bellevistat

2008

Summary

1.0 Executive Summary

We are pleased to present you our proposal for "Bellevistat", the second space station, as an answer for the Foundation Society's request. Known for the seriousness that we have proven in our previous projects, and proud of our experience gained over time, we are convinced that we will not only reach our clients' expectations by creating a vibrant community and a challenge for all who wish to be a part of the process of humanity's extension into outer space, but we will also create a centre of space industry.

Our company, before the proposal was made to mine an asteroid located in the Lagrangian point L4, had in mind the possibility of using a Near Earth Object called Apophis to deviate it in the Lagrangian point to avoid a devastating collision and further develop the plans for a Space Settlement built around this planetoid. The opportunity given by us by the Space Foundation that has identified a similar celestial body in the Lagrangian point, and due to the fact Apophis will not pose a danger to Earth's future, will allow us to put in motion our developing process. Also, the composition of the identified asteroid, nicknamed Argo, of Fe-Ni, is going to prove extremely useful in the context of high ore demands and increasing mineral prices.

Bellevistat will ensure a pleasant habitable environment for 18000 people and will also offer entertainment resources and a pleasurable stay for another 1000 transients. The design is made in such a way that the residents would have a natural view of Earth; we will use advanced systems of modern technology to ensure all the necessary conditions for sustaining life and to offer our clients a high quality life style. The workers will stay in a safe environment with a high operational efficiency.

We hope that our proposal will reach the Foundation Society's expectations and we are sure that if we have the opportunity, we will succeed in making our century's greatest achievement possible.

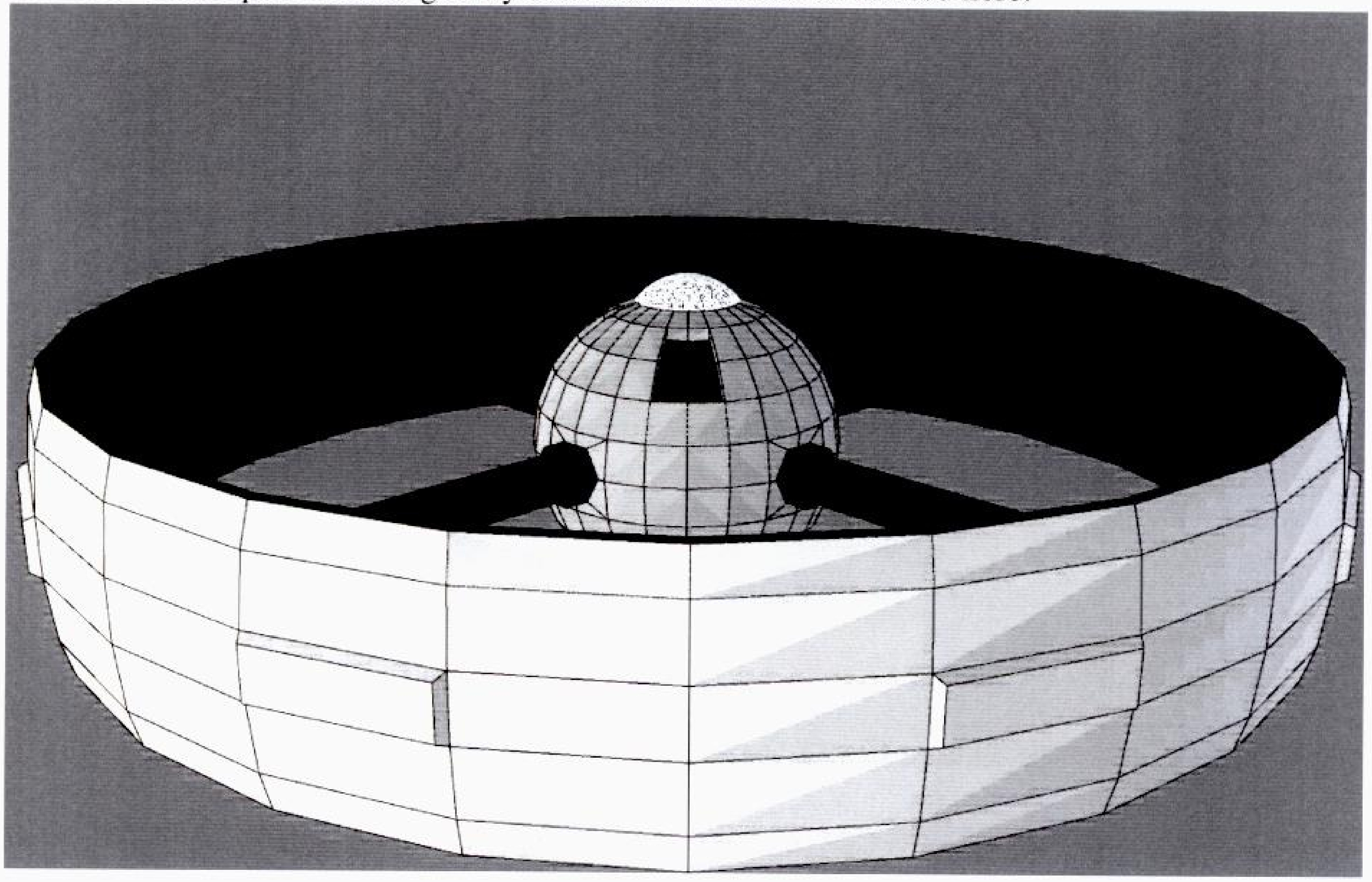
2.0 Structural Design

Bellevistat is intended to become the backbone of space research and development. It provides a pleasant environment for the 18000 inhabitants and the additional 1000 transient population (business and official visitors, guests of residents and vacationers). The space settlement design overwhelms the viewer with the sight offered from Belllevisat's viewing dome by using as a core an asteroid. The viewing dome is a structure build above the asteroid, with a diameter of 120 m and a height of 50 m, offering various activities including zero-g oriented sports and entertaining activities.

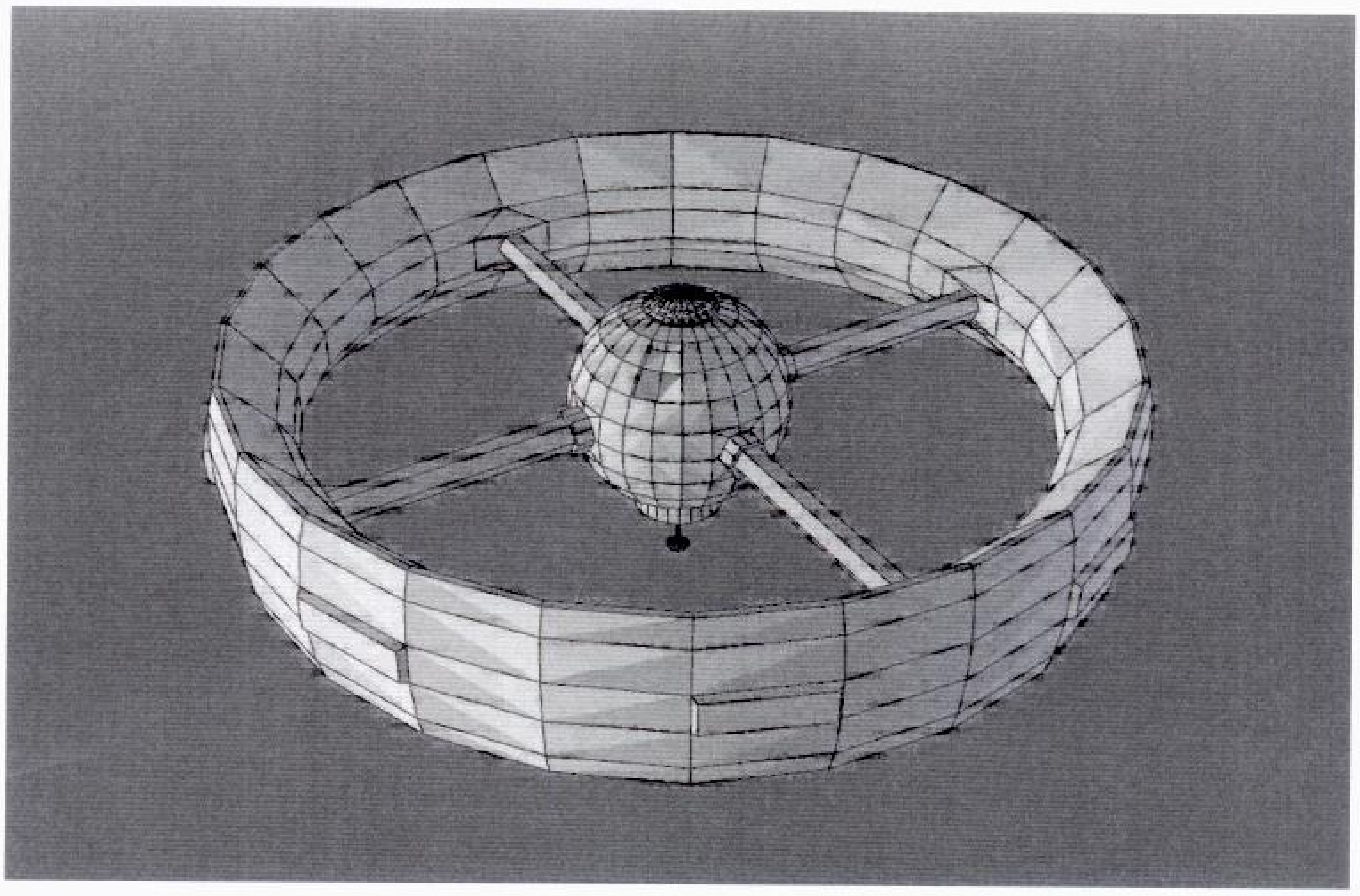
2.1 External Configuration

There are five main enclosed volumes:

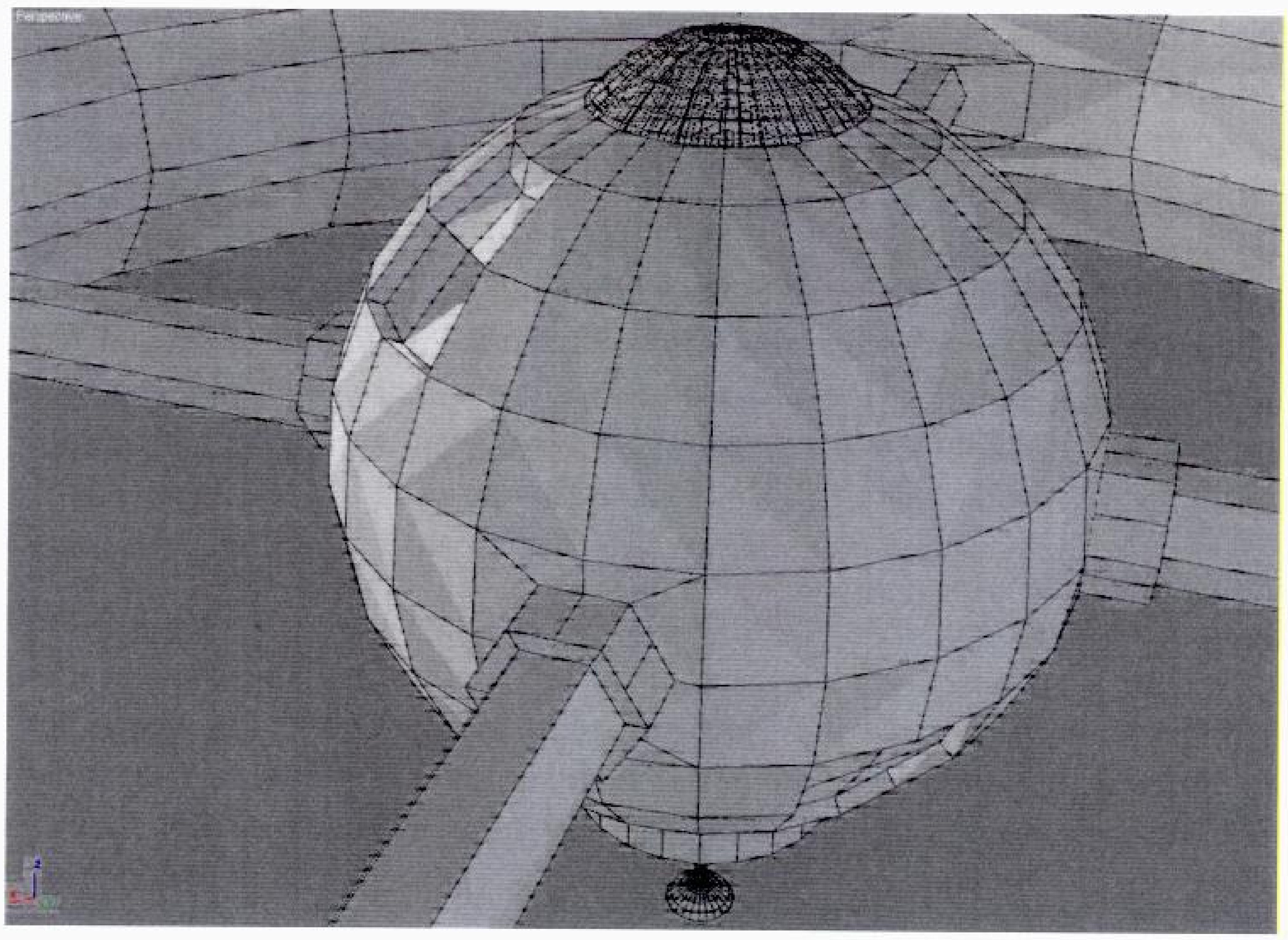
1. The asteroid, which will play the role of a deposit for various materials and also shelter in case of evacuation; the main port operations (cargo shipping for example) and heavy industry will take place there because of low gravity conditions.
2. The torus, where the people live and commercial activities will take place; the industrial activities that require normal gravity conditions will also be housed here.



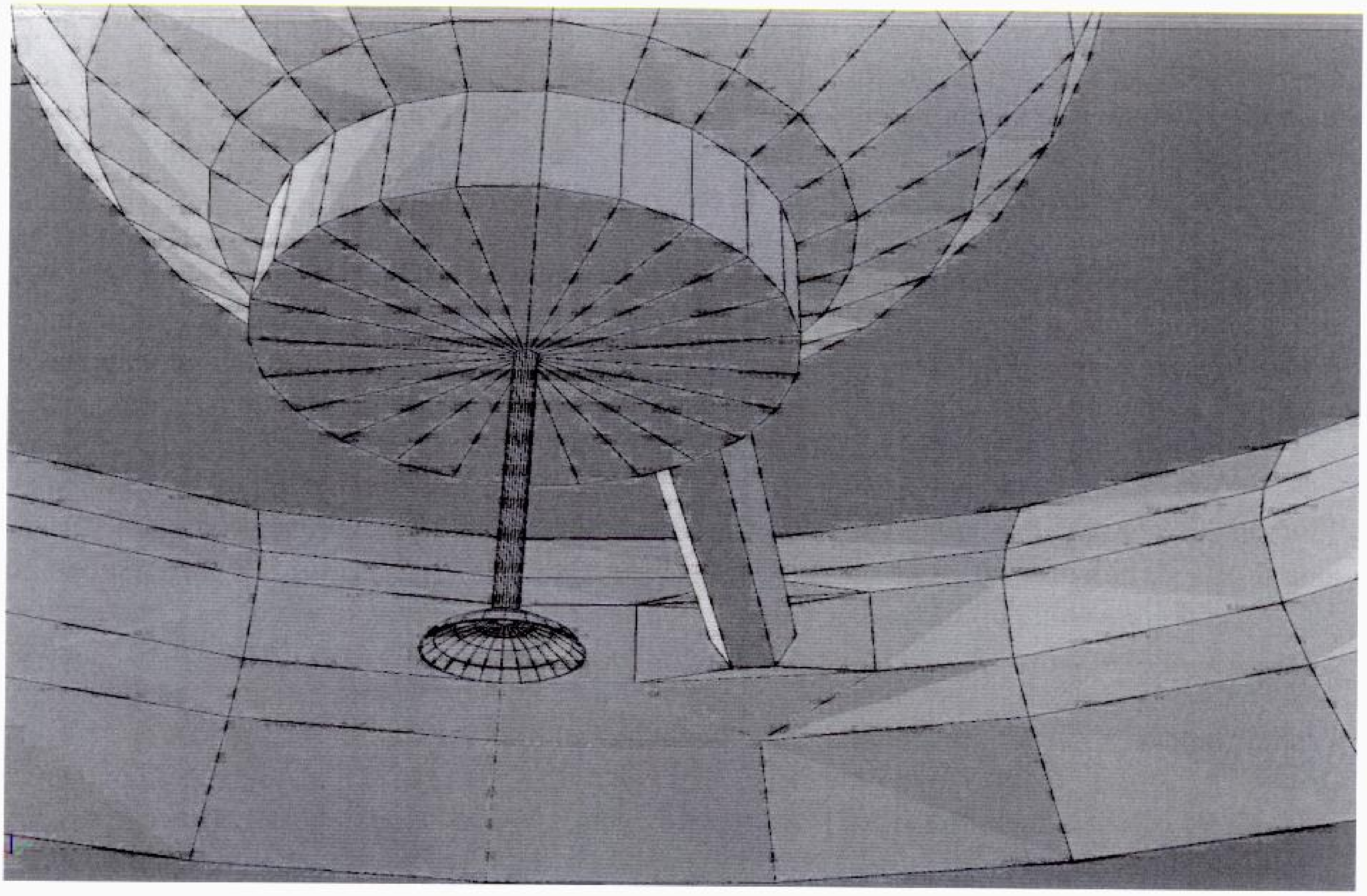
3. The towers extending from the asteroid through which refined material and the modular plates from the asteroid will be transported by conveyor belts to the torus.



4. The viewing dome



5. The control center located below the asteroid.



The torus is the main part of the settlement where artificial gravity will be supplied and will be fully pressurized. There are two conditions the rotation of the settlement has to fulfill: first, to supply a 1 g environment for the inhabitants, secondly, the Coriolis force on any object in motion within the space settlement has to be negligible compared with its weight. For 18000 hundred inhabitants, a torus with a major radius of 1 km and minor one of 250 meters, provides enough space to conduct all urban activities on one floor. The NASA research team has each individual requires 155,2 square meters of land. $\pi \cdot 4 \cdot r \cdot R = 314000 > 2793600$ which is the area of the main level, so we are well within meeting the space allocation requirements. Now let's consider if these dimensions respect the two conditions noted above.

$$\frac{v^2}{R} = g \Rightarrow v = \sqrt{(g \cdot R)} \Rightarrow v = 98.99\frac{m}{s} \Rightarrow \omega = 0.0989\ \frac{rad}{sT} = \frac{2 \cdot \pi}{\omega} = 63.4s.$$

Let's take an average man of 80 kg moving with a speed of 2 m/s. The maximum Coriolis force is equal to 2*m*speed of person*omega. The Coriolis force is equal with 31.6 N or 3% of the persons weight, quite reasonable meeting the second condition. Large, heavy cargo will be moved in zero g conditions or with low speed in higher gravity, so the Coriolis force doesn't pose a problem here.

The main issue is with transportation of people from one place to another. The longest distance a person will have to travel to reach their destination is half of circumference of the torus or 3141,5 m. Presuming 10 minutes is fairly quick enough, 4.95 m/s or 18 km/h should be the speed of travel to limit the Coriolis force to, at most, 10% of the weight of the moving object.

The speed may seem small, but giving the relatively small space in the settlement compared with conditions on Earth, moving a large number of people or heavy cargo with great speed is quite useless and reckless undergoing because there is no need. Any shipping or person can reach their destination safely in 10 minutes. Taking into consideration the orientation the Coriolis force, the issue seems almost resolved. Objects moving along the minor radius have a velocity parallel to the angular velocity and therefore the Coriolis force is null on them. Objects moving on the circumference of the torus will experience a greater g if moving in the sense of rotation of the torus, and a smaller g in the opposite sense, hence no modification in trajectory would be expected.

Object moving vertically in the settlement (ex.: elevators) will experience the Coriolis force pushing sideways. This inconvenience can be countered with magnetic repulsion from the elevator shaft. The carved out interior of the asteroid during the construction process will mostly not be pressurized; only areas where supervisors or workers live will have air at atmospheric pressure. Large areas within the asteroid can be sealed tight and filled with air is case of immediate evacuation from the torus.

The torus will be constructed from the materials found in the asteroid. The towers will be made in a similar fashion by which skyscrapers on Earth are made from materials also found in the asteroid. The starting point of the construction is the spacecraft that house the first "miners". Robots will perform adequate technological processes to start construction: drilling, excavating and powder metallurgy.

Protection from radiation will be provided by thick the layer of asteroid material the torus will be covered in. Debris penetration will not constitute a major threat because of special microscopic structure the torus shell will have. The shock wave is rapidly dissipated by the combination of hollow, strong and weak spots the shell will have. This special configuration is hopefully obtainable given the right produces and treatments at zero gravity of heated metal. Also we must into consideration the thermal shock that the settlement is subjected during the exposure to the sun. Due to the fact that Bellevistat will complete a full rotation in less than 63 second, any structural component will not suffer from the fast variation of temperature, mostly because the exterior plates are highly treated in extreme conditions.

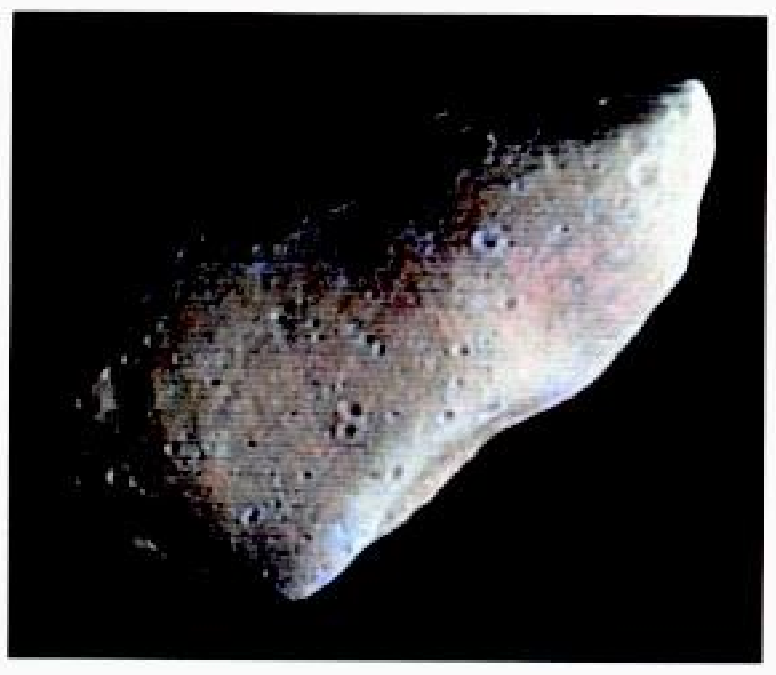
2.2 Internal Arrangement

There are three levels in the torus: the industry level situated at the highest point in the torus, where artificial gravity is lest, the residential and institutions level where most or urban activity takes place and the lower level where various infrastructure operations take place (like food processing, repair and maintenance of robots, water circulation and waste management).

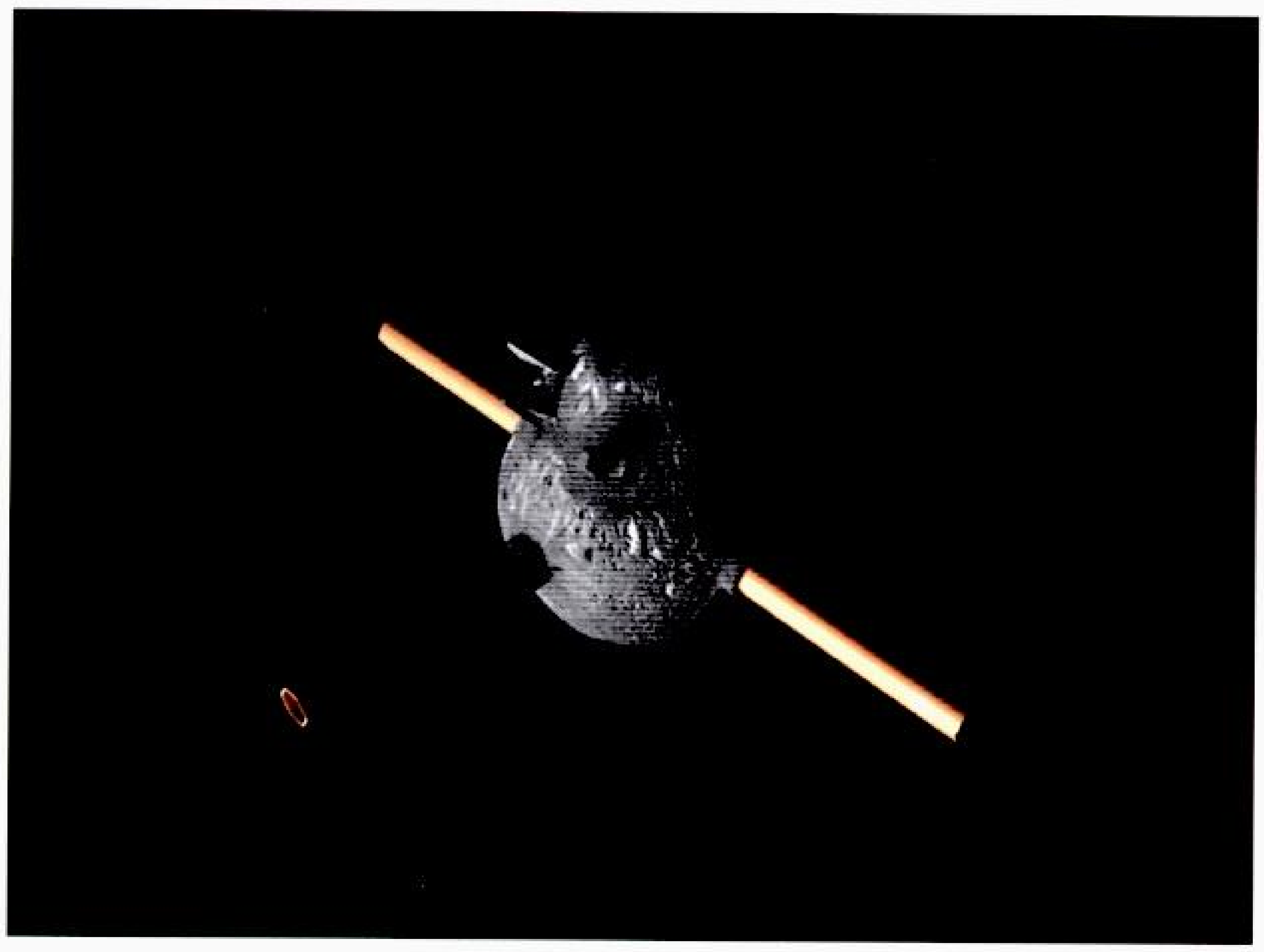
2.3 Constructions Sequence

1.

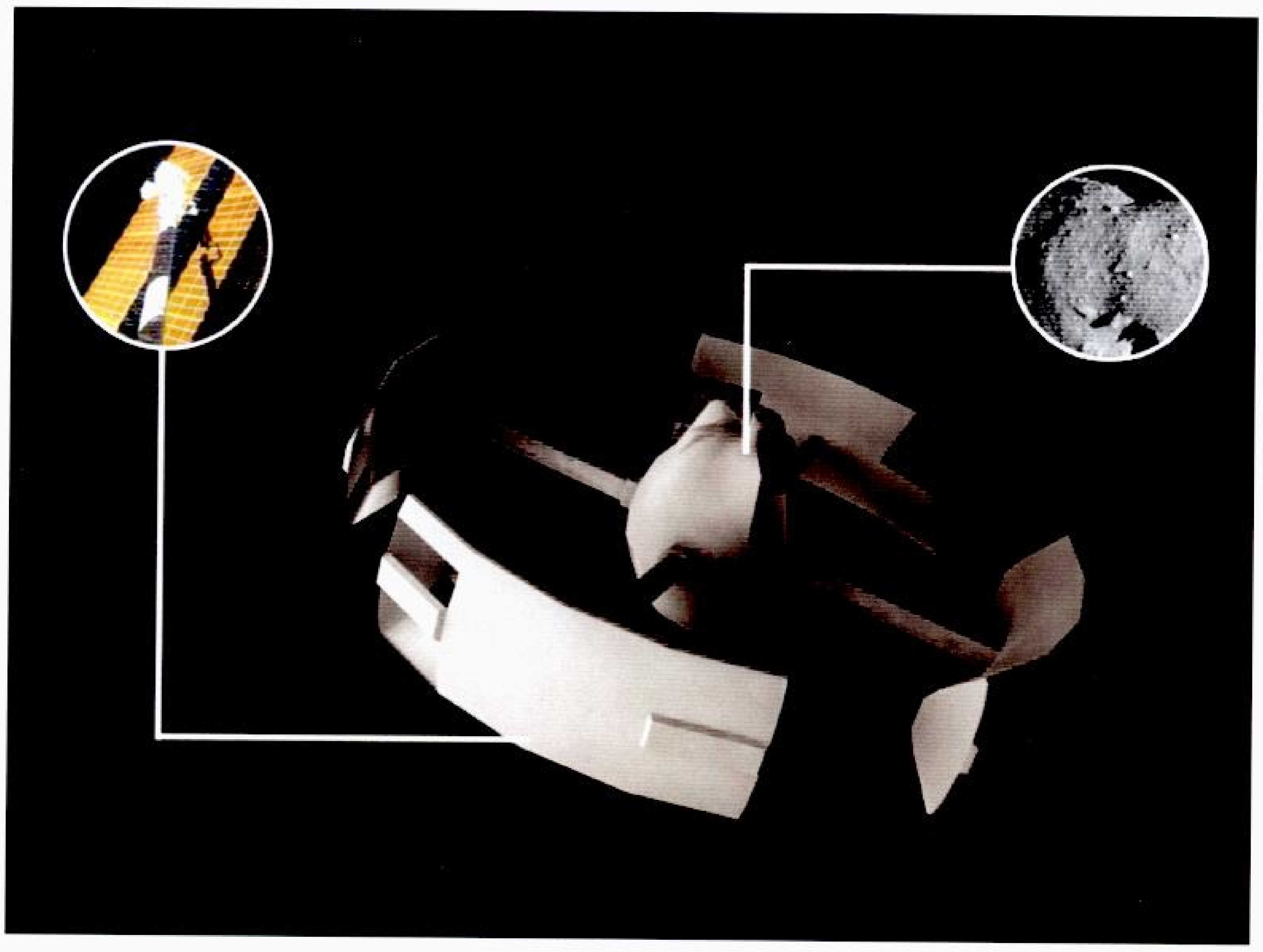
Gather information about asteroid in L4/L5: identify exact composition, motion characteristics, materials distribution in the asteroid, photograph exterior, take samples from the surface and inner core, delimitate future drill areas.



2. Send a temporary work station in orbit or near the asteroid; the station is basis to sending the initial drill machinery and start the construction sites on the asteroid; it will also house the mining process supervisors and workers.



3. Mounting the temporary domes that will house the refining facilities and temporary industry

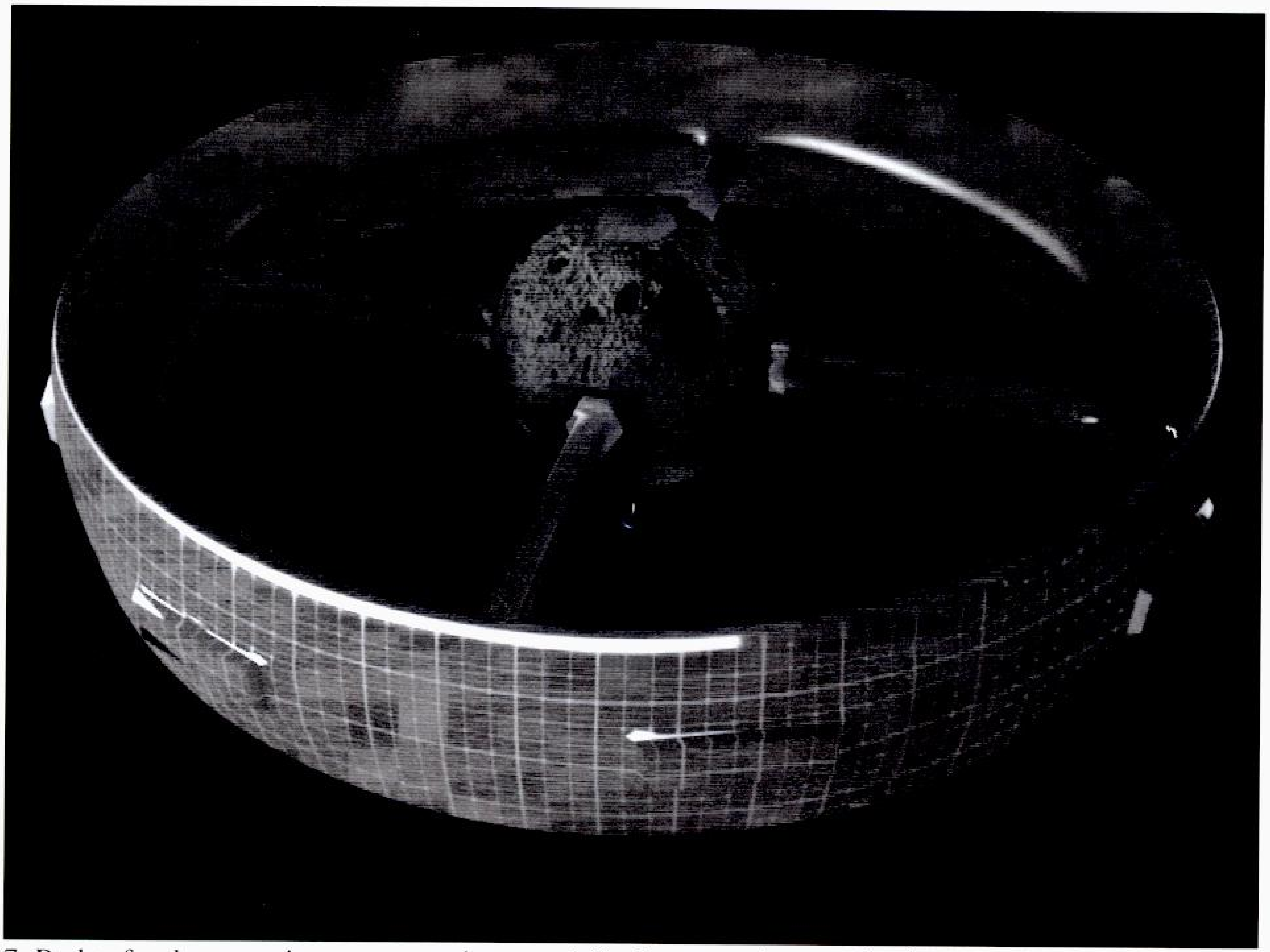


4. The construction sites are fully functional and major drilling procedures begin. Giant tunnel diggers will burrow to the center of the asteroid. The interior of the asteroid will ultimately serve as a deposit of material and an escape solution in case the settlement is damaged. The asteroid will gradually start to have a spherical appearance, the excavated material being transported through a series of towers on the asteroid to a belt around the asteroid, where the torus will be constructed.

5. By a series of technological process, most notably powder metallurgy, the excavated material from the asteroid is molded in prefabricates that form the basic building blocks of the torus. The torus gradual takes shape, starting from the tower ends that send the material and prefabricates from inside the asteroid.

6. The major hull sections are finished and work starts on interior areas. Automated machinery carves out the landscape and the infrastructure of the future city is created.

Bellevistat



7. Parks, food processing areas are done, and final automation mechanisms are incorporated in the newly formed urban space. Bellevistat is inaugurated and the first business, commercial and industrial activities take off.

The inner side of the torus will the one most exposed to dust from asteroid material because the terminal points of the transports towers are located there. The general air flow is the station is from the exterior of the torus to the interior, this means air is pumped in the dusty zones and so dilution ventilation takes place. This technique reduces the dust concentration in the area by diluting the contaminated air with uncontaminated fresh air. Dust collection systems, which are industrial ventilation principles to capture airborne dust from the source, will transported to a dust collector, which cleans the dusty air. Occasionally the work zones will be water sprayed by sprinklers in the ceiling, the same sprinklers that start working in case of a fire. In the same way smoke particles are detected, the sprinklers will trigger if the dust levels reach certain levels and stop after a prescribed time. This technique suppresses airborne dust by spraying fine droplets of water on the dust cloud. The water droplets and dust particles collide and form agglomerates.

Once these agglomerates become too heavy to remain airborne, they settle from the air stream. The air from the areas exposed to dust will be vented through the ceiling, thus minimizing the amount of dust that escapes the area.

In processing the material extracted from the asteroid we will use traditional , as well as new techniques. One of the most inovative and potentially fruitful methods is powder metallurgy. It is a three step process: the primary material is physically powdered, divided into many small individual particles; the powder is injected into a mold or passed through a die to produce a weakly cohesive structure (via cold welding) very near the dimensions of the object ultimately to be manufactured; the end part is formed by applying pressure, high temperature, long setting times (during which self-welding occurs), or any combination thereof.

Powder metallurgy in the microgravity and vacuum conditions of orbit or on the Moon offer several potential advantages over similar applications on Earth because of several reasons: the absence of atmosphere (and therefore, the elimination of undesirable reactivity with atmospheric gases)will result in far more pronounced and dependable cold-welding effects due to the absence of surface coatings, gravitational settling in polydiameter powder mixtures can largely be avoided, permitting the use of a wide range of grain sizes in the initial compact and producing correspondingly lower porosities. Finally, particles could be selectively coated with special films which artificially inhibit contact welding until the powder mixture is properly shaped. (The film is then removed by low heat or by chemical means, forming the powder in microgravity conditions without a mold). The availability of zero-g may suggest alternative techniques for the production of spherical or unusually shaped grains.

Atomization and centrifugal disintegration will be the main powder metallurgic techniques used. Direct Solar energy can be used to melt the working materials, so the most energy-intensive portion of the operation requires a minimum of capital equipment mass per unit of output rate since low-mass solar collectors can be employed either on the Moon or in space. The two major energy input stages - powder manufacturing and sintering - require 19 MJ/kg and 17 MJ/kg, respectively. At a mean energy cost of \$0.007/MJ, this corresponds to about \$0.13/kg. Major savings might be possible in space using solar energy.

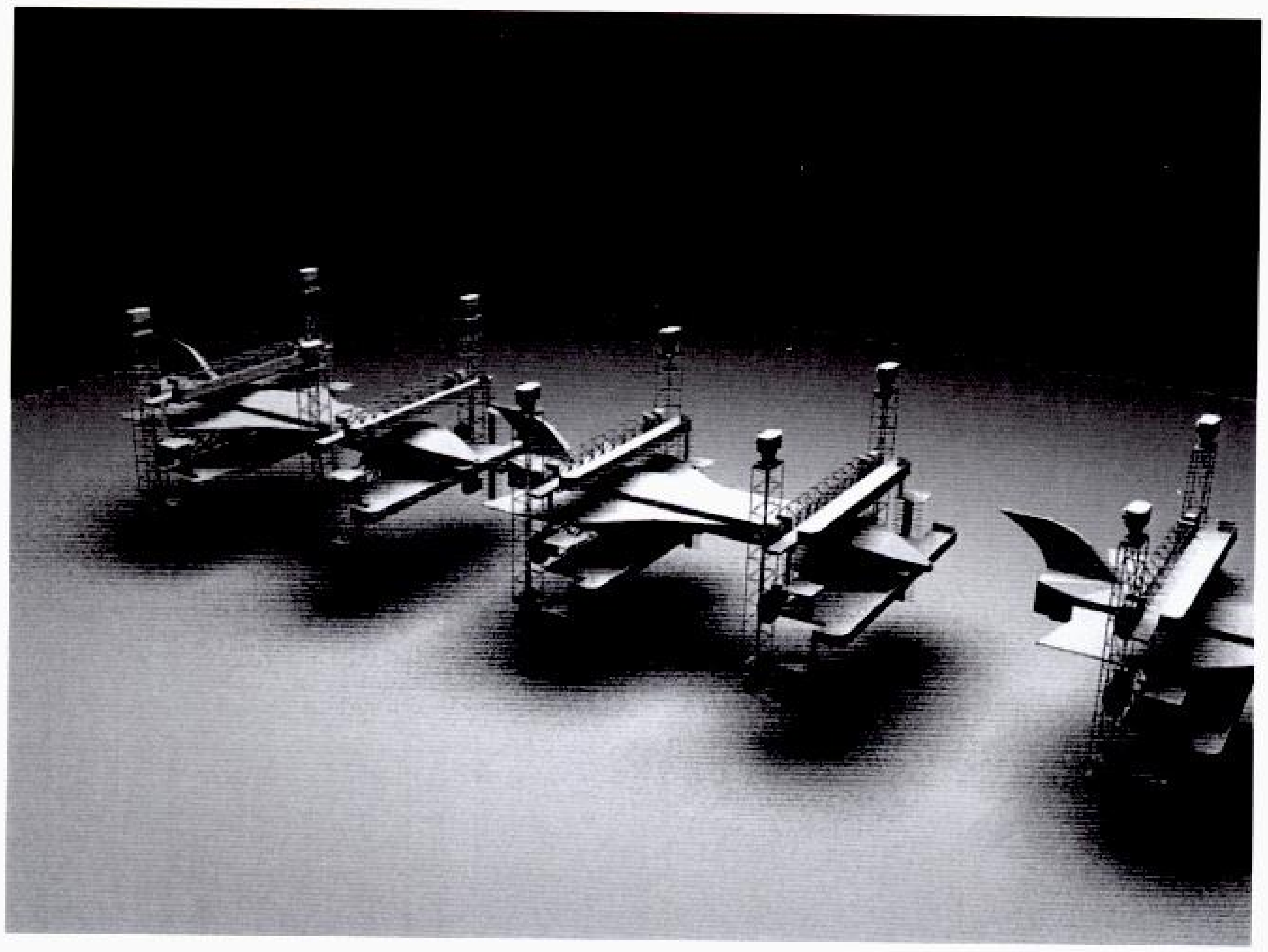
The materials that are processed through this method form the basis of the settlement structure: the walls, plumbing installations, kitchen equipment and various other functional elements.

Besides powder metallurgy, a number of other techniques need mention: the casting process, deformation in manufacturing and metal joining. Casting has its limitations in space. Gravity is a major problem but can be overcome with development of centrifugal systems which work in concert with other systems. The cold-welding effect is also of major concern. To overcome this, it is suggested that fabrication should take place within a closed atmospheric unit. Lunar basalt molds possibly may replace iron molds. But basalt has a low coefficient of thermal conduction and more research is needed to ensure feasibility of the concept. Lunar basalt should provide adequate molds for aluminum alloys as the former melts at 1753 K (1480°C) and the latter around 873 K (600°C).These problems are hardly intractable and will be solved.

In deformation metal is forced to assume new shapes by the application of large mechanical forces to the material while it is either hot or cold. The purpose of this mechanical working is twofold: first, to bring the feedstock into a desired shape, and second, to alter the structure and properties of the metal in a favorable manner (e.g., strengthening, redistribution of impurities).Novel techniques must be considered in manufacturing designs intended for non-terrestrial applications. For instance, thread rolling offers a solution to fastener production, electroforming appears suitable for thin-walled containers, and non-centrifugal basalt casting may prove useful in low- or zero-g and yield a more homogeneous product. Vacuum enhances the characteristics of some metals, e.g., cold rolling increases the tensile strength of steel and improves the ductility of chromium. Electrostatic fields may enhance bubble coalescence in metallurgical or rock-melt products.

All joining processes from the standpoint of automation in space of interest appear readily automatable. Joining should pose no insurmountable problems for space or lunar manufacturing facilities. General-purpose repair welding must probably be accomplished initially via Tele-operation, as this activity requires a much higher degree of intelligence and adaptability.

Bellevistat space ports location is crucial in its design. We are planning to equip the station with 4 ports that will allow the link of the inhabitants with the other settlements in the near Earth solar system area. We will place them in 4 opposite corners that, in case of an incident on one of the space port, the other 3 will permit the daily activities to go on as usual. The major feature of the docking areas is the fact that 80% of it is located inside the asteroid, providing thus an increase in safety of the docking and undocking facilities, as seen in the drawings below. To improve the chances of survival, Bellevistat will be equipped with 8 escape pods areas.



3.0 Operations and Infrastructure

3.1 Construction Materials Sources

Named after the Italian-French mathematician Joseph Louis Lagrange, the lagrangian points are defined as stationary solutions of the circular restricted three-body problem. Basically, they mark positions where the combined gravitational force of two large masses provides the required centripetal force required to rotate with them. Lagrange, during his studies concerning this issue, has identified 5 positions, where a third body with a negligible mass can be placed to maintain the relative position to two other massive bodies and we name:L1 ,L2 ,L3 ,L4 and L5.The first three lagrangian points are technically stable only in the plane perpendicular to the line between the two bodies, perturbing an object placed in these areas causing it to drift away from it's previous location. However, the Lagrangian points L4 and L5, in contrast with the collinear L1,L2 and L3 are in a stable equilibrium, the Coriolis effect bending the objects path into a stable orbit around the point. Taking into consideration the stated above, Northdonning Heedwell is intending to place the Bellevistat space settlement in the lagrangian point L4 of the Earth-Moon system. The chosen location will also allow the station to become the linking point between major settlements across the solar system .Due to the fact that the company has already signed to contract to mine an existing asteroid, located in L4 point, Bellevistat will use the planetoid as a primary source for materials necessary for construction and as a core. Also, the entire process will also be backed by the refining facilities and automated systems from Earth, Moon, in-orbit facilities and, in a smaller degree, by Allexandriat.The following tables show the materials and equipment needed to complete the construction process of the Bellevistat and the means of shipping them to the site. Note that we refer to Argo as the core asteroid and Bellevistat as the station when it's at 70% completion.

Material	Source	Form(ore/ processed/ compound)	Estimated percentage of the total mass of material needed	Requires processing in the on Argo	Destination	Storage options	Method of shipping
Iron<Fe>	Earth's moon	processed	30%	No	Passive protection, infrastructure, robots	Storage facilities on Argo and in-orbit, Bellevistat cargo area	Heracles/ Hermes
	Argo	ore	65%	Yes			transport systems located on Argo
Titanium <Ti>	Earth	Processed	5%	No	Passive protection, Infrastructure, Robots, special alloys, solar panels	Storage facilities on Argo and in-orbit, Bellevistat cargo area	Hermes
	Earth's moon	Processed	35%	No			Heracles/ Hermes
	Argo	Ore	60%	Yes			Transport systems located on Argo
Silicon	Earth's moon	Processed	90%	No	Solar cells, special glass. isolation	Storage facilities on Argo	Heracles/ Hermes
	Earth	Processed	10%	Yes			Hermes
H_2O	Earth	Processed	80%	No	Human usage	Water	Hermes

	Chemical reactions	Impure	20%	Yes	and additional systems that support life, fuel,	reservoir on Bellevistat	
Oxygen <O_2>	Earth	Processed, liquefied state	10%	No	Atmospheric conditions, fuel, various production processes	Bellevistat special tanks	Hermes
	Earth's Moon	Processed, liquefied state	90%	No			Heracle/ Hermes
Nitrogen <N_2>	Earth	Processed, liquefied state	100%	No	Atmospheric conditions	Bellevistat special tanks	Hermes
Al, Mg, Ca, Cr,	Earth's Moon	Processed	70%	No	Alloys ,various production processes	Argo storage facilities, Bellevistat cargo area	Heracle Hermes
	Argo	Ore, Minerals	30%	Yes			Transport systems on Argo
Carbon <C>	C –type Asteroids	Raw	100%	Yes	Synthesis of various carbon based materials	Bellevistat cargo area	Heracle Hermes

The equipment used to harvest and process, the mounting systems and any other automation that allows the construction process is presented in the following table

Equipment	Subsystem	Source	Destination	Storage	Transport methods
Assembly robots	-	Earth	Mounting and repairing preliminary and final modules of the station	Argo storage facilities, Bellevistat cargo area	Hermes
		Allexandriat			Heracle/Hermes
		In-orbit stations			Heracle/Hermes
Boring Machine	Cutting head	Earth	Boring Argo and creating the cavern	Argo storage facilities	Hermes
	Control systems and	Allexandriat,In			Heracle/Hermes

	computing	orbit stations			
	Other components	Moon, Earth, In-orbit stations			Heracle/Hermes
Mining robots	-	Earth's moon	Mining and enlarging the Argo cavern	Argo storage facilities	Heracle/Hermes
		Earth			Hermes
Harvesting Robots	-	Earth's Moon	Harvesting dust and other materials on the surface of Argo	Argo storage facilities	Heracle/Hermes
		Earth			Hermes/Hermes
Control systems	-	Allexandriat, In-orbit facilities	Coordinating and maintaining the construction process at 100% 24/7	Argo storage facilities,	Heracles/Hermes
		Earth			Hermes
Temporary solar panels and power plants	Solar panels	Moon,Earth, Allexandriat, In-orbit facilities	Powering boring machines and assembly robots across Argo and Bellevistat	Argo storage facilities	Hermes/Heracles
	Power converters, additional systems	Earth			Hermes

3.2 Community Infrastructure

Electric Power Generation.

The Sun - which can be accurately treated as a black body - radiates thermal energy according to the Stefan-Boltzmann law: $\frac{dE}{dA \cdot dt} = \sigma \cdot T_S^{\,4}$, where T_S represents the Sun's surface temperature. The total energy emitted per unit time - the luminosity - is then: $L = 4\pi R_S^{\,2} \cdot \sigma T_S^{\,4}$. This energy is distributed izotropically in a solid angle of 4π - that is, it is evenly spread on a sphere. For our settlement's location, the available power per unit-projected area – the solar constant – is: $J = \dfrac{L}{4\pi R_{SE}^{\ 2}}$

The solar energy will be captured using solar panels – arrays of solar cells. The panels will be placed on the outer surface of the torus. At any moment, half of the panels – those facing the Sun at that instant - will receive energy. The entire energy received by the array of solar panels is: $E_{received} = J \cdot S_{effective}$, where $S_{effective}$ is the effective cross-section – that is, the area of the projection on a plane perpendicular to the solar rays:

$$S_{effective} = 4 \bullet r_{torus} \bullet R_{torus}$$

The silicon based solar cells that will be incorporated in the solar panel typically have the efficiency of $\eta = 0.2$. Therefore, the total energy produced by the solar panels is:

$E_{produced} = 2 \bullet \eta \bullet J \bullet r_{torus} \bullet R_{torus}$==4*0.2*250*1380=276000W=2760MW

Taking into consideration the fact that a population of 19000 in a developed country uses approximately 2300MW,we can see that the energy generated by solar panels is more than enough for the colony's needs. The excess energy can be stored using rechargeable batteries and can later be used if needed in cases of emergency or power failure. For example, the stored energy can be used during eclipses, when solar energy is obstructed from reaching the station. For safety reasons, the Bellevistat space settlement will be equipped with a number of fuel cells, including here DMFC(or direct methanol fuel cell)or alkaline batteries that will take on the energy production in case of failure of current energy production systems. During its orbit of 382000 km around the Earth, the station is eclipsed only when it passes behind Earth – that is, during the time it takes to advance by $2R_E \approx 12800$ km on its orbit. Thus, the duration of the eclipse is: $T_{eclipse} = T \cdot \dfrac{2R_E}{2\pi d_{EM}}$, where $T \approx 28$ days. Thus, $T_{eclipse} = 3.6$ hours which means that the station will be eclipsed for 3.6 hours every 28 days.

Power Distribution

In order to minimize the losses caused by the resistance of the wires, $P_{lost} = I^2 \cdot R_{wires}$, we have to minimize intensity. This requires using high voltages. High voltages are dangerous for humans, so that the voltage will be "stepped-down" by using transformers. Also, taking into consideration the fact that copper has the one of the lowest resistivity

The table below shows the priority order from 1 to 6 in which the consumers will receive electric energy to ensure maximum safety of the inhabitants

Priority number	Consumer type
1.	Life Support systems-Atmospheric control
1.	Structural integrity support systems

1.	Escape routes and escape pods area
1.	Space Port
2.	Active defense
2.	Control center
3.	Water management and food supply management
3.	Heavy industry
5.	Public and home illumination
6.	Additional consumers

In case of emergency and power failure, the consumers will shut down from 6 to 1.

Atmosphere composition

The partial pressure of oxygen on Earth is ~22.7 kPa, which ensures normal breathing. We must not deviate too much from this value. Therefore: $\boxed{p_{O_2} = 22.7\ kPa}$

Nitrogen is not as essential for humans as oxygen is; however, its presence helps prevent certain respiratory problems and minimizes the risk of fire [4]. Moreover, it is needed by nitrogen-fixing plants. Nitrogen has to be transported from Earth and is therefore very expensive. Moreover, cost efficiency dictates that the atmospheric pressure inside the colony be small, as large pressures require larger hull thickness and thus greater costs. Therefore, the partial pressure of nitrogen should be chosen such that it offers adequate protection against fires and aids in human respiration, but at the same time minimizes costs.

Taking these factors into account, we chose a partial pressure 0.4 that on Earth: $\boxed{p_{N_2} = 21.3\ kPa}$.

The partial pressure of carbon dioxide on Earth is $0.032\ kPa$. Higher rates would increase plant photosynthesis, but they are not indicated for the colonists; lower rates would reduce the efficiency of photosynthesis. Therefore, $\boxed{p_{CO_2} = 0.032\ kPa}$

Thus, the total pressure of the colony's atmosphere is: $\boxed{p_{int} = 44.0\ kPa}$. Water vapor also contributes in partial pressure, according to its relative humidity and temperature.

Weather control

There is an obvious need to ensure a certain unpredictability of these factors, so as to prevent psychological issues as Solipsism Syndrome from developing.

The mean air temperature will be randomly determined. However, the randomness is not total – it is a "controlled randomness". That is, the season will also be accounted for when determining the mean air temperature. Thus, temperatures of $2^{o}\,C$ are more likely to occur during winter than during summer. Also, while the exact date of rain will be random, the total amount of rain in a year will be predetermined. It will be considered more of a special event to allow the residents to feel just like on Earth.

A relative humidity between 30% and 60% is found to be comfortable by most people (the peak being at 45%).Therefore, each day, the mean relative humidity at noon (relative humidity is different in different parts of the day) will be randomly determined, but in such a way that at the end of the year the relative humidity distribution will be Gaussian, centered at 45%.

Time and seasons

On Earth, a mean solar day is the interval between two consecutive upper meridian transits of the Mean Sun (a fictive Sun, which moves uniformly along the celestial equator). On the colony, a mean solar day will have lost its significance, as the Sun transits the upper meridian every 1.42 minutes. Thus, the question of whether time should be kept as on Earth appears.

First, the colony will be permanently in contact with Earth. Colonists will want to communicate with their friends and relatives from their home planet. They will have access to the Earth mass information resources, so they will be informed about what goes on there. Second, the human circadian rhythm requires a 24 hour day. Thus, the necessity of adopting the same time system as on Earth becomes obvious. The time of the colony will equal the Greenwich Mean Time – GMT (the mean solar time at the zero meridian). This, however, will bring some difficulties to the colonists from countries which are way ahead or behind GMT. That is, a colonists of American origin will find it difficult to communicate with his/her family and friends, as the time difference will be, for example, 8 hours. Assuming the colonists are more or less equally representing different countries, regions and continents, it would be correct to set the time of the colony equal with GMT. If, however, most of the colonists are from a single country or region, it would be fair to vote in order to determine the time of the colony.

There will be four seasons, just like on temperate regions on Earth. The reasons why seasons exist on Earth are:

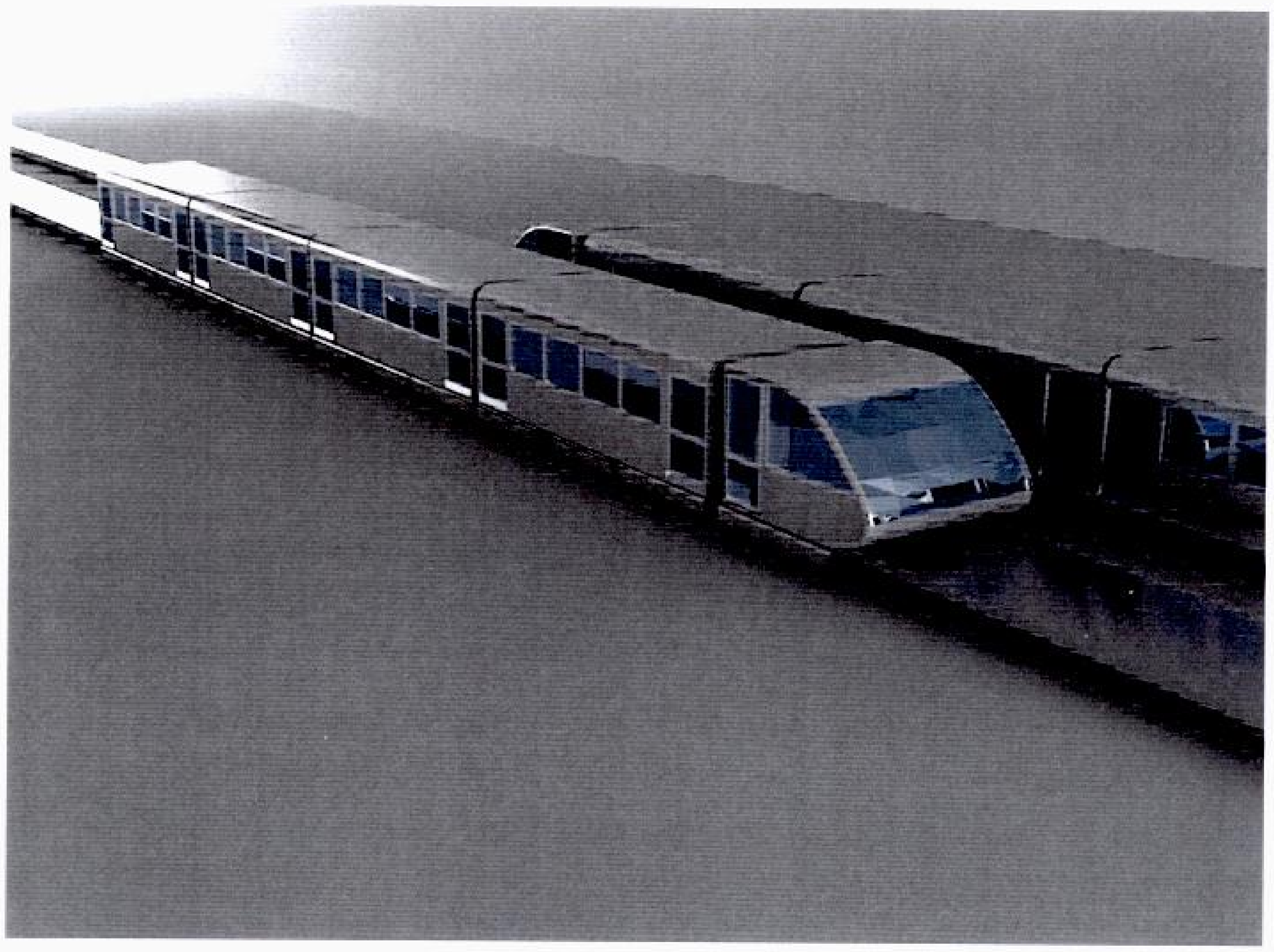
- At different points of the ecliptic, the angle of incidence of the solar rays at a given latitude is different. The angle of incidence determines the amount of solar energy received per unit area, that is: $\phi = \phi_0 \cos i$
- Differences between day and night lengths; That is, winter is colder than summer also because the time the sun spends above the horizon, warming the Earth, is lower.

Thus, seasons are determined by the angle of incidence of the solar rays and by the amount of time the Sun spends above the horizon. Altering the angle of incidence of the light is technically difficult. Thus, the only way to simulate seasons is by simulating the day/night length cycle.

Day/night lengths

Choosing a day/night length that does not vary will have negative psychological effects on the colonists. Thus, the day/night lengths will vary throughout the year: they will follow typical Earth-like variations of a 45° latitude region on Earth – that is, there will be equinoxes and solstices. Equinoxes and solstices will also help in mimicking the seasons.

Internal transportation system



Moving from one side of the settlement to the other may be a difficult task for walking, considering the large distances that must be crossed. In planning for the provision of easy road access, a transportation system based on the maglev principle it's imposed, a system made out of a two way ‚railroad' with 2 trains per direction that pass one after the other at about 4 minutes, at a speed of 45 km/h.

Stations are to be placed so that the passengers can have direct access to the train. Each one is situated at 600 m from the previous one to encourage walking and it is thought to disjoin the two directions of the route such as it to become a both-way station.

Waste Management

The waste management system on a space station operates integrated into the other systems associated with the environmental control, and as far as possible, all waste is recycled, being a potential source of any infection calamity.

Any food containing garbage or any other damp organic compounds begins rotting from the moment it's cool enough to eat. Bacteria and other life-forms in it multiply at an alarming rate and overall, the garbage becomes a health hazard, and all this can occur within hours of disposal. By bagging and sealing it may burst out because of the gas pressure created within, so the minimum of rotting garbage must be produced. Similar conditions in garbage may occur, like as the ones that arise on farms or hayricks, where damp hay, microbes and anaerobic conditions conspire together to create high temperatures and create a potential spontaneously combustion. Disposable food containers are to be washed, dried and exposed to ultraviolet before being bagged as inactive garbage. The garbage that emits gas will be placed in a container that allows gases to vent into the air conditioning system, where they are neutralized. The recycling of waste water will be done through a sewage system similar to those on Earth, but smaller and completely automated, that would operate in minimum gravity values. The treatment of the sewage waste relies on partial cleansing by removal of unpleasant chemicals and organic contaminants like feces from the water; it takes up some areas of land. The volume of remaining dry tank will probably be incinerated and thrown into space as cosmic dust.

Food

TABLE 5-17.– (a) AVERAGE DAILY SPACE COLONY DIET (g/PERSON)

Source	Amt, g	Calories, kcal	Carbo-hydrates, g	Fats, g	Protein, g
Meat					
Trout	40	78	0	4.6	8.6
Rabbit	40	64	0	3.2	8.4
Beef	40	142	0	12.8	6.3
Chicken	40	49	0	1.3	8.8
Produce					
Eggs	24	39	0.2	2.8	3.1
Milk	500	330	24.5	19.0	17.5
Dry plant produce					
Wheat	180	608	130.1	3.6	24.3
Rice	100	363	80.4	.4	6.7
Sugar	100	385	99.5	0	0
Vegetables and fruit					
Carrots	100	42	9.7	0.2	1.1
Lettuce	100	14	2.5	.2	1.2
Peas	150	126	21.6	.6	9.5
Apple	100	56	14.1	.6	.2
Potato	100	76	17.1	.1	2.1
Tomato	100	22	4.7	.2	1.1
Orange	100	51	12.7	.1	1.3
Totals	1814	2445	417.1	49.7	100.2

Farms (industrialized and ordinary)	Animals (livestock, poultry and fish)
Crops	Greenhouses and harvest fields
Packaging and transport	Tubes and trains

3.3 Space Infrastructure

Linking Bellevistat and other human posts across space must be carefully taken into consideration due to the design issues regarding space travel. Also there is a growing concern regarding the current infrastructure reliability and it capability of sustaining the increasing number in space flights.

For Earth, having a permanent connection with Alexandriat, the newly constructed Bellevistat ,space ports and human avanposts, is heavily dependent on our Percherons and Palomino fleet service and requires a great deal of planning and monetary support. Taking this into consideration and the fact that a new payload requires five months of preflight preparation, we are willing to rebuild the entire space infrastructure and redesign the way humans are travelling. This issue has been debated for a while in our company's team and, after the Bellevistat proposal; we have decided that, in parallel with the space settlement, we will start one of the largest construction processes that humanity has ever seen.

We will first give special attention to Earth's Infrastructure and to that on the Moon, as a major supplier of resources for future projects.

Launching pads have not been improved for several years and can no longer sustain the increase in missions and the needs for Alexandriat and Bellevistat. For that, we are developing mass drivers launchers on specific locations across the earth and, as a future project, on the moon; a mass driver is basically a coil gun that magnetically accelerates a holder and payload. Once the payload has been accelerated, the two separate and the holder is recycled and reused for another payload. Although this system is highly practical in the case of moon settlements, the presence of the atmosphere and the strong gravity make the installation difficult in the case of the Earth. As an answer, we will use a compromise: the mass driver accelerates the shuttle at a high speed which is not enough for solo launch, it releases its payload that continues its launch by self propelling.

Also the Lunar settlements will be equipped with new refining facilities and harvesting units that can provide humanity the necessary materials in the search of the stars.

To accommodate the new launching pads and needs, our current Percherons and Palomino space shuttles will also be redesigned. Our research and engineering team has developed a new, functional prototype of the future space vehicle called Hermes. With a wingspan of 37 meters, 78 meters long and having 13 meters in diameter, combined with the improvements of the engines of the current shuttles, Hermes can carry 25% more payload compared to our actual fleet's Percheron. Also the civilian transport designed shuttle, H-2902 or Athena, is able to accommodate 40% more passengers, from 80 to 112 maintaining the current 250lb. weight allowance for persons and possessions.

However, in space such things as an aerodynamic design does not matter so the company proposes another type of ship that is cargo-oriented called Heracles. Heracles is composed of a piloting area, a cargo bay that contains specific containers that can reenter the atmosphere and deliver materials to be used, and the engine room.

We believe that with the newly developed launch pads, the overall cost of space flight will drop down with almost 50% in the case of civilian transport and more than 40% for cargo. This allows for a better exchange between Earth and the space ports and speeds up the space exploration and colonization program of Earth.

The project includes a number of research satellites that will increase the detection rate of near Earth objects or NEO's that can be a potential threat to the transportation routes and the Bellevistat construction.

Also we will continue to use the in-orbit facilities and believe that, after the completion of the project, we will prove that Northdonning Heedwell is worthy of the position of the no.1 space development oriented company.

The following Table presents the in-orbit facilities, satellites, infrastructure systems and vehicles.

Equipment type	Equipment name	Destination	Description(components)	Contract bounded
Static infrastructure	Mass launcher Earth	Launch pad necessary to improves mission timetables and reduce their cost	-2*20 km long rail -control center -preflight preparation chamber -High voltage Transformers -power plants to deliver sufficient energy to power up the linear motors. -docking area	Not bound
	Mass Launcher	Launch pad necessary to allow a reliable	-1*20 km long rail	Partially

	Moon	connection path between Moon settlements and other human facilities	control center -preflight preparation chamber -High voltage Transformers -solar panels -power plants -docking area -landing area	
	Moon refining facilities	Refining Facilities for minerals and ores found on the moon	-Refining Factory -Harvesting Drones -Mining Robots -Power plants	Partially
Vehicles	Hermes	Human transportation	Wingspan-37m Length-78m Diameter-13m Effective capacity-21700kg	Not bound
	Athena (H-2902)	Cargo transport ship designed for Earth and space usage	Wingspan-37m Length-78m Diameter-13m Effective capacity-118 persons	Not Bound
	Heracle	Cargo transport ship designed for space use only	Length-78m Diameter 13m	Partially
Vehicles	Artemis	Container capable of Earth atmospheric reentry	Length 10m Diameter 12m	Fully bound
In orbit facilities	Space Telescopes	NEO's detection and space research	Length 11m Diameter 3m	Fully Bound

	Radio telescopes	Space research	Length 12 m Diameter 2.5m	Fully Bound

4.0 Human Factors

The role of the architectural environment on Bellevistat space settlement represents an important factor regarding the community health. The art and practice of constructing a building has often been described as an act of optimism, thus, the architecture from the space settlement is viewed as a symbol of high aspirations.

The residential architectural infrastructure of the space settlement has a total area of $4\pi Rr=4\pi 250000=3141592$ square meters (33815814 square feet) and it will be divided in 8 major sectors, each measuring $\frac{1}{8}(2\pi R) = 785.3982$ m length and 2r=500 m width. The division was made to increase the safety of the inhabitants, the space settlement being equipped with an emergency evacuation system for each sector.

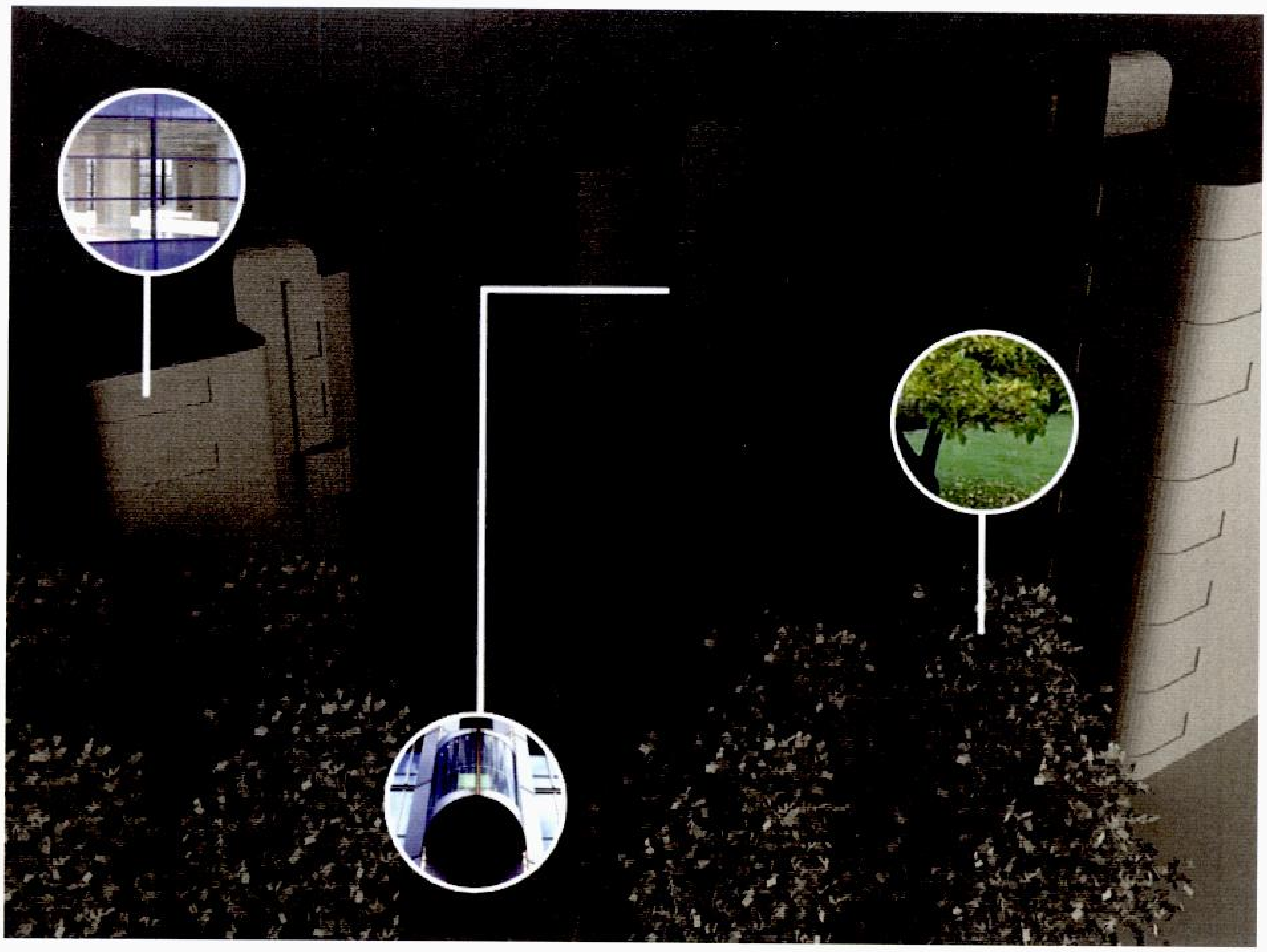
4.1 Community Design

Due to the fact that quality of life is very important, facilities will be provided for services that residents could expect in a comfortable modern community environment. Having the anticipated demographics percentages of the population – 30% married adults, 37% single men, 30% single women and 3% children, Bellevistat will house up to 19000 people. Therefore, we propose five types of residential buildings, each one of them distributed in a different environment to simulate the diversity, a very important psychological factor for the inhabitants. Also we must say that every building and community construction across Bellevistat is modular. The modularity is based on the material economy and efficiency, while maintaining the necessity of the human for freedom of speech. Every house and building allows the inhabitant to choose how to organize his own space, redesign his home and choose from a variety of homes that will best suit his aspirations.

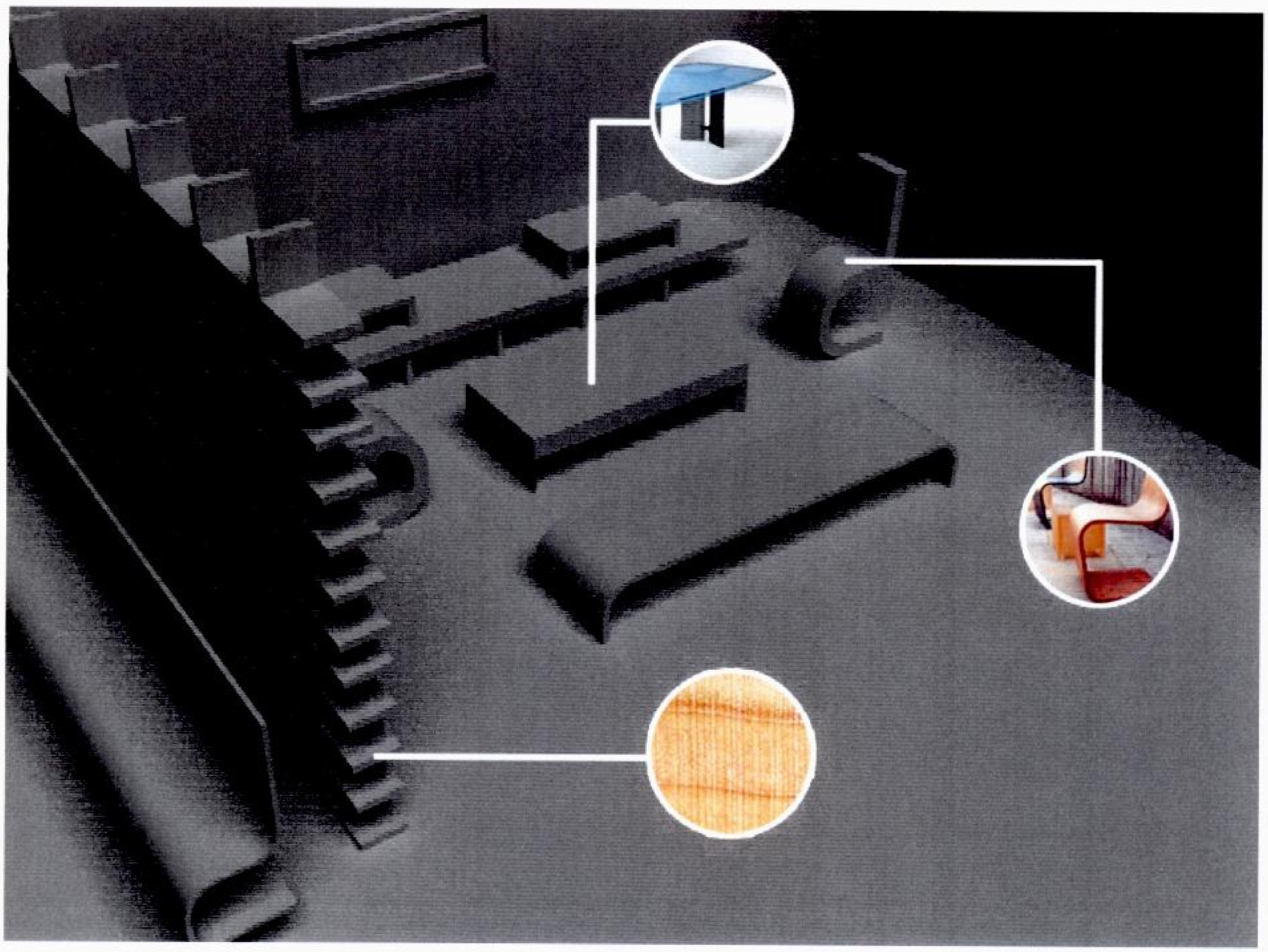
4.2 Residential Design

Individualism is one of the main features of our contemporary society. Given this case, we managed to create a residential area with a good use of the land, fit for the site and the space settlement architecture, and also providing an outstanding character.

Residential building Type A – apartments dedicated to single persons:

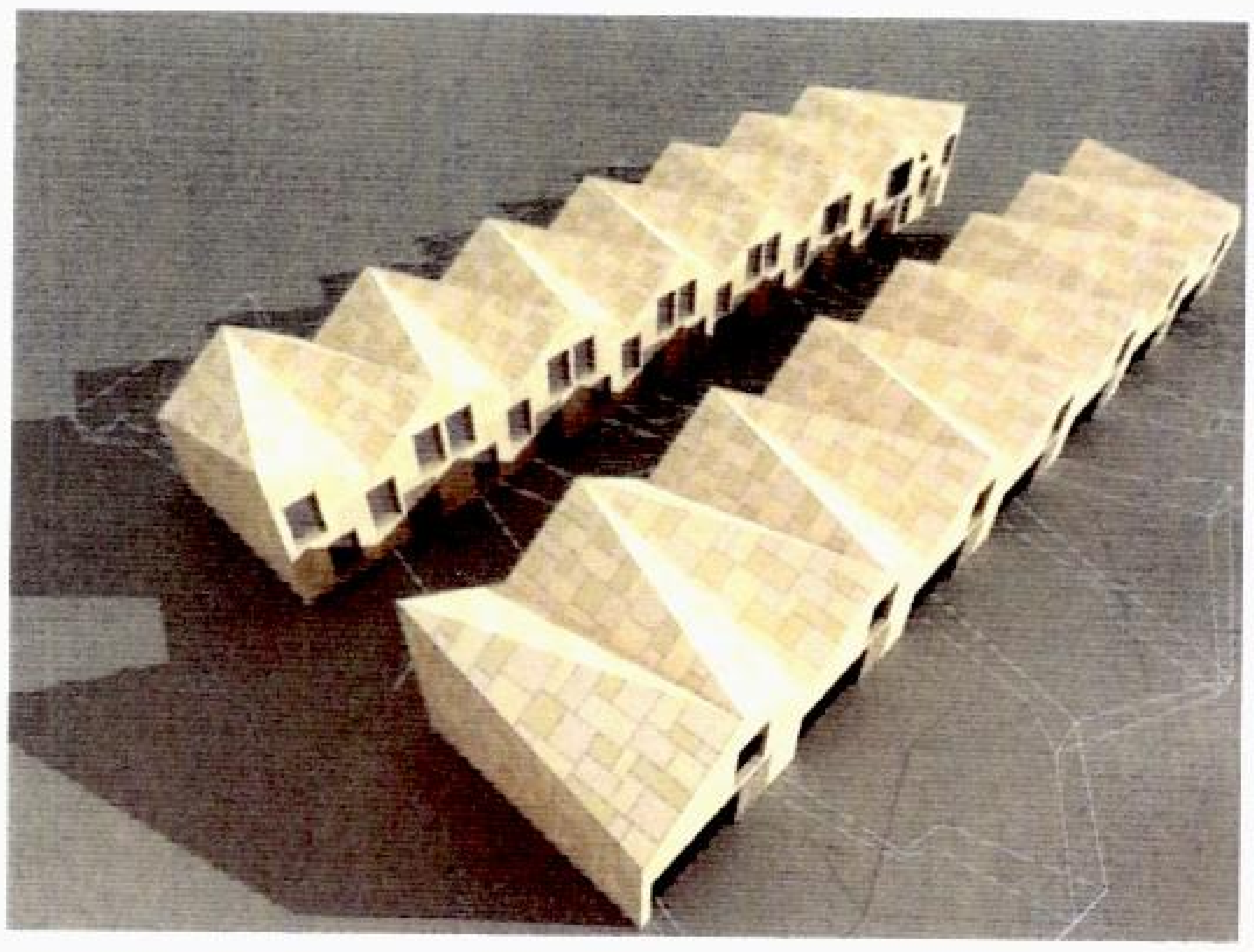


bellevistat



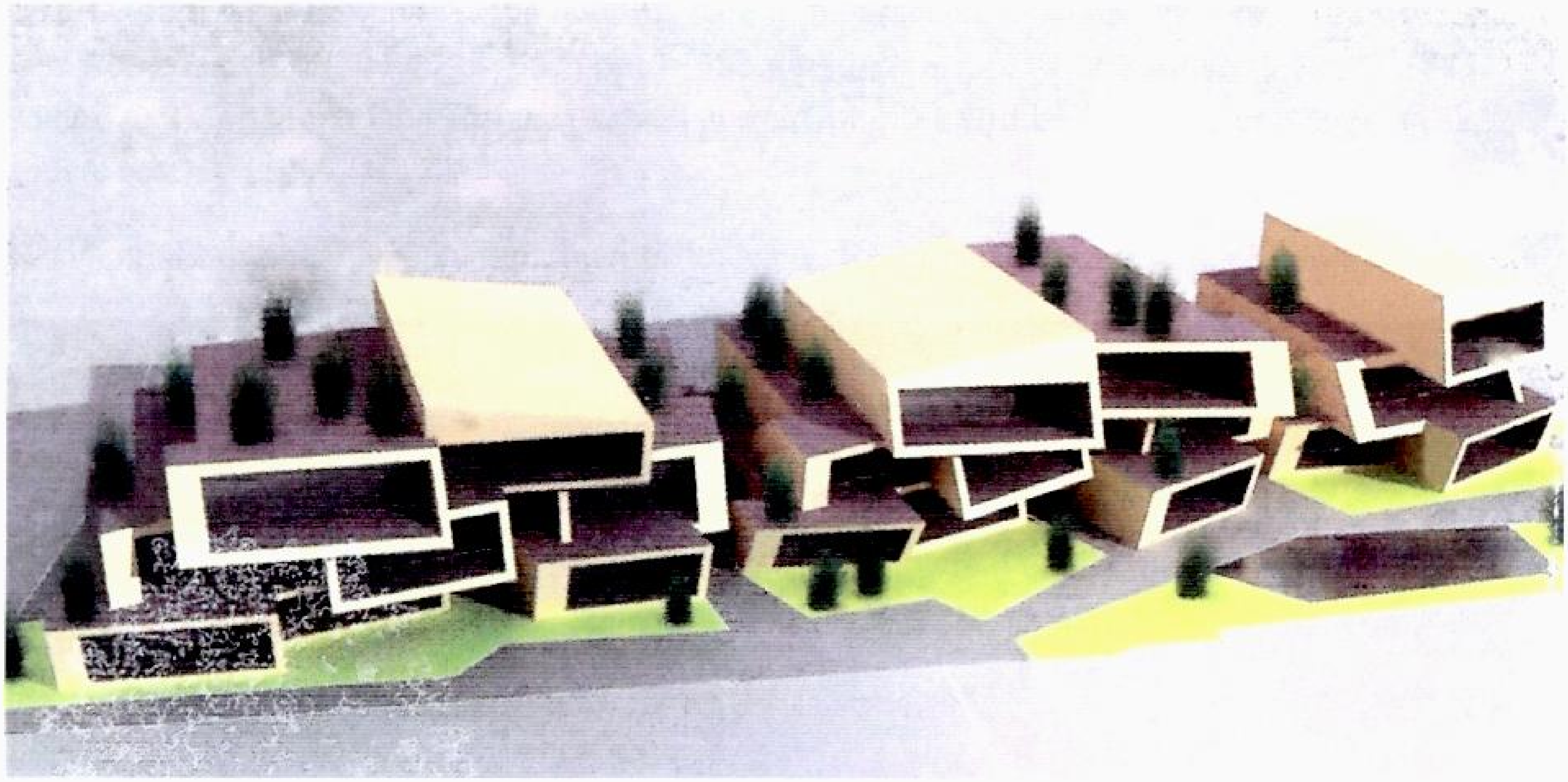
The complex consists of 3 types of buildings, with 3 different levels, with a total of 61 single-apartments. Each Type A apartment will be 62 square meters (667 square feet). The total land surface of the Type A Complex will be 2304 square meters (24800 square feet).

Residential building Type B – apartments dedicated to single persons:



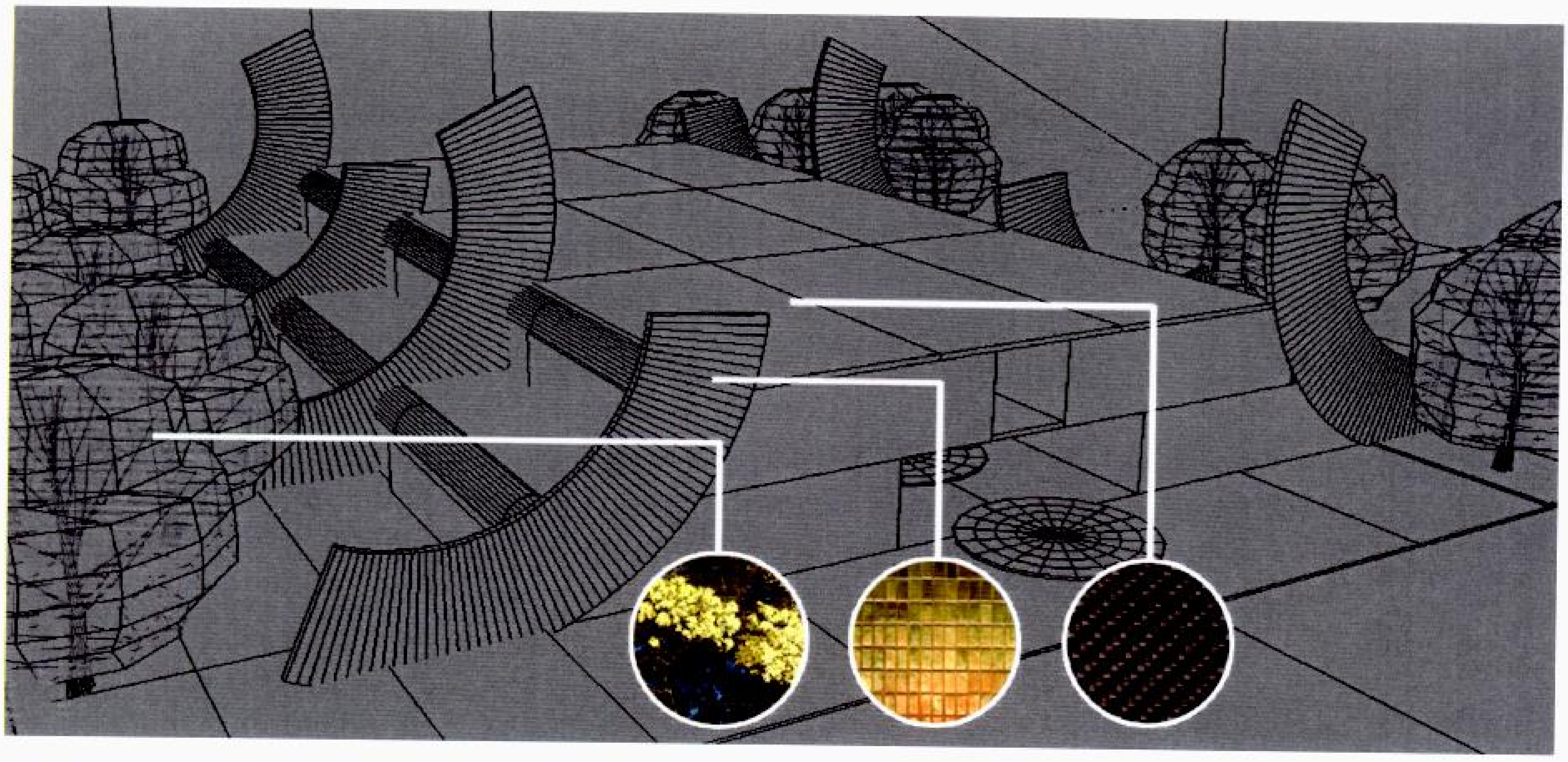
The complex consists of 28 apartments; each Type B apartment will be 63 square meters (678 square feet). The total land surface of the Type B Complex will be 980 square meters (10548 square feet).

Residential building Type C – apartments dedicated to couples/couples with children:



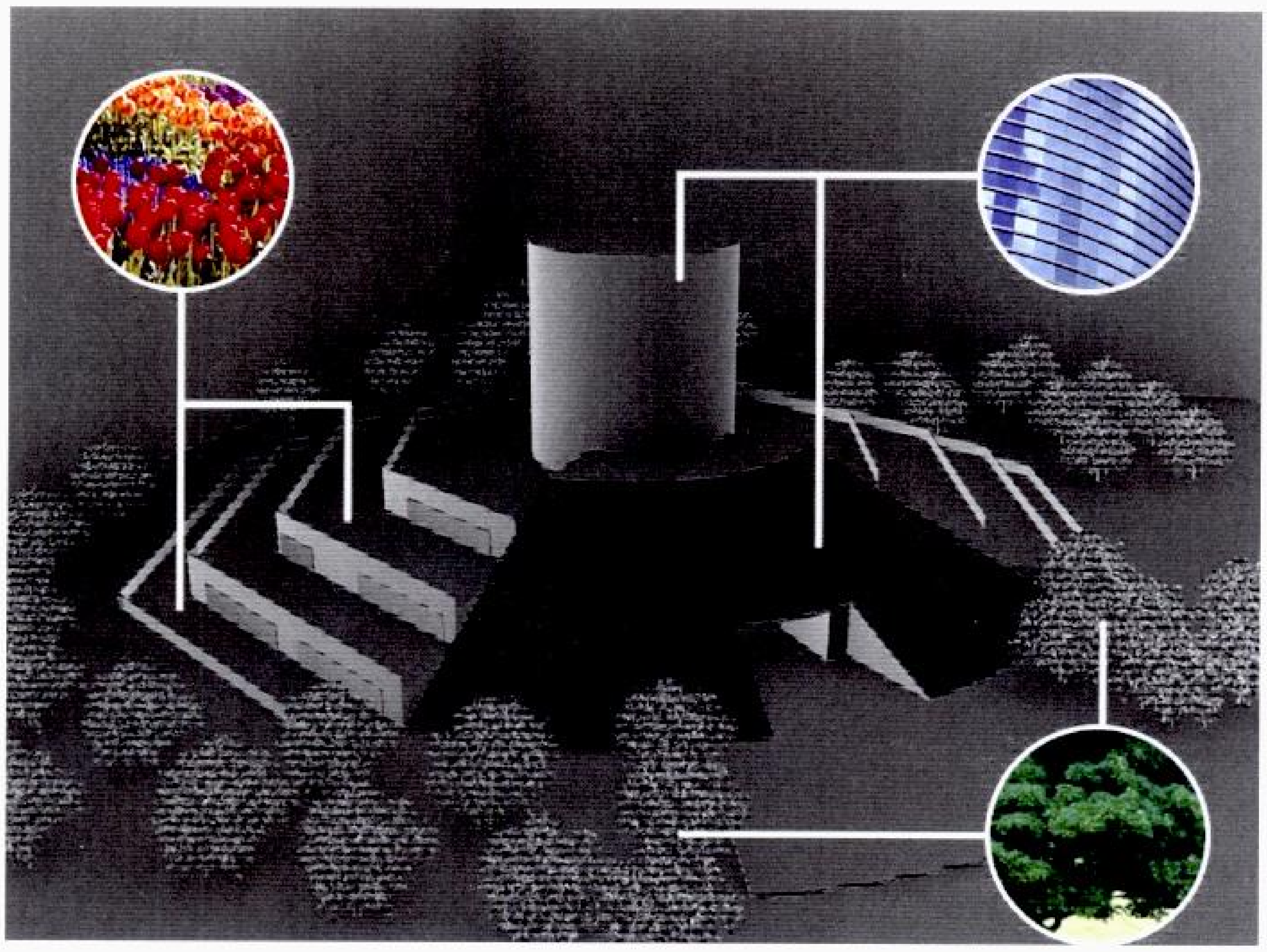
The buildings include two types of housings: villas placed on successive terraces down the area and flats in a condominium in the higher area. As they are placed in a succession , each house has a garden on the roof of the other, so interstitial areas fit for a green space or access areas result. Spare areas in between the buildings are to be greened, used and kept in common. The complex consists of 30 houses, each one of them with a surface of 162 square meters (1743 square feet). The total land surface of the Type C Complex will be 1600 square meters (17222 square feet).

Residential building Type D - apartments dedicated to couples/couples with children:



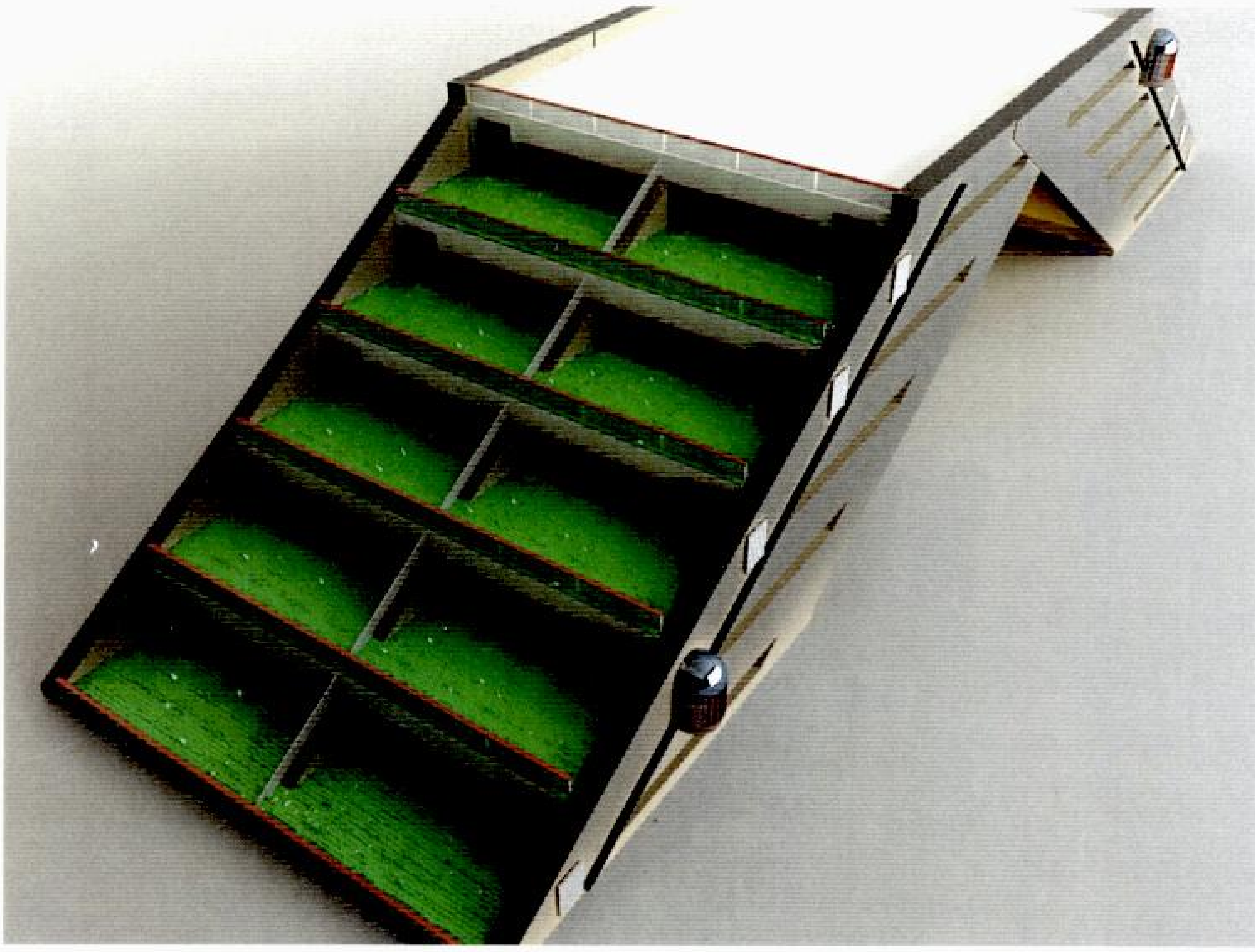
The building consists of 8 apartments, each measuring an area of 150 square meters (1614 square feet). The total land surface of the Type D Complex will be 1920 square meters (20666 square feet).

Residential building Type E – apartments dedicated to couples/couples with children:



The building consists of 20 apartments, each measuring an area of 174 square meters (1872 square feet). The assembly also includes a commercial centre. The total land surface of the type E Complex will be 6358 square meters (68436 square feet).

Residential building Type F – apartments dedicated to couples/couples with children:



The building consists of 20 apartments, each measuring an area of 150 square meters (1614 square feet). Each apartment has its own 50 square meters (538 square feet) garden. The total land surface of the Type F Complex will be 900 square meters (9687 square feet).

Taking into consideration that on the space settlement will live approximately 12800 single persons and 5700 couples with children, it will be enough if we build:

105 Complexes Type A with a total land area of 241920 square meters (2604005 square feet);

230 Complexes Type B with a total land area of 225400 square meters (2426185 square feet)

34 Complexes Type C with a total land area of 54400 square meters (585556 square feet)

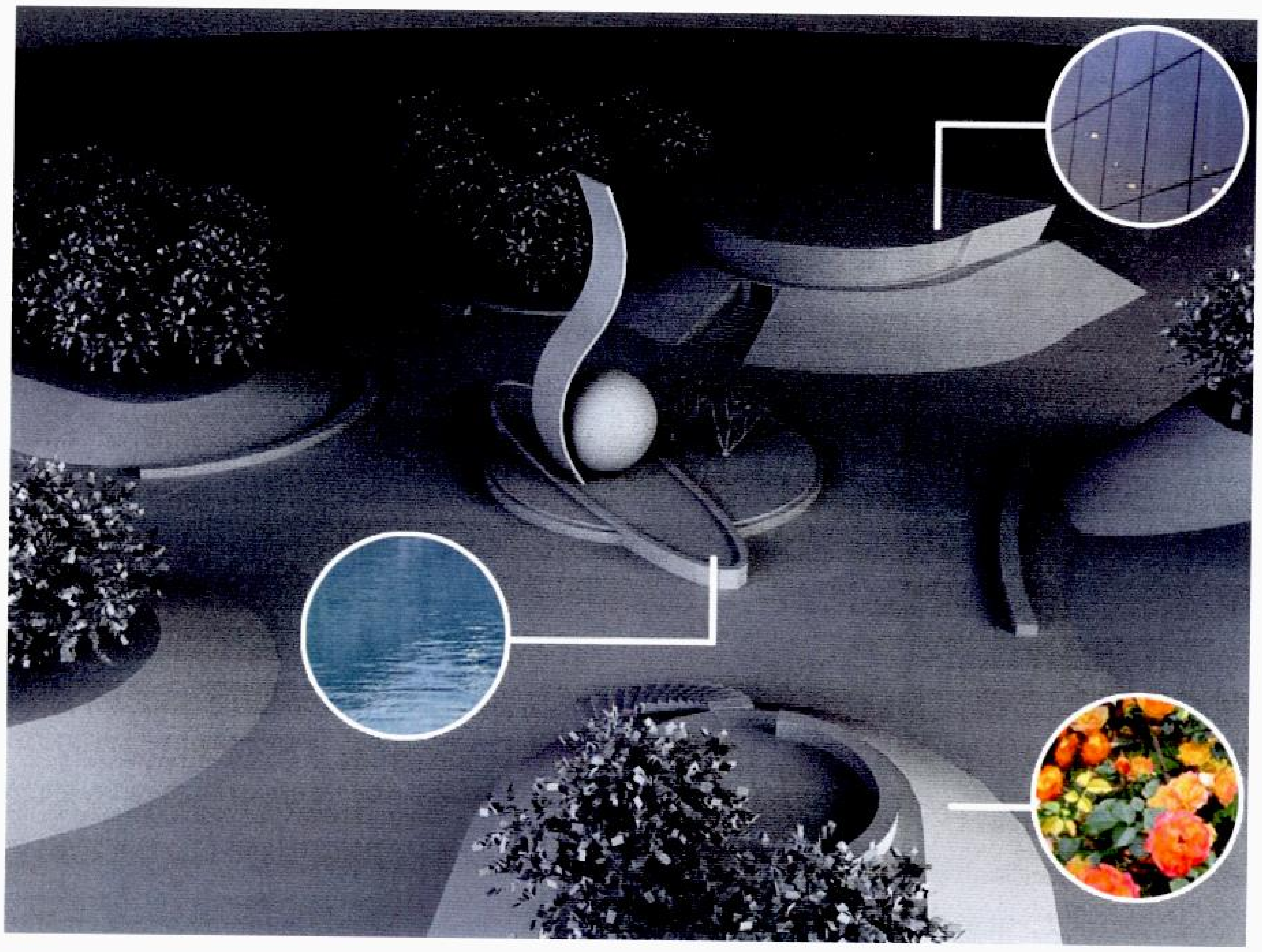
80 Complexes Type D with a total land area of 153600 square meters (1653336 square feet)

50 Complexes Type E with a total land area of 317900 square meters (3421847 square feet)

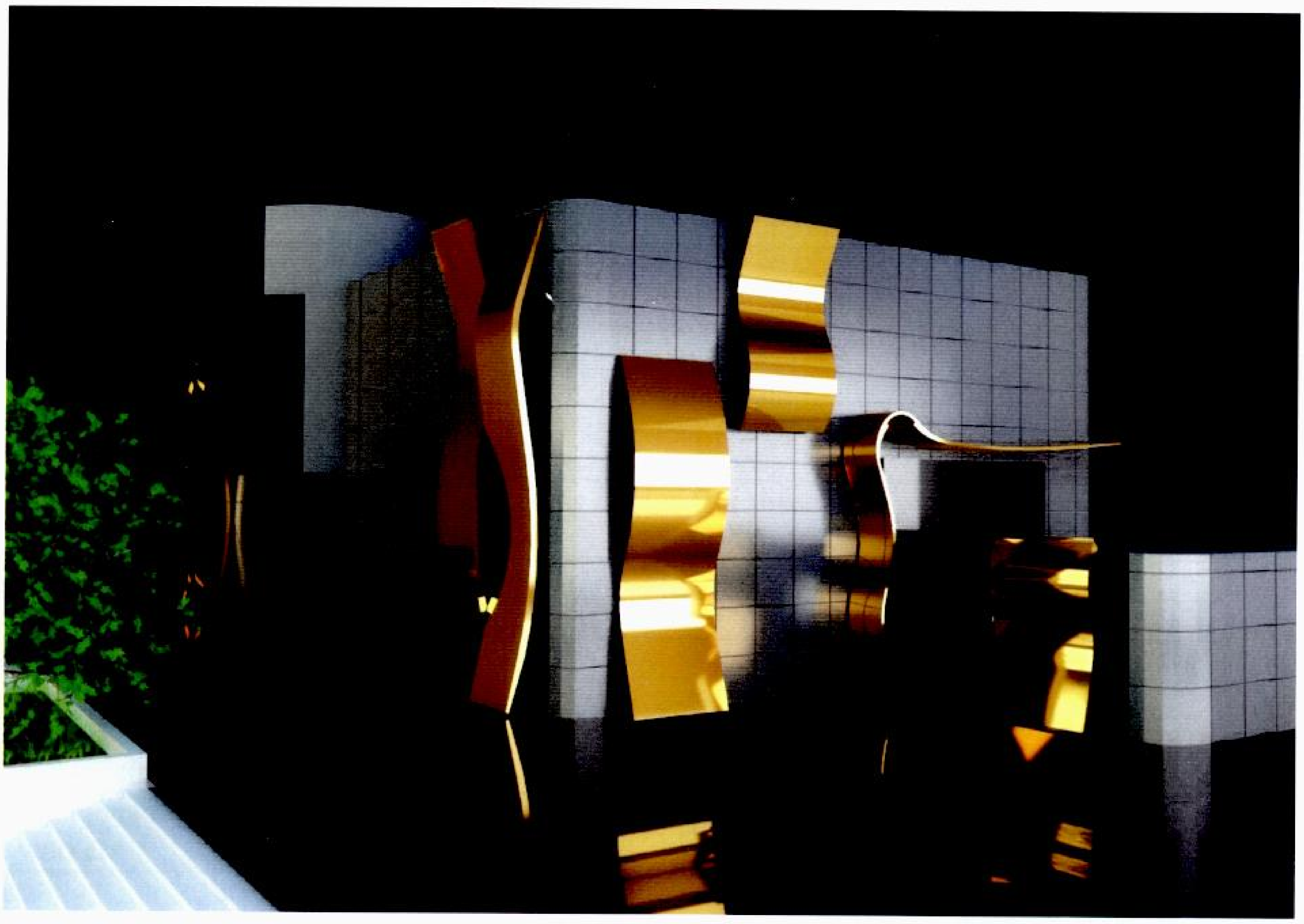
90 Complexes Type F with a total land area of 81000 square meters (871876 square feet)

The living area will occupy a surface of 1074220 square meters (11562808 square feet) from the total 3141592 square meters (33815814 square feet). The rest of the area will be divided for:

Residential parks and environmental design (approx. 600000 square meters- 6458346 square feet)



Administrative buildings: hospital, schools, university, commercial buildings, business centers



Tourism area – land will be auctioned for the big travel companies from earth, so that we would be able to cover some of our expenses.

4.3 Work Environments

Although the settlement is essentially designed to mimic Earth as much as possible, there are some inherent differences (e.g. the conspicuousness of the Coriolis force, nonpressurized units, zero-gravity areas) which give rise to specific needs such as new occupational domains (e.g. atmosphere/shield maintenance). These space-specific needs and demands also determine a different distribution of occupational domains – e.g. greater emphasis is placed on domains such as research, mining, etc. For example, on Earth there are 23 major occupational groups ; some of them may prove superfluous on Bellevistat, while other occupations will arise. Because of space-specific conditions, some tools/machines can be designed to enhance productivity in some of the occupational domains; another means of increasing productivity is automation. In the table below we present some of the occupational domains that could benefit in productivity from automation or from new devices:

Management occupations	Materials
Scientists	Science Labs
Recreation workers	recreation facilities (zero-g and normal gravity)
Legal Occupations	advanced lie detection devices
Education workers	E-learning
Healthcare system workers	Calcium-in-bones level monitoring device (for those with potentially prolonged exposure to zero-g condtions)
	radiation level monitoring device (for those with potentially prolonged exposure to radiations)
Protective services	sprinklers
	firefighters
	Law enforcement
Food preparation and serving	Robots
Maintenance workers	sensors to detect anomalies in air pressure / temperature
	fire detectors
Firefighters	Advanced fireproof suites and small intervention trucks
	shield anomalies detecting device
	water / air quality monitor
Sales and related occupations	transport-robots
Transportation	Transportation
Construction	Robots
Mining	robots
	mining equipment
Low g manufacturing / research	handholds
	tethers
	conveyer belts
Exterior maintenance	spacesuits
Agriculture	artificial light
	Hydroponics nutrients
Storage	robots
	conveyer belts
	Sensitive detectors and

5.0 Automation Design and Services

5.1 Automation of Construction Processes

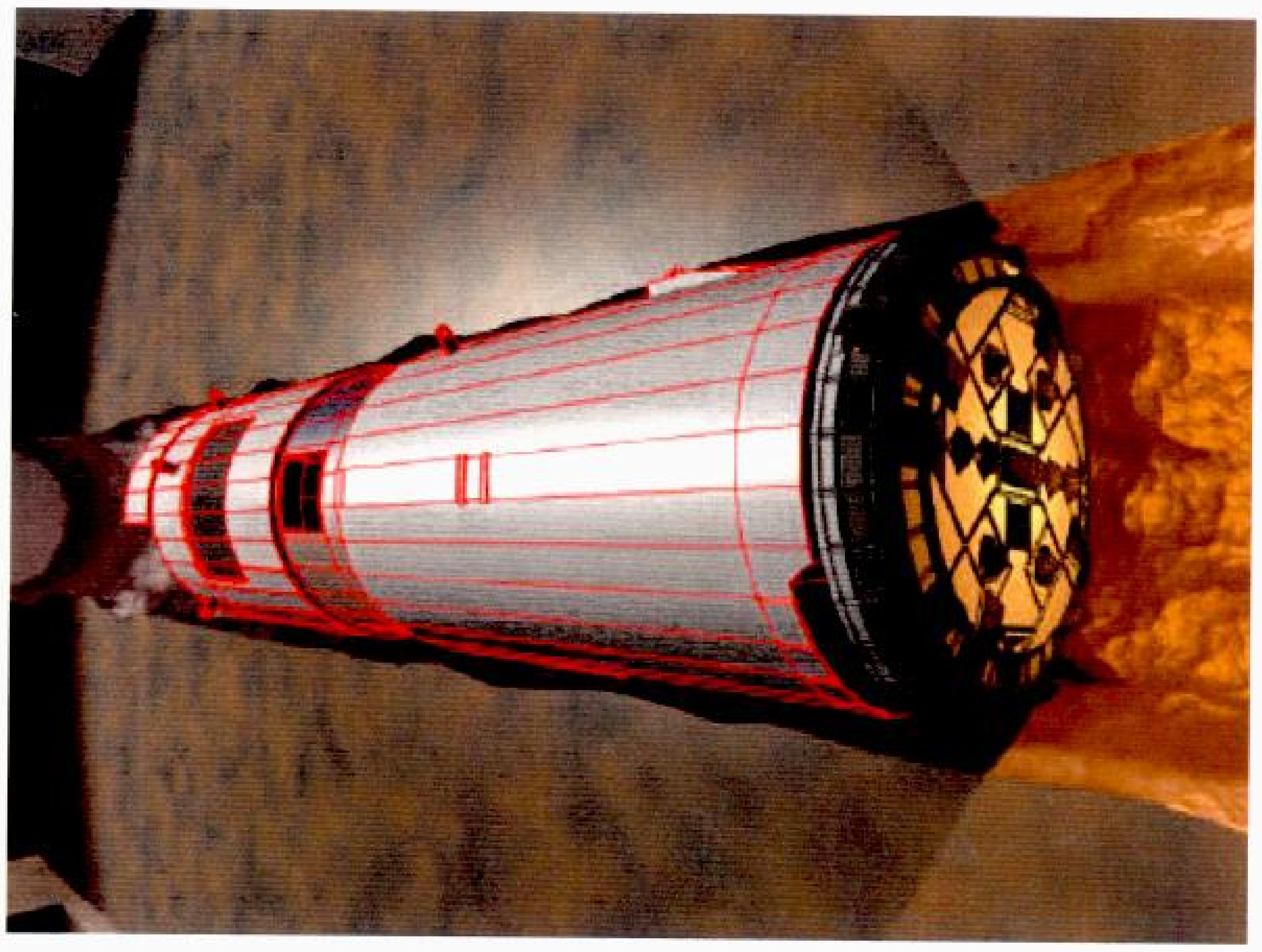
Multifunctional robot (human costume design)

Two important types of machines used in the settlement construction are "tunnelers" and "spiders". Drilling and blasting method are not adequate because of the high rick the resulting debris might pose. The name "tunneler" refers to all boring, excavating and mining robots and machinery, most notably the tunnel boring machines that will be used to burrow into the asteroid's interior. The tunnel boring machine consists of one or two shields (large metal cylinders) and trailing support mechanisms. At the front end of the shield a rotating cutting wheel is located. Behind the cutting wheel there is a chamber where the excavated material is collected and sent to the conveyor belt. Behind the chamber there is a set of hydraulic jacks supported by the finished part of the tunnel which push the TBM forward. The action here is very much like an earthworm. The rear section of the TBM is braced against the tunnel walls and used to push the TBM head forward. At maximum extension the TBM head is then braced against the tunnel walls and the TBM rear is dragged forward. The tunnel will be mostly left unlined.

The conveyor belt consist of a long belt on metallic rotating cylinders. The belt has metallic crates attached to it that carry rocks and brut material from the asteroid to the torus, and equipment from the torus to the asteroid. The conveyer belts are located in towers that house and support the rotating cylinders as well as the items the belt is carrying.

"Spiders" are the name given to the robots working on the construction of the torus; they produce the prefabricates that go into the settlement structure and shell/shield, weld metallic parts together and do the finishing on the interior landscape of the settlement. The main components of these robots are: robotic arms that hold on to a support surface (hence the name spiders), a body that houses different equipment or industrial machinery (for example: a centrifuge for powder metallurgy based products) and snake arms that place, join, deform or break structural elements of the settlement.

Snake arms have multiple applications on Earth which can be plausibly extended to outer space operations. For example, they are used in the aerospace industry to manufacture and assembly (inside wing boxes, jet engines and ducts), for surface preparation (wielding pneumatic sanders for all stages of surface finishing prior to final paint application) and maintenance, repair and overhaul. Snake-arm robots allow structures to be assembled in a different way and find great use in the manufacturing processes of the automotive industry, as they will find use in the operations of placing shield components into their designated spots. They are precise, strong and dependable robotic units.



5.2 Facility Automation

The automation system regarding settlement interior maintenance, repair and safety/security functions will be specified in subchapter 5.3.

Concerning the physical location of all necessary primary and backup hardware for the network system and other utilities of the space settlement, it will be explained in the following paragraph.

Because basically all utilities and functions available in settlement are linked mainly by wireless connections it will be easy to group the hardware into primary and secondary system generic unit. Each building and service system will be fitted with such a unit, thus making maintenance of the settlements network a much simpler task. Although the structure of such a unit will be common for all, individual upgrades will be installed so as to meet different necessities for which they are created. Because of these differences in operability and tasks of each unit the data stored in each server will run according to different protocols. That is why, in case of unit failure, to keep permanent system functionality, the utilities connected to that specific unit will reconnect to one of the main settlement servers, called core servers. There are twelve core servers, two for each settlement compartment, each one including all system protocols of the station so that all utilities could be handled from one server in case of failure, this being the main contingency plan for such scenarios.

The robots from within the settlement will permanently be on duty and, if disabled or on stand-by, near generic system units described before there will be repair and recharge stations for all types of robots. Such stations will be fitted on the exterior of the station, the main and only purpose of exterior settlement robots being the station's maintenance (it includes repairing, changing damaged parts, periodical check-ups etc).

The main security system that allows preferential access to human personnel will be by identification through electronic bracelets (described in subchapter 5.3) and/or through finger-print and voice recognition systems. Such systems will be installed at all access points for residential and work areas. Access authorization at different areas will be granted in accordance with specified and allowed purposes.

Besides building automation systems (BAS), which include home and office automation systems (defined and explained in subchapter 5.3), the settlement will also require a public automation system (PAS). Its main purpose will be to monitor and control automatic utilities and robots concerned with maintenance and public services (informative interactive units, auto-service restaurants etc). According to schedule, events and specific areas PAS will manage necessary tasks.

5.3 habitability and Community Automation

This subchapter contains information regarding the automation systems provided for private (home) and public (work environments, community areas) networks.

Starting with the private residences, the station will guarantee minimal automation network tasks as provided in the following presentation. Further installations regarding network customizations will be provided according to the resident's necessities.

Each building and other facilities will have a BAS (building automation system) which will assure the monitorization and control of mechanical, lighting and other computer based systems. The BAS core functionality will be to keep climate control within a specified range, in accordance with the system administrator, will provide lighting based open occupancy schedules and human detector sensors, and computer networks reliability, functionality and accessibility. Depending upon the system performance and device failures, the administrator of the BAS or the residents of the building will be notified by text, e-mail or through the station's private messaging network.

The infrastructure of the BAS will rely on controllers, purpose-built computers with input and output capabilities, in this case, the PLC (programmable logic controller) types. Compared to other types of controllers the PLC provides the most responsiveness and processing power. The occupancy mode integrated in the BAS monitor will be set according to the time of day schedule provided by the administrator and the feedback provided by sensors installed in the building. The occupancy mode represents a parent system for tasks such lighting, air handlers, heating, water and alarm and security systems.

The lighting can be controlled manually, but will mainly be controlled manually based on time of day, or the occupancy sensors and timers. Air handlers will control the air flow, pressure and also the heating (manually set temperature ranges) through Variable air volume handler units (VAV) installed in every room by necessity. A VAV unit will supply pressurized air using fans or blowers with a variable frequency drive (controls the rotational speed of the alternating current electric motor by controlling the frequency of the electrical power supplied to the motor) and temperature control by using water valves at different temperatures according to need. The automatic water supply system assures permanent access to hot and cooled water with an assigned temperature range according to room necessities (bathroom, kitchen).

The security system will be programmed so that, according to certain system or sensor feedbacks, it will notify the qualified personnel to handle the problem or take the necessary measures to resolve the problem automatically. For example if the smoke detectors will be activated, or the air composition sensors detect high carbon dioxide levels, or the amperage sensors detect low amperage conditions caused by slipping fan belts, or clogging strainers at pumps, the security system will provide feedback with information and requirements to the BAS that will take the appropriate action.

In some cases certain systems will have priority protocols that allow overriding other building automations. For example fire and smoke alarm systems, if activated, will c lose the outside air dampers to prevent air coming into the building, while an exhaust system will isolate the alarmed area and activate an exhaust fan to move smoke out of the area. The BAS will be installed with a backup system in case of primary system failure, as well as all other subsystems.

A specialized automation system called Domotics will be installed in residential buildings with the basic purpose of meeting al home automation requirements for the comfort and security of human occupants. In addition to the BAS tasks Domotics functions include personalized climate control, control of doors and window shutters, security and surveillance systems, control of multi-media home entertainment systems, automatic plant watering and pet feeding, automatic scenes for dinners and parties, personal computer functionality and a more user-friendly control interface.

For interaction purposes between Domotics systems and human residents, each person will be required to wear an electronic bracelet that has a unique signature specially assigned to the wearer. This is done by sensor reading of the unique signature and thus enabling personalized settings for the user. This includes lighting effects, climate control, multi-media players etc.

Communication between the sensors and stand-alone units of all networks is wireless through different technologies like WiMAX, Wi-Fi etc.

Tasks executed by Domotics include audio switching by selecting an audio source based on the users location and audio distribution by enabling multi-zone audio (meaning that the audio source is heard in one or more rooms). The Video category includes the Audio category's capabilities and is also an integrated part of the intercom and telephone system (this feature requires multiple LCD screens). The intercom system allows communication via audio-video units between multiple rooms and with the video door entry system. It also interlinked with the station's network system, allowing access trough a secure channel between different users.

The Robotics category is in charge of the domestic (home) robots control system. Based on resident occupancy and schedules, Robotics will enable robots to perform different chores such as: vacuuming, dish washing, bathroom cleaning, repairing etc. It can also perform tasks concerning human attendance (playing with children, serving food and beverages etc).

For additional comfort an automation system will be developed and installed in work areas that includes today's office automation systems. Basically the OAS (office automation system) will execute three basic activities: data storage of information, data exchange and data management.

Because every work area and, generally, all areas of the station that require supervision and data analysis, it is necessary that they all have capable data storage, exchange and management system with no exceptions.

Data storage will usually include records of all activities performed in that area or different documents. Data applications, included in this system, involve the capture and editing of files, images, or spreadsheets. Word processing and desktop presentation packages accommodate raw textual and graphical data, while spreadsheet applications provide users with the capacity to engage in the easy manipulation and output of numbers. Image applications allow the capture and editing of visual images for better work supervision and for security systems Presentation software packages in the media application category simplify the creation of multimedia presentations that use computer video, images, sound, and text in an integrated information package.

The data exchange OAS component that allows electronic transfer of stored data between different system users as well as access to different work area group utilities such as scanners, printers, maintenance robots etc.

Regarding the data management component, its main function is to track short-term and long-term data in the realms of financial plans, workforce allocation plans, marketing expenditures, inventory purchases, data transfer analysis, security system recordings maintenance etc. The management systems monitor and control office activities and tasks through timelines, resource equations, and electronic scheduling.

By ensuring the functionality of these automation systems the livability in the community, productivity in work environments and convenience in residents are enhanced.

In case of both primary and secondary system failure, because of stand-alone capabilities for all automation network units, the link with the main server will be disabled and then enabled linking them to one of the main servers (core server) that contain all system protocols for the settlement's network servers and utilities. In case of physical damage the system will run on safe mode (minimal requirements or less) until the damaged units will be repaired or replaced by the administrators.

6.0 Schedule and Cost

6.1 Design and Construction Schedule

Bellevistat project will begin immediately after the proposal has been accepted by the Space Foundation. Estimated to last over 5 years, Bellevistat construction is a fast project, considered to be one of the largest engineering projects that man has ever seen. It will not be just metal and rock, it will redefine the way we think, communicate, travel and will open new doors toward space exploration. Bellevistat will be built in approximately 5 years and is due to completion on 5th June 2033.

6.2 Costs

The following table presents the expenses that are necessary to complete this amazing project

Equipment type	Name	Cost/unit($*10^6$ Dollars)	Number of units	Cost ($*10^6$Dollars)	Total Cost
Infrastructure	Earth Launch pad	40000	1	40000	
	Moon Launch pad	80000	1	80000	
	Moon refining facilities	40000	1	40000	
Equipment	Assembly robots	400	15	6000	
	Boring Machines	4000	6	20000	
	Various Robots	70	150	9500	
In-orbit facilities	Satellites	900	5	4500	
Space missions	Space missions	40	700	28000	Aprox. 298000
Control System and computing technology	-	20000	-	20000	
Other materials from Earth and Moon	Titanium, Al, Ni, Pt, Ag, Si	-	-	50000	

The calculations that were made above are indicating a sum of 298000000000.This sum might not look very plausible, but we need to keep in mind that the entire company is directing the harvesting.

As a conclusion we believe that Bellevistat will be one of the most important space settlements and revolutionize the entire Space Industry.

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