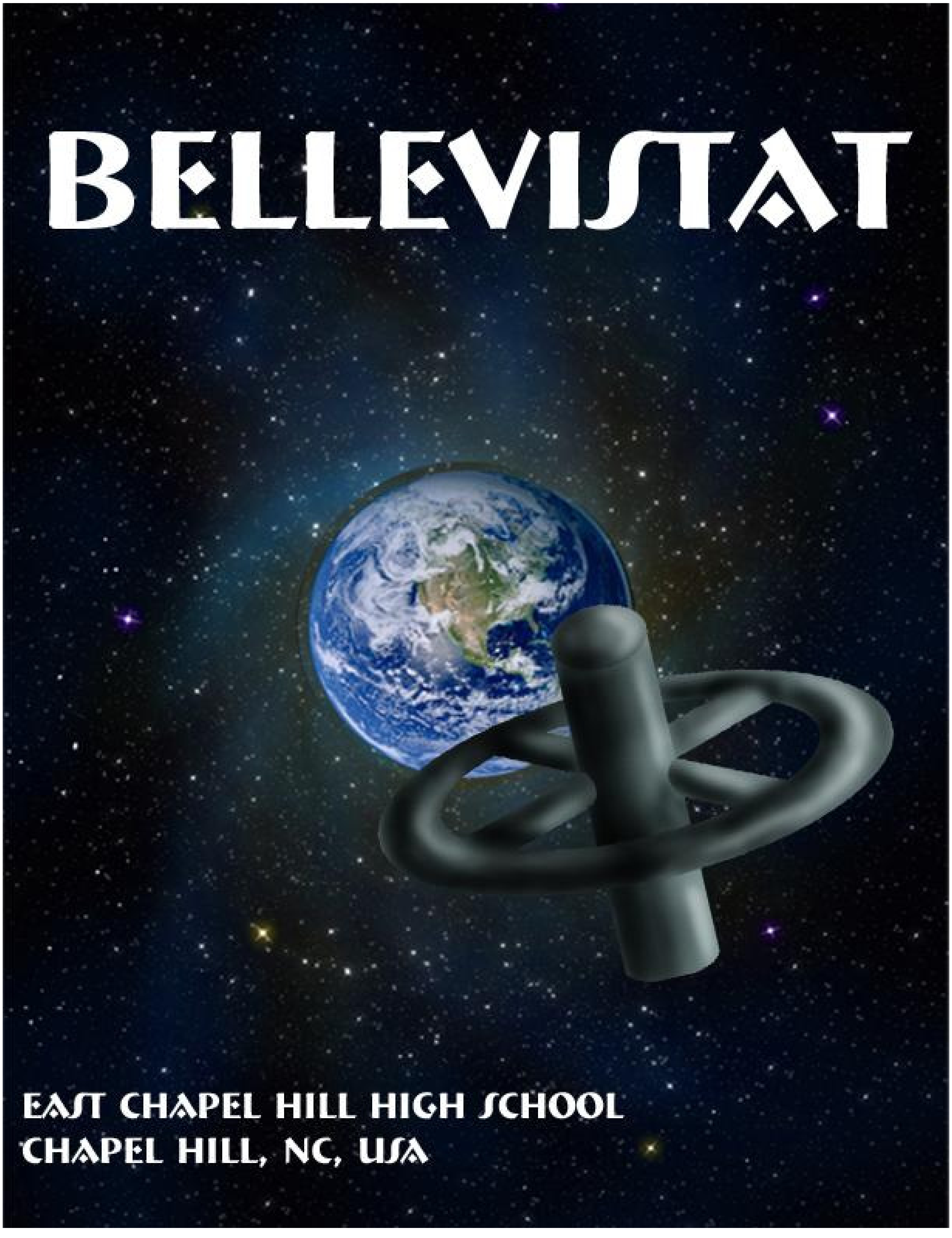

BELLEVISTAT
EAST CHAPEL HILL HIGH SCHOOL
CHAPEL HILL, NC, USA

Contents

1.0 Executive Summary

The Alexandriat station has enjoyed unprecedented success in technological innovation made possible by the unique environment it has created, wherein the top minds in science and engineering have been allowed to experiment for many cumulative hours in zero gravity and vacuum conditions. These innovations, including the invention of buckystructures, demand large-scale manufacturing to fully take advantage of the opportunity that they present humankind. The Alexandriat station was not designed for heavy industry, however, so it will be necessary to build another settlement in space for this purpose. Bellevistat will be that station. It will both provide a site for manufacturing and materials refining, and provide homes for a community of 11,000 permanent residents, as well as space for visitors.

The Bellevistat station will consist of one torus ring connected to a central cylinder by four spokes. Residents will live in the torus. Agriculture will be located in the spokes and in most of the cylinder. Manufacturing will also take place in the cylinder, where low gravity will allow manufacturing techniques not possible on Earth. The Bellevistat settlement will interface with the external world via a Receiving Station positioned in its immediate vicinity. All goods to be exported will be sent here from the station by space tug. Both transient visitors and imported goods will be offloaded to this station, where they will be quarantined until their sanitation is assured and then brought by tugs directly to the proper station. Space tugs may enter the settlement through the “top” of the cylinder, which may be airlocked and opened to allow the space tugs in. Bellevistat will be powered by nuclear energy, the fuel for which will be brought from Earth. Its agriculture and textiles are expected to be almost entirely self-sufficient

The design of the Bellevistat settlement incorporates several innovative and novel concepts which will make it function more efficiently. One such idea is the separate docking facility. Another is the use of aeroponic agriculture, which has been shown to grow plants faster, use less space, use less water, and have less disease than conventional agriculture or even normal hydroponic agriculture. Another innovation is the placement of residences beneath the one-gravity "ground surface" of the torus to create more space and also to prevent bone atrophy and other medical problems associated with prolonged exposure to low gravity.

Residents living on the Bellevistat settlement will enjoy a frugal but comfortable life with all necessities provided to them as well as the facilities for enjoyable recreational activities. True to its name, the settlement will provide beautiful views of Earth and of the starfield. Diverse facilities at different gravities will also be available for residents and wealthy tourists. The settlement will be small enough to make powered vehicles unnecessary for most transportation, so public bicycles will be provided to all residents. This will provide transportation but will also give residents a way to exercise and to enjoy themselves and will facilitate bonding within the Bellevistat community. Life aboard the settlement will be pleasant and each resident can enjoy the knowledge that they are helping humanity spread throughout the solar system.

2.0 Structural Design

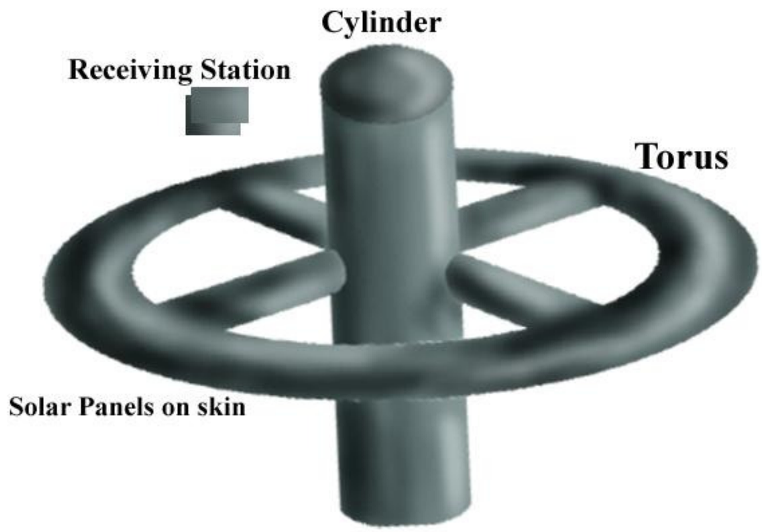


figure 2.0

The Bellevistat settlement will consist of one torus ring around a cylinder, connected by four spokes evenly spaced around the cylinder. The cylinder will contain a docking and take-off bay for inbound and outbound space vessels, as well as the facilities to manufacture buckystructures, and a nuclear reactor that is the principal power source of the settlement. The lower 73.5% of the cylinder will be devoted to aeroponic agriculture, and will provide for close to 79.4% of the settlement's dietary needs (the remainder will be made up by agriculture in the rest of the settlement). The spokes will serve as means for transportation between the torus and the cylinder, and will provide a space for aeroponic agriculture. Portions of the spokes at 0.8 and 0.5 gravity will also serve as recreational and habitation zones for colonists, in addition to the torus ring where most residents will live. Four rockets on the outside of the torus will constantly correct for orbital decay and rotational errors. Along with a nuclear reactor in the cylinder, solar panels on the outer skin of the torus will provide energy for the settlement. A layer of metal and ceramics will protect the settlement from radiation.

2.1 External Configuration

The shell (outer surface) will be protected by a layer of relatively small buckystructure plates (1 meter square, 1 cm thick), attached to a layer of plastics and a layer of 1 molar sodium chloride solution, which will be kept circulating to prevent freezing. Sodium chloride is used to create freezing point depression in the water. These three layers have a combined thickness of 5 centimeters. The buckystructure plates will serve to absorb the shock of micrometeorite impacts. Shattered plates will be replaced without damage to any neighboring plates, as needed, by a small fleet of repairing automatons. Plastics, and water, have been shown to block protons and alpha particles, which make up most radiation in space. Within this, there will be five centimeters of titanium which will support the structure of the settlement.

2.1.1 Volumes

Volume of Torus	$3.00^{*} \times 10^{6}$ m^3 ($1.06^{*} \times 10^{8}$ ft^3)
Volume of Torus allocated to [a]residential areas:	9.550×10^{5} m^3 ($3.37^{*} \times 10^{7}$ ft^3)
Volume of lower half of torus:	1.500×10^{6} m^3 (5.297×10^{7} ft^3)
Volume of lower half of torus devoted to habitation:	1.035×10^{6} m^3 (3.655×10^{7} ft^3)
Total Volume of Spokes:	1.332×10^{6} m^3 (4.704×10^{7} ft^3)
Volume per Spoke:	3.330×10^{5} m^3 (1.176×10^{7} ft^3)
Volume of Spokes devoted to 0.5 g human habitation:	2.513×10^{4} m^3 (8.876×10^{5} ft^3)
Volume of Spokes devoted to 0.8 g human habitation:	2.513×10^{4} m^3 (8.876×10^{5} ft^3)
Volume of Spokes devoted to aeroponics:	1.252×10^{6} m^3 (4.421×10^{7} ft^3)
Volume of [b]Central Cylinder	5.671×10^{6} m^3 (2.003×10^{8} ft^3)
Volume allocated to on-site docking and take-off (Division 1):	8.397×10^{5} m^3 (2.966×10^{7} ft^3)
Volume allocated to manufacturing (Division 2):	5.0894×10^{5} m^3 (1.797×10^{7} ft^3)
Volume allocated to aeroponic agriculture (Division 3):	4.168×10^{6} m^3 (1.472×10^{8} ft^3)
Total Volume of Receiving Station:	3.200×10^{4} m^3 (1.130×10^{6} ft^3)
Volume of Primary Cube of Receiving Station:	16000 m^3 (5.650×10^{5} ft^3)
Volume of Each Auxiliary Portion of Receiving Station:	4000 m^3 (1.413×10^{5} ft^3)

[a]This is in addition to housing space, which is located directly beneath the residential areas, as diagrammed below
[b]Discrepancies between volume of central cylinder and its subdivisions will be explained below

2.1.2 Dimensions

Outer radius, torus:	400.0 m (1.312×10^3 ft)
Inner radius, torus:	360.0 m (1.181×10^3 ft)
[a]Maximum height of human residential zone	15.00 m (49.21 ft)
Width of human floorspace:	40.00 m
Floorspace of torus residential areas:	9.550×10^4 m^2 (1.028×10^6 ft^2)
Cylinder radius:	95.00 m (311.7 ft)
Cylinder height:	200.0 m (656.2 ft)
Height of Division 1:	33.00 m (108.3 ft)
Height of Division 2:	20.00 m (6.562 ft)
Height of DIvision 3:	147.0 m (482.3 ft)
Length of spokes from torus to cylinder:	265.0 m (869.4 ft)
Spoke Radius:	20.00 m (65.61 ft)
Width of Elevator Shaft:	3.000 m (9.843 ft)
[b]Height of 0.5 g and 0.8 g human habitation zones	10.00 m (32.81 ft)
Edge Length of Receiving Station's Cube:	40.00 m (1.312 ft)
[c]# of Auxiliary Receiving Station Sections	4
Length of Auxiliary Sections:	40.00 m (1.312 ft)

[a]The human habitation zone of the torus is parabolic in shape due to a parabola's structural stability, the curve at its vertex which may be made to appear reminiscent of the sky, and the steep walls which still permit efficient space allocation.

[b]This is the height from the top of the human residency zone to its base, not relative to the torus, cylinder, or any external measure.

cTo be discussed in section 5.

2.1.3 Materials

Material	Quantity (metric tons)	Purpose	Source
Aluminum	300,000	Main skin of settlement	Moon
Titanium	280,000	Debris protection, settlement structure	Earth
Steel	320,000	Settlement structure	Earth, Alexandriat
Water	150,000	Radiation protection	Earth, Moon
Plastics, organic materials, other	50,000	Uses in settlement interior	Earth, Moon

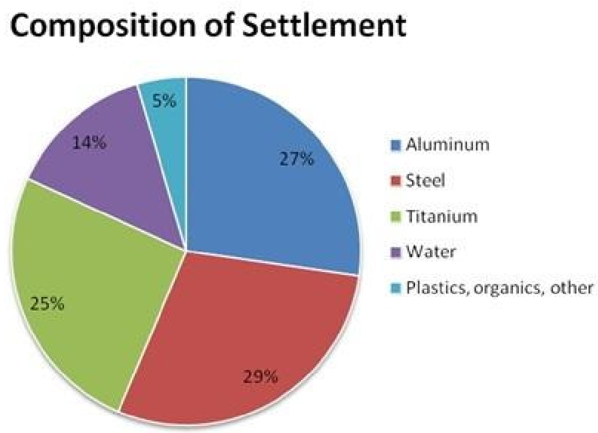


figure 2.13a

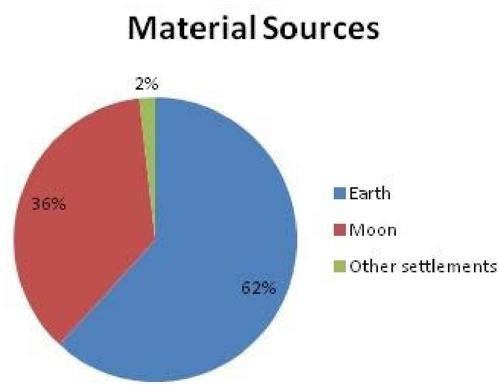


figure 2.13b

2.1.4 Artificial Gravity

Artificial gravity will be generated by rotating the settlement at a rate of 1.53 RPM, or 0.160 radians/second, so that gravity on ground level in the torus is 1 g.This number is calculated by the equation $a=\omega^2 r$, where a is the acceleration towards the center of mass necessary to maintain circular rotation in meters/second^2 (i.e. the perceived acceleration exerted by 'gravity' on people at a given distance r from the center of mass of the settlement), and ω is the angular velocity of the settlement in radians/second. ω*60 seconds/1 minute*1 revolution/2π radians=9.549 RPM*seconds/radian*ω. With r=380 m (the distance from the center of the cylinder to the floor of the torus), and a=9.8 m/s^2 (1 g), ω=0.1606 and the settlement rotates at a rate of 1.53 RPM.

Because housing is located below 'ground' level in the torus, people in their houses will be subjected to forces greater than 1 g, though no greater than 1.4 g. This will increase bone strength and will partially counteract the effects of living at lower than 1 g gravitational forces while in the cylinder and spokes of the settlement. Usefully, most of the time spent at above Earth gravity will be while the residents are sleeping and will not notice the greater effort associated with motion. Gravity in the spokes will vary by position. Recreational and residential areas and some residential areas will be placed in the spokes at positions giving 0.8 and 0.5 Earth gravity (304 m and 190 m, respectively). The cylinder will have 0.25 Earth gravity on its sides (which are the floor, relative to residents) and 0 gravity at its center.

2.1.4.1 Volumes in Low or Zero Gravity

Gravity in the central cylinder will range from 0.25 earth gravities (2.45 m/s^2) at the outer edges to zero gravity in the center. Low gravity in the cylinder will allow for more efficient manufacturing and for the production of buckystructures, as well as scientific experimentation. The power plant will be located on the inside wall of the cylinder where gravity will be strong enough to allow nuclear fission, directly adjacent to the manufacturing centers for buckystructures. Most of the settlement's food supply will come from aeroponic agriculture located in the lower part of the cylinder. Studies have shown that aeroponic crops produce higher yields in low gravity.

2.1.5 Pressurized/Unpressurized Areas

Almost all of the settlement except for the docking bays will be pressurized. Docking bays will be sealed off by air-locks. Four separate, parallel pneumatic systems will exist on the torus, one for each section, which may be air-locked against each other if necessary. Some portions of the torus used in storage or otherwise not typically inhabited by humans will be generally left depressurized. Pressure on the spokes will be held consistently at 0.8 atm, except that at both one of the 0.5 g human habitation sectors and one of the 0.8 g atmospheric sectors, they will instead be pressurized at 0.6 atm. The manufacturing core of the cylinder may be pumped to a vacuum if necessary for research or construction of exotic materials: in addition, the space above the 10 m of depth allocated to 0.25 g in the manufacturing portion of the cylinder will be kept as a constant vacuum so that no air turbulence disturbs the 0 g buckystructure manufacturuing area *(see section 2.4.1)*

2.1.6 Windows

Some translucent buckystructure windows will be placed in public areas from which colonists will be able to look out and see the Earth or the starfield. Windows are expected to be important for the psychological health of the colonists and can be used to combat problems such as claustrophobia, and boredom. The radiation-shielding properties and tensile strength of buckystructures makes them safe for use as material for windows.

2.2 Internal Arrangement

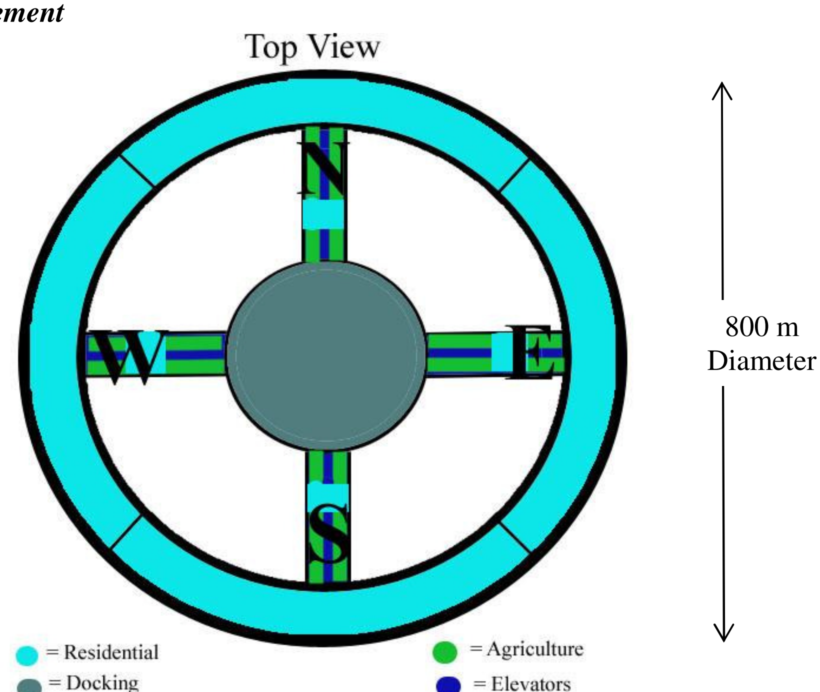


Figure 2.2a

Living spaces will be located almost entirely in the outer torus. Sufficient living space is provided in the torus alone for 11,000 permanent residents and 500 transient residents. On average, every four people will be provided with 120 m^2 of floorspace split over four stories “underground,” though a host of different residencies for different demographics (large families, small families, single workers, etc.) will be provided. Small areas in the spokes will also be available for limited numbers of people to inhabit: at maximum 575 people may comfortably live at 0.8 g, and another 575 people may live at 0.5 g. The cross-section of the torus ring will be divided in half, with the “ground,” at 1 g, in the center.

Though the ground will experience one earth gravity (9.8 m/s^2), most residences and public buildings will be underground where gravity will be slightly higher than one g. This will counteract low gravity exposure in the workplaces of most of the colonists. Infrastructure will be under residences, in secluded areas on the ground surface, or, in the case of plumbing, running along the “ceiling” of the torus, where lower gravity will cause less energy to be expended in transporting water. Most of the ground surface will be public parks where colonists can experience wide open, green spaces like on Earth. For specifying directions, spokes will be labeled with the cardinal directions, and the middle of the area between the spokes will be the “transition” between the cardinal directions.

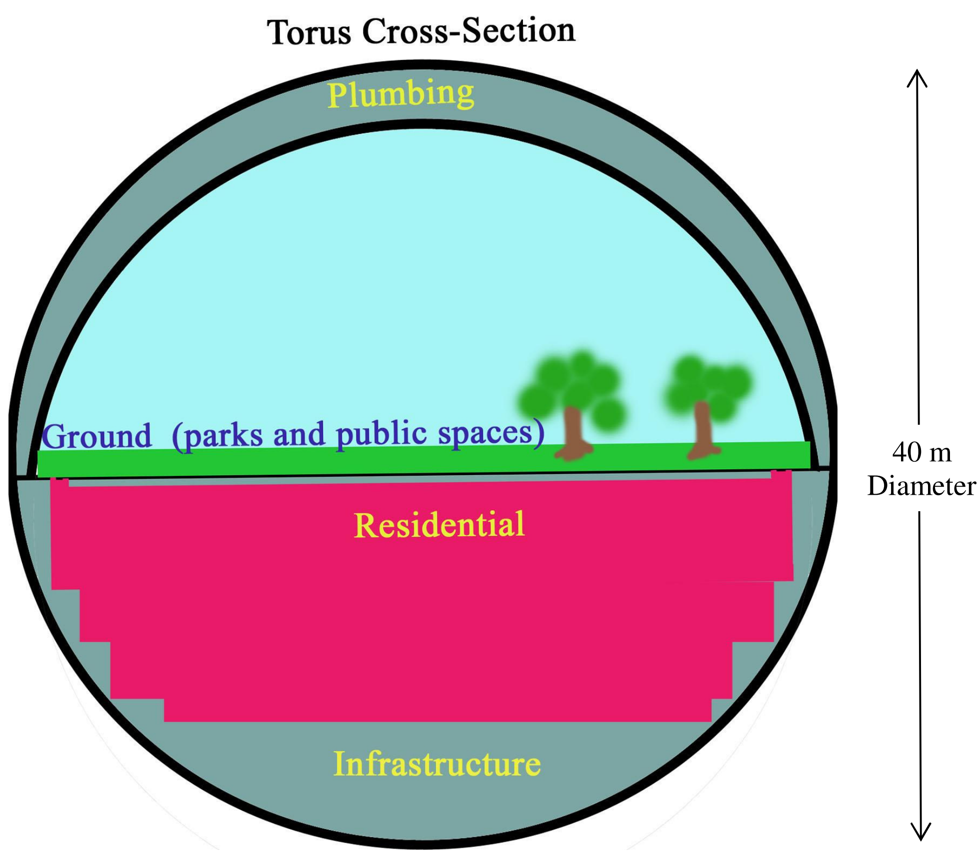


Figure 2.2b

The top section of the cylinder will consist of ports and technology for docking and repair services for incoming ships. The middle section will consist of the settlement’s factories and manufacturing centers. The bottom section will consist of the bulk of the settlement’s aeroponic agriculture. The low gravity of the central cylinder will aid in all of these functions.

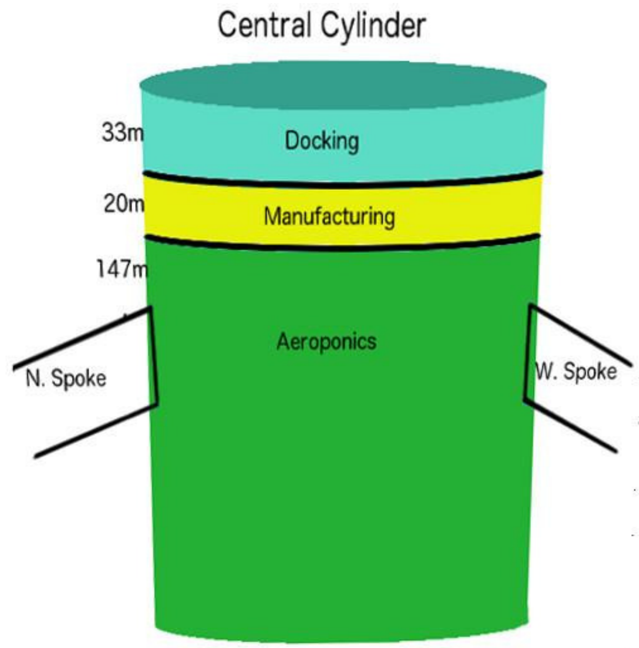


Figure 2.2c

2.3 Construction Sequence

Construction will begin on earth, where *Pangea*, a shuttle, will be constructed and launched into orbit. The nuclear reactor core will be stored in its cargo hold, and *Pangea* will fly to its permanent position in the L4 (lagrange point). A second, specially-designed craft, the *Nautilus* will also be launched into orbit, where it will attach itself to the *Pangea* to serve as a docking-bay and cargo hold for supplies.

A full/part-time crew will inhabit this small space station, the *Dorado* to supervise the installation of the rest of Bellevistat around the station, which will eventually become the reactor core. Materials from the moon will be flown to Alexandriat for processing and manufacturing, whereas materials from earth will be assembled "at Terra" and flown up to the main construction site.

Once the structure is complete and sealed, the atmosphere will be introduced via Water Electrolysis and evaporation of liquid nitrogen and carbon dioxide. Due to the initial volatile atmosphere, Bellevistat will be vacated until all the excess hydrogen is filtered from the atmosphere and stored in secure containers for emergency fuel.

The internal infrastructure will then begin to be constructed. Residential and their corresponding districts will be completed one at a time, so residents can begin to arrive as soon as possible to begin work and assist the construction of the rest of the station. In this manner, Bellevistat will become a reality.

2.4 Location of Buckystructure Production

Buckystructure production will be located in the central cylinder in the center where gravity will be very close to zero. At the surface of the cylinder, gravity is at 0.25 g, and this will be where "high" gravity buckystructures will be manufactured, with facilities extending from cylinder "ground" to 10 m of altitude: that is, it forms a hollow cylinder of inner radius 85 m, and an outer radius of 95 m. Built atop this are the facilities to facilitate 0 g manufacturing.

2.4.1 Buckystructure Manufacturing at 0 g

Immediately within (or above) the 0.25 g manufacturing sector, closer to the center of the cylinder, there are a series of three 2 m wide cylinders: the first one has an outer radius 83 m and inner radius 81 m, the second has an outer radius of 81 m and an inner radius of 79 m, and the third has an outer radius of 79 m and an inner radius of 77 m. Each cylinder is being spun in the opposite direction of the larger

Bellevistat settlement by the cylinder before it, at 0.38 RPM, so that gravity drops quickly from 2.2 g, outside of any spinning cylinder, to 1.2 g, to 0.52 g, to 0.13 g. Inside of the third hollow cylinder, there is another cylinder, also being spun at 0.38 RPM relative to the cylinder encircling it: this cylinder, of a radius of 77 m, is filled, however, with 0 gravity buckystructure manufacturing facilities and instruments and laboratories to experiment in 0 g. Transition between cylinders is made in an elevator, which moves between layers over time intervals determined by a simple computer. There are four elevators of this sort, positioned an even distance radially from one another.

2.5 Port Facilities

In addition to docking on the cylinder, there will be a port station separate from the main body of the settlement and orbiting around it. This port station will be cube-shaped and will be known as the Receiving Station. (figure 2.5.2). It will provide both a quarantining zone between Bellevistat and the rest of the world and a more convenient shipping interface.

2.5.1 On Station

Docking will take place at ports located at one end of the central cylinder where high gravity will not interfere with the docking procedure (figure 2.2c). The docking will be accomplished by the tugs using their primary grabbers around a nipple. A swim tube will be extended to the hatch, pressurized, and people will be able to get in and out of the ship. Goods will be placed in the space tugs at the Receiving Station.

2.5.2 External Structures

The Receiving Station cube, largely composed of the same materials as the Bellevistat settlement, will be in orbit parallel to the to the main Bellevistat position, kept between 1 and 3 km at all times by small thrusters located at each of its four corners. It will possess five primary sections.

Part A of the Receiving Station will be capable of opening up on one side. It will typically be kept empty of air to prevent pressure imbalances but may be pressurized to 0.5 atm if necessary, as when it is used to house all settlers brought up before hydrolysis on the Bellevistat station begins. Part A will be an unloading platform for particularly large shipments of cargo from Earth. When used in this capacity, part A will be depressurized, the ship will be flown in, but will typically be used only to provide a skeleton and structural support for the other four parts of the receiving station.

Part B is a simultaneous quarantine zone and first view of Bellevistat for visitors from Earth, Alexandriat, or the moon. Visitors progress through four zones, of different sizes (not shown), marked by different levels of sterilization, each of which has windows onto Bellevistat made of transparent buckystructures. The first level is completely unsterilized; entry to the second level demands passing through a voluntary washing facility (water is steamed and reused) and getting a complete change of clothes; the third level contains simple housing facilities suitable for a few days' wait, as well as a small, rotating team of doctors who are qualified to ascertain the health of the hopeful visitors; the fourth and level adds electromagnetic and chemical sterilization, after which visitors can board the space tugs in section B and head to the Bellevistat station.

Part C provides a preliminary refinery for any materials harvested from the moon, or potentially in the future from asteroids as well. Processes such as smelting, distillation, and some pyro-processing can occur here, and three centrifuges are located on-site as well.

Part D is divided into two sections (not shown): the larger section is a pneumatic pump leading into flexible buckystructure "pipes," which have the capacity to store the collective air of the entire Receiving Station. The second part of Part D is fuel storage, which contains fuels processed from methane *(see section 3.9)* and hydrogen from hydrolysis. This can be used for refueling ships to be sent back to Earth, and for the mini-thrusters that keep the cube oriented and positioned properly relative to the main Bellevistat station.

Part E will provide a second place for incoming or outgoing ships to dock: because it is only a fourth of the size of part A, and is in turn divided into four smaller compartments, it will be easy to pressurize and depressurize.

The first and third compartments are typically empty and may be opened to allow small shops from beyond Bellevistat to dock, unload, and then take off again. They are sterilized by repeated exposure to outer space. The second and fourth sections are equipped with state-of-the art facilities for ship repair and restoration, as necessary.

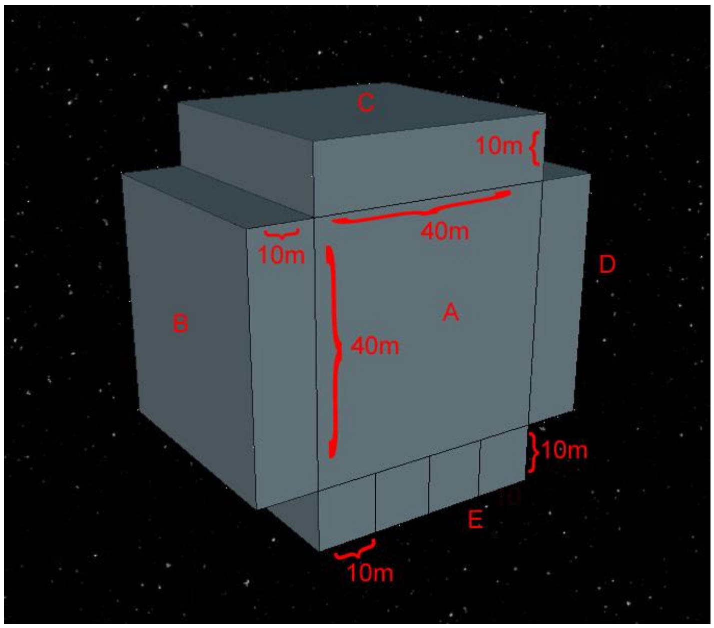


Figure 2.5.2

3.0 Operations and Infrastructure

As with any effective program, colony, or organization in history, logistics is everything. Materials need transportation, food needs to be distributed, facilities must be provided, the environment needs to be maintained, and people need to be paid. This section deals with all of the fine-print work that consists holds the station together and makes life possible for those onboard. Rome was not built in a day, and neither will Bellevistat.

3.1 Construction

For the most part, construction will be made done by a full-time work crew of about twenty men, who will live in the *NS Pangea* (later on known as *RV Dorado*), and will be in charge of operating robotic workers who while assemble the station around the reactor core, which will not be on at the time (power for *RV Dorado* will be completely solar as the crew would be dangerously close to the reactor core). The only time the station will be vacated is during the Water Electrolysis Process. Once the atmosphere is stable and safe for human life, the core will be powered on and a larger construction force of five hundred men will arrive to begin building up the interior of the station, one section at a time. Once a section is complete, colonists will arrive to begin living and working in the station, or possibly further speeding along the construction process.

3.1.1 Orbital Location

Bellevistat will be located at the fourth Lagrange point (L4), as this is a stable point in Earth orbit with access to both the Earth and the Moon. Unlike the first, second, and third Lagrange points, the fourth and fifth points are stable equilibria and an object which is disturbed will be forced into a stable orbit around the point. This makes it the ideal location for a settlement in orbit around the Earth.

3.1.1.1 Orbitiatal Orientation

The Bellevisat settlement will be oriented with the cylinder 10° towards L1. This permits the viewing platforms in the 0.5 g and 0.8 g residential areas to give views of the Earth and the Moon rotating around an invisible central point partially between the Earth and the Moon at a rate of one rotation/39 seconds. By moving to the opposite side of the spoke, one may view the Sun through heavily polarized buckystructures in similar orientation.

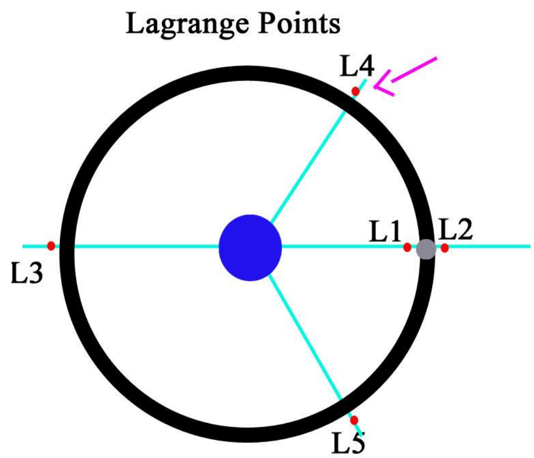


Figure 3.1.1.1

3.1.2 Materials Sources

All materials will come from either the Earth or the Moon. Materials from the Earth, such as organic materials and steel, will be shipped into orbit during the initial construction and any time in the future if the settlement is expanded. Materials from the moon will be collected through strip-mining and processed on-site by a materials processing facility established before initial construction.

3.1.2.1 Transportation and Storage

Materials from the Earth will be shipped on regular shuttles each carrying 4500 kg and arriving every two weeks until the settlement is complete. Materials from the Moon will be launched from the surface by a mass-driver, collected in lunar orbit by an orbiting collection pod, and then transferred to a shuttle which will bring the refined materials to the settlement.

3.2 Community Infrastructure

3.2.1 Atmosphere and Weather Control

The partial pressures of the gases in the artificial atmosphere are as follows: 20.43kPa Oxygen (at 90% pressure of earth's atmosphere), 0.36 kPa Carbon Dioxide and the rest of the pressure will be achieved through nitrogen gas. A predicted amount of 2.70×10^6 liters of water will be electrified to generate the necessary oxygen, and 1.03×10^7 liters of liquid Nitrogen will be evaporated for the atmosphere as well. Carbon dioxide will be produced by the crew and stabilized by the plants, however, before human habitation can begin, approximately 2.87×10^9 of Hydrogen Gas will have to be filtered from the atmosphere for safety reasons. This gas will be stored in very secure containers to be used as emergency fuel. A predicted humidity will be regulated at low levels to prevent natural condensation and precipitation from occurring. Water will be collected from dehumidifiers throughout the settlement and used for drinking.

3.2.2 Food Production

To avoid the prohibitive costs of meat production, the Bellevisat station will be completely vegetarian. To prevent protein deficiency, legumes, chiefly beans, will be a staple part of colonists' diet. Assorted tubers will be staple in colonist diet (i.e. potatoes, yams, cassava, etc.) Crops will be grown by aeroponics to reduce waste, conserve water, and cut down on necessary materials. Lower gravity (even 0 g) has been shown to cause these aeroponic plants to grow better than plants on earth. Crop yields are expected to be 30% higher because of aeroponics. However, space has been allocated to food production on the assumption that production rates will match Earth efficiency. Yields in excess of necessary production can be stored in the lower section of the torus, and agriculture space can be reallocated to grow flax, cotton and hemp so that the Bellevisat settlement can be self-sufficient in its textiles.

A diverse array of crops will be grown; rice and beans will be the most common, but some wheat and plots of fruits and vegetables will also be grown. Bees will be kept to help with pollination and provide honey; bees pollinate ⅓ of the food on American tables, and hand pollination is not nearly so efficient. Honey bees are known to have very resilient circadian rhythms that evolve to suit their environments. The floor will be consistently cleaned of dead bees by automated robots.

3.2.2.1 Food Harvesting

Spokes will be split into 3 m (9.8 ft) high sections that will be independently accessible via the elevator hemispheres. Each section will be organized according to the diagram below with aluminum latticework for walls, on which the crops will grow. Crops will be fed by nutrient solutions that will be sprayed directly on them by pneumatically powered spray bottles, every four hours. The tubers and plants grown will be observed by simple visual sensors which note contrast in colors, interfaced with a simple logic circuit. When the tubers grow large enough, either by virtue of being healthy and ripe, or overgrown and moldy, a light will turn on next to the crop. These lights and sensor interfaces will be placed at 0.304 meter (1.00 foot) intervals in a grid along the wall). Aeroponic growth cycles are four months long, and these cycles will be staggered for different crops so that fresh crops can be harvested every day.

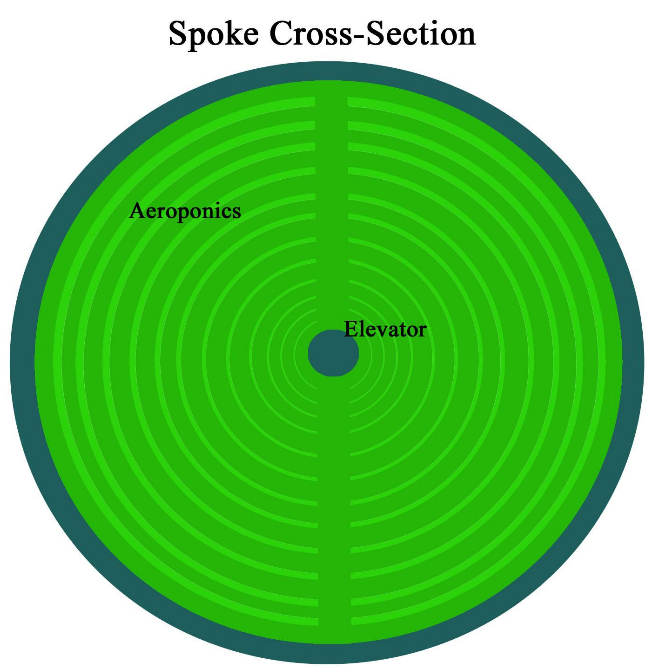


Figure 3.2.2.1 The radial lines represent the aluminum lattices on which crops will be grown. The spaces in between are halls where people will walk to harvest the crops.

Each person in the settlement will be expected to harvest 160 tubers or the equivalent, from the illuminated plants, during their one free day each week. This will require under an hour of work. If that day is inconvenient for them, informal arrangements for one resident to harvest on behalf of another can be made.

3.2.2.2 Food Distribution and Storage

The majority of the crops will be canned (aluminum cans will be recycled) and stored in warehouses present in every residential zone. What is not canned will be freeze-dried and stored in a vacuum-filled chamber for emergency use. Food will be distributed based on a credit system wherein each resident will be given a certain number of credits able to be exchanged for food or other products based on the health needs of the resident.

3.2.3 Electrical Power Generation

Solar panels will be assembled in space prior to main settlement assembly, and used as a power source to get basic framework assembled and fission power generation online in the central sphere. At this point, fission power will become the main energy source for the industrial processes and agriculture of the station, and solar panels will be affixed to the outside of the station as a power supply for life support in an emergency.

3.2.3.1 Power Distribution

Power Distribution will be simple because there will be one power source in the center of the plant--the fission reactor--and another power source on the outside of the plant--the solar panels. Ideally, significant interchange of power on the inside and the outside should be negligible, because most of the power will be consumed in industrial processes near the center of the plant and agriculture, which is also near the center of the plant. Life support will be run off of solar panels under normal conditions.

3.2.4 Water Management

All water on the station will be divided into three closed circuits. Some water will be used in the main reactor, some will be used in the agricultural zones and the rest will be used for domestic functions. If there is a shortage in any of the three circuits, water will be diverted to it from other circuits in the following order of preference.

1) Reactor
2) Residential
3) Agriculture

3.2.4.1 Storage

Water travels in continuous circuits throughout the station. An emergency reservoir containing 120,000 liters of water will be placed in each residential area of the station, and water will be drawn from them in emergency situations.

3.2.5 Household and Industrial Solid Waste Management

Nuclear waste from the reactor will be vented (away from Earth) out into space along with any potentially hazardous waste. Organic Waste will be filtered from the water supply, recycled into nutrient solution for the plants or processes, and used as fertilizer in parks. Waste water will be filtered thoroughly and reused. Garbage and other non-compostable waste will be recycled. All waste will thus be reused. Worms will be kept to aid with decomposition.

Compost will be placed in the Agricultural sections as fertilizer.Disposal bins will be available at all times in recreational areas, with different bins for different materials. Every “day” at 0600, it will be collected and transported to the recycling center, positioned in the center of the station by the main reactor core. The raw materials will then be sent back to the industrial areas of the station for reuse.

3.2.6 Communication Systems

Much of the communication (internal and external) can be achieved via the Internet. All residents will have access to handheld communication devices similar to the current iPad and will be able to have complete communication with every non-encrypted, human-built computer in existence.

3.2.6.1 Internal Communications

In addition to the handheld devices, a wireless mesh system will be installed for quicker communication between workers, much like walkie-talkies. Station records will be kept on the main computer, known as Anahita, named after the Persian Goddess of Knowledge. Time delays will be insignificant due to the small size of the settlement.

3.2.6.2 External Communications

External communications will primarily be via radio. Data can also be transmitted via internet under some circumstances. The settlement will be in perpetual radio contact with Earth at all times to keep Earth aware of Bellevistat's operations and ensure that Earth can send help as quickly as possible in the case of an emergency. Residents will also be able to send messages to friends and relatives that they left behind.

3.2.7 Internal Transportation Systems

The majority of people will travel throughout the outer rings by walking or using man-powered vehicles like bicycles. Some operations such as moving large equipment will require other vehicles, so a small amount of buses, trucks, and vans will be used by the settlement, all powered by electric motors. Emergency vehicles will be needed as well, so a small fleet of combined ambulance-fire truck vehicles will be present as well throughout the torus.

Inside the spokes, connecting the rings and central cylinder there will be two continuously moving conveyor belt-like structures (Fig. 8), one moving towards the center and one moving outwards. For transport along the spokes, people and items of transport will enter pods which will then be mechanically attached to the belts and then detached at the chosen destination. If no pods are moving along the belts, the belts will stop to conserve energy.

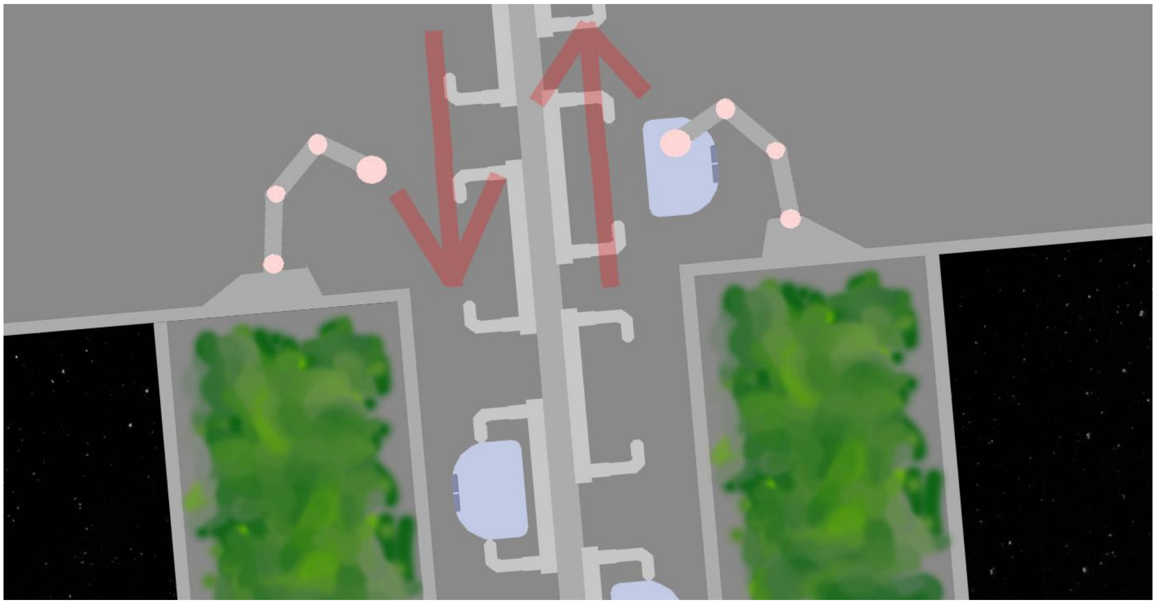


Figure 8

3.2.7.1 Routes

Transportation will primarily be on foot. However buses and bikes will also be used. There are also emergency vehicles to transport people to hospitals and carry a small volunteer policing force. Travel between the torus and the central cylinder will consist of the "conveyor belt" method *(see figure 8, above)*.

3.2.8 Day/Night Cycle Provisions

Since people do not function well at constant light levels, we will cycle through light cycles with a period of 24.2 hours, to align with natural circadian rhythms. Within the outer ring, where humans live, light is provided by fluorescent T5 tubes composed of a flexible polymer. The ventilation shafts will be placed immediately around and behind the T5 tubes in case of rupture, but this is merely a precaution.

3.2.9 Waste Management

Waste management is primarily about sewage treatment. Solids will be filtered out with three filters. Some remaining effluent solids is sprayed onto rock and block filter beds, which has a variety of microbes. The suspended effluent solids are broken down by the microbes with vigorous aeration. The remaining water will be treated to become drinking water. Since the water does not contain industrial or chemical pollutants such as heavy metals or motor oil, it can become drinking water easily. The water goes through desalination, disinfection, and chlorination etc. to become drinking water. The activated sludge will become land fertilizer. The methane given off during the process will be cooled and made into rocket fuel.

3.3 Space Infrastructure

Cargo will be shipped to Bellevistat via transport ships similar to the one shown in the diagram below:

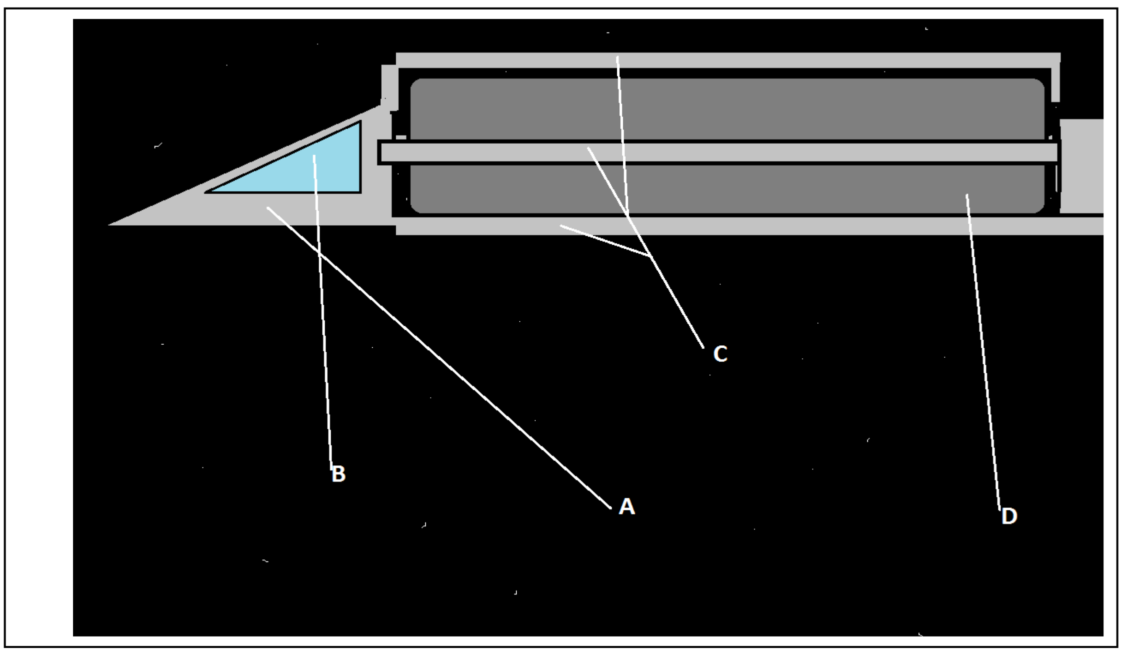


Figure 9

A. Main Cabin, the only pressurized part of the ship.
B. Bridge
C. Latches for securing cargo
D. Cargo
E. Thrusters

HLV Behemoth

3.3.1 On-Orbit Infrastructure

3.3.1.1 Vehicles

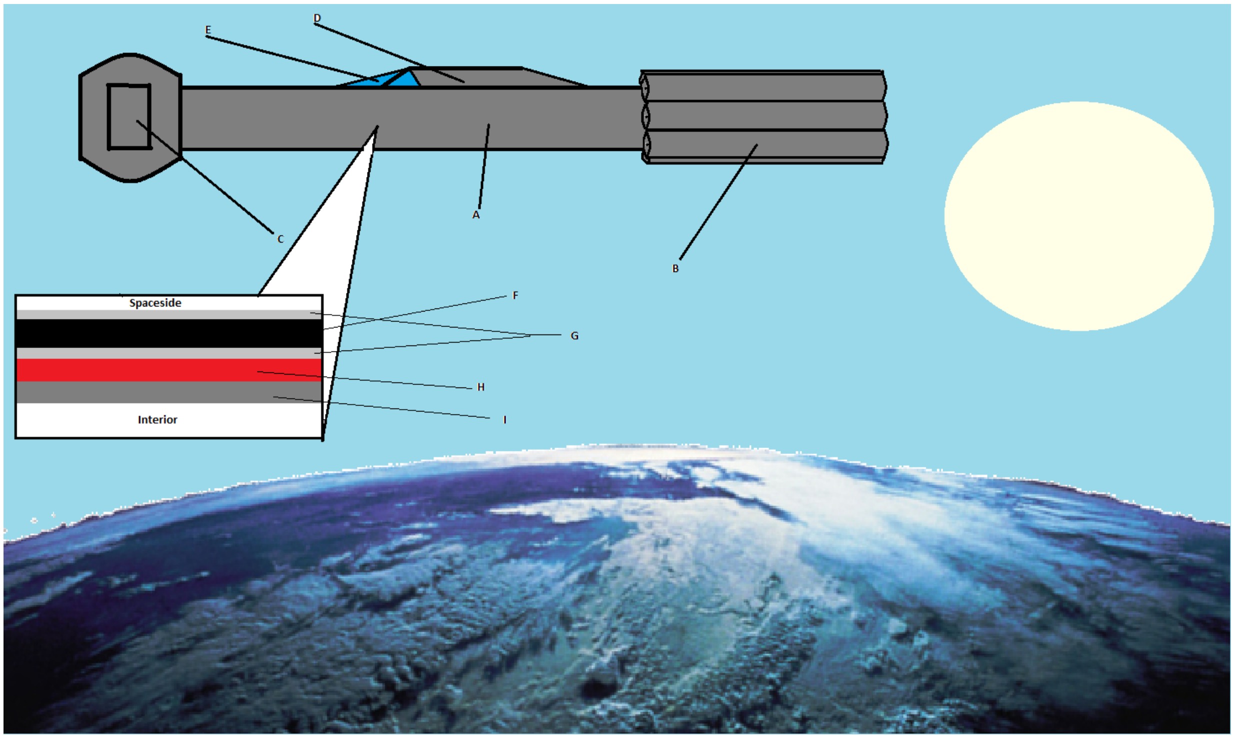


Figure 3.3.1.1a

RV Argo II

A. Passenger Section, contains everything needed for 200 passengers to survive the 2 day trip to the station.
B. Thrusters
C. Airlock (mirrored on the starboard)
D. Main bridge
E. Plasma-Glass Windows for visual navigation
F. Lead (For radiation shielding) about 3 in thick. This may seem unrealistic and unnecessary for radiation protection, and water and plastics would probably work just fine protecting the crew from protons, but the shuttles will be used more than once, and prolonged exposure to potential radiation poses a risk that should not be taken at the expense of the lives of the passengers on board the craft. The passengers on board need to receive as many safety precautions as possible.
G. Aluminum Plating (also for radiation shielding) about 1 in thick
H. Thermal Insulation Pads (Similar to that used on Space Shuttles)
I. Interior Paneling

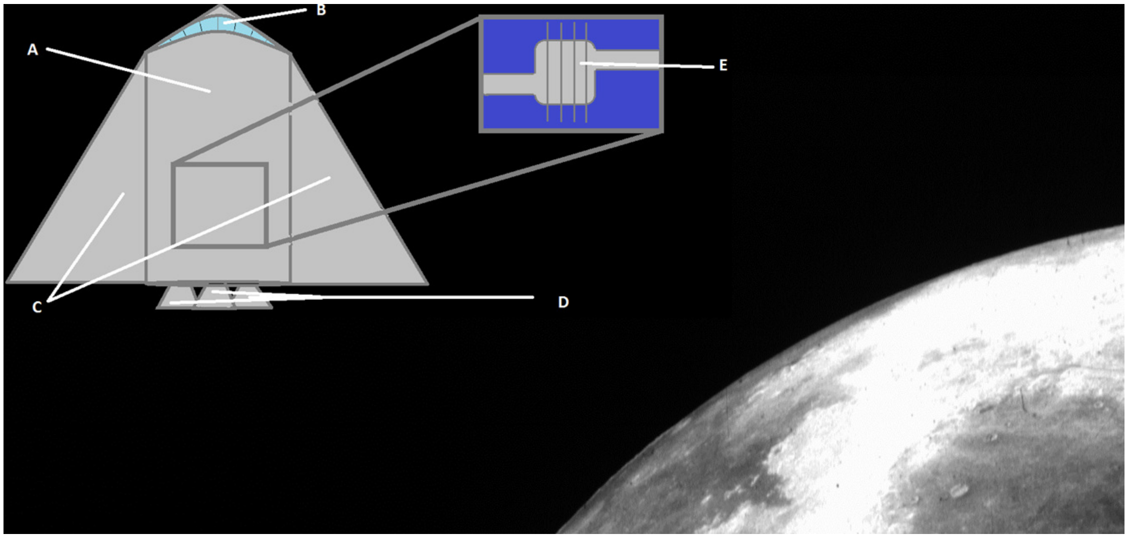


Figure 3.3.1.1b

NS Pangea
A. Main Body (Radiation Shielding similar to that of RV Argo II)
B. Bridge (With Plasma Glass Windows)
C. Main Body stabilizers (will be detached once in orbit)
D. Main Thrusters
E. Reactor Core (for future Bellevistat)

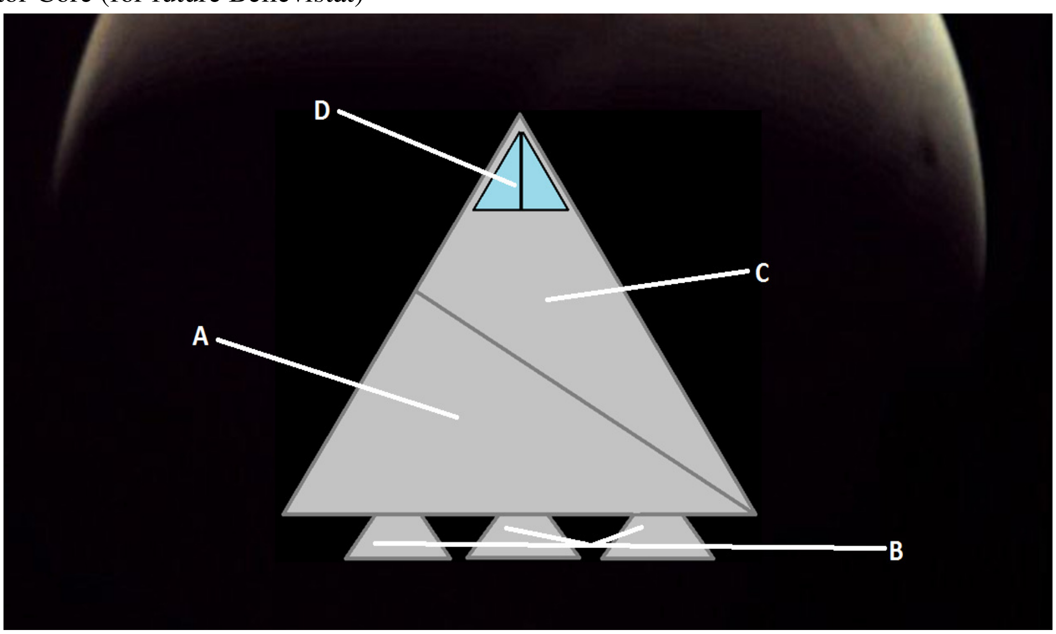


Figure 3.3.1c (On next page)

HLV Nautilus
A. Main Body I: Engine Block (will detach from craft upon arrival at *NS Pangea*)
B. Thrusters (will detach with Engine Block)
C. Main Body II: Future Docking Bay for *RV Dorado*
D. Bridge (standard plasma glass and radiation shielding)

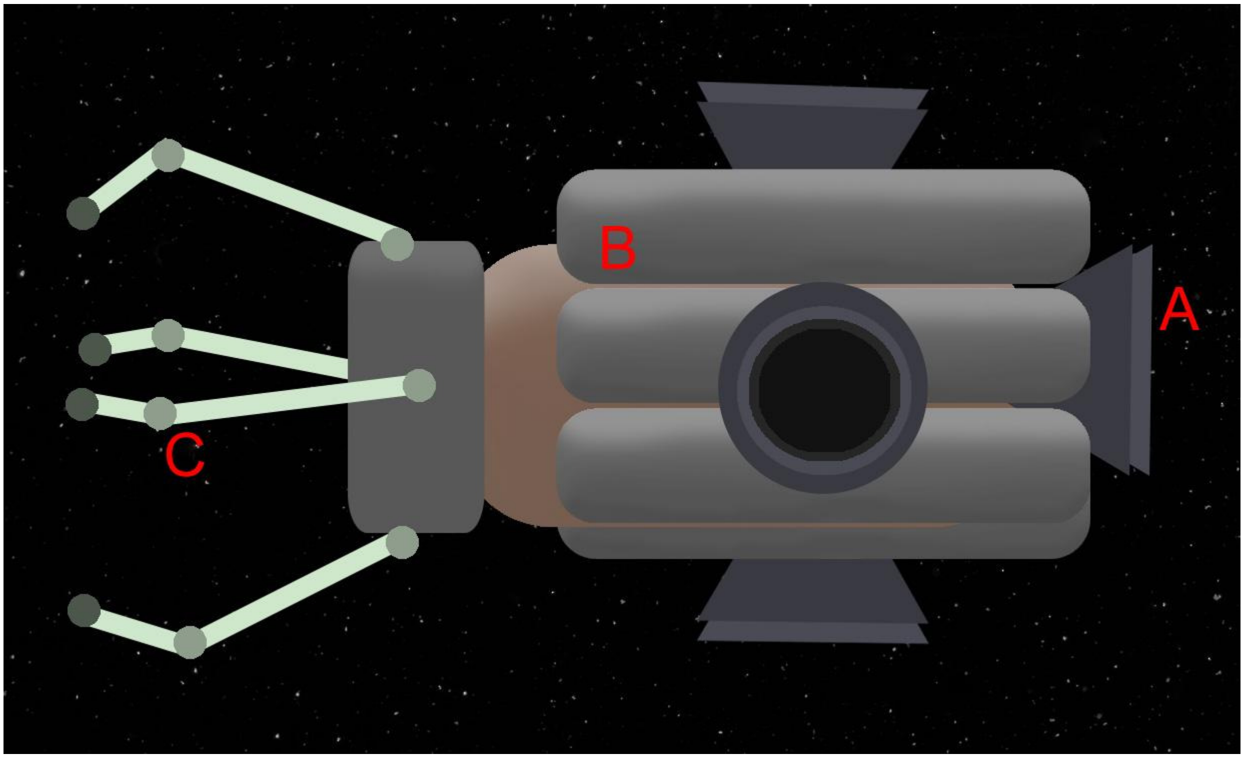


Figure 3.3.1.1d

PSV 917-4-K "Ye Ol' Deathtrap"

A. Main Thrusters for navigation through difficult maneuvers.

B. Fuel Cells

C. Robotic Arms ("grippers") for interface with station and payloads.

Usage:

Ten of these "Space Tugs" will be operated by the settlement. These high-thrust low-speed vehicles which move payloads of various shapes and sizes around the settlement, such as containers of incoming materials or people coming to and from the receiving station. Visitors will be transported to the receiving station around the settlement by space shuttle, and to the settlement by this space tug.

3.4 Paper Supply

Paper conventionally used for hygienics, such as toilet paper and tissues, will be replaced with reuseable cloth. Other types of paper will be manufactured from plastics produced from bacterial sources, which will be housed in the agricultural sector of the torus. Most writing supply will be digital.

3.5 Visiting Ship Repair

Visiting Ships that require repair work will be held in the main station's docking bay. After the problem is diagnosed, any damaged equipment will be stripped of the ship via robotic vessels and taken inside the station. After repairs are done, the part(s) will be taken back out to the ship where they will be reattached *(see section 7.3).*

4.0 Human Factors

4.1 Community Services

4.1.1 Residential Neighbourhoods and Housing

There will be one large residential neighbourhood in each community block and one community block for each sector of the settlement. The residential buildings will range from city-sized apartments to condominiums; however, the home designs will vary according to household size. All houses will be attached by halls. All residences in the torus will be “underground” beneath the one-gravity surface.

4.1.2 Entertainment

Community blocks will be made up of housing areas, parks, recreation areas, schools, shopping centers, health centers and emergency centers, and other public facilities like restaurants and cafes. Recreation facilities will vary by sector and will include athletic centers or gyms, dance clubs, video game clubs, cinemas, and art studios. Sectors will have different central entertainment focuses, although people may freely move between sectors or partake in various activities. All facilities will be run by members of the settlement community. Everyone will have access to the settlement’s internet. This would provide an opportunity for people to download movies, access social network sites, and connect with each other through *Spacebook*, a social networking site designed exclusively for residents on this settlement.

4.1.3 Medical Care

There will be one major hospital on the torus which will include an emergency room. Ambulances powered by electric motors will transport people there if they are too sick to walk or bike. There will also be multiple clinics scattered throughout the station for simpler procedures. Some of these will also have dental and optometric places as well as pharmacies. Surgeon robots will be present on the settlement if major operations are necessary, but human part-time doctors will deal with most medical problems.

4.1.4 Parks and Recreation

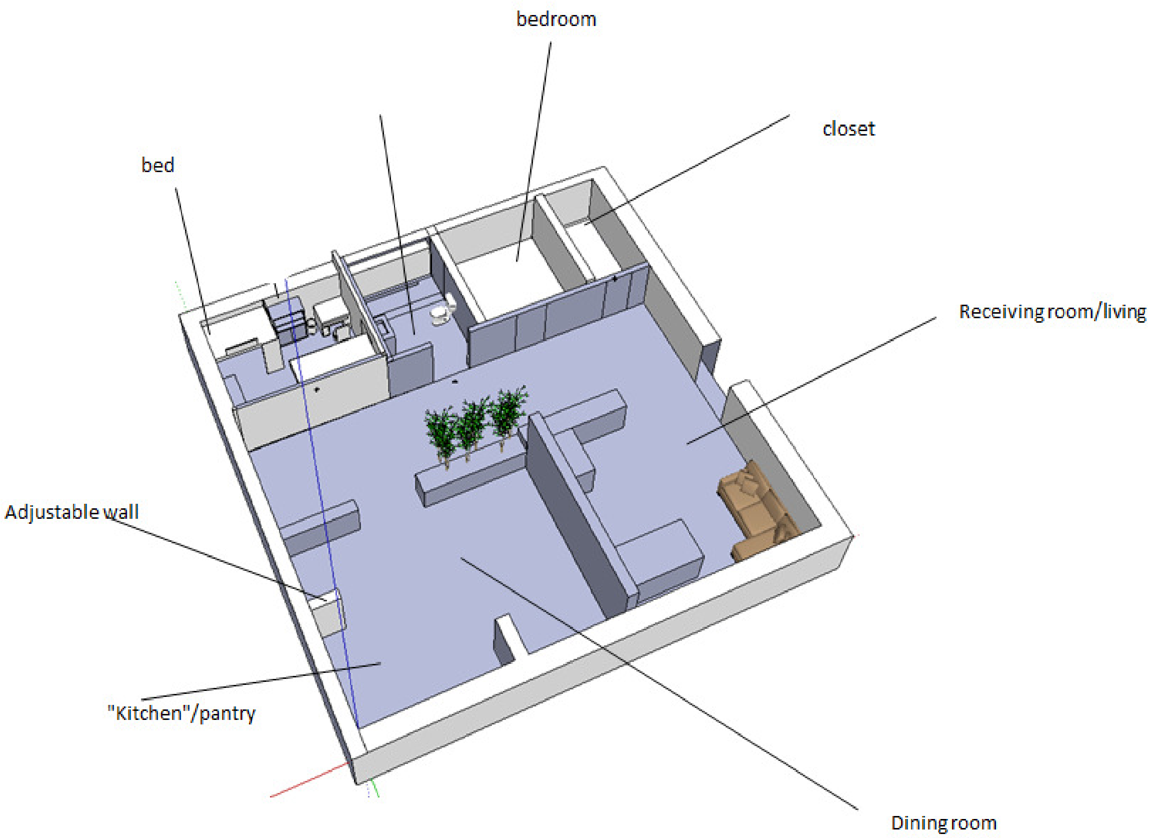
The only difference between community blocks would be their variation in respect to their recreational opportunities. Parks would include trees and other types of plants. There would be one playground for children. Community blocks will contain underground parks which will have gardens and playgrounds. Much of the surface will also be open fields or arboretums where residents can feel most “outside”.

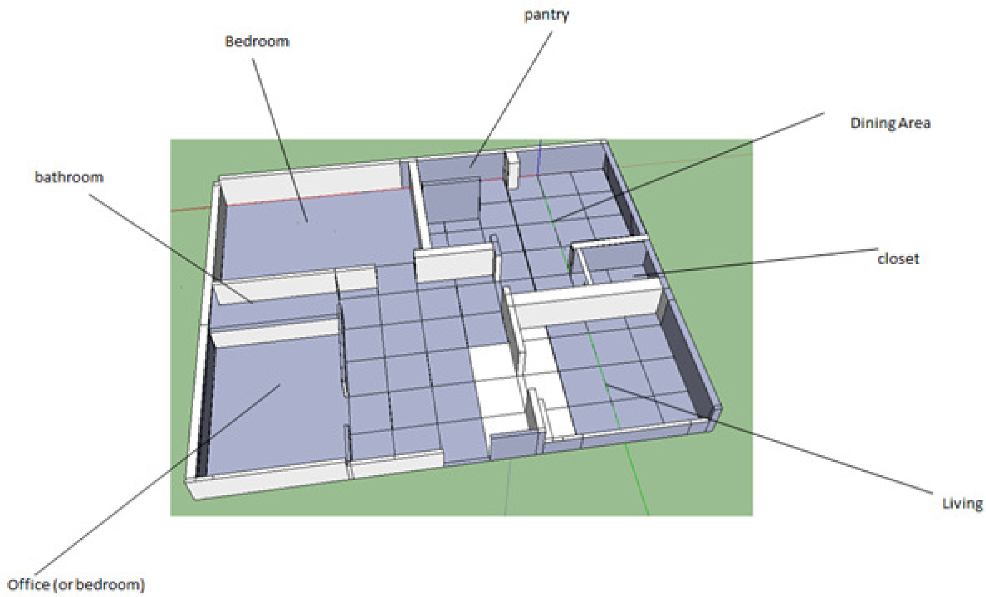
4.1.5 Distribution of Consumables

The distribution of consumables (including food, clothing, and personal items) will be implemented based on a credit system. Wherein the amount of credits for consumables are given to residents based on demographic factors such as age, gender, and health conditions, as well as on the basis of productivity. Identification for credit distribution will be based on retinal scanning, as retinal patterns are difficult to fake and impossible to steal.

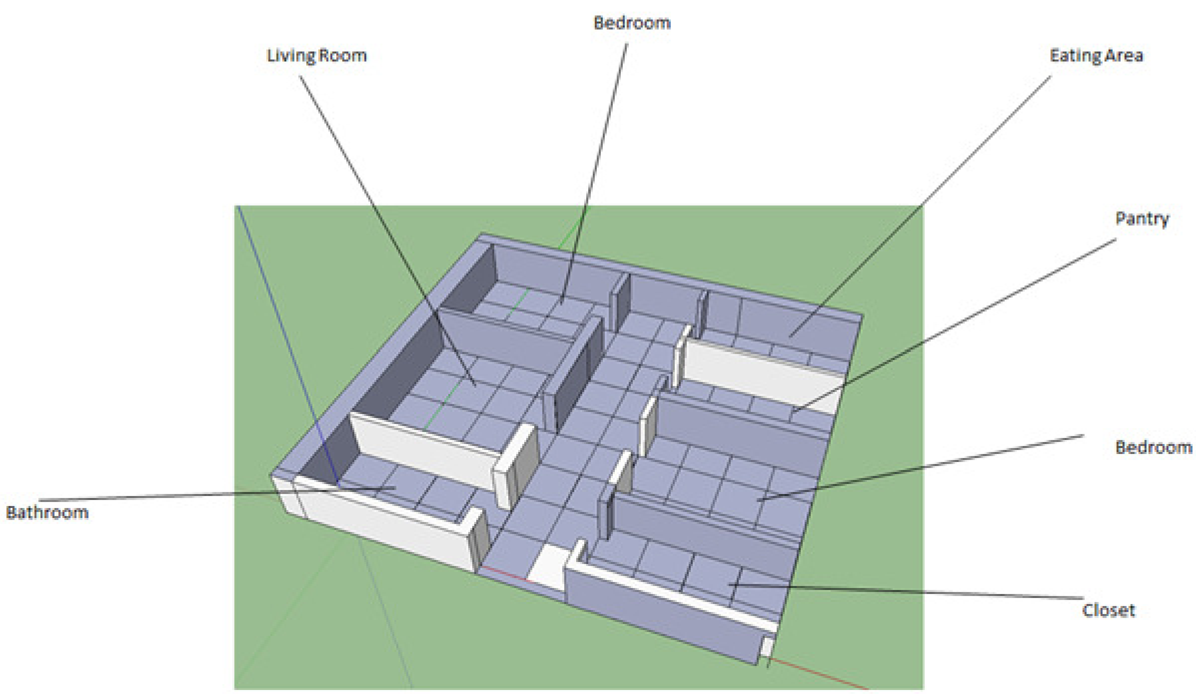
4.2 Residential Designs

The torus will be divided into four community blocks that will be identical in every respect except for the nature of their recreational spaces for colonists. The four different communities will be named the Anacreon, Sayshell, Santanni, and Arcturus Sectors. Each block will be capable of sealing itself off from the others in the case of emergency, but under normal conditions residents will be able to travel freely between sectors. Each sector will have access to one spoke connecting it to the cylinder. A limited number (550 people at each gravity level) of residents will be able to live in certain areas (at 0.5 g and 0.8 g) in the spokes. For residents who work in the cylinder, this will save time traveling to and from work. Housing areas will vary between 75 and 130 m^2 depending on the number of people living there. There will be four houses stacked on top of each other. Also all houses will have a pressure door on the front and will be self contained environments with algae tanks to provide air and food to the occupants in case of an emergency. Since the houses will be at the bottom of the torus, the gravity will be slightly greater than 1 g.





(above) Example of two bedroom suite for singles

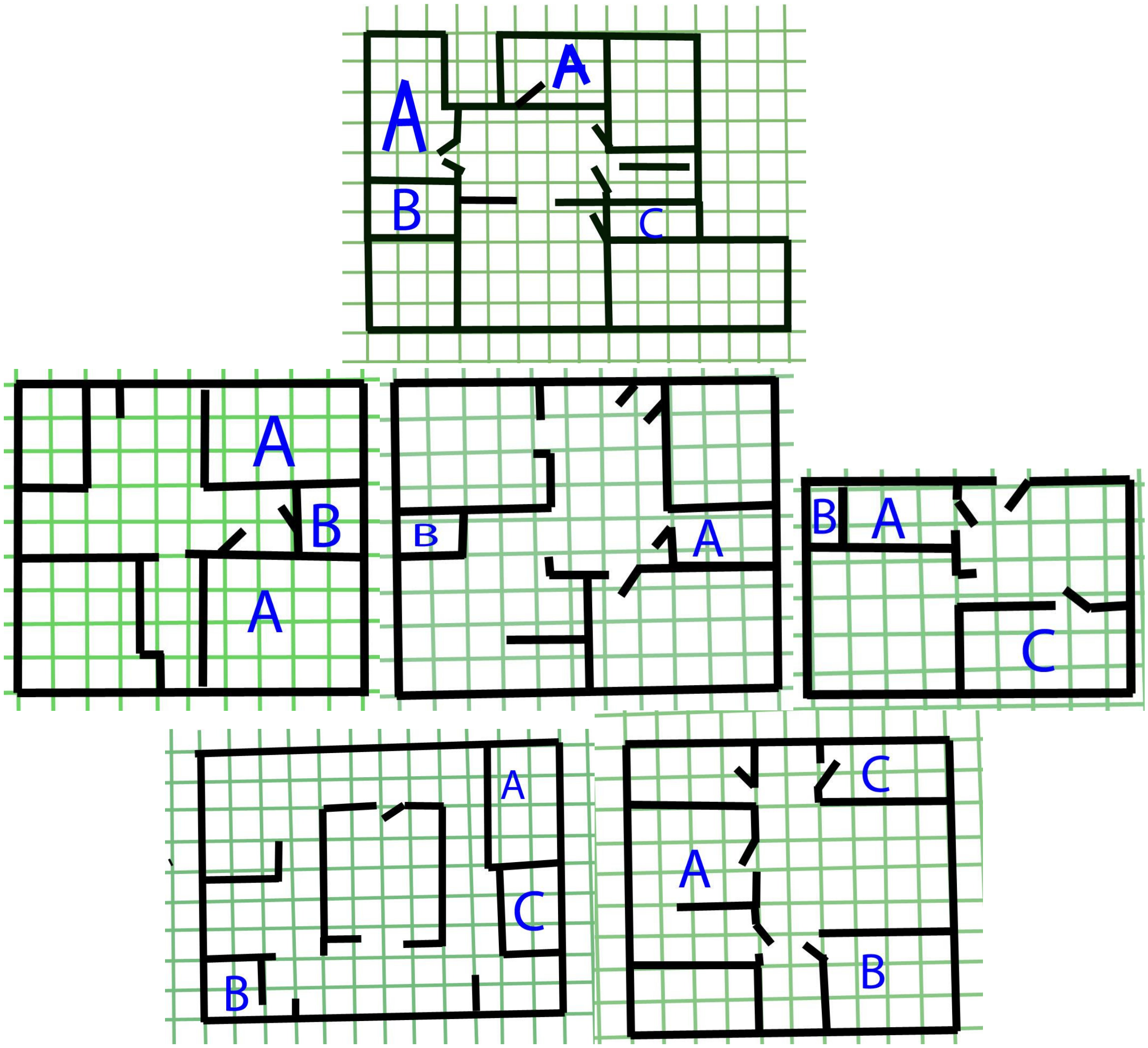


(above) Two-bedroom, hallway style suite

Figure 4.2.1

Individual living units will have adjustable walls for some of the rooms, to allow for flexibility in design. Electrical routes (i.e. outlets etc) will be primarily located on the floors. Furniture will largely be imported to the space station in individual units to be easily assembled by hand on Bellevistat. Each individual residential unit will be air-locked in the case of pressure issues.

Floor plans:



1 square = 1 m²

A= Bedroom B= Bathroom C= Study

Figure 4.2.2

Kitchen utilities will be limited to a small refrigerator, a simple microwave oven, a sink, and one set of cabinets, as well as a table and one chair per resident. There will be water monitors that keep track of water usage (shower time, sink usage, leak detectors) to maximize water conservation.

4.3 Systems, Devices, and Vehicles Designs

Device	**About**	**Design**
Bicycle	People will be required to wear a helmet when riding a bike.	Largely the same as Earth bicycle. Unisex and made of interchangeable parts.
Bus	Buses will be driven automatically on a specified track. If a bus sees something unusual in the road, it will stop as soon as possible without injuring the passengers.	Run on electricity from the power plant, which it receives from a powerline located deep within its tracking line, below where people are likely to injure themselves but within reach as a powersource
Ambulance/Fire truck	The ambulance/fire truck will have a special track and can drive automatically at speeds up to 120 km/h.	Designed with the same schematic and powersource as buses
Tablet computer	Each person will be provided with a tablet that has 512 GB of memory and can make “calls” on-station.	Silicon-based parallel processing, slightly less than state-of-the art to cut back on costs.
Spacesuits	Donning and Doffing, only for residents who need to do work outside the settlement	Made of buckystructure fabric

4.4 Comfortable modern community: facilities and services

4.4.1. Community Integration

Much of the entertainment (gyms, dance clubs, cinemas) will involve community interaction. People can also spend time in the parks spread throughout the settlement. People can go to stores to exchange their credits for supplies and food. Residents will be highly encouraged to visit Earth periodically. Transients new to Bellevistat will have introductory tours, guided by permanent residents, upon their visit to the settlement. Additionally, free community activities, such as dances and public celebrations, will enable both permanent and temporary residents to interact and bond as a community. Each community block will also have its own sports teams which will participate in friendly competitions with those of the other blocks.

4.4.2 Communication with Non-Bellevistat-Residents

The *RV Argo II* will travel between the Earth and the settlement once a month. A maximum of five hundred visitors can stay in the settlement at once. Each visitor can only stay on the settlement for a month. To get to the settlement, they will take a space shuttle to the Receiving Station, and then move to the settlement by a space tug.

Residents on the settlement can communicate with the people on earth through the Internet (email). A network of stations is organized around the world. Two-way communications between the settlement and ground receiving stations is accomplished using communication radios that transmit and receive high-frequency radio waves. A network of stations is organized around the world to receive the radio waves. Since there is a 384,400-kilometer distance between L4 and the earth, there will be a 1.28-second time lag (single trip). Usual communication is still possible with about 3 seconds of time lag (assume the time lag for computer processing is negligible because of the advance technology).

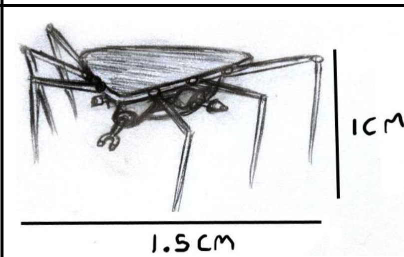
4.5 Passenger Receiving Areas

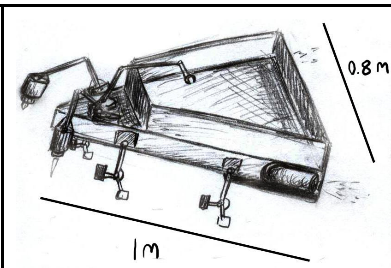
The entry and exit areas will be quite similar to those of airport terminals. Comfortable seating areas, bathrooms, vendors, and a view of the artificial sky will be available in the receiving area, providing visitors with familiar accommodations and showing the spectacular aesthetic appeal that Bellevistat has to offer. For transit security purposes, only security guards and authorized greeters will be allowed to meet entering residents in the receiving area. Security guards will ensure that all receptions are safe and efficient, while greeters will make entering passengers feel welcome.

5.0 Automations

5.1 Automation of Construction Process

Assembly of the settlement will be performed by construction robots fabricated on Earth and shipped out with the initial building materials. The robots will work cooperatively with each other under the direction of one central computer. After the settlement is complete, the construction robots will continue to be used for repairs. The initial construction of the central cylinder will be almost entirely automated and most human workers will be incorporated only after a habitable base has been established at the construction site.

Name	Description	Purpose	Dimensions	Quantity	Image
	Swarms of tiny repair robots will move freely through the settlement, receiving orders of where to go and what to repair from a central computer system.	External constructio n and repair	Vary from 5/5/6 mm to 1/1/1.5 cm	10,000 (initial)	

	These robots will attach to the settlement with magnets and will propel themselves with rotating rockets shooting small pellets of water. They will carry torches, drills, and space for materials.	Internal constructio n and repair	0.8/1/0.3 m	1000	

5.1.1 Transportation and Delivery of Materials and Equipment

Materials from Earth will be shipped on regular shuttles which will be completely automated with no human pilots necessary. Ships will be programmed with the correct route and docking procedure. Unloading of the shuttles will also be carried out by robot. Materials from the moon will be launched by mass-driver and collected in-orbit to be transferred to the settlement. A small human team will be present at the moon mining base, but the mass driver will launch materials regularly without needing human direction. The collection pod will run on an automated schedule. All delivery processes will be automated under normal circumstances, but processes can be overrode by humans if necessary.

5.1.2 Assembly

The Bellevistat settlement will be assembled completely by robots which will employ welding torches and screw drivers and will be controlled by a central computer. The settlement will be primarily composed of simple, repeating parts, so it will be a simple task for robots to connect them.

5.1.3 Interior Finishing

Interior finishing will be carried out by a combination of robots and human construction workers, as the settlement will by then be habitable for people. One team of human/robot construction workers will build basic parts for houses and furniture and another team will assemble and install them. Residents will be allowed to paint their homes themselves.

5.2 Facility Automation and Settlement Maintenance

Most of the facilities in the settlement will be completely automated to as to save time on the part of the settlement's workers for more important business. The settlement will have a number of routine processes carried out continuously or regularly to ensure that it can function effectively. Monitors regulating air pressure, air composition, and temperature will be placed around the settlement to alert the central computers if something is wrong with the regulation.

5.2.1 Repair

5.2.1.1 External Repair

A limited number of external construction robots will be kept after the construction process has been completed and will be used for external repair. Robots will also replace the buckystructre plates covering the outer skin of the settlement when they are broken by micrometeorites. *(see section 2.1)*

Figure 5.2.1.1

5.2.1.2 Internal Repair

Internal repair robots will be small enough to fit inside most machinery and will travel through the walls and hardware of the settlement in swarms. Malfunctioning machines will broadcast a signal alerting nearby swarms to come and perform repairs. If necessary, swarms can produce more of themselves when materials are available.

5.2.2 Safety Functions

5.2.2.1 Backup Systems

Redundancy in life support systems will ensure that no one system failure will harm the settlement. Air, water, and power systems will each consist of several identical units separate and independently functioning from each other in different areas. Failure in one system will result in an automatic rerouting to another system until repairs are complete.

5.2.2.2 Contingency Plans (chart)

Hull Breach	Loss of air pressure will be detected with automated air-monitoring system. System will summon swarm of small, internal repair robots which will patch the leak until it can be completely repaired by external repair robots on the outside. If the breach is not repaired within ten minutes or if the air pressure drops to (value?), the sector will be evacuated and sealed off until the repairs are complete.
Water Contamination	Water contamination will be detected by the automated water-monitoring system and a warning will be sent to all areas receiving

	water from the contaminated system. Water will be re-routed from other, isolated water systems and contaminated system will be shut off until the source of the contamination can be determined and neutralized.
Air Contamination	Air contamination will be detected by automated air-monitoring system. If the contaminant is immediately detrimental to human health, the contaminated sector will be evacuated. Air will be re-routed from other, isolated air circulation systems until the source of the contamination can be determined and neutralized.
Small Fire	Fire will be detected by smoke detectors throughout the settlement. Inside buildings, this will trigger sprinkler systems which will spray water continuously until they are manually turned off. In areas containing flammable chemicals, the sprinklers will spray flame-retarding chemicals. Smoke detectors will also send warning messages to all residents nearby and to firefighting robots if necessary.
Large Fire	In the case of a large fire that cannot be extinguished by conventional means or that cannot be extinguished fast enough to prevent loss of life, the sector will be completely evacuated and then sealed off, and dense gases will be used to push oxygen out to suffocate the fire.
Solar Flares	During a solar flare storm all shuttles and external robots will be recalled into the settlement where they will be protected by the settlement's radiation shielding.
Nuclear Power Failure	During a nuclear power failure, all non-vital power consuming operations will be shut off and life support will be powered by the solar panels until the nuclear power plant is able to function again. The central cylinder will be evacuated during repairs, which will be carried out by robots. Various pods located at the sides of the settlement will be available to transfer out settlers to Earth.
Solar Power Failure	The nuclear power plant will supply the settlement with energy until external repair robots are able to repair the panels.

5.2.2.3 Computers and Robots for Critical Functions (location)

Computers controlling the critical functions of the settlement will be located in the central cylinder underneath the aeroponics, which will protect them from accidents associated with manufacturing, while the controls for the computers will be located in the manufacturing section where they will be more easily accessible. The circuitry which connects the computers to their controls will have a deliberate weak point which will give out and terminate the connection in the case of an emergency so that the computers will not be affected.

Most life support functions in the settlement will be controlled independently by sector by computers located there. The redundancy in control computers will ensure that the life support systems will not be vulnerable to disasters.

The computers for robotic control will be on the floor beneath the primary station control in the cylinder, directly connected both physically and with cables to allow efficiency of communication between the two. Critical systems will be completely inaccessible from the public settlement computers.

5.2.2.4 Data Access and Computer System Control

There will be terminals for data access in all rooms (a form of personal computer hooked into the primary server system) also in the western portion of the torus. The area of the torus directly adjacent to the western torus will contain the primary server area's as well as the primary control loci for the space station.

5.3 Habitability and Community Automations

5.3.1 Community/Residential Automations

Many aspects of daily life on Bellevistat will be performed by various kinds of robots. Most home maintenance tasks such as cooking and cleaning will be automated, and many recreational activities will involve mechanized processes. Many robots will exist in public spaces within communities and can be accessed by all residents.

5.3.2 Automations for Work Environments

Automations will be provided to make work environments both in manufacturing and scientific experimentation, and in business and management. Most of the factory fabrication will be carried out by robotic assembly line workers and experiments with dangerous components will be carried out long-distance by remote-controlled robot arms. Offices for business will all be equipped with computers and simple robotic secretaries which will be able to accept calls and transport small objects as well as keep track of meeting schedules

5.3.3 Automations to Reduce Manual Labor

Time will be a valuable commodity on Bellevistat, as continuous productivity is necessary from all of the working residents in order for the settlement to carry out its function. Therefore, automations will be provided to residents to make some time-consuming, routine tasks unnecessary. Robots will be present in the communities to carry out certain tasks such as cleaning, monitoring plant health, working in manufacturing factories, assisting in medical procedures, and driving the vehicles. All robots will be powered by batteries. Food harvesting will not be automated because it will be easy and relatively non-time consuming for children on the settlement to collect ripe crops from the aeroponic frames.

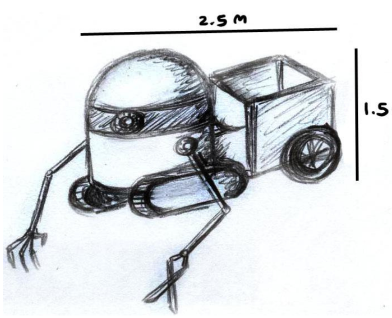


Figure 5.3.3a: Crop tending robot

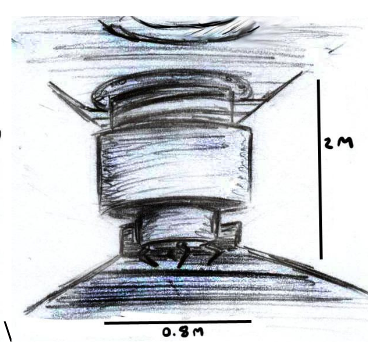


Figure 5.3.3b: Factory conveyor-belt robot

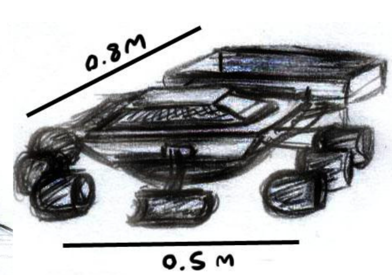


Figure 5.3.3c: cleaning robot

5.3.4 Privacy of Personal Data

Individuals in the space settlement will possess personal computer interfaces, and only a few settlement authorities will have the access codes to encroach on this privacy: any such encroachment would be strictly regulated.

5.3.5 Access to Community Computing and Robot Resources

Figure 5.3.5

Bellevistat will create its own internet separate from that of the Earth. In addition, 500 Earth websites requested in polls by colonists will be periodically uploaded in their most recent form to the settlement internet so that they can be accessed by settlement residents without the time-lag that would result from continuous uploading.

Each resident will posses a phone/computer device which will provide them with access to the settlement internet as well as providing a number of other services such as voice or video communication, health monitoring (by detecting heart rates, body temperature, and other external indicators of health), and tracking in emergencies.

5.3.5.1 Computer Networks and Bandwidth Requirements

The computer networks will be a glass fiber network connecting all immobile computers in the station as well as an overlapping network of wireless broadcasters to ensure proper accessibility. This will give an average of a gigabit/second of internal network speed.

5.4 Unloading of Material Shipments

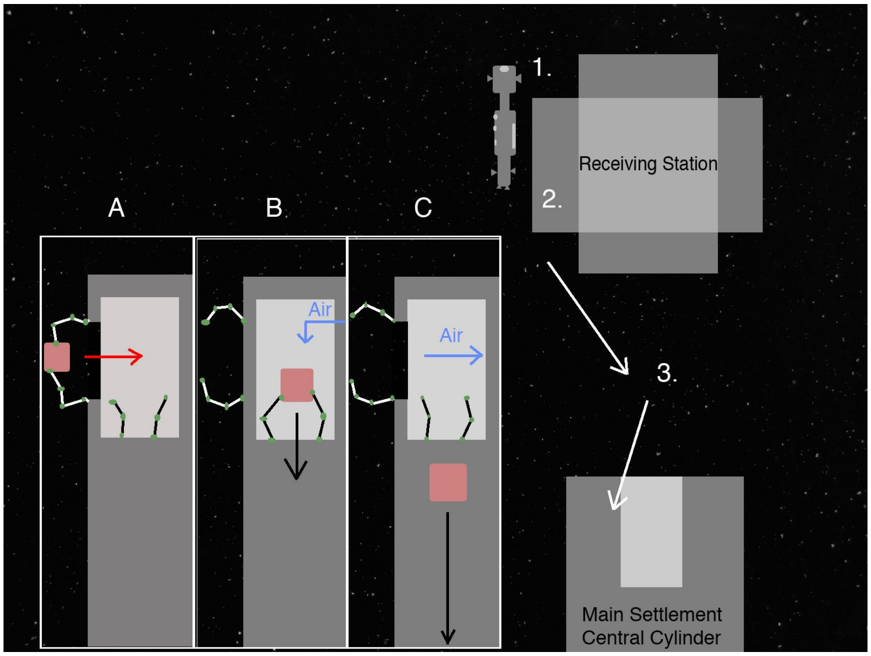


Figure 5.4

1. Ships carrying material shipments will dock outside the receiving station and release shipping containers, which will then be maneuvered by robotic arms into an open chamber (A). The chamber will then be sealed off (B) and air will fill the chamber. Another pair of robotic arms will maneuver the shipping container onto a set of tracks, which will move it throughout the station. When the container leaves the chamber, air will be removed (C) and it will be opened to the outside for additional shipments as needed.

2. Containers are maneuvered on tracks, the materials in the shipping container will undergo some processing and refinement available on the receiving station, depending on the materials, and packaged into another container.

3. The container will then be released in a similar chamber system to be maneuvered by a space-tug to the main settlement's central cylinder, where all further materials processing will take place.

5.5 Docking Procedure Automations

Smaller ships will approach the receiving station at a low speed, where robotic arms will maneuver them into appropriately-sized chambers. Larger ships will decelerate a larger distance away from the receiving station, where one or more space tugs will precisely direct them into appropriate chambers.

6.0 Schedule and Cost

6.1 Design and Construction Sequence

Completion Date	**Event**
15 May 2033	Contractors receive contract award
December 2033	Minimum docking and airlock structures completed
June 2034	Central cylinder completed
November 2034	Spokes constructed to the furthest edge of torus
November 2038	All materials and sections of torus shipped to site
March 2040	All sections of torus assembled, connected and attached to spokes
December 2040	Suitable environment, agriculture, and life support established
June 2042	Residential communities constructed and ready for arrivals
May 2044	Population settled into homes

6.2 Cost

Cost for Building the Settlement		
Items	**Amount**	**Cost**
Structure	**1,089,000**	**$2,194,240,000**
Iron/Steel	320,000	$224,000,000
Aluminum	300,000	$240,000,000
Titanium	280,000	$1,680,000,000
Buckystructures	30,000	$30,000,000
Water	150,000	$450,000

Other	9,000	$13,000,000
Human labor (per year)	$14/hour	$6,720,000
Robot labor (per year)	dozens-hundreds	$70,000
Transportation	**N/A**	**$4,157,230**
Buses	20	$1,600,000
Elevators	4 or 8	$400,000
Emergency vehicles	10	$600,000
Bikes	10,000	$1,500,000
Pathways	4,774 m	$57,230
Housing/Entertainment	**N/A**	**$599,655,000**
Housing	11,500 100 m^2 **houses**	$575,000,000
Furniture	See floor plans	$14,375,000
Entertainment	cinema, dance club, art studio, video game club, gym— one each	$4,500,000
Technology	11,500 devices, plus a few dozen control devices	$5,780,000
Services	**N/A**	**$21,116,000**
Education	1 k-12 school	$1,716,000
Medical	1 ER, several clinics	$9,500,000
Police	1 jail, 1 courtroom	$900,000
Industry/Power	**N/A**	**$79,200,000**
Initial industry	1 buckystructures factory	$10,000,000
Initial nuclear power	1 nuclear power plant	$60,000,000
Initial solar power	92,000 solar panels	$9,200,000
Initial Construction	**N/A**	**$6,970,000,000**

Fuel	3,600,000 m^3 **at $ 1.75/liter**	$6,300,000,000
Nautilus	1	$50,000,000
Pangaea	1	$50,000,000
Behemoth	1	$80,000,000
Argo II	1	$90,000,000
Smaller rockets	0-dozens	$400,000,000
Utilities	**N/A**	**$3,897,450**
Electrical	381,920 m of wire, 230,000 lights	$2,338,200
Plumbing	23,870 m of pipe	$358,050
Water purification	600,000 liters, treatment facility	$701,200
Waste management	treatment/recycling facility	$500,000
Small Station	**1**	**$72,250,000**
Structure metal, buckystructure, infrastructure	N/A	$70,000,000
Docking station	1 docking station (doors, anchors)	$1,700,000
Welcome area	Chairs, windows	$550,000
Robots	**11,686**	**$1,535,000**
Construction	150	$300,000
Internal repair	1,000	$500,000
External repair	10,000	$400,000
Cleaning	100	$50,000
Conveyor	belt 80	$72,000
Shipping	6	$3,000
Agriculture	350	$210,000
Total for Building	**N/A**	**$9,946,050,680**

Cost for Maintaining the Settlement (per year)		
Services	**N/A**	**$12,000,000**
Labor	300 people at $20/hour	$12,000,000
Industry/Power	**N/A**	**$10,000,000**
Industry maintenance	N/A	$5,000,000
Industry maintenance	N/A	$5,000,000
Utilities	**N/A**	**$13,650,000**
Climate control	$600/person	$6,900,000
Labor	225 people at $30/hour	$13,500,000
Agriculture	**N/A**	**$1,032,360**
Supplies	**N/A**	**$150,000**
Food	**seeds, but weight= amount when grown (kg)**	**$10,588,320**
Legumes	287,280	$861,840
Vegetables	871,800	$3,487,200
Starches	2,453,160	$4,906,320
Other food	258,240	$1,032,960
Other crops	120,000	$300,000
Total for Maintenance	**N/A**	**$ 54,170,680**
Grand Total (per year)	**N/A**	**$10,000,221,360**

7.0 Business Development

There will be open rooms in the torus which can be refitted with interiors for the various local businesses. Companies will be encouraged to lease space for manufacturing facilities.

7.1 Port for receiving Lunar and asteroid material

Lunar and asteroid materials may be brought to the settlement by way of the Receiving Station (*see section 2.5.2).* Materials can be partially processed on-site there, and if this is insufficient, they may be brought by "Ye Old Deathtrap"s to the settlement docking for further processing.

7.2 Production of goods manufactured from extraterrestrial materials

Materials will be processed with centrifuges located in the Receiving Station. Some lunar materials will also be separated and processed on site at the lunar mine base. Processing which requires gravity between 0 and 0.25 can be performed in the manufacturing section of the cylinder. Extraterrestrial materials will be used to create products for export as well as for provisioning visiting ships and for internal use. Outgoing shuttles will transport exported materials to Earth or other settlements. Additional sections will eventually be built onto the Receiving Station to allow for expansion in manufacturing.

7.3 Repair/restoration of ships

Ships will be examined on a regular basis: a thorough examination that checks every single part of the ship will be performed once a year; a rough examination that checks only on the most-used parts (i.e. engine) will be performed every two months. Spaceship examinations and repairs will be performed on Earth because it will be more convenient and efficient to do them with sufficient resources around. Space tug will also have a thorough examination every once a year, but it will have a rough examination only every half a year because it will not wear out as fast by traveling in between the receiving station and the settlement with the low speed. All the examinations and repairs will be done on the settlement, specifically on the docking area in the central cylinder (Figure 2.2 c). The area big enough (33 meters high) to contain the whole space tug, and the settlement will have enough resources to repair the tug, which is a lot smaller than spaceship.

Basic restoration of shops may be done in the Receiving Station (*see section 2.5.2)*. If a ship 's integrity is too badly compromised for this to be adequate, more sophisticated reparation may be made in the docking section of the Bellevistat station.

8. Appendix

A.1 Response to Hull Breach

In the case of a hull breach between two habitable volumes the repair bots, (upon internal sensors detecting a drop in pressure) will begin to stream towards the hole (following the direction of the airflow) and upon reaching it begin to form a clot around the hole (forming a support structure as they flow inwards). Also upon the sensing the pressure drop sirens will go off, and all people will receive a message via their mobile device (this will have a special ring tone, both vibration and loud sound) to begin evacuation of the affected compartments to the peoples homes, where they would seal themselves until rescue.

A.2 Response to Volatile Waste or Chemical Reactions

Upon the detection of a violent reaction, a siren will go off (as well as the mobile message) warning the people to get to their places of residency. They will be able to seal their homes off from the rest of the atmosphere and protect themselves from toxic gasses and heat. Once the computer systems know (from positioning software in the mobile computer phones) that all residents are safely in their homes, the affected sector of the torus will be shut off from the rest of the settlement and its atmosphere will be vented into space.

B Bibliography:

Cover picture- http://taicarmen.files.wordpress.com/2011/05/earth-from-space-1.jpg

Information on aeroponics-
http://www.lookatvietnam.com/2009/11/aeroponic-farming-speeds-production.html> (a seedling grown by aeroponics gives 50-60 tubers while planting in soil only produces four to five potatoes.)
http://www.thenational.ae/featured-content/channel-page/business/middle-article-list/growing-vegetables-in-the-mist> (Aeroponic farming ...requires only a tenth of the water needed for traditional agriculture. The farm harvests its water from the humidity in the air in an effort to be self-sufficient. Whereas a soil-based farm can require up to three months for each harvest, AeroFarms units can produce crops in 18 days.)

Growing Plants in Low Gravity-
http://www.ars.usda.gov/research/publications/publications.htm?seq_no_115=188736

Circadian Rhythms- http://pacificsleepprogram.com/blog/post/circadian_rhythms_the_body_has_a_timer

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C. Compliance Matrix

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