbiat can experience the final frontier while still being in a comfortable, safe, and recognizable environment.

SECTION 2.2 INTERNAL ARRANGEMENT

The interior of Columbiat has been designed to allow for maximum comfort, safety and familiarity for its residents. The settlement has the ability to adapt to the developing economic and social environment of space, significantly prolonging its service life and maximizing

Northdonning Heedwell has also focused on emphasizing safety and productivity. Pressure doors are located at every Major Spoke so all communities may be isolated and quarantined from the rest of the settlement. Safe floors – located in every building throughout the station – have their own supply of atmosphere and amenities needed for residential survival while repair takes place. This ensures that residents can stay in a comfortable and sustainable environment in the rare case of an emergency. Evacuation is possible and convenient by means of the emergency capsules



called Pretereos (Section 3.2.9 & 3.3.2), allowing peace of mind and perfecting residential safety.

2.2.2 MAJOR SPOKES

Traditionally, spokes on a rotating space settlement merely fulfilled the role of providing structural stability and a conduit for transportation. Northdonning Heedwell has evolved the idea of a spoke far beyond just a support beam and into a fully-functioning agricultural, residential, and commercial district. As the spoke extends out from the Operations Core, it flares, significantly increasing the amount of down-area that the settlement offers while improving the structural stability of a standard spoke design. Additionally, this design provides variable gravity within the spoke depending on location (gravity levels are proportional to the

Figure 2.2.1 Columbiat showing aesthetic down surface division of Residential Torus, Major Spoke with elevators and agriculture, Residential Torus cross section with the rolling hill landscape, and the simple organisation of the Operations Core

distance from the Operations Core), giving inhabitants the ability to select the gravity magnitude of their choice for living quarters or commercial endeavors.

3 of the 6 Major Spokes are divided into different gravity intensities. Space from 1 to $\frac{3}{4}$ gravity is utilized as a massive commercial and residential tower, with hundreds of floors of apartment and office rooms. These “towers” utilize a flexible modular design; though their general layout and segmentation is predetermined; interiors of offices and residential spaces may be altered with little effort. Every aspect of an area may be custom-

Figure 2.2.2 Chart demonstrating residential, commercial, and recreational allocations within the Residential Torus

Station Section	Vertical Clearance (m)	Down Area (m2)
Residential	60	1,602,000
Industrial	NA	Variable
Recreational	60	911,000
Commercial	60; Variable2.2.3	1,256,000; Variable2.2.3
Agricultural	6/Floor	500,000



ized by a tenant providing an unprecedented amount of commercial and personal freedom. Several floors at $\frac{3}{4}$ and $\frac{1}{2}$ gravity are set aside as a location for visitor acclimation (Section 2.5). Finally, the volume between $\frac{3}{4}$ and 0 gravity and the 3 remaining Major Spokes are designated for food production systems and low-gravity laboratories. The core 15m of each spoke contains infrastructure routing and cargo elevators, while passenger elevators spiral down the exterior of the spoke, providing beautiful views to residents in transit.

2.2.3 OPERATIONS CORE

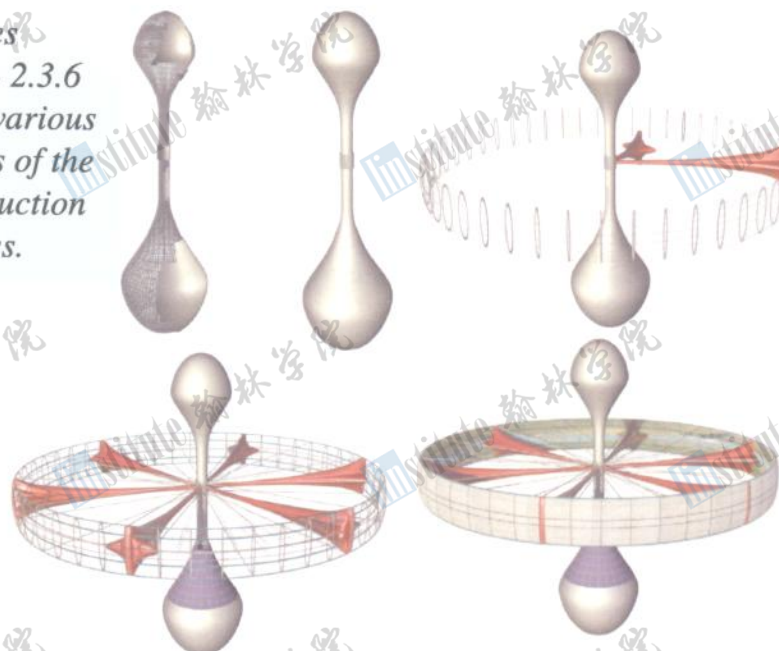
The Operations Core is a massive micro-gravity structure, with a total volume of a staggering 640,000,000m³. Contained within are all of Columbiat's industrial structures and operational systems, vast warehouses, docking and terminal facilities, and the infrastructure to support the largest space settlement ever built. Therefore, structuring this colossus is one of our top priorities so as to ensure the safety, productivity, and efficiency of all functions and ventures in Columbiat's Operations Core.

To achieve this most effectively, we have developed a 3D organizational system to create a solid structure and sense of location in this otherwise non-directional environment (Figure 2.2.1). The skeleton of the interior consists of a cubic guide wire grid, spaced 5m in each direction (125m³), with larger cubes ranging up to 1,000,000m³ available for pursuits that request them. These cubes are compartmentalized by deploying a colored fluorescing metallic film wall over the cube sides. Each side of the cube fluoresces a different color, allowing for a sense of orientation while simultaneously providing a pleasant ambient light. As each wall may be deployed as needed, structures of any configuration imaginable may be constructed at a moments notice. Because this system is constant throughout the Operations Core, movement, organization, and entrepreneurial pursuits become simple and efficient tasks, expediting the business and trade that make Columbiat a true "Singapore in orbit."

2.3 CONSTRUCTION SEQUENCE

Even though Columbiat is one of the largest space settlements ever constructed, Northdonning Heedwell's use of subcontracts, systemized development process, and specialized construction automation, allow the settlement to take a mere 12 years for completion reducing the time-frame for return on investment and giving the Foundation Society the oppor-

Figures 2.3.2 - 2.3.6 show various phases of the construction process.



tunity to move into their new headquarters earlier.

Columbiat has three initial stages in the construction sequence. First, DSPS satellites (Section 5.1.1) are sent to the Earth-moon L2 location in order to create a three-dimensional reference point where the station will reside. Then, Northdonning Heedwell manufactures the solar satellites that produce the primary power source of Columbiat. Finally, Bellevistat constructs the Primoris (Figure 2.3.1), the primary ship in the construction of the settlement. This ship will contain initial automations for construction (Section 5.1), solar collectors for an initial power supply, heavy manufacturing equipment, and a small portion of the construction materials. Alaskol ships titanium to Bellevistat who is subcontracted to construct the hexagonal geodesic lattice shapes that are shipped to the location and built into a frame that is the basis of the settlement's structure. The Primoris is built into the lattice structure of the Operations Core (Figure 2.3.2), as it will later become Columbiat's manufacturing center. Next, the Operations Core lattice structure is filled with the infrastructure and connecting joint (Section 2.1.3). The Hex Laying Robot (Section 5.1.1) lays the construction materials (Section 2.1.2), in the shape of

hexagonal tiles, into the lattice structure. The Operations Core is pressurized (Figure 2.3.3) and the fabrication of the Major Spokes and Residential Torus begins (Figure 2.3.4). These structures are constructed in the same sequence as the Operations Core of lattice, infrastructure, and materials except with the transparent material combination.



Figure 2.3.1 – Bellevistat's constructed Primoris vehicle containing automations for construction, a manufacturing center, and construction materials to jump-start the creation of Columbiat



Agriculture production begins in three of the Major Spokes and the other three are used for commercial endeavors and $\frac{1}{2}$ and $\frac{3}{4}$ gravity zones (Section 2.5). The Major Spokes are completed (Figure 2.3.5) and the support for the contoured floor begins while infrastructure is being positioned in the Residential Torus. The geodesic structure of the Residential Torus is filled in with the transparent and hull material combinations and the torus is pressurized. Finally, buildings and the interior are constructed; radiation, structural, and impact safety tests are completed; and Columbiat is deemed fully operational and is available for population (Figure 2.3.6). A full graphic of the schedule including construction of major hull components is located in Section 6.2.

2.4 DOCKING CONFIGURATION

As a "Singapore in orbit," Columbiat maintains and organizes the complex and constant transfer of cargo and personnel through our 6 different dock bays. The separation of bays between orbs of the Operations Core allows for an efficient distribution of docking transactions, creating an effective combination of speed, safety, and dependability.

2.4.1 PASSENGER BAY

The majority of visitors arriving at Columbiat enter through the Passenger Bay located on the Accolunar Orb of the Operations Core. The Passenger Bay consists of three unpressurized docks that are each capable of docking one ship at a time. The docking procedure begins as the ship nears the settlement.

The vehicle traffic around Columbiat is monitored by flight controllers who assess and transmit flight patterns to the oncoming vehicles with directions and orientations required to make

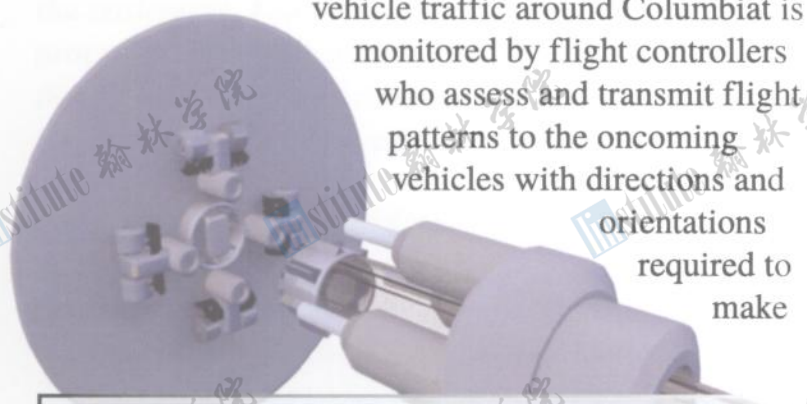


Figure 2.4.2 – Unpressurized docking system attaching to airlock with ease and speed making the docking procedure efficient and simple.

docking easy, simple, and safe. The vehicle is monitored and can be controlled via automation if any variation in the flight pattern is noticed. Upon arriving at the dock a transparent "Jetway" extends to the vehicle. The Jetway is equipped with a geared male segment that fits into an opposing female socket. The Jetway is guided to the

airlock robotically and has a magnetic interface to help account for minor variations in the vehicle's location. Upon contact with the airlock, the male segment spins and magnetic pins extend to lock the Jetway in place and seal the environment inside. Airlock doors open as the passengers unload using the handrails provided as they welcome the astounding view of Columbiat as it extends out away from them.

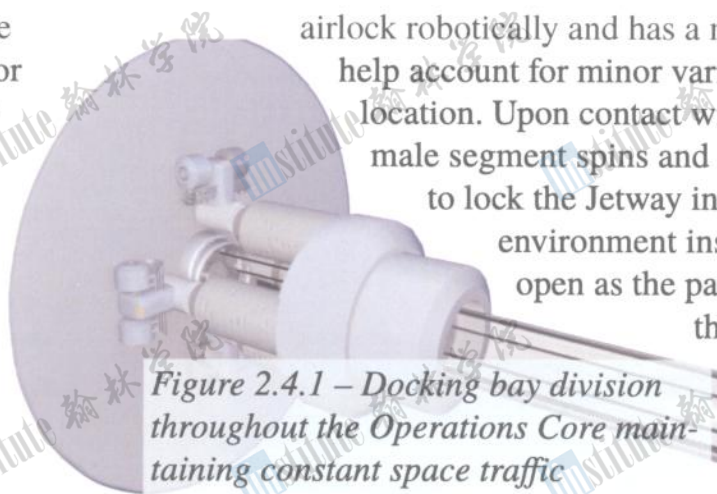


Figure 2.4.1 – Docking bay division throughout the Operations Core maintaining constant space traffic

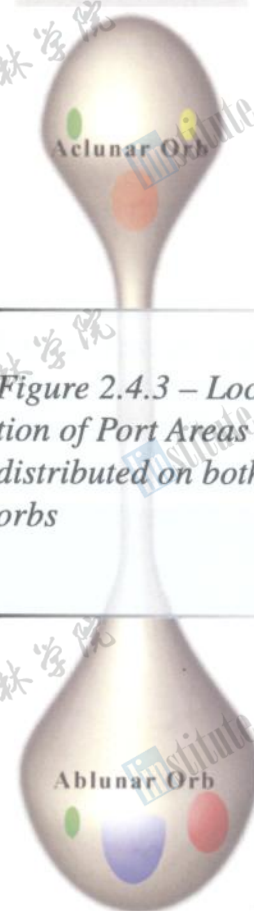
Because Northdonning Heedwell wants to ensure that all vehicles can dock at Columbiat we have offered a subsidy incentive for companies to produce and use our airlock design (Section 7.2.2). By the time Columbiat is constructed, this airlock design will be a standard in space vehicles and the Foundation Society will be sure that it's investment will be universally accessible.

Key:	
■	Passenger
■	Business
■	Emergency
■	Auxillary

2.4.2 BUSINESS BAYS

Maximizing our ability to cater to our expansive commercial audience, Columbiat is equipped with two Business Bays focused around the movement of cargo. One of the Business Bays is located on the Accolunar Orb and one on the Ablunar Orb. By utilizing two bays, docking is separated into normal business functions and distinguished corporate customer docking. Two unpressurized docks comprise the corporate docking on the Accolunar Orb. Similarly, the normal business function bay on the Ablunar Orb is capable of simultaneously docking and loading/unloading six cargo vehicles with its six unpressurized ports, centralizing the commercial transactions that Columbiat consistently sees. Unlike passenger docking, the primary function of the business docks is the fast and easy loading/unloading of cargo. In order to maximize the efficiency of the cargo transfer, the business bays are equipped with cargo tram systems (Section 5.4.2).

Figure 2.4.3 – Location of Port Areas are distributed on both orbs





2.4.3 AUXILIARY BAY

The Auxiliary Docking Bay is located on the Ablunar Orb of the Operations Core. This bay utilizes pressurized docking systems consisting of a hangar capable of sealing and pressurizing with a space vehicle inside. After it is sealed and pressurized, the functions of loading/unloading, maintenance, and repair can commence safely. The Auxiliary Bay utilizes four pressurized docks, two designed for construction and two reserved for long term repair, maintenance, and docking of vehicles that are not equipped with the subsidized airlocks.

2.4.4 EMERGENCY BAYS

Because safety is Northdonning Heedwell's highest priority, we have worked to perfect the emergency systems present on Columbiat including the settlement's Emergency Bays. These bays are capable of landing both emergency vehicles such as the Pretereo (Section 3.3.2) and Escapade (Section 3.3.2) and other space vehicles requiring vital attention and repair. There is an Emergency Bay located on both the Accolunar and Ablunar Orbs, each consisting of a pressurized dock containing multiple conventional docks. The bay is oriented this way to allow Pretereo to dock and unload quickly using the unpressurized docks. However, in the case of a damaged or contaminated Pretereo, the pressurized function of the port is utilized to guarantee the safety of the occupants.

SECTION 2.5 VARIED GRAVITY AREAS

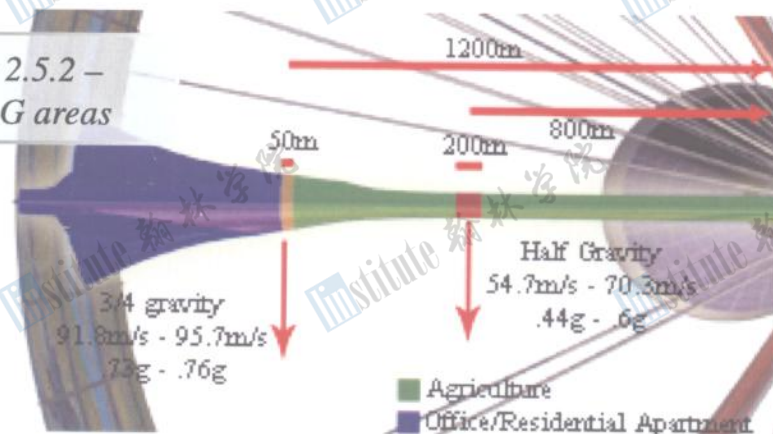
The Columbiat space settlement has micro gravity areas built into the major spokes (Section 2.2) to provide a luxurious acclimation process for visitors to the settlement. The thorough and relaxed nature of this process is enjoyable to all visitors establishing a reputation of tranquility and comfort prompting longer stays, frequent returns, and a greater popularity.

2.5.1 HALF AND THREE QUARTER GRAVITY ENVIRONMENTS

Half and three quarter gravity environments are located conveniently between the Operations Core and the Residential Torus in 3 of the Major Spokes (Figure 2.5.1). Their locations allow for a short transit time from either the Residential Torus or docking. The half gravity areas are located at a radius of 700-900m and rotate at a velocity of 54.7-70.3m/s creating an acceleration of 4.3- 5.5m/s². The three quarter gravity areas are located 1175-1225m and rotate at a velocity of 91.8-95.7m/s creating a gravitational acceleration of 7.2-7.48m/s². To accommodate to the lower gravity the ceilings are 6m in the half gravity and 4.5m in the three quarter gravity areas. There are 30 floors of half gravity and 11

floors of three quarter gravity in each of the three Major Spokes providing a down area of 2,073,000m³ for the 5000 transient and permanent residents who reside there.

Figure 2.5.2 – Lower G areas



2.5.2 ACCLIMATION PROCESS

The primary focus of the varied gravity locations is for transient acclimation to greater gravity. Columbiat offers the process to all visitors, but it is not mandatory. After leaving the medical quarantine visitors undergoing this process proceed to the half gravity levels. The variable gravity levels are designed to be the prime vacation introduction, filled with cinemas, recreation areas, spas, shopping centers, and deluxe hotels. This process offers treatments to ailments that are often prevalent in people who have had extended exposure to zero gravity environments. To begin, a fitness program is available to strengthen muscles and resist the effects of osteoporosis. Vibration therapy and hormone supplements can also be used to combat these symptoms. The accelerated heart rate of the workout also combats potential orthostatic hypotension that may start to take place. Safety is a major concern as the acclimation process occurs so all



Figure 2.5.1 Major spoke with variable gravity areas located and allocated to the luxurious acclimation process, commercial endeavors, living areas, and agricultural locations

participants will be monitored in order to recognize potential dangers before they can condense into a fatal issue. All these treatments occur in a natural, organic environment with vast views of the station and space as seen in Figure 2.5.2. It is Northdonning Heedwell's goal to instill all visitors with a desire to return to the extraordinary, inviting facilities available on Columbiat.



E.O. OPERATIONS AND INFRASTRUCTURE



3.0 OPERATIONS AND INFRASTRUCTURE

By seamlessly coordinating various pre existing resources in conjunction with unique and innovative Northdonning Heedwell's designs, Columbiat embraces originality as well as resourcefulness. This combination is reflected in such systems as power generation and transportation systems, both of which stand out in their functionality through simplicity. Terminals for future expansion indicate Northdonning Heedwell's preparation for future growth in both Columbiat and the space industry. Every system is designed with redundancy and efficiency in mind, providing the Foundation Society with a unified and simplistically comprehensive operations system.

3.1 CONSTRUCTION MATERIAL SOURCES

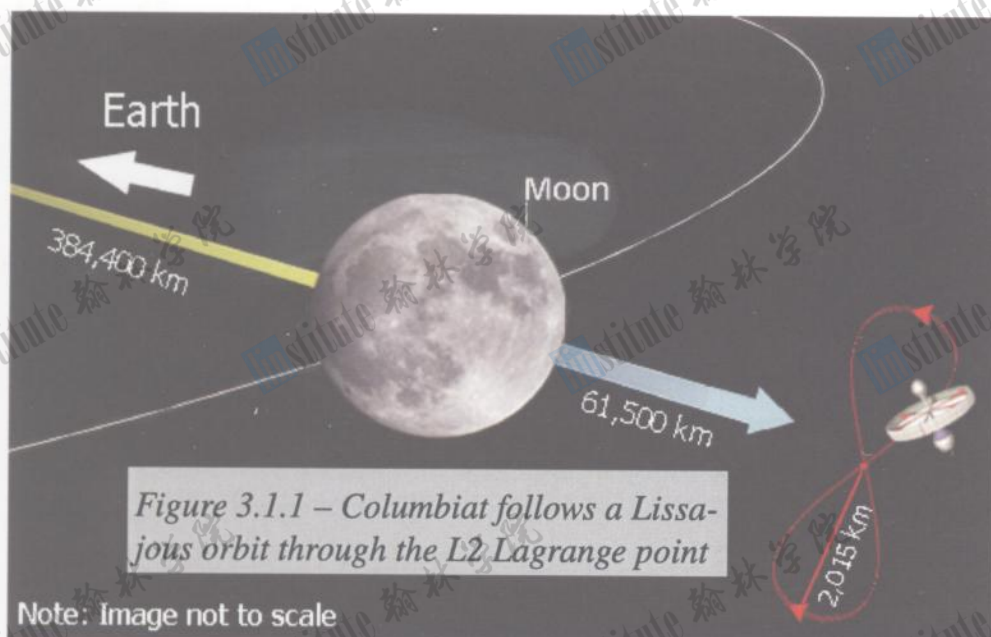
Columbiat's orbit in the L2 Lagrange point offers not only natural views of earth but stability and safety for both residents and the Foundation Society's investment. In addition, this L2 point is in close proximity to Alaskol, which serves as the main source of materials, minimizing transit time and costs for construction and materials.

3.1.1 ORBITAL LOCATION

The Foundation Society has requested that Columbiat be located in an L2 orbit. Northdonning Heedwell has found the easiest and most stable way to facilitate that objective is through figure-8 Lissajous orbit with a six month period, centered on the L2 Lagrange point 61,500 km from the Moon. As a result, at the apex of the settlement's orbit, residents witness Earthrise over the Lunar surface, an experience unique to Columbiat.

3.1.2 SPACE ELEVATOR

Although Columbiat is not stationary in the Lagrange point, it's Lissajous orbit passes through the center of L2 every three months. This allows it to serve as an orbital terminus for a future lunar Space Elevator.



through the use of short-range transportation vehicles. The terminals for expansion onboard (Section 3.2.8), allow simple, rapid construction of the terminus.

3.1.3 ORIGIN OF MATERIALS

Because the majority of materials required for construction can be found on the Moon, Alaskol is subcontracted to mine and refine these materials. Alaskol's proximity facilitates the most effective transportation costs possible. Materials that cannot be mined or refined on the Moon are acquired from Earth or other settlements at higher costs.

The Primoris transports construction materials, the initial construction platform, automation for construction, solar panel generation units, and housing for the construction crew to the Columbiat build site. Equipment and materials that are not transported by the Primoris are shipped via Wingless Percheron vehicles (see section 3.3.2). As materials arrive on site, they are placed in temporary storage facilities inside the Primoris and Operations Core until their use.

3.2 COMMUNITY INFRASTRUCTURE

The infrastructure systems on Columbiat redefine efficiency and innovation through state of the art technologies and cutting edge processes. Each system is redundant in nature to ensure constant operation and resident safety onboard the settlement. Simple, yet high yield systems riddle the Operations Core providing the Foundation Society with the greatest comfort in knowing all aspects of their investments are of the highest caliper.

3.2.1 ATMOSPHERE AND CLIMATE CONTROL

Columbiat's atmospheric composition and pressure are identical to that of Earth's at sea level in order to ensure residents comfort and health. The average atmospheric temperature of the settlement varies between



Figure 3.1.2—Materials and equipment for initial construction and operation

Material/ Equipment	Source	Transportation	Use	Amount
Titanium Alloy	Alaskol	Primoris & Wingless Percheron	Geodesic Lattice Structure and Hull	7.7429×10 ¹⁰ kg
Silicon	Alaskol	Primoris & Wingless Percheron	Basic Construction	5.1756×10 ⁸ kg
Transparent Aluminum	Alaskol	Primoris & Wingless Percheron	Hull and Window Construction	8.1368×10 ¹⁰ kg
RAGuard	Earth	Wingless Percheron	Hull and Window Construction	93,240 kg
Oxygen + Nitrogen	Earth & Alaskol	Primoris & Wingless Percheron	Atmospheric composition	6.366×10 ¹⁰ kg 5.58×10 ⁷ (m ³) at STP
Water	Alaskol	Primoris & Wingless Percheron	Sustaining life on settlement	6.50×10 ⁷ kg
Construction Robots	Bellevistat	Primoris	Settlement Construction	3,100 robots
DSPS	Bellevistat	Primoris	Construction and Operation	16 satellites



Figure 3.2.1 - Honeycomb tubes within the hull use coolant and glycol-diluted water to heat and cool the station

50o F and 80o F while relative humidity varies between 35% and 60%. Artificial rain periodically falls in the park areas from sprinklers imbedded in the hull to further the sense of climate and weather. This creates an Earth-like sense of climate fluctuation, which is psychologically comforting to residents. Temperature and humidity within a resident's own

home can be controlled using an interface on his or her OPC (Section 5.3.2). Temperature control pipes are embedded in the settlement hull, circulating coolant and glycol-diluted water throughout Columbiat, depending on required temperature.

There are three independent air filtration and pressurization systems throughout Columbiat, ensuring the safety of residents through redundancy. All three units are located in the Operations Core, but service different portions of the settlement. The first system filters and pressurizes the Residential Torus, Major Spokes, and the Operations Core. The second system pressurizes safe floors and the transportation system, allowing these areas to remain functional for resident safety during

emergencies. The third system pressurizes and filters the docking areas and terminal facility creating a sanitary environment for Columbiat's transient population.

3.2.2 FOOD PRODUCTION

Cultured tissue and natural growth are the two principle methods of food production aboard Columbiat. These methods have the highest yields in restricted spaces, while still providing natural products for those opposed to cultured food, providing residents of them most advanced space settlement ever built a variety of food options.

Bacterial cultures and livestock are the primary sources of meat aboard Columbiat, respectively providing one third, and two thirds of the meat on the Settlement. Livestock is kept near full gravity to ensure normal growth, while trout, rabbit, and fowl, which are high-energy-yielding animals, can be kept at lesser gravitational magnitudes. Animals are transported to sterile autonomous slaughterhouses once they are ready to be consumed. The second method of meat production, tissue cultivation, produces meat in an incredibly space and time efficient manner, combining stem cells and bacteria to create myofibers. These fibers are identical to naturally raised meats, and are significantly more space efficient, rapid, and sanitary than livestock. These fibers are robotically harvested and packaged for distribution and consumption.

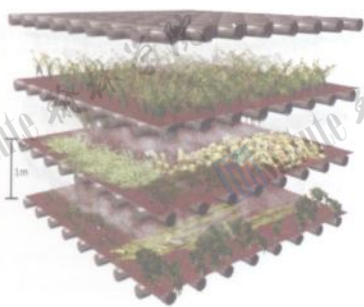


Figure 3.2.2 – Plants receive nutrients via an aeroponic system to enhance growing efficiency.

One third of agriculture products are grown using an aeroponic system; the other two thirds are grown using a culture process. All agriculture is located in the Major Spokes between $\frac{1}{2}$ and $\frac{1}{4}$ gravity to reduce the strain of gravity and increase growing efficiency. Light is provided to the plants through fiber optic cables and nutrient

enriched water is sprayed onto the exposed roots of the plants, guaranteeing full-bodied growth. Agriculture Robots (Section 5.3.4) harvest and transport fully grown plants to the Operations Core, where they are cleaned and packaged for consumption.

Cultured plant growth takes place in the major spokes, using small amounts of eukaryotic and prokaryotic cells from parent plants (Figure 3.2.2), suspended in a solution of growth-stimulating enzymes, nutrients, and water. These cells multiply and grow until they form a full-bodied plant, which is identical to a naturally grown plant. Cultured plants grow rapidly and efficiently, providing residents with the highest quality of agriculture.

After harvesting, food is transported to the Operations Core where it is cleaned, sanitized, and packaged in recyclable bio-bags for storage and distribution. Bio-bags are made of organic biopolymers, increasing longevity and retaining freshness. A three-week backup food supply for the entire settlement is kept in the Operations Core in case of an emergency. OPCs (Section 5.3.2) allow residents to order food from anywhere on the settlement. Their order is then transported through the Commodities Delivery Network (Section 5.3.1) to its destination. Food is also distributed through traditional grocery stores on the Residential Torus, where it is sold to residents.

3.2.3 POWER GENERATION

After analyzing numerous alternative power generation techniques, Northdonning Heedwell has decided to utilize its own simple and cost effective zero-g solar panel manufacturing system in order to expedite the construction of Columbiat and produce large amounts of inexpensive power for the settlement. This system utilizes 2 solar cell producing units, each capable of producing 10,000 panels per day from silicate mined off the Moon. Each individual panel is capable of producing 40-watts, enabling a 1 GW solar array to be operational

Number of Satellites	8
Number of Panels per Satellite	3,125,000
Total Number of Panels	25 million
Watts per Panel	40
Total System Power	1 Gigawatt
Total Area of Panels per Satellite	0.6 km square
Cost per Panel Producing Unit	\$40 million
Cost per kilowatt	\$60
Transport Costs	\$20 million
Total Cost of System	\$160 million

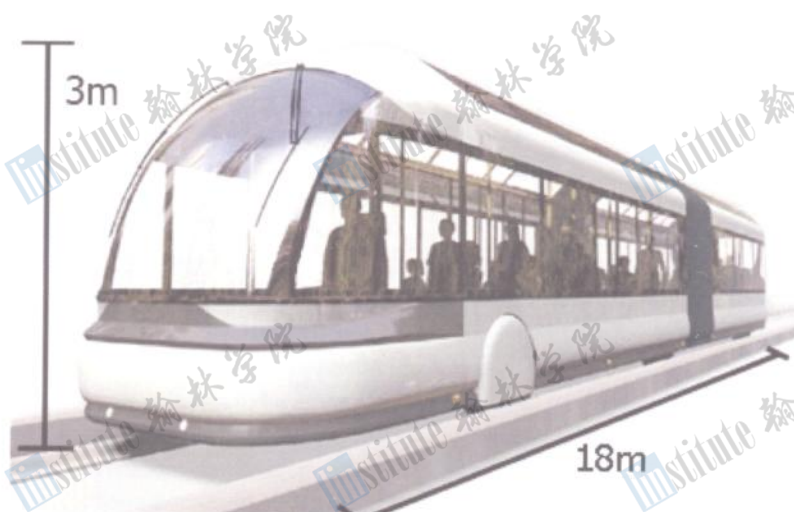
Figure 3.2.3 – Breakdown of power system and costs for 1 GW of power from solar satellites.

in just over 3 years. These panels are distributed over 8 solar power satellites that share Columbiat's Lissajous orbit in L2. This orbit assures constant sunlight on 5 of the 8 panels, ensuring constant power flow, protecting the Foundation Societies investment. The solar satellites transfer their energy to the settlement via microwave beams that are collected by one of 12 microwave receptors located on Columbiat's Operations Core. Once on Columbiat, the energy is transformed into electricity and distributed to the Operations Core and Residential Tours via Copper-oxide superconductors cooled by liquid nitrogen. See the infrastructure routing map (figure 3.2.11) for power distribution lines. Columbiat only utilizes 450 MW; 100 MW for the residents and 350 for operations and infrastructure. The highly cost effective solar panels have prompted us to provide a full 1 GW. This ensures the safety and security of Columbiat residents in the hostile environment of space and provides the infrastructure for future expansion and unforeseen industry growth.

3.2.4 WATER/WASTE MANAGEMENT

A highly efficient multi-step system recycles both liquid and solid waste, returning purified water back to residents. Our system provides complete water and waste recycling and redundant power systems that not only enable an efficient reuse of resources, but return energy to our systems, lowering operating costs.

Solid waste management utilizes a biomass gasification system. This system heats waste to 800 degrees Celsius using modest amounts of oxygen. The resulting reaction yields excess energy that is fed into the system. The remaining slag contains essential minerals and



3.2.5 – Trams run around the circumference of the Residential Torus to provide mass public transportation.

dential Torus' rotation. One line travels at $1\frac{1}{4}$ the velocity of the torus while the other moves at $\frac{3}{4}$ the velocity, therefore enhancing mobility and reducing transit time. Each line houses 12 trams, made up of 7 cars, and each car is capable of holding 100 people, allowing the tram system to transport over 75% of the settlements permanent population at any given time.

A diagram of a cylindrical roller coaster car. The car is shown in cross-section, revealing its interior. It has a height of 2.5 m and a diameter of 1.5 m. Inside, a woman stands on the left holding a white object, and a man sits in a red wheelchair on the right. The car is supported by two vertical blue pillars. A large, faint watermark '翰林学院' is visible across the image.

Figure 3.2.6 – Electric elevators provide transportation throughout the major spokes

If residents choose to not take the trams, travel using a multitude of walkways and paths is facilitated for. These walkways and paths, weaving through the Residential Torus also provide transportation for inhabitants in-between the tram stations. Residents may choose to travel on foot, by bicycle, or by Segway to their destination using these paths and walkways. For residents whose mobility is impaired, small, electrically powered carts are provided to ease their transportation.

Transportation within the spokes occurs by electrically powered elevators. Each major spoke houses 20 elevators; 16 residential elevators and 4 cargo elevators, each gravity sensitive to its cargo, moving between 4 m/sec and 7.5 m/sec. This allows for transit to the Operations Core in as little as 3.3 minutes. Seatbelts and cargo straps are provided in every elevator to ensure passenger and cargo safety.

Public transportation on Columbiat is facilitated through underground, electrically powered trams that run through the entire circumference of the Residential Torus. Residents board the tram at any of 12 equally placed stations, located at each major spoke base, and one in between every major spoke. Each station services two tram lines, moving in the same direction as the Resi-



3.0 Operations and Infrastructure

Once in the Operations Core, transportation is achieved through P.I.P.E.S (see section 4.3.2). This system allows for safe and rapid transportation between the sections of the Operations Core for personnel and cargo.

In case of emergency, all modes of public transportation are independently pressurized and powered. Furthermore, all are stocked with adequate food, water, and medical supplies for 24 hours of survival. These factors allow for residents to move easily and safely through parts of the settlement during an emergency. In case a transportation system cannot be reached in time or is not functioning, a large number of Pretereo (section 3.3.2) vehicles are spaced around the settlement.

3.2.7 DAY-NIGHT CYCLES

Day-night cycles on Columbiat emulate those on Earth, consisting of 12 hours of day and 12 hours of night. To induce artificial days while the settlement is not in direct sunlight, fiber optic cables around the hull provide natural light to the settlement. While in direct

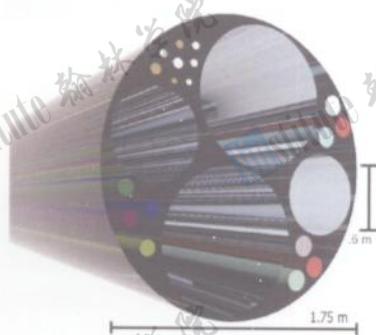


Figure 3.2.8 - Expansion Terminals contain a multitude of various infrastructure lines

sunlight, Columbiat utilizes electrochromatic glass incorporated in the RAGuard of the settlement's hull to simulate artificial night. When a current is run through the glass, the particles polarize and the glass turns opaque to block out sunlight. The fiber optic cables and the electrochromatic glass are turned on and off as a gradient across the settlement,

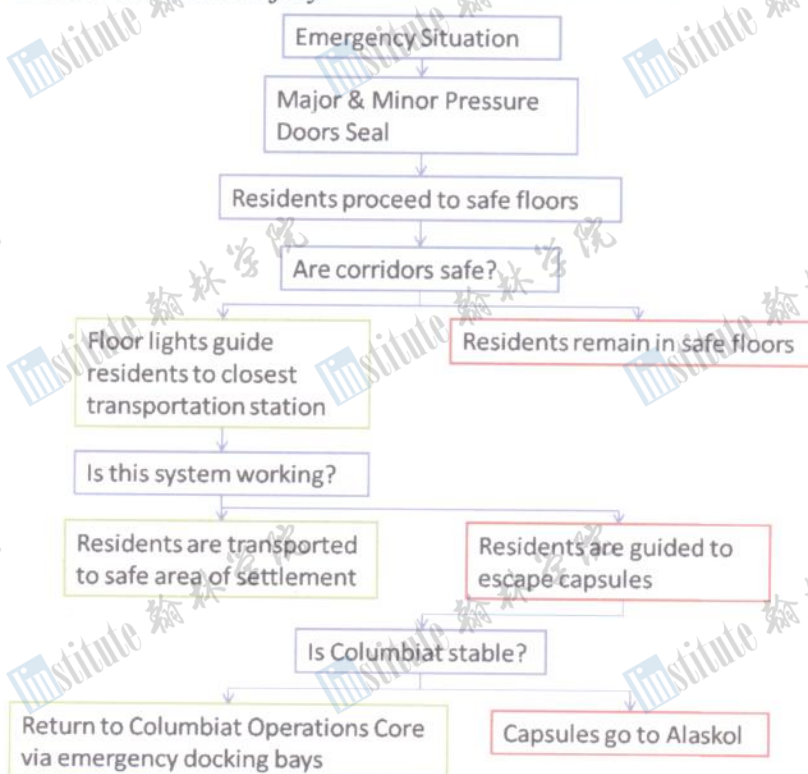
simulating sunrise and sunset.

3.2.8 TERMINALS FOR FUTURE EXPANSION

Northdonning Heedwell has engineered three terminals for future expansion of Columbiat, including one terminal on each end of the Operations Core, and one just below the Residential Torus. These terminals house every infrastructure line necessary to sustain life and operations within the station. During expansion, the terminals may be uncapped and another terminal, leading to the addition, may be plugged directly in. This provides for infrastructure to be connected and flow seamlessly without extensive construction and renovation.

Due to the fact that the terminals for expansion are built into the original structure, the need to disassemble and reconstruct parts of the station in times of expansion

Figure 3.2.9 - Emergency procedures are simplistic to ensure resident safety



is eliminated. In addition, because these terminals are standardized and carry every infrastructure line needed on Columbiat, any variety of additions may be made, ranging from another torus for residents to another docking area to a lunar space elevator.

3.2.9 EMERGENCY PROTOCOL

Northdonning Heedwell provides a simple yet highly responsive arrangement of procedures for emergencies. The emergency protocol emphasizes simplicity for residents to reduce confusion, complimented by a timely response to ensure safety of inhabitants during a hazardous event.

Pressure Doors – Major pressure doors extend from each major spoke into the residential torus, sealing each 1.4 km section of the torus. Minor pressure doors are located every 100 m in the Operations Core, and every five floors in the major spokes. Pressure doors enable containment of any emergency situation while the non-affected portions continue normal operation.

Safe Floors – Safe floors are independently pressurized floors or rooms that are connected by pressurized tunnels to the nearest transportation station allowing residents to evacuate compromised settlement areas. These floors contain 24 hours of emergency supplies including food, water, and first aid, and have reinforced exterior walls, providing residents a secure place to stay in case of emergency.

Transportation Modules – All transportation stations and conduits become independently pressurized during

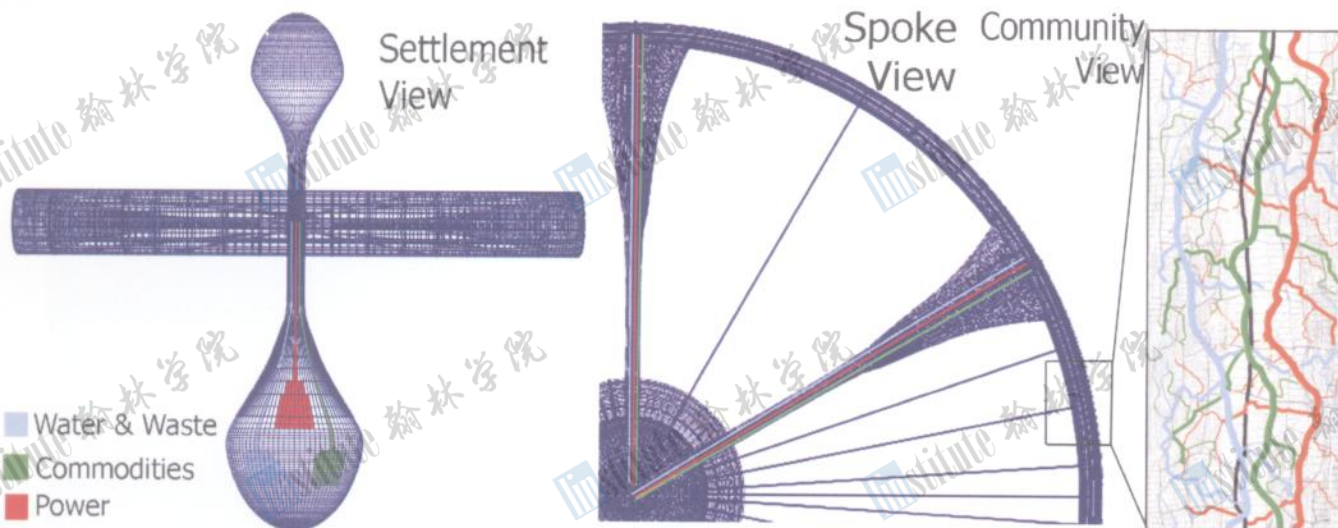


Figure 3.2.10 – Major Infrastructure lines and transportation routing throughout Columbiat. (Transportation lines are marked in black on the Community View)

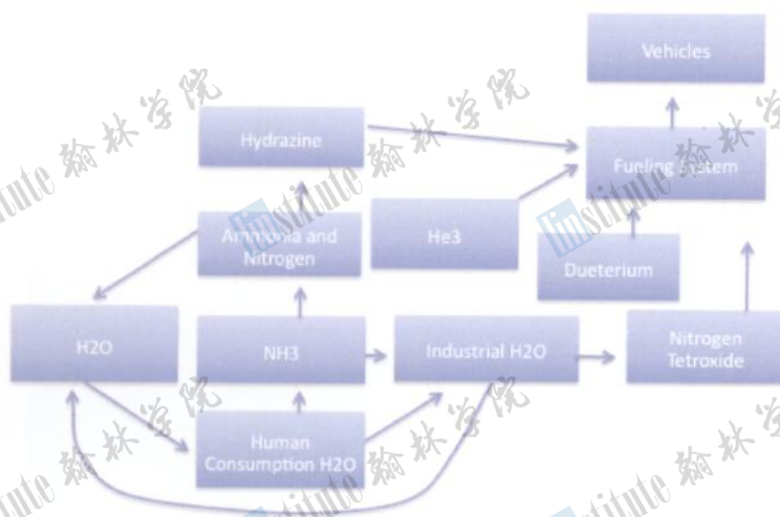


Figure 3.2.9 - Four different fuels are produced from Northdonning Heedwell's Dynamic Fuel Production System

an emergency to provide inhabitants with a secure mode of transportation away from emergency.

3.2.10 FUELING SYSTEMS

Columbiat provides fuel resources in the forms of Hydrazine, Nitrogen Tetroxide, Deuterium, and Helium 3. Northdonning Heedwell's revolutionary Dynamic Fuel Production System allows Columbiat to synthesize hydrazine and nitrogen tetroxide on site to minimize storage of hazardous explosive chemicals. The Station utilizes a large, on site tank of ammonia that is continuously restored through the harvesting of urine and other human/animal wastes.

Ammonia is the critical ingredient, and will react with water to create Nitrogen Tetroxide in one reaction, while

remaining ammonia is then reacted with a separate tank of sodium hypochlorite (from Earth) to produce Hydrazine. The benefits of creating fuel on the fly are numerous; the station can adjust to demand for different fuels and is not tied to a finite amount of a specific fuel. It is safer to store the relatively inert compounds used in synthesis than to store the unstable

fuels themselves, and finally Columbiat can use various waste products to refill our tanks of NH_3 and H_2O . Columbiat also has facilities in the Operations Core to store a generous amount of both helium-3 shipped from Alaskol, and deuterium shipped from Earth.

3.3 SPACE INFRASTRUCTURE

Columbiat uses a variety of new and existing space based infrastructure, contracting and reusing a multitude of different pre-existing sources. This minimizes the Foundation Society's initial investment and the time spent in R&D, therefore allowing resources to be mobilized in the most rapid manner possible.

Figure 3.3.1 – Vehicles and turnaround times to other settlements and earth.

Type of Vehicle	Time to Belle-vistat	Time to Alexan-driat	Time to the Moon	Time to Earth
Percheron	80 hours	120 hours	4 hours	58 hours
Tug	90 hours	135 hours	5 hours	62 hours
Palomino	80 hours	120 hours	3 hours	50 hours

3.3.1 SPACE INFRASTRUCTURE

The numerous space based infrastructure systems that aid Columbiat's operation include a plethora of satellites, settlements, and vehicles.

3.3.2 SPACE VEHICLES

Northdonning Heedwell focuses on utilizing second-generation vehicles from previous contracts to operate as the workhorses that lower transportation costs. Northdonning Heedwell utilizes second-generation Percherons in transporting cargo from Earth into orbit. A portion of this fleet has been renovated, creating the wingless Percheron to increase effectiveness and maximize



3.0 Operations and Infrastructure

Figure 3.3.2 - New and existing infrastructure for utilization with Columbiat

Existing on-orbit Infrastructure	Function
Percheron and Palomino Vehicles	Transportation of inhabitants and materials
Bellevistat	Provides manufactured materials once the facility is operational.
Alaskol	Obtains raw materials from the lunar surface and transports to settlements for refining capabilities.
New on-orbit Infrastructure	Function
Solar Power Satellites	Orbiting near Columbiat to collect and provide power to the settlement, double as communication satellites
Communication Satellites	Relay communications via the Free Space Optical Data Link
Solar Panel Production Units	Cost effective production of solar panels from lunar silicate
DSPS Satellites	Provides 3-D map of Columbiat and its surroundings

payloads of in-orbit travel while still maintaining the high degree of both safety and speed.

Figure 3.3.4 - Pretereo capsules provide emergency evacuation



utilized in prior ventures. Space Tugs are utilized for transportation of pre-fabricated materials in space. These are modeled after the fundamental design of



Figure 3.3.3 - Palomino vehicles provide transportation to and from Earth

For personnel transportation, Columbiat uses the second-generation Palomino fleet. This fleet does not require retrofitting because the winged and wingless versions, for launch and in-orbit travel, have already constructed and utilized in prior ventures. Space Tugs are utilized for transportation of pre-fabricated materials in space. These are modeled after the fundamental design of the prototype tugs that Northdonning Heedwell has previously manufactured.

Different emergency vehicles are used during crisis. In the event that a resident is stranded outside of the settlement, the autonomous

Figure 3.3.5 - Columbiat provides a multitude of vehicles to facilitate for cargo and personal transportation.

Vehicle	New/ Existing	Function	Payload	Docking Area
Palomino	Existing	Personnel Transport	110 passengers, 15,000 kg	Acco-Lunar Operations
Percheron	Existing	Cargo Transport	27,200 kg	Acco-Lunar Operations
Wingless Palomino	Existing	In-orbit Personnel Transport	110 passengers, 15,000 kg	Acco-Lunar Operations
Wingless Percheron	New	In-orbit Cargo Transport	2,900,000 kg	Ab-Lunar Operations
Space Tug	Existing	Transports Pre-constructed Materials	6,000,000 kg	Ab-Lunar Operations
Pretereo	New	Emergency Personnel Transport	20 passengers	Ab-Lunar Acco-Lunar Operations
Escapade Vehicle	New	Rescues Stranded Personnel	8 passengers	Ab-Lunar Acco-Lunar Operations



Escapade is dispatched to assist and return the stranded individual to the emergency bay (section 4.3.2 & 5.4.5). In the unlikely event that the structural stability of the hull is compromised, residents proceed to tram stations and board Pretereos. These vehicles are then ejected from the residential torus and perform one of two actions; autonomously transfer residents to the emergency bays on the Operations Core or if Operations Core is unstable, transport residents directly to other settlements, (section 3.2.9). Northdonning Heedwell's use of pre-existing vehicles separate from this contract minimizes stress upon the Foundation Society while assuring quality control.

Northdonning Heedwell's fleet of transport vehicles primarily use Modernized Viking 5C engines for launch applications out of Earth and Moon atmosphere while the VASIMR, (section 3.4.1), provides efficiency of travel and safety of cargo in space based transportation. The Modernized Viking 5C engines use Aerozine 50, a 50/50 mixture of hydrazine and dimethylhydrazine as propellant. Both the Viking 5C and the VASIMR engines are equipped with a PDDC System, (section 3.5.3) to allow for quick maintenance and turn-around time (section 3.5).

3.4 PROPULSION SYSTEMS

VASIMR engines placed around the settlement provide artificial gravity volumes and hold the settlement in it's orbit in the L2 Lagrange point. These engines offer variable degrees of thrust while remaining fuel efficient and reliable, ensuring safety for the Foundation Society and residents alike.

3.4.1 ENGINE DESIGN

Propulsion of the Columbiat settlement occurs via 250 Variable Specific Impulse Magnetoplasma Rocket (VASIMR) engines placed around the Residential Torus and Operations Core. VASIMR engines are a plasma based propulsion system, which utilize electricity to ionize deuterium into plasma as it enters the engine. Electric fields then heat and accelerate the plasma, which is directed by magnetic fields, out the engine, creating thrust. The regulation of deuterium and electricity allows for a variable amount of thrust, anywhere from 25 Newtons to 650 Newtons. VASIMR engines can vary between high and low thrust to time ratios. This provides Columbiat with large thrust capability for orbital corrections as well as small thrust capability for maintaining artificial gravity volumes through one type of engine.

3.4.2 PROPELLANT

All 250 VASIMR engines on Columbiat use electricity and deuterium as propellant. Deuterium is readily

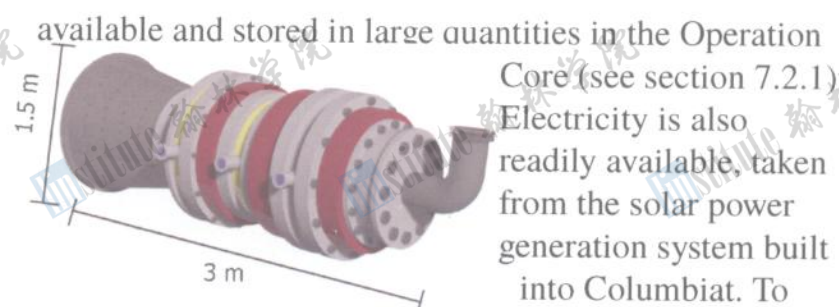


Figure 3.4.1 – VASIMR engines produce variable thrust while remaining highly fuel-efficient

available and stored in large quantities in the Operation Core (see section 7.2.1). Electricity is also readily available, taken from the solar power generation system built into Columbiat. To provide 1 Newton of thrust through the VASIMR engines, 100 kilowatts are required from the power generation system. The availability of both electricity and deuterium on Columbiat eliminates the need for additional fuels to be transported to the settlement and minimize operational costs for the Foundation Society.

3.4.3 ORBITAL CORRECTIONS AND ARTIFICIAL GRAVITY VOLUMES

There are 75 VASIMR engines placed periodically

DOK - 50 Engine

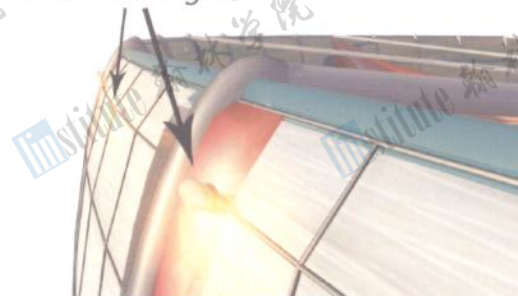


Figure 3.4.2 - VASIMR engines provide thrust in the direction of the Residential Torus' spin to produce artificial gravity volumes

around the Residential Torus, 75 on the Acco-Lunar Core, 50 on the Ab-Lunar Core, and 50 on the central conduit of the Operation Core. The engines on the Residential Torus provide the necessary thrust to maintain artificial gravity volumes for residents

in both the Residential Torus and Major Spokes, (see figure 3.4.2). To ensure the greatest stability of rotation and minimize fluctuations in gravity volumes, the VASIMR engines are constantly producing small amounts of thrust to maintain rotation. In the unlikely event of an emergency, each engine is capable of rotating 180° to provide thrust in the opposite direction of normal rotation to halt the Residential Torus.

150 VASIMR engines located around the Operations Core provide nearly infinite directions of movement for Columbiat. These engines provide the thrust to keep the settlement in the Lissajous orbit around the L-2 Lagrange Point. In addition to orbital corrections, the engines also maintain Columbiat's orientation to the Moon, keeping the Ab-Lunar Orb pointed towards the lunar surface. In the case of an emergency, these engines also provide thrust to move the settlement out of its normal orbit. Variability provides a stable



environment aboard Columbiat by allowing flexibility with the orbit; in the event of an impending collision the station can move to avoid the collision. After the settlement shifts out of orbit and the potential threat passes, the station can easily move back into its original position in orbit, ensuring the utmost safety for residents and the Foundation Society's investment.

3.5 DOCKING SERVICES

Vehicles visiting Columbiat receive far more than the standardized docking service. We offer a wide range of veterinary, maintenance, and food and commodity replenishment services, in addition to top-of-the-line layover accommodations for craft traveling to and beyond the settlement. The convenience offered by this system encourages travelers to go out of their way to experience Columbiat: The highest luxury the space industry has to offer.

3.5.1 VETERINARY SERVICES

Columbiat provides livestock on visiting ships with the finest veterinary services available through physical examinations and state of the art diagnostic systems. Veterinary services include a vast array of examinations and medical care encompassing disease prevention, parasite control, surgery, complex medical problems, and much more. Columbiat's QPM, (section 5.2.1), allows the veterinary staff to analyze proteins within livestock and predict how they will react with antibiotics and other medical treatments, providing cutting edge medical services and ensuring the utmost safety for livestock.

3.5.2 FOOD AND COMMODITY REPLENISHMENT

Ships visiting Columbiat are provided with replenishments of food, water, and other commodities through the Commodities Delivery Network, (section 5.3.1). Upon arrival, the ship's diagnostics report the amount of required replenishments to Columbiat's QPM. The replenishments are moved from the Operations Core through the Commodities Delivery Network and delivered to the ship. Columbiat's water and waste recycling system, (section 3.2.4), takes solid and liquid waste from visiting ships, filters it, and returns recycled resources to the ship. In the event that crews upon visiting ships must procure additional items, a large variety of commodities and supplementary food is available for purchase in the terminal facility.

3.5.3 VEHICLE MAINTENANCE AND FUELING

Columbiat's advanced and streamlined docking facilities supply visiting ships with rapid and thorough maintenance procedures, minimizing completion time for complex repairs like engine overhaul. The

Figure 3.5.1 – Maintenance and repair turnaround times are shortened with the PDDC

Type Of Repair	Using PDDC	Not Using PDDC
Hull repair	2 – 4 hours	3 – 5.5 hours
Refueling	.25 hours	13 hours
Waste Management	.5 hours	.5 hours
Engine Overhaul	20 – 24 hours	26 – 29 hours
Engine Tune	4 hours	6 hours
Hydraulic Systems	8 hours	10 hours
Electrical Systems	1 – 10 hours	3 – 15 hours
Computer Systems	10 – 15 hours	13 – 17 hours
Installation of (PDDC)	N/A	5 hours

Infrastructure Repair robots and Multi-purpose Construction robots (section 5.2.2 & 5.1.2) autonomously complete maintenance procedures in the docking facilities to ensure efficiency and crew safety. Parts and maintenance equipment for visiting vehicles are stored in the Operations Core near the docking facilities. Fuel is acquired from the Dynamic Fuel Production System in the Operations Core.

To further expedite vehicle maintenance and fueling, Northdonning Heedwell has engineered a Pre-Docking Diagnostic Communication System (PDDC) for use with vehicles that frequently dock at Columbiat. The PDDC collects diagnostic information from the vehicle as it approaches the settlement and the QPM determines whether maintenance is required. If maintenance is necessary, the appropriate equipment and robots are moved to the designated docking area, thereby greatly reducing overall maintenance time. Vehicles without the PDDC receive similar diagnostic scans in the docking areas.



51.0 HUMAN FACTORS



4.0 HUMAN FACTORS

While staying on Northdonning Heedwell's Columbiat, people have the opportunity of living in space and the pleasure of residing in a comfortable, safe atmosphere. We, in the Human Factors Department, make this possible by providing residents with a comfortable, fluid community setting similar to those on Earth that ensures physical fitness and mental stability while emphasizing the unique space experience. Facilities such as our state-of-the-art medical center and the advanced security network systems allow for this experience to be as safe and secure as possible. This setting is the perfect backdrop not only for the future of space finance and trade, but also for the new Foundation Society Headquarters.



Figure 4.1.1 –Columbiat's Residential Torus presents residents with a comfortable sense of community and vast amounts of green space.

4.1 COMMUNITY DESIGN

Columbiat's unique community sets it apart from any other space colony. Unlike the geometric layout of many other space settlements, Northdonning Heedwell has strived to incorporate an organic landscape with rolling hills and a snaking river into a highly innovative and advanced space setting. Each diverse neighborhood is designed to keep a continuous motif of contemporary space age architecture while maintaining unique neighborhood distinctions. Finally, inhabitants' are exposed to expanses of green area located continually throughout the torus and long lines of sight - 880 meters in either direction.

4.1.1 COMMERCIAL SPACE

Urban areas, woven throughout the settlement, add metropolitan spice to Columbiat. The Major Spokes house banks, financial services, and business centers to accommodate for the growing age of space-based business. Furthermore, the Foundation Society headquarters are placed at the heart of Columbiat, in the $\frac{3}{4}$ gravity area of a Major Spoke, with sweeping views of its entire investment. Shopping options similar to Earth's are part of many accommodations that optimize the livability of the settlement. These commercial districts, located in the Residential Torus, give residents a sense of comfort and familiarity, preventing nostalgia caused by alien surroundings. While strolling down a boulevard winding through the commercial district, any Columbiat local or guest can enjoy the true metropolitan atmosphere.

4.1.2 HOUSING

Numerous housing options accommodate for any resident's unique lifestyle. Four main types of neighborhoods correspond with four styles of housing: Woodland, Singapore, Italianate, and Contemporary (Section 4.2.1). Woodland neighborhoods give a rural feel with larger yards and plenty of room for keeping personal gardens.

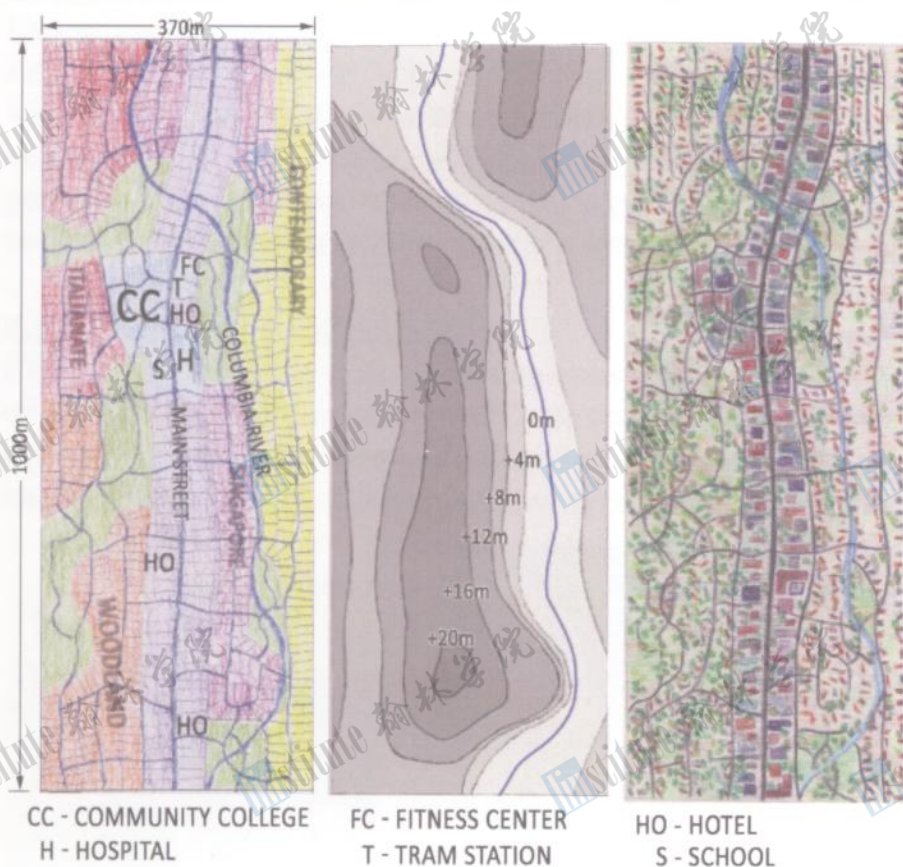


Figure 4.1.2 –The community layout of Columbiat is designed for comfort and convenience while portraying a sense of Earth throughout.



Figure 4.1.3 – The neighborhoods throughout the settlement add variety to everyone's living accommodations.

Singapore neighborhoods offer a metropolitan tenor with more houses located closer together. The Italianate neighborhoods present a suburban environment with community green areas. Finally, Contemporary neighborhoods give a futuristic ambiance with a unique sense of living in space that adds to the settlement's exceptional innovative style. A Modern motif is incorporated into the overall housing scheme, causing the different neighborhoods to flow together for an aesthetically pleasing community. Residents can choose their residential accommodations to suit their varying lifestyles.

4.1.3 UNDEVELOPED PROPERTY

Undeveloped property is located throughout the Residential Torus and the Major Spokes for residents who desire to open a small business, practice unobtrusive religious activities, or follow many other pursuits. These personal touches allow people of all cultures to feel comfortable living on the settlement.

4.1.4 PARKS AND RECREATION

Columbiat's park system contains numerous styles of recreational environments to fulfill the residents' psychological need to experience a familiar, green, and natural landscape. Columbiat's two types of parks



Figure 4.1.4 – The park systems give Columbiat a natural, Earth-like feel.

include green areas, which have an isolated, forested feel, and traditional parks, which have a well kept, community feel. These parks are distributed in great quantity throughout the settlement allowing all residents easy access to natural areas when desired. The most innovative feature of Columbiat's park system is the Columbia River, an artificial water system that snakes around the entire Residential Torus in a 12km loop. Six recreation centers in the Residential Torus and Major Spokes further provide residents with numerous options for exercising as well as organized sporting events. Paths occupy 2% of the down area, thus encouraging large amounts of walking or biking, stimulating the body and mind.

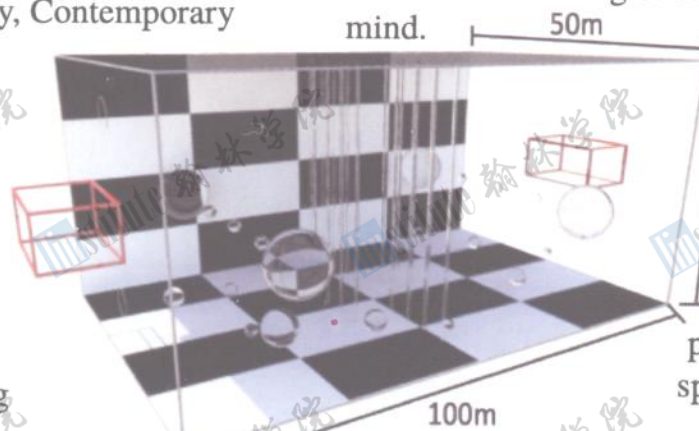


Figure 4.1.5 – Velocityball brings people to Columbiat from Earth and other settlements to participate in this engaging sport.

4.1.5 ENTERTAINMENT

The settlement's entertainment encompasses everything from ordinary Earth-like activities to new and innovative approaches to entertainment in space, diversifying the attractions that bring inhabitants to the Foundation Society's Columbiat.

As a unifying element for the settlement, Northdonning Heedwell

has brought to you a new sport and sporting league that will engage not only station residents, but teams from other settlements in massive tournaments that showcase the Foundation Society's prowess. Velocityball involves teams attempting to take a ball to either end of a micro-gravity sporting arena. Inside, the arena contains numerous floating objects that can be utilized by teams for strategic play adding a dynamic aspect to the sport that cannot be attained under normal gravity. Other micro-gravity activities include observatories for unobstructed views of distant space. Furthermore, space tours and walks, and micro gravity recreational gyms are available. Earth-like entertainment includes activities normally found in downtown areas such as shopping and exciting nightlife with restaurants, cinemas, theatres, and clubs. The more adventuresome can engage in a roller coaster in the Residential Torus; Ultimate Extender Boots allow participation in an innovative and exciting activity that increases the user's speed and agility.

4.1.6 EDUCATION

People in grades kindergarten through twelve have access to three education centers located in the commercial areas. Older residents have access to continued education from a small community college. These secondary schooling options allow residents to contrib-



ute to an educated future. The education facilities are split into small classes, which are taught by teachers to optimize the comfort of the student. Teachers are aided by a fully integrated, interactive computer system called the Enhanced Teaching Network (ETN) (Section 5.3.2). The ETN is built into each student's desk and is incorporated into the surrounding walls to provoke kinesthetic learning and visual stimulation. To expand each student's social environment, the schooling system provides extracurricular activities that include sporting teams and academic clubs, such as Columbiat Aerospace Design Team (CADT). For those who do not desire to attend public school, the On Person Computer (OPC) (Section 5.3.2) makes education possible elsewhere through technology that is compatible with the ETN.

4.1.7 MEDICAL SERVICES

To ensure a healthy and burgeoning Columbiat, we ensure first-rate medical care for all residents. The settlement has thirteen medical facilities interspersed throughout the Residential Torus, Major Spokes, and Operations Core. Eleven first-aid clinics are located every two kilometers on the Residential Torus and in the half-gravity portion of the non-agricultural Major Spokes, allowing rapid access to medical care. Each first-aid clinic is staffed 24-hours a day with two paramedics who work with medical automation (Section 5.3.1) to respond to medical emergencies that require immediate attention. Patients are stabilized before proceeding to the hospital complex, aided by medical transport robots (Section 5.2.2). The small zero-g hospital, with a staff of fifty, located near the passenger terminal in the Operations Core, aids those in close proximity and provides medical procedures enhanced by a micro-gravity environment. Finally, in the interest of creating new standards of medical care for all members of the Columbiat community, the hospital complex, located in the Residential Torus, is equipped with a world-class staff and the newest and most advanced technology to provide residents with necessary medical care without leaving the settlement. The hospital complex has a staff of 200, including 25 specialized doctors and surgeons who provide care for nearly any medical situation. Technology, such as medical micro-sensors (Section 5.3.1), expedites medical response and ensures a healthy community.

4.1.8 REDUCED GRAVITY ACCOMMODATIONS

Half and three quarter gravity areas in three of the Major Spokes are aimed specifically at new arrivals on the settlement and elderly residents. The areas with less gravity give newly arriving residents the chance to acclimate to full gravity, while increasing elderly resident's comfort with less physical stress. Areas

below $\frac{3}{4}$ gravity are available for habitation by any resident who desires large apartment living with fully furnished apartment rooms. Each person can roam through other floors of their Major Spoke that consist of natural-like green areas, exercise facilities, or commercial districts that are similar to anything found on the Residential Torus. The green area floors satisfy the desire for being in an outdoor-like environment and are still easily accessible. Several floors within each Major Spoke contain exercise facilities that speed the acclimation process (Section 2.5.2) by strengthening bone and muscle tissue to repel symptoms like nausea and motion sickness upon their arrival in full gravity.

4.1.9 CONSUMABLES

After consumables are produced in the Operations Core, the Commodity Delivery Network (CDN) (Section 5.3.1) distributes them to residents' houses upon request. The CDN also distributes these consumables to small markets located around the Residential Torus and the Major Spokes providing the option of shopping for food and supplies creating greater customer satisfaction. Table on page 30.

4.2 RESIDENTIAL DESIGNS

4.2.1 HOUSING DESIGNS

A variety of housing designs are provided on Columbiat to comply with each resident's needs and lifestyle choices. Four main styles of architectural designs are applied to married adult and family housing and correspond with the four styles of neighborhoods (Section 4.1.2). Each design is primarily based off modern architecture, but include hints of architecture from different backgrounds to add to the overall diversity on the station. Although these houses have different designs, the modern architecture motif, present in each house, allows the neighborhoods to flow into one another. Residents also have the option of living in the commercial district in an apartment complex or the Major Spokes.

Hints of rural and rustic qualities are present in the Woodland House's modern architectural design. High vaulted ceilings and large windows give the inside of this house an open feel as if one was outdoors.

The Singapore House has accents of Eastern architecture while still applying the modern theme. Walking through, the resident finds the inside simple, with graceful lines and Eastern style decoration, such as hardwood looking floors and bamboo-like walls.

Touches of old Victorian architecture are at hand in the Italianate house, which also has its foundation in modern



Figure 4.1.6 – Columbiat's self-replenishing system, based off the recycling of agricultural products, greatly reduces demand on external entities for commodity replenishment. Material that cannot be manufactured on Columbiat including nylon and polyester, are shipped from Earth via wingless Percherons (Section 3.3.2).

Consumable	Annual Replenishment of Raw Materials	Sources of Production
Cloth	Polyester: 45,000 kg Nylon: 15,000 kg Cotton	Operations Core
Paper	Pulp for cotton based paper manufacturing is received from excess agricultural growth.	Operations Core
Toiletries	Raw materials for toiletry items are garnered from materials found in agricultural growth in the Major Spokes.	Operations Core
Food	Food is produced on Columbiat through a self-sustaining system of agriculture, life stock, and cultured products.	Operations Core -1/3 Meat: Cultured -2/3 Meat: Livestock -1/3 Produce: Standard Agriculture -2/3 Produce: Tissue Cultured

architecture. The old Victorian style is seen in the large

bay windows, Roman style

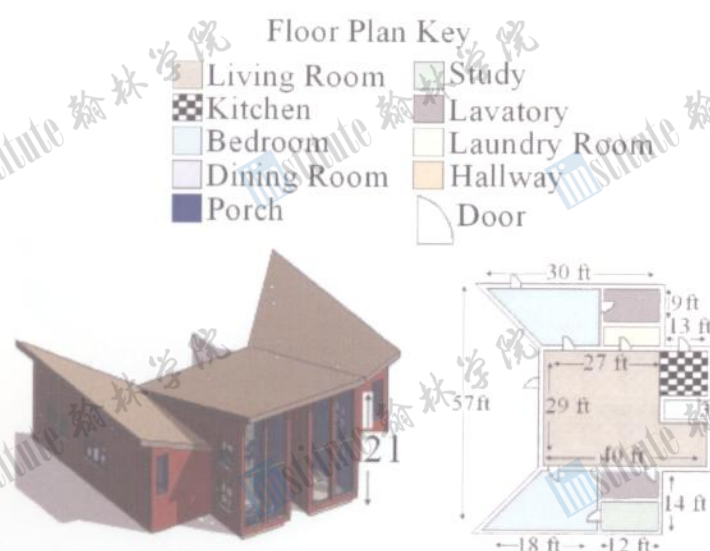


Figure 4.2.1 – The exterior and interior designs of the Woodland House offer a rural feel for residents' living accommodations. Area: 1,919 sq ft.

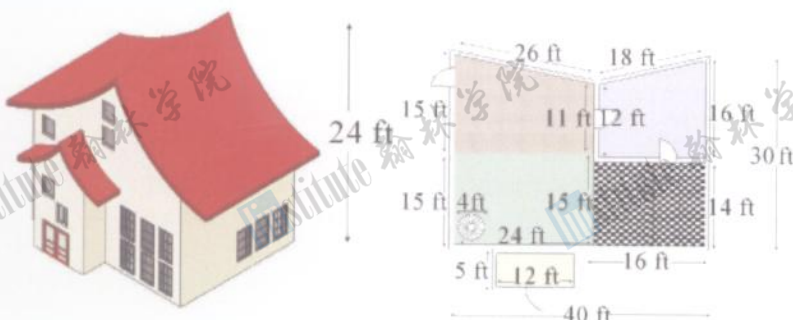


Figure 4.2.2 – The Singapore housing design creates subtle hints of Eastern architecture within the modern motif throughout. Area: 2,360 sq ft.



Figure 4.2.3 – The Italianate House allows residents to live in a suburban environment while being exposed to hints of Victorian architecture. Area: 2,736 sq ft.



Figure 4.2.4 – People are serenaded with new, innovative aspects of the final frontier while living in the Contemporary house. Area: 2,626 sq ft.



Figure 4.2.5 – Community members have the option of living in an artistic apartment complex in the downtown areas of the settlement. Area: 962 sq ft. per room.

Corinthian-like moldings, and metallic looking accents.

For those who come to Columbiat to experience something completely new, the Contemporary House is available. This house includes features within its modern look that have never before been seen on Earth. Residents who choose to live in this housing design get the true experience of what it is like to live in space.

Residents can live in an apartment complex located in the metropolitan area. Each complex is influenced with artistic designs and is suited with landscaped courtyards on the roof, permitting an overlooking view of the community.

4.2.2 DEMOGRAPHICS

Figure 4.2.6-Chart showing demographics

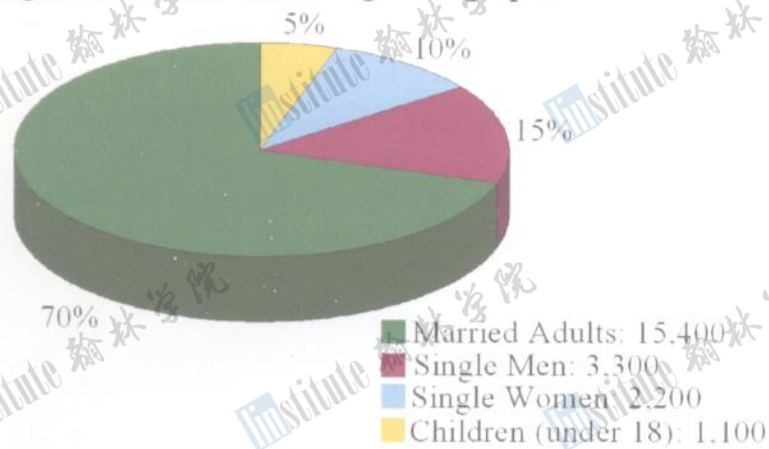


Figure 4.2.7 – Quantity of type of residence and housing design

Type of Residence	Quantity of Individual Houses/Apartment Rooms
Married Adult	7,700
Family	550
Single	5,500
Type of Housing Design	Quantity of Houses/ Apartment Complexes
Woodland	2,063
Singapore	2,063
Italianate	2,063
Contemporary	2,063
Apartment Complex	343

4.2.3 FURNITURE

Beds	22,550
Dining Room Tables	13,750
Dining Room Chairs	52,250
Coffee Tables	8,250
Couches	23,750
Desks	23,750
Arm Chairs	62,550
Book Shelves	33,750

Figure 4.2.8 – Quantity of furniture, which is manufactured from silicon material in the Operations Core.

4.3 SAFE ACCESS IN MICRO-GRAVITY

Travel in micro-gravity volumes can be very dangerous if precautions are not made. Therefore, we have taken extra care to ensure that Columbiat – the busiest and most populous space settlement in existence – has systems to ensure inhabitant safety. In fact, Northdonning Heedwell has met and gone beyond just safety requirements to bring rapid efficiency to micro-gravity transportation.

4.3.1 MEANS OF SAFE ACCESS IN NON-PRESSURIZED AREAS

It is required that people wear a Personal Booster Engine (PBE) and oxygen and life support at all times while outside the hull. The rocket-pack-like PBE's enable residents to quickly travel with ease and safety anywhere outside of the settlement and are equipped with thrusters and hand controls to enable maximum, personal control.

The OPC (On Person Computer, Section 5.3.2) equips the spacesuit with the capability of interacting with the Deep Space Positioning System (DSPS, Section 5.1.1) at all times. The OPC contains a track node that receives data from the DSPS. While outside of the settlement, the OPC gives the occupant awareness of

Figure 4.3.1 – The Personal Booster Engine adds to the simplicity and safety of travel in micro-gravity areas.

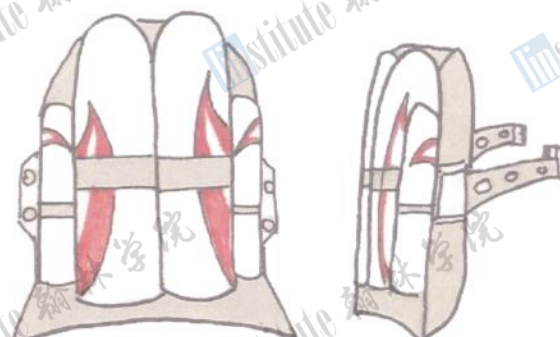
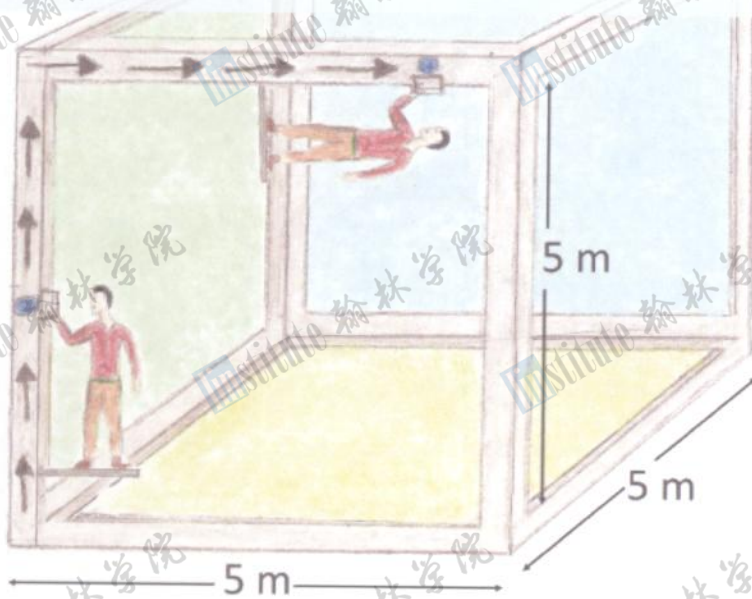




Figure 4.3.2 – The innovative design of PIPES makes travel through the operations core safe and easy.



their location with positioning data based off a three-dimensional grid from the DSPS. If an unlikely mishap were to occur, the OPC sends the docking bay precise coordinates to the person's location, which then immediately sends the Escapade Vehicle (Section 3.3.2) to the location to transport the person back to safety. This system optimizes safety outside of pressurized areas.

4.3.2 MEANS OF SAFE ACCESS IN PRESSURIZED AREAS

Columbiat holds innovative and efficient transportation systems that offer residents safe and

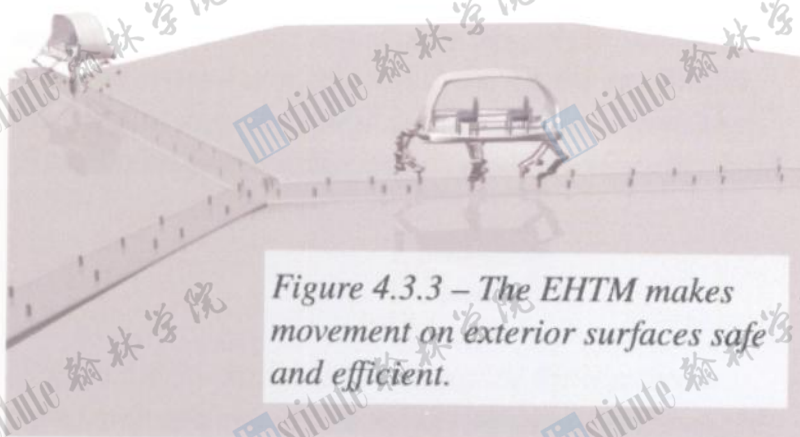
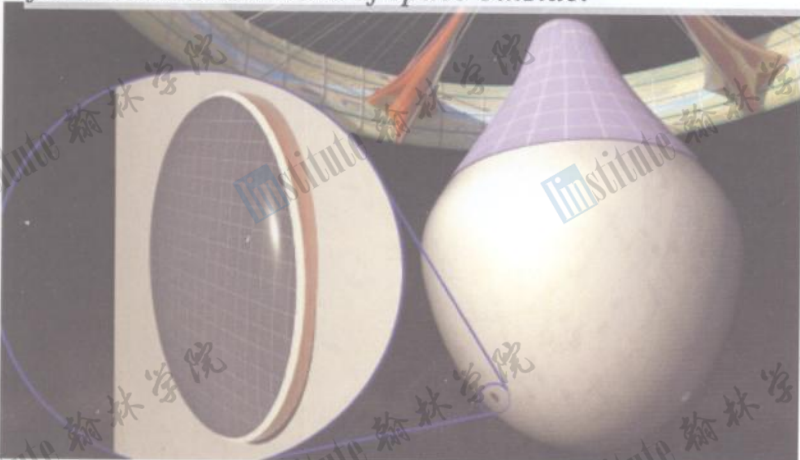


Figure 4.3.3 – The EHTM makes movement on exterior surfaces safe and efficient.

Figure 4.3.4 – The micro gravity observatories allow for unobstructed views of space outside.



simple access to and from any location in pressurized, micro-gravity environments.

Sixteen elevators running up each of the six Major Spokes provide transportation for residents between the Operations Core and the main torus (Section 3.2.6). Each elevator is pressurized to maintain a comfortable environment during travel between the two hulls and contains safety belts to avoid uncontrolled movement in low-gravity areas.

The Personal Interior Pneumatic Elevator System (PIPES) is incorporated into the design of the Operations Core to facilitate transportation on a three-dimensional grid. To travel, personnel enter the destination into the OPC (Section 5.3.2) either by voice activation or visual aid in the touch screen. The OPC communicates with the DSPS to initiate a transportation route along the Modular Three-Dimensional Grid System (Section 2.2.3) and informs personnel of the specific color of wall to travel along. Pneumatic tubes run along each outer edge of the Modular Cube (Section 2.2.3) containing pressurized air moving at a high speed in one direction. A handle is electromagnetically latched to the pneumatic tube and an oval disk, located inside the pneumatic tube, is magnetically connected to the handle. When positioned vertically, the disk does not move, but when adjusted 90 degrees to a horizontal position, the disk is pushed by the pneumatic system. This simultaneously moves the handle and the person to their desired destination. A platform is also magnetically attached to the tube and travels, 2 meters from the handle, and travels at the same speed as the disk. To slow to a stop, the handle is returned to the vertical position. PIPES allows for a simple, safe transportation method throughout the Operations Core.

To allow for safe movement on the exterior surface of the hull, Northdonning Heedwell has engineered the Exterior Hull Transit Module (EHTM). This module works off a socket system and has 6 sockets that plug into holes spaced every one half meter along the frame struts on the exterior of Columbiat. The module transports up to two passengers and facilitates for four hours of travel.

To provide effortless travel in all directions through the Micro-Gravity Observatories, (Section 4.1.5) the Tether System is incorporated into the overall design. This system incorporates tethers attached from the ceiling to the floor that span across the observatory. The tethers are all located 3 meters from one another allowing people easy access from one tether to the next, while still allowing freedom



Figure 4.4.3 Table depicting spacesuit materials and purposes.

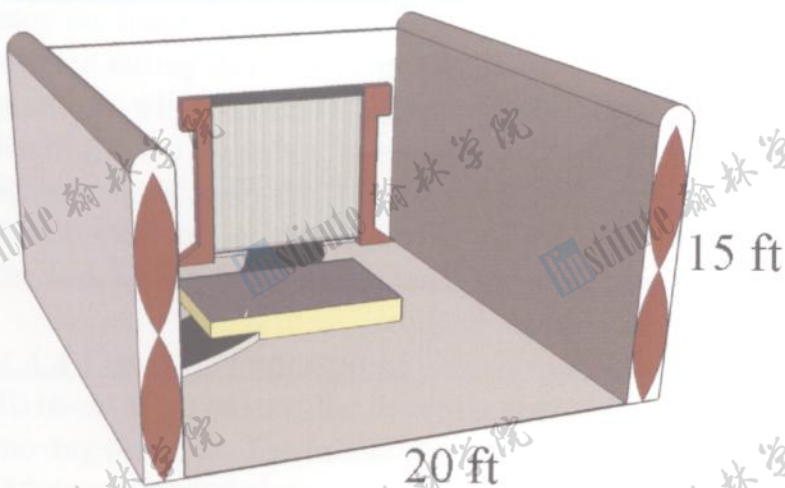
Material	Description
Inner Suit	
Thermal Micrometeoroid Garment (TMG)	Prevents impact of micrometeoroids. Protection against heat loss and solar radiation.
Aerogel	Shields and captures space dust.
Kevlar	Prevents from harmful ultra-violet rays.
Nomex	Performs as a flame and heat retardant.
Biaxially-Oriented Polyethylene Terephthalate (BOPET) Film	Provides structural integrity and electrical insulation.
Twaron	Protection from radiation and extreme temperatures.
Sentrex Netting	Prevents dust build up on joints.
Exoskeleton	
Metal Foam	Extremely strong and light: makes up Exoskeleton.
Outer Suit	
Polytetrafluoroethylene (PTFE)	A strong outer shell to protect inner layers from debris and dust.

of movement. Telescopes are located around the circumference of the observatory to maximize the visual experience. Tethers are also attached to the base of each stationary telescope to enable transportation and guidance to each observing post.

4.4 SPACESUIT DESIGN

Northdonning Heedwell prides itself in its spacesuit design, which works seamlessly in correspondence with the airlock and other systems on the settlement. We present only the finest quality design to you, the Foundation Society, in comfort and functionality both

Figure 4.4.1 – Airlocks are designed for maximum efficiency and ease of travel in and out of pressurized areas.



in spacesuit and airlock designs.

4.4.1 AIRLOCKS

Twenty airlocks, throughout the Operations Core, are designed to minimize the loss of air during donning and doffing procedures as well as being comfortable and efficient. The airlock doors contain a special rubber epoxy seal. Airlock walls are hollow, and contain large bladders to capture air. When the air is removed, a robotic arm pulls the rubber back while a clamp squeezes the bladder's opening shut. When the air is put back into the chamber, the clamps open and the air is released, resulting in a self-sustaining system. All airlock storage containers and other appliances are designed to function in a vacuum, so no malfunctions occur. Approximately, only 1.83 grams of atmosphere (1.47 cubic m3 at STP) is lost in each airlock procedure.



Figure 4.4.2 – The spacesuit design ensures safety while outside of Columbiat's pressurized zones.

4.4.2 SPACESUIT COMPOSITION

Spacesuits on Columbiat are designed for utmost comfort and functionality and have three layers, each serving a different purpose. The occupant is protected from thermal radiation, space dust, and

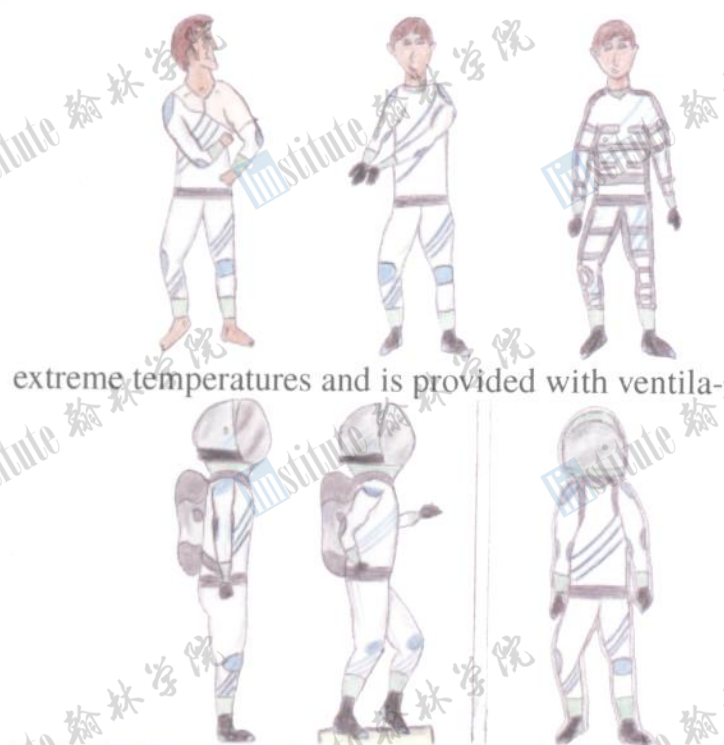


Figure 4.4.5 – The donning procedure is made simple and effective to allow for quick application of the spacesuit.

tion and insulation while being exposed to maximum flexibility and comfort. The helmet includes a transparent visor to enhance visibility and eye protection while oxygen systems supply life support for up to nine hours for augmented safety. Furthermore, the occupant's strength is enhanced mechanically with the suit's Exoskeleton. The Outer Suit is made from a Polytetrafluoroethylene (PTFE) material, which prevents contamination of space dust.

4.4.3 DONNING PROCEDURE

To allow for easy application, Northdonning Heedwell has created a simple step-by-step process for donning and doffing.

The occupant enters the airlock and manually puts on the Inner Suit. The gloves and boots are then manually situated. The helmet and life support system are placed atop the Inner Suit. The Exoskeleton is optionally donned during this time. The occupant steps onto a platform, which slides along a set of curved tracks leading into a Polytetrafluoroethylene film partition. Robotic arms apply the film around the occupant. The film is then secured to a line of locks along the back of the suit. Lastly, the platform leads the occupant outside.

4.4.4 DOFFING PROCEDURE

To re-enter the airlock, the occupant first steps onto the moving platform. The robotic arms then remove the Polytetrafluoroethylene cover from the occupant. As the film is unlocked from the suit, the platform revolves

and the occupant re-enters the airlock. Afterwards, the film is washed and recycled for later use. A large electromagnet beneath the floor attracts remaining loose space dust from the suit to prevent further dust contamination. The helmet, life support, and Inner Suit are removed to be cleaned and later used. Finally, the occupant goes through the last airlock door to re-enter the settlement. After the spacesuit is doffed, it is stowed in a sealed compartment near the airlock.

4.5 VISITOR ACCOMMODATIONS

Every guest's experience on Columbiat is of utmost importance to Northdonning Heedwell. For this reason, our company has planned unique visitor accommodations to bring complete safety and satisfaction to each guest during their stay.

4.5.1 MEDICAL QUARANTINE

Because Columbiat's status as a commercial and financial center, passenger transit must be as fast as possible, so Northdonning Heedwell has eliminated any unnecessary quarantine time between docking and the Residential Torus. Instead of remaining in quarantine for any length of time, all residents and guests are required to consume a pill containing micro medical sensors (Section 5.3.1), which monitor the bloodstream and report contagious diseases to the Quantum Processing Mainframe (QPM) (Section 5.2.1). If the contagious disease is deemed dangerous enough, the carrier is immediately escorted to the quarantine facilities, located at the zero-gravity hospital in the Operations Core and the condition is treated away from the majority of the settlement's population. Due to the fact that all community members are provided with medical nanobots, any outbreak of a harmful disease can be controlled through the communication with the QPM and expedient transfer of patients to the medical quarantine.

4.5.2 EDUCATION ABOUT LIFE ON THE STATION

Columbiat can present an unfamiliar environment to new arrivals. Therefore, guests and new residents must learn about life on the settlement by participating in an interactive tour. After exiting the docking bay, people are greeted by a tour guide, led through the Residential Torus and shown the Operations Core. During this tour, guests and residents learn about the dos and don'ts of life on the station and are provided an initial chance to grow accustomed to the station's environment. To accommodate for guests visiting Columbiat strictly for business purposes, an educational video is accessed on their space vehicle before they arrive on Columbiat. This video teaches people the same concepts taught in the interactive tour, but through a virtual tour that lasts a mere ten minutes.

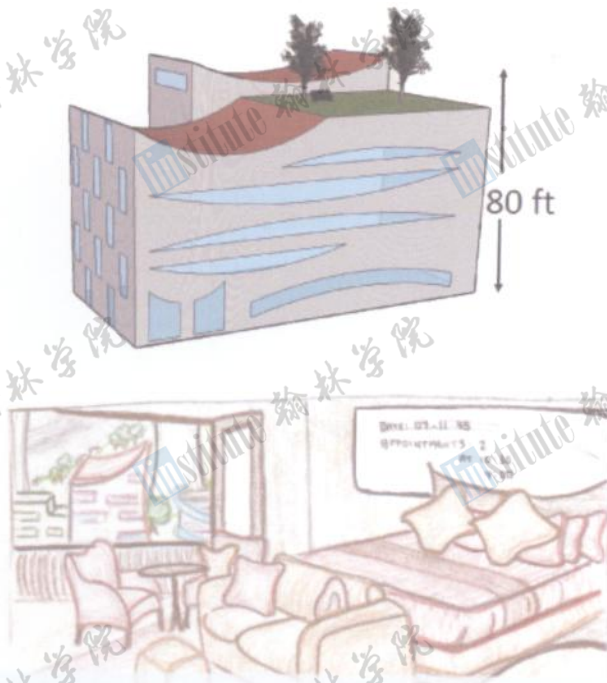


Figure 4.5.1 – Columbiat's state of the art hotels make for a more pleasant and convenient stay for all guests.

4.5.3 HOTEL DESIGN

Visitors arriving on Columbiat are offered accommodations to suit their needs during their duration on the settlement. The guests' stays are made more pleasurable by staying in Columbiat's state of the art hotels located throughout the commercial districts. Every hotel design includes unique features to add to the convenience of each guest's experience. For example, people have the option of checking in at the hotel's front desk or at a self-check in. These options each have benefits of their own. The availability of a desk check in allows for augmented human interaction, making guests feel more at home, while the self-check in, however, takes a faster, more technologically advanced approach to the same situation. Along with every hotel's innovative features, each is equipped with utilities that create a more advantageous stay for everyone.

An abundance of conference rooms are available to provide businessmen and women the finest meeting environment while cutting edge fitness centers are just around the corner to offer any guest the optimum opportunity for a healthy lifestyle. Many options of restaurants and cafés satisfy any guest's palate. A tram system stops every 8 km (Section 3.2.6) to give people safe access to anywhere on the torus. Bed and Breakfasts are also available for a more relaxing and tranquil stay. Their location in the rural neighborhoods of Columbiat presents guests with more private lodging. Guests are treated like they are right at home on Columbiat with a full kitchen, living room, bedroom, and bath in each suite. The option of dining at each Bed and Breakfast's small café for complimentary

Figure 4.5.2 – Table of anticipated security issues and responses

Security Issue	Response
Misdemeanor and Felony	Cameras are strategically located throughout the torus and security robots are on call to be sent to the location of violation.
Unauthorized Intruder	Security robots are sent to the location of the unauthorized intruder and Columbiat officials are notified immediately.

breakfasts, lunches and dinners are also offered.

4.5.4 SECURITY

Monitoring cameras are located throughout the Residential Torus to unobtrusively monitor residents and guests at all times. Wall mounted cameras are strategically stationed on various structures and have full viewing areas, while Rolling Monitors subtly travel throughout all parts of the torus. Upon occurrence of a security violation, all cameras are connected to the QPM (Section



Figure 4.5.3 – Rolling monitors enhance security throughout Columbiat.

5.2.1), which analyzes the event to dictate how it should be handled. If necessary, security robots (Section 5.2.2) are notified and sent to the situation. Because every guest and community member carries the OPC at all times, Columbiat can further enhance security through the tracking of each person's OPC. The OPC's are also linked to the QPM making each one easily traceable while accounting for every person on Columbiat at all times (Section 5.3.2). These security measures help in unobtrusively monitoring guests as to prevent them from inferring with the permanent residents' daily lives.



S.O. AUTOMATION DESIGN AND SERVICES

5.0 AUTOMATION DESIGN AND SERVICES

Through the use of streamlined, interconnected automation systems, Northdonning Heedwell ensures that the Columbiat settlement is the pinnacle of modern technology. Revolutionary hot-swappable tool sets in construction robots grant unparalleled versatility and variability in mass robotic construction, creating the most efficient autonomous workforce ever designed. A centralized Quantum Processing Mainframe integrates the many complex automation systems aboard Columbiat into a seamless, flourishing organism, bringing the foundation society unprecedented computing efficiency and resourcefulness. The OPC is the gateway to pleasant life on Columbiat, bringing information and control to the resident's fingertips, interconnecting the residents of Columbiat into an inclusive invested community. Effective cargo handling systems easily move a high volume of cargo traffic that passes through a transportation hub of Columbiat's magnitude, making the settlement an incredibly effective resource management center and further encouraging space development. Without the state of the art automations systems present on Columbiat, a space venture of this scale would surely fail.

5.1 AUTOMATION FOR CONSTRUCTION

Columbiat's innovative range of construction robots allow for quicker build times, more efficient utilization of materials, and the reuse of robots throughout the construction process as well as the entire operational life of the settlement. This decreases the overall cost of the settlement and increases the economical distribution of time, money, and materials, granting Columbiat an expedited construction schedule and in turn a faster return on the Foundation Society's investment.

5.1.1 TRANSPORTATION FOR CONSTRUCTION

Columbiat is assembled by a system of robots that work collectively to ensure an efficient and systematic construction process. A Deep Space Positioning System (DSPS) is used to allow robots and spacecraft to determine their relative position in the settlement area.

The DSPS is a space-based radio-navigation system that provides reliable positioning, navigation, and timing services to all users on a continuous basis. 16 DSPS satellite nodes are deployed 10,000 meters apart around the Primoris in a cubic arrangement to form a three-dimensional positioning grid. The DSPS satellites transmit relative positioning data to the Quantum Processing Mainframe (Section 5.2.1) located aboard the Primoris to triangulate a dynamic coordinate grid on which all exterior operating robots and vehicles are tracked in real time. After the construction process is complete the DSPS continues to operate as a navigational aide to all automations and incoming vehicles.

5.1.2 AUTOMATION FOR CONSTRUCTION

The settlement's structural frame skeleton is assembled from prefabricated strut lengths by the Frame Con-

necting Robot. This robot systematically insets the ends of six strut lengths into an angled corner piece and welds the seams to form the frame.

Immediately after frame sections have been assembled, the Hex Tile Layer places hull tiles in these frame segments. It secures to the corner pieces of the the geodesic lattice structure of the settlement and places prefabricated sections of the hull on the frame, welding them into place and sealing the seams. Once the hull piece is secured, the robot moves to an adjacent section. The Hex Tile Layer inserts both the internal and external hull sections.

The Multi Purpose Robot is the main construction robot throughout the bulk of the construction and finishing

process. We have designed it with versatility in mind, as it includes a variable set of tools that can accomplish a very diverse set of tasks during initial construction. Each robot ships with a software set that allows it to interact with a variety of swappable tool sets, each addressing a different aspect of construction. This grants a dynamic workforce that can easily adapt to changing demand.

Accompanying each construction payload is a Multi Purpose

Retrofitting Center that quickly hot-swaps between several different tool sets. This allows the Multi Purpose Robot to be a welder one minute and a surface liquid coat sprayer the next. These retrofitting bays come with multiple tool sets including:

- Arc Welders
- Liquid Coat Sprayers with interchangeable reservoirs

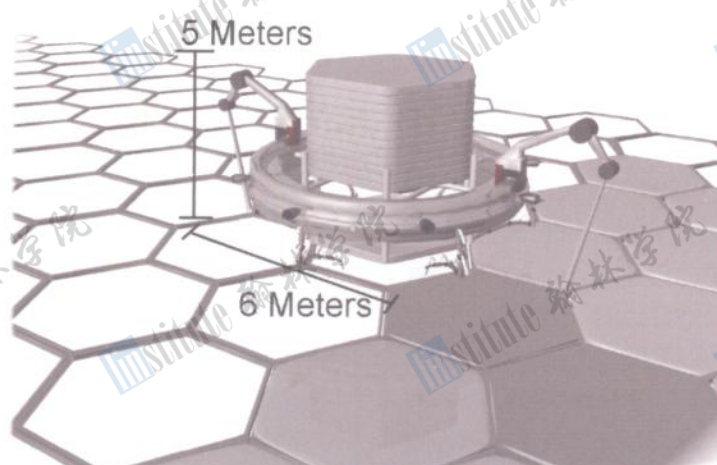


Figure 5.1.1 - Exterior Transportation Robots assist in the placement of every aspect of the construction process



Figure 5.1.2—A Table showing construction robots and their functions.

Robot	Function	Dimensions (m3)	Quantity	Storage Location
Directional Space Positioning System (DSPS)	Provides navigation and location data for all robots and personnel	.5m x .5m x .5m	16	Space
Exterior Transportation Robot (ETR)	Moves and positions materials robots used for construction	1m x .5m x .5m	800	Operations Core
Frame Connecting Robot	Connects and welds framing strut lengths	5m x 5m x 1m	500	Operations Core
Multi Purpose Robot	Assembles, finishes, inspects, and completes the interior of the settlement	2m x 1m x 1m	1000	Operations Core
Hex Tile Layer	Inserts hull tiles into completed frame sections	6m x 6m x 5m	500	Operations Core
Utility Laying Robot	Places infrastructure and utility lines	3m x 2m x 2m	300	Operations Core
Contour crafters	Constructs building walls and houses	Ranging from 10m x 10m x 15m-30m x 30m x 40m	100	Operations Core



of electric wiring, optical data lines, plumbing, ventilation, and other infrastructure components.

Although robotics have been designed with an emphasis on versatility, certain circumstances may require specialized robotics. A custom robotics lab is located in the Primoris to develop and construct robots to address any needs not met by preliminary robotics, on site.

Left: Figure 5.1.3 - Frame Connecting Robots quickly assemble the settlement's frame.

Right: Figure 5.1.4 - Hex Tile Layers expediently set the settlements exterior hull.

- Riveters
- Pneumatic Bolt Tensioning wrenches
- Pneumatic Power Grinders
- Transportation Arms
- Plaster Applicators

Once the frame of the settlement is complete, Utility Laying Robots begin running infrastructure and utility lines throughout the station. Utility Laying Robots utilize large, interchangeable spools

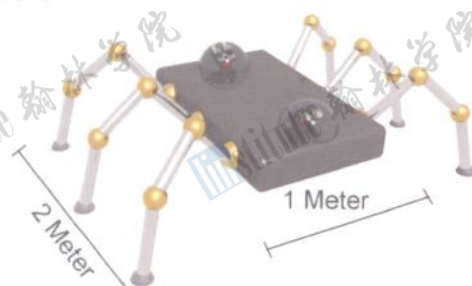


Figure 5.1.5 - Multi Purpose Robots can easily traverse the settlements frame or surfaces

5.1.3 AUTOMATION FOR INTERIOR FINISHING.

The interior finishing process is streamlined by only utilizing a small number of robots. For the construction of houses, foundations, and some large building, Northdonning Heedwell uses an array of contour crafters, printing structures floor by floor from the ground up using a lightweight silicon-based material while Utility Laying Robots insert infrastructure. This allows most interior structures to be constructed in less than 24 hours. Once the construction of houses is completed, Multi Purpose Robots, refitted with wheels for interior movement, place doors, windows, and any other major components that are needed. They also complete any required riveting and application of paint and plaster.



Figure 5.2.1 Table of Automations for Maintenance & Server Data

Robot/System	Job Description	Population	Location	Dimensions (m3)
Infrastructure Repair Robot	Interior Maintenance	760	Infrastructure	.3m x .6m x .15m
Multi Purpose Robot	External / Solar Flare Management	1000	Exterior of Station	2m x 1m x 1m
Security Bot	Public / Infrastructure Security	400	Residential & Ops	.2m x .25m x .15m
First Response Robot	Stabilizes injured residents	2000	Residential	.2m x .25m x .15m
Medical Transportation Robot	Transports ailing residents to medical facilities	600	Residential	1m x 2.5m x .5m
QPM	Optical Quantum Processors	6	Ops, Earth	48,000 Nodes
QPM Hard Drive Servers	Storage banks for the QPM; Each containing 300 Petabytes	200	Ops	

5.2 FACILITY AUTOMATIONS

Northdonning Heedwell has developed a state-of-the-art Quantum Processing Mainframe (QPM) system which utilizes the innumerable advantages of optical quantum computing to centralize, interconnect and standardized information between all systems. The efficiency gain from this system allows for a safe reliable and secure operation of the Foundation Society's investment.

5.2.1 QUANTUM PROCESSING MAINFRAME

Northdonning Heedwell's revolutionary Quantum Processing Mainframe (QPM) allows for near instantaneous data computation which provides for effortless data management and execution. The QPM is a redundant matrix of five interfacing optical quantum computers which process all computational demands on the settlement. Northdonning Heedwell has chosen an optical quantum computer to perform the entirety of the computation on the settlement because this form of computing is a million fold faster than traditional electronic computation. Columbiat, through these systems, may process and store data with more efficiency than ever before, and adds diagnostic and integral options to analyze situations with more accuracy. Three fifths of the total throughput is provided for operational and administration purposes as determined by the Foundation Society; approximately two fifth is allocated exclusively for general residential use. One Columbiat quantum computer is located on Earth, which is utilized to transmit data to and from the settlement on a quantum node-secured line (see 5.2.5.). All necessities on the station, including execution of medical, residential, security, and maintenance protocol, and interior robotics are managed by the QPM so that the system may in the most appropriate fashion. The QPM is

initially integrated into the Primoris to allow immediate operation upon arrival at the construction site.

5.2.2 AUTOMATIONS FOR MAINTENANCE, REPAIR, AND SAFETY FUNCTIONS; BACKUP AND CONTINGENCY PLANS

All medical problems are dealt with through a standard operating procedure, which consists of first response, transportation, and professional medical attention.

First, if micro-medical sensors (Section 3.5.1) detect a dangerous anomaly in an inhabitant the QPM is notified. The QPM then proceeds to dispatch a first response robot from the nearest medical station. First response robots stabilize the victim until they may be transported by the Medical Transportation Robot to the nearest medical facility. Upon reaching the hospital facility, the patient is waited upon by human medical staff. The QPM's massive processing resources are utilized throughout to aid in the medical process. This ensures efficient diagnosis, quarantine, and vaccination of diseases and the management of viral threats even in the space setting where viral evolution is considerably accelerated. Columbiat's maintenance system focuses on rapid response and thorough repair. Optical Time-Domain Reflectometers in the fiber optic system and hypersonic pulse leak monitors in gas and liquid pipelines alert the QPM of any infrastructural integrity breaches. In the case of a liquid pipeline breach the flow of fluids through the area is stopped and an epoxide polymer is applied by the Infrastructure Repair Robots to the fracture. This permanently repairs infrastructure without prolonged disruption. If the damage is significant, an entire section may be replaced by Multi Purpose Robots. Multi Purpose Robots from the construction process are also used for hull repair during station operation. Hull breaches are

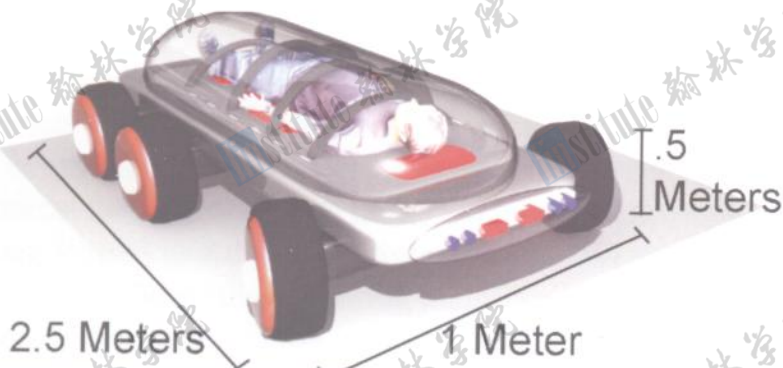


Figure 5.2.2 - The Medical Transportation robot responds to micro-medical sensors in the event of homeostasis disruption

further alleviated by one of six padded carbon fiber-reinforced polymer hull patching bands spanning the breadth of the torus's interior. When a breach occurs, one of such bands is moved autonomously to the breach location to effectively seal it through atmospheric pressure differential, until Multi Purpose Robots repair. This allows breaches to be repaired with minimal atmospheric loss and disruption to settlement life.

5.2.3 PERSONNEL ACCESS: SECURITY MEASURES

Due to the massive functionality of Columbiat's computer systems security in access of computer services is paramount in settlement security. Access privileges are divided into four levels as described in figure 5.2.6. Misuse of access privileges is taken very seriously and results in reduction of privileges and possible expulsion from the settlement.

Two forms of quantum encryption-based password verifications are utilized for data protection. This grants an unprecedented large scale data security, ensuring the privacy of residents and integrity of

critical systems on Columbiat. Lamport Signature algorithm generators is a software encryption method that ensures the highest mathematically possible level of data security and can only be utilized because of our quantum computing capabilities. The other quantum specific security measure exclusive to Columbiat utilizes Heisenberg Uncertainty Principle. Under this principle, each node of two communicating computers measure the transfer of entangled photon pairs each generating a random passkey. If the photon

stream is intercepted data integrity will be disrupted and a new key will be generated, effectively averting any data theft. These nodes are integrated into every computer system communicating directly with the QPM.

Figure 5.2.4 - Security Robots work in conjunction with customs screening to identify and detain threats, protecting all occupants and systems onboard Columbiat.

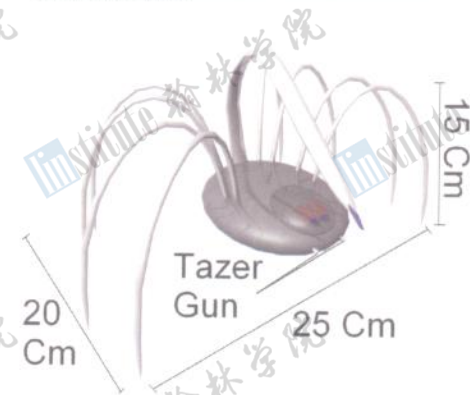
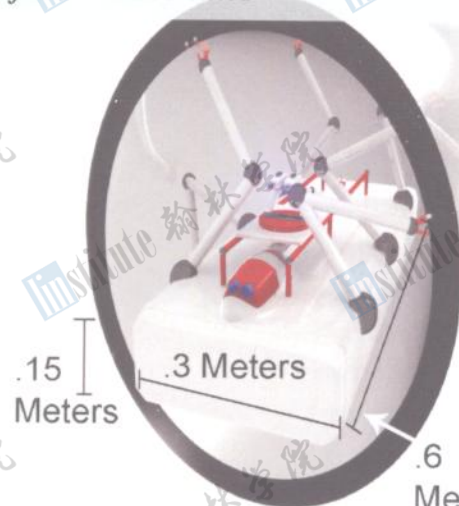


Figure 5.2.3 - Infrastructure Repair Robots effectively repair subterranean infrastructure lines



5.2.4 PHYSICAL LOCATIONS OF COMPUTERS AND ROBOTS

The distribution of robotics in evenly spaced hubs while maintaining a centralized location for quantum processing creates a flexible yet thorough distribution of robot resources based off of a powerful computing core to most effectively respond to any situation. 60% of robots lay ready for operation at automation hubs spaced evenly throughout the settlement. These hubs, 85 meters apart, contain medical, security, and

Figure 5.2.5 - Security access protocol is simple and effective

Level	Situation	Requirements	Access Granted
1	Visitor	Iris Scan (Temp. Data)	Temporary user account
2	Residential	Iris Scan	Residential permanent account, household functions
3	Business/Minor	Iris Scan, Vein Map	Localized command centers, medical robotics
4	Critical	Iris Scans, Vein Map, Official Preapproval, Two Employees, limited time access	QPM functionality, systems analysis data, maintenance robotics, manual override



maintenance robots, as well as Multi Purpose tool sets and other robotic accessories providing rapid response to routine and emergency situations with ease. The other 40% of robots remain dormant in operations warehouses waiting for emergency activation or routine circulation of robot workforce. Exterior robotic hubs are located in airlock bays for ease of access to the exterior. Quantum processing mainframes are stored in a highly secured location in the ablunar orb of the Operations Core while an identical backup server is located in a secured location in the accolunar. This separated redundancy ensures constant computational up time.

5.2.5 ROBOT SURVIVABILITY IN SOLAR FLARE ACTIVITY

In order to protect all externally functioning robotics from solar flare activity, RAGuard, RFX1, and gold foil are employed to absorb radiation. This provides a lightweight alternative to cumbersome metals or cements. Because solar flares will block any radio frequency communication, all robots that operate in flares have self contained computing systems so as to function normally without a stream of commands from the QPM. Intermittent commands however, can be sent through LIDAR transmissions, providing robots with basic operation guidelines.



Figure 5.3.1 – Micro-Medical sensors flow through the bloodstream monitoring the health of all residents.

5.3 AUTOMATION FOR ENHANCED LIVABILITY

Columbiat's wide range of community automation provides for enhanced union, efficacy and quality of operations throughout the settlement. In turn, this both expedites business transactions and operations and relieves residents of menial chores.

5.3.1 AUTOMATION FOR LIVABILITY IN THE COMMUNITY

In order to ensure the well-being of both full-time residents and visitors to Columbiat, the health of all inhabitants is closely monitored. This is done through

Micro-medical sensors that are ingested into the body in pill form. The pill contains a collection of sensors that distribute throughout the bloodstream and monitor bodily functions. If they detect a problem, the monitors wirelessly notify both their host and the QPM's medical database so that the appropriate steps can be taken to prevent serious illness (Section 5.2.2). To prevent complications, the sensors are naturally flushed out of the body every month and are replenished with a new pill.

We at Northdonning Heedwell recognize the importance people place on their time, so on Columbiat, the need to travel to the traditional grocery store for food and other day-to-day items has been alleviated. Residents on Columbiat have the opportunity to use the quick and efficient Commodities Delivery Network, although traditional grocery stores are still available. Using any available computer, the Commodities Delivery Network allows residents to order a wide variety of consumables including food items and commodities, for which they are billed. This network of subterranean pneumatic tubes ships goods in standard capsules directly to customer's homes from a central distribution center in the Operations Core. Upon the request of residents, material goods such as silverware, tableware, etc., are fabricated using a 3D printing process by which items are formed by printing items layer by layer in silicon.

5.3.2 AUTOMATION FOR PRODUCTIVITY IN WORK ENVIRONMENTS

Columbiat is focused on ease of business, so Northdonning Heedwell has accordingly provided many methods to increase productivity and efficiency in the workplace. Occupants of Columbiat have many different options when it comes to computing. Everyone has access to home, work, public, and personal computers. The traditional home computer, however, has been revolutionized, wall-sized displays. These computers utilize autosterioscopic technology through the use of a lenticular lens barrier that allows for 3D viewing by the inhabitant without the need for cumbersome eyewear. These computers respond to both touch and voice commands granting more streamlined human interfacing.

Computing and connectivity on the move are high priorities for inhabitants of Columbiat. Therefore, residents are issued with their very own

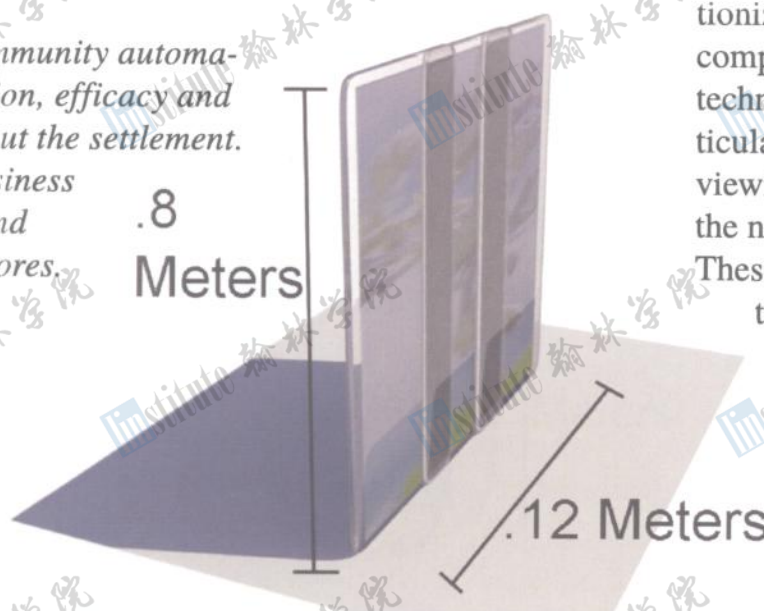


Figure 5.3.2 – The OPC slides out sideways providing a large screen in a small form factor.



Figure 5.3.3—Chart displaying residential station computer numbers.

Computer Name	Function	Quantity
OPC	Mobile computing solution carried by all residents	25,000
Home Computers	Large display personal and business computers	25,000
Business Computers	Computers used in business environments	35,000
Public Computers	Public computer access terminals	8,000

On-Person Computer, or OPC. The OPC is carried by residents wherever they go, allowing them to access their profiles no matter where they are in the station and complete a variety of tasks, whether that task is communicating with work clients over the Occupation and Informational Network, scheduling dinner on the Personal Computing Network, or studying on the Enhanced Teaching Network. Because of the centralized computing on Columbiat, the device itself carries only graphics hardware for rendering interface allowing a very powerful computing solution in a very small form factor. Folded up, the OPC is only 8cm by 4cm by .5cm yet, with the press of a button, a larger screen unfolds.

The screen itself is a touch sensitive LCD autostereoscopic display for 3D viewing and interaction. Additionally, the OPC allows the QPM to maintain data regarding resident locations, increasing settlement security.

To connect residents more effectively, Northdonning Heedwell has developed the Occupational and Informational Network as a communication utility. This tool keeps residents updated with all of the news and information they desire and facilitates the personal distribution and cooperative editing of documents and data. This system creates fluid cooperation between any and all fields of employment and facilitates rapid and thorough access to all manners of data information.

Addressing all automated and computational needs of education aboard Columbiat, classrooms are integrated with touch and voice stimulated wall computers, touch screen desks, and student OPCs to give a more integrated learning experience in and out of the classroom. These computers run the Enhanced Teaching Network (Section 4.1.2), giving teachers a more efficient tool for student interaction.

5.3.3 AUTOMATION FOR CONVE-

NIENCE IN RESIDENCES

Northdonning Heedwell aims to make life at home on the station as effortless and well-organized as possible. To make dusting and cleaning processes easier, all hard surfaces are coated with an extremely thin anti-static coating of Octylphenoxypolyethoxy-ethanol effectively preventing dust from adhering to surfaces. Therefore, dust remains airborne, where it is swept by an undetectable air current circulated throughout the house to a vent located under a carpeted section in the home. The dust is then caught in the carpet and vacuum removed during the night.

All other home-related activities are part of the Personal Computing Network (See Section 5.3.1). The house is able autonomously schedule a wide variety of tasks desired by the resident. However, the resident may take control of whatever functions they please whenever they want to.

5.3.4 AUTOMATION FOR MAINTENANCE AND ROUTINE TASKS

Columbiat is a thriving business metropolis. Therefore, Northdonning Heedwell, in the spirit of safety and efficiency, has automated almost all maintenance, labor intensive, and routine tasks. Routine maintenance tasks are completed by a small repair robot similar to the Multi Purpose Robot. Problems are reported to the repair database and a robot is dispatched to perform required maintenance. Settlement janitorial needs are assuaged with the Waste Control System. This system is comprised of both sensors in the ceiling of Columbiat that spot trash and other waste materials and janitorial robots that clean anything tagged for removal.

Alleviating the need for an agricultural workforce, the Agricultural Robot accomplishes the majority of agriculture needs. This robot slides along rails in the various agricultural

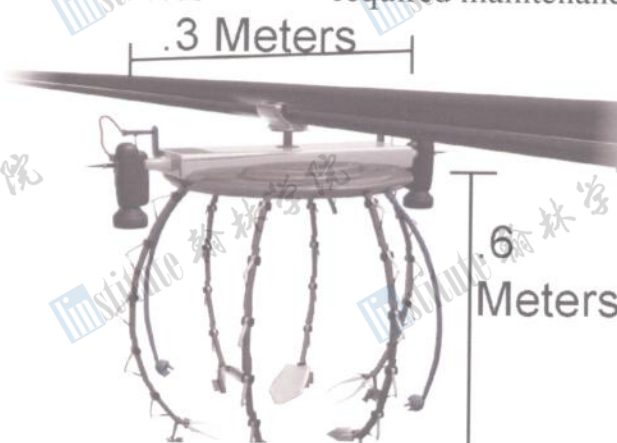


Figure 5.3.4—Agricultural Robots follow plants through the entire lifecycle

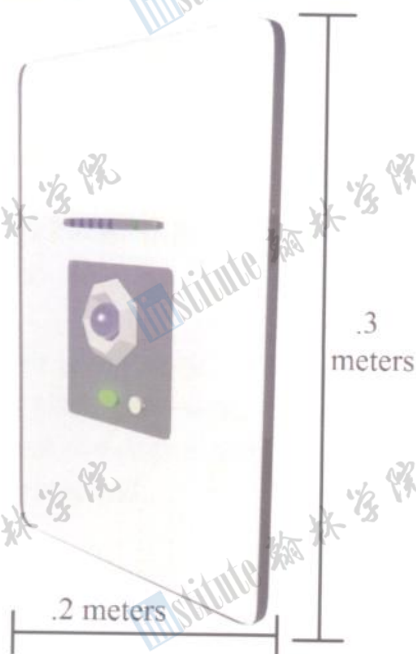


areas, cultivating and maintaining agricultural beds using a set of tools including trowel appendages and Aeroponic sprayers. Come harvest time, the agricultural robot collects crops and deposits them in the proper receptacles. A smaller, wheel mounted consumer version is also available to maintain residential gardens.

5.3.5 AUTOMATION FOR PERSONAL PRIVACY AND SYSTEM CONTROL

Privacy of personal computing is essential for all residents on Columbiat. Therefore, a system of iris scans and palm-vein mapping scans are used to allow individuals secure access to their personal files. The user simply places their hand on the computer's display and looks into the integrated camera to gain access to their personal profile. Once the user has been verified they may gain access to their homes and home system controls. QPM network security systems work in conjunction with these measures to completely all aspects of personal computing (Section 5.2.4).

Figure 5.3.5 – Iris scanning ensures total privacy of personal data on the Quantum Processing Mainframe.



5.3.6 ACCESS TO COMMUNITY COMPUTING AND ROBOT RESOURCES

Settlement computing throughout Columbiat is done by the Quantum Processing Mainframe (Section 5.2.1) making a universal access system a reality. All workstations including home computers, work computers, OPCs, and periodically positioned public computing

terminals process and store data through personal profiles on the QPM, granting access to personal computing resources from anywhere in the station while maintaining personal data and flawless security.

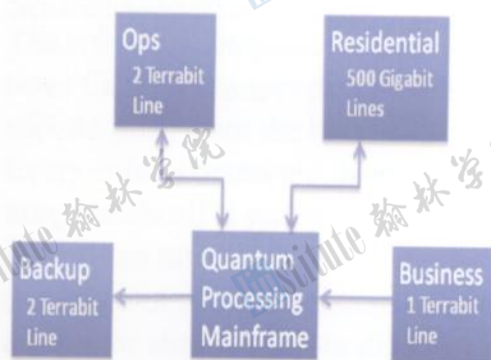


Figure 5.3.6 – Columbiat's network and bandwidth capabilities allow instantaneous connectivity throughout the settlement.

Residents on Columbiat have easy access to a variety of robotic resources. By simply connecting to the Automations Nerve Center which oversees all robotics needs of residents and businesses, inhabitants may request the services of anything from maintenance to janitorial robots. Occupants simply input a request for robotic assistance, which is reviewed and if approved the proper robotic resources are dispatched. Administrative supervisors oversee all robotic requests ensuring quick response to valid needs.

5.4 CARGO HANDLING

Columbiat's cargo transfer networks and inventory handling systems utilize RFID tags and a fully automated transfer system to provide The Foundation Society with a worker-free cargo handling system that saves you time and money, and ensures automated efficiency.

5.4.1 CARGO TRACKING

Immediately after a vehicle docks at Columbiat, RFID (Radio Frequency Identification) tags are placed on all cargo containers entering the automated cargo handling system. These RFID tags broadcast secure data pertaining to cargo contents, the recipient of the cargo, and the final destination over a low power signal. These tags are constantly scanned, allowing the customer and the Foundation Society to easily monitor and adjust container location at any point in transit. This in turn accelerates the sorting process of all containers and ensures that containers arrive at designated locations.

5.4.2 CARGO HANDLING SYSTEM

Columbiat's fully automated cargo control system offers an exceptional level of control and dynamic manipulation. All cargo processed by the system is shipped in standard 15x15x60ft sealed containers allowing Columbiat to handle higher volumes of cargo traffic. Immediately after a vehicle docks at Columbiat, a length of shielded cargo-tram rail extends from the station to the vehicle. Trams then pick up shipping containers from the vehicle and cycle them into the handling system. Once in the system, cargo trams run shipping containers on tracks to their destinations. Shipping containers can be sent to: three passenger baggage claim, two storage warehouses, two product delivery cargo stations located within the residential torus and any number of waiting vehicles. Two of the major spokes contain tracks in order to facilitate cargo transfer between the Operations Core and the Residential Torus.

5.4.3 CARGO WAREHOUSING

Two cargo warehouses are integrated into the cargo handling system. One warehouse is located in the accolunar orb and one in the ablunar orb. The ablunar



Figure 5.4.1 – Cargo-tram railways allow accelerated delivery of sealed cargo containers to any of several depots across the settlement



warehouse is 8,000,000m³, allowing storage of 16,000 containers. The accolunar warehouse is 1,000,000m³, allowing storage of 2,000 storage containers. Each cargo warehouse allocates

a dynamic part of its volume for temporary storage of shipping containers waiting on destination vehicles to arrive, which are organized so as to be rapidly placed and removed.

5.5 ROBOT MAINTENANCE

Maintaining and servicing robotic systems is essential in the smooth transition to life in orbit. Northdonning Heedwell utilizes a comprehensive plan for maintenance, over haul, and dust removal. This system allows us to service all robots both foreign and local, enabling the foundation society's investment to be universally compatible.

5.5.1 MAINTENANCE AND OVERHAUL

The robotic maintenance center, located in the Operations Core, is equipped to repair and fully refit any robotic unit, from the station or any visiting vehicle. Every robot contracted or manufactured by Northdonning Heedwell is equipped with a diagnostics analysis system, an integrated sensor network which monitors the status of all other systems aboard the robot. This allows for simple plug-in diagnostics and autonomous replacement of malfunctioning parts from our massive database of hardware. Due to our inability to anticipate all hardware specifications aboard foreign robotic systems, we employ an extensive diagnostic system to autonomously run electronics and hardware tests to

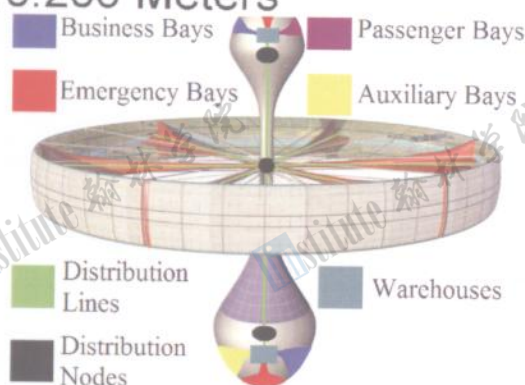


Figure 5.4.2 – Cargo-Tram network distributes cargo across the entire settlement

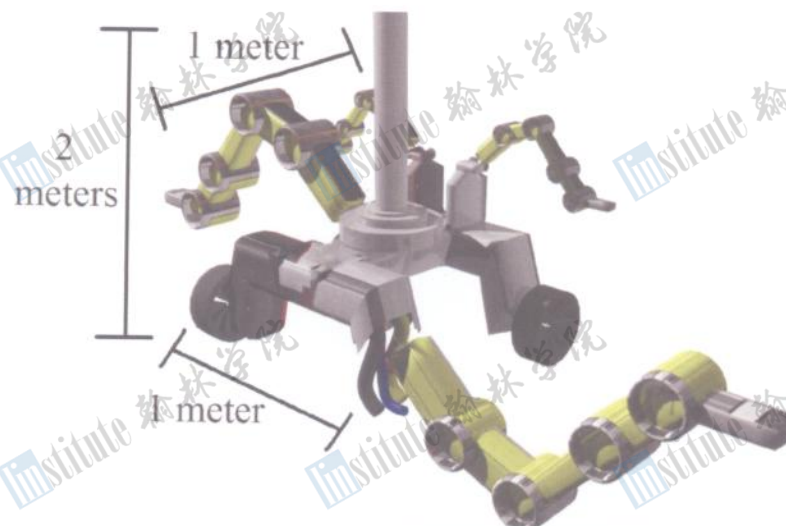


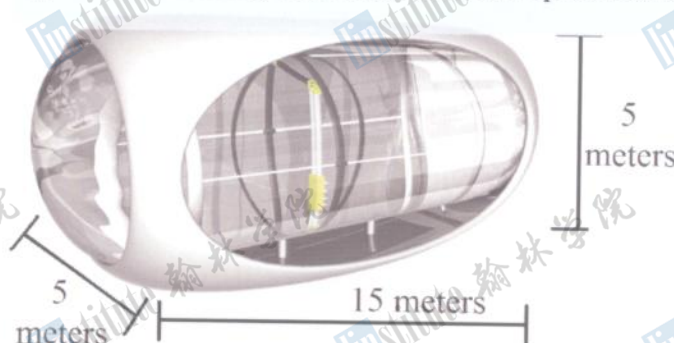
Figure 5.5.1 – Columbiat's robotic maintenance facilities allow for robots to be repaired quickly and cost-effectively, increasing repair turnover times and decreasing costs.

find any failures. Malfunctioning parts are replaced if possible, or machined in the maintenance center allowing most robots to be maintained and repaired entirely autonomously. If a robot cannot be diagnosed or repaired using computerized equipment, technicians are always standing by to operate manually. All exterior operating robots and robots from visiting vehicles must go through the dust decontamination process before entering the station and the robotic maintenance center.

5.5.2 DUST DECONTAMINATION

In order to guarantee that no dust enters Columbiat, Northdonning Heedwell has implemented a series of dust mitigation techniques. First, robotic systems must enter a containment chamber where they are exposed to ion beams, statically exciting dust particles and significantly loosening them from robotic hulls. Then the robot is thoroughly brushed by CO₂ Dual Nozzle sprayers that dislodge surface dust. The statically charged dust is collected on large EM plates. In the final stage of the process, the chambers are subjected to a high power CO₂ cross current, sweeping loosened dust particles to the collection plates. When the dust removal process is complete, the robot exits the chamber, the EM plates reverse charge and the dust particles are collected and deposited in the proper receptacle.

Figure 5.5.2 – The three-fold dust decontamination process employed by Columbiat prevents dust from entering the station, mitigating all difficulties incurred by dust accumulated in a space environment.





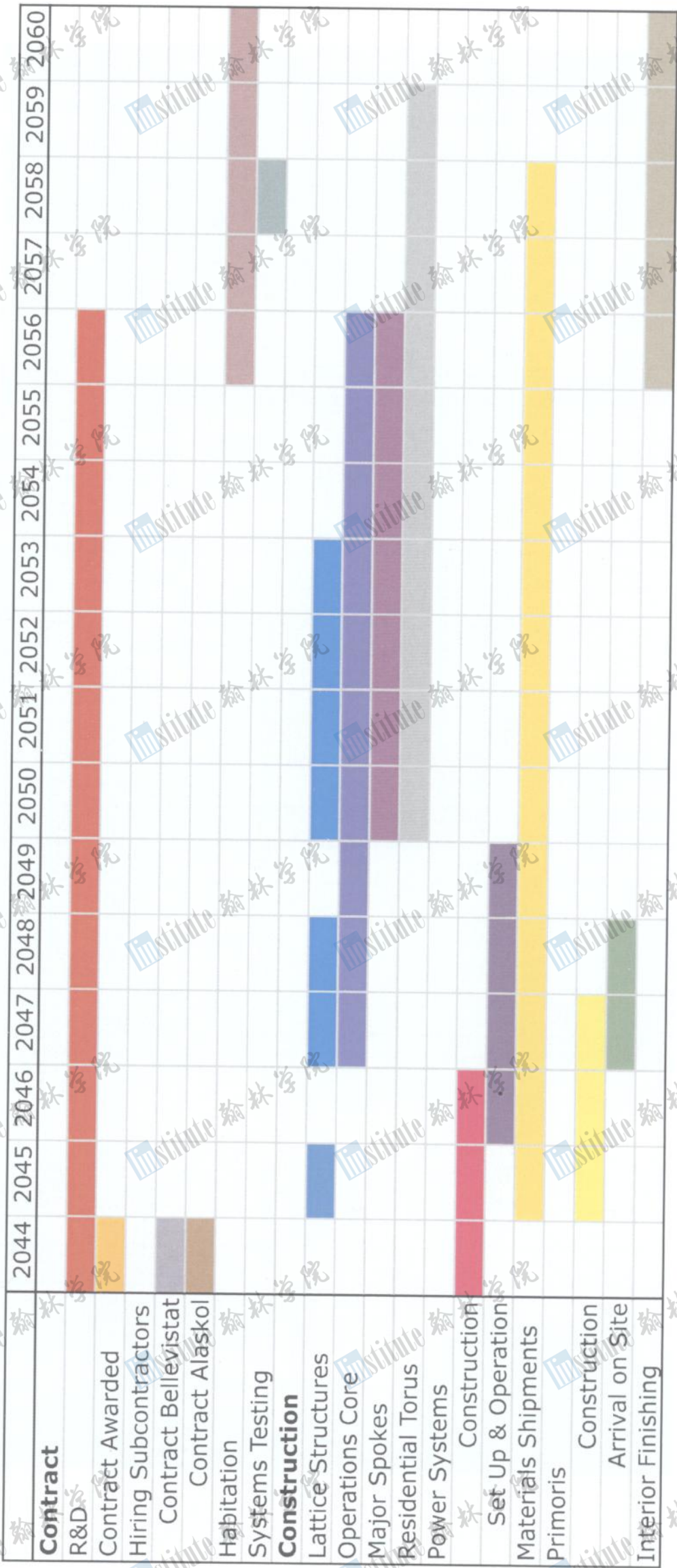
ISO 9001 SCHEDULE AND COST



6.0 SCHEDULE AND COST

As we well know, the construction of a space settlement is not easy or cheap. With this in mind, Northdonning Heedwell has developed a plan to not only reduce the cost of the Columbiat but also the time it takes for construction as far as we can without compromising quality. The key to our dynamic plan is our selection of subcontractors. Northdonning Heedwell has found the most reliable, hard-working, and cost-effective subcontractors to not only greatly reduce the investment required from the Foundation Society but also minimize the time before you reach a return-on-investment.

6.1 SCHEDULE





6.2 Cost

Phase	Items	Cost of Items (\$)	Employees
Research and Development	N/A	60,000,000,000	2,400
		Total Cost of Phase: 60,000,000,000	
Primoris	Primoris	42,000,000,000	850
	DSPS Satellites	54,000,000	
	Solar Satellite Production Units	80,000,000	
	Construction Robotics	7,400,000,000	
	QPM	700,000,000	
		Total Cost of Phase: 50,634,000,000	
Operations Core Construction	Infrastructure Systems	48,000,000,000	1,290
	Manufacturing Systems	6,500,000,000	
	Docking Facilities	14,700,000,000	
	System Robotics	5,800,000,000	
		Total Cost of Phase: 75,000,000,000	
Torus & Major Spokes Construction	Agricultural Systems	2,000,000,000	2,045
	Transportation Systems	5,600,000,000	
	Additional Infrastructure	12,000,000,000	
	Cargo Handling Systems	800,000,000	
		Total Cost of Phase: 20,400,000,000	
Major Spokes Finishing & Pressurization	Propulsion Systems	2,400,000,000	1,850
	Automation Infrastructure	2,500,000,000	
	Airlock Integration	450,000,000	
	Pressure Door System	2,600,000,000	
		Total Cost of Phase: 7,950,000,000	
Torus Interior Finishing	Building Construction	13,800,000,000	1,200
	Interior Finishings	2,000,000,000	
	Infrastructure Routing	500,000,000	
		Total Cost of Phase: 16,300,000,000	
Materials and Equipment	N/A	117,500,000,000	N/A
Transportation of Materials and Equipment	N/A	40,600,000,000	N/A
		TOTAL COST: 388,384,000,000	



INSTITUTE OF BUSINESS DEVELOPMENT



7.0 BUSINESS DEVELOPMENT

Northdonning Heedwell recognizes that Columbiat is first and foremost a business venture. As such, returns on the Foundation Society's investment will begin on the day of contract acceptance, and will continue indefinitely. Northdonning Heedwell's business plan generates revenue from two major sources: hard businesses that provide necessity goods and services, while soft businesses provide the services that enhance settlement life. Pre sold real estate, trade capacity, and tourism provide a few of the inevitable revenue streams. The settlement is a living, breathing entity, with real estate constantly changing hands and purposes, materials and resources flowing freely, generating rapid returns and a solid economic base for the Foundation Society.

7.1 BUSINESS PLAN

The overall objective of the Business Division faculty at Northdonning Heedwell is to provide the best product at the least possible cost to the Foundation Society, with the widest variety of revenue sources possible. With this objective in mind, we present the overall Business Plan for the Columbiat Space Settlement.

2044 – After the contract for Columbiat is awarded to Northdonning Heedwell, we immediately open real estate offices on Alexandriat, Alaskol, Bellevistat, Hong Kong, Singapore, London, New York, and Los Angeles. These offices will immediately begin marketing the available real estate in all sectors of Columbiat not obscured by operations equipment.

2052 – Most of the Operations Core is constructed, this allows part of Columbiat's zero-g environment to be developed as automated lab space. This space is available for purchase, but until that purchase time Northdonning Heedwell utilizes it for Research and Design purposes in order to develop new space based technologies. We believe that after Columbiat is turned over to the Foundation Society, you will find it to be a very profitable resource to develop advanced, marketable technologies.

2056 – Both the Operations Core and the Major Spokes reach completion at this date, allowing the Foundation Society to open these parts of the station to habitation while interior finishing on the Residential Torus is completed. This allows us to open the Transportation and Trade port aspects, initial Commercial operations, and an initial Real Estate market to the general population interested in Columbiat.

2060 – Columbiat is turned over to the Foundation Society after completion of the Residential Torus. The full capacity of Columbiat's economic potential is realized at this point when Real Estate and Commerce can be in full swing, and the Soft Businesses like Tourism/Customer Service, Cus-

tomized Robotics, and Resident-Owned Small Businesses can begin operating at full capacity.

Northdonning Heedwell's Business Plan for Columbiat helps the Foundation Society realize your ultimate goal: Space Settlement and Infrastructure in our Solar System, as fast as possible. Unlike other proposals, generating fixed resource quantities and finite incomes only after construction is complete, Northdonning Heedwell enables dynamic property use, unbounded profits, and above all, a functioning economy.

7.2 HARD BUSINESSES

The foundation of Columbiat's revenue is generated from Trade and Materials Management, Commerce, and flexible Real Estate markets. These Businesses will serve the Foundation Society well from day one, providing a reliable platform for future growth.

7.2.1 COMMERCE

Recognizing Columbiat's importance to the Foundation Society as a central hub for the future of space commerce, Northdonning Heedwell has designed Columbiat as a pleasant and efficient place to do business. Northdonning Heedwell has allocated our most precious space, the center of a Major Spoke, to form the heart of the Foundation Society's Headquarters for the foreseeable future. This location provides the perfect combination of rapid access to the port, the Residential Torus, and the Operations Core. This placement helps the Foundation Society utilize Columbiat to its full potential by providing easy access to resources, vehicles, and the ever-growing population of spacers.

Residents or interested corporations desiring to move their operations into space have myriad purchasing and leasing options to suit their individual needs. These spaces are located in all parts of the settlement, but in large quantities in the Major Spokes. Northdonning Heedwell's design accommodates the request of several businesses for offices by allocating 20% of the available office space aboard Columbiat to those companies that have already expressed interest. This



space includes 4 companies with 150 person offices, 8 companies with 100 person offices, 15 companies with 30 person offices, 30 companies with 5 person offices. The remaining 80% of office locations are sold to residents or interested corporations attempting to move their operations into space.

Corporations and business requiring any computing power aboard the station can lease the exact amount required from Columbiat's central QPM. Leasing computational power allows for a flexible computing environment with many benefits. Clients are no longer bothered by the dangers and expenses of failing hardware; Northdonning Heedwell maintains computer hardware and software, keeping it up to date and ensuring security integrity. A client can dramatically increase processing resources without the burden of



Figure 7.2.2 - A figure detailing offices available in Columbiat's business districts.

hardware purchase. All of Columbiat's computing, both personal and commercial, is already designed for central mainframe processing enabling dynamic redistribution of power on the fly and ensuring compatibility across all systems. Some of the business

aboard Columbiat will require local storage systems for highly sensitive data. In these instances we offer a special local server that remains under private administration. These servers are maintained by the clients hired technicians and remain off the major network. In the rare occasion that a massive corporate entity requires extensive private processing ability, and unprecedented data security, Northdonning Heedwell provides the option to install a private QPM.

Space for 3 major banks has been allocated primarily in the Terminal Facilities and the Residential Torus, where most transactions will occur. Smaller spaces for banking kiosks and extension offices exist in the Major Spokes so residents can always access financial services. Like the rest of the land aboard Columbiat, customers can develop space how they choose to, allowing variability in the banking industry.

The final piece of Columbiat's business friendly environment is the active stock market. At this point in the development space, Northdonning Heedwell foresees the future expansion of mankind and the development associated with it as a primary source of economic

growth. As a large scale economic power, and on account of being the principle financial location for space business, Columbiat will host the first space-based stock market, allowing greater commercial flexibility.

7.2.2 TRANSPORTATION NODE & PORT/ PROVISIONING

To encourage financial transactions, Northdonning Heedwell recommends that the Foundation Society designate Columbiat a Free Trade Zone. Doing so would mean resources and materials moving through Columbiat's port facilities would go untaxed, encouraging a greater volume of customers. In lieu of taxation, we would charge a Docking and Handling fee to each vessel docking with Columbiat (for system, see 5.4.3). To encourage frequent business, Columbiat will waive the docking fee for frequent visitors, and charge only for cargo handling, allowing frequent customers greater accessibility.

While vessels receive equity provisioning and cleaning services free of charge, refueling services, repairs to spacecraft, veterinary services, and other services come at a cost to the customer. For customer convenience the Settlement provides 4 different types of commonly used fuels for purchase through the Dynamic Fuel Production System (section 3.2.10). These fuels include nitrogen tetroxide, hydrazine, helium 3, and deuterium that together cover nearly the entire spectrum of fueling needs.

Aboard Columbiat, Northdonning Heedwell maintains an unprecedented level of biological security, while maintaining a quarantine process that is both simple and expeditious; this allows all customers and clients to enter the settlement with nearly no wait time, allowing fast and easy transactions and travel (see sections 4.5.1, 5.3.1). Columbiat is an agricultural powerhouse that produces and stores abundance of excess resources allowing lucrative sales to incoming vehicles, and preparation for any unlikely crisis aboard Columbiat and other stations. (see 3.2.4).

Northdonning Heedwell recognizes the Foundation Society's eventual goal of creating a Lunar Space elevator and therefore includes an easily developed expansion port on the Operations Core (see section 3.1.2). This involves warehousing space, utilities, and a pressure section so the Foundation Society can develop it as they wish. This expansion port will make Columbiat's eventual transition to an orbital terminus expedient and cost effective.



7.2.3 REAL ESTATE MARKET

After considering many different designs for Columbiat's real estate system, Northdonning Heedwell has decided that a fully functional free market real estate system would be the most profitable and flexible option. Real estate transactions between individuals, small businesses, and large corporations are both allowed and encouraged aboard the settlement. Initially, land and housing are purchased directly from the Foundation Society through preorders at real estate offices worldwide. After a customer has purchased land or a house on the settlement, it becomes theirs to do what they wish (under the zoning regulations laid down by the Foundation society). Owners can sell or even redevelop this land for other purposes outside its original intent. This allows free enterprising systems to rein dominant aboard Columbiat, generating a greater profit for the Foundation Society.

This system gives the Foundation Society sustained profits (taking a 5% cut off all transactions) while giving the owners increased property freedoms. After open space is allocated, all other land (not including Major Spoke anchor points) is subject to purchase and development by third parties for housing, commercial development, or other purposes as the Foundation Society sees fit.

To encourage additional business variation, Northdonning Heedwell will subcontract various contractors from Earth and other settlements to design and develop properties on Columbiat according to buyer's wishes. This enterprising spirit brings new design concepts for variable environments and brings more people into the financial loop aboard Columbiat.

7.3 SOFT BUSINESSES

7.3.1 TOURISM & CUSTOMER SERVICE INDUSTRIES

Completion of Columbiat allows costumer service and entertainment businesses to emerge aboard the settlement. These "Soft Businesses" primarily target tourists, but enhance livability for the residents of Columbiat as well.

The revolutionary ease of access to space provided by Columbiat generates a vast tourist base that encompasses everyone from the business tycoon to the average vacationer. These "soft businesses" provide the non-essential amenities that create both a comfortable consumer atmosphere while stimulating Columbiat's

thriving economy. These soft business include:

- Hotels (can accommodate up to 5000 guests)
- Vacation Packages
- Different Itineraries dependent on price
- Access to everything that the settlement has to offer
- 5 star accommodations
- Restaurants and Dining options
- ½ gravity spas
- Space specific entertainment options
- Orbital tours: both L2 and Lunar
- Sold in the terminal facility
- Convention Center to be booked by interested parties
- Casinos and other conventional entertainment options

Customer services and tourism provide vitality to Columbiat's solid economy. Columbiat keeps its finger on the pulse of the times, adapting as trends demand in order to remain relevant and attractive to future investors and tourists. This surface flexibility creates an unabridged monetary system and generates major revenue.

7.3.2 CUSTOM COMMODITIES

Many specialized manufacturing facilities on Columbiat cease production for required goods after initial construction is complete, rendering these facilities dormant. Rather than let these advanced facilities go to waste, Northdonning Heedwell proposes the use of these systems, and variations of them, to produce customized commodities for the population

of Columbiat. The specialized production facilities aboard the Primoris are capable of manufacturing finely crafted technologies. After the initial construction need for this production bay no longer exists, we use these manufacturing mechanisms in the creation of customized robotic systems, specialized spacecraft parts, and personalized vehicles to meet customer requests.

Many of our enterprising residents have refined and innovative design tastes. In order to satisfy their aesthetic desires, and as proof of our flexible economic model, Columbiat offers customized housing, landscape and personalized amenities. For a fee, residents can design everything from their house to their silverware. The Requisition Offices is the final major innovation in customer convenience found aboard Columbiat. For the price of launch costs, docking and handling fees, and a profit for the Foundation Society, residents can request items from Earth to be sent up to their residence aboard Columbiat. This allows residents to have authentic items that cannot otherwise be created in space for an added familiarity with home.



Figure 7.3.1-Downtown business district & shopping center.



XI'AN JIAOYU UNIVERSITY 8.0 COMPLIANCE MATRIX



8.0 COMPLIANCE MATRIX

Requirement	Where Addressed	P. #
1.0 – The contractor will describe the design, development, construction, and operations/maintenance planning for the Columbiat space settlement in Earth orbit	1.0 Executive Summary	7
2.0 – Provide safe and pleasant working environments for 22,000 residents and 2500 transient	2.0 Structural Design	9
2.0 – Design must enable residents to have natural views of Earth below	2.1.2 Construction Materials	10
2.1 – Identify large enclosed volumes and their uses	Figure 2.1.2 Dimensions of the Exterior of Columbiat	9
2.1 – Show dimensions of major structural components and design features	Figure 2.1.3 Side View of Columbiat and Figure 2.1.4 Top View of Columbiat	9
2.1 – Identify construction materials for major hull components	Figure 2.1.5 Construction Materials and Figure 2.1.6 Construction Material Arrangement	10, 11
2.1 – Specify volumes where artificial gravity will be supplied, and rationale for selection of rotation rate and magnitude	2.5.1 Half and Three-Quarters Gravity Environments	15
2.1 – Identify structural interfaces between rotation and non-rotating sections	2.1.3 Connection Joint Between Rotating and Non-Rotating Sections	11
2.1 – Identify volumes in pressurized and unpressurized environments	Figure 2.1.3 Side View of Columbiat	9
2.1 – Specify means for providing protection from radiation and debris	Figure 2.1.5 Construction Materials and Figure 2.1.6 Construction Material Arrangement	10, 11
2.1 Minimum Requirements		
<i>An overall exterior view of the settlement with major visible features (solar arrays, antennas, telescopes, etc.)</i>	Figure 2.1.1 Welcome to Columbiat	9
<i>Show rotating and non-rotating sections</i>	Figure 2.1.2 Major Structural Components	9
<i>Show pressurized and non-pressurized sections</i>	Figure 2.1.2 Major Structural Components	9
<i>Indicate functions inside each volume (e.g., port, residential areas, and agriculture).</i>	Figure 2.1.2 Major Structural Components	9
2.2 – Specify allocation of interior down surfaces with	Figure 2.2.1 Columbiat	12



areas designated and dimensions labeled	Showing Aesthetic Down Surface Division	
2.2 – Show residential, industrial, commercial, agricultural, and other uses	2.2 Internal Arrangement	11
2.2 – Specify volume and state how microgravity and unpressurized facilities are used	2.2.2 Major Spokes and Section 2.2.3 Operations Core	12, 13
2.2 – Show orientation of down surfaces with respect to overall settlement design and vertical clearance in each area.	Figure 2.2.1 Columbiat Showing Aesthetic Down Surface Division	12
2.2 Minimum Requirements		
Overall map or layout of interior land areas	Figure 2.2.1 – Allocations of Interior Space	12
Show use of these areas	Figure 2.2.1 – Allocations of Interior Space	12
2.3 – Describe the process required to construct the settlement design	2.3 Construction Sequence	13
2.3 – Show the sequence in which major structural components will be assembled	2.3 Construction Sequence	13
2.3 Minimum Requirements		
Drawing showing at least 6 intermediate steps of settlement assembly	Figures 2.3.1-2.3.6 – Construction Sequence	13
2.4 – Port facilities must simultaneously dock and unload/load 4 cargo ships and one passenger ship	2.4 Docking Configuration	14
2.4 – Long term docking for one ship requiring emergency repair	2.4.4 Emergency Bays	15
2.4 Minimum Requirements		
Drawings/maps showing location of port areas for handling incoming and outgoing ships	Figure 2.4.3 – Locations of Port Areas	14
Show long-term docking for one ship requiring emergency repair	2.4.4 Emergency Bays	15
2.5 – Provide some accommodations at half the g level of primary settlement volumes for visitor adaptation	2.5 Varied Gravity Areas	15
2.5 Minimum Requirements		
Show lower-g sections on overall settlement drawing and their rotation rate	Figure 2.5.2 Lower G areas	15
3.0 – Describe facilities and infrastructure necessary for building and operating community	3.0 Operations and Infrastructure	17
3.0 – Include conduct of business and accommodating incoming and outgoing vehicles	3.3.2 – Vehicles	22
3.1 – Show operation at the Earth-Moon L2 libration	3.1.1 – Orbital Location	17



point	Figure 3.1.1 – orbital location	
3.1 – Enable future conversion to serve as the orbital terminus of a lunar Space Elevator	3.1.2 – Space Elevator 3.2.8 – Terminals for future Expansion	17, 21
3.1 – Identify sources of materials and equipment to be used in construction and operations (Earth, asteroids, existing on-orbit facilities, Earth's moon, or elsewhere)	3.1.3 – Origin of materials Figure 3.1.2 - Materials	17, 18
3.1 – Means for transporting materials to Columbiat and storage between arrival and use	3.1.3 – Origin of Materials	17
3.1 Minimum Requirements		
<i>Chart or table identifying types and amounts of various materials and equipment required for settlement construction process</i>	Figure 3.1.2 - Materials	18
<i>Where and how those materials and equipment are shipped</i>	Figure 3.1.2 – Materials	18
3.2 – Show elements of basic infrastructure required for the activities of residents and customers of the station	3.2 - Community Infrastructure	17
3.2 – Show atmosphere, climate, and weather control (identify air composition, pressure, and quantity)	3.2.1 – Atmosphere and Climate Control	17
3.2 – Show food production (Including growing, harvesting, storing, packaging, delivering, and selling)	3.2.2 – Food Production	18
3.2 – Electrical power generation (Specify Kilowatts) Distribution and allocation for specific uses	3.2.3 – Power Generation	19
3.2 – Specify water management (required water quantity and facilities)	3.2.4 – Water/waste Management	19
3.2 – Specify household and industrial solid waste management (specify recycling and/or disposal)	3.2.4 – Water/waste Management Figure 3.2.4 – Waste Management	19, 20
3.2 – Specify internal and external communication systems (specify devices and central equipment)	3.2.5 – Communications	20
3.2 – Internal transportation systems (show routes and vehicles, with dimensions)	3.2.6 – Internal Transportation	20
3.2 – Specify day and night cycle provisions (specify schedule and mechanisms/operations for providing it)	3.2.7 – Day-Night Cycles	21
3.2 Minimum Requirements		
<i>Dimensioned drawings showing systems which provide required infrastructure and as appropriate, there configurations (e.g., show routing of utilities services</i>	Figure 3.2.10 – Infrastructure Routing	22
3.3 – Identify existing or new on-orbit infrastructure required to develop and sustain settlement operations	3.3.1 – Space Infrastructure Figure 3.3.2 – Out of	22, 23



(e.g., vehicles, satellites, and power plants)	Contact Infrastructure Figure 3.3.2 – In Contract Infrastructure	
3.3 – Provide concessions for the commercial development and operation of vehicles for transporting goods and personnel from Earth orbit to the Columbiat orbital location and/or for transporting construction materials from extraterrestrial sources	3.3.1 – Space Infrastructure 3.3.2 - Vehicles	22
3.3 Minimum Requirements		
<i>Chart or table describing space based infrastructure in vehicles required for settlement operation</i>	Figure 3.3.1 - Vehicles Figure 3.3.2 – New and existing space infrastructure	22, 23
<i>Include notation of which will be included in this contract and which will be developed commercially without Foundation Society investment</i>	3.3.2 - Vehicles Figure 3.3.5 – Vehicles	22, 23
3.4 – Define propulsion systems required on Columbiat to maintain the station rotating and in Earth-Moon L2	3.4 – Propulsion Systems	24
3.4 Minimum Requirements		
<i>Drawings of propulsion systems, locations and interfaces with structure, propellant types, propellant storage, and identifying thrust produced by each type</i>	Figure 3.4.1 – VASIMR engines Figure 3.4.2 – Production of artificial gravity	24
3.5 – provide and maintain food and agricultural replenishment, livestock/veterinary services, engine overhaul, fueling, liquid and solid waste disposal, water replenishment, and replacement of common items in living areas for visiting ships	3.5 – Docking Services	25
3.5 Minimum Requirements		
<i>Show provisioning and maintenance services including warehousing and loading systems</i>	3.5.3 – Vehicle Maintenance and Fueling	25
4.0 – Maintain the quality of life for residents by offering community attributes that citizens of Earth's small cities enjoy (e.g., comfortable homes, fine food, access to entertainment)	4.0 – Human Factors	27
4.0 – Assure that natural sunlight and views of space outside and Earth below the settlement are readily available	4.1 – Community Design Figure 4.1.1 - Interior of the Residential Torus	27
4.1 – Provide services that residents expect in comfortable modern communities (e.g., housing, education, entertainment, medical, parks, and recreation)	4.1 – Community Design	27
4.1 – Supply a variety and quantity of consumables and	4.1.9 - Consumables	29



other supplies		
4.1 – Provide public areas designed with open space and consideration of psychological factors (e.g. long lines of sight)	4.1 – Community Design 4.1.4 – Parks and Recreation	27, 28
4.1 – List major categories of consumables in particular estimate annual replenishment of clothing and paper and describe sources	4.1.9 – Consumables	29
4.1 – Depict or specify means of distributing consumables (including food) to residents	4.1.9 - Consumables	29
4.1 Minimum Requirements		
<i>Depict community design and locations of amenities with a distance scale</i>	Figure 4.1.2 – Community Layout of Columbiat	27
<i>Identify percentage of land area allocated to roads and paths</i>	4.1.4 – Parks and Recreation	28
4.2 – Provide designs of typical residential homes showing room sizes	4.2.1 - Housing Designs	29
4.2 – Offer residents differentiated neighborhoods to suit a variety of preferences of architecture and lifestyle	4.2.1 – Housing Designs	29
4.2 – Estimate numbers and sources of different types of furniture required for residential and office use	4.2.3 - Furniture	31
4.2 Minimum Requirements		
<i>External drawing and interior floor plan of at least four home designs with area (in sq feet) and required number</i>	4.2.1 – Housing Designs 4.2.2 - Demographics	29, 31
4.3 – Designs of systems, devices, and vehicles intended for use by humans outside of artificial gravity volumes that emphasize safety	4.3 – Safe Access in Micro-Gravity	31
4.3 – Provide means for safe access at/to any location in parts of the low gravity environments of the settlement, inside the hull, or on hull exterior surfaces	4.3 – Safe Access in Micro-Gravity	31
4.3 Minimum Requirements		
<i>Drawings showing examples of handrails, tethers, cages, and/or other systems enabling safe human access to any location on or in low-g environments</i>	Figure 4.3.1 – Personal Booster Engine Figure 4.3.2 – PIPES Figure 4.3.3 – EHTM Figure 4.3.4 – Micro-Gravity Observatories	31, 32
4.4 – Design spacesuits that will be required to work outside of pressurized settlement volumes	4.4 Spacesuit Designs	33
4.4 – Show stowage and donning/doffing procedures of spacesuit	4.4.3 – Donning Procedure 4.4.4 – Doffing Procedure	34
4.4 – Airlock designs for entering/exiting the settlement from unpressurized volumes will	4.4.1 – Airlocks	33



minimized the loss of air during operation		
4.4 Minimum Requirements		
<i>Drawings showing spacesuit and airlock operations with estimates of air volume lost during each cycle (i.e., on/off or in/out) of these systems</i>	4.4.1 Airlocks Figure 4.4.1 – Airlock Figure 4.4.2 – Spacesuit Figure 4.4.5 – Donning Procedure	33, 34
4.5– Show locations and designs of hotels or other accommodations for visitors	Figure 4.1.2 – Community Layout of Columbiat Figure 4.5.1 – Exterior and Interior Design of Hotel	27 35
4.5 – Describe security measures to unobtrusively monitor activities of visitors and assure that their activities do not interfere with the lives of permanent residents	4.5.4 – Security	35
4.5 – Provide capability for medical quarantine of visitors if necessary	4.5.1 – Medical Quarantine	34
4.5 Minimum Requirements		
<i>Chart or table listing anticipated security issues/situations and security responses to each situation</i>	Figure 4.5.2 – Table of Anticipated Security Issues and Responses	35
<i>Description of precesses to respond to unanticipated security issues</i>	4.5.4 - Security	35
5.0 – Specify number and types of computers, servers, software, network devices, and robots required for Columbiat's facility, community, and business operations	Figure 5.1.2 – Construction Robots Figure 5.2.1 – Maintenance and Server Automations 5.3.2 – OPC's Figure 5.3.3 – Residential Station Computers	38, 39, 41, 42,
5.0 – Include types and capacities of data storage media, data collection, data distribution, and user access to networks for in computer system descriptions	Figure 5.2.1 - Maintenance and Server Automations 5.3.2 – OPCs 5.3.6 – Access to Community Computing	39, 41, 43
5.0 – Show robot designs with dimensions and how they perform their tasks	5.0 Automation Design and Services	37
5.1 – Describe use of automation for construction	5.1.1 – Transportation 5.1.2 – Construction Automation 5.1.3 – Interior Finishing	37, 38
5.1 – Show automations use for transportation and delivery of materials and equipment, assembly of the	5.1.1 – Transportation 5.1.2 – Construction	37 38



settlement, and interior finishing	Automation 5.1.3 – Interior Finishing	
5.1 Minimum Requirements		
<i>Chart/table describing automated construction and assembly devices—exterior and interior applications-- and purposes for each</i>	Figure 5.1.2 – Construction Robots	38
5.2 – Specify automation systems for settlement maintenance, repair, and safety functions (backup systems and contingency plans for failures)	5.2.1 – QPM 5.2.2 – Maintenance, Safety, Repair, and Contingency Plans	39
5.2 – Define physical locations of computers, servers, and robots for critical functions	5.2.4 – Physical Locations of Computers and Robots	40
5.2 – Emergency external repair robots must survive and accomplish tasks during solar flare activity	5.2.5 – Robot Survivability in Solar Flare Activity	41
5.2 – Describe means for authorized personnel to access critical data and command robot and computer systems	5.2.3 – Personnel Access	40
5.2 – Describe security measures to assure only authorized personnel have access and only for authorized purposes	5.2.3 – Personnel Access	40
5.2 Minimum Requirements		
<i>Chart/table listing anticipated automation requirements for operation of settlement</i>	Figure 5.2.1 - Maintenance and Server Automations	39
<i>Identify computers and robots to meet each automation need</i>	Figure 5.2.1 - Maintenance and Server Automations	39
5.3 – Specify automation systems to enhance community living, productivity in work environments, and convenience in residences	5.3.1 – Livability in Community 5.3.2 – Productivity in Work Environments 5.3.3 – Convenience in Residences	41, 42
5.3 – Emphasize use of automation to perform maintenance and routine tasks and reduce need for manual labor	5.3.4 – Maintenance and Routine Tasks	42
5.3 – Provide privacy of personal data and control systems in private spaces	5.3.5 – Personal Privacy and System Control	43
5.3 – Describe access to community computing and the robot resources of individuals' home and work	5.3.6 – Community Computing and Robot Resources	43
5.3 Minimum Requirements		
<i>Drawings of robots and computers encountered in everyday life at Columbiat</i>	Figure 5.3.1 – Micro-Medical Sensors	41, 42,



	Figure 5.3.2 – OPC Figure 5.3.4 – Agricultural Robot Figure 5.3.5 – Iris Scanners	43
<i>Diagrams of networks and bandwidth requirements to enable computer connectivity</i>	Figure 5.3.6 – Network Diagram	43
5.4 – Cargo ships will require automated cargo handling systems, warehouses for temporary storage of goods and bulk materials and inventory management while they completely load/unload	5.4.1 – Cargo Tracking 5.4.2 – Cargo Handling System 5.4.3 – Cargo Warehousing	43
Account for anything moving in near-Earth space may transfer between vehicles at Columbiat	5.4.2 – Cargo Handling System 5.4.3 – Cargo Warehousing	43 44
5.4 Minimum Requirements		
<i>Illustrate/chart/matrix showing inventory management systems</i>	Figure 5.4.2 – Cargo-Tram Network	44
<i>Illustrate automated unloading/loading systems</i>	Figure 5.4.1 – Cargo- Tram Rails	44
5.5 – Provide maintenance and overhaul for robots from visiting ships which might be contaminated with dust from planetary, lunar, and asteroid environments	5.5.1 – Robot Maintenance and Overhaul 5.5.2 – Dust Decontamination	44
5.5 Minimum Requirements		
<i>Drawings of robot repair facilities including measures implemented to prevent the spread of contaminant dust</i>	Figure 5.5.1 – Robot Maintenance Facility Figure 5.5.2 – Dust Decontamination Chamber	44
6.0 – Include a schedule for completion and occupation of Columbiat	6.1 Schedule	46
6.0 – Include costs for design through construction phases of the schedule	6.2 Costs	47
6.1 – Describe contractor tasks from time of contract award until the customer assumes responsibility for operations of completed settlement	6.1 Schedule	46
6.1 – Show schedule dates when Foundation Society members may move into their new homes and when original population will be established in the community	6.1 Schedule	46
6.1 Minimum Requirements		
<i>List/chart/draw durations and completion dates of major design, construction, and occupation tasks</i>	6.1 Schedule	46
6.2 – Specify costs of Columbiat design through construction in US dollars without inflation	6.2 Costs	47
6.2 – Estimate numbers of employees working during	6.2 Costs	47



each phase of design and construction		
6.2 – Justifications for contract costs to design and build settlement	6.2 Costs	47
6.2 Minimum Requirements		
<i>Charts/tables listing separate costs associated with different phases of construction clearly showing total costs billed to Foundation Society</i>	6.2 Costs	47
7.0 – Columbiat's design must be sufficiently flexible to add compatible business types with little configuration change	7.0 - Business Requirements 7.2.1 - Commerce	49 49
7.0 – Provide opportunity to host a variety of commercial and industrial ventures which may change	7.0 – Business Requirements 7.3.3 – Small Business Development and Economic Integration 7.2.1 - Commerce	49 51 49
7.1 – Provide docking, warehousing, and cargo-handling capabilities to transfer freight between spacecraft	7.2.2 – Transportation Node and Port/ Provisioning	50
7.1 - Include cargo associated with large-scale lunar developments and industrial enterprises planned for Mars and the asteroids	7.2.2 – Transportation Node and Port/ Provision	50
7.1 – Provide terminal facilities to handle passenger traffic between Earth, Earth orbit destinations, the Moon, and other locations in the solar system	7.3.1 – Tourism in Customer Service Industries	51
7.1 – Anticipate that materials may be available within 15 years to enable adaptation of Columbiat to be the orbital terminus of a lunar Space Elevator	7.2.2 – Transportation Node and Port/ Provisioning	50
7.1 – Offer a wide variety of activities to visitors meaning rest and recreation options in a big city environment away from the confines of ships	7.3.1 – Tourism in Customer Service Industries	51
7.1 – Provide resorts, restaurants, theaters, and amusement parts for vacationers	7.3.1 – Tourism in Customer Service Industries	51
7.1 – Medical and quarantine services assure treatment and isolation of serious illnesses	7.3.1 – Tourism in Customer Service Industries	51
7.1 – Numbers of visitors in transit may temporarily reach 5000 when operations of settlements near and on Mars is initiated	7.3.1 – Tourism in Customer Service Industries	51
7.2 – Office facilities need to enable businesses to establish a presence in space	7.2.1 – Commerce	49
7.2 – Provide space for 4 companies with 150-person offices, 8 companies with 100-person offices, 15 companies with 30-person offices, and 30 with 5-	7.2.1 – Commerce	49



8.0 Compliance Matrix

person field offices		
7.2 – Provide facilities for offices of three banks that will service financial needs of space-based companies, residents and crews	7.2.1 – Commerce	49
7.2 – Offer suitable facilities for new Foundation Society headquarters for 300 people managing its business and investment empire researching new settlement opportunities and services to members	7.2.1 – Commerce	49
7.2 – Offer computing centers enabling secure networked internal communications for each company while providing interconnectivity for transferring data between companies	7.2.1 – Commerce	49
7.3 – Offer fueling services and storage facilities for hydrazine, nitrogen tetroxide, helium-3, and deuterium	7.2.2 – Transportation Node Port/ Provisioning	50
7.3 – Maintenance, cleaning, waste collection, and routine repair services for visiting ships	7.2.2 – Transportation Node Port/ Provisioning	50
7.3 – Show excess agricultural production, storage, and processing capability (beyond needs and requirements of residents) for replenishment of visiting ships and back-up supply in case of food crisis	7.2.2 – Transportation Node Port/ Provisioning	50



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