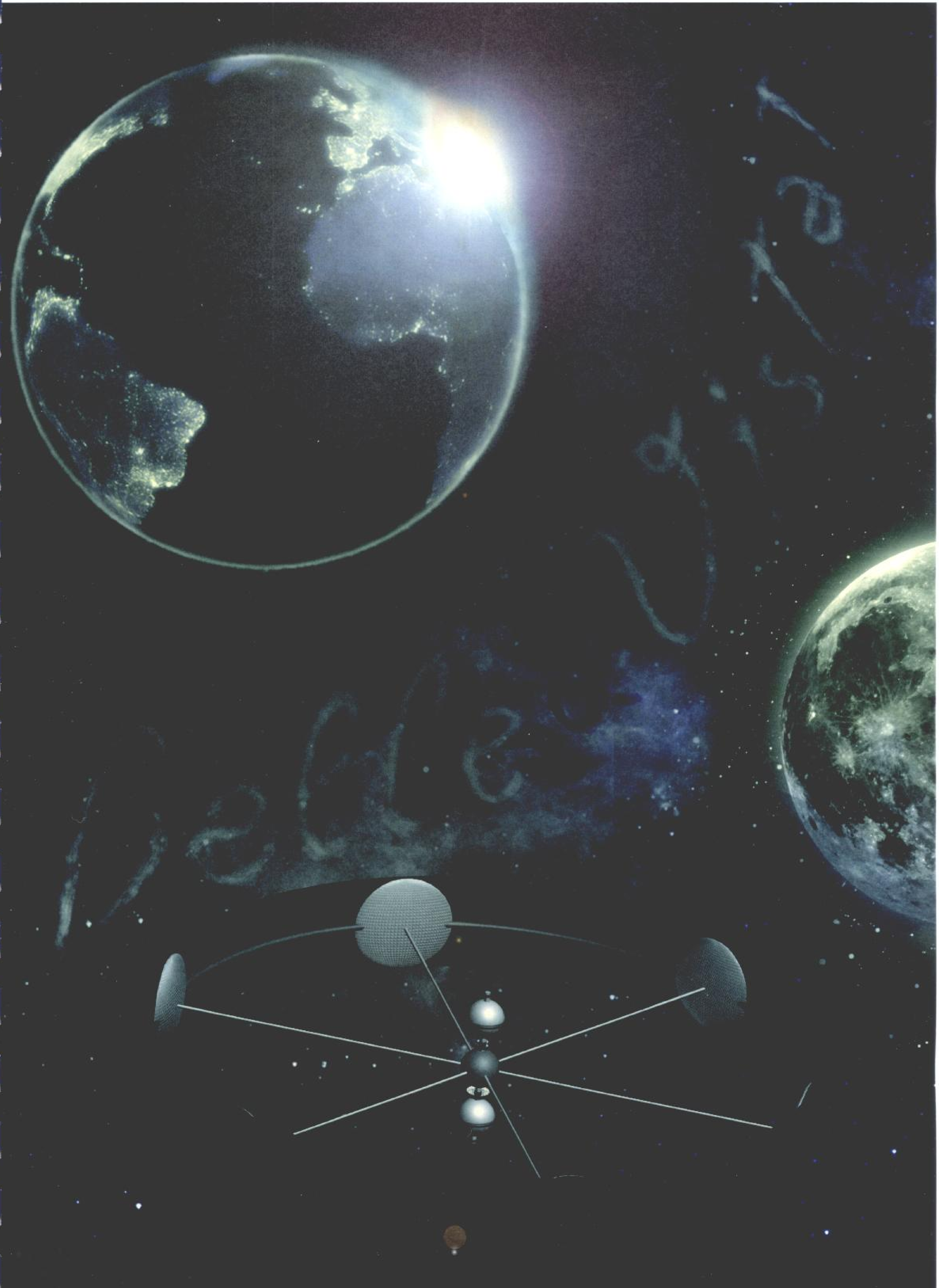
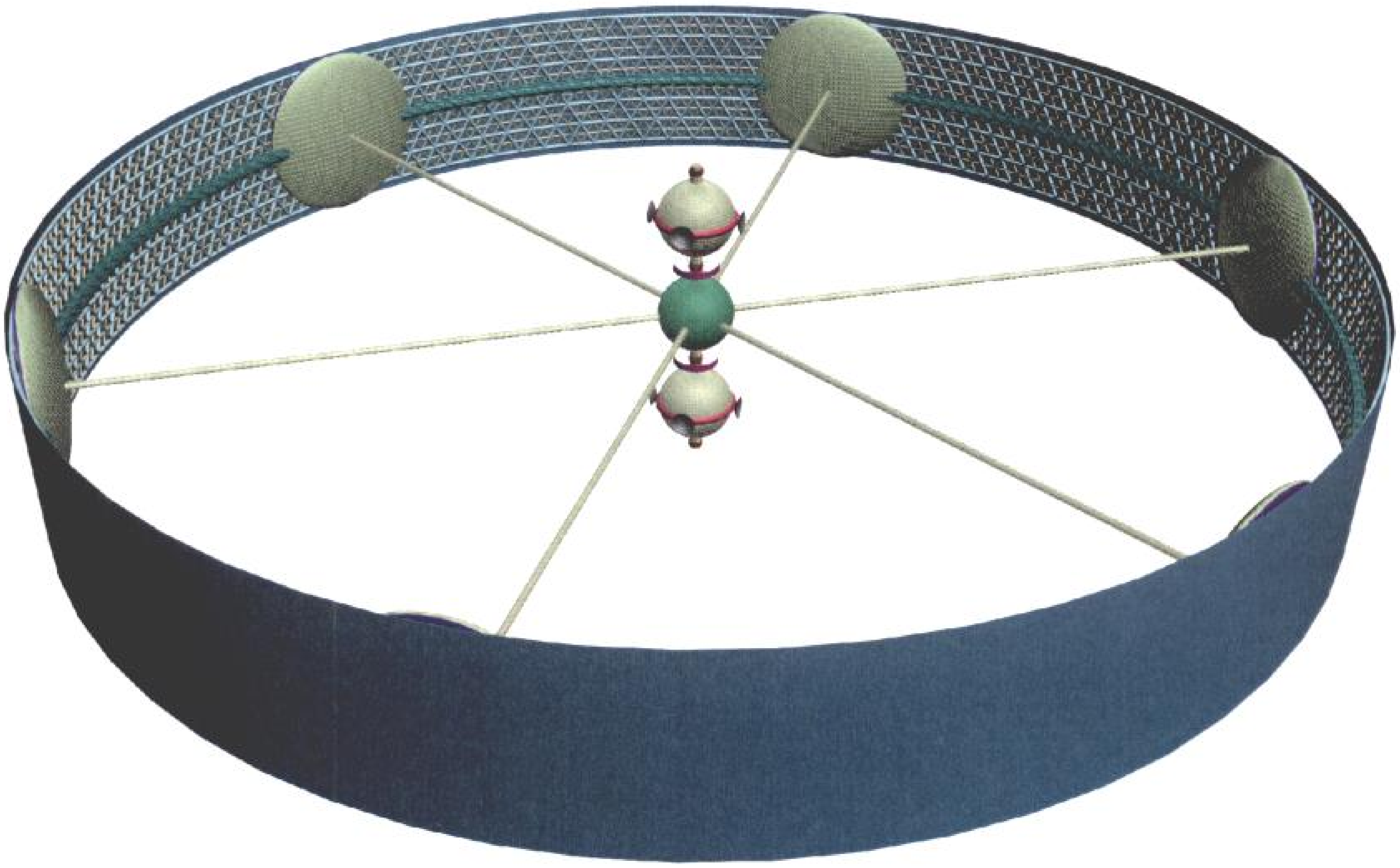


Belle-α-vistat, Student Research Centre of Alumni Foundation of National College "Mircea cel Batran" , Constanta, Romania



1.0 Basic Requirements

Bellevistat, built by Northdonning Heedwell, is the state-of-the-art orbiting space settlement, second in the daring plans of the Foundation Society. Placed at L4 Libration point of the Earth-Moon system, it is capable of accommodating a number of 18000 permanent residents and 1000 tourists.

Although essentially focused on mining, it is also competent is research and space exploration. Its decisive economic role stands mainly in extraction and refining of ore, provision of materials, building high profit assemblies and facilities for the benefit of the development of subsequent space colonies or other clients.

Bellevistat is built in three separate stages: two of the on them on Alexandriat while one is autonomous, on a schedule especially designed in such a way to productively minimize the construction period and to induce an early start to the industrial activity. The project is commenced on the 10th of May 2028, it continues for 10 years and is expected to be fulfilled on the 13th of July 2038.

To ensure maximum physical and psychical comfort for Bellevistat's residents, the conditions on Earth are simulated, such as providing artificial 1g gravity by means of rotation, attractive neighborhoods, daylight artificial illumination that very closely imitates natural light and a wide range of amenities and opportunities for leisure and professional achievement.

All in all, Bellevistat is a dynamic environment, suited for those young professionals who are dedicated to serve their lives to the expansion of human infrastructure in space, while not missing anything from the typical enjoyment an Earth based existence would encompass.

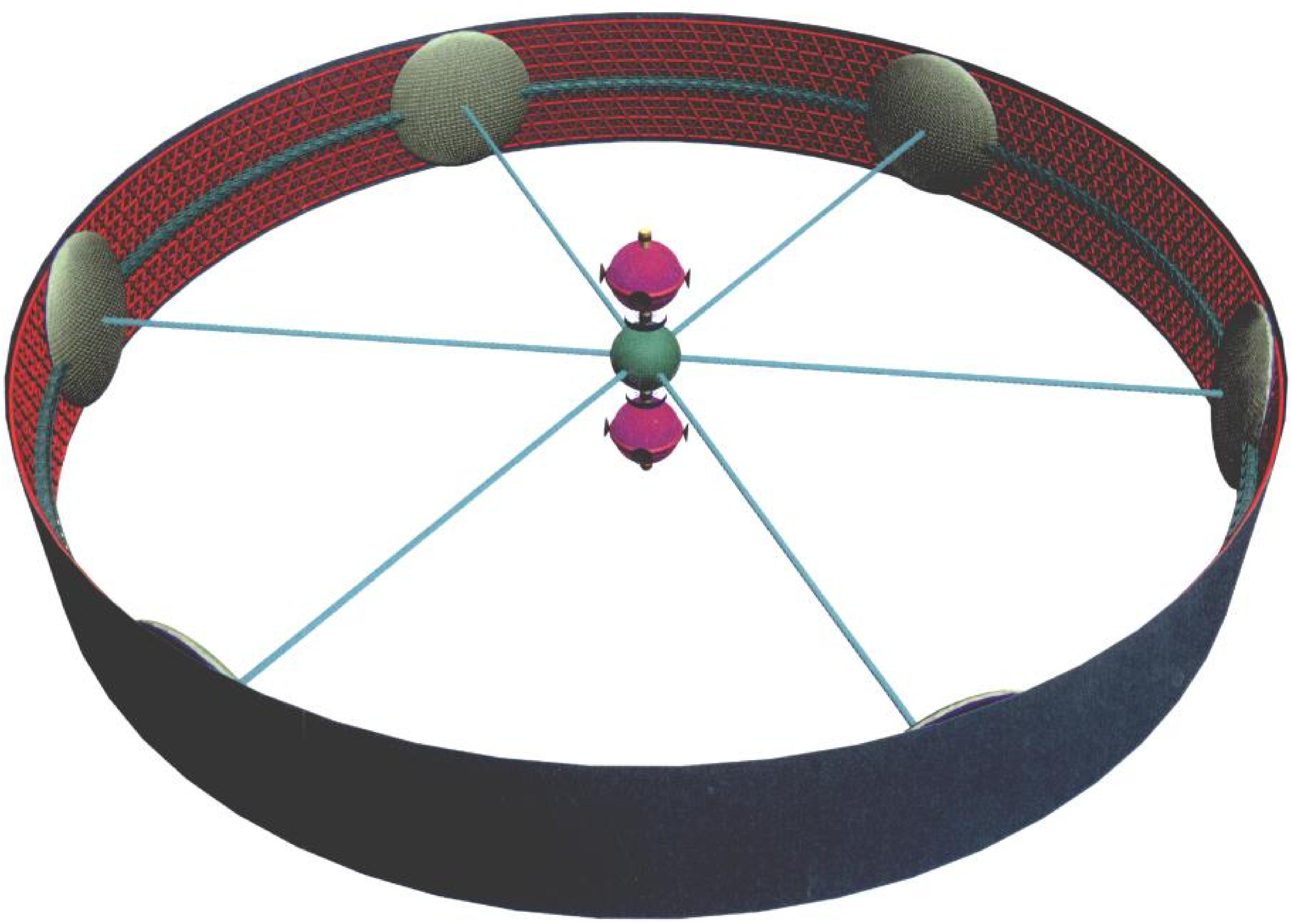
2. Structural Design

2.1. External Configuration

Bellevistat hosts a population of 18000 people. Considering that it is, essentially, a mining colony, for psychological comfort it must offer a very comfortable environment. For this reason, conditions as close as possible to those on Earth are simulated, in order for people to be able to perform activities in normal conditions.

One of the most important conditions is the gravitational acceleration g=9.8 m*s^{-2}, identical to that of Earth. It is obtained artificially, by means of rotating the station around its own axis. The habitable surface is placed so that there is constant acceleration in all points where humans are located. Because a frequency of more than 2 rotations per minute may have negative secondary effects on humans, and because of the wide variation of this sensibility at different individuals, the rotation period is chosen as T=100s. To fulfill both the fore mentioned conditions, and using the formula $R = g_m \cdot \frac{T^2}{4\pi^2}$, the distance from the rotation axis to the habitable surface is R=2482 m.

The 6 FELDs (Functional Element and Living District) are connected to the central sphere through linkage and resistance structures. The central sphere, two spaceports for small ships, two spheres for heavy industry and deposits pertaining to it, as well as two space-ports for massive ships (cargo bull) are located on the central axis. The structures along the central axis are located symmetrically with respect to the central sphere. The solar panels surround the station, as shown on the picture of major components on the exterior.



Picture 2.1.a

Because of the physical location of Bellevistat, it is possible to observe outer space and the Earth below, from the Observatory belt. Dimensions and other information regarding the design of major volumes are displayed in table 2.1.b:

Table 2.1.b

No	Component	Destination	Dimensions (m)	Volume (m^3) *Values for one entity*	Artificial gravity (m/s^2)	Rotating (Y/N)	Pressurized (Y/N)
1	FELD	Residential area, agriculture	Rotation radius: 2,482 Avg. radius: 360.5 Avg. height: 56.5	Residential: 23,088,800 Agriculture: 6,127,500	Residential: 9.8 Agricultural: 9.8 – 9.9	Y	Y
2	Central sphere	Research, entertainment, light industry	Radius:150	Total: 14,137,166 Effective: 11,993,029	<0.59	Y	Y, except light industry
3	Industrial sphere	Heavy industry, storage	Industry radius: 124 Total radius: 150 (incl. storage)	Total: 14,137,166 Industrial effective: 6,111,548 Storage:7,631,993	Industrial area: <0.49 Storage: 0.49 – 0.59	Y	Only access areas
4	Observatory belt	Entertainment, research	Large radius: 150 Small radius:15	Total: 333,099	0	N	Y
5	Bulkcarrier dock	Docking, construction facility	Radius: 25	Open dock, can accommodate vessels of indefinite size	0	N	Only access areas
6	Personnel dock	Docking	Radius: 100	Closed dock, can accommodate vessels smaller than 70x20x20	0	N	Y
7	Gravlift shaft	Transportation (FELD – Central axis)	Radius: 10 Length: 2,495 (from core to agricultural area)		0 – 9.8 (from central sphere to FELD)	Y	Y
8	Train tunnel	Transportation (FELD – FELD)	Radius: 25 Length: 2,599 (between two adjacent FELDs)		9.8 – 9.9	Y	Y
9	Central axis	Transportation (bulkcarrier dock, industrial sphere, personnel dock, central sphere)	Radius: 20 Total length: 1,260 (between extremities)		~0	Y	Only central sphere to industrial sphere
10	Solar panel belt	Electric energy production	Radius: 2,511 Width: 721	*Total surface:* 11,248,570 m^2 *Projected surface:* 3,580,530 m^2	9.8 – 9.9	Y	N

Considering the NASA studies from 1975, the station's dimensions have been established by allocating the surfaces and volumes from table 2.1.c for every individual. Additionally, the height requirements for public open space have imposed the average height of the livable area of 56.5 meters. The height of the agricultural area has been set to 15 meters to allow for a better allocation of space.

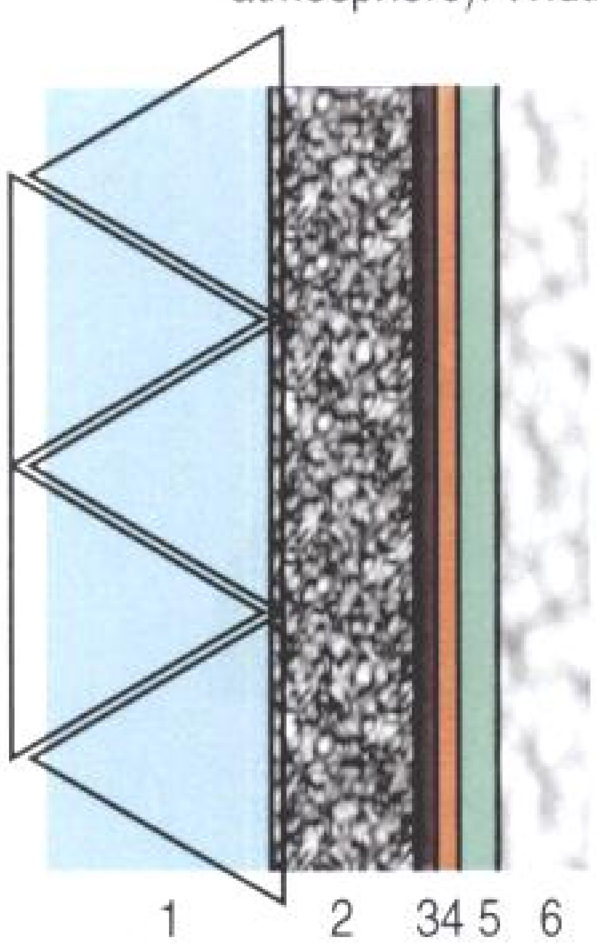
Purpose	Area (m2)	Height (m)	Volume (m3)
Residential	77.9	3	233.7
Stores	3.3	4	13.2
Offices	1	4	4
Schools	1	3.8	3.8
Hospital	0.3	5	1.5
Meeting halls	1.5	10	15
Recreation	1	3	3
Private garden	14	3	42
Permanent forest	15	25	375
Public open space	10	50	500
Service industry	4	6	24
Total residential area	129		1215.2
Storage	5	3.2	16
Transportation	12	6	72
Infrastructure	7.1	4	28.4
Total infrastructure			116.4
Animal growth	5	15	75
Food industry	4	15	60
Agricultural storage	8	15	120
Agricultural crops	50	15	750
Total agriculture			1005

Table 2.1.c

The internal structure of the hull

The hull is multi-layered, as follows (from the outside to the inside, as in picture 2.1.d):

1. A layer of polyethylene impregnated with hydrogen. This layer offers shielding against radiation and, being elastic, repelling of micrometeorites. It also determines heavy ions to fission into lighter ones. Width: 1m.
2. A layer of panels made of Inconel 600, fixed on a structure composed of linear elements of Inconel X750, which are assembled in triangular elements. This assembly is an endurance structure. This solution offers maximum resistance to tension and stress and is appropriate considering the metallical resources that are available. Width: 0.7m.
3. A layer of Demron, whose purpose is to stop the ions which passed the polyethilene layer and which, being elastic, allows the metallical endurance structure to suffer small dilatations. Width: 0.1m.
4. A layer of airproof rubber, to prevent leakage of atmospheric gasses from the colony. Width: 0.03m.
5. A layer of aerogel, for thermal insulation. Width: 0.3m.
6. A layer of polystyrene for thermal insulation (the aerogel is hydrophilic and must not be in direct contact with the atmosphere). Width: 0.5m.

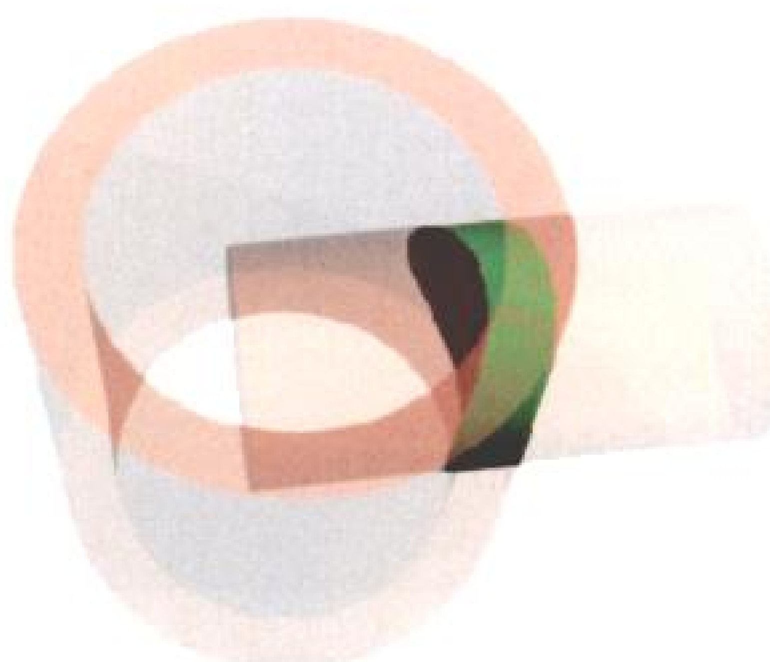


Picture 2.1.d

Major enclosed volumes

1. FELD – Functional Element and Living District

The FELD is the composition between the intersection of a cylinder with a tube (as depicted in picture 2.1.e), and the calotte of a rotational ellipsoid. The interior inhabitable surface is a Steinmetz surface, to ensure constant gravitation. Above it, there is an elipsoidal dome, in order to maximize the volume of the habitable space and to reduce psychological side effects. The shape was chosen to eliminate the stress factor generated by living in a closed, predominantly linear environment, like a torus segment. A Steinmetz surface closely resembles a circle and creates the illusion of the horizon.


Picture 2.1.e

2. and 3. Central Sphere and Industrial Spheres

The exterior surface of these volumes is formed of triangular elements, the « spheres » being actually truncated icosahedrons, a very stable structure.

4. Observation Belt :

The belt is torus-shaped, with half of the volume inside the corresponding industrial sphere. The antennas for communications in Ka-band, the LASER communication systems, telescopes (for researchers and tourists) as well as other sensors which receive information from space are all attached to it. The windows on the observation belt have solar filters, to protect humans from burns and damaging effects of strong light. They are made of glass treated with quartz.

5. and 6. Personnel Docks and Bulkcarrier Docks :

There are in total four docking facilities separated one from another by at least 300 meters for redundancy in case of an accident. There are two types of docks : the personnel docks are enclosed and can accommodate smaller vessels ; while they are usually used to transfer people in/out of the colony, they can also be used for small assemblies. On the other hand, the bulkcarrier ports are open and vessels of virtually unlimited size can dock in them. Mainly used to transfer merchandise in bulk quantities, they can also be used in case of a cataclysm to evacuate the colony. They are not pressurized at all, so humans would have to be transported in modified airtight containers.

7., 8. and 9. Gravlift shaft, train tunnels and central axis :

On the exterior, they are formed of a endurance structure which suffers a constant tension. Only the necessary areas are closed and pressurized.

10. Solar panel array:

Made of photovoltaic cells based on silicon dioxide, the solar panel array is sustained by a endurance structure made of Inconel X7500, similar to the one used in the hull of the colony : linear elements form together triangular elements to ensure maximum stress resistance.

The endurance structure:

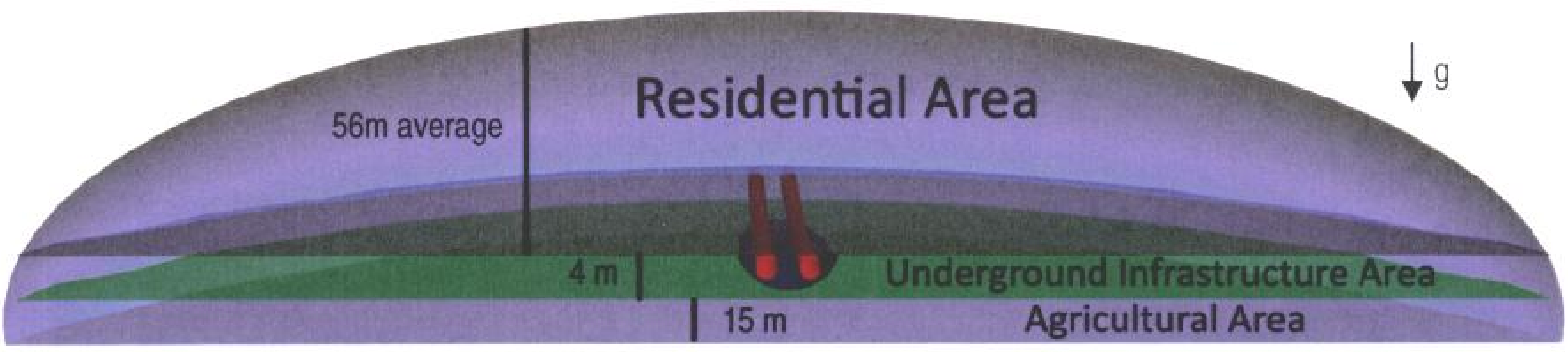
The exterior robots are designed so that they can move along the endurance structure formed of triangular elements which cover the entire surface of the station, except the docks and the exterior of the panels. The latter structures are covered by a rail structure shaped like a grid along which the robots can move.

2.2. Internal Arrangement

A. FELD – Functional Element and Living District

On Bellevistat, there are 6 FELDs placed axisymmetrically, each being divided as in picture 2.2.a:

1. The residential layer – contains houses and other buildings (hospitals, business centers, etc).
2. The underground layer - this space is allocated for the basement of houses, plumbing, IFT and wiring.
3. The agricultural layer – it is divided on floors depending on necessities. It also includes the tubes through which the trains move.
4. Vertical transportation is done with gravlifts (not shown in picture below)



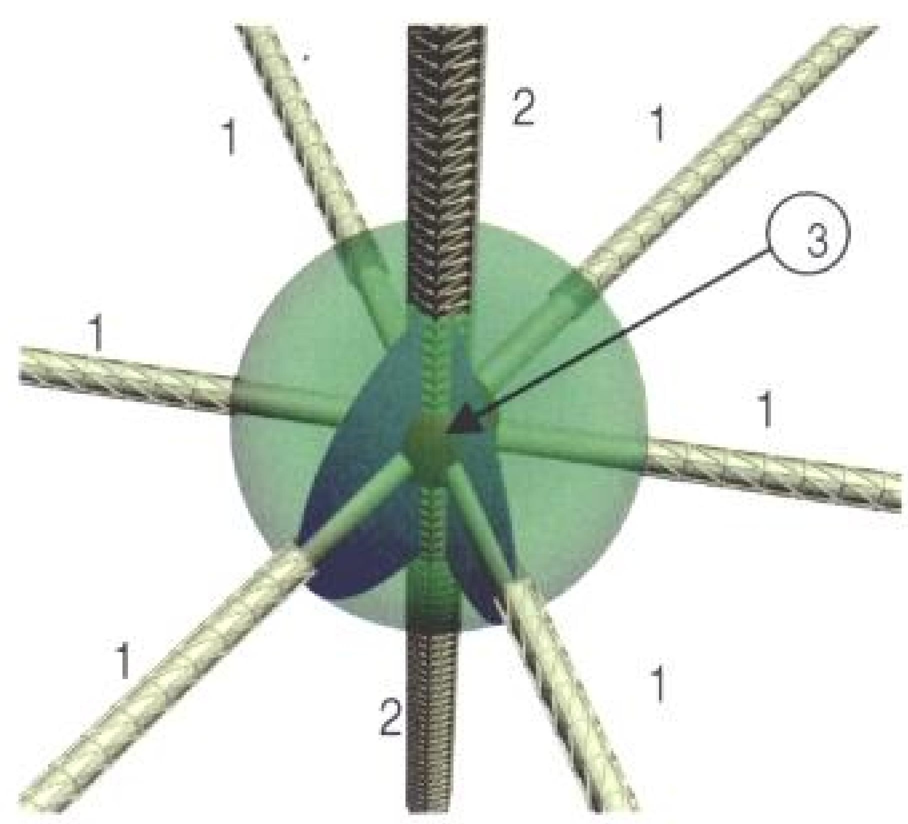
Picture 2.2.a

B. Central sphere (picture 2.2.b):

This sphere connects FELDs to industrial areas, docks and the observation belt. The six tubes through which gravlifts move (1) and the central axis through which the freelifts move (2) pass through here.

In this area, there are areas allocated for entertainment and mostly for research, considering the advantage that 0g experiments can be performed. The research is not placed near the industry, to avoid it being affected by vibrations.

Between the entertainment and research areas, there is a RMA (robot maintenance area). In the center, there are the intersection of all gravlifts and freelifts, the mechanism which moves a transportation container from one lift to another (3), the area for storage of unused containers and the maintenance area. The main computers of Bellevistat are also located in the central sphere.



Picture 2.2.b

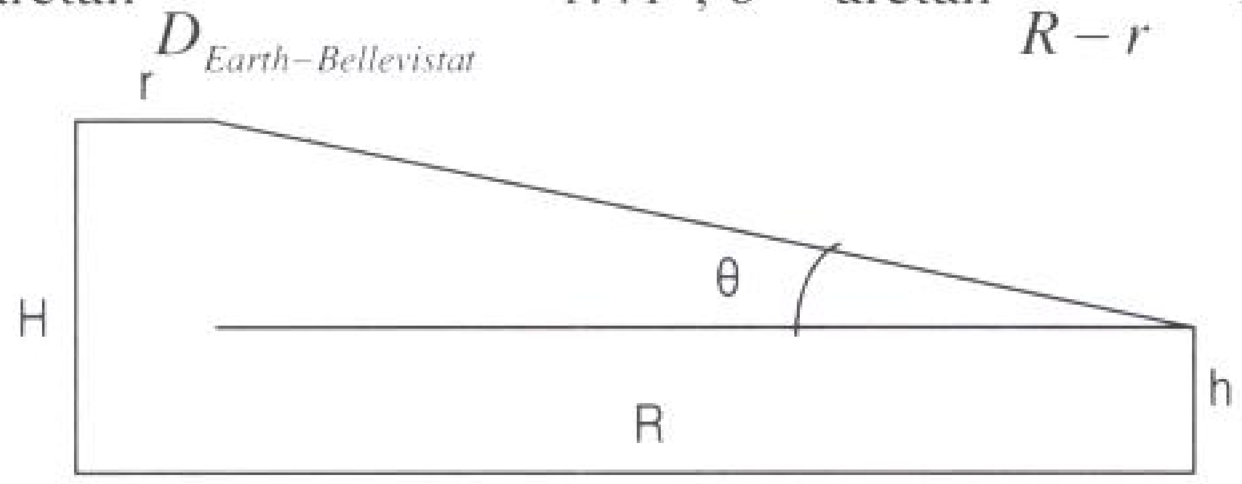
The central sphere is symmetrical with respect to the plan around which Bellevistat rotates, and is divided as described in picture 2.2.b (see the blue planes).

C. Industrial spheres:
The industrial spheres are divided in :
1. storage area
2. industrial areas– with the radius chosen so that, in this area, the gravitational acceleration is lower than 0,05 g.
3. the transition area – this area is divided in multiple subsections:
    1. The area in which people descend from freelifts
    2. The intermediate area, which starts rotating after people enter it, so that they may pass into the observation belt.
4. the area allocated for the central axis

D. The observation belt
This belt rotates in opposite direction with respect to the station, so that people may observe a fixed point outside the station (the absolute rotation speed being 0). The belt has two purposes : entertainment and research. Here, people may enjoy views of Earth at different moments of the day. Also, researchers may perform astronomical studies by means of sensors, telescopes, etc.

In order for the Earth to be completely visible, it is necessary that the θ angle be greater than

$\arctan \frac{2R_{Earth}}{D_{Earth-Bellevistat}} = 1.41°$; $\theta = \arctan \frac{H-h}{R-r} = 1.73°$ Therefore, Earth is completely visible from the "belts".

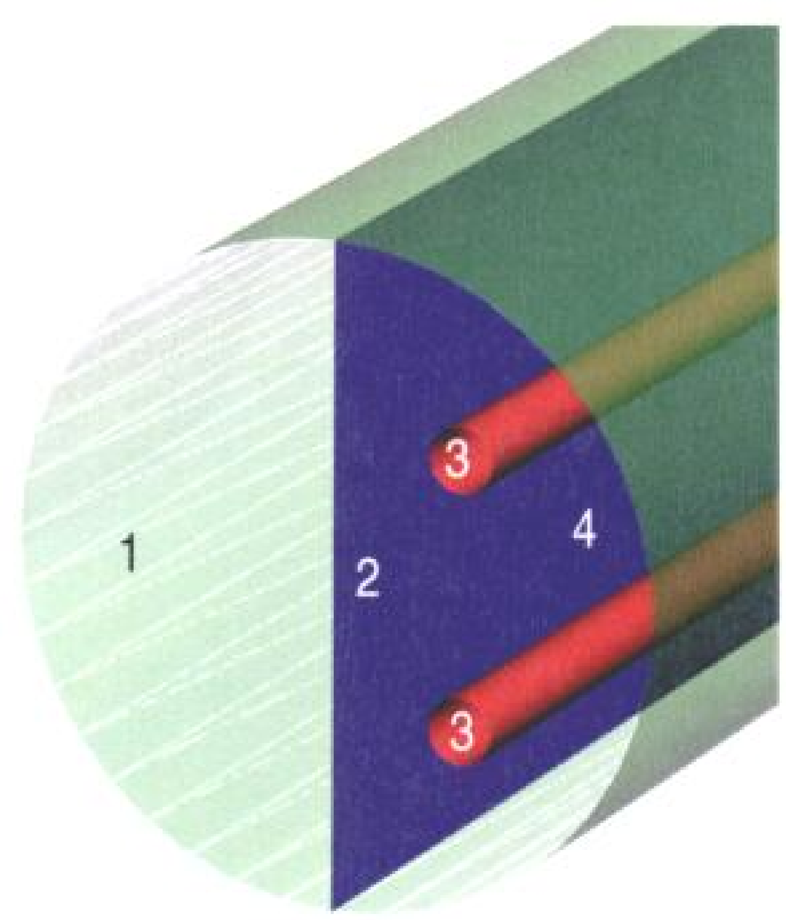


R – radius of the station
r- distance from the observation location to the central axis
H – distance from the observation location to the station's plane
h- Semiheight of solar panels

Picture 2.2.c

E. Gravlift tubes
These transport the lifts which connect the FELDs to the central sphere. They enter the agricultural area. Wiring is also located in these tubes.

F. InterFELD Circular Tubes (IFCT)
These connect two consecutive FELDs and are divided:
1. Interfeld parks: these are at the level of residential areas and offer the possibility of walking through a forest.
2. Auxiliary infrastructure: This area allows the IFT to pass between FELDs, and also includes wiring. It is also a backup system, to allow transportation of water and other resources in case a FELD is damaged.
3. Transportation area : The tubes through which interFELD trains move are located here. Most of the interFELD population flow passes through them. These tubes have a radius of 5m.
4. On the exterior, there are Li-Ion batteries which store electrical energy, as well as infrastructure necessary to maintain optimal parameters. Intermittently, there are areas where solar panel robots can rest and charge and areas with fuel cells (not shown here).



Picture 2.2.d.

G. Freelift tubes
These tubes connect the central sphere to the small docks and the industrial spheres and their corresponding belts.

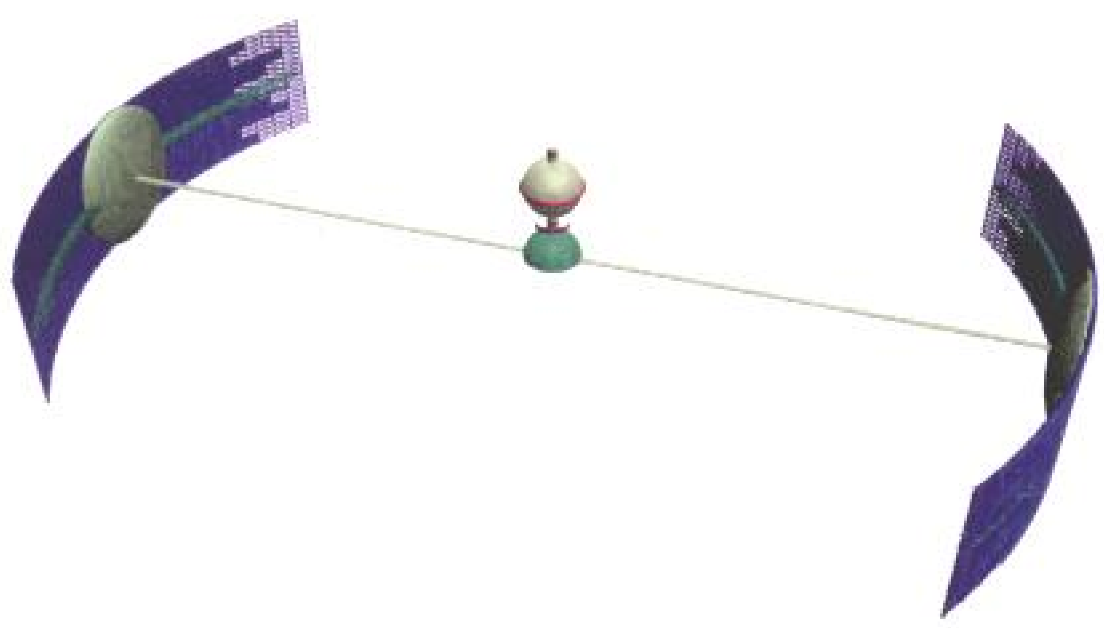
There are two such tubes towards each industrial sphere for fluidization of traffic. This sector is pressurized and separated from the access paths from the industrial sphere to the large ports, which are not pressurized. Wiring is also located here. Docks are discussed separately in *section 2.5*. Top down maps of the FELDs are in *section 4.*

2.3. Construction

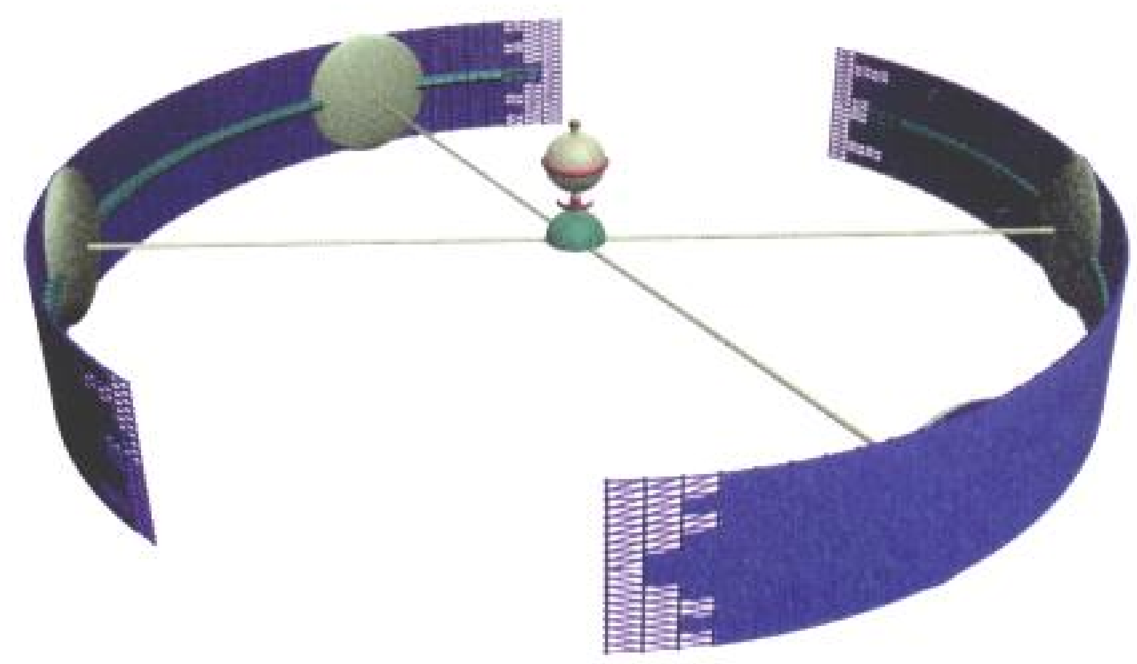
The construction stages are chosen in order to satisfy two conditions:

- It must be possible to redesign at least the second part of the station, in case testing of the first one reveals deficiency in the design
- The costs must be reduced, by beginning the amortization as soon as possible

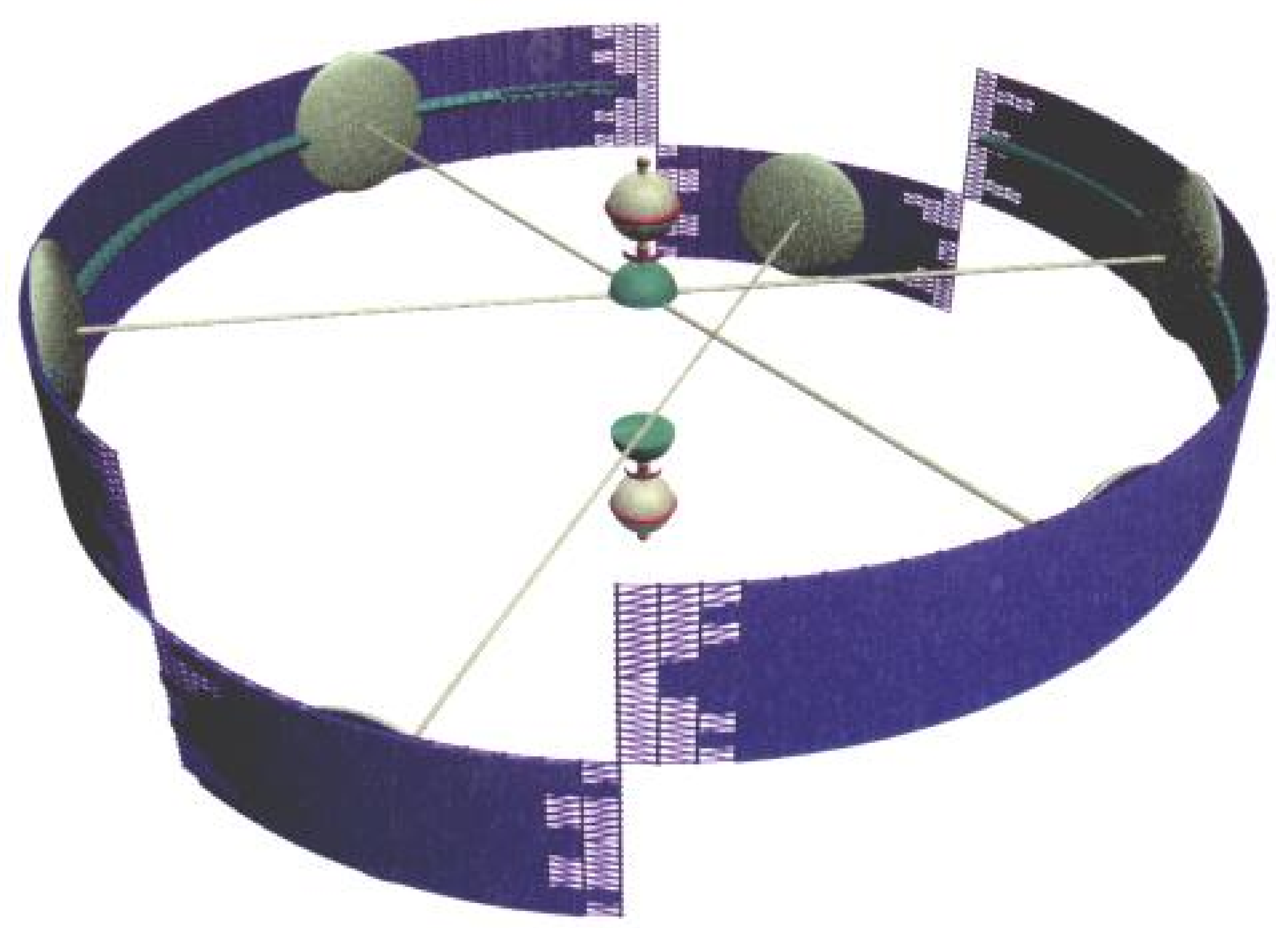
The first module is built on Alexandriat. It includes two diametrically opposite FELDs and half of the central axis with the corresponding structures (solar panels, half of the central sphere, one industrial sphere, a small dock and a large dock) and, once built, is sent to L4. It « hosts » 6000 residents. The second module is built on Bellevistat with resources gathered from the captured asteroid and includes two more diametrically opposite FELDs. When the second module is finished, the third module (symmetrical to the first one, constructed near Alexandriat as well) reaches its destination in L4 with 6000 more residents and is assembled. In the final stage of the construction, for Bellevistat to be fully populated, Hucul vessels are used to bring the last 6000 dwellers from the spaceports in LEO, where they were brought from Earth using Palominos. The construction sequence is detailed in *section 6.1.*



First phase of the construction – first module



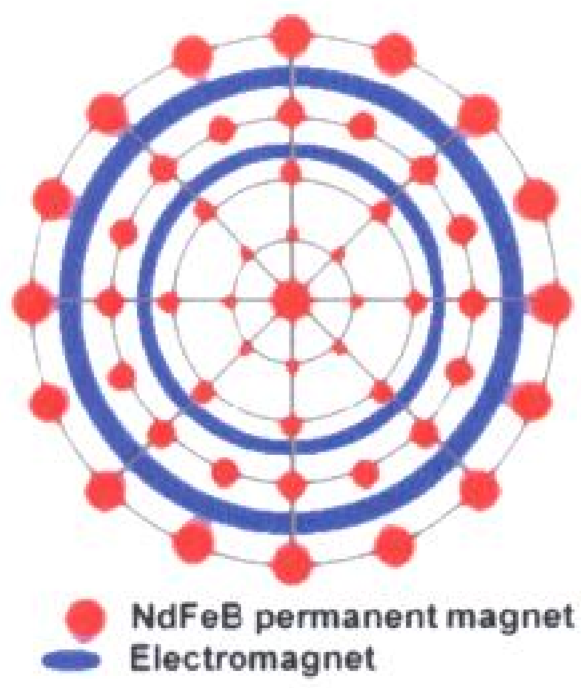
Second phase of the construction – first and second modules



Construction almost finished – aligning the third module

Picture 2.3.a to 2.3.c

2.4. Mining of the captured asteroid

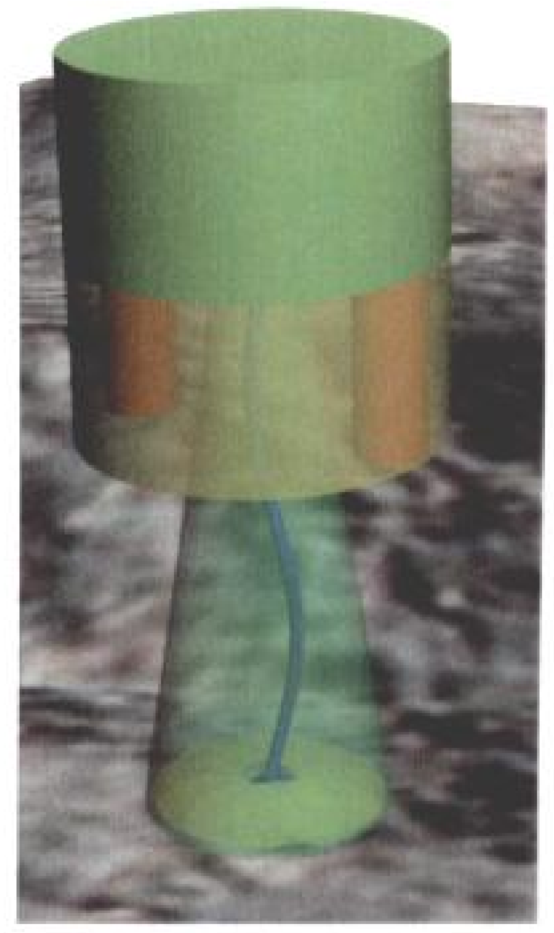


Picture 2.4.a

In orbit around Libration point L4, a metallic asteroid is captured. Its mass is approximately $4x10^{13}$kg. Being a nickel-iron asteroid, it contains large quantities of Fe, Ni and Co, traces of Ti and other materials in small quantities.

Considering the presence of Fe, maintaining of robots on the asteroid and fixation of structures on its surface will be done magnetically. The attachment structures have a system formed of an elastic membrane on which there are more small, neodim permanent magnets. The design includes electromagnets which are enabled during detachment. Because of the flexibility of the membrane, this structure can attach to the asteroid regardless of the terrain roughness (see 2.4.a).

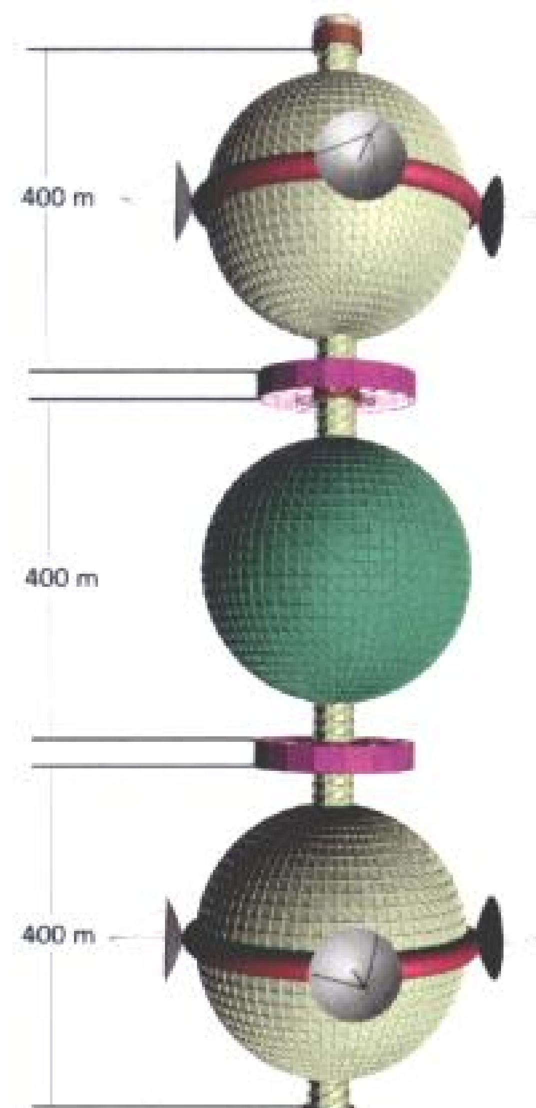
The mining process is described in more detail in *section 5.3.3.* After the Harvester (picture 2.5.b) has mined a cache of ore, it is brought with Huculs to the settlement and unloaded through one of the two bulkcarrier docks. The ore is stored in the storage area around the respective industrial sphere, where it is processed. The products are then stored in the same storage area, in a different section, and loaded on a bulkcarrier transport through the same dock. Under normal circumstances, no trace of the ore is in contact with any pressurized volume.



Picture 2.4.b

2.5. Spaceports

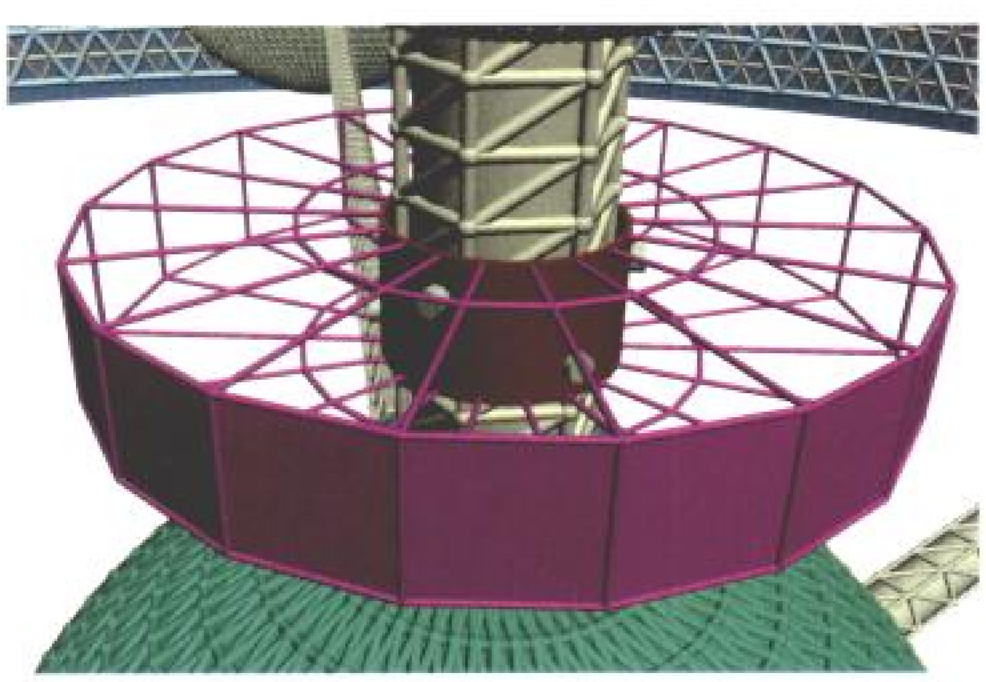
There are in total four docking facilities separated one from another by about 400 meters for redundancy in case of an accident (picture 2.5.a). Moreover, they are placed so that in the event of a vessel deviating from the approach path there is plenty of room available so it can maneuver safely, without risking damaging any pressurized volume. In a worst case scenario, the vessel collides with the storage spherical shell of the respective industrial sphere, an occurring much less threatening than a collision with an inhabited area, for example.



Picture 2.5.a

2.5.1. Bulkcarrier docks

The docking of ships is done along the main axis. The attachment system has six points which form a regular hexagon, such that the axis of the transfer cylinder passes through the center of the hexagon. The attachment points are sustained as in picture 2.5.b and have arms which extend and pull the ship until the attachment is successful.



Picture 2.5.c

2.5.2. Personnel docks

A port is made of six docks arranged as in picture 2.5.c, so that the distance between any two ships docked and between the ships and the central structure are maximized. The attachment of ships is done perpendicularly on the central axis. The port and the docks rotate in a direction opposite to that of the station, so they are stationary with respect to the fixed stars. There is a segment in the axis which serves as an intermediate chamber, through which people and cargo may pass between Bellevistat and the docked ship. The intermediate segment adapts its speed so that the transfer may proceed: synchronized with the colony when people and materials are transported from the intermediate chamber to the colony or from the colony into the intermediate chamber, and synchronized with the docks, when materials and people are transferred from the docks into the intermediate chamber or from the intermediate chamber to the docks. Therefore, the intermediate chamber accelerates and decelerates at least one for each transfer between the settlement and a vessel docked in a personnel dock. All access areas of the personnel

Picture 2.5.b

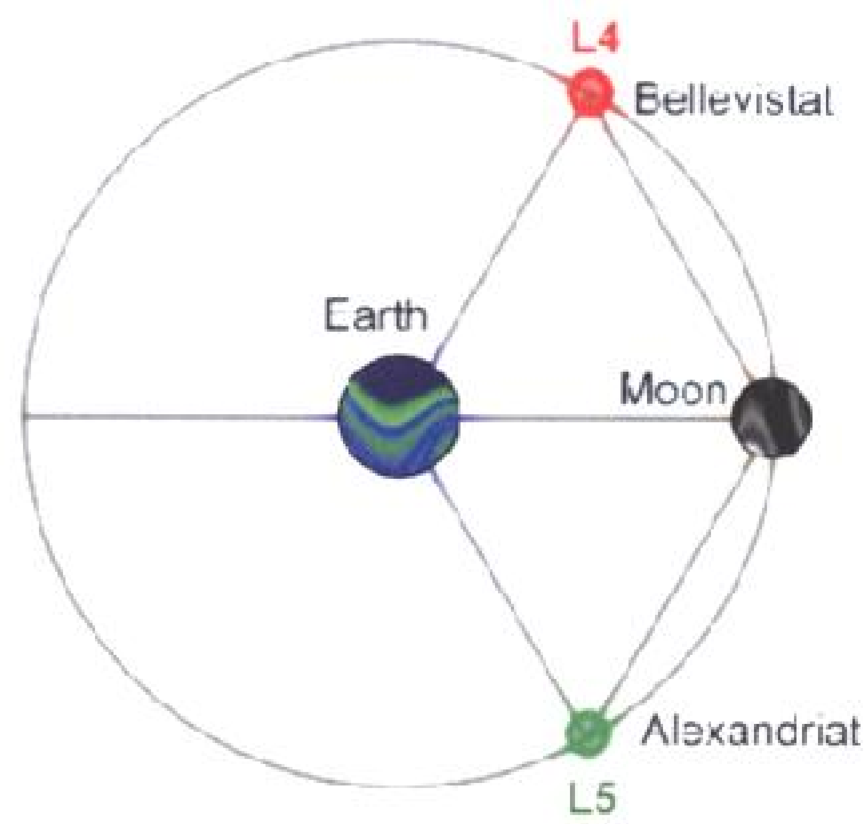
docks are pressurized. To protect docked ships from external threats, there is a cylindrical protection structure, which includes elements that slide along the rest of the structure at transfer.

3. Operations and infrastructure

3.1. Orbital location, materials and equipment

Bellevistat is located in the libration point L4 of the Earth-Moon system basically because of the proximity of a captured asteroid as shown in fig.3.1.a. Furthermore, L4 is a stable location and there is no need for additional energy to maintain the settlement on the orbit around Earth and it brings great benefit to the research field and space exploration.

Fig. 3.1.a



Part of the materials used for construction are taken from Alexandriat, and the rest are mined from the asteroid. The equipment used is also taken from Alexandriat and are purchased from AAD. Two parts of the station are entirely constructed on Alexandriat and send afterward to the final location. Raw materials are transported from the asteroid with the space-vessels "hucul", and are further processed in the industrial spheres where are partially used for finishing the settlement.

Material	Purpose	Source	Shipping method
Fe, Ni, Cr, Co, traces of other metals	Superalloy production	From Alexandriat during the first two construction stages, from the captured asteroid afterwards	Hucul
Inconel 600/X750 Superalloy	Structural support, interior structuring	Ore deposited in industrial spheres	Using freelifts
SiO2	Solar panel array	Moon and S-type asteroids, via Alexandriat during the first two construction stages, directly afterwards	Hucul
Demron	Radiation shielding	Earth	Percheron (Earth to LEO) Hucul (LEO to OSC)
Polyethylene		Alexandriat	Hucul
Aerogel	Thermal insulation		
Polystyrene			
Airproof rubber	Minimization of air loss		
Quartz treated glass	Space observation		
H2O	Multiple (life support)	Earth via Alexandriat in the first two construction stages, directly from Earth during the third	Percheron + Hucul
N2, O2, minor atmospheric gases (noble, etc)	Atmosphere of colony, agriculture		Percheron + Hucul, gas in liquid state (pressurized container)

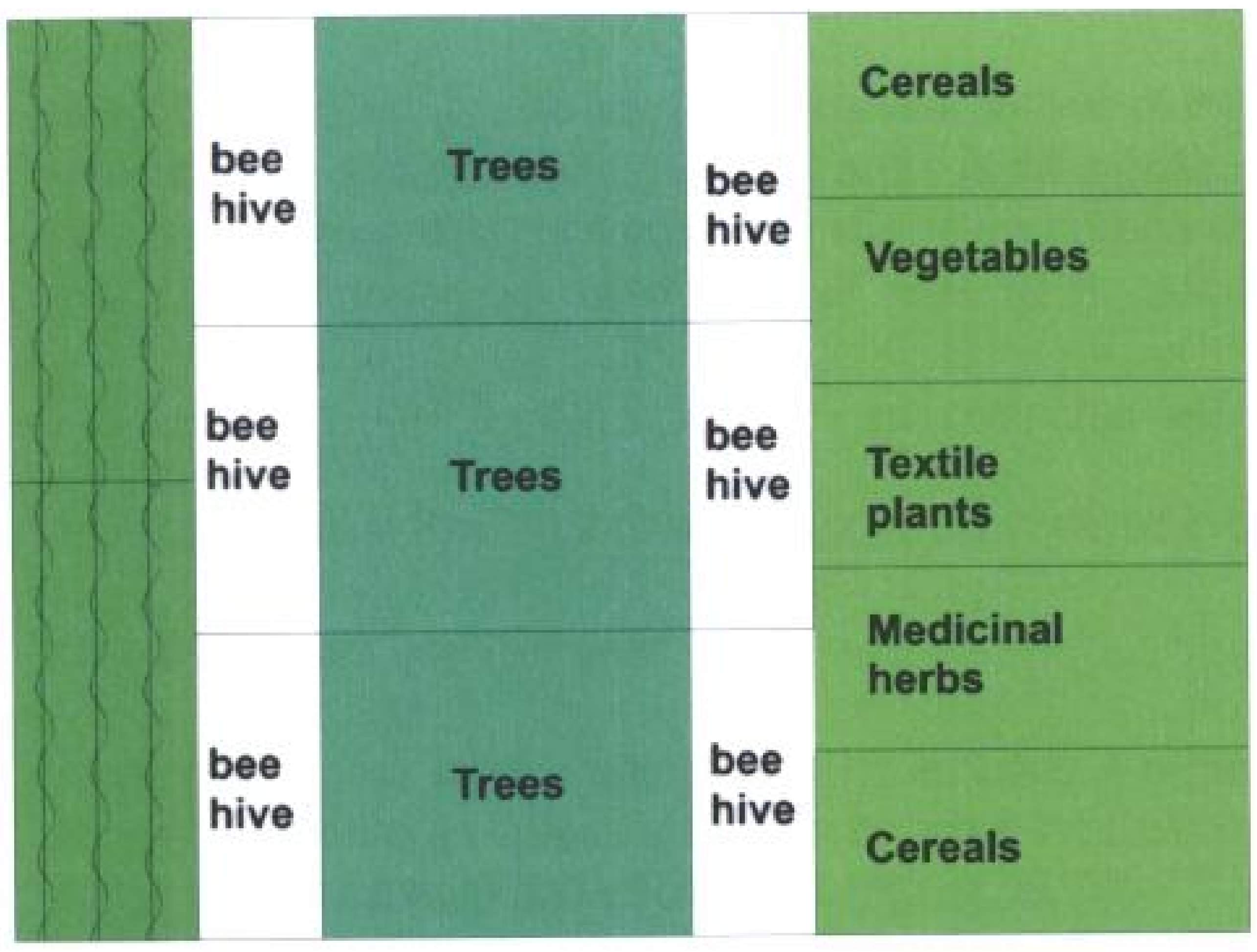
In the first two steps of the construction process most of the materials are taken from Alexandriat, while the third step is realized with materials from the captured asteroid.

3.2. Infrastructure and operations

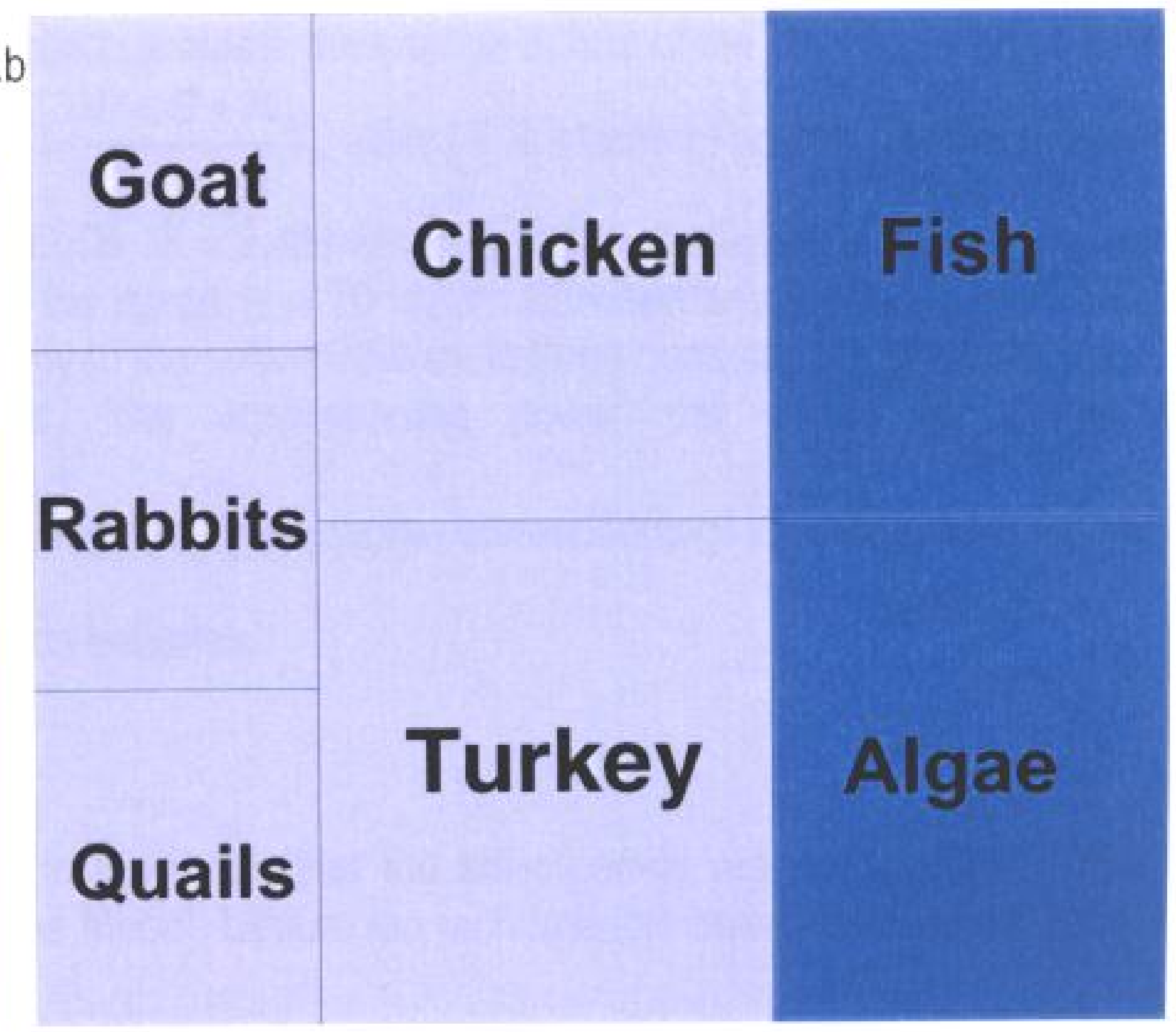
3.2.1. Food production

Feed on Bellevistat is being made centralized and resembling the vegetarian diet a lot. It is mainly based on vegeables, fruits, algae and mushrooms , each being chosen so that it consists of the necesarry substance intake for humans. A list with the chosen plants can be found at section 4.1. Although many studies show that a vegetarian diet is most likely to have, Bellevistat also offers a large variety of meat, encouraging the consumption of less complex proteins found in fish, seashells etc.
In the area especially designated zone for agriculture , below the habitable level of the FELDs, the space is properly divided as shown in picture 3.2.1.a:

Picture 3.2.1.a



Picture 3.2.1.b



Vegetables are being grown in hydroponics, while animals are grown in a separate place. The distribution of the agricultural are distributed as shown in picture 3.2.1.b

Fruit trees are grown in both the agricultural and rezidential areas. To control the environmental aspect of the comunity , mantainence robots will be responsible for picking up the fruits. This process in explained in detail at section 5.2. The goods in raw state are deposited in the agricultural area, in a storage place, near the „Kitchen", until they are needed. Residents are able to choose their menues in advance using a specialized system. The products are then proessed it the FELD's „kitchen" according to a predefined recipe and delivered through IFT system, so that they get to the destination at the requested time.

The food packing is being done, by default in the comestible plates obtained by pressing rice. One can choose whether he would like to receive his food in aluminium foil, instead of the default rice bread. The food is included in the facilities offered by the settlement so, whenever one erquests for a delivery he doesn't have to pay.

3.2.2. Electrical power

Electricity is a crucial element for the operations that are taking place on Bellvistat.

3.2.2.1. Solar Panels

The whole energetic requirement is assured by the solar panel belt. They are based on photovoltaic cells with silicon dioxide, with efficiency $\eta = 0{,}33$. They are placed in the exterior of the settlement, along a belt. They are being fixed on the endurance structures, formed by triangular elements similar with the ones of the settlement, also formed by Inconel X750 linear elements. The settlement's size allows for enough energy to sustain a mining colony because numerous chemical processes and material processing take place here. Taking in consideration that the solar flux at panel level is $E = 1366 W / m^2$ and the projected surface is $S = 3{,}580{,}530\,\mathrm{m}^2$, according to $P = E\,S\,\eta$,the settlement's power is $P = 1{,}614{,}031\,\mathrm{kW}$.

Bellevistat's whole maintenance system depends on the solar panels. One of the most important factors for sustaining life is light.

The illumination on the FELDs is being made artificially, with the help of a combination of fluorescent lamps, sulfur plasma lamps and halogen lamps, which closely resemble the solar light (Color Rendering Index >95%). This method was chosen because there is no practical method to bring the solar light to the FELDs by means of succesive reflections and to enssure an illumination close to the daylight value of 10^4 lux, without the impractical dimensioned mirrors. These lamps are placed on the "ceiling" of every FELD, on structures that hold them in place, power them and cool them with air currents. Those structures are suited to allow the maintainence robot, "Daniel", to do different routine operations as part of its job. The maximal illumination at Earth's surface is aprox. 90000 lux, but this value is met in the tropics in the noon, in best atmospheric conditions. A maximum value of 45 000 lux is more apropiate for a sunny day on 45° latitude. In order to make the day-night cycle, indispensable to humans, illumination varies periodically between 0 and 45000 lux in 24 hours. With the help of a mobile structure, with a higher concentration of high-power lamps (sulfur plasma) it is simullated the passing of the Sun on the sky, and also the moon during nighttime. There are specific variations regarding the maximum illumination, concording with the simulation of seasons from

Earth's northern hemisphere. There is a small number of lamps which simulate the change in hue of the sky. The electric power allocated to illumination is 788 MW, according to the formula $P = \frac{L * S * K_t}{\varepsilon}$, where P is electrical power, L is the maximum daylight illumination (L = 45 klux), S is the total surface of the FELDs (S = 2.451 km2), K_t is the coefficient associated with the existence of a circadian cycle (K_t = 0.5) and ε is the efficacy of the lamps (ε = 70 lm/W). Between any 2 consecutive FELDs there is a timezone delay of 4 h each, to ensure the uniform activity of the colony and the uniform consumption of electricity. The rest of the power is used for all the other activities. The coresponding power per capita for Bellevistat $P_1 = \frac{P_{total} - P_{lighting}}{N} = 43.5kW$, as compared with the power per capita corresponding to Germany, a highly industrialized state P1=710 W. The excess power in stored in Li-Ion batteries.

3.2.2.2. Batteries and fuel cells

For storing excess electric energy and for ensuring a backup in the event that the solar panels are not functional (due to damaging or during an eclipse of the Sun by either the Earth or the Moon), Lithium Ion rechargeable batteries are used, because of high specific capacity and efficiency as high as 99.9%.
During the movement of revolution around the Earth, Bellevistat is eclipsed both by the Earth and the Moon. This is a factor to be considered, as the energy collected by the solar panels depends on illumination.

$$\Delta t_{Earth} = \frac{2R_p}{v_t} = \frac{2R_p}{\omega_L \cdot R_{PL}} = \frac{2R_p}{\frac{2\pi}{T_L} \cdot 81R_p} = \frac{T_L}{81\pi} \cong \frac{28 days}{3.14 \cdot 81} = \frac{28 \cdot 24\ hours}{3.14 \cdot 81} = 2.6 hours$$

$$\Delta t_{Luna} = \frac{2R_L}{v_t} = \frac{2R_L}{\omega_L \cdot R_{PL}} = \frac{2R_L}{\frac{2\pi}{T_L} \cdot 81R_p} = \frac{T_L}{81\pi} \cong \frac{0.273 \cdot 28 days}{3.14 \cdot 81} = 0.7 hours$$

Where Rp = 6.4 x 106 m is Earth's radius, TL = 28 days is moon's period of revolution, RL = 0.273 Rp is Luna's radius.

The batteries should be able to withstand all the colony's activity for a period of blackout of at least 5 hours (in the event of a minor malfunction of the solar panel array). In the event of a major malfuntion or calamity, when the FELD daylight lighting system and heavy industry would be interrupted, but the artificial interior lighting and outdoor night lighting would be kept active, batteries and fuel cells should be able to produce the necessary power for at least a week. This way, an approximative capacity of 8 GWh is required, that, using a specific volumetric capacity of 160Wh/dm3 of batteries charged at 60%, leads to a volume of approximatively 50 000 m3 of batteries. On the other hand, the batteries have a volumetric specific maximum power of about 3 kW/dm3, so a volume of 530 m3 is necessary to cover the consumption for the full operation of the colony. Consequently, a volume of 50 000 m3 of bateries are sufficient for both the power and capacity requirements of Bellevistat for five hours. The batteries are placed in the lower part of the tube that links the FELDs, below the train tunnel level. There also exist batteries in the proximity of critic areas (for example, in the central sphere, near the computer core, near the observation belts and the personnel docks).

There also exists a second backup system: fuel cells. These are based on the reaction between hydrogen and oxygen $2H_2 + O_2 \Rightarrow 2H_2O$. Alkaline fuel cells are being used because they have a high efficiency (60%-70%) and because they only use hydrogen and oxygen and produce water. According to the table in section 3.2.2.3, in case of an emergency, the average power necessary for one inhabitant is 2.7 kW. Because fuel cells require fuel that is difficult or expensive to obtain, they are activated only when the malfunction cannot be repaired in less than 5 hours. The electric capacity required to run the colony in emergency state for one week is aproximatively 8600 MWh. Since the batteries have a capacity of approximatively 8000 MWh, the fuel cells need to have aminimum capacity of 600 MWh. This double backup solution ensures a high safety standard for the inhabitants and the colony and a swift functioning of the space settlement in the event of various malfunctions of the electrical production and distribution system.

3.2.2.3. Allocation of electrical power

Consumer	Power (kW)	Power per capita (kW)
Daylight FELD lighting	788 000	41.5
Light industry	19 000	1
Transportation	120	0.006
Heavy industry	410 000	21.6
Agriculture	280 000	14.7
Keeping the observation belts and docks stationary, use of intermediary chambers	1000	0.052
Household use	9500	0.5
Entertainment	2400	0.13
Research	20 000	1.05
Batteries	80700	4,24
Total	1 610 000	84.7

3.2.3. Communication systems

3.2.3.1. Internal communication systems

The internal communication system is based on an 802.11n wireless network. There are access points that cover the entire station, as described at section 5.2.2. Personal communication is done through small mobile devices, described at section 5.2.1.

3.2.3.2. External communication systems

The primary communication system with Earth is based on two optical (LASER) links between the station and Earth. This system allows for a much wider bandwidth than Ka-band communication. The two observation belts around the industrial spheres are at rest in respect to Earth's position. Each of these has a laser beam pointed towards a sattelite in LEO.

Two beams exist because it is possible that an object crosses one of the beams and interrupts the communication for a short time. The pair of beams transmit the same information simultaneously, to avoid interruptions and perform error correction in sensitive applications.

The same communication system is used for communication with the Moon and Alexandriat. In the latter case, the two bodies have a small speed with respect to each other. For that reason, the beams' directions are adjusted automatically by permanently calculating Alexandriat's trajectry. In case one of the settlements needs to perform maneuvers (to avoid asteroids) it communicates the exact parameters of the movement, so that they direction of the beams can be adjusted.

Apart from the optical communication system, Bellevistat can also communicate in Ka-band radio by using 8 antennas, also attached to the observation belts. This system is used to communicate with nearby ships and is also a fallback solution, in case the position of the station is modified unexpectedly, to be able to realign the optical communication system.

3.2.4. Internal transportation

Because the radius of a FELD is 360m, transportation vehicles are not necessary.

3.2.4.1. Transportation between FELDs

Between FELDs, transportation takes place with small trains called Railsters. These are safe, as rails ensure that the trains do not deviate from their normal trajectory. Railsters travel through tubes, under the inhabitable level, between every two adiacents FELDs. The transportation tubes are underground to avoid accidents and and to improve fluidization of traffic.

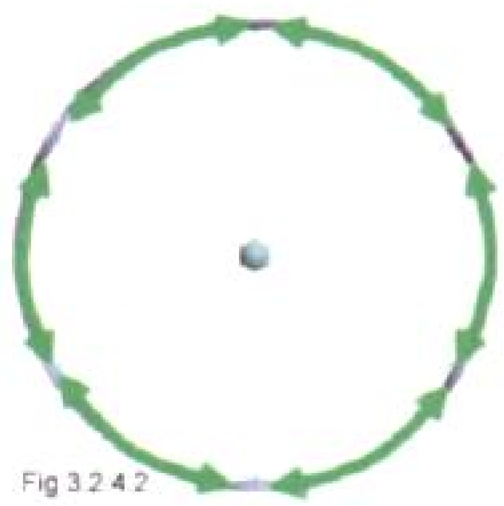


Fig 3.2.4.2

On each FELD, there are two railster stations for failsafety, located near the center. From each station, trains can be taken towards both ways. Considering that the maximum distance between two points in the settlement is $d = \pi R = 7798\,m$, and the time necessary to reach between

two FELDs 1 minute, the average speed of the trains is $v = 36km/h$.
A railster can carry 15 people. To ensure the traffic flow can be handled, there are 8 railsters, 2 on each tube, 4 on each way.

3.2.4.2. The IntraFELD Transportation system

The IFT is a set of tubes distributed radially, which ramify to reach each building as in fig. 3.2.4.2. The purpose of these tubes is to allow transportation of food, shopping items and robots. The capsules that travel in these tubes are paralelipipedal, having two fixed dimensions (0.5x0.5m) and an adjustable length, augmentable by concatenation of multiple ones (one element having the length of 1m). The capsules travel on rails and are controlled by computers, so that no collisions appear.
The dimension of the tubes decreases with the degree of ramification, the minimum supporting one capsule, while the main arteries supporting 3.The tubes are parralel with the water distribution pipes.

3.2.4.3. Lift transportation

There is a lift in each transport tube to the center. Each of these lifts have specific leanings to compensate for the Coriolis effect. They operate with minimum charge restrictions. If it is not possible to form a group of people to justify a transport from a single FELD, people are transported by Railsters to a common location to form a bigger group. These lifts are called „gravlifts".
Through the tubes that connect the central sphere to the industrial spheres a different kind of lifts exist. For these, there are no restrictions because the energy consumption to move them is small. For this reason, they are called „freelifts". There are two shafts towards each industrial sphere.
Both types of lifts transfer sphere-shaped containers which may contain either passengers or cargo.
In the center, there is a transfer mechanism which allows a container to be exchanged both between two gravlifts and between a gravlift and a freelift. Its length is the same as the diameter of the exchange area. The mechanism rotates around the center, and it can be aligned with any of the gravlift tubes. When a gravlift arrives, the mechanism aligns itself with its tube and the container is transfered to the center of the mechanism. After that, if a transfer to another gravlift is desired, the mechanism is realigned and the container transfered to a new list. Otherwise, the container is forwarded directly to a freelift.

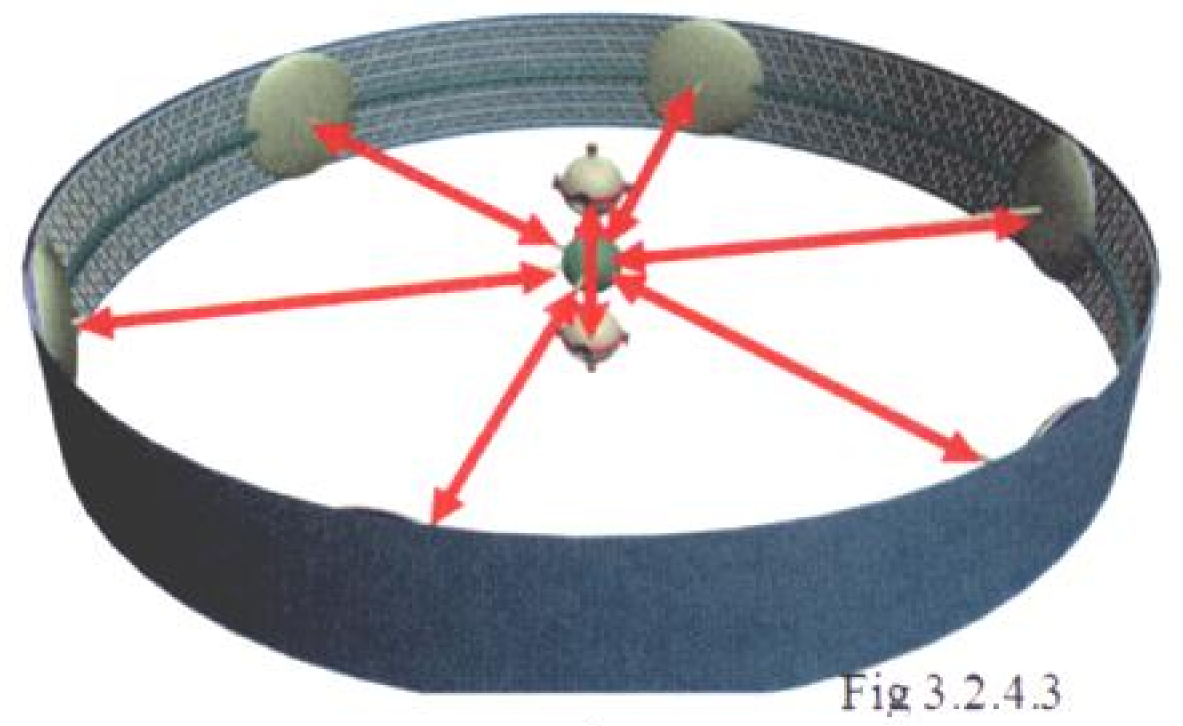


Fig 3.2.4.3

3.2.4.4. Moving in 0g

Among the advantages of a space settlement is access to 0g areas. People move between 0g facilities with the help of Guiders. A person selects the desired destination and gets attached to a glider, by holding on to the handle of the structure. Before reaching the destination, the guider reduces the speed to 0 to allow the human to let go. The gilders have a speed of 10km/h, ensuring an efficient and fast transportation on distances lower than 500m.

3.2.4.5. The intermediate areas:

These areas are located in the industrial spheres to allow passing to the observation belts. The areas vary their speeds, from 0 to the speed of the belt, to allow safe passage between the two areas. Before the rotation begins, people attach themselves to the margin of the area with a safety belt to avoid accidents.

Such areas also exist at the location of small docks, having a similar functionality.

3.2.5. Atmosphere control

Atmosphere control is essential for the good functionality of the settlement. The Atmospheric conditions are similar to Earth's: 78% N_2, 21% O_2 and 1% other gases. The oxygen is produced by the plants on the settlement so that the air is produced as natural as possible. The atmosphere control system equalizes the gas concentration so that they remain the same over time. Relative humidity is constantly kept at 50%, and the air temperature is 23-25 °C. The settlement is completely thermally insulated, so that there is no heat loss. Heating is maintained by the electrical system located under the residential area and in the walls. The atmospheric pressure is maintained at 95,350 Pa.

3.2.6. Waste Management

The waste management process includes reduction, reuse and recycling of all materials so that the loss of all materials is minimal. The purpose of this process is to extract the maximum quantity of material. That is why all materials are permanently and constantly recycled as in fig. 3.2.6.

Fig. 3.2.6

- Organic matter is recycled through the composting process. This process allows the aerobic bacteria to transform waste in fertile topsoil. Plant waste can be used to produce paper.
- Metals are initially turned into small pieces, and then they are melted. This reduces energy costs and has a great benefit on the environment. Also, metal alloys are separated on the basis of different melting points between metals.
- Glass is initially monitored, so that any trace of contamination is eliminated. Glass is turned into small pieces, melted and then remodeled. Glass is permanently recycled and it is not deteriorated during the process.
- lastic recycling process involves a condensation polymer essentially undergoes the inverse of the polymerization reaction to manufacture it. This yields the same mix of chemicals that formed the original polymer, which can be purified and used to synthesize new polymer chains of the same type.
- Recycling liquid waste (including urine and brine residues) using The Oxygen Generation Assembly (OGA) consisting of 18 electrolysis cells. Oxygen and Hydrogen is produced through ion exchange membranes.

3.2.7. Water circuit:

Water is a necessary condition for life. Studies show that a human being needs 31 liters of water per day to live a normal life, considering the following: drinking water, the water from the food, the water necessary for cooking, the water necessary for daily hygiene and the water needed for washing dishes and clothes. First, the water is brought from Earth and Moon, so that the initial quantity is 600 m^3. Each FELD has its own water storage as well as its own radial water management system. If one FELD loses its water storage, there are additional pipes between the storages so it can access any other storage to temporarily supply from them. There is a similar system in the industrial spheres

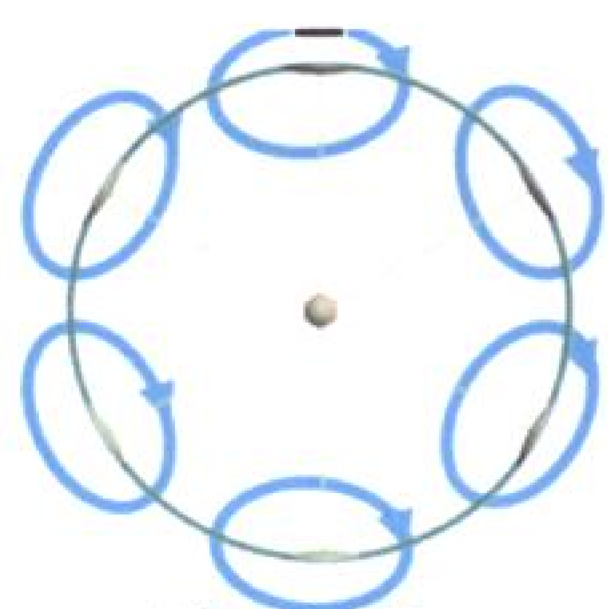


Fig. 3.2.7

To maintain the autonomy of the settlement, water is recycled so that loss is minimal. Water purification facilities are built in every FELD to provide constant and efficient recycling of water.

Water purification process consists of three smaller processes: physical process, chemical process and biological process. The first filter separates the particles and the impurities in water. Then the water goes through several multi-filtration beds that contain substances which separates the water from the organic and inorganic impurities. Bacteria, viruses and others volatile organic compounds are finally removed with the catalytic oxidation reactor. The efficiency of this process is maximal so that the losses are minimal. Furthermore, the stored water suffers an UV treatment in order to slow the cell division hence the foreign organisms.

Water quality is constantly monitored to prevent any contamination.

3.2.8. Day-Night cycle

Each day on the settlement is as long as a day on earth, which is 24 hours. People work in several shifts, so that Bellevistat operates on full capacity at any time. Between two adjacent FELDs there is a time difference of four hours, so that the inhabitants do not disturb their biorhythm because of time shifts and to globally illuminate only half of the settlement in any moment, reducing costs.

3.3. On-Orbit Infrastructure

Fleet

Type	Number	Source	Use
Hucul	8	Bellevistat	"Hucul" is a space-vessel with large dimensions, especially used for transporting mined materials from the asteroid and from the Moon. It can transport 90,000 m^3 of materials in its hull. The vessel in versatile, since it can be converted to serve other purposes. "Hucul" can be used to transport 400 people, and it can also tow other vessel.
Space tug	2	Northdonning	Transport people from LEO to Bellevistat,

		Heedwell	
Palomino	2	Foundation Society	Transport people from Earth to LEO. This ship is capable of carrying 80 passengers.
Percheron	10	Foundation Society	Transport materials from Earth to LEO. This ship is capable of carrying 18000 Kg at a cost of $2200 / Kg.
Harvester	90	Bellevistat	Harvesters are machines used to mine the captured asteroid from L4. These are capable of mining 1,000 kg per day The mining procedure is described in section 5.3
Selena	20	Bellevistat	Mining , research of Moon

3.4. Agricultural issues

Growing all kinds of plants in the residential area is very unaesthetic and it is also very inefficient. That is why there are only fruit trees in the residential and commercial areas. However, every resident has a 14 m^2 space dedicated to plant growth, where they can choose the plants they grow. If they wish not to grow anything, that space is filled with sod.

The food for the animals mainly consists of cereals and fruits, which is distributed to every animal using the maintenance robots. It is taken from a special animal food storage

3.5. Innovative approaches for home interior finishing

In order to offering extra psychological comfort, people have the option to customize their furniture, which is modular. The default pieces are linked using bars. One resident can use predefined models or can create new ones. The latter are analyzed by the computer which generates the assembly software for robots. After the departure of residents from their houses, the furniture is disassembled and used in other models.

The default pieces are the following:

- Square prisms with the base side of 25, 50, 100 cm
- The subtraction of a cylinder which has the height of the prisms and the radius equal to the diagonal of the base square(minuend) with a square prism(subtrahend) with the base side of 25, 50, 100 cm

The default pieces are automatically brushed up (chamfered, painted, etc.). The resident can choose one of the materials from the following table:

Material	Usage	Source
Cotton, linen	Natural external coatings, for better comfort	Agricultural Zone
Kashmir		Agricultural Zone
Polyurethane foam	Filling for sofas, chair, mattresses	Light industry
Polyurethane	Finishing furniture edges, floor isolation	
Glass, stained glass	Prefabricated modules, decorative elements	Industrial zone using harvested materials from moon and asteroids
Carbon fiber	Prefabricated elements for furniture frames	Industrial Sphere, using materials Ni, Fe and refining of Fe for Steel production
Stainless steel		
Nickel plated steel		
Iron		
Iron Oxides	Coloring of furniture elements	Industrial zone, harvested from the Moon

3.6. Construction of building structures

The materials that are used for construction the exterior structure of the house and the interior walls are the following:

Material	Usage	Source
Glass, stained glass	Transparent portions of walls	Industrial zone using harvested materials from moon and asteroids
Stainless steel	Non-transparent portions of	Industrial Sphere, using materials Ni, Fe and

Nickel plated steel	walls	refining of Fe for Steel production
Iron		
Iron Oxides	Coloring of walls	Industrial zone, harvested from the Moon

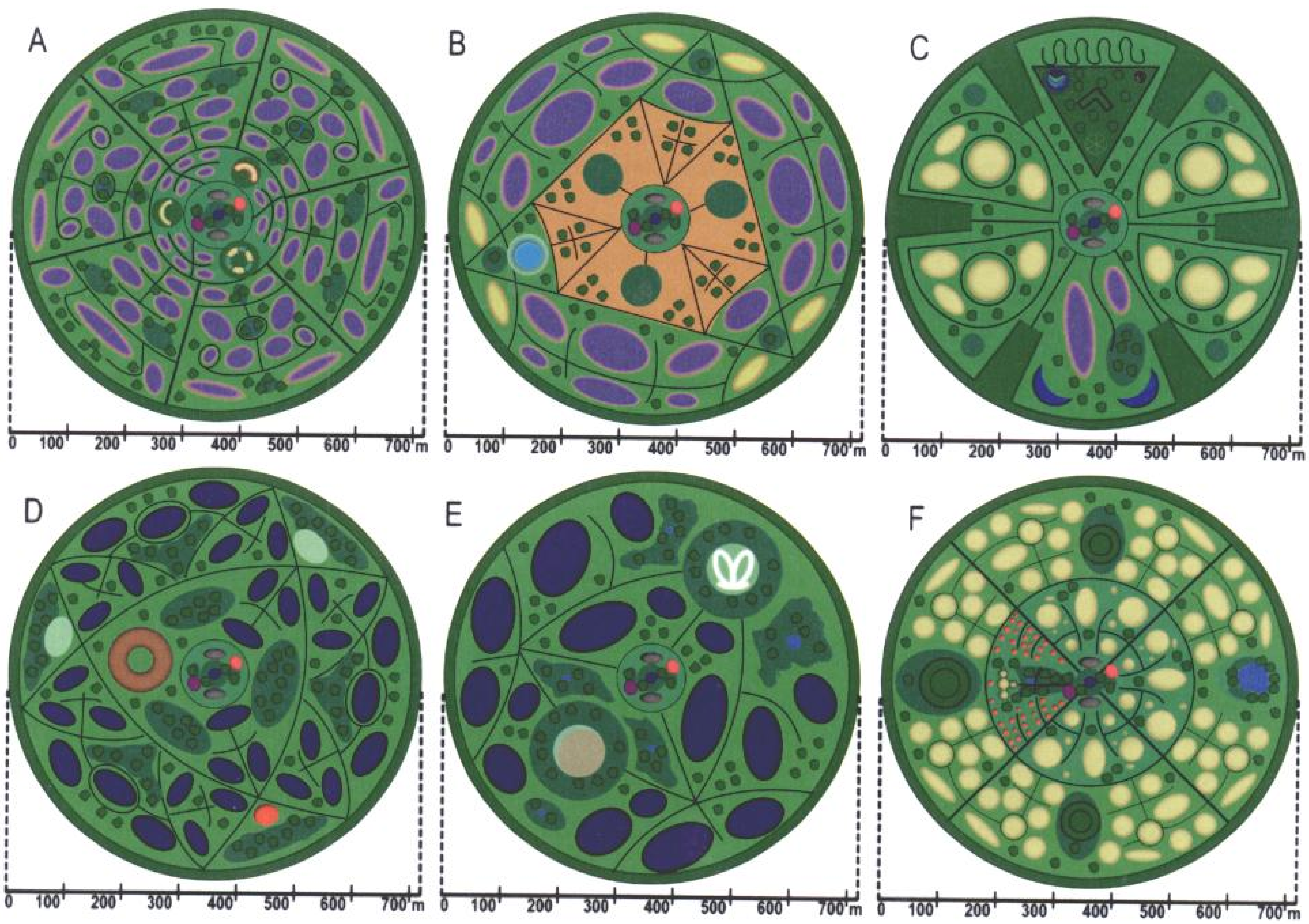
4. Human Factors

Bellevistat's residents and visitors are provided with a high comfort environment, with wide, open spaces, more than spacious houses, a vibrant community, the design of all facilities being advantageous to all psychological considerations. All the recreation and entertainment necessities are covered by Bellevistat, and its location in orbit around Earth allows for unique possibilities, such as direct views of Moon and Earth and other celestial bodies, and zero g entertainment.

4.1. Community design

Bellevistat satisfies all the urban needs of a dweller of one of Earth's large cities, such as comfortable houses, large open areas, fine food, access to cafeterias, restaurants, recreation and other amenities.

No	Timezone offset	Specific	Buildings
1	0	Medical (A)	Hospital, spa, fitness center
2	+4h	Research (B)	Research center, Tranquility Park
3	+8h	Touristic (C)	Hotel, museum, restaurant and lounge
4	+12h	Business and administration (D)	Offices, stores, multiplex cinema / theater
5	+16h	Entertainment (E)	Polyvalent hall, fun fair
6	+20h	Educational (F)	School, maze parks, lake



Note: the dark green edge of every FELD's map represents the 22 meter wide „belt" of permanent forest. In the center of each FELD, there is a common complex that incorporates the gravlift shaft, two subway entrances to the interFELD trains, small convenience shops and first aid centers.

The total area of the FELDs is divided as follows: 38% buildings, 59% public open space (including parks, lakes) and 3% main roads. Likewise, inhabitants walk on grass, side roads being undefined.

A. Medical FELD

The hospital, spa and fitness center are located here. This FELD is suited for calm, balanced people, probably elderly. The spa provides beauty care with algae, honey, aromatherapy and solar soil packings. Visits to the fitness center and spa relax and help people have a healthy lifestyle.

B. Research FELD

The research centre is placed here. To ensure a balance between pleasure and work, this FELD is rich in green areas, being a favorable environment for the intellect, as well as the soul. It is best suited for dynamic people. The Tranquility Park on this FELD, similarly to the one in Houston, pays homage to the space missions of the colony.

C. Touristic FELD

There are four residential areas, the hotel complex and the museal complex on this FELD. The hotel complex encompasses the houses for Bellevistat's visitors, together with two restaurants and lounges, where the visitors can meet and spend time together. The museum complex is outdoors, with the exhibits in open air. There are three monuments placed in the vertices of an equilateral triangle, representing the Earth, the Moon and Bellevistat. Likewise, the exhibits include the colony's robots' models, lunar rocks, asteroid fragments and local art created by the residents in the art studios.

D. Economic and administrative FELD

This FELD includes two business centers and two restaurants where business dinners will take place; there also is a multiplex cinema that can be converted to a theatre. The inhabitants of this FELD are generally taking part in the colony's administration.

E. Entertainment FELD

The Polyvalent Hall is where big events (such as matches, meetings or shows) take place; when no such activity is performed, the hall functions as a hangout bar. In the opposite side of the FELD there is the Fun Fair, which includes a Hall of Mirrors, Merry-go-rounds and 3D cinema (the Virtual Reality Hall). The fair is surrounded by a larger green area to phonically isolate it from the neighboring houses.

F. Educational FELD

This FELD is generally dedicated to families with children, because the educational center is placed here. In addition to this, there is also a park with a lake, where people can come to find tranquility and to meditate. On the lake, water lilies are grown for aesthetical and hygienic purposes, as they help cleaning the lake by filtering the water. On the lake there is also a small fountain with a vertical water jet, the effect of which is amplified by the Coriolis effect and which creates rainbows with the aid of lights placed under it.

4.1.1. Housing

The houses on Bellevistat are designed for offering a maximum psychological comfort. Every resident may allocate their interior space and design their furniture according to their tastes (choosing from a vast offering of templates), assisted by CAD software. In addition, every inhabitant is reserved 14 sq m of gardening area near the house, which they can use to grow fruit, vegetables or plant flowers; if the resident does not wish to use this area in this manner, grass is planted by default.

4.1.2. Education

There are approximately 540 children on the colony, and they receive high grade education from professionals. The Bellevistat school offers education for all levels. Students learn in six shifts so they always start classes from 8 o'clock in the morning according to the time zone in the FELD they live in. Mandatory classes include mathematics, physics, IT, chemistry, biology, astronomy and sport, but optional courses, such as literature, painting, sculpture, cinematography, journalism, economy or photography are also available. There are about 90 teachers and professors. Their activity is complemented by researchers and artists that hold seminars.

4.1.3. Entertainment, parks and recreation

Bellevistat's inhabitants have access to entertainment facilities similar to those on Earth: the Fun Fair, multiplex cinema, restaurants, spa and fitness center. There is a Polyvalent Hall where shows are held and sport activities are organized. When there are no activities planned, the Polyvalent Hall acts as a meeting place.

A large part of the FELDs' area is covered by parks. There is also a permanent forest belt on the edge of every FELD, with a width of 22 meters. In every FELD there is a different type of forest, to ensure variance of the neighborhoods. Throughout the tube that contains the interFELD train tunnels there is also a forest area which transitions between the species in the two adjacent FELDs.

A special type of entertainment is available due to the existence of areas with microgravity in the central sphere. Some of the games are described in section 4.5.

4.1.4. Medical

In the center of every FELD there is a first aid area that is easy and fast to reach. Most light injuries can be treated here and medicine can be prescribed. For more difficult interventions and surgery, there is a hospital in the Medical FELD. Those who need immediate medical assistance are transported to the first aid center of the FELD they are in by a pair of maintenance robots and are accompanied by paramedics. If necessary, they can be further transported to the hospital through the interFELD transportation trains.

4.1.5. Consumables

Residents have access to a varied and healthy menu based predominantly on vegetable products. However, for variety and psychological comfort, they can order meat-based foods as well.

The daily diet is adapted to the work conditions and stress factors of the environment. Therefore, it is recommended that every inhabitant consumes minimum 2 liters of water daily, 450-470 grams dry equivalent of food containing carbohydrates and fat and 60-70 grams dry equivalent of food containing varied proteins, minerals and vitamins; the energy value of the daily diet is approximately 2500-300 kcal. The automated "kitchen" facility prepares balanced menus which provide the daily necessary of every person. The computerized kitchen identifies who makes the order and recommends a variety of menus specially suited for the individual. All menus have an added informative value, as they contain detailed information regarding the ingredients used, the nutrients included and the role of each of these in the metabolism of the individual. The person making the order can, however, select a menu outside the list of recommendations. Although the surface designated for agriculture exceeds the necessary surface for production, plants and animals are grown on multiple floors as follows:

Plants like mushrooms are grown in special shaped structures with many levels, to get the highest productivity on the same surface area. Another example, one square meter of locust tree produces on average 150 grams of honey, and one square meter of Tilia produces on average 100 grams of honey.
Plants are illuminated artificially with special lamps for agricultural use, that have a high efficacy and predominantly output light in the red and blue spectrum. As there are no seasons (plants are cultivated in hydroponics) they are harvested once every 60 to 90 days. As the nutrient necessities for humans and animals vary during the year, so does the crop distribution. The excess production is stored and commercialized to other space missions. The following table shows what plants are grown on the colony:

Name	Calories (kcal) / 100gr	Importance	Use
Tomato (*Lycopersicon esculentum*), Cauliflower (*Brassica oleracea (Botrytis Group)*), Lemon *(Citrus limon)*, *Cucumber (Cucumis sativus)*	<30	Antioxidant (vitamin A)	Food and cosmetics
Apricot (*Cucumis melo*), Watermelon (*Citrullus lanatus*), Peach (*Prunus persica*), Onion (*Allium cepa or Allium fistulosum*), Beet (*Beta vulgaris*), Blackberry (Rubus Eubatus), Grapefruit (*Citrus paradisi*), Cherry (*Malpighia punicifolia*), Kiwi (*Actinidia chinensis*), Japanese Gooseberry (Ribes grossularioides), Mulberry (Morus nigra), Sour cherry (Prunus cerasus)	<50		Food and medicine

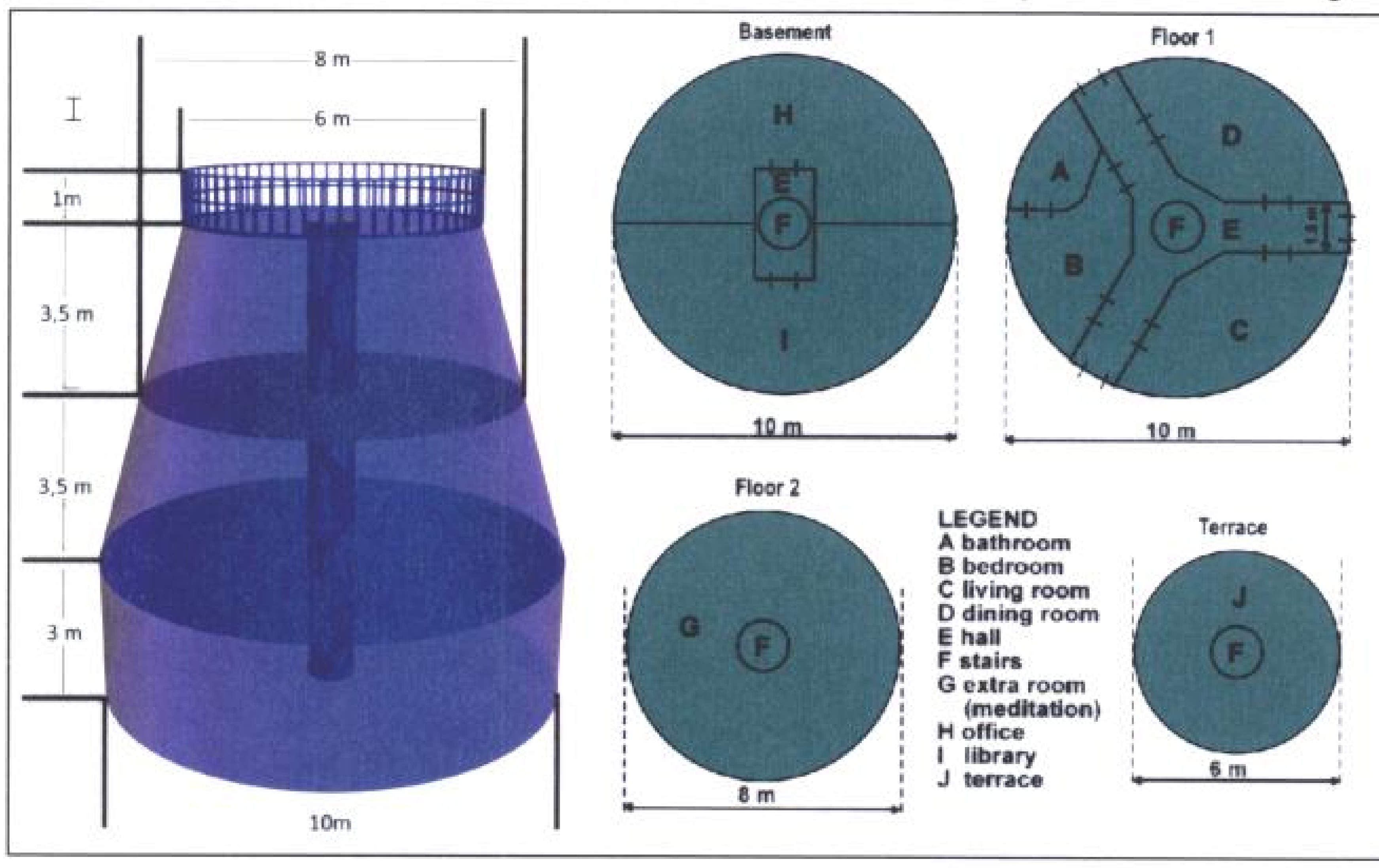
Mango (*Mangifera indica*), Strawberry (*Psidium cattleianum*), Raspberry (Rubus idaeus)	<100		Food and cosmetics
Dog-rose (Rosa canina), Olive (Olea europaea), Orange (*Citrus sinensis*), Melon (*Cucumis melo*)	<200		Food and cosmetics
Groundnut (*Arachis hypogaea*), Mulberry *(Morus nigra)*	>200		Food and medicine
Celery (*Apium graveolens*), Radish (*Raphanus sativus*), Eggplant (*Solanum malongena*), Pear (*Pyrus communis*), Mere (*Malus domestica*)	<60	B complex	
Rice, Soymilk, Olive oil	≈100	Vitamin D	Cosmetics
Pistachio (*Pistacia vera*), Honey	>300	Vitamin E	
Capsicum, Carrots (*Daucus carota*)	<40	Beta-carotene	
Onion (*Allium cepa or Allium fistulosum*), Egg yolk, Spinach (*Spinacia oleracea*)		Coenzima Q10	Cosmetics
Broccoli (*Brassica oleracea var. italica*), Turnip (*Brassica rapa (Rapifera Group)*)	<50	Calcium , magnesium	
Milk, Yoghurt	<200		
Grain, Cheddar cheese	>300		
Almond (*Prunus dulcis*), Sesame	>500		
Eggs, Chicken, Quail, Goat, Turkey, Rabbit (*Sylvilagus spp. Oryctolagus spp*)	<200	Iron	
Groundnut (*Arachis hypogaea*), Sunflower seeds (*Helianthus annuus*)	>500		
Banana (*Musa acuminata Colla*), Grapes (*Vitis vinifera*), Fig (*Ficus carica*)	<100	Magnesium, Potassium, salts	
Potato (*Solanum tuberosum*)	58	Starch	
Parsley (*Petroselinum crispum*), Garlic *(Allium sativum)*		Digestion	Medicine
Maize (*Zea mays*), Plum *(Prunus spp.)*, Mushroom *(Agaricus bisporus)*, Cabbage *(Brassica oleracea (Capitata Group))*, Kidney bean (*Phaseolus vulgaris*), Pea (*Pisum sativum*), Oat (*Avena sativa L.*), Rye (*Secale cereale L.*)	<100	Fibre	
Currant (*Vitis vinifera*), Nuts (*Juglans nigra*), Soybean (*Glycine max*)	>300		
Fish, Date palm (*Phoenix dactylifera*)	≈200	Phosphorus	
Algae (*Ulva lactuca)*, Blue mussel *(Mytilus edulis L.)*	<100		Cosmetics
Sugar (Sugarcane, Sugar beet)	>300	Sugars	
Cacao, Vanilla, Cinnamon, Oregano, Pepper, Tarragon, Basil	-	-	Condiments
Coffee, Tea, Ginseng, Ginkgo *(ginkgo biloba)*, Aloe, Marigold, Lesser celandine, Rose of Sharon, Dandelion, Hibiscus, Fenicul, Hawthorn, Camomile, Melilot, Lavender, Brotherwort, Tea, Mint, Tilia, Elder, Locust Tree, *Spirulina* and *Chlorella, Aphanizonmenon flos-aquae*	-	-	Medicinal herbs
Flax, Hemp, Cotton	-	-	Textile industry

The food products are available in every house, in restaurants and other places where IFT endpoints exist. They can be eaten directly, but raw food can also be ordered (for example, in restaurants). This way, inhabitants can prepare their own food if they wish to.

4.2. Houses

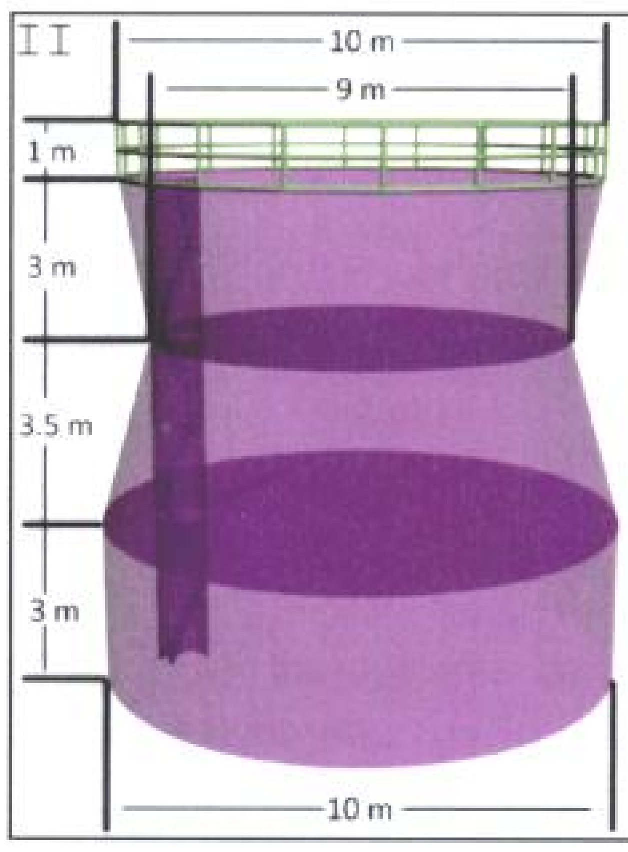
Every inhabitant is allocated 77.9 sq m of residential area. This area is sufficient to offer a positive psychological background. There are three main shapes that are the basis of the design of any residence. All of them are rotation bodies. This invests resistance of the volumes with less material; moreover, round spaces are psychologically favorable.

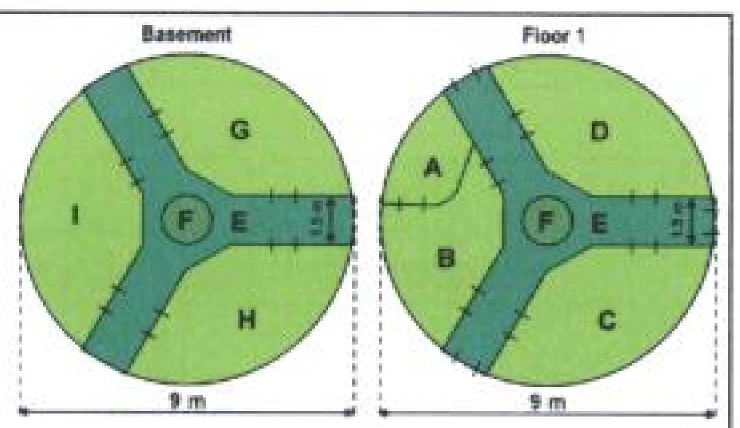
One cone-based residential building for 2 people predefined design is shown in the figures:



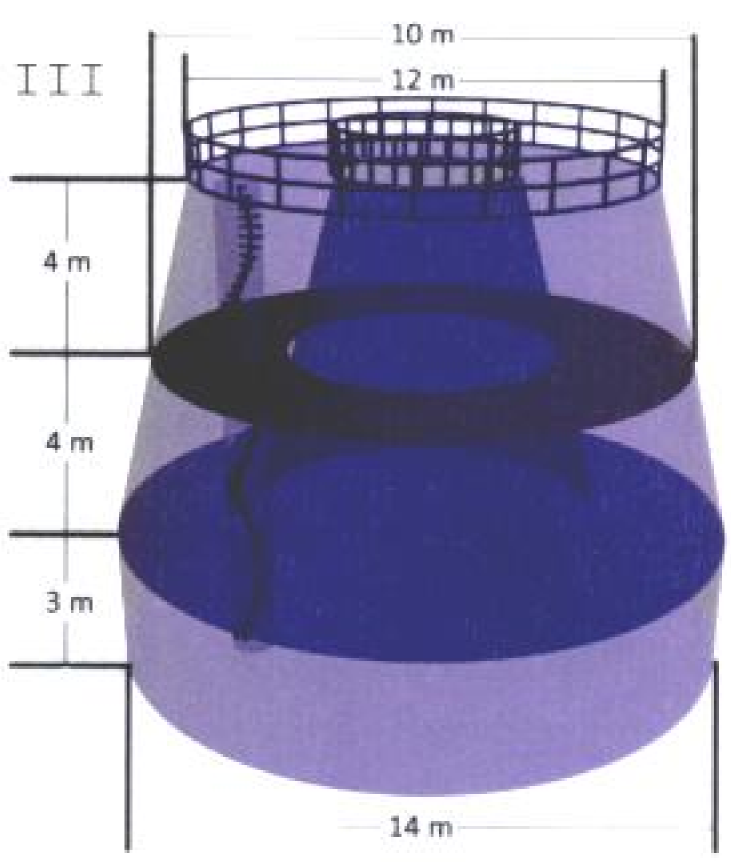
The total area of this design is 157 sq m; the terrace has 28 sq m surface

Some other designs are provided below, the first one for 2 members-family, the other one for 3:

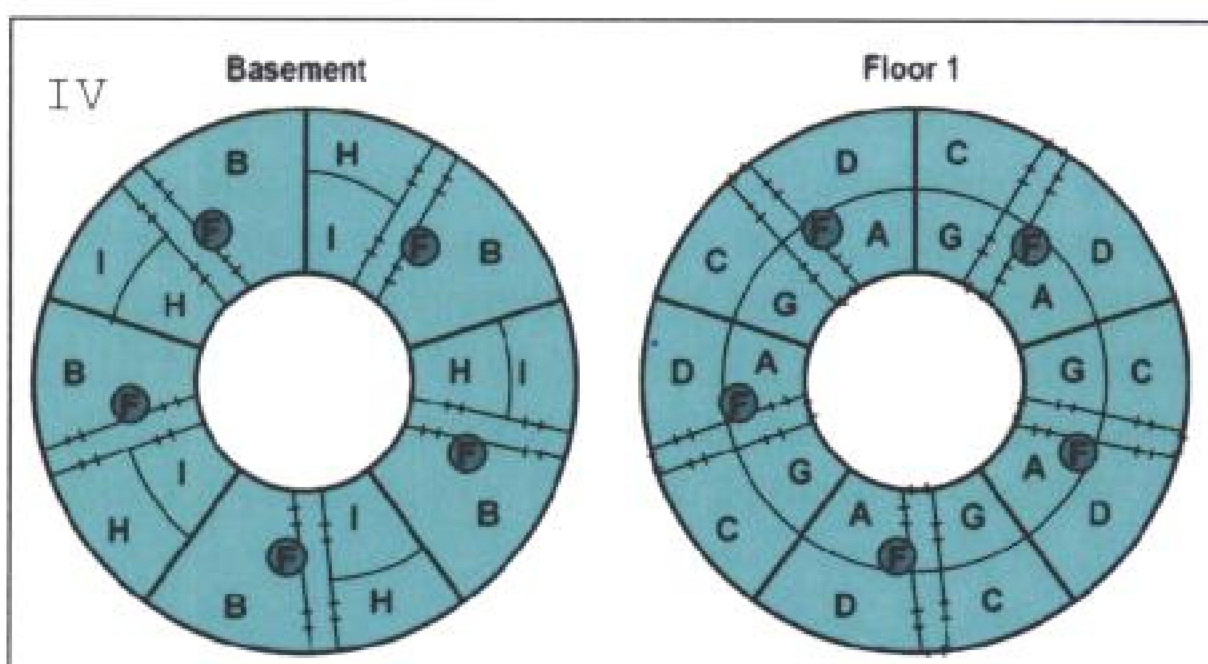


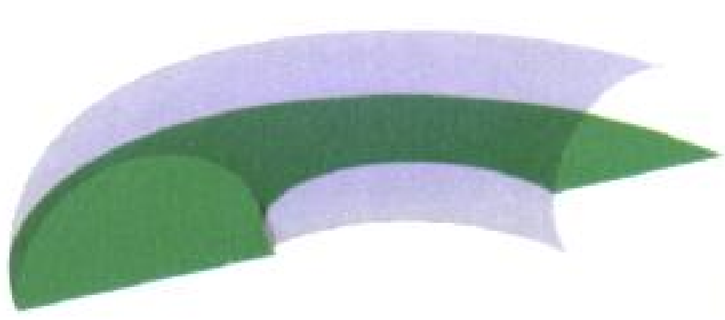


The total area of this design is 192 sq m; the terrace has 62 sq m surface



Note: the cylinder form on the lower part of the 3D-pictures of the three cone-based houses represents the basement. Another predefined torus-based building for 5 single adults has the following interior floor design:





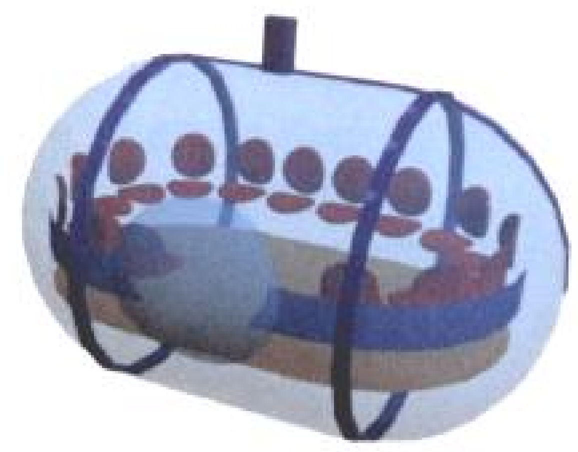
Section through a torus; the green plane represents the first floor's floor

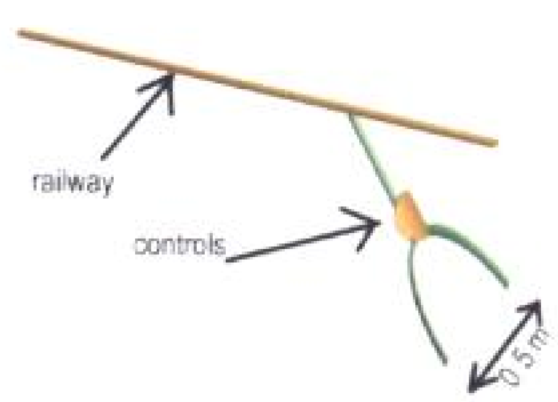
Basic shape	for No people	Area (sq m)	(sq f)	No of houses	Total No of people
	2 [II]	192,42	2071,22	1214	2428
	2 [I]	157,08	1690,80	1214	2428
Cone	3 [III]	408,41	4396,07	500	1500
	1 [segment]	79,17	852,16	4820	4820
	2	169,65	1826,05	500	1000
Torus	5	412,34	4438,34	100	500
	2	185,91	2001,12	600	1200
	3	289,97	3121,21	100	300
Sphere	4	394,06	4241,63	1206	4824

4.3. Tools and various instruments

Human staff is necessary in the fields, once more the percentages allocated:

Supervisors : industry, electricity, agriculture, transports, lighting, general repairs, external communication systems, internal communications and computers, maintenance and pipe robots, exterior robots	27.8%
Internal interventions : operate in unautomatizable situations	0.7%
Researchers (including social matters)	50.0%
Astronauts : external interventions	0.7%
Programmer : robots, computing systems	8.3%
PR : internal television, tourism&entertainment, inhabitants' support	2.8%
Doctors	2.0%
Teachers	0.5%
Administration : Foundation Society deputies, local council	1.1%
Other (artists, freelancer students, etc)	3.2%
Unemployed : children	3.0%





Most maintenance operations inside and outside the settlement are automated. Robots are used at their best.

The railster that assures transportation directly between FELDs has a capsule shape with the radius 2.5 metres and has the length of 8 meters.

Transportation of people in zero g environment as the Central Sphere is made using guiders. These allow them to choose, on a controls pad, their destination.

In special cases, human intervention outside the settlement is possible; astronaut suits are used. The astronaut suits' purpose is to protect the human and make him comfortable in space. Suits ensure the necessary conditions of temperature, pressure (0.5 atmospheres), humidity and atmosphere necessary for the survival of the human body. Additionally, they protect the wearer from cosmic radiation and impact with micrometeorites, through a layer of Thermal Micrometeoroid Garment. The oxygen tank enables activity in space for three hours. It is composed of a fixed component and a detachable one. The fixed component enables breathing during the short interval in which the mobile one is replaced by robots. The suit stores water for maintaining the air humidity and liquid necessity. It also has a belt attached on which tools and equipment necessary for the intervention are attached. It is mandatory to maintain the suits' volume constant, so that the astronaut does less effort for moving. The Bellevistat suit is only pressurized in the head's proximity; the lower part elastically tightens around the body.

4.4. Neighborhoods

As shown in *4.1. Community Design*, houses in FELDs A and B are based on torii, D and E on cones and C and F on spheres. On A, there are 2 neighborhoods designs that are used, 3 by 3, over the 6 ones separated by the main roads that connect the center of the FELD with the forest belt. On B, there are 3 big neighborhoods that resemble; additionally, there are 3 small neighborhoods with houses based on spheres. On C, there are 4 big neighborhoods with the same design and there is the Hotel Complex, with buildings based on torii. On D, the 3 big neighborhoods resemble, are axisymmetric and are separated by 2 big restaurants and the Cinema Multiplex. On E, the neighborhood design is the same and a symmetry axis can be distinguished. On F, the 4 big neighborhoods nearer to the edge of the FELD have the same design and are separated by 3 maze parks and a lake; 3 of the neighborhoods near the center have similar design and there is a special designed neighborhood around the school.

4.5. Entertainment

From the observation belts around the industrial spheres inhabitants have the possibility of observing the outer space, simply for entertainment or for research. The area is equipped with specialized equipment which provide a remarkable panorama, visible with the naked eye or using telescopes. To provide the dwellers the comfort associated with life on Earth, on the colony special areas were arranged where spare time can be spent „in the nature", physical activity being encouraged. For example, in the forests walks can be taken, in the parks climbing can be practiced (on tracks with different difficulty levels, partially due to the Coriolis force), skateboarding, rollerblading, etc. Every FELD has either a spa center, theater/multiplex cinema, bars, or an arts studio, where people manifest their constructive, creative and artistic spirit and their interest for art. Here they are granted access to instrumentation and materials (especially recyclables), tools, ovens etc. The resulting products may be commercialized as souvenirs or promoted as exhibits belonging to a certain artistic movement that had appeared on the colony.
Probably the most popular attraction will be represented by zero g activities and games. There are specially arranged centers where inhabitants can observe various phenomena and processes, some of them analyzed by specialists as well (water electrolysis, plant growth) or involve in their own experiments.

Games:

1.For zero g: in a room full with threads tied to different walls are introduced balls of variable size but same mass. They have a core made of a small NdFeB magnet and are made of Fe + (0.7 – 5)% Si, thus acting as a soft magnet spherical shell, amplifying the magnetic attraction. The player wears a suit that has random magnetic inserts (more are applied on hands and feet) that attract the balls. The purpose of the game is to cross the room in the least time and with the least balls attached to the suit (their mass will make movement more difficult). The game is singleplayer or multiplayer. In the latter case, the balls will be weighted to select a winner. The suit is afterwards introduced in a "washing machine" that, using a magnetic field, "cleans" the balls from the suit.

2. For Fun Fair: a team based game that uses an electrostatically charged ball. All the players are charged with charge of the same type, so the ball and players repel each other. The purpose of the game is to catch the ball and score FELDs of the colony. The first team to build the Bellevistat wins.

3. A museum in zero g. There is a large hall where, using 3D grasses the outer space can be observed. With virtual reality glove equipment, the trip becomes an interactive one, with the viewer able to control naturally what he wishes to see. The same hall can also be used for 3D gaming or virtual presentations.

All the games relax, but they also have an educative purpose and develop their intellect, imagination and team spirit.

On the margin of every FELD, there is a belt of permanent forest of width approximately 22 meters and length approximately its circumference. The associated surface of forest is 45000 m2/FELD, for a total of 270 000 m2. In the interFELD tube with the train tunnels, at the same level with the residential area there is a 50 m wide strip of forest. This is a mixed forest, gradually marking the change of FELD.

5. Automation Design & Services

5.0.1. Robot stations

In the center of each FELD there is a robot station. The robots are in staying in this position in an inactive state until their intervention is required, and their batteries are charged. Materials and tools which the robots may need to use are also stored here.

The robots are dispatched to the locations where they are needed through the IFT system. For this reason, the robot models do not exceed 0.5x0.5m in compact state, so that they fit in a standard IFT capsule.

Stations are also located in the proximity of each industrial sphere and the central sphere, as well as along the train tubes and the gravlift tubes.

5.0.2. Types of robots used on the station

5.0.2.1. Exterior robots

These robots' hull is made of Inconel X750 which allows them to repel an asteroid from the second dimension class (popcorn to grapefruit) with minimal damage. This property also makes them useful for the protection of solar panels against such an asteroid. They possess a mobile arm with which they can pneumatically divert an asteroid. In the best case, the asteroid will not collide with Bellevistat, and in the worst case, it will not damage a vital component.

On the outside, these robots move along the endurance structure that surrounds all the stations' volumes. The tools and some materials are stored inside their shell, and additional materials can be transported in containers along the same structures. The active side of the solar panels and the docks lack the usual endurance structure. In these locations, the robots move on a rail structure similar to a grid. The electronic circuits of these robots are protected by Faraday cages, so that they may function outside the settlement during solar flares. These robots are able to energetically self-sustain themselves with the help of batteries and the attached solar panels.

5.0.2.2. Maintenance robots

The maintenance robots have six telescopic feet, composed of three segments. The last segment can be replaced with different tools that are stored inside the robot. One of the feet is used to change the terminal tools on the other ones. In case a robot malfunctions, another robot can send it through IFT or carry it to the nearest robot station, where it is sent to the robot factory to be repaired.

These robots can move in areas with low or zero gravity, using the same transportation system as humans, described in *section 3.2.4.4.* The maintenance robots normally use Li-Ion batteries that allow them to operate until they can reach the house at which they must intervene, as they can plug themselves in once they are there. However, robots that must act in emergency situations or robots assigned for tasks outside buildings are equipped with higher-capacity batteries.

5.0.2.3 The pipe robot

The pipe robot is adapted to move through water pipes. It has two tiltable propellers in the front and in the back. The robot cleans the water using a brush that contains substances which dissolve impurities. Two varieties of robots move through clean water pipes and waste pipes. The latter have sensors which measure the parameters of water, like the acidity, temperature and composition. The robots have a coupling device with which they can pull each other in case they malfunction.

These robots have Li-Ion batteries which allow them to function for 3 hours. There are places along the water pipes where the robots can rest and charge through magnetic induction.

5.1. Construction Processes' Automation

5.1.1. Construction of exterior structure and infrastructure

The construction of the second segment of the station is completely automated, using materials harvested from the asteroid and processed in the industrial spheres. Exterior and maintenance robots are used.

The exterior robots assemble prefabricates from the industrial spheres, moving along the endurance structure which they build themselves. Simultaneously, they also build the exterior hull of the corresponding volumes. When assembling prefabricates, they place micro bots similar to nanobots that tighten the bindings.
Simultaneously, the maintenance robots build the interior infrastructure, including the agricultural sector, IFT tubes, plumbing and wiring. After the volumes are closed, all buildings and parks are constructed by the maintenance robots. Also, air is inserted in the volumes that must be pressurized.

The construction of the second module begins with the two „grav" tubes, simultaneously (for the reduction of construction times, but more importantly, for symmetry, so that the rotation of Bellevistat is not affected). After the finalization of the tubes, the robots begin the FELD constructions. Then, simultaneously, the solar panels' endurance structure and the tunnels that contain the interFELD trains and forests are built.

The robots are preprogrammed, but their activity is supervised by humans.

5.1.2. Construction of buildings

The maintenance robots perform the initial cabling, as well as plumbing. They assemble prefabricates for exterior walls.

The apartments are divided in rooms before the arrival of the occupant, either according to some default plans, or according to the person's desire, the only fixed rooms being the bathroom and the IFT reception area. This process is reversible, and the house can be redivided when the inhabitant changes.

Through the walls, there is a tubular structure in which cables are placed. The cables are replaced outside the walls, and they are inserted by attaching a magnet to one end of the cable, being guided by another magnet attached to the arm of a robot. Magnets are used because they enable the wires to pass through the nonlinear structure of the tubes.

Using another set of tools, robots perform the interior finishing, paint the walls, apply and paint the parquet, and perform other operations requested by the resident (installation of panels, curtain rods etc).

The estimated time to complete the interior of a typical residence is between 2 and 5 days, depending on the size of the house and the complexity of the arrangement.

5.2. Facility Automation

5.2.1. The public computing system

The public computing system is based on storage of each individual's data centralized. All terminals on the settlement authentify the user through a fingerprint reader. This way, a citizen may use any terminal on the station, having access to the same personalized environment and the same files („profile").

The following terminals exist:

- In houses, one fixed terminal in each room
- At every work station, a fixed terminal
- A mobile device in size 86x54x4mm, for every citizen, with a 78x50mm touch screen and a camera for video telephony. The device charges through magnetic induction and connects to the settlement's wireless network. These devices do not have any slots and are impermeable. They are used as phones. For video calling, wireless headsets are used. The mobile devices display the time in the owner's FELD, as well as the local time, when the user travels to other parts of the station.
- In public areas, portable computers are located in „recharge stations". These are sized 21x30 and have two 21x15cm touch screens. Anyone can take a portable computer and use it anywhere on the station, as long as he eventually brings it back to a „recharge station". Portable computers can be used to read electronic books very comfortably, as they can be folded in two.

Fixed and portable terminals are computers with normal processing power. In a classical system, the processor is used in a very small proportion. For that reason, on all fixed terminals, as well as laptops, when they are being charged, distributed computing processes are run with minimal priority. The priority can be elevated in case it is necessary to perform very urgent calculations (for example, the trajectory of an incoming asteroid).

The terminals do not store any personal data; they have a quantity of nonvolatile memory that they use to cache usual applications. Executables and personal files are retrieved from the server network described at section *5.2.2.*

The terminals offer free access to:
- Personal files
- Applications and games
- The internal video telephony system
- The internal computer network
- TV channels from Earth and Bellevistat's local TV stations
- Online shops (the goods that the clients order are transported through IFT)

The terminals also offer limited access to the Internet on Earth, including: all web pages (http), mail services, instant messaging services, as well as the telephony system, paid by traffic. These services are offered by the proxy server that caches and groups requests so that the latency because of the L4-Earth distance is minimal.

5.2.2. The computing and communication infrastructure

For public access, on each FELD, there are six 802.11n access points. These operate on 5GHz. The system ensures access to the network through two redundant systems on most of the FELD's surface.
In each of the central axis spheres there are two access points. Along each interFELD tunnel there are four access points to cover the entire length between FELDs.

On each FELD there are two file servers, located under the inhabitable area. The profile of each user is stored on two servers, for redundancy and fast access.

In the central sphere, there are:
- A network of supercomputers for scientifically calculations. These split the necessary workload in chunks that can be processed by the terminals and distribute them. They also receive the results of partial calculations and assemble them.
- 6 „backup servers", one for each FELD, that incrementally download the profiles of all users from the corresponding FELD when the activity level is low (during the night)
- Two proxy servers for connections to Earth. These cache DNS requests and are used to avoid the roundtrip times normally associated with direct TCP connections.

The communication between all wireless access points, between FELDs as well as the connection between the servers, is ensured by optical fiber.

Link	Type	Bandwidth
Terminals – File servers Terminals – Terminals	Wireless 802.11n	248 Mbit/s
FELD Router – FELD Router FELD Router – Central sphere	Optical fiber	100 Gbit/s
Bellevistat Proxy – Earth Bellevistat Proxy – Alexandriat Proxy Bellevistat Proxy – Moon	LASER communication	50 Mbit/s
	Ka-Band communication	5 Mbit/s

5.2.3 Maintenance, repair and safety functions

Against asteroids larger than an orange, Bellevistat is equipped with 18 LOX and LH_2 bipropellant located on the central sphere. The settlement is capable of moving fast on the direction of its axis, to avoid collision. Considering that such asteroids can be detected some time before they reach the settlement, it must be able to move on a distance d=1300m (the distance between the two large docks) in an interval of t=1 day.

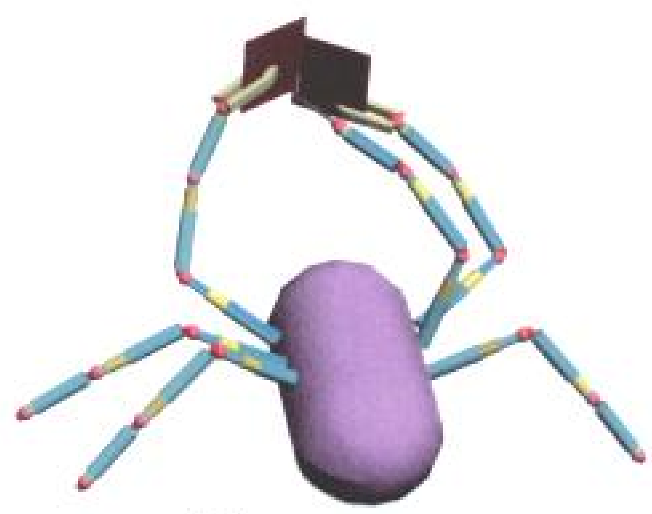
On half of the distance, the settlement accelerates and on half it breaks. The acceleration time is $t_a = 43200\ s$.

Considering $d = \frac{at^2}{2}$ the acceleration is $a = 6{,}96 \cdot 10^{-7} \frac{m}{s^2}$. The force necessary to move the station is $F_{settlement} = m \cdot a = 25950\ N$, where m is its mass $m = 37{,}2 \cdot 10^9\ kg$.

The force necessary for such an engine is $F_{thruster} = I \cdot \frac{\Delta m}{\Delta t} \cdot g_0 = \frac{F_{settlement}}{18} = 1441\ N$, where I is the specific impulse of the engines I=450 s, $\frac{\Delta m}{\Delta t}$ is the fuel mass flow rate, and g_0 the gravitational acceleration at Earth's level.

The quantity of fuel necessary for acceleration is m_a=254.2 tons of fuel, and the total mass of fuel used for a move is $m_{total} = 508.4\ tons$ of LOX and LH_2 in a ratio of 6 :1.

To perform trajectory correction and to increase and decrease angular speed, 6 similar engines are placed on each FELD.



Picture 5.3.1.a

5.3. Habitability and community automation

5.3.1. The maintenance robots are used for the following processes:

(1) Changing the FELD lamps

Through sensors, when a malfunction is detected, computers that maintain the illumination system program a robot to repair a lamp; the robot leaves the FELD's robot station through the IFT, climbs the gravlift tube structure and moves along the ceiling grid to the location of the malfunction. The tools allow it to change the lamp that malfunctions.

(2) Assembly of the furniture (picture 5.3.1.a)

Tools used: screwdrivers, pliers (to connect pieces), suction cups (to raise them). These robots can use five of their arms in the same time, by lowering themselves on the ground. They follow assembly instructions received through the network. They are transported automatically after the furniture is ordered or on demand, to fix it.

(3) House cleaning

Tools used: brushes of different sizes, sprays, wipers, vacuum cleaners. These robots clean the toilet, the bathtub and the sink, they vacuum and wipe the dust when nobody is home or on demand.

(4) Interventions in case of emergencies

The maintenance robots are capable of intervening in case there are malfunctions at the electric or plumbing systems, as well as in critical situations, like fires and floods.

When such a problem emerges, the computer network commands the activation of an appropriate number of robots, which take the necessary tools and move to the location through the IFT.

For emergencies like fires, human personnel are also dispatched to supervise the operation and provide support.

(5) Usage in agriculture

Maintenance robots move through the forests and parks and analyze, with a camera, the color of fruit on the ground and in the trees. If it indicates that the fruit is ripe, the robot uses a net and garden scissors to pick it. These fruit are sent through the IFT to be processed in the agricultural area.

5.3.2. The exterior robots are used for the following processes:

(1) Maintenance of solar panels

Meteorites of very small sizes will permanently collide with segments of the solar panels and they cannot be detected in time to protect from them. Computers monitor the power output of each frame of solar panels and detect the underfunctional ones. According to this information, exterior robots are sent to perform repairs.

The robots disassemble the malfunctioning frame (which contains 36 cells), and inserts it in an internal compartment where individual cells (4x4cm) are checked and replaced with new ones.

(2) Repairs of ships

The exterior robots are used to repair ships that dock at Bellevistat.

(3) Other structural repairs
The robots can move along the endurance structure of the settlement and perform repairs.

5.3.3. Mining of the asteroid (HARVESTER) – picture 5.3.3.a
The mining of the captured asteroid is performed by a number of *harvesters*. These devices are moved in the proximity of the asteroid by a Hucul. These devices attach themselves to the asteroid through a system described at *section 2.4*. The harvesters deploy a cone with a height of 5m and a radius of 1m made of Inconel elements. The scraping device of the harvester is brought in the proximity of the asteroid and starts mining. The resulting pieces receive a small impulse towards the top of the cone, where they are caught and packed in containers.

Each Harvester is powered by Li-Ion batteries capable of sustaining them to mine continually for 3 days. The harvester mines a standard pallet of 1 m^3 per day. A Hucul vessel arrives every 3 days to pick up the cargo from each harvester and to replace their batteries. When the Hucul's cargo hold is completely filled, it heads towards Bellevistat.

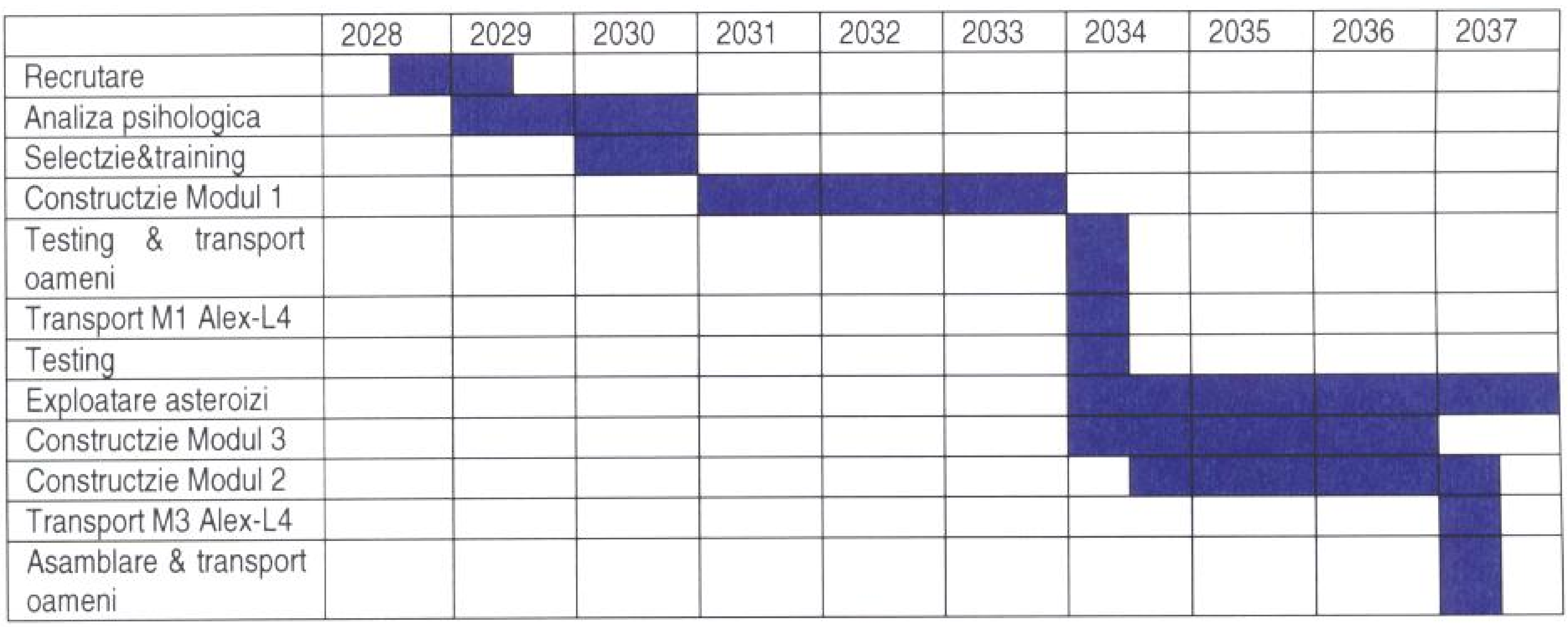
The Harvesters and Huculs are monitored remotely from Bellevistat, but are fully automated. A group of 20 employees supervises the fleet of harvesters. The Hucul is monitored by 30 people.

Picture 5.3.3.a

6. Schedule and costs

6.1. Schedule

Because of the amplitude of the construction process, the stages of construction have been chosen so that the costs are reduced as much as possible. The project begins on the 10th of May 2028 with recruitment of a specialized team, their psychological analysis, their selection and training for life on the station. The structure of the station is decided, and in 01.03.2031 the construction of the first module begins in Alexandriat. The construction takes 3 years (during which about 150 astronauts work in 0g by rotation, 1 month each), then the station is tested for a month and taken from Alexandriat in L4, loaded with 6000 inhabitants from Earth and Alexandriat. Once it reaches L4, the station continues to be tested. After the testing, construction of module 3 begins in Alexandriat, as well as the harvesting of the asteroid in L4. After a month of harvesting, the construction of module 2 begins on Bellevistat. After the third module is built and transported to Bellevistat, more people are brought from Earth with Palominos and HUCULs. Another week of testing follows, and on 13.07.2037, the station is officially declared functional.



6.2. Costs

First stage of construction

Name	Price ($) x Unit	Total (millions)
Industrial sphere	471240$ x1	0.47124
Central sphere	221482.8$ x1	0.2214828
Gravlift shaft	29717808.12$ x2	59.43561624
FELD	49722848000$ x2	99445.696
Solar panel belt	15$ x3749523.33	56.24285
Train tunnel	91856457$ x2	183.712914
Central axis	6220368$ x2	12.440736
Bulkcarrier dock	422152.5$ x1	0.4221525
Personnel dock	13194720$ x1	13.19472
House - 1 person	12000$ x3820	45.84
House - 2 persons	20000$ x500	10
House – 5 persons	50000$ x100	5
Hotel	10000000$ x1	10
Hospital,SPA&Fitness	5400000$ x1	5.4

Shopping centre	500000$ x4	2
Employees	900000$ x150	135
Maintenance robots	200$ x2000	0.4
Pipe robots	150$ x300	0.045
Exterior robots	175$ x1000	0.175
Harvester	1000000$ x100	100
Hucul	5500000$ x8	44
Computers	1000$ x 12000	12
Water	222$ x800000	177.6
Animals	222$ x10000	2.22
Fuel	222$ x1000000	222

Second stage of construction

Name	Price ($) x Unit	Total (millions)
Gravlift shaft	29717808.12$ x2	59.43561624
FELD	49722848000$ x2	99445.696
Solar panel belt	15$ x3749523.33	56.24285
Train tunnel	91856457$ x2	183.712914
House – 2 persons	20000$ x2428	48.56
House – 3 persons	31000$ x500	15.5
Office	3700000$ x1	3.7
Research centre	6750000$ x1	6.75
Shopping centre	500000$ x4	2
Employees	900000$ x150	135
Computers	1000$ x 12000	12

Third stage of construction

Name	Price($) x Unit	Total (millions)
Gravlift shaft	3047980.32$ x2	6.09596064
FELD	7103264000$ x2	14206.528
Solar panel belt	15$ x3749523.33	56.24285
Train tunnel	7348516.56$ x2	14.69703312
Central axis	339292.8$ x2	0.6785856
Bulkcarrier dock	27489$ x1	0.027489
Personnel dock	753984$ x1	0.753984
House - 2 persons	20000$ x600	12
House – 3 persons	31000$ x100	3.1
House – 4 persons	35000$ x1206	42.21
Schoonl	450000$ x1	0.45
Polyvalent hall	680000$ x1	0.68
Shopping centre	500000$ x4	2
Computers	1000$ x 12000	12
Employees	25000$ x150	3.75
Fuel	222$ x1000000	222

Income

Name	Price($) x Unit	Total(millions)
Solar panel belt	25$ x200000	5
Harvesting	73000000$ x250	18250
Tourism	720000$ x1000	720
Souvenirs	2000$ x1000	2
Food production	2.5$ x3,000,000	7.5
Repair services	50000$ x60	3

Costs

Name	Price($) xUnit	Total(millions)
Employees salaries	300000$ x18000	5400
Robots maintenance	45$ x3405	0.153225
Waste management	115$ x550000	63.25
Ships reparation	100000$ x12	1.2
Food production	3200$ x1000	3.2

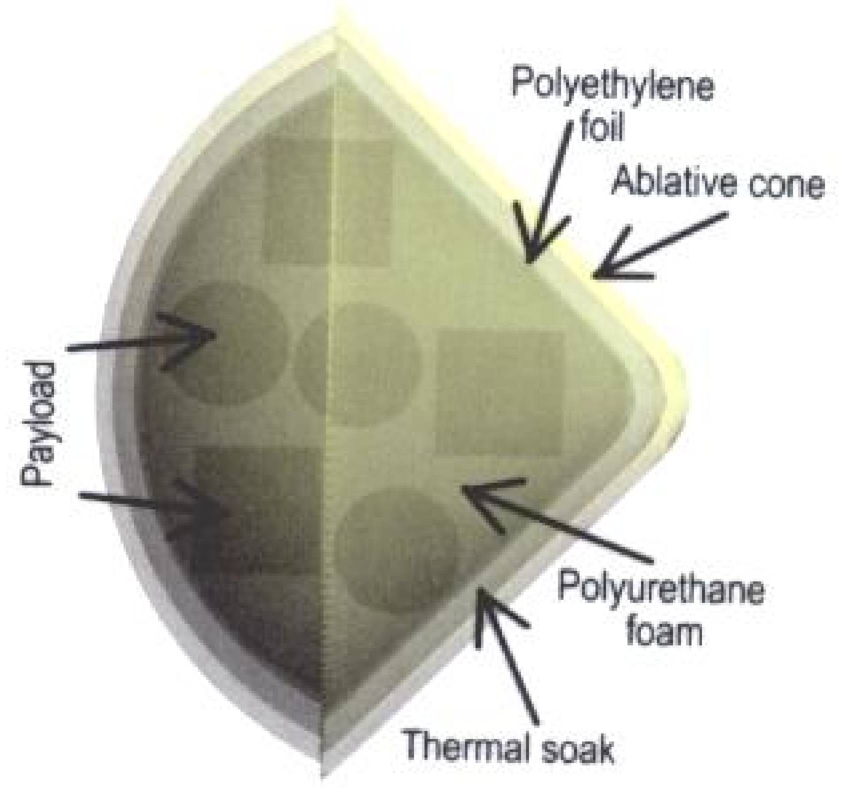
Subtracting the costs from the income, the annual profit is obtained (18987.5mil - 5467.803225mil = 13519.69678mil). As a security measure, although the amortization of construction costs is delayed one more year, an emergency fund of 100.000.000$/year is considered. Consequently, the time in which Bellevistat returns the invested money to the Foundation Society is approximately 16 years and 1 month.

7. Business development opportunities

a. Deployment of extraterrestrial materials on Earth

The captured asteroid is a valuable source of minerals which is used both during the construction of Bellevistat (for the second module), as well as afterwards for heavy industry (in-orbit manufacturing). Part of the materials and resulting products are sent back to Earth in one-way containers. These containers must fulfill three conditions: to protect the payload from the extreme re-entry temperatures, to protect the payload from the impact (or reduce impact speed until it is no more of a problem) and to be built from materials readily available on Bellevistat, that are non-polluting and can be reused on Earth.

As the containers are only used once, they can be designed as sacrifice material to bring the payload safely on Earth. The container is a bag of polyethylene which is placed in a sphere-cone (DS/2) container made of thermal soak (silica foam) reinforced with inconel X750, covered by an ablative layer (PICA). The ablative layer heats in the atmosphere on reentry and, through pyrolysis, releases gasses which push the hot shock layer away from the container. This way, most of the heat is not absorbed by the container, but is released in the atmosphere. The thermal soak is an insulating layer, which keeps the heat away from the payload. The payload is inserted in the polyethylene sack, which is sealed and filled with polyurethanic foam to fill empty spaces. If the payload is composed of multiple elements, they are separated by polyurethanic foam to minimize landing damage.



The container is sent to LEO with a small impulse, where the LOX/LH_2 reentry thrusters are activated to make it enter the atmosphere at a correct angle. The same thrusters can make small trajectory corrections (if unfavorable atmospheric conditions are encountered) and can rotate the container if it rolls.

The thermal soak absorbs the heat which, if it is not removed after landing, rapidly transfers to the payload. For example, space shuttles require cooling with Freon immediately after landing to not suffer damage. For this reason, and to prevent accidents if the landing is unsuccessful or off-course, landings take place in the ocean. To ensure floatability, containers are loaded so that the average density at landing is smaller than that of water. The container also contains a GPS emitter and a beacon to allow its recovery. It also contains a computer which receives data regarding the temperature of the ablative layer, so that it can initiate local fission heaters in case the temperature drops below the one required for pyrolysis. The computer also deploys parachutes for breaking once reaching the altitude of 9000m. After landing, cold water facilitates very fast cooling of thermal soaks, so that the payload is not thermally deteriorated.

b. Computing power

The distributed computing system on Bellevistat offers a very high processing power. Moore's law (considering that processing power doubles every 24 months) has been accurate for the last 20 years and has correctly predicted today's average computer processing power – 512 TFLOP. Latest years have shown that the processing of a micro-processor is not influenced mainly by switching frequency, due to architectural advantages. The total computing power of the Bellevistat computers is 512*54000=27648 PFLOP. Considering 0.9 of the processing power allocated for distributed computing, and 0.66 the fraction of computers that run distributed computing (fixed terminals that are partly idle, or mobile computers in charging stations), the resulting processing power is 16422 PFLOP.

This power is partly used for research on the station, but it can also be exported to Earth or to other colonies.

c. Lunar development opportunities

The construction of a lunar base facilitates an important economic and scientific growth. The base can be constructed initially with materials and services offered by Bellevistat, and afterwards from its own resources.
Mining of lunar materials is done by SELENA, a harvester whose characteristics and functionality are described through a separate contract.

Production of oxygen, titan dioxide and iron
On the Moon *ilimite* (FeTiO3) can be found. This substance can be exploited to separate iron, titan dioxide and water, through the reaction :

$$FeTiO_3 + H_2 \rightarrow Fe + TiO_2 + H_2O$$

Hydrogen is brought to the Moon from Bellevistat, where it is produced by biomass.
Through electrolysis, hydrogen is separated from oxygen. The hydrogen reenters the cycle. The oxygen is bottled; iron and titan dioxide are packed. The production of these materials directly on the Moon facilitates the construction of a settlement because the costs associated with transporting them from Bellevistat are removed.

Production of cement
Cement can be made on the Moon by heating lunar soil and combining it with water.

Exporting materials from the moon
Harvested Moon materials can be sent in orbit with *mass drivers*. On orbit, they are loaded in Hucul ships and transported on the station or sent back to Earth through the system described at section *7.a.*

Research on the Moon
The existence of a lunar base allows for the prospection of the lunar soil to evaluate the composition of the soil in various regions. This way, the presence of hydrogen in lunar soil can be determined.
There is also the possibility of bacterial processing research.

Variable-g research on Bellevistat
Before deploying facilities on the Moon, where gravity is 1/6g, it is necessary to test technology in this environment. The settlement's gravlifts' gravity varies from 1 to 0g, depending on its position. The gravlift can be stopped at the appropriate position in order to simulate necessary conditions for experiments regarding new scooping technologies, as well as processing materials from lunar soil. The latter are conducted using soil samples taken from previous missions.

If the gravlift no longer descends cvasistatically, an astronaut can be trained to sustain gravitational accelerations over 5g.

0 g research themes
On Belevistat there will be available a lot of space designated to research. One of the research themes is experimenting with growing fish in a high humidity environment. If the experiment is proved to be reliable, growing fish, and maintaining the specially allocated places will be much easier, and more space effective.
To encourage educational bonding with other settlements(Alexandriat) and with Earth, Bellevistat organizes contests for students. There is a certain amount of space allocated in the research sectors in the central sphere, where the winning teams' ideas will be set up and tested. In the future, Bellevistat may even offer scholarships and an invitation to visit the settlement with free hosting included.

d. Space manufacturing

The main purpose of Bellevistat is ore mining and refining, so it is designed to offer industrial facilities that surpass the colony's needs, so that it develops economically by exports of prefab products (Inconel elements) and finished products (for example, solar panel array elements or robots). These and other products are built in industrial spheres and transported through freelifts to bulkcarrier docks where they are loaded in Huculs.

On Bellevistat, larger construction operations can be performed. Ships of virtually unlimited size can be built, such a project occupying a bulkcarrier port. Also, machines to perform tasks similar to Earth-based cranes, trucks, bulldozers and mining equipment can be built. Any large scale product (which cannot be built in industrial spheres and transported through freelifts) is constructed directly in a bulkcarrier dock.

e. Tourism

Because the idea of living in space or visiting a colony like Bellevistat is very attractive to Earth people, it is estimated that Bellevistat receives about 6000 tourists anually, including businessmen, official visitors and guests of residents, which remain on the station for an average of 60 days. Bellevistat is a touristic attraction and several actions are taken to offer tourists and residents multiple possibilities of entertainment and recreation.

Bellevistat can accomodate 1000 visitors which stay in the hotels in the touristic FELD. Because of architectural variety on the station, the experience is similar to visiting six different cities, with museums, exhibits of space art. Visitors can spend their time in cafes and commercial centers, from where they can buy souvenirs. Also, tourists may spend time in the 0g entertainment area or in the funfair. They can also perform artistic activities, like sculpture and modelling in lunar soil.

Tourists can attend a tour through the industrial spheres, observing from safe positions the stages of processing materials and the manufacturing of different products. In the virtual reality rooms in 0g areas they can witness the mining activity on the Moon or the captured asteroid, take a virtual tour of the solar system or play virtual reality computer games.

Visitors and residents can set up their own ideas in controlled 0g environments, to observe growth of plants, the way water behaves in microgravity. A Labyrinth of Mirors in 0g is also available. The Xtreem Guider resembles the actual guider, but it runs at considerably higher velocity, incorporates secure handles and because it is not limited by gravity, it has unusual twists and turns at high speed. The speed can be varied to suit the preferences. The 0g entertainment area also includes MagnetiChase, a game with the purpose of passing through a room dressed in a magnetic suit, using ropes attached to walls to avoid the magnetic spheres that fly through the room.

When they arrive in the colony, the tourists' fingerprints are recorded into the Bellevistat database and they receive a personalized mobile device. Accounts are created for them in the computing system, which allows them to use mobile and fixed terminals on Bellevistat, with limited access. When they leave the colony, the devices are returned and their accounts are archived.

	settlement	
5.3. Automation to enhance livability	Emphasize use of automation to perform maintenance and routine tasks.	28, 29
	Provide for privacy of personal data.	26, 27
	Drawings of robots and computers that people will encounter during their everyday lives in Bellevistat	28, 29
	Diagram of network and bandwidth requirements	27
5.4. Automated systems for interior finishing	Drawings of interior finishing systems in operations	28
	Estimated time to complete interior of typical buildings	26
5.5. Automated systems for mining	Drawing of mining system in operation	28, 8
	Description of how many human controllers are required	29
6. Schedule & cost	Schedule	30
	Cost	30-32
7. Business development	Design one-way reentry vehicles	33
	Provide specialized equipment for large scale space and lunar construction projects	33, 34
	Show location of hotels	35, 18
	Describe amenities available to visitors	18, 35
	Describe visitors' access to communications, computing and robot resources, including security	35

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