



# Belleλvistat

**Northdonning  
Heedwell**



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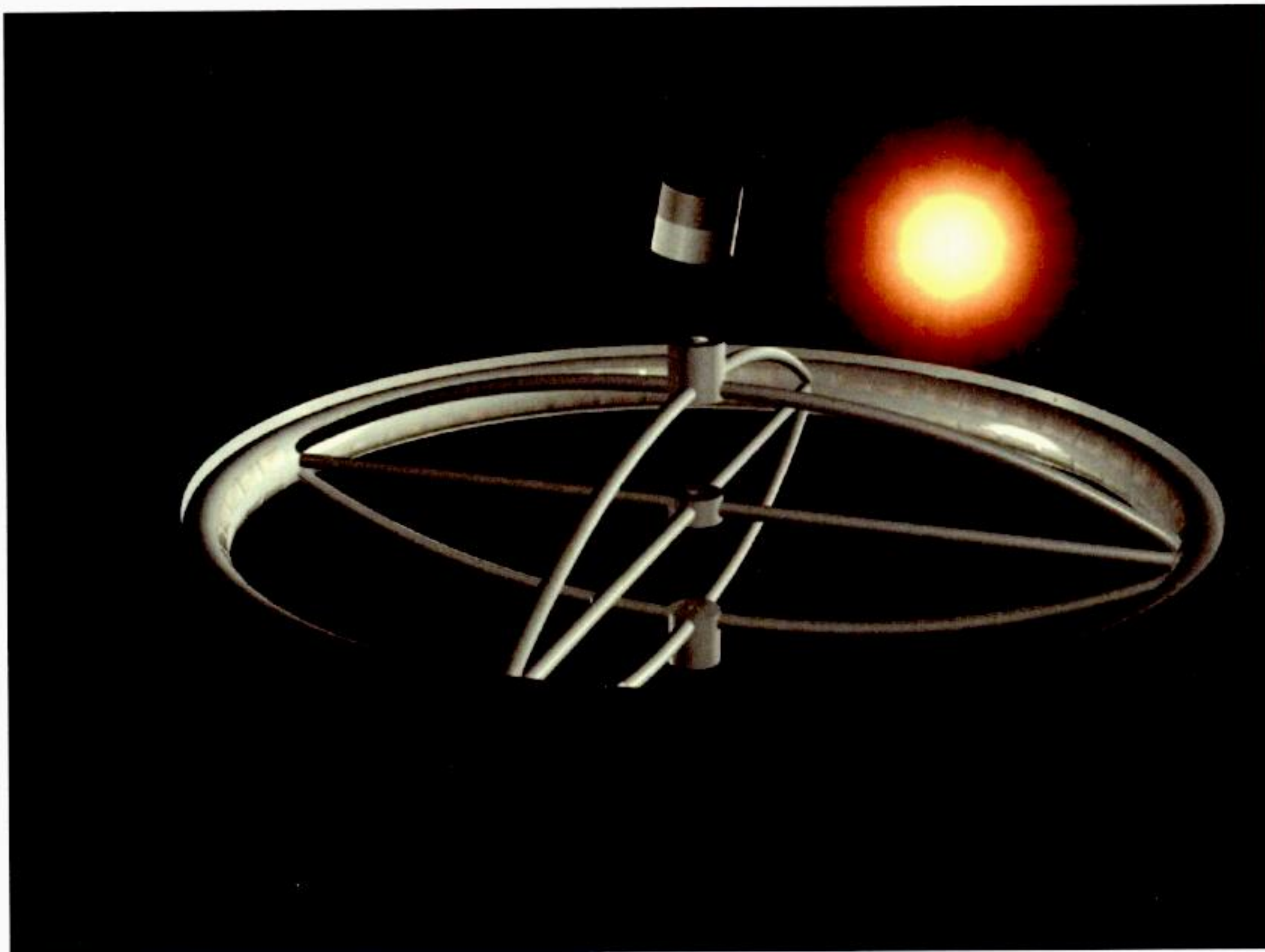
## **1. Basic Requirements**

Located in the L4 Lagrange point, Belleλvistat space settlement is meant to provide a safe, pleasant living and working environment for its 18000 residents and 1000 visitors. We are likely to expect that our station represents an attraction for young professionals eager for knowledge and experience and devoted to the importance of the expansion of human infrastructure in outer space. As the resources on Earth will eventually come to an end, new solutions must be found so as to ensure evolution and life. This is the prime reason for the creation of Belleλvistat colony.

With assistance from the Alexandriat space settlement located as an all-purpose human outpost in the Earth-Moon L5 orbit, the Belleλvistat space settlement will be built following a series of steps.

To begin with, a Moon base will be built so as to provide the necessary materials for the assembly of the components sent from Alexandriat, which are to be used for the future settlement. The main occupation of the first residents will consist of mining. The construction itself will begin with the center of the settlement, following a continuous process that will result in a symmetrical design.

## **2. Structural Design**



*Fig. 2 Exterior design*



## 2.1. External Configuration

### 2.1.1. Cylinders

They have microgravity. In the docking zone, transport will be realized via rails on the exterior of the spokes.

Each cylinder has two docking zones, each on the ends. The cylinders from the extremities have docking zones for large ships, with mechanized arms that grab a hold of the ship and slowly get it rotating at the same speed with the settlement. Each small ship docking zone has six airlocks.

Each of the small ship-docking port has three robotic arms for capturing the incoming vehicles and directing them to the airlocks. There are 4 small ship-docking zones and two zones for unloading large ships.

- both pressurized and unpressurized volumes
- shielded
- attachments

The train-like vehicle that moves relatively to the settlement, giving a stationary view, is used mainly for tourism. Moving up and down on a tall, solid titanium alloy rod, it is able to counter rotate, for a 0 pseudo gravity and good views. The people are exposed to UV rays, due to its quartz windows. Pressurized, it has a hatch for spacewalks and also an independent life support system.

The train has uses for heavy industry, recreational areas, docking, temporary stocking for transmitting goods, tourism, science laboratories, location for most remote sensors, and can serve as a location for most external communication devices.

For Belleλvistat station we have chosen the following dimensions:

- Height= 200 m\*2 (the 1<sup>st</sup> and 3<sup>rd</sup> cylinder) and 100 m (the second one)
- Radius=100 m

The materials used for our settlement building are: titanium with aluminum plating for structure skeleton, titanium for the interior of floor panels and walls, covered in soft silicone rubber coating, so that people won't get hurt when they hit the walls in microgravity and for extra grip, windows made out of thick glass, for the observation points.

### 2.1.2. Spokes

There are 12 spokes organized in groups of 4 spokes for each cylinder. The spokes that connect to the 1<sup>st</sup> and 3<sup>rd</sup> are bent and they allow a bigger mobility. The spokes are shielded and the artificial gravity will differ in different areas of them, depending on the distance to the center of rotation.

Uses: they provide access route between the central body and the main body, keep the settlement from deforming, provide a route for wiring and cooling conduits, provide support for the radiators, provide support for the mirror, other utilities like: air, water, electricity, data and for people transport (elevators that help human transportation).

The spokes have the shape of a cylinder and they are fully pressurized. Each cargo transport spoke contains a large elevator. The spokes have also maintenance spheres, with airlocks, used in case of danger



Dimensions of the spokes are: Length: 1600 m and Radius: 30 m  
The main material is ATI425 titanium alloy.

### 2.1.3. Mirror and Disperser Glass

Along with the space settlement there will be two half reflective-half refractive objects: the mirrors. There will be two 300 m tall half cylinder structures (160 m radius) with reflective and refractive computer-controlled panels which will redirect the light coming from the Sun to the main body. The mirrors will float along with the settlement, being near the L5 point. The correction needed done to the trajectory will be achieved by 4 oxygen-hydrogen jet thrusters. The reflective panels will give light to the half of the main body facing the sun and the refractive panels will deflect the light to the half of the main body opposing the Sun.

To simulate night time the colony will have some opaque panels covering the windows which will block the natural light during night time in any given sector.

It's made out of aluminum plated glass for the mirrors, glass for the refracting panels, on a titanium alloy backbone.

### 2.1.4. Main Body

The main body has a toroidal shape with the main radius of 1600m, which is measured from the center to the residential floor. The settlement will spin around its central axis, at one revolution at 80 seconds. Therefore an artificial gravity of 1g will be assured by the centripetal acceleration:

$$a_{cp} = \omega^2 R = (2\pi/T)^2 \cdot R = 10\text{m/s}^2 \approx 1g$$

The main body is shielded and pressurized and it contains the residential area. The uses for the main body are: it has a living area and it is a place where social and economical activities take place (light industry, commerce, entertainment etc.)

The main body is made of the following materials: titanium for the structural skeleton (the rim) and internal structures, glass for the overhead windows and observation spots, many other materials for the interior. It has solar panels on the outside. The solar panels also shade the settlement to reduce the thermal stress. The solar panels are situated on the exterior of the main body, having a width of 250 m. They give the required energy to the settlement. They are attached to the settlement by ceramic mounts. The panels have spacing for dilation.

The main body is being illuminated both by natural sunlight that passes through the disperser glasses and that reflects from the mirrors and by artificial light from the ceiling of the upper deck. The ceiling of the upper deck contains a cooling system for the settlement.

### 2.1.5. Shield

First layer (outermost): thick titanium alloy plate (ATI 425: 91.75 % Ti-4Al, 2.5% V 1.5% Fe %0.25 O) - 20 cm



Second layer: honeycomb-shaped titanium alloy structure (73%Ti, 13%V, 11%Cr, and 3% Al). The thickness of the plates that form the hexagons of the honeycomb is 1 cm. The total thickness of the structure is 50 cm.

Third layer: astroquartz II (9  $\mu$ m woven strands), 30 cm.

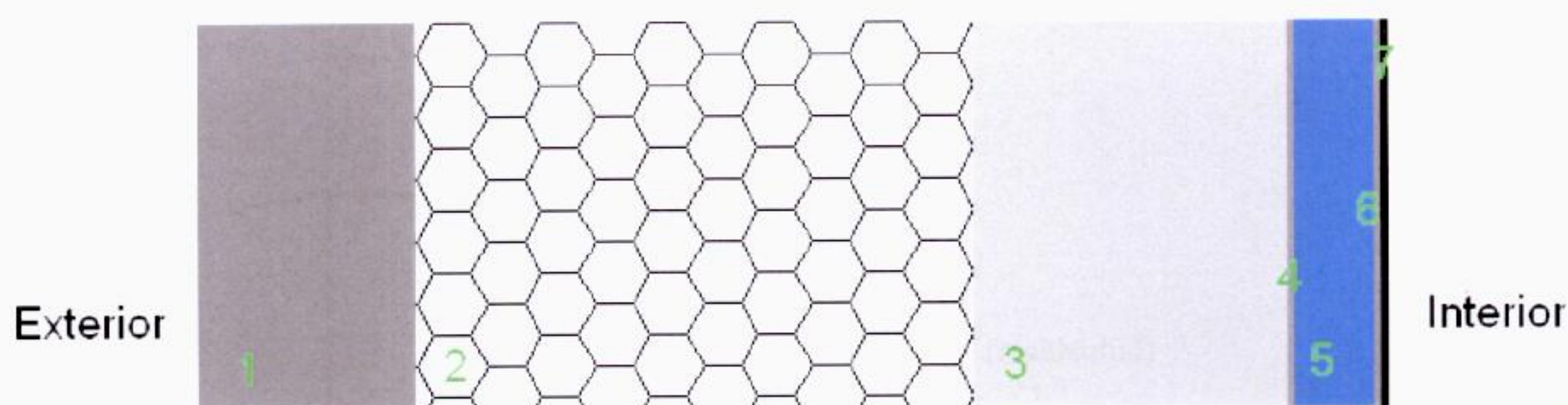
Forth layer: titanium plate (73% Ti, 13% V, 11% Cr, 3% Al), 2 cm

Fifth layer: silica aerogel, 10 cm.

Sixth layer: titanium plate (ATI 425), 5 cm.

Seventh layer: titanium plate (94.5% Ti, 3.0%Al, 2.5% V), easy to weld, 5 cm.

The shield is situated on the outside of the central cylinder, the spokes and the main body.



*Fig. 2.1.5 The shield*

The honeycomb structure improves the shielding to mass ratio and increases the thickness of the walls. The advantage of the spacing between the honeycomb walls over a thick solid shield is that the initial wall shock can melt the incoming particle (depending on its speed) and molten bits of the particle strike a wider area of the subsequent cell walls, therefore reducing the pressure.

For extra shielding, in case of major radiation, people will take cover in specially assigned areas, protected by extra layers of shield and by a magnetic field that will protect from radiation.

## 2.2. Internal Arrangement

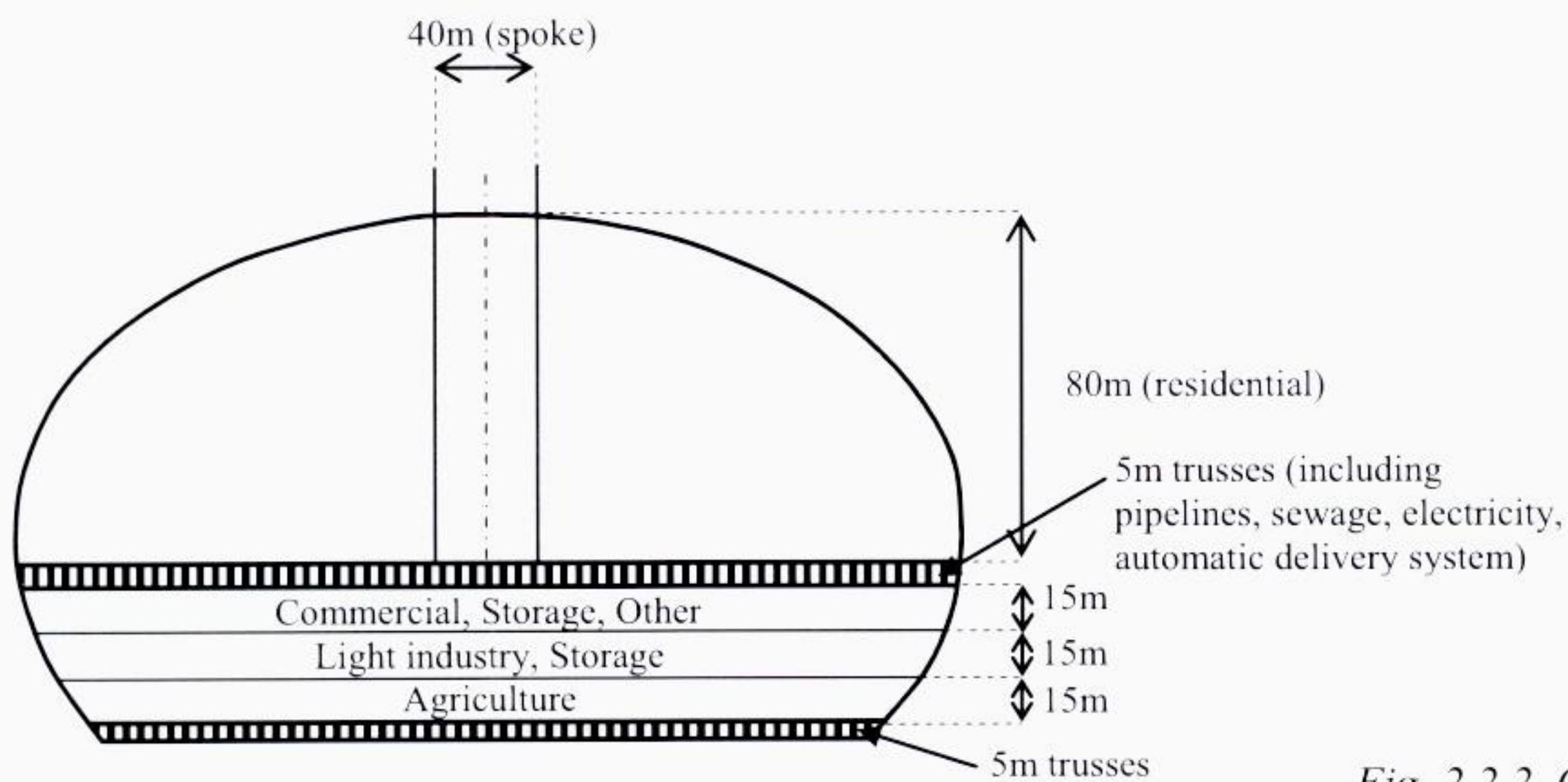
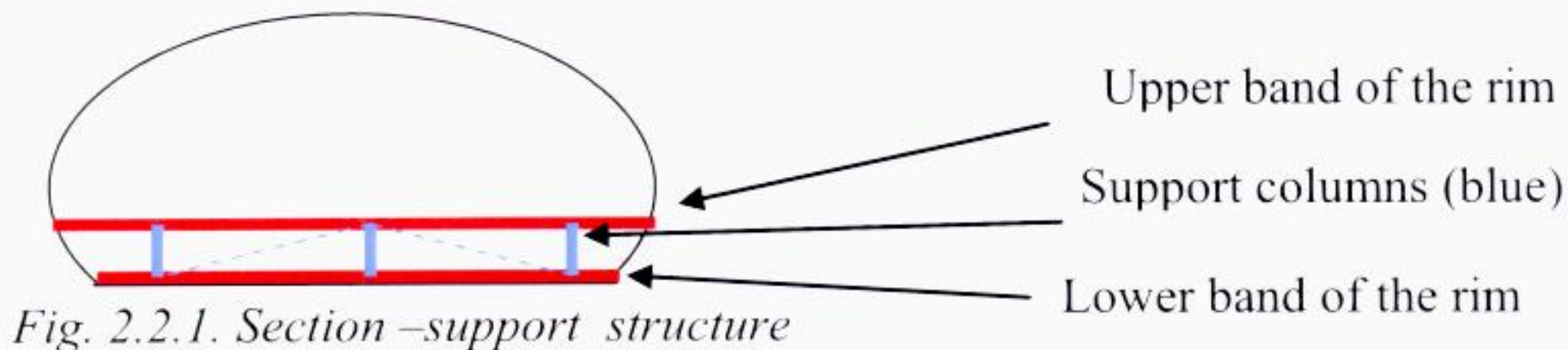
The rim will sustain all the structures inside the settlement; it is the skeleton of the main body and it is supported by titanium columns. It is situated from place to place, to keep the two bands apart, as spacers.

The two bands have to support the pseudo-weight of the entire settlement and because of the rotation of the settlement, they will tend to increase their radius. The main tension in the bands will be the tensing caused by the rotation and, if the mass that rests on the rim is perfectly distributed, the rim will maintain its circular shape. Else, the spokes and the support columns will help them maintain the shape.

Made out of titanium trusses that form two bands (the length of the settlement):



the lower band forms the lowest deck, where the maintenance area is and the upper band, which is the platform for the main upper level, the one illuminated by the mirrors and the one that houses are situated on.



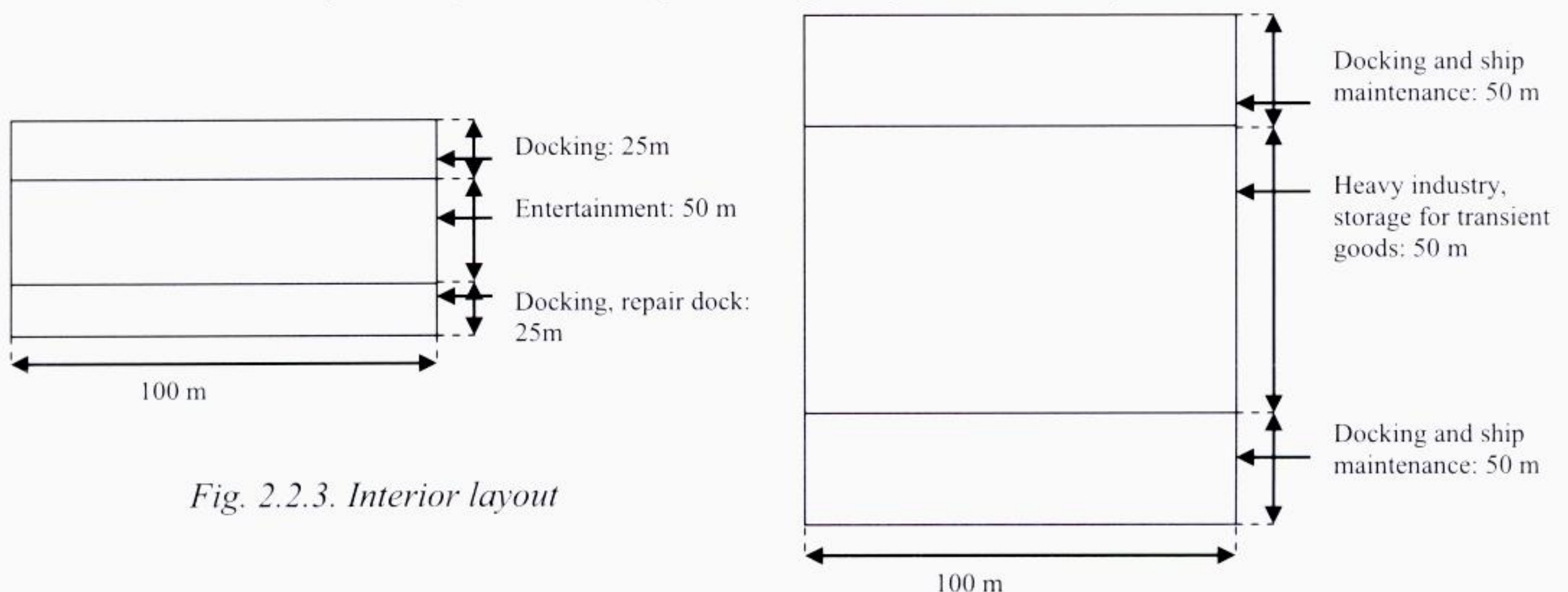
*Fig. 2.2.2. Compartments*

Each level has a maintenance area underneath it.

The main levels are:

1. The residential level on which houses are situated on
2. The commercial, storage (and other uses)
3. Light industry (and other uses)
4. The agricultural area

The use of the cylinders (left: middle cylinder, right: top and bottom cylinder):



*Fig. 2.2.3. Interior layout*



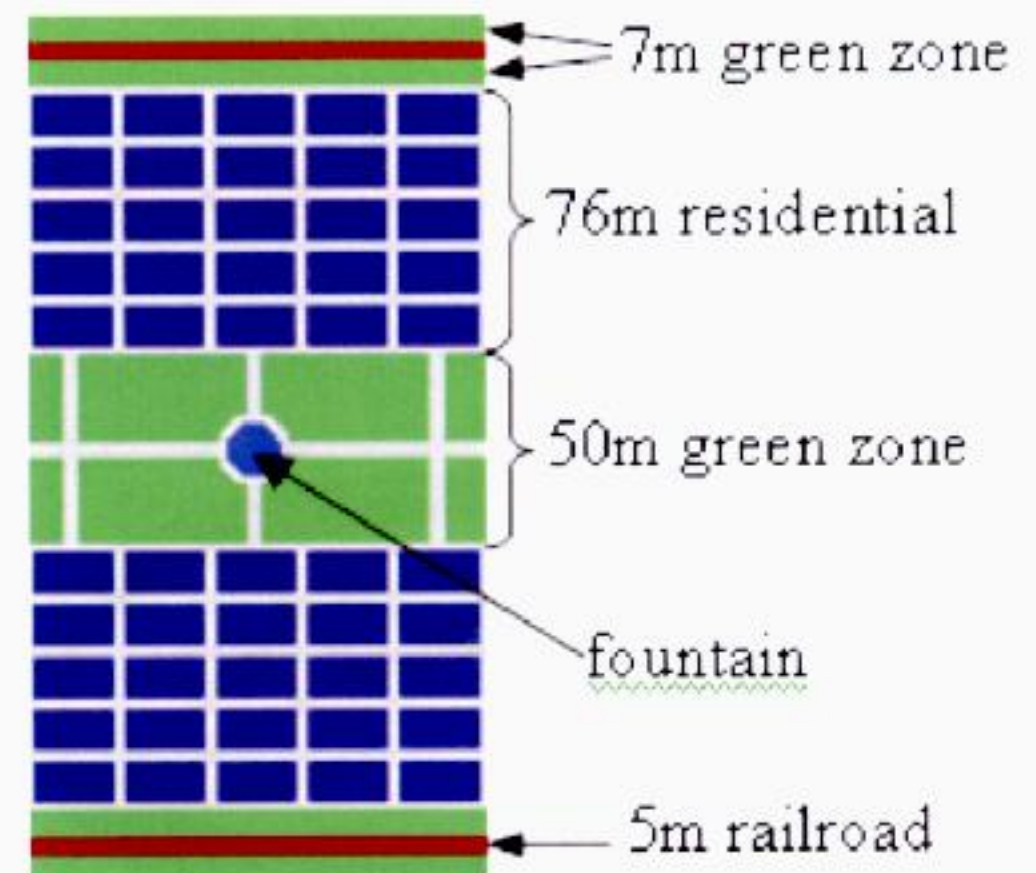
The allocation of interior “down-surfaces”: The settlement will be symmetrical to the middle where it will have a park. After the park there will be houses, followed by the train rails. On the edge of the settlement trees and plants that climb the exterior settlement walls will help reducing the feeling of claustrophobia.

## 2.3. Construction Sequence

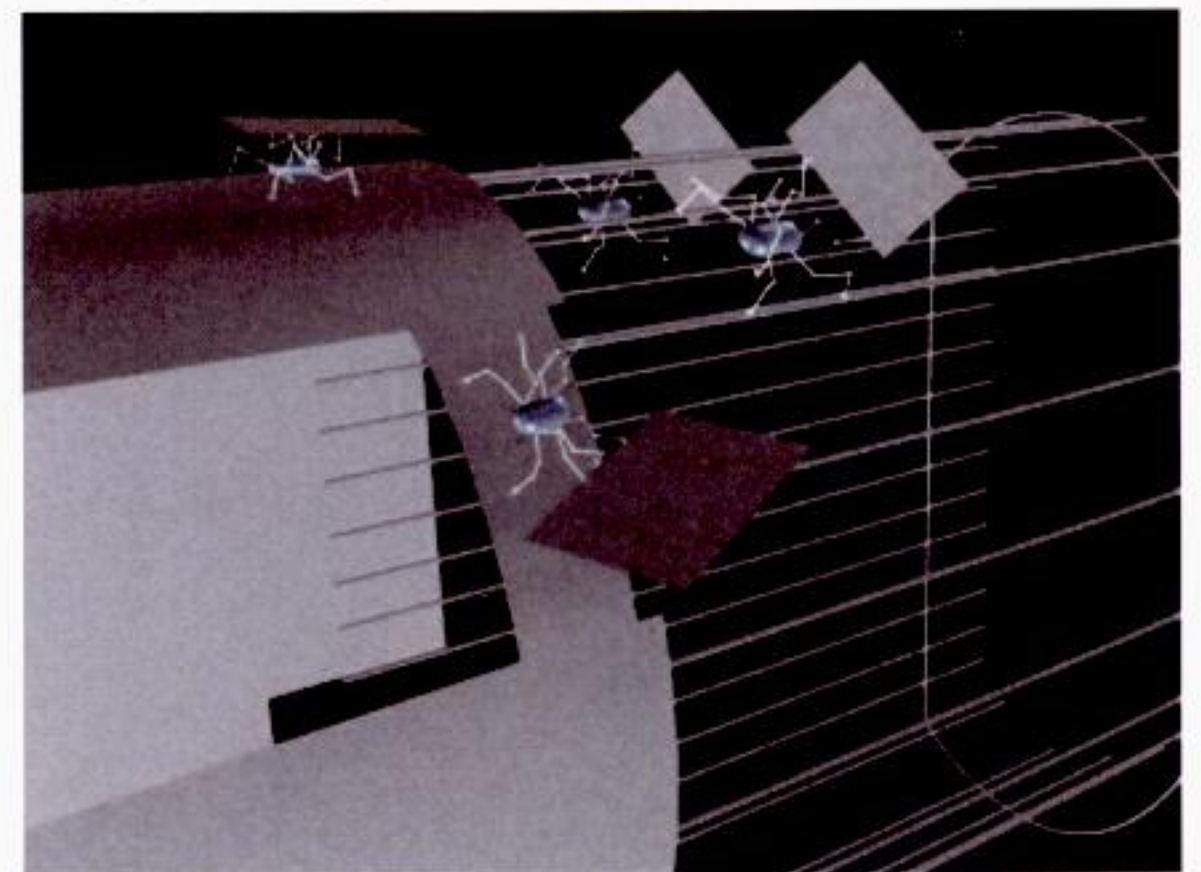
1. Building large mass launchers on Earth
2. Sending materials and equipment to the Moon
3. Building a mining base and a mass driver on the Moon
4. Mining lunar resources. Mining the asteroid in L4
5. Importing parts from Alexandriat
6. Beginning the build in L4, while still mining for resources to produce parts.

The actual build:

1. The central middle cylinder and its major attachments are built
2. 2 opposite spokes that connect the middle cylinder to the main body
3. The settlement is given an impulse to rotate from the engines.
4. The toroidal shape will be built, starting from where it meets the 2 spokes
5. During the building process, residential zones will also be created, in order to accommodate people. It will be populated by the workers who will continue the build.
6. The two livable areas are being extended, construction to each segment advancing symmetrically to the one on the opposite side of the center of mass, maintaining the latter in the same point.
7. The first settlers arrive
8. The inner automated systems and life support systems are installed and activated
9. After the toroidal shape is finished, the other 2 spokes will be built.
10. The automated systems are installed on the outside of the settlement
11. The settlers move in as construction advances
12. The outer cylinders and their spokes are completed, managing the requirements of a growing settlement.
13. Once the inside is completed, the outside systems are also completed
14. The final adjustments and detail work is completed

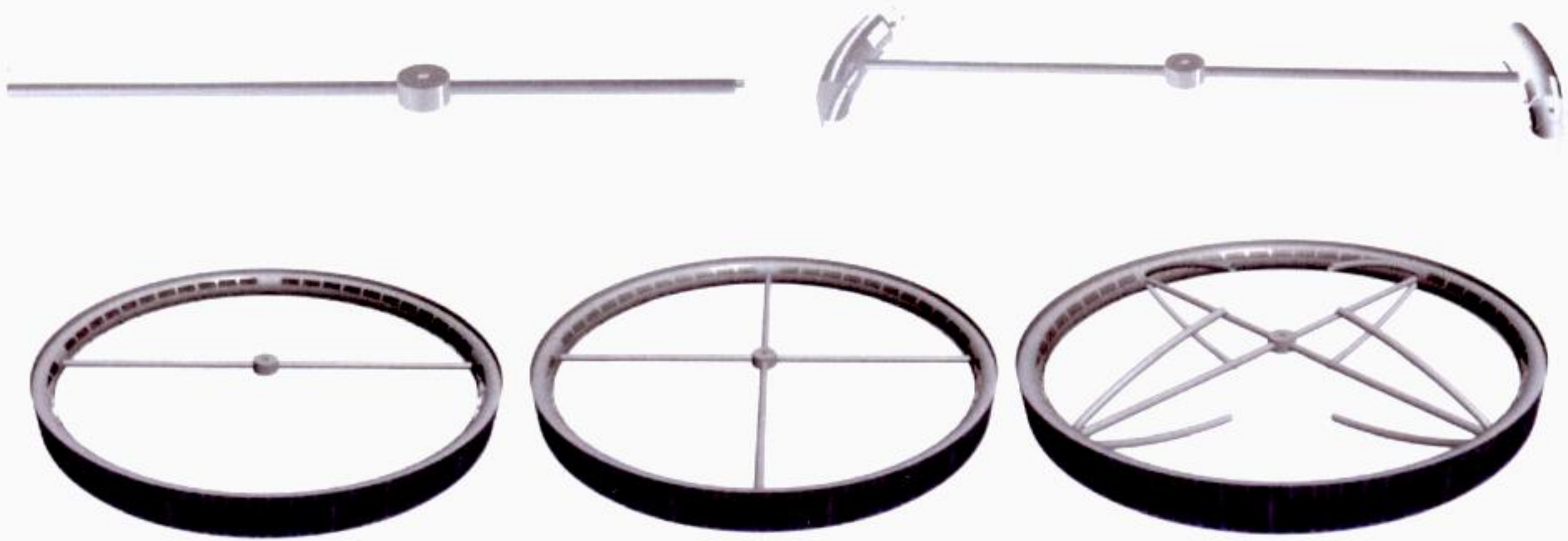


*Fig 2.2.4. Neighborhood top view*



*Fig.2.3.1. Construction robots working*

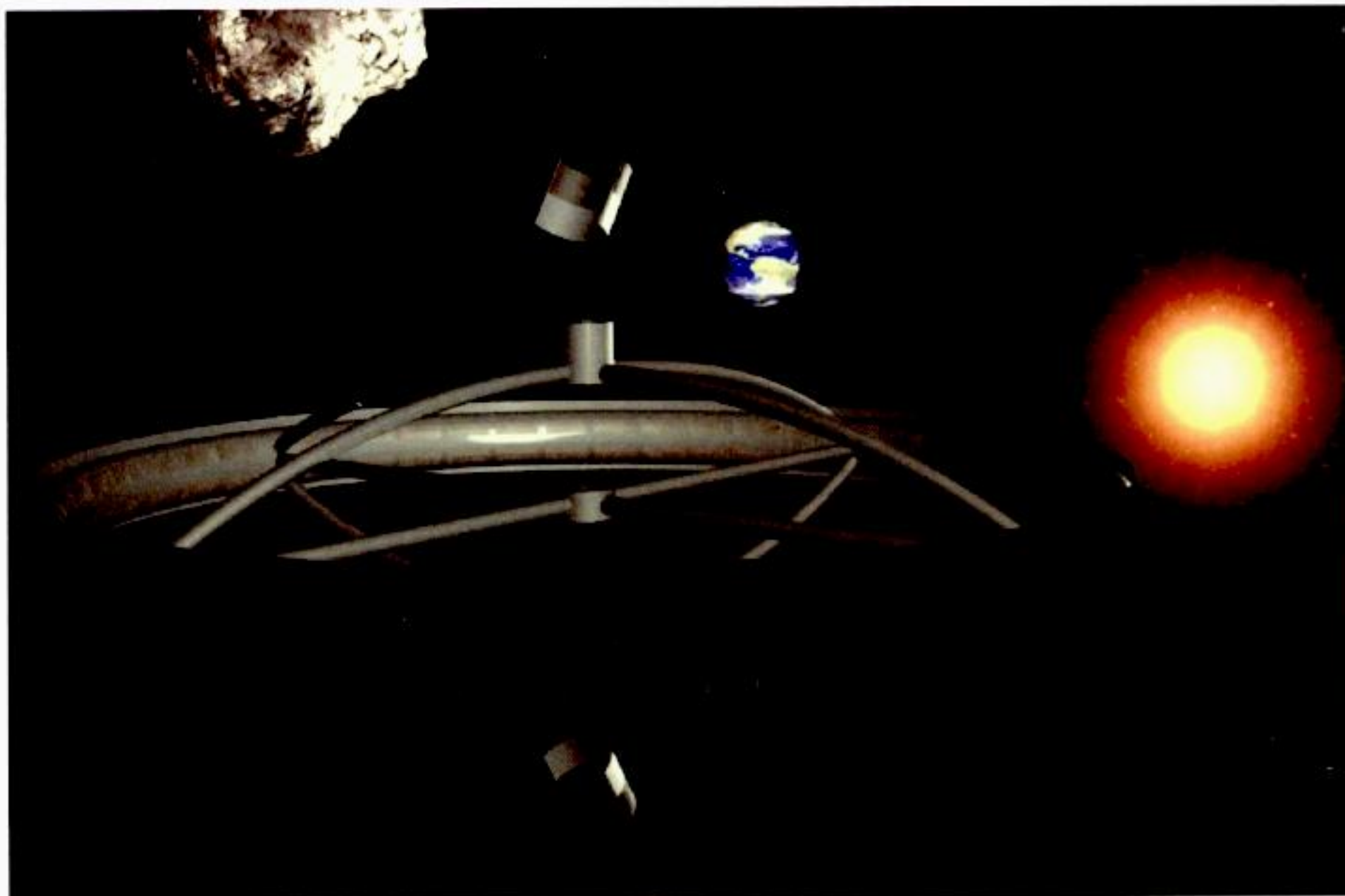




*Fig 2.3.2. Construction Stages*

## 2.4. Harvesting

Asteroids have sand-like materials on the surface. The first stage of mining consists of sweeping-up the dust, using a sweeper attachment to the mining robot.



*Fig. 2.4. Asteroid used for mining*

After the sand has been cleared, robots will use the mining attachment to shred the rock on the surface of the asteroid. The resulting materials will be run between two cylinders that crush it, for better storing. When one of the robot's cargo holder is full, its container will be replaced by transporters with an empty one. The filled container is then transported to the mass launcher and sent to the settlement.



To control the asteroid's position, we will mount thrusters throughout. The cutting will be done using borazon cutting heads. Solar panels and mass launcher will be the main structures on the asteroids.

Decontamination for:

- inorganic particles
  - Water jet will blow the entire outer surface of the contaminated object
  - The water will be eliminated and filtered
  - Airborne dust particles will be filtered using SULPA air filters (super ultra low penetration air), electromagnetic and electrostatic filters
- organic particles (such as bacteria)
  - UV light

## 2.5. Docking Ports

The settlement has a total of six spaceports, two on the caps of each cylinder. The large spaceship docking zones are situated on the end of the 1<sup>st</sup> and 3<sup>rd</sup> cylinder, on the caps that face the outwards. They have four strong arms for grabbing incoming ships and make them rotate once with the settlement. Large ships will not enter the cylinder, but just unload the cargo and send it to the settlement. Small ships will be grabbed by the robotic arms and safely guided inside cylinders, for repairs and safe docking. Once inside through the airlock, a ship will be decontaminated and stored in a specially designated area. After this procedure, the ship's cargo and crew will pass through decontamination. It's quintessential that the incoming objects pass through decontamination, to avoid the introduction of foreign materials that could unbalance the settlement's fragile ecosystem.



*Fig 2.5. Docking port*



3. Operations and infrastructure

3.1. Construction Materials Sources

The space settlement will be assembled in the Lagrangian point L4. The Lagrange L4 point lies in Earth’s higher orbit, situated at an equal distance between Earth and Moon. It is a stable equilibrium point where an object will keep its relative position to the Earth and the Moon. This point (and its counterpart, L5) provides a ideal place for a space settlement.

3.1.1. Construction:

Launch vehicles carry materials from Earth and Alexandriat to the moon where they will build a platform and solar panels. The platform will help mine and process materials (especially titanium, silica, aluminum, iron, oxygen and, according to some data even frozen ice; also, the Moon *should* contain all the chemical elements found on Earth, including vanadium, hydrogen and even carbon) on Moon, constructing parts of the settlement. The prefabricated parts will then be sent to the assembly spot by mass drivers. Also some materials will be mined on the asteroid which already exists in L4. The payloads sent from the moon by the mass drivers will reach the L4 point where a mass catcher is ready to decelerate and handle the payloads to storage areas around the space settlement and inside the central cylinder. Delicate shipments will be carried by space crafts.

The lunar base will be built on the rims of the Shackleton crater, close to the lunar South Pole, in an area that is lit up by the sunlight almost all the time, and where the Lunar Prospector spacecraft has bound traces of Hydrogen, which may indicate the presence of frozen water.

We will exploit lunar materials using a fleet of S.E.L.E.N.A. robots and some other larger robots. S.E.L.E.N.A. is a robot designed for mining the Moon, capable of processing up to 2 square meters in a terrestrial day.

Some other facilities on the moon include: solar ovens, electrical and microwaves ovens, microwaves power transmitters, mass launchers (drivers), solar panels, science laboratories and so on.

Another source that provides us with parts is Alexandriat. It will, too, send the payloads using mass launchers.

The space settlement will be built in the vicinity of a ferro-nickel asteroid that will be mined for raw materials. If the asteroid in not larger than two kilometers in diameter, it will not cause any problems to the settlement, the attraction forces being negligible.

Needful materials:

Table 3.1.1.

Place	Resources	Means of transporting
Moon	Titanium, Aluminum, Silica Dioxide, Iron, Calcium, Oxygen, possibly ice, Magnesium, Vanadium, etc.	Mass launcher
Earth	Carbon, Nitrogen, Hydrogen, Boron, water	Rocket
Asteroids	Iron, Nickel, Carbon	Mass launcher



## 3.2. Community Infrastructure

### 3.2.1. Internal and External Communication Systems

The settlers will communicate to each other using the internal communications system. This consists of mobile wireless terminals that can receive and initiate voice and video calls, connect to the internet and intranet. They also support VoIP and TVoIP. The settlers will be able to communicate to the people outside the settlement using the internet and the voice and video call networks that link the settlement to Earth and other settlements around Earth.

### 3.2.2. Internal Transportation Systems

The transportation on the main deck, inside the living area, people can walk, ride bicycles and even use roller-blades.

There are three transportation systems. The first links the four areas of the settlement length-wise. It consists of two small monorail electrical trains that span the entire length of the settlement on which run small, 8 seats trains. The trains have four stations, one in each area of the settlement. The stations are situated on secondary rails, so that a stationary train will not disrupt the traffic. In every station there will be up to five stationary trains waiting for passengers. The trains are eight meters in length, two in width and two meters tall. They will have a cruising speed of 30km/h, so that the resulting acceleration will not be too much for the passengers to withstand. Because of the fact that the four areas of the settlement have different night/day cycles, there will not be much need for people to travel to another area than the one that they live and reside in. The trains will be controlled by autopilots.

The second transportation system consists of elevators that link the surface (where the houses are located) to the lower levels. About 25-35% of the working population has a job on one of the lower levels. These elevators have stops on every level. These elevators can fit 30 passengers and can transport the entire workforce in just under 30 minutes. The elevator shafts are placed every 50 m (lengthwise) on both the left and the right side of the settlement, symmetrically, elevators facing each other being 200 m apart. The elevators will be used (outside the rush hours) to haul cargo. The elevators will be driven by fixed rotors and counterweights. The shaft will have rails on the side that the Coriolis force will push the elevators. The elevators will be 5m by 5m and will have a height of 2.5 m. There will also be stairs that can be used for the same purpose of reaching the lower levels.

The third and most important transport system is the one that connects the main body of the settlement to the three cylinders. It will, too, use counterweights, but it will not have stationary rotors for the lift but a motor that drives cog wheels for propulsion. It will be able to function independent to the rest of the systems, in case of damage, having its own battery.

There will be two types of elevators. The first one will function inside the spokes that connect the main body to the middle cylinder. It will have the capacity to transport 100 passengers on each of its two levels. The passengers will be strapped in so that the Coriolis force won't cause too much discomfort. The elevator floor will be 6.5m by 6.5m and 2.5m tall, each level. This type of elevator will run through the straight spokes.

The second type of elevator will link the main body to the 1<sup>st</sup> and 3<sup>rd</sup> cylinder. It will work like the first type, only it will be able to carry 150 and will be 12.5m by 12.5m and 2.5m



each level, having a maximal capacity of 450 passengers. This type will run through the curved spokes.

Both types will be able to transport the required number of passengers in less than half an hour at a cruising speed of 4 m/s. Once the rush hours will be over, the elevators can be reconfigured for transporting goods.

Transport inside the microgravity zones of the settlement will be accomplished by capsules that move close to the interior wall of the cylinders. They will have a capacity of 50 passengers, 11m by 3m, and 2 m tall. These capsules will seat people like a regular bus, only the exit will be through the roof. The capsules will move clamped onto rails, self propelled. Again, these transporters can be reconfigured for cargo hauling or if cleared from the tracks can allow other transporters to pass. These transporters will move across the circumference and on the height of the cylinders, connecting each area in the cylinder (including the spaceports) to the spokes and finally to the main body of the cylinder.

There will be one more transportation system, which will help deliver goods to settlers, directly from the supplier.

Electrical cords, fiber optics, water and sewage conduits will run the entire area of the main body, on maintenance levels underneath each main level. These will also run through the spokes to connect the cylinders. The spokes will also contain air conduits to deliver fresh air to the cylinders. All conduits have pressure valves across their span, so that if the pressure drops, indicating a leak, they will be sealed off, to contain the leak. The remaining conduits will take over, to compensate.

The “ceiling” of the main body will have, on its exterior, radiators, to help regulate the temperature. The coolant conduits will run through the ceiling, connecting the radiators on the inside to the ones on the outside.

### **3.2.3. Electrical Power**

#### **3.2.3.1. Capturing and Transforming the Solar Energy**

The best power source that we have is the sun. To transform the solar energy into electricity we use solar cells.

From the diversity of solar cells available we will have to choose the most efficient type.

Economical solar cells have an efficiency of about 8-10%, medium solar cells have an efficiency of 10-17%, and high end solar cells, the most performant of all have an efficiency of about 30%(this is the maximum) and in laboratory conditions the efficiency can rise to 40%. The best solar cells are those made from Gallium Arsenide, a chemical compound composed of gallium and arsenic. The material used to make this type of cells is also used in microwave frequency integrated circuits, laser diodes and even in infrared diodes, also, in case of necessity the Gallium Arsenide cells can be used to emit light. We will combine GaAs with germanium and indium gallium phosphide, this process will make the cells efficiency rise up to 32% and they could operate with very high concentrated light

We know that this types of cells had a very good success because they were successfully used to power Spirit and Opportunity, robots that are exploring Mars surface.



### 3.2.3.2. Microwave Power Receptors and Emitters

Beside the solar panels used to produce power for the station we will have two microwave receivers that can receive power from the moon (where there will be a power plant or other power sources such as solar cells) or from the earth or other stations. This device will be used if the solar cells are destroyed and the batteries could not supply the necessary power to keep the station functionally in normal parameters or at least minimal parameters or from any reason the power generating system collapses.

Because we will produce enough energy for our station, even more that we will need in a normal day, we could send electricity to other station or to the moon or to the earth by the microwave emitters, and we could help the other and sell energy that we don't use.

### 3.2.3.3. Power Distribution

The electricity will be produced by solar panels or the microwave receivers, will be stabilized and monitored by computers. The voltage will be higher for industry and lower for home use.

The voltage will be transformed with toroidal transformers (they are more efficient than classic transformers, there is no noise and much lower leaks and they don't heat much)

For longer distances, the electricity will be transported by superconductors. The superconductors will be placed outside the station (example: Calcium cannot be used on earth because it oxidizes instantly, because of the air, but it is a better conductor than Copper and Aluminum)

For short distances copper will be used, because is the most efficient of the conductors. The copper cables will be used to transport the energy in the houses and in the interior of the station.

### 3.2.3.4. Power Storage and Infrastructure

Because we cannot use directly the power generated by the solar panels and because we may have situations that will impose to have some power stored (example: some of the solar panel will be destroyed and we need to have energy for repairing them and keep the station functional)

Form the diversity of batteries available:

- Nickel Cadmium
- Nickel Metal
- with acid
- Lithium ion cobalt
- Lithium ion Magnesium
- Lithium ion Phosphate

We chose the first Nickel Cadmium because is the most efficient of all has the highest number of cycles and the lowest percent of self discharge. Specific energy densities (energy per unit mass) of 10 Whr/kg are common at the 10- to 20-percent depths of discharge used to provide cycle life. As a rule, the energy storage subsystem is the heaviest and largest part of a solar power system. This need poses additional system constraints as power system voltage increases to the 100-kilowatt level and beyond.



The electrical cables will be placed on lower levels of the station, to avoid people touching them and get electrocuted, and in case of a fire, people remain safe on higher levels. Operators and computers will monitor the parameters of the electrical system and repair with maintenance robots the problems.

#### **3.2.3.5. Secondary Power System**

On the station we will have a secondary power system that will engage in case of a major damage on the master electrical delivery system (the electricity cannot be delivered to the survival equipment of the settlement-hospitals, ventilation, lights, air filters, water pumping and recycling system, etc) or if we have to change essential parts on the master system that will impose to shut down it (this is the moment when the secondary system starts)

#### **3.2.3.6. Solar Cells, Cables and other Electrical Materials**

On the station we need to constantly produce solar cells.

The cells produced on the station will replace the ones that are too aged to work, or are damaged or destroyed by meteors. Also, we can sell photovoltaic cells to other stations or use them in other places.

#### **3.2.4. Food production**

Belleλvistat will be able to supply its population with a balanced source of nourishment from purely natural crop and also from animals that will be grown on the space colony.

First of all, the plants will be cultivated and harvested inside greenhouses, each of them providing the necessary conditions for the plant species. The variety of plants will ensure the nourishment for the humans, as well as for the animals raised in the nearby farms. We have considered the choice of diets for the population of Belleλvistat and we have concluded that a balanced diet, based on both vegetables and meat, will have benefic effects on the settlement's population. Although the diet based on vegetables is proved to be healthier, the lack of different substances and compounds (sometimes dangerous when consumed in excess) found in the terrestrial one, can lead to dysfunctions of the human organism. Furthermore, the diet which includes meat provides a beneficial psychological effect for the residents, as it will clearly resemble the diet they used to have on Earth. The amount of vitamins, minerals, fats, carbohydrates and proteins supplied through the meals will be adjusted to match their RDAs (Recommended Daily Amounts), as well as to supply enough calories for their daily activities. Thus, the human diet on the settlement will be healthy and will prevent nutritional diseases.

The species of plants and animals that we intend to grow on the settlement have different quantities of various nutrients, thus making the diet very diverse. The plants species are represented in the table below with their specific nutritional values, based on the 1975 NASA Summer Study and our own studies.



Table 3.2.4.

Source	Amount/ day	Yield/ day	Area/ nerso	Calories	Nutritional values/amount			Season	Genus
					Fat	Protei	Carbohydrat		
Measures	g/day	g/m <sup>2</sup> /day	m <sup>2</sup>	kcal/100g	g	g	g	days	
Maize	50	58	0.86	89	1.1	3	18	90	Zea
Rice	100	36	2.85	363	0.6	7	79	90	Oryza
Sorghum	320	83	3.85	339	3	11	75	90	Sorghum
Soybean	500	20	25	30	0.18	3.04	5.94	90	Glycine
Tomato	100	13	7.7	22	0.2	1.1	4.7	70	Solanum
Wheat	180	31	5.8	608	2.6	24.3	130.1	90	Triticum
Potato	100	28	3.5	76	0.1	2.1	17.1	80	Solanum

The plants will be grown through the high pressure aeroponics technology: it consists of the plants' roots being introduced into a chamber where hydro-atomizers will create a fine mist near the root, while partially leaving it uncovered in order to oxygenize it. The spread solution will be composed of water and all the necessary nutrients for the types of plants that will be cultivated. By calculating the difference between the quantity of solution introduced and the quantity of solution evacuated, we can estimate the plant's absorption level. Thus, we can limit the quantity of administered solution and consequently maximize the efficiency of water usage on the settlement and redirecting the energy to other places that require it. Furthermore, this system prevents transmission of plant diseases because the contact between plants is very low and the spray pulse can be sterilized with pesticides. This system is more efficient both in cost and effectiveness because the roots, being exposed to oxygen and to the nutrients contained in the solution, will grow at a faster rate, speeding up the plant's development. Due to the fact that the solution which is transported contains so many minerals, mineralization can occur at the nebulizer level. In order to prevent this, we will use low-mass polymers at the spray which will completely eliminate this threat. In case there is a problem in the electrical section, or even in the aeroponical system, we will immediately manually revert to a hydroponical system, by enclosing the roots in a more diluted solution of nutrients. Thus, this action will be vital in order to sustain the plants in case of an emergency.

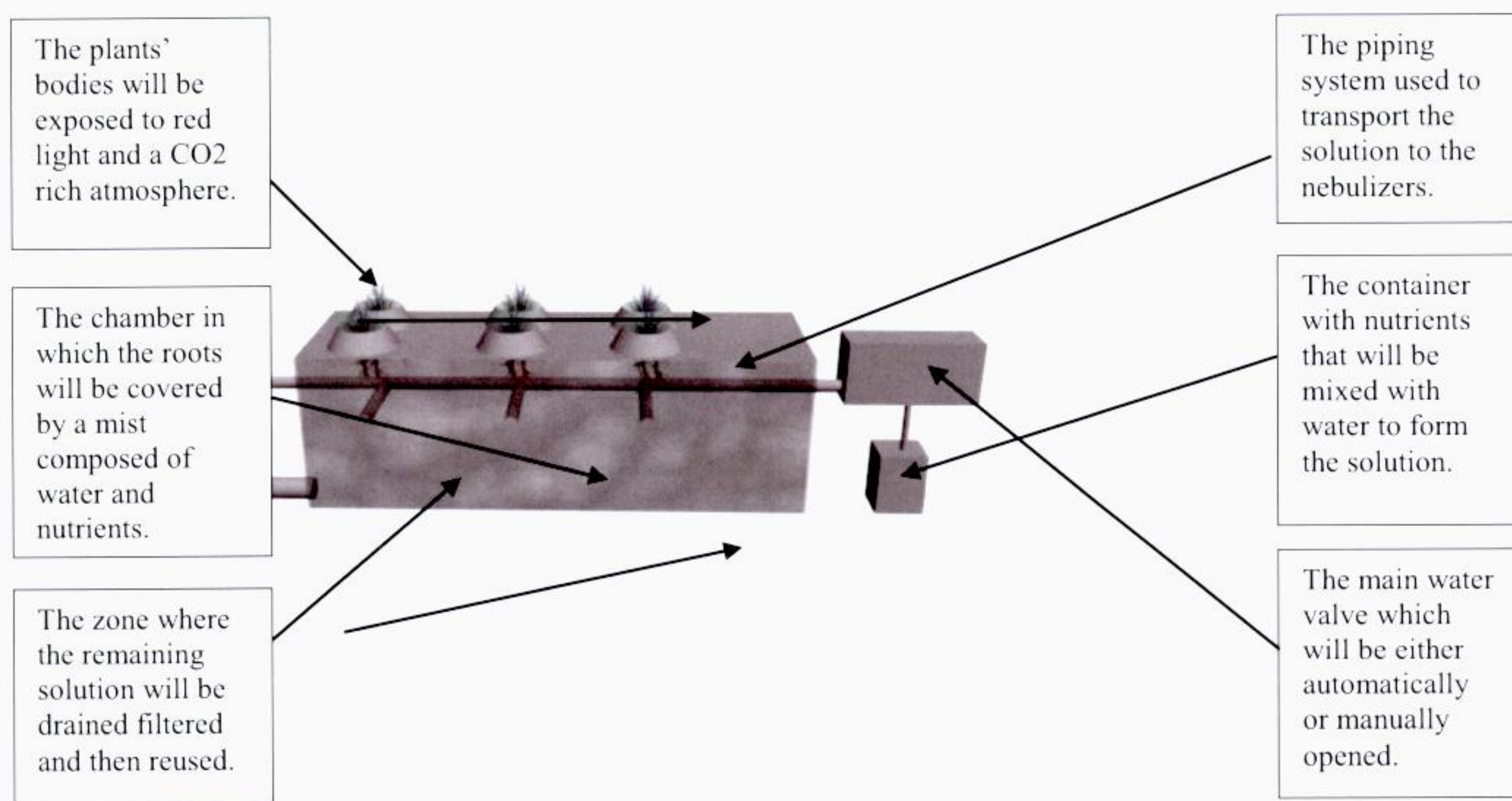
The solution will contain nutrients that will be obtained in a natural way. Both human and animal wastes will be introduced in a container, where a dense flora of bacteria and fungi will reduce it through fermentation to mineral substances. Thus, there will be an efficient way to dispose of the wastes with minimal loss of matter and energy.

The greenhouses will be located separately from the residential area, while creating small greenhouses above the homes of the people that wish to participate in the growing of the plants.

The greenhouses will contain aeroponical systems that will be made of special rubber, for the smaller plants, or solid ones as shown below designed for the bigger plants. The greenhouse will have a ventilation system that will introduce carbon dioxide and will evacuate the excess oxygen resulted from the photosynthesis process. This system will prevent the increase of the



oxygen concentration of the air and so it will minimize the chances that photorespiration will occur in the plants' cells.



*Fig.3.2.4. The aeroponic system*

The red light spectrum will be used to illuminate the crops, as the plants are known to best absorb the red light (650 nm wavelength) for the photosynthesis process. For the algae that will be raised for the aquaponics system, there will be a variety of light colors as they will range from blue to green.

The species of plants that we have chosen to cultivate in the greenhouses are known to be very nourishing, containing valuable vitamins and minerals and, of course, carbohydrates (glucose, fructose, maltose, and polysaccharides in the form of starch, cellulose and cellulose-derivates: hemicelluloses, pectin and other), proteins and fats. Vitamins are special compounds which prevent oxidations which are known to be a source of toxic by-products in the organism. Only some vitamins can be synthesized in the human body (D, K) while others cannot be synthesized at all (C, A), or synthesized but in insufficient quantities (the rest). Minerals maintain the hydro balance in the organism and act as electrolytes in the cell structure and function.

The inhabitants will also be able to participate in the production of the food by either supervising the process and monitoring the parameters of the plants, or by helping with pollination, especially in the case of cereals which require wind as the primary spreading factor.

- **Wheat** is a very valuable cereal that represents the base of agriculture. It contains many vitamins, a high quantity of starch, and minerals such as potassium, magnesium, phosphorous that are essential to the well-being and balance of the human organism. It also contains gluten, a natural bactericide that is also sticky and slows down the digestion of food.



- **Rice** is a very valuable cereal due to its high quantity of starch and to the fact that it is easily degradable in the digestive tract so it is highly favored by the young and elder section of the population.
  - The **tomato** is a vegetable that contains a large quantity of vitamin C, therefore partially eliminating the need of growing citruses. It also contains various amounts of ions necessary to the organism.
  - The **potato** is the most favored plant of the modern age, containing the largest quantity of starch and being able to be cooked in many different ways. In addition to this, it contains a high quantity of vitamins (C and B6) and minerals, namely zinc, a large quantity of iron, and potassium. Its growing process is a bit special due to fact that, when exposed to the light, the tuber accumulates toxic solanine and gives the potato a greenish color. Thus, there will be an opaque material that will cover the tuber layer.
  - **Soybean** contains, like all legumes, a high quantity of proteins full of all the essential amino-acids needed by the human body. It also contains a high quantity of vitamin K, necessary to the blood clotting process. Soy milk can also be used by the vegetarian people, as it fills the lack of proteins obtained from the meat products.
  - **Maize** contains a high quantity of magnesium, as well as vitamins from the B complex.
- In addition, we propose to have a covered orchard at the edge of the residential area, with different trees such as apple, citrus, apricot and peach trees. There will also be created bee hives (*Apis mellifera*) that will produce honey, a natural source of fructose and glucose, propolis, a natural preserving substance and will also make possible the natural pollination of the trees' flowers. The trees will be grown in an artificial soil composed of dehydrated manure and nutrients, and decomposing bacteria which will further supply the tree with nourishment in the blooming and fruit development periods.
- The animals will be raised in farms, where robots will ensure their feeding and cleaning, as well as processing into meats. Their feed will consist of barley, oats and other plants that will be grown near the farms through either aeroponics or hydroponics technology. The waste from these animals will be decomposed by bacteria and then used as nutrients for the plants. The species of animals raised are shown in the table below.

Table 3.2.4.2. Animals

Animal	Area/Animal (m <sup>2</sup> )	Number/Person	Type of feed	Area / person
Rabbit	1	2.8	Oats, hay(from wheat and maize)	2.8
Chicken	0.3	6	Grains(wheat, corn)	1.8
Goats	1,5	0.8	Plant remains	1.2
Fish	0.15	30	Algae, Meat	4.5
Other	6	-	Plants	-



The fish will be raised in special tanks that will be connected to containers with algae. The algae will produce the food for the fish, while the fish's waste will act as nourishment for the plants, thereby cleaning the water in the process.

The products obtained from the animals will be: eggs which contain all the necessary vitamins from the B complex, vitamin A, D (one of the few sources of this vitamin) and E. Milk obtained from cows and goats is very high in calcium and therefore is essential for the growth of infants, as well as a source of vitamin D, B12 and B2.

Apart from the meat obtained from the animals, we have considered the possibility of creating a laboratory in which we will be able to obtain muscle tissue of other animals, especially chicken and rabbit muscle. This will be done by depositing stem cells in special containers filled with nutrients necessary to the cell development and applying hormones that will cause cell specialization. The stem cells will be obtained by laparoscopic means consisting of extracting the embryo from the mother.

We have also considered creating a genome bank, composed of stem cells of many animal and plant species, cryogenically conserved in special containers at very low temperatures. Thus, this bank will prove useful for introducing new species of plants and animals in later development of the settlement.

**Food processing and stocking.** The section that will process the food obtained from the agricultural section will be located above it, in the light industry section of the settlement. The food will be transported using elevators to the food processing robots. The milk will be deposited in special containers where enzymes and bacteria will transform it into cheese or yogurt. The eggs will be washed and sterilized to prevent contamination with pathogenic agents. Meat and meat-based products will be partially heated to prevent dangerous substances from poisoning the products. The meat will be obtained using robots in sterilized slaughter rooms that will prevent contamination of the meat. The vegetables will be either dried (seeds of wheat, maize or soy) or vacuum-sealed in special packages to prolong the freshness of the product. Finally, all the products will be either conserved and stored in the special refrigerating rooms, or stored temporarily in rooms with lowered temperature, to be shipped off to the commercial centers or exported to other settlements.

The food can also be sent to the light industry section, to obtain more complex foods, ranging from juices to powdered products (flour) and extract oil from oleaginous plants (soy, sun-flower).

In case of malfunction at any level of the food production systems, depending on the situation, the food reserve will be used to supply the settlement's population and will last about 1 week, until the ship from either Alexandriat or Earth arrives.

### 3.2.5. Atmosphere

In order to maintain the vital functions of any human organism, the quality of the air must be maintained at certain levels. The air is comprised of many gasses, of which the most important one is oxygen, the element which is essential to all living organisms, as it is the only element which can be used in cell respiration. Other gases include nitrogen, carbon



dioxide, argon, water vapors, helium, methane, krypton, and hydrogen. The density of these gases in the colony's atmosphere must be maintained at levels normally found at sea-level, which can be found in the table below. Furthermore, the concentration of carbon dioxide will be at about 2-3% in greenhouses, to obtain maximum productivity of the plants' photosynthesis, while decreasing the oxygen concentration at about 18%, to prevent photorespiration.

The air pressure will have the same value as that of the sea-level, at about 101.32 KPa, due to the fact that at this level the oxygen, having its partial pressure at around 22.7 KPa, will be optimal for it to diffuse at the lung alveoli level, or at the plants' stomata. The carbon dioxide is essential to the photosynthesis process, while having a partial pressure of less than 0.4 KPa and the nitrogen, with a partial pressure of at least 26.7 KPa is essential for preventing respiratory problems.

The temperature will be maintained between 22 and 25°C, being suggested by most studies. The temperature will be modifiable at a room-level scale having an atmosphere control panel.

The humidity will be at around 50%, being controllable at either residential or community level. It will be controlled through ventilation systems which will nebulise the water into a fine mist.

The atmosphere's parameters in the settlement will be continuously controlled through multiple processes.

Gas	Concentration
Oxygen	20.946 %
Nitrogen	70.084%
Carbon dioxide	0.0383%
Other gases	0.931%

Although the only natural process by which oxygen can be released in the atmosphere is the photosynthesis, its efficiency is very low and therefore additional oxygen sources will be utilized: electrolysis and storing liquid oxygen in special tanks at very low temperatures. We will totally rely on the respiration process of plants, animals and humans. The excess quantity of CO<sub>2</sub> will be moved into the greenhouses to increase its concentration and thus maximizing the efficiency of the photosynthesis and increasing the quantity of oxygen supplied in the rest of the settlement. It is important to control the CO<sub>2</sub> emissions and we propose to have certain materials placed in the ventilation system, which will be used in order to maintain balance. These materials are: molecular sieves, solid phase amines, silver oxide.

Molecular sieves consist of zeolites which are composed of silicon and aluminum and have a crystalline structure. This system uses a Four Bed Molecular Sieve and it is thermally renewable: while two beds are in sorption mode, the other two beds undergo regeneration.

The solid phase amines system is based on the use of three common alkanolamine CO<sub>2</sub> sorbents, monoethanolamine, diethanolamine and methyldiethanolamine. The difference between them is that while the tertiary amine only requires only one reaction, the other two must undergo two successive reactions. These chemicals will be produced in the industrial laboratories.

The chemisorption reaction of silver oxide is reversible and it requires the presence of water. Additional oxides, including magnesium and zinc, can be used as reversible CO<sub>2</sub>



chemisorbents. However, each of them have different densities, CO<sub>2</sub> capacities, and regeneration rates.

### 3.2.6. Water management

Water is the major component in both foods and the human body. It is used in digestion, absorption of food and it is the medium in which most of the chemical reactions take place within the body. Water also helps regulate body temperature.

The food and fluids which are consumed provide 80-90% of the daily water intake. Water is lost each day in urine, sweat and through evaporation from lungs. In order to maintain balance, it is needed about 1 ml of water for each calorie to be burn, approximately 2,7 liters/day in the case of women and 3,7 liters/day in the case of men.

Water plays an important part in: hygiene, plant photosynthesis, agriculture, temperature transfer, fire extinguishing, food processing, oxygen generation, scientific experiments and it is also used for consumption (drinking).

Water will be obtained through filtration processes that will extract it from urine, moisture from the greenhouses, and residual waters. The total amount of water necessary per person is estimated at 35 liters.

First of all, physical water filtration is mainly concerned with filtration techniques. Through these processes solids are removed from liquids. Water is forced through a membrane under pressure, leaving impurities behind. Cross flow membrane filtration methods will be used to separate matter from water. The finest membranes will be able to filter particles as small as 0.001 microns (reversed osmosis). That includes most salts, bacteria, viruses and metal ions.

Chemicals will be added to prevent the formation of certain reaction products. Chelating agents are added to prevent the storing of calcium and magnesium. Oxidizing agents act as biocides and may also neutralize reducing agents which help preventing the degradation of purification membranes.

Deionization consists of a tank with small beds of synthetic resin treated to absorb certain cations or anions and replace them by counter-ions. The water softener removes calcium and magnesium and replaces them with positive charged ions, such as sodium. Ethanol, methanol, isopropanol, acetone and urea cannot be removed through physical water filtration so the Aqueous Phase Catalytic Oxidation technology is needed. Due to the fact that the temperature of the reactor is high, 125C, most microorganisms do not survive.

For the reclamation of water from urine there are two processes which are used: the Air Evaporation System and the Vapor Compression Distillation.

The adjustment of the pH is necessary for the prevention of corrosion from pipes and dissolution of lead into water supplies and it is possible through addition of hydrogen chloride, in the case of a basic liquid, or sodium hydroxide, in the case of an acidic liquid. The pH after the addition will be converted to approximately 7 to 7.5.

The biological water purification may be done either through aerobic treatment or anaerobic treatment with iodine.

Oxygen is the primary oxidizer used in this process. It consists of a sequence of oxidation reactions that occur at temperatures above the normal boiling point of water, and



also below the critical point, 374C. It is a form of hydrothermal treatment by oxidizing the dissolved or suspended components in water. In order to take place the pressure in the reactors must be above  $10^7$ MPa. This form of oxidation can only be done under wet conditions, as under dry conditions it has no effect.

The means of transporting water and sewage will be realized through a system of pipes which discharge themselves in special tanks, where the filtration processes will occur.

### 3.2.7. Solid waste management

Waste results from either human, animal or plant activity. Because there should be total independence of the Earth and Alexandriat, we have come up with a method of recycling almost every type of waste, whether biodegradable or non-biodegradable. The biodegradable waste will be transformed by bacteria and fungus (held in special containers) which are genetically modified to increase the metabolism rate, thus increasing the speed of the process. The substances obtained from this process will be used as nourishment for the plants, as they will have high concentrations of minerals.

The non-biodegradable substances, such as glass or plastics, will have different methods of recycling. First of all, plastics will be cleaned and sterilized before being melted at high temperatures in order to be liquefied and modeled into other forms. Glass on the other hand will be crushed to little fragments before being introduced in a furnace where high temperatures will melt it in order to shape it in different models.

Apart from growing medicinal plants in the agricultural area, we also propose in creating a small interferon factory. Interferon is known as being a very effective substance against viruses and cancer, the latter being the target on the settlement. Bacteria and yeasts will be genetically modified in order to produce this protein.

### 3.2.8. Day/night Cycle

On Earth, the human body was adapted to the day-night cycle that lasted 24 hours. In order to reduce stress, the cycle should be maintained on the settlement. The settlement will be divided into 4 time belts, each of them being divided into 6 hours. When artificial night time approaches, the windows will be covered from the interior by special metal plates, and the intensity of the illuminators will be significantly reduced, therefore resembling the terrestrial night.

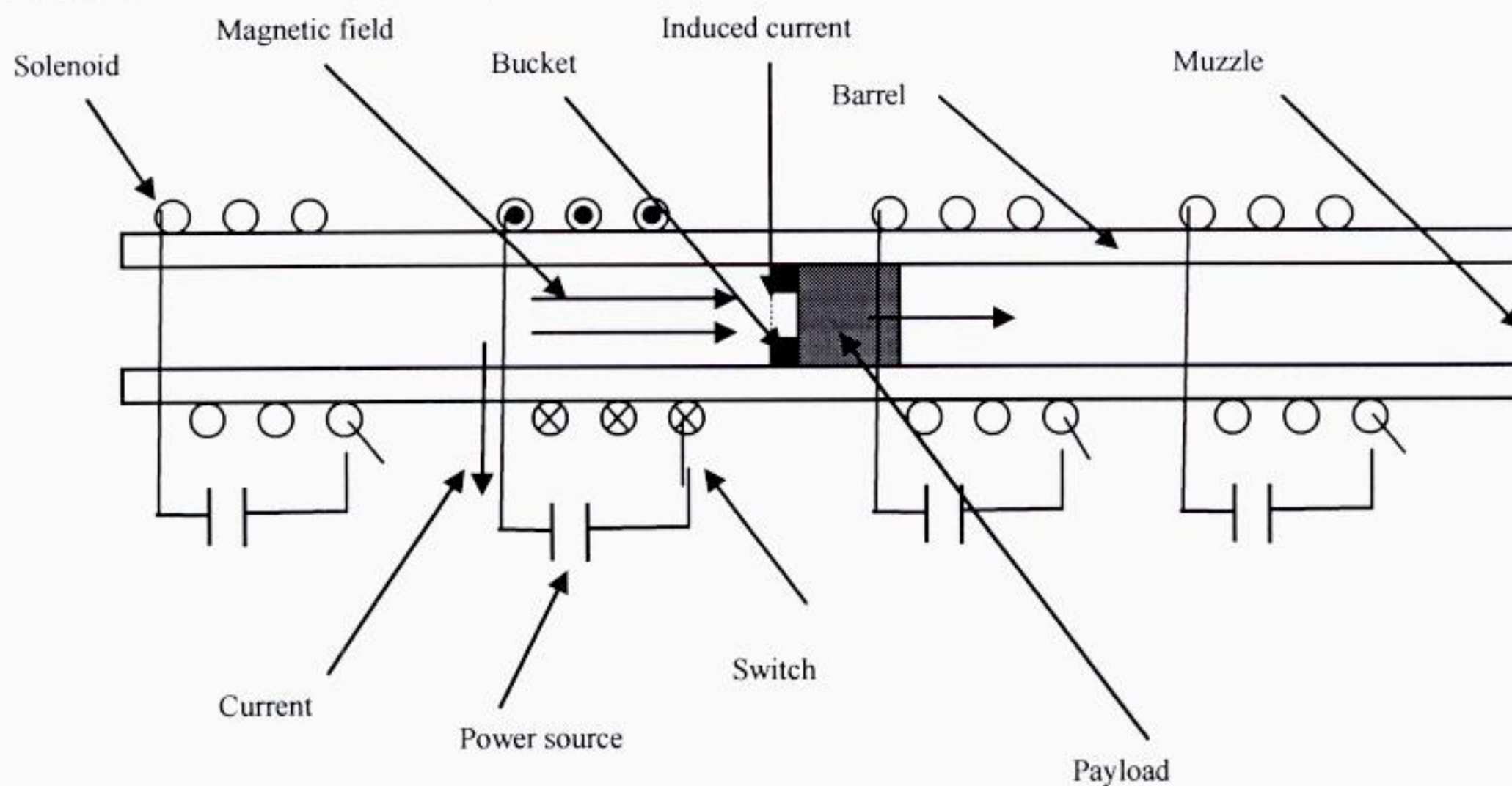
## 3.3. Space Infrastructure

Space infrastructure required for the building of the L4 space settlement includes a lunar base, situated on the rim of the Shackleton crater, Alexandriat, located in L5, existing spaceports in Earth's lower orbit, Palomino and Percheron vehicles. Also, the building of the space settlement requires a mining operation on the nearby captured asteroid.

Payloads from the Moon will be sent using mass electromagnetic launchers.



The mass launcher is powered by electricity, and produces magnetic fields to accelerate the cargo through an accelerator tube. For receiving the payload, we will use active mass catchers, devices that can catch the cargo. Active mass catchers can adjust their position in order to make a precise catch.



*Fig. 3.3. Mass driver*

### 3.4. Agriculture

For efficient land use we will also grow plant on the upper deck of the main body, in parks and on the roof of the buildings. The vegetation on the roof of the buildings and in the parks will have both a functional use and aesthetical one. People will have a great view on the roof of the buildings, similar to a green field. Each house will have access to the roof, so the people can enjoy the vegetation on the upper level.

### 3.5. Interior finishing

To conserve resources, the furniture will be made out of aluminum, ceramics, glass, titanium, iron, nickel etc. and be painted using silica based paints, all these conferring a genuine interior of the house. We will use racks, tables and night tables out of aluminum and glass, materials that ensure a pleasant ambient and durability. The wardrobe including the racks will be made out of opaque glass. The sofas and the beds will have the structures made out of titanium and will be covered with flax mattresses providing comfort and durability. There will be also comfortable chairs with an innovative design made out of aluminum and ceramics, covered with silicon and flax. Titanium and nickel will also be used at decorations. A part of the walls – walls that will not have a sustaining role - will be mobile so that people can arrange the chambers in order to satisfy their necessities, or in case a couple will have a child. The stairs will be circular thus they will occupy less space and the middle pillar will also have a sustaining role.

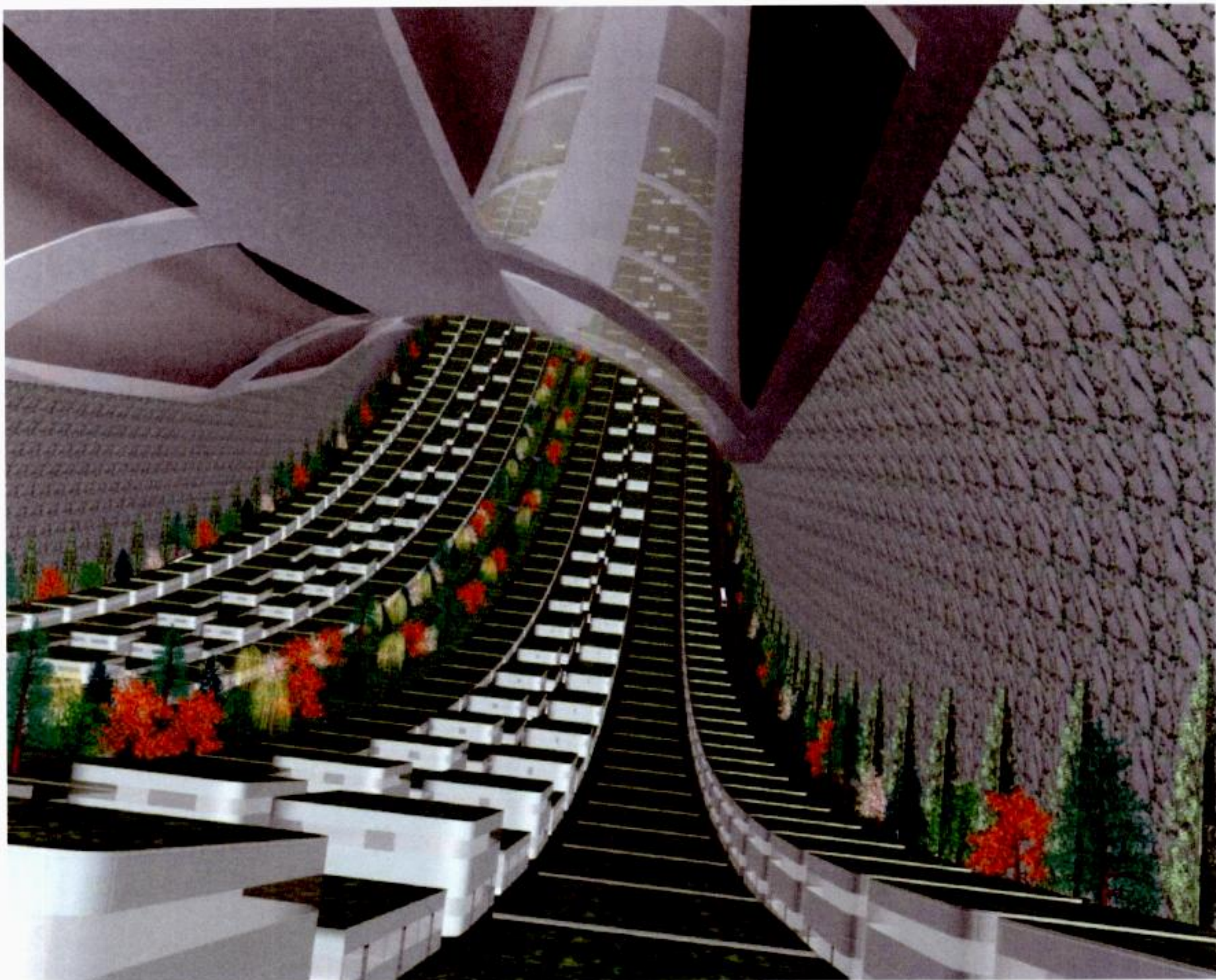


## 4. Human factors

### 4.1. Community Design

Commercial areas with malls and shops will be situated underneath the main deck on which houses are situated. Access to the lower parts of the settlement is realized via large 30 people elevators, located every 50 meters length-wise, on both sides of the central park, 200 m apart width-wise.

Settlers will have access to the shops using the elevators, or can order goods that will be delivered by a conveyor system that runs underneath the main deck.



*Fig. 4.1. Community Design*

The main source of material used in the production of clothing will be 100% natural fibers, due to the fact that the synthetic fibers do not permit the elimination of the excessive heat from our bodies and that they can cause skin irritation in certain cases. The fibers will be obtained from flax and cotton plants that will be grown in special greenhouses in the agricultural section of the settlement and which will be elaborated using a machine-process.



Health is a very important aspect of the space settlement like in every community. The main principle of maintaining a healthy body as well as a healthy mind is to prevent instead of mending. Health exams, tests and immunizations are vital to preventive care.

Avoiding different types of illnesses can be quite easily assured at a decent level by maintaining and respecting a strict personal hygiene.

Firstly, every citizen is due to pay a medical fee, used for the funding of hospitals. There will be a central hospital which conducts the most important procedures, including the treatment for people of a high social standard. A series of smaller hospitals and clinics will be located all around the station, approximately one per module.

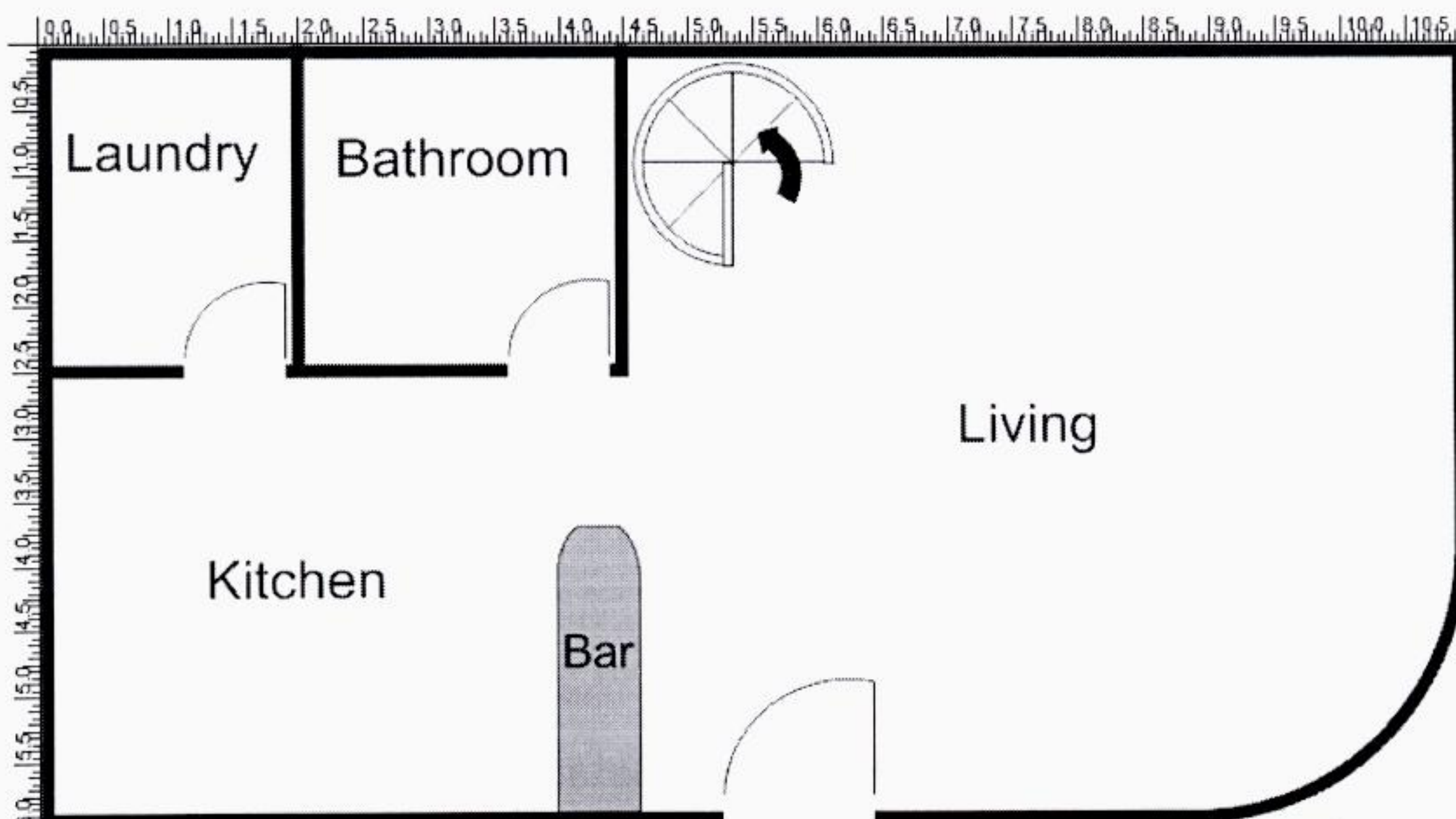
The effectiveness of every social system depends on the professional qualifications of the staff in question. Therefore, staff will be fully trained so as to be prepared for critical situations as well as isolation from the average conditions on Earth. The number of doctors reaches roughly 1% of the settlement's population (1 doctor at 100 inhabitants).

An implanted chip will monitor the settler's vital signals and send it to the medical center. The medical center's computers will create statistics and even hint possible diagnosis.

The road system connects all the houses throughout the entire settlement, covering under 5% of the entire surface of the living area.

## 4.2. Residential design

There are three designs of houses on the settlement, each serving the needs of the inhabitants. There's the single man/woman house, the couple and couple with children house. The three different designs are spread across the settlement to break the monotony of the settlement.



*Fig.4.2.1. Ground floor for couples*



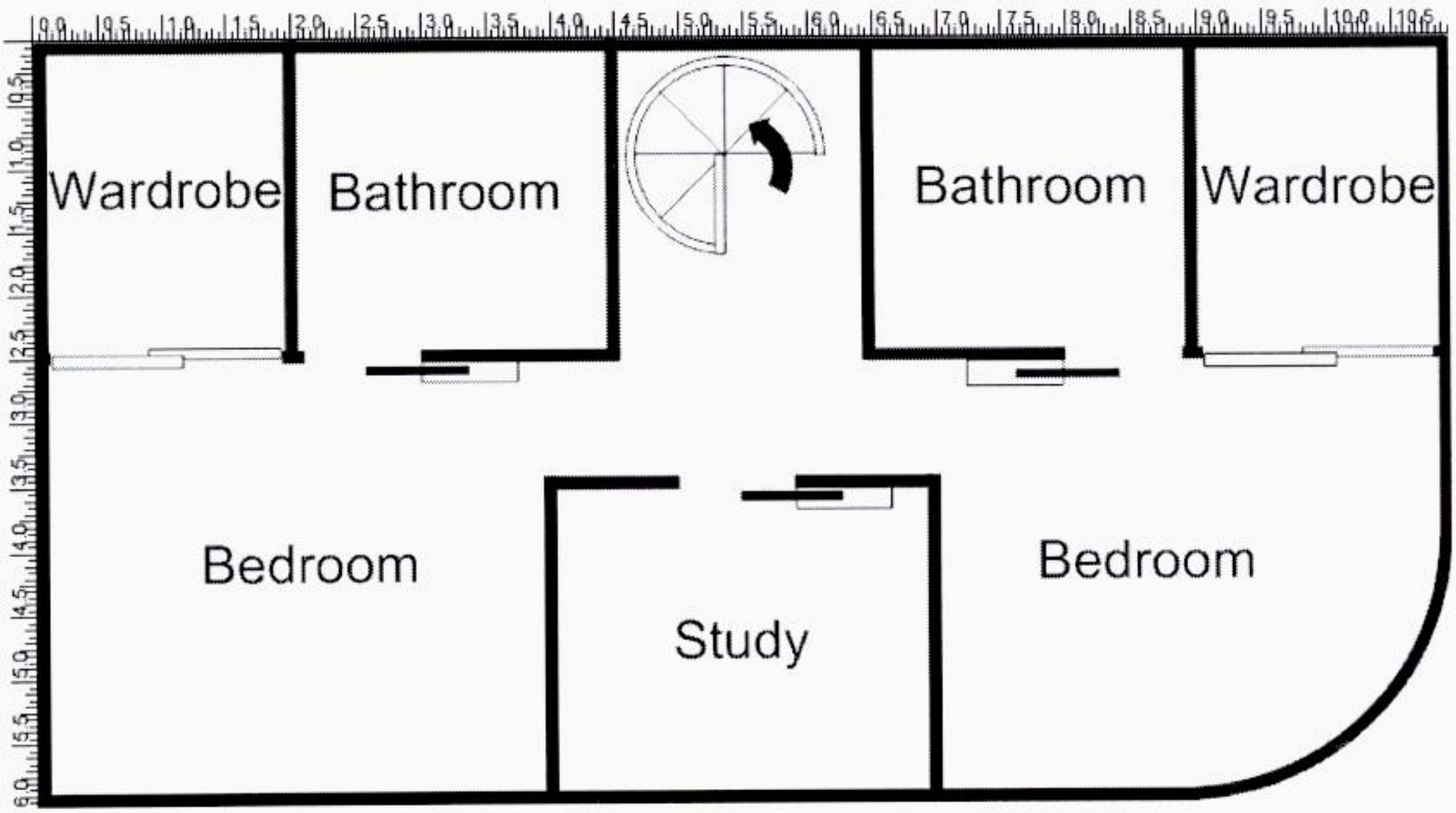


Fig.4.2.2. First floor for couples

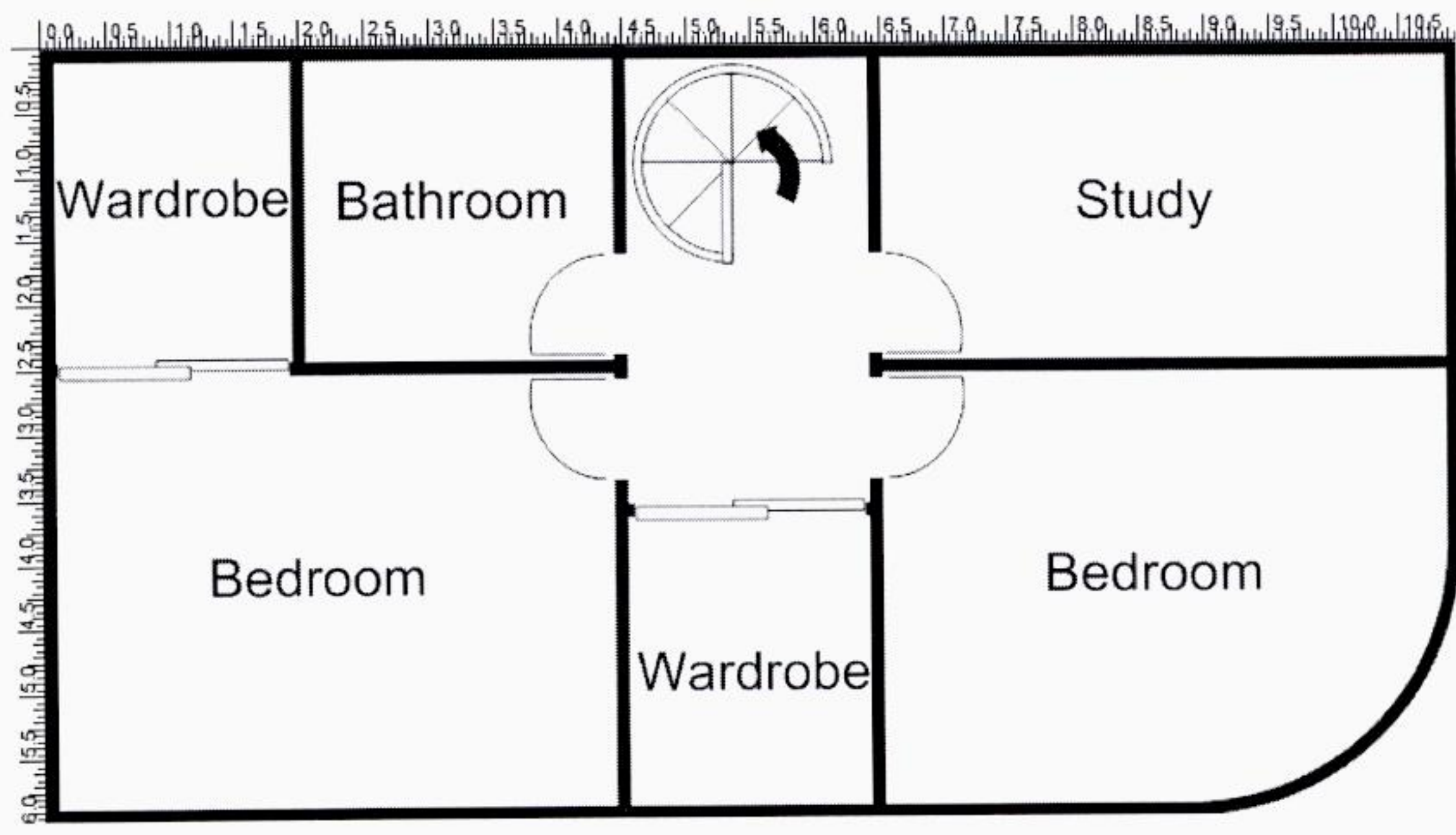
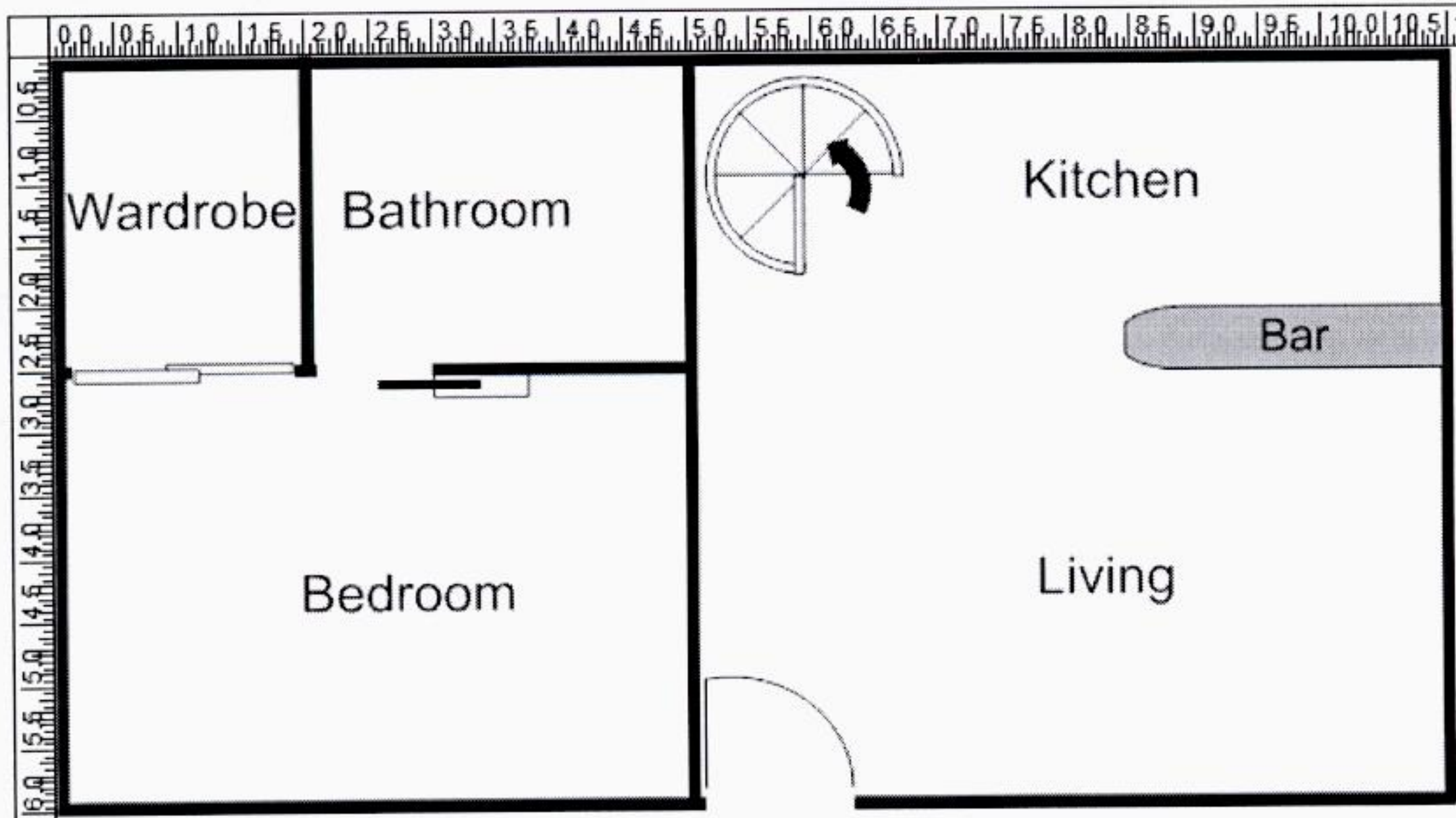


Fig.4.2.3. First floor for couples(second design)





*Fig.4.2.4.Ground floor for singles*

### 4.3. Work environments

In order to be able to move around freely and in a predictable manner, each resident entering a low g area will be equipped with two strong magnets in the soles of their boots to them from rising from the ground. The floor will contain iron to provide easy coordination of movement.

The major categories of work people will do in and around the settlement and the listing of tools provided for each of the required tasks:

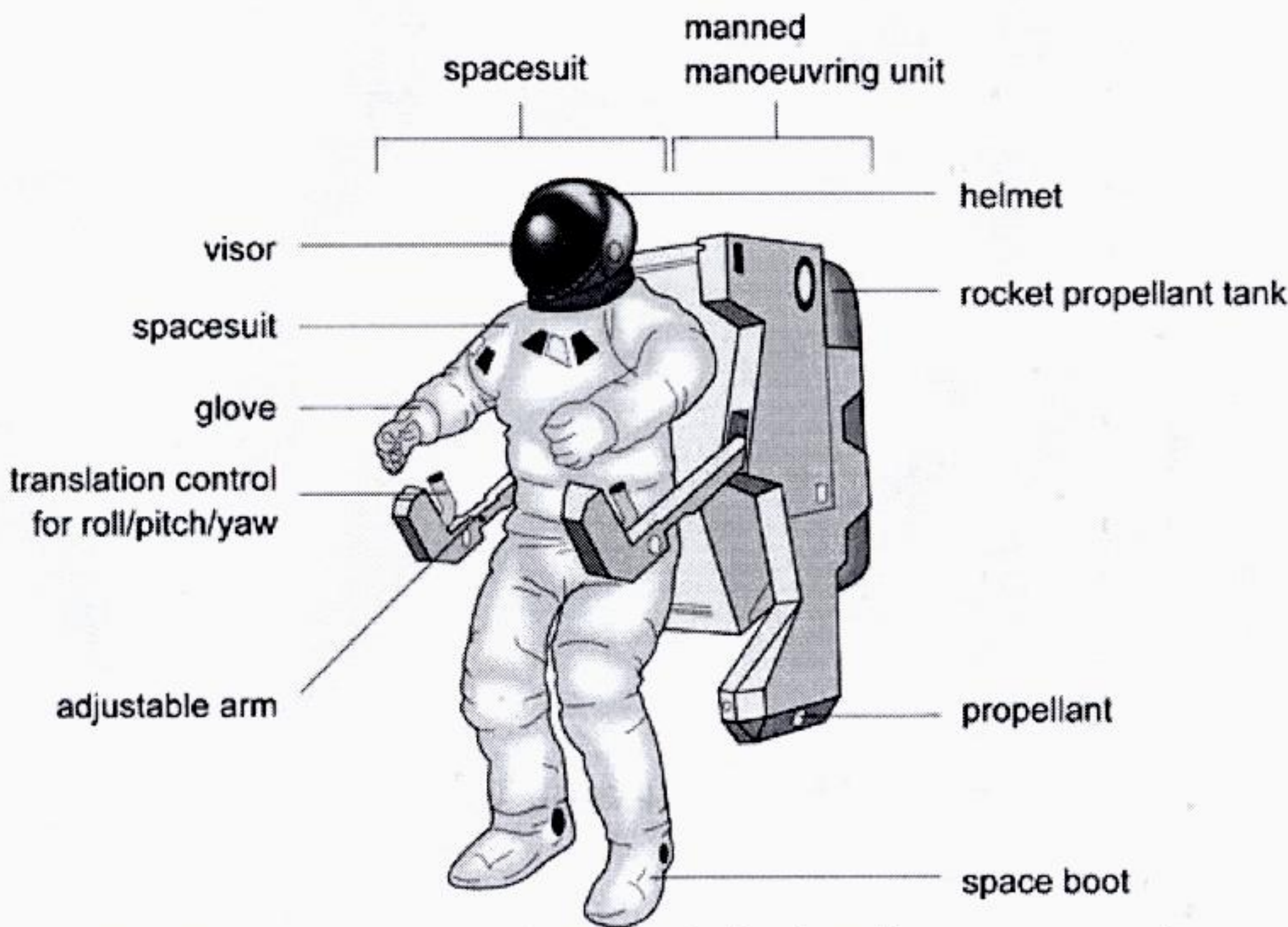
Types of Work	Tools
Heavy Industry	fully equipped automatic factory
Mining	robots (gatherers, harvesters, placers)
Supervisors or Rescuers	spaceships , robots, special designed suits
Agriculture	specialized robots
Maintenance	robots designed for vocal commands or remote controlled
Defensive system	exterior monitoring system, panel protection robots
Doctor	State of the art instruments ,access to documentation, research laboratory ,fully equipped PC
Engineer	computers equipped with supervision program



Cook	state of the art kitchen, access to documentation
Education	fully equipped PCs, access to information, different teaching methods
Low-g workers	special designed costumes
Commerce	economical programs ,fully equipped PC, fast delivery systems
Police	Special designed suits, guns with a low level of danger

Fig.4.3.1. Jobs

SPACESUIT



- Spacesuit:** hermetically sealed equipment including breathing apparatus and a propulsion system, that allows an astronaut to move around freely in space.
- Spacesuit:** Hermetically sealed equipment that allows astronaut to go into space.
- Manned manoeuvring unit:** system that allows an astronaut to walk alone in space.
- Helmet:** part of the spacesuit that protects the astronaut's head.
- Rocket propellant tank:** part of the manned manoeuvring unit used for storing fuel.
- Propellant:** part of the manned manoeuvring unit that pushed it forward.
- Space boot:** part of the spacesuit that protects the astronaut's feet.
- Adjustable arm:** part of the manned manoeuvring unit that adjust according to the length of the astronaut's arm.
- Translation control for roll/pitch/yaw:** stick that allows the astronaut to rotate the manned manoeuvring unit.



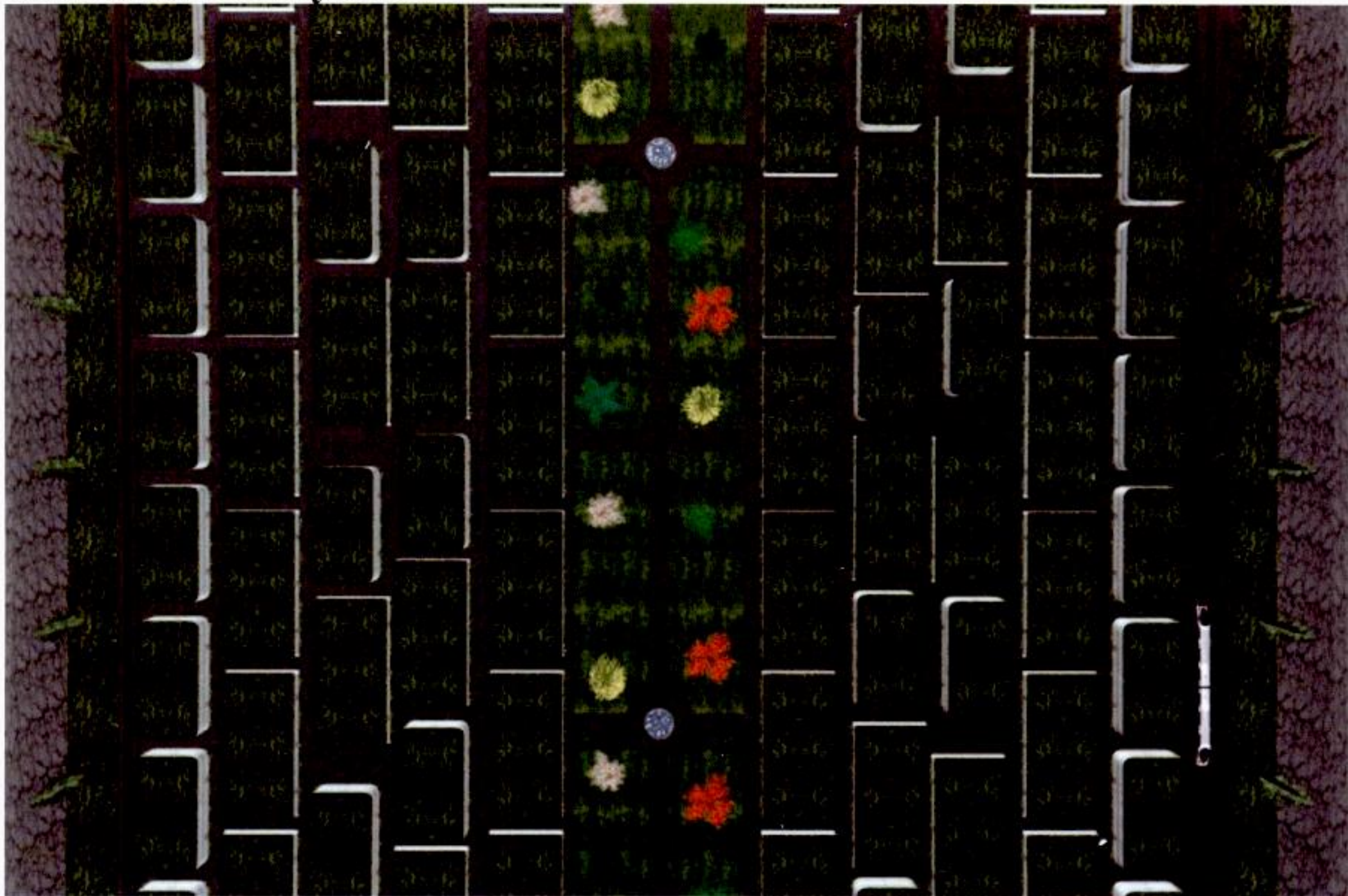


**Glove:** part of the spacesuit that protects the astronaut's hand.

**Spacesuit:** part of the spacesuit that protects the astronaut's body.

**Visor:** part of the spacesuit that protects the astronaut's face.

#### 4.4. Interior layout



There's the single men/women house, the couple and couple with children house. The three different designs are spread across the settlement to break the monotony of the settlement. The houses can be moved so that the neighborhoods will never stay the same.

#### 4.5. Entertainment

As the vital needs of human psychology remain the same even in outer space, entertainment plays a vital part in the survival of the settlement. Having major implications in the metabolism, so therefore: physical and mental well-being, means of entertainment will have to meet up with peoples' desires. These means will mostly resemble the ones on Earth, as well as develop a certain originality of their own.

Receivers will be placed on the back of the station's mirrors so as to avoid any interference from outer space. Therefore transmissions will be received from any location on the stations' premises and people will have access to both internet from Earth, as well as to radio and television. The small inconvenience caused by the difference between the revolution periods of the Earth and station will be solved by creating a network of communication satellites around the Earth.

In the 1G area the settlers will have cinemas, theatres, clubs, pubs, stadiums



A series of other facilities will be also relieving for the boredom of day-to-day life. Such facilities refer to: large concert halls (some located in low-g areas), theaters, museums (having all of Earth's representative art pieces on display, reconstructed as holograms), opera-houses etc. A transparent wall will also be built in the connector tubes so that people can admire the wonderful views of both Earth and the space surrounding them.

The presence of a microgravity zone represents a great advantage in developing new means of entertainment:

- A 0 gravity rotating swimming pool: Most people know that blobs of air float in the air inside orbiting spacecraft. It is interesting to imagine how it is to swim in a large spherical mass of water. Even if in 0g, movements will be effective through water, by creating a reaction against it, there will be no forces acting to pull a person to the surface of the water, or to guide them towards the nearest surface. Therefore, people will wear compact emergency air-breathing equipment.
- A 0 gravity stadium: Progressively more advanced leisure uses of zero-gravity will require progressively larger sports centers, some beyond the size of a stadium on Earth. Two prospective uses for such as stadium are team-sports (3D American football, 3D soccer, rugby) and 0 gravity flying.
- A 0 gravity amusement park (where the prime attraction is a 0g rollercoaster).
- 3D Tennis courts as well as skating-rinks.

## **5. Automation design and services**

### **5.1. Automation of construction processes**

To build the interior of the settlement we will use prefabricated sections of the structures. The prefabricated sections of the structures will be made by robots and automated machines on a moving production line. To gain assembly time, the interior finishing, painting, plumbing, wiring and other detail work will be done on the production line by specialized robots that can do the job very fast.

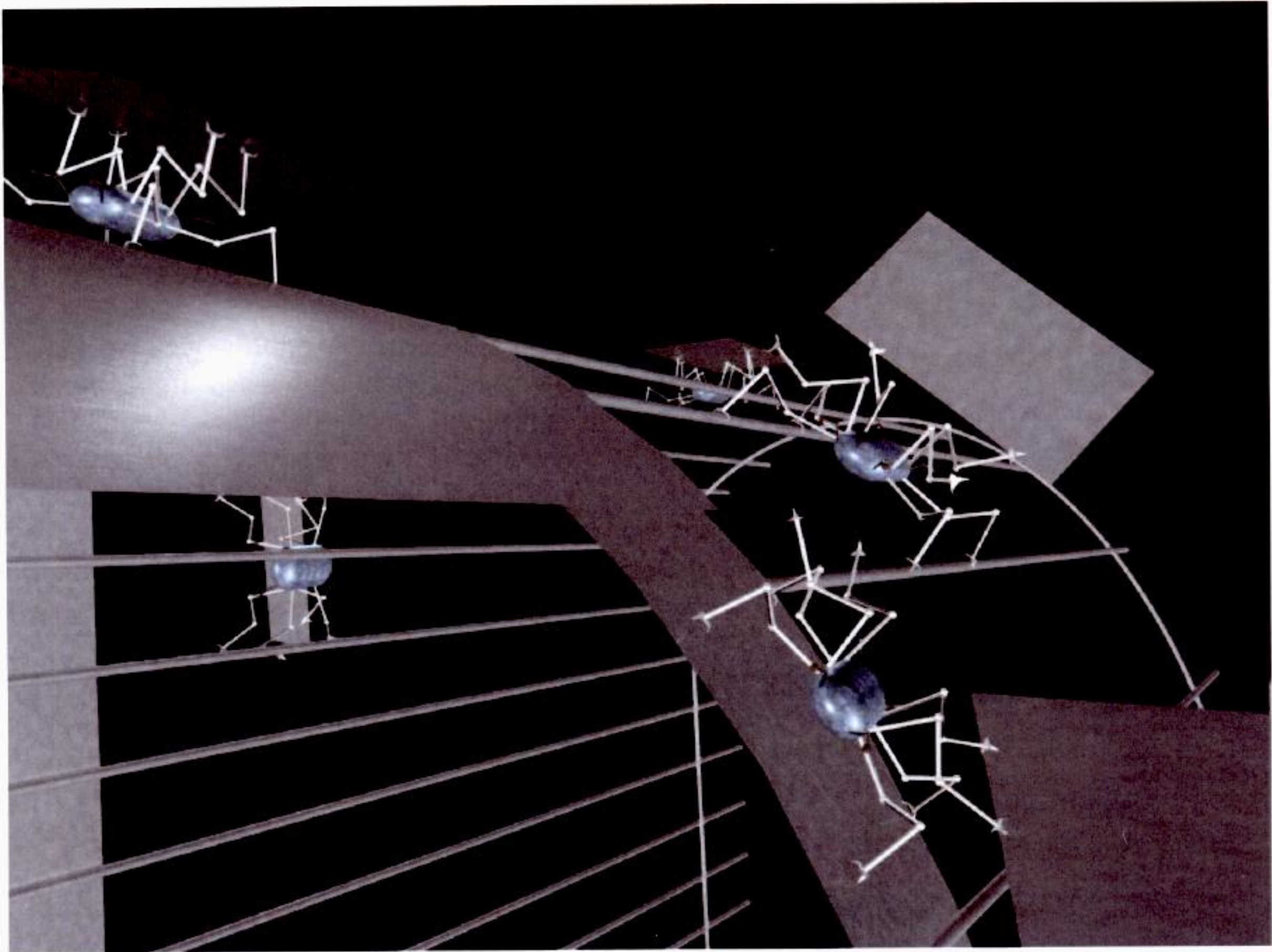
The prefabricated parts will be assembled and connected to the utilities on site. All this operations will be made by specialized robots that will eventually be reconfigured for other uses.

The medium and small sized construction materials and prefabricated sections will be transported on an underground conveyor. After the building process is completed, the conveyors will be used for delivering ordered goods.

Larger building components will be delivered via the rails that will later be used for transportation of people.

On the settlement will be specially designed robots that will assemble the structural components and the prefabricated sections of houses into position.





*Fig 5.1.1. Construction of the torus*

## 5.2 Facility automation

Once the building process is complete, many of the building robots will be reconfigured to be used in the many branches of industry. Some of them will still produce parts for the settlement to replace the damaged ones.

The assembly robots will be reconfigured too. They will serve as maintenance robots. The emergency robots have an extra layer of shielding, able to function during solar flares and other emergency situations.

The maintenance robots will be capable of working on the outside of the settlement, some of them having maneuver thrusters. They will be able to repair damaged houses, exterior walls, and solar panels and even nearby small ships.

The maintenance robots can move on the exterior of the settlement on rails, to reach the solar panels fast. In case of an imminent collision, the panels will be folded back, to avoid damaging.

They will, among doing other chores, clean the settlement, ensure that every system works properly, and take care of the vegetation.

The robots will be stored in the light industrial sections of the settlement, where they will sustain repairs and be recharged. For fast deployment, the storage depots will be situated along the length of the settlement, every 200 m.



The main body of the settlement will be divided lengthwise in four large sections.

Each will be in a different time zone. The sections will be divided by large transparent panels, with airtight doors. If a section of the settlement will sustain major damage, it will be evacuated in the neighboring sections and the airtight doors will be closed. In normal conditions, these doors will remain opened, allowing air, people and goods to pass through freely.

The spokes will be used for transport. In case of damage, they will be, too, isolated by airtight doors. The airtight doors don't need to stay closed all the time, in normal conditions, to maintain the air pressure in the microgravity areas because the difference in air pressure between the ends of the spokes is small.

The six space ports are situated on three different bodies, thus, if one is damaged, the settlement will not be isolated from the rest of the world.

If a section of the outer wall is damaged, it will quickly be repaired by the maintenance robots. If a glass panel is broken, it is quickly replaced by the robots.

In case of an imminent collision, the solar panels that are in the impact area, they will be retracted in order to protect them.

If by some reason the lights of the settlement fail, the emergency lights will be turned on. They are battery-powered, lights placed on the buildings, at street level and inside all other regions of the settlement.

Access to critical areas of the settlement will be restricted. To enforce this rule, settlers will be identified by the unique ID of their implanted microchips and by retinal scans. Each computer on the settlement can identify its user by its chip's unique ID, so it can only be used by users that are granted access, and restrict their actions accordingly.

### 5.3. Habitability and community automation

There will be one central server that will act as a gateway, placed in the middle cylinder. There will be one server per living section, a total of 4 servers in the living areas. The servers will be connected to switches that will form local area networks that will group in wide area networks. Three more servers will be located in each cylinder. Each server is connected to the neighboring two servers and to the ones in the cylinder, avoiding problems if the central server fails.

There will be an underground system of conveyors for the automatic delivery of ordered goods. The system will connect stores, restaurants and other commercial facilities to the consumers. It will have a main high speed conveyor that runs the length of the settlement and system of peripheral conveyors that run the width of the settlement that links to the consumer-end conveyor. It can also deliver mail and packages between settlers.

$$F_{cf} = F_{p_1} - F_{p_2}$$

$$dm\omega^2 r = p \cdot S - (p - dp) \cdot S$$

$$dm = \rho \cdot dV = \rho \cdot S \cdot dr$$

$$\rho \cdot S \cdot dr \cdot \omega^2 r = dp \cdot S$$

$$\rho = \frac{\mu \cdot p}{RT}$$

$$\frac{\mu \cdot p}{RT} \cdot dr \cdot \omega^2 \cdot r = dp$$

$$\frac{dp}{p} = \frac{\omega^2 \mu}{RT} \cdot r \cdot dr$$

$$\int_{p_c}^{p_0} \frac{dp}{p} = \frac{\omega^2 \mu}{RT} \cdot \int_0^{R_0} r \cdot dr$$

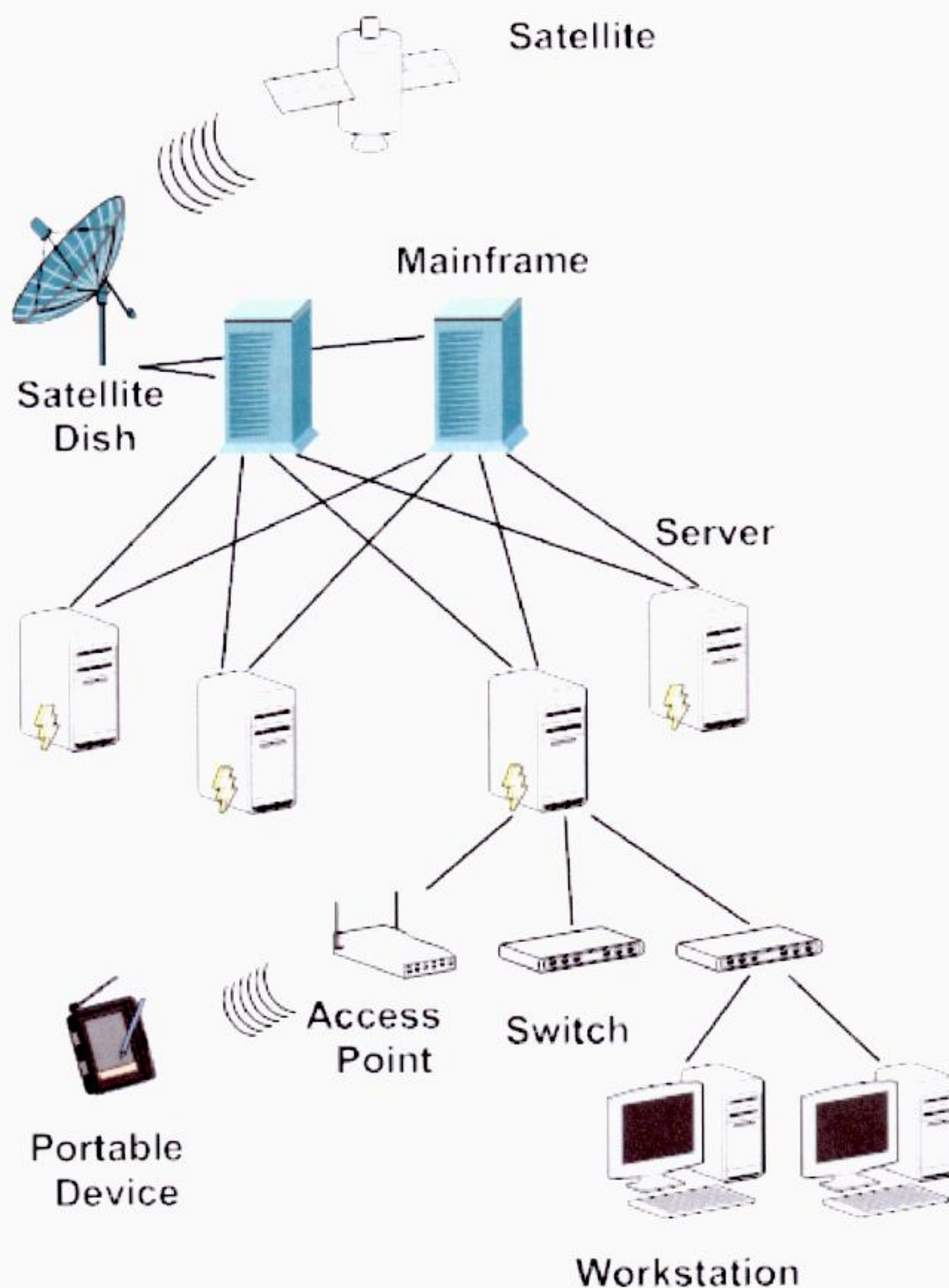
$$\ln \frac{p_0}{p_c} = \frac{\omega^2 \mu}{RT} \cdot \frac{R_0^2}{2}$$

$$p_c = p_0 \cdot \exp\left(-\frac{\omega^2 \mu}{2RT} \cdot R_0^2\right)$$

$$p_c = p_0 \cdot e^{1/5} = 1.22 \cdot p_0$$

Fig.5.2 : Pressure Calculations





*Fig. 5.3. Network diagram*

On the settlement each house will have a high-tech computer that will provide a data storage capacity of 5TB per person than can be extended. This capacity will be used to store multimedia files, documents and history of the house parameters (humidity, temperature, especially radiation). Also the computer controls every function in the house, including temperature, humidity, light, multimedia, home appliances, etc. and will be connected to the internet and intranet network through fiber optics. These terminals will be connected to the internet both via fiber optics and 2.4GHz wireless. At their working places, each settler will have a computer that will assist him and help minimizing human error.

Each inhabitant will have a mobile personal mobile terminals equipped with virtual keyboard and screen (projected on surfaces). This device can be used as a mobile PC. Also, the mobile terminals will be equipped with a touch screen, will have sensors for



atmospheric composition and radiations, and will monitor vital functions using an implant inside the user. Mobile terminals will be made out of flexible materials and it can be modeled to look like a mobile-phone, a palm computer or even a bracelet. Mobile terminals will also have a 2.4GHZ mobile internet and will support Voice over Internet Protocol (VoIP), Television over Internet Protocol (TVoIP), voice calls, video calls, and other capabilities. Each mobile terminal can remote control the home computer of each settler.

The settlement will house a variety of robots. This includes robots used for maintenance, robots used in the industrial processes, infrastructure maintenance robots, vending machines, security robots and many others including robotically pets.

The construction robots will have eight legs, each having three joints. Four of the legs will be used for transportation, walking, crawling and climbing. The other four legs will carry materials, and assemble them. The eight legs and another four flexible arms that hold the cameras and sensor arrays allow the robot to work in virtually any position. Each leg has 2.1 m and its body is 1.5 in length, 1m wide and 0.5m thick. On the end of each arm there will be a robotic hand with high dexterity that can use any tool that a human would. Each robot incorporates a tool box. The tools can be changed, adjusting to the situation. The tools can also be used by humans, if required. This makes the tools very versatile and easy to replace if anything is to happen. The robot can grab almost any material and carry it. If a payload is too heavy or too large for one robot, two or more will perform the task working together. The robots are designed to carry the 2m by 2m panels that fit on the skeleton of the settlement while climbing on it. The robot can be adapted to carry many payloads.

The pet robots come in many sizes. They can be built to imitate dogs of different heights, on the owner's liking. They are great fun to play with and don't require much taking care after. The pet robots are battery-powered and are programmed to search for a charger when the batteries are low. The personality of the robot is programmable, to suit the owner's.

All robots, computers and computer operated devices are programmed to follow Isaac Asimov's three laws of robotics, to anticipate the possible development of artificial intelligence and ensure that the robots will never harm people.

The home appliances in every house will make life better for the inhabitants. Advanced software will learn its user's everyday habits and will act accordingly.

#### **5.4. Automations for interior finishing**

Houses will be built from prefabricated sections. Each section will have all the interior finishing, plumbing, wiring, and lighting installations done on the construction lines. The modules will be painted during the manufacturing process using silicate based paint.

The furniture will be delivered inside the modules. It will mainly be built using aluminum, ceramics, glass, titanium, iron and nickel.

The houses are assembled on site, with speed and precision by specialized robots.

The building will mainly be done by robots, supervised by people. Most of the building will be done by the versatile maintenance robots.

The building of an entire house will last less than two hours from scratch to module.



The assembly of the modules that form a house will be done in less than an hour.

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### **5.5. Ore Transportation**

For mining asteroids the settlement will deploy robots for mining operations. The batteries will be placed on the sides of the robot. The robot will contain four hydraulics arms, each with two articulations. Every arm has a retaining claw, equipped with a driller that makes a hole and inserts an expandable pin. With the expandable pin and the retaining claws the robot will be safely secure to the asteroid ground. Thanks to its structure (4 legs with 2 articulations), the robot can move freely and easily on all types of ground, even on the most rough land and fasten in almost all conditions. The expandable pin has the same diameter as the hole, but once its inside, its volume is increased and it has a better grip.

The robot will have, in the front, three mining heads (to better adjust to an inconsistent terrain) made out of borazon, a very tough material. The materials dugged out by the three mining heads is thrown towards the two conveyors that have a special system to catch and retain the material in boxes that are formed by the two conveyors when they are close to each other. The conveyor has perpendicular plates that enclose the material like in a box when they meet with the others conveyors walls. The material is transported by the two conveyors to the crusher (two cylinders that crush the rocks) than to the container. When the container is full, a transporting robot carries it to the mass launcher. The power is supplied by the 16 m<sup>2</sup> of solar panels and rechargeable batteries

The mass launcher throws the containers towards the settlement's mass catchers. It's powered by solar panes.

Once the asteroid is small enough to fit inside the cargo hull of a craft, it will be carried to the settlement for further processing.

Each mining robot is capable of operating independent to the controllers, but, to minimize risks, a human controller will supervise the actions of three miners.

There are three cutting heads, each 1 m in diameter. The storage capacity is 10 m<sup>2</sup>, in the container placed in the back of the robot.





*Fig. 5.5. Mining robot*

## **6. Schedule and Costs**

### **6.1. Design and Construction Schedule**

10 may 2028 – awarding of the contract

15 march 2029 to 1 may 2030 – the building of the lunar

1 April 2030 – the lunar base is able to supply parts for the space settlement

1 April 2030 – Alexandriat exports parts to the building site

1 April 2030 to 1 February 2031 – the building of the middle cylinder and the four spokes that will connect it to the main body

1 February 2031 to 15 august 2033 the building of the skeleton

15 august 2033 to 1 February 2034 the build of the first four livable areas

1 February 2034 to 1 April 2034– the testing of the settlement's systems

1 April – the first 2000 settlers (80 peers in each livable segment, transported by four Palomino ships)

1 April 2034 to 1 may 2037 the settlers keep arriving as the livable area increases and the eight other spokes and two cylinders.



## 6.2. Costs

Table 6.2. Construction costs

Item	Quantity	Price per unit	Subtotal
Transportation of settlers	18000	600000	10,800 M
Biomass of plants and animals	54286721,05	2000	108,573 M
Metallic structure	18899821404	50	944,991 M
Atmosphere	24375000	2000	48,750 M
Hydrogen	81000	2000	162 M
Other Costs			222,655 M
<b>TOTAL</b>			<b>1,335,931 M</b>

Construction will be mainly done by robots and machines, but a small number of employees (approx. 200 people) will be required to supervise.

By estimating the price of the most expensive parts and materials that we have to use, we can have a rough approximate of the costs.  
1,336,000,000,000 \$

## 7. Business development

### 7.1. Extraterrestrial materials harvesting and refining

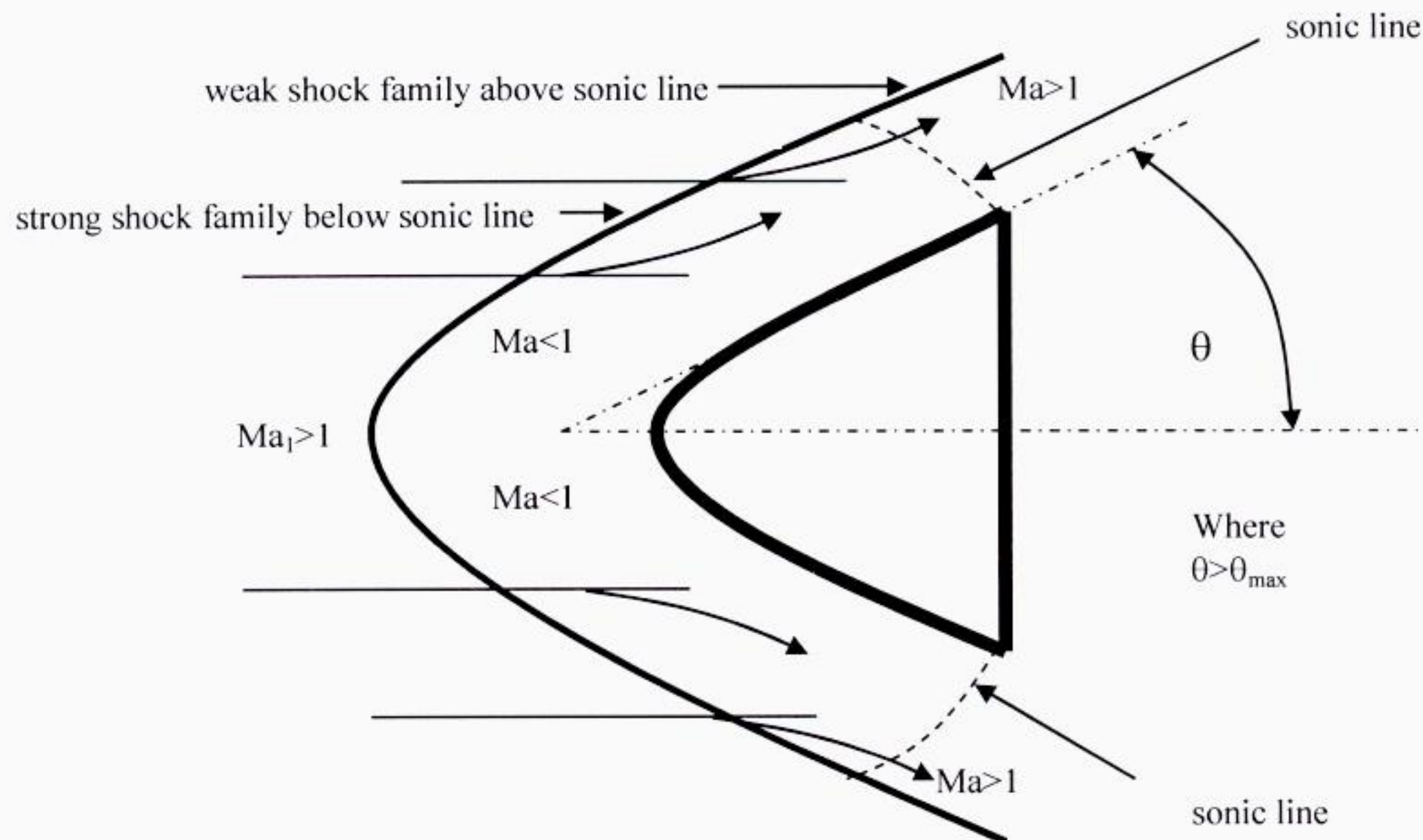
The settlement will host a large variety of commercial and industrial venues, which may change with time.

The ore that is extracted from the nearby captured asteroid imported from the moon or from extraterrestrial sources will be refined on the space settlement, in microgravity areas with modified atmospheric composition or with no atmosphere whatsoever. These conditions can enable some industrial processes impossible on Earth. The low gravity reduces production costs.

#### 7.1.1. One Way Re-entry Vehicle

For a one way reentry vehicle, we will use a high drag, counter intuitive body. Because of the high speed that the reentry vehicle travels at, we need slow it down.





*Fig.7.1. One way reentry vehicle*

The reentry vehicle has a conical shape, with a 3 m radius and 3 m in height. Once the vehicle has slowed down enough, it will deploy a set of parachutes. The capsule will land on a specially designated safe area.

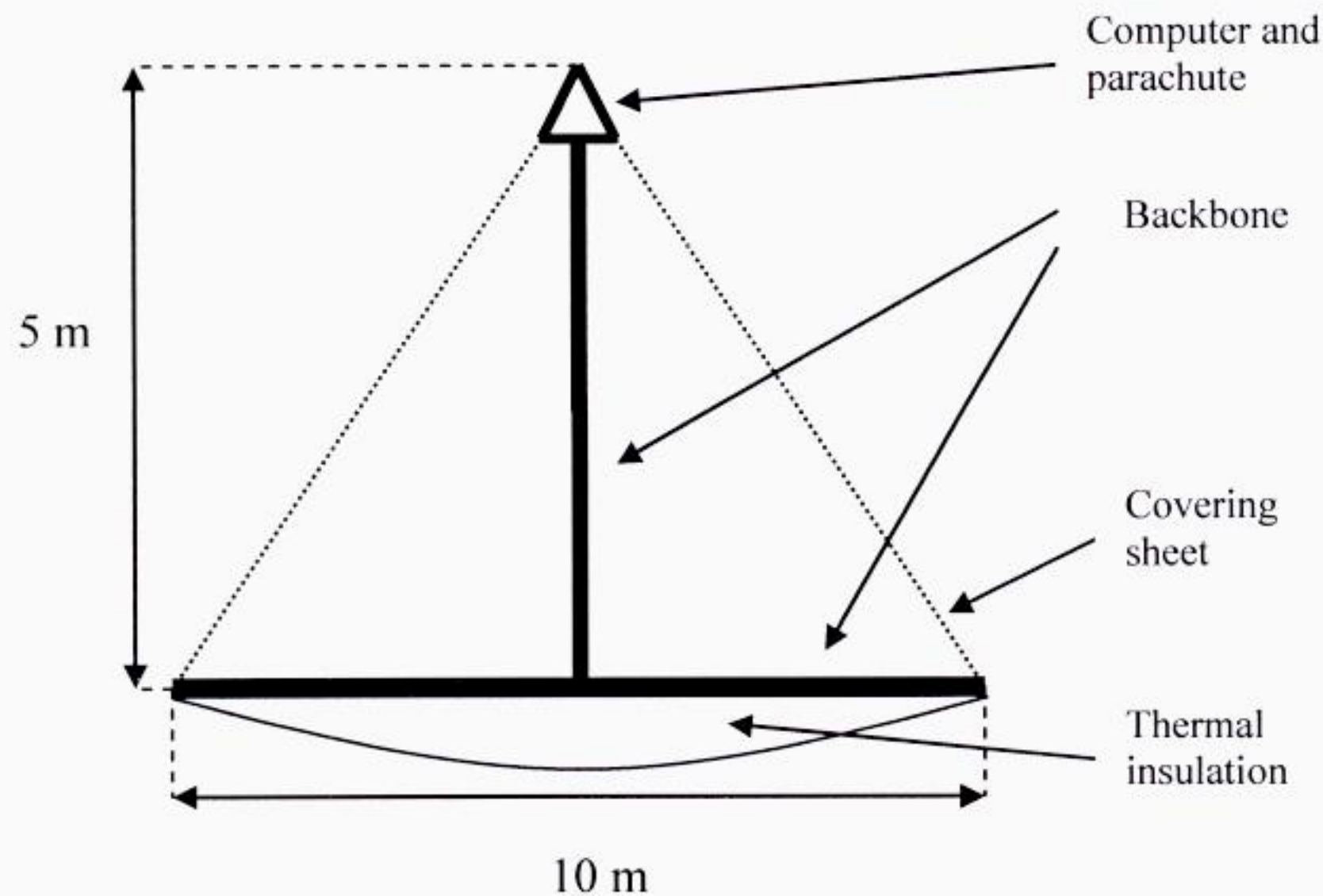
The reentry capsule will have a computer and a parachute in the top of the pyramid. The delivered goods will be placed on the backbone. The entire payload will be covered with a thermal insulation sheet. The backbone and the covering sheet will protect the payload from the extreme temperatures. It contains maneuvering thrusters.

Because this delivery system requires the payload to withstand brutal forces and extreme temperatures, it can only transport very tough materials like solid blocks of metal cast around the backbone. Another alternative is to fit a capsule around the backbone, or a better protection.

The bottom of the capsule has an extra layer of thermal insulation.

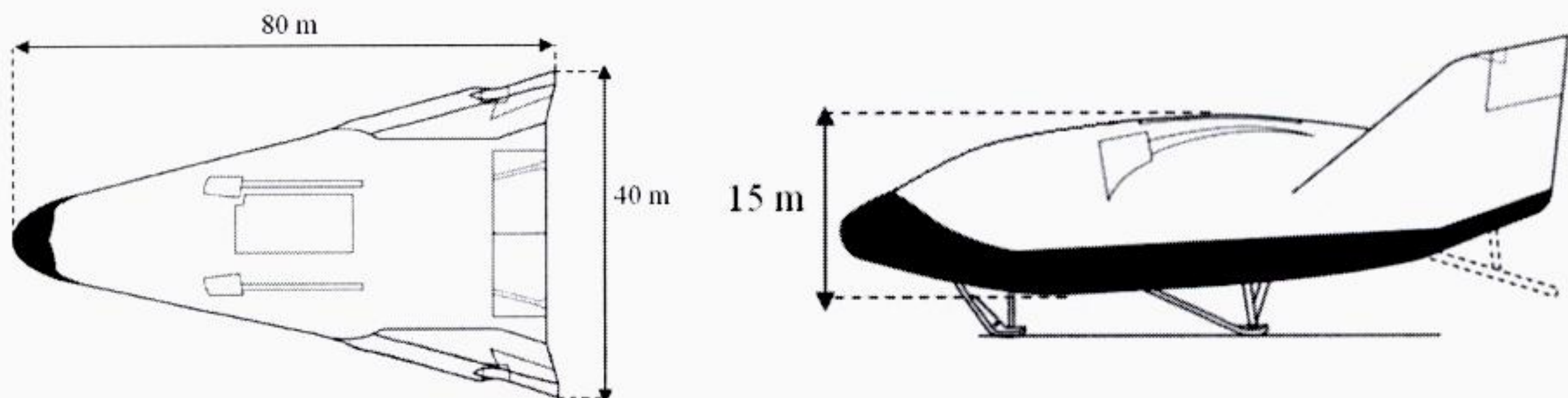
This system relies on aero braking, a much better alternative to using thruster to slow down.





*Fig.7.2. One way reentry vehicle*

The second reentry vehicle relies, too, on aero braking. It is a lifting body craft. It relies on its shape to slow down and create lift. It will also require a set of parachutes for the landing. It's more expensive than the first but it can transport more delicate payloads without the risk of damaging them.



## 7.2. Space manufacturing

The settlement will house a thriving aerospace industry. The building plants, situated close to the dry docks in microgravity areas will develop and build new vehicles for interplanetary and lunar landing applications.

The settlement will also produce and supply components for solar power satellites, antennas, parts for other large space structures, including lunar mining bases. Once the settlement is completed, it will help increase the capacity of the lunar bases that have took part in the building of the settlement by supplying it with equipment.



Industrial branches: aerospace industry, chemical industry, textile industry, electronics, power generation, metallurgy, IT&C industry, services (restaurants, shops, mass media, consultancy entertainment, etc)

### 7.3. Tourism

Whether for entertainment or for economical purposes, tourism is one of the key factors of the settlement's society. As people have developed throughout time, an insatiable desire for challenging vacation destinations, a guided tour of the settlement will not only fulfill their desire, but also engage them in new experiences.

Tourists' first insight of the settlement will be conducted by a specialized guide who will also provide recommendations for accommodation. A series of trips around the spacecraft will be available for those interested. Visitors will be involved in the everyday process of maintenance, they will have a glance at the different types of processes which take place on the station: mining, the observatory, manufactory of materials used on the station, operations etc., all from a safe point of view. They will thus be involved in the life of the residents, without being the target of any possible danger.

For those eager for fun and laughter, special offers will include trips in 0g areas:

- They will be housed in special hotels (either in each of the modules on Belleλvistat, or in 0g areas);
- Visitors will be encouraged to attend different types of competitions held in the central Stadium in the 0g zone;
- People will enjoy exhilarating experiences having a dive in the rotating pool (swimming gear will be available at low costs for visitors);
- Another point worth visiting is the 0g amusement park , at low costs for visitors;
- They will enjoy the breathtaking views of both Earth and the surrounding areas in the bell-view train, on the outside of the 1<sup>st</sup> cylinder, that is moving relatively to the settlement and it's stable to Earth;



## **8. Compliance Matrix**

1.0.Basic requirement	-description of the design, development, construction of the Belleλvistat space settlement community	3
	-develop plans for operating and maintaining the community	3
2.0.Structural Design	-18,000 residents	3
	-1,000 transient population	3
2.1.External Configuration	- volumes, their uses and dimensions	4-6
	-construction materials	11
	-artificial gravity	5
	-low-gravity environment	4
2.2.Internal Arrangement	-utilization of all interior areas	7
	-overall map of interior land areas showing their utilization	8
2.3.Construction Sequence	-process required to construct the settlement	8
	-drawings showing several intermediate steps of settlement assembly	9
2.4.Material Harvesting	-systems to minimize transfer of asteroidal surface materials (dust)	9-10
	-drawing with captured asteroid incorporated in overall exterior	9
	-drawing of structure on asteroid surface	36
2.5.Docking Ports	-multiple docking port facilities	10
3.0.Operations and Infrastructure		11-23
3.1.Construction Materials Sources	-sources of materials and means of transporting	11
3.2.Community Infrastructure	Internal and External Communication Systems	12
	Internal Transportation Systems	12-13
	Electrical Power	13-15
	Food production	15-19
	Atmosphere	19-21
	Water management	21-22
	Solid waste management	22
	Day/night Cycle	22
3.3.Space Infrastructure	-space-based infrastructure and vehicles	22-23
3.4. Agriculture	-agriculture not included in food production	23
3.5.Interior Finishing	-materials required	23
	-innovative design approaches	
4.0.Human Factors		24-30



4.1.Community Design	-maps of community design -percentage allocated to roads	24-25
4.2.Residential Design	-exterior drawing and interior floor plan	25-27
4.3.Work Environments	-major categories of work people	27-29
4.4.Interior Layout	-interior maps with neighborhoods	29
4.5.Entertainment	-examples of pastimes available for residents	29-30
5.0.Automation Design and Services	-computer system description	30-36
5.1.Automation of Construction Processes	- description of use of automation in construction and main available functions -device purposes	30-31
5.2.Facility Automation	-automation systems for maintenance, repair and safety functions -identification of computers that meet automation needs	31-32
5.3.Habitability and Community Automation	-drawings of every-day robots and computers -diagrams which enable connectivity	32-34
5.4.Automations for Interior Finishing	-drawings of interior finishing system and estimated time for completion	34-35
5.5.Ore Transportation	-drawing of mining system in operation -description of required human controllers	35-36
6.0.Schedule and Cost	-schedule for development and overall cost	36-37
6.1.Design and Construction Schedule	-duration and completion dates of major processes	36
6.2.Costs	-costs associated with phases of construction and overall cost	37
7.0.Business Development		37-40
7.1.Extraterrestrial Materials Harvesting and Refining	-rough description of the process involved in commercial venues	37-39
7.1.1.One Way Re-entry Vehicle	-description of process and designs	37-39
7.2.Space Manufacturing	-facilities for manufacture and assembly for landing applications	39-40
7.3.Tourism	-main attractions and visiting possibilities	40



See bibliography at

<http://www.blambdaat.lx.ro>