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BELLEVISTAT

SPACE SETTLEMENT PROPOSAL

COMBINED AUSTRALIAN TEAM
BRISBANE AUSTRALIA
ST. AIDAN'S ANGLICAN GIRLS SCHOOL
ALL HALLOWS' SCHOOL

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1.0

EXECUTIVE SUMMARY

"For I dipped into the Future, far as human eye could see; saw the vision of the world, and all the wonder that would be."

– Lord Alfred Tennyson

1.0 Executive Summary

We at Magellan, the Australian based subsidiary of Grumbo Aerospace, are proud to present to the Foundation Society our design for the space settlement *Bellevistat*. *Bellevistat* will primarily focus on industrial procedures, facilitating all extra-terrestrial manufacturing of goods in unique zero-gravity. This design will incorporate new technologies and provide a core for space trade and further exploration.

Bellevistat will utilise both zero-gravity and simulated gravity, providing ample space for its 18 000 permanent residents and 1 000 transient guests. Magneto-Dynamic Suspension (MDS) will be utilised in order to create individual gravity intensities required for specific sectors throughout the settlement. Multiple docking facilities will be situated upon the exterior of the settlement to accommodate for the mass influx of residents and supplies. Advanced materials will be utilised in the construction of the settlement, involving Non-Explosive Reactive Armour (NERA) for protection against collisions.

The settlement will be constructed at the Earth-Moon L_1 before being transported to L_4 for orbital stability. Magellan has incorporated advanced technology into its design for agricultural production, with crops being cultivated using zeoponics and the majority of meat produced using in-vitro techniques. These techniques have been used to optimise space usage and are achieved by integrating agricultural production into residential and commercial sectors. Transportation between the rotating rings and stationary industrial sector will be achieved through Magellan's innovative Inter Ring Transportation System (IRTS).

As a major residential settlement, *Bellevistat* has generated an unprecedented demand for variation in human living environments and consideration of psychological factors in orbital living. Immense significance will be placed on education and advanced medical facilities, with *Bellevistat* encompassing over 260 medical specialists as well as a progressive student-orientated syllabus. The design of the settlement incorporates the underlying concept of open space, with parks and recreation areas allowing for the enjoyment of traditional sports as well as various zero-gravity games. Natural sunlight and views of space will also be accessible, enabling citizens to experience the vastness of space, while at the same time, allowing for earth-like living.

The settlement will feature automations to enhance liveability and productivity for residents, providing an Earth-like environment. All robots are based on Magellan's modular F1M8 robots allowing significant reductions in repair and maintenance costs as well as manual labour. Contingency systems and devices have been implemented to ensure complete security of *Bellevistat* and all its residents. The settlement will house computer networking and hardware which will be incorporated into all facets of living.

Business ventures will include tourism, the mining and refining of raw space materials with importance placed on the primary industry of manufacturing exportable goods. Construction of *Bellevistat* is expected to take 17.16 years and cost the Foundation Society USD $566 billion. Revenue generated from its commercial ventures will exceed costs after 10 full years of operation.

Magellan anticipates that the experience gained from the *Alexandriat* project can be brought to this venture, enabling close relations with the Foundation Society. We have designed *Bellevistat* with the most technologically advanced protocols and facilities of our age so as to provide the most comprehensive service possible to the Foundation Society.

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2.0 STRUCTURAL DESIGN

"Design is not just what it looks like and feels like. Design is how it works."

– Steve Jobs

2.0 Structural Design

Destined to become the industrial heart of the space industry, *Bellevistat* has been designed with technologically advanced features to ensure mankind's inevitable ascent into space. It will provide superior manufacturing facilities capable of producing the quality work that is required for this expansion. The safety of all residents will be of paramount importance, with both structural redundancy measures and operational protocols implemented to avoid any foreseeable catastrophes. *Bellevistat's* 18 000 residents and 1000 transients will be able to live comfortably within the luxurious confines of the settlement whilst enjoying the beautiful vistas of Earth from the limitless freedom of space.

2.1 External Configuration

2.1.1 Space Settlement Design

Magellan's unique design for the proposed settlement *Bellevistat* focuses on innovation and the elimination of reliance upon centralised structures, thereby increasing redundancy and reducing the impact of potential hazards and failures. In concordance with this, the settlement will comprise of a system of two adjacent dynamic 'rings' encompassed by a stationary outer 'ring'.

The two innermost rings *Solinvictus* and *Balaat*, situated directly in line with one another on the Y axis, will house the residential, commercial and agricultural sectors of the settlement (Refer to *Section 2.2.1*). So as to accommodate differentiation between communities and minimise affects of conformism on the human psyche, *Solinvictus* will be physically separated into three distinct communities, whilst *Balaat* will remain integrated as a single community, simulating the 'city' and its 'suburbs'. This provides a redundancy in the case that if one region is rendered uninhabitable, its residents can occupy another of the four sectors until repairs are complete. The interior location of *Solinvictus* and *Balaat* will provide natural light for their inhabitants unobstructed by other structures. Inside of these rings and shielded by other sectors will be numerous utilities, which will be separated so as to achieve de-centralisation and redundancy.

Surrounding these rings will be the industrial sector, dubbed *Hephaestus* after the Greek 'Smith of Heaven'. It shall remain stationary and thereby situated within the realm of zero-G so as to streamline construction processes within. Providing the copious amounts of space required to make *Bellevistat* a true manufacturing giant, *Hephaestus* will be the corner-stone of the station. In an effort to correct the 'bottleneck' oversight experienced within *Alexandriat*, twin continuous port facilities will be located directly adjacent to *Hephaestus*. This will also minimise transportation requirements for the settlement. As *Bellevistat* will at certain points be called upon to aid in the creation of fleets of ships, numerous 'dry-docks' will be contained within these abundant port facilities. Their proximity to *Hephaestus* will aid in streamlining of the construction process. In the case that the settlement is required to be moved, numerous tugs will be kept within the aforementioned dry docks. Scientific laboratories, unobstructed by gravity in their research will also be present within *Hephaestus*. Small segments of this ring will house the zero-G recreational facilities that the settlement will provide for both tourists and residents (Refer to *Section 2.2.2*).

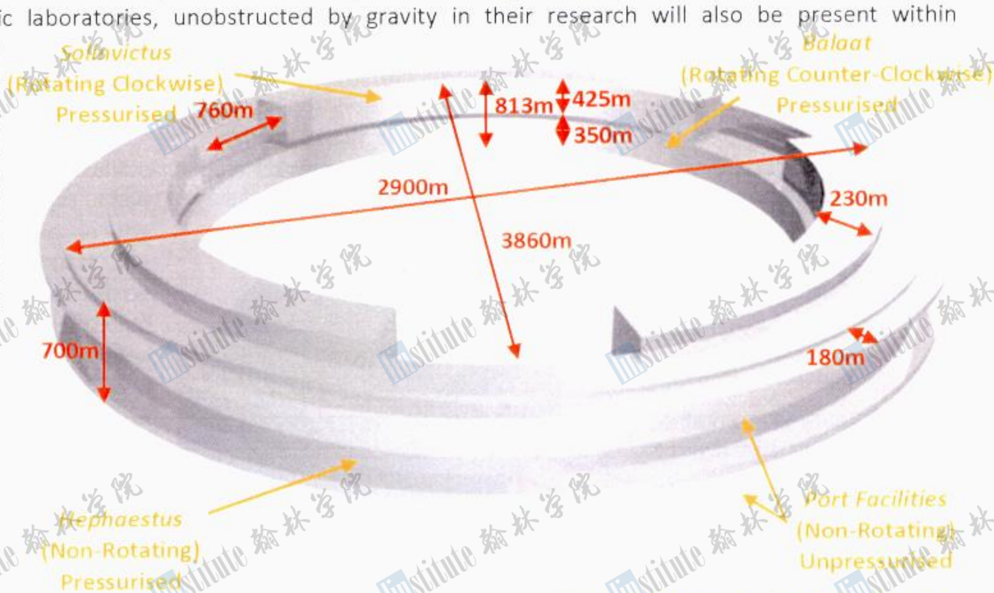

Figure 2.1: External View of Bellevistat

2.1.2 Construction Materials

Bellevistat will rely upon advanced technologies and superior materials so as to survive the harsh environment of the vacuum of space. Integral to this protection is the composition of the settlement's hull. Composed of a multi-layered 'sandwich' of materials, *Bellevistat's* hull will provide ample protection from radiation and micro-meteorite collisions.

Material	Composition	Mass ('000 t)	Utilisation
Aluminium	Al	281	Chevron Mirrors
Dual-Phase Steel	Fe (96.34%), Mn (2.00%), Cr+Mo (1.00%), Si (0.30%), C (0.17%), Al (0.08%), P (0.05%), Nb+Ti (0.05%), S (0.01%)	156,232	Inner hull – Structural integrity Interior building material Structural support for Chevron Mirrors
HD Methylene diphenyl diisocyanate	$C_{15}H_{10}N_2O_2$	3,642	Component of breach sealant
HD Polyethylene	$(C_2H_4)_n$	31,218	Radiation Protection Component of breach sealant
HD Polyurethane	$(\text{-R-OOCNH-R'-})_n$	14,567	Component of breach sealant
HNS Polymer	U^{235}	2989	Radiation Protection within Chevron Mirrors
Lucite	$(C_5O_2H_8)_n$	24,269	Chevron Mirrors Radiation protection
Polyaniline	$([C_6N_2H_2]_n[C_6N_2]_m)_x$	21,942	Electrochromatic glass
RTV-3145	Solution of $C_4H_{12}SiO_3$ & $SiO(CH_3)_2$ & $(C_2H_6OSi)_n$	109	Adhesive
Shear-thickening fluid	Suspension of $HO(CH_2CH_2O)_nH$ & SiO_2	24,029	Outer hull – Lining substance Component of NERA
Vitreloy	Zr (52.2%), Cu (17.9%), Ni (14.6%), Al (10%), Ti (5%)	399,830	Outer hull – Debris protection Component of NERA
Water	H_2O	27,185	Radiation protection Water storage

Table 2.1: Construction Materials

The outer layer of the hull will be constructed of a variant of Non-Explosive Reactive Armour (NERA) and will be the first line of defence against impacts. NERA consists of two metal plates 'sandwiching' a lining substance. When an incoming body collides with the outer plate, the lining substance absorbs the force of the collision and transfers the kinetic energy throughout the entire hull, dispersing the force of the impact. The twin plates will be constructed of the amorphous metal Vitreloy. Due to its lack of crystalline structure, it is able to completely reform after collisions with minimal repair. It also exhibits superior elasticity, corrosion resistance, thermal resistance and durability. Sheets (10m x 10m) will be joined together by RTV-3145 adhesive, an advancement on what was utilised for joining the heat shields to the original Space Shuttle Orbiter. The plates can easily be replaced in the event of a damaging impact. The lining substance employed will be shear-thickening fluid, a liquid that becomes rigid when assaulted, before returning to a flexible state after the trauma has ceased. These properties will enable its successful use as the lining of *Bellevistat's* NERA.

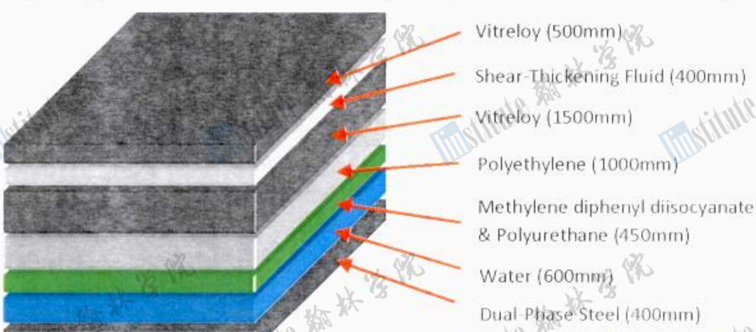

Figure 2.2: Hull Composition

Layers of polyethylene will be utilised to protect against radiation from the Sun and solar flares. In addition to this, polyethylene is able to chemically bond with an inner layer of methylene diphenyl diisocyanate and polyurethane so as to produce an expanding foam-like substance, which will be utilised in the rare event that a foreign body penetrates the outer shell of the hull. Water will be stored and circulated in the interior of the hull as further prevention against radiation, as well as preventing stagnation of the water.

Dual-Phase Steel will be utilised for the inner shell and as a base material for construction within *Bellevistat* itself. This is because of its high tensile strength in comparison to more traditional High-Strength-Low-Alloy (HSLA) steels. Dual-phase steel contains both a ferrite and martensic microstructure, which provides this extra strength.

2.1.3 Natural Lighting and Views

Chevron mirrors will be utilised so as to allow natural views and lighting of space whilst preventing ionising radiation from entering the settlement. The mirrors' shape and their configuration allow light to be reflected into the settlement, whereas radiation collides with the Chevrons and is halted by its component materials. This design takes into account radiation coming from any angle.

Two 500mm thick layers of polyethylene will be the major radiation-proofing material, with a single 30mm thick layer of HNS polymer (created from nuclear waste, specifically uranium hexafluoride) providing an additional fifteen halving-thicknesses worth of radiation shielding. Dual-phase steel will be utilised for structural support within the Chevrons. The outer layer of the mirrors will be composed of a 3mm thick layer of polished aluminium to produce the reflective properties required.

To filter the light through the openings, three redundant dual-layers of Lucite and electrochromatic glass will be utilised. Lucite has been identified with having high radiation protection properties, whereas the electrochromatic glass (the major component of which is polyaniline) is able to regulate the intensity of light and heat that is allowed through the window. A burst of electricity can alter the opacity of the layer, with the material able to retain the shade when the electrical supply is cut off.

So as to prevent against devastation in the event of a breach, branches of polyethylene, polyurethane and methyl diphenyl diisocyanate will be located within the central transparent panel (Refer to *Section 2.1.2*).

The chevron mirrors will be installed in 1/6 of the ceiling and 1/4 of the walls in the residential rings. A crosshatching pattern will be implicated to increase structural stability.

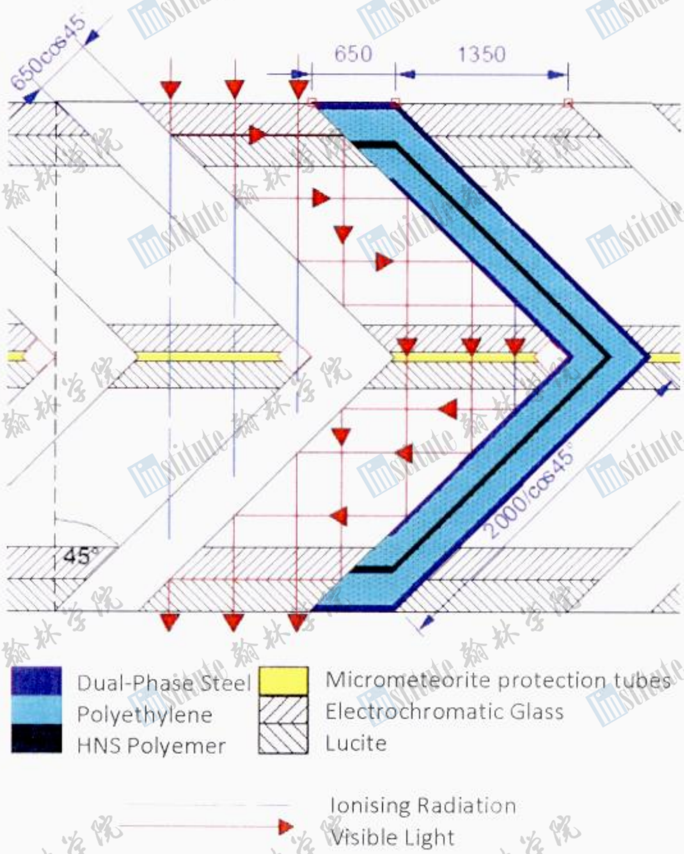

Figure 2.3: Chevron Mirrors (Dimensions in Millimetres)

2.1.4 Artificial Gravity

Gravity is often regarded as both a blessing and a curse. Humans need it to live without physical degradation; yet industry often functions better without it. Taking this into account, Magellan's design of the settlement *Bellevistat* will include segments that generate artificial gravity as well as segments that are not restricted by it.

2.1.4.1 Rotating & Non-Rotating Volumes

Due to the benefits that zero-G has upon industry, the entirety of *Hephaestus* will remain stationary. Docking facilities and recreational areas attached to *Hephaestus* will also experience zero-G forces. The stationary aspect of the ports will be readily accessible for incoming ships.

As gravitational force is required for day-to-day activities of humanity, both *Solinvictus* and *Balaat* will simulate gravity through rotation and the forces that it applies. The large radius of this segment will enable fluctuations of gravitational strength to be minimal when one transverses the multiple levels of this sector. To produce a force of 1G at the ground level of the living area, which holds a radius of 1600m, these sectors will need to rotate on their axes at a rate of 0.748 RPM. To achieve this, the living floor will require a tangential velocity of 125 ms^{-1}. Spinning at this rate will also virtually eliminate the Coriolis Effect. At this velocity, the outer floors housing agriculture and storage will experience a gravitational force less than 1.05G.

To sustain and initiate rotation within one or more rings whilst maintaining a state of non-rotation within another, contra-rotating rings must be utilised. Using this method, the outer ring remains stationary, whilst the two inner rings of equal mass rotate at the same centripetal velocity in opposite directions. This produces a net rotational force of zero on the outer ring, which enables it to remain motionless. Due to inconsistencies within the structure of *Solinvictus* and *Balaat*, their heights must be calculated so as to maintain equal mass. To produce equal mass whilst still maintaining enough living space, *Solinvictus* will have a height of 425m whilst *Balaat* must have a height of 350m.

2.1.4.2 Rotational Suspension

Once the two contra-rotating rings have been initiated, forces acting upon them will be negligible, excepting friction. If friction between the rotating rings and *Hephaestus* is eliminated, then the rings will continue spinning indefinitely and will only require very minor adjustments. To eliminate the friction caused by physically joining the rings together, they will be held in place through Magneto-Dynamic Suspension (MDS). MDS utilises a failsafe series of permanent magnets and magnetic insulation within specified arrays so as to create saturated magnetic fields that force an object to stay within the minimum energy point on a rail.

Two tracks of rails will be utilised for each of the rotating volumes so as to provide additional stability and will be located on the non-rotating segment of the settlement. Rather than having the entire circumference joined through MDS, only 12 specific areas of each track on the rotating segment will be affixed by the magnetic fields and will operate similar to tugs, hauling the rest of the station. Once in place, this system requires no power to run and its utilisation of multiple tracks and joins creates redundancy and failsafe measures.

2.1.4.3 Rotation Initiation

As the MDS does not provide propulsion, only suspension, the rotation will need to be initiated with a different method. Magellan proposes to utilise the Inter-Ring Transportation System (IRTS) to fulfil this requirement (Refer to *Section 3.2.4.2*). The dual connection that the IRTS uses can be utilised to create rotation of segments of the settlement. Acting like tugs, they will magnetically connect with the rotating segment and gradually (over the course of weeks) accelerate in relation to the non-rotating segment until *Solinvictus* and *Balaat* are spinning. All of the trains will work concurrently on this endeavour. Minute course corrections will occur during the 'late-night' period of work, when few of the IRTS Maglev trains are in standard operation.

2.2 Internal Arrangement

Within *Bellevistat*, Magellan has partitioned areas to be dedicated to specific zones. This will aid in the efficient running of the settlement. The two rotating rings, *Solinvictus* and *Balaat* will house agricultural and storage regions, as well as a conglomerate 'living' floor. Commercial, residential and recreational sectors will be integrated together for the convenience of the residents as well as effective utilisation of interior space and minimisation of internal transport required. Transport corridors and certain utilities will also be located within each of these two rings.

The outer ring, *Hephaestus*, will house all sectors of the settlement that are required to be within zero-G. This includes heavy industry, research, the port facilities and specific recreational areas. Particular utilities as well as transportation corridors will also be positioned for the easy transfer of goods between industrial and port facilities and vice-versa.

	'Down' Area (m^2)	Volume (m^3)	Gravitational Force
Residential	3,670,000	608,000,000	1G
Commercial	1,220,000	203,000,000	1G
Recreational	1,830,000	304,000,000	1G
Recreational	N/A	23,500,000	0G
Agricultural	42,110,000	420,000,000	1.02G to 1.05G
Storage	6,870,000	137,000,000	1.01G
Storage	N/A	22,300,000	0G
Industrial	N/A	1,071,000,000	0G
Research	N/A	98,700,000	0G
Transportation	N/A	264,000,000	Varies
Utilities	N/A	31,800,000	Varies
TOTAL	55,700,000	3,183,300 000	N/A

Table 2.2: Utilisation of Down Surfaces & Volume

2.2.1 *Solinvictus* & *Balaat* Living Rings

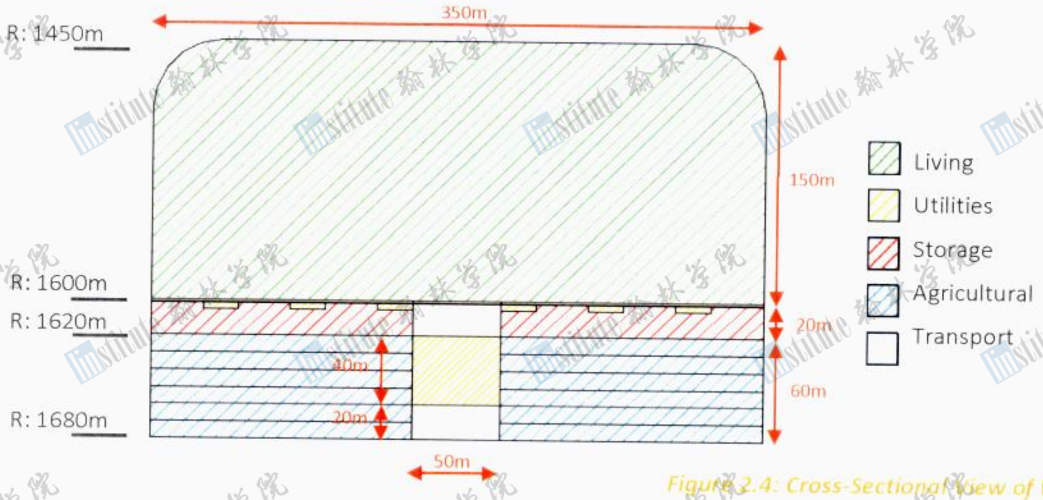

Figure 2.4: Cross-Sectional View of Balaat

In basic design, both *Solinvictus* and *Balaat* will be identical. Both will feature a 'living' floor on top, so as to enable maximum levels of natural light to permeate to where residents will spend the majority of their time. Ceiling heights of 150 metres will limit the claustrophobic effects on the human psyche. Storage will be located directly beneath which will enable easy access. The section devoted to agriculture will be subdivided into six floors, which will allow differentiation between different types of agricultural growth, including different temperatures and processes.

Within the floor of the living sector, one metre of space will be designated to the linkage of utilities (i.e. water, power, waste grids) to various parts of the settlement. Six 4m *x* 20m tunnels will also be utilised for larger utilities and maintenance and robot access. The utilities themselves (e.g. water/waste recycling plant) will be located within the centre of the ring for protection from hazards. Mass-transit pathways will be located beneath the surface of the living floor. Excepting only the mass-transit tracks, the entirety of *Solinvictus* and *Balaat* will be pressurised.

2.2.3 Hephaestus Industrial Segment

The majority of *Hephaestus* will be devoted to industry. Three separate floors, each with a 'ceiling' height of 50 metres will provide copious amounts of space to pursue *Bellevistat's* industrial needs. The zero-G environment will aid in manufacturing because of the lack of weight of the materials, making them easier to transport as well as through the utilisation of unique methods that are impossible whilst under the influence of Earth-like gravity. Also situated within this segment will be zero-G recreational facilities, which will include viewing areas and sporting fields so as to enable tourists and residents to enjoy the influence of zero-G. Areas of *Hephaestus* will be partitioned off for use as scientific research. Storage will be located directly adjacent to the industrial regions.

Located on the outer layer of *Hephaestus* will be numerous port facilities, which transportation routes will link to the majority of this ring. Both of these regions will remain without pressure so as to eliminate air friction. However, transportation stations that connect *Hephaestus* to the outer rings will remain pressurised due to their frequent usage by residents and tourists, as will the rest of *Hephaestus*.

Volatiles and utilities including power storage and generation will be situated within the centre of this segment, so as to provide maximum protection from outside influences.

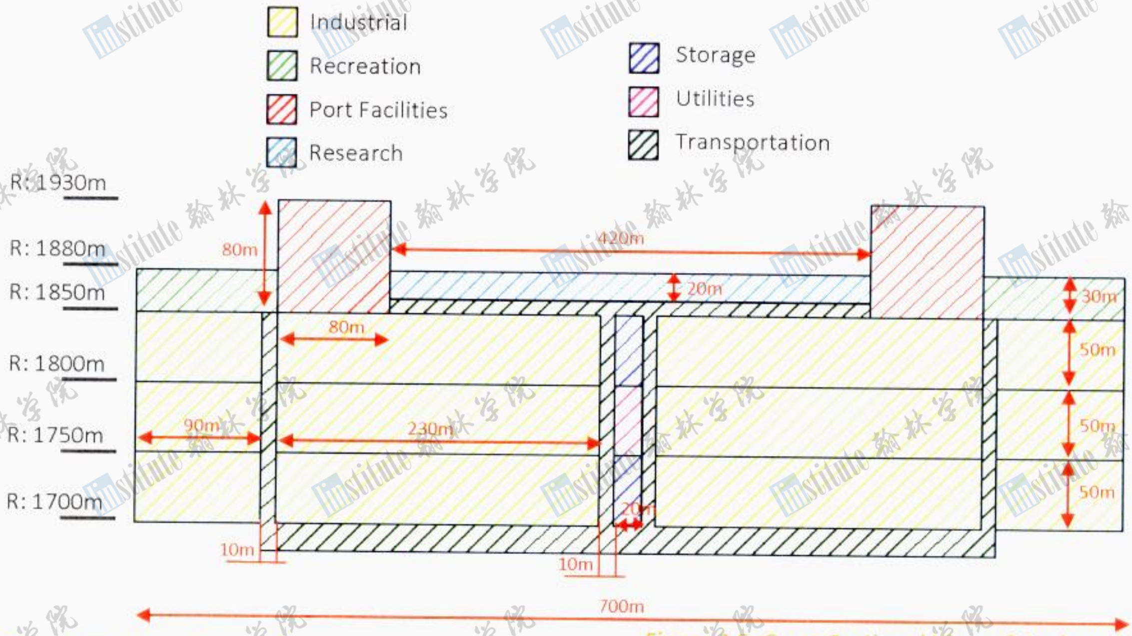

Figure 2.5: Cross-Sectional View of Hephaestus

2.3 Construction Sequence

Bellevistat will utilise phased construction so as to minimise outlay costs due to the reuse of equipment over specific stages. Radial construction will be employed for both *Hephaestus* and *Solinvictus*, in that differing sections will be completed in sequence around the circumference of the settlement. Conversely, due to the nature of its structure, each of *Balaat's* three sectors (*Tara*, *Sallavecu* and *Laotzu* – Refer to *Section 4.4*) will be built in three distinct stages, which will enable specialised equipment used during stage one to be applied to all three sectors.

Stage	Description	Time (Months)
1	Exterior frame of *Balaat*, *Hephaestus* and *Solinvictus* constructed independently; MDS constructed	30
2	*Balaat*, *Hephaestus* and *Solinvictus* positioned and stationarily attached using MDS	2
3	Radial construction of *Balaat* and *Hephaestus* begins; Complete framework of *Tara* constructed	24

4	Hull of *Tara*, complete framework of *Sallavecu* constructed	18
5	Interior finishings of *Tara*, hull of *Sallavecu*, complete framework of *Laotzu* constructed	20
6	Interior finishings of *Sallavecu*, hull of *Laotzu* constructed	20
7	Radial construction of *Balaat* and Hephaestus ends; Interior finishings of *Laotzu* constructed	18
8	Rotation initiated by IRTS Maglev trains	12
	Total Time	144 (12 years)

Table 2.3: Construction Process for Bellevistat

Figure 2.6: Artist's Impression of Construction Stages

2.4 Asteroid Harvesting

One of *Bellevistat*'s primary functions will be to serve as a mining facility, which will harvest various minerals from asteroids, for use on Earth and on other settlements. Potential mining ventures include the harvesting of carbon, iron, nickel, titanium, magnesium and silicon, all of which are readily available upon multitudes of asteroids. Minerals will be harvested from asteroids using a primarily automated mobile mining facility, *Lyell*, before they are transported back to the settlement for refinement and manufacturing.

2.4.1 *Lyell* Mining Facility

The *Lyell* mining facility will be fully equipped for the mining of asteroids. Almost completely automated, it will be overseen by a small team of three personnel with live contact with command on *Bellevistat*. The mobile facility will utilise ion thrusters for positioning as opposed to standard chemical rockets, utilising stored waste material from the mining process as fuel and deriving energy for the propulsion process from solar energy collected by retractable solar cells.

Immediately after contact with the target asteroid, the *Lyell* mining facility will drill into the asteroid to a depth of 20m before bracing itself with pressure-driven spikes. The facility will then effectively mine the asteroid 'inside-out', using a central core (50m diameter) as its primary drilling location. Multiple *Lyell* mining facilities will be utilised concurrently for fast and efficient mining operations.

The facility will feature a sorting mechanism so as to differentiate between different mineral types, before sending them back to the settlement for refining. It will include a port facility with adequate space for three large docked vessels.

2.4.2 Mining, Refining & Transportation

Primary mining of the asteroid will be undertaken through a central cylindrical bore hole through the asteroid. RDX explosives will be utilised so as to separate chunks of rock from the asteroid, which will then be collected by the *Lyell* mining facility. Asteroid Mining Robots (DIGGER – Refer to *Section 5.5*) will be used as secondary mining rigs, which will operate on the surface of the asteroid using the *Lyell* mining facility as a central base of operations.

Once mined, the rock will then be automatically sorted and grouped into specific minerals, before being pressed into cargo containers. These containers will then be conveyed back to *Bellevistat* by the Grumbo Jumbo Mk II class mining transport (Refer to *Section 3.3*). Once on *Bellevistat*, the materials will be transported to sections of *Hephaestus*, where they will be refined into both base and alloyed metals ready for sale and manufacture.

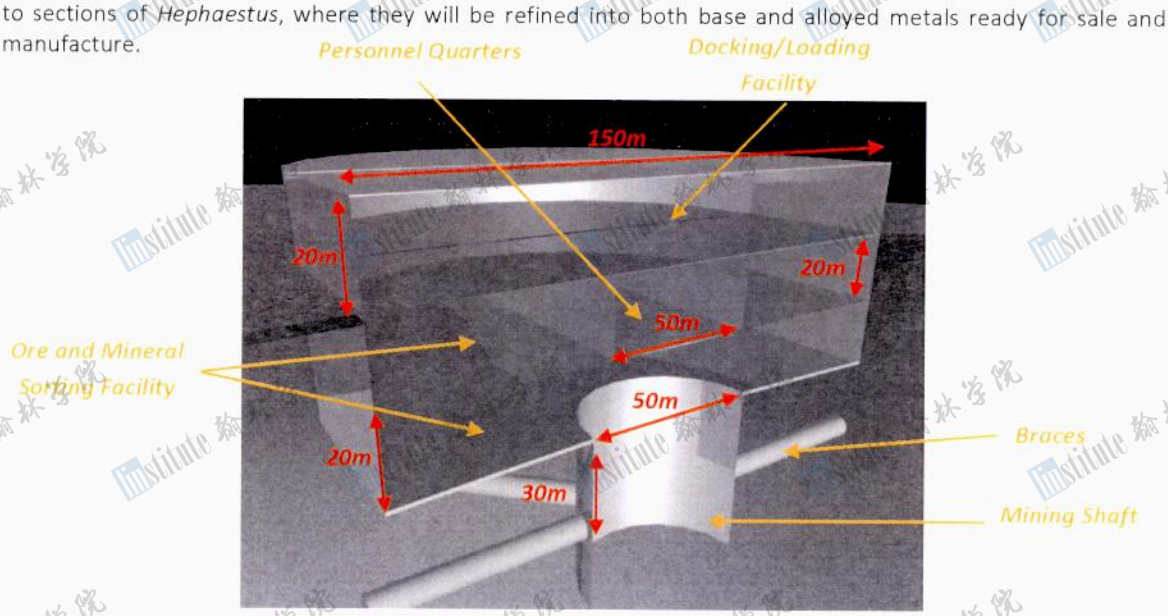

Figure 2.7: Artist's Impression of Cutaway View of Lyell Mining Facility

2.4.3 Dust Prevention

Dust poses a threat to the proper functioning of asteroid mining equipment and by extension the entire *Bellevistat* settlement. To protect equipment from its corrosive repercussions, a number of countermeasures will be employed within the *Lyell* Mining Facility.

So as to ensure that dust remains at a minimum, the mining facility will be purged of dust every two weeks. This purging process, estimated to take no more than one day, consists of running a series of electromagnetic pulses throughout the station. Due to the metallic nature of the dust, its affixation will be negated and will be released into the temporary atmosphere of the mining facility. This atmosphere will then pass through a filter, which will extract the dust and deposit it outside the facility before recycling the air. In between the fortnightly purges, the atmosphere will be extensively filtered so as to remove large amounts of dust before it has the chance to settle.

2.5 Port Facilities

So as to accommodate incoming and outgoing spacecraft, *Bellevistat* will feature a large number of port facilities. Including both 'dry-docks' for the construction and repair of vehicles and 'hangers' for their storage, port facilities will be located adjacent to Hephaestus for easy transportation of materials and manufactured goods between the settlement and transport vessels.

A number of length-orientated docks will operate completely independently from one another, and will be further subdivided into 1km lengths with a separation gap of 10 meters. Twelve facilities will be located around the entire circumference of the settlement to increase the number of exit routes for residents in the event of an accident. Thus, a total of 20 separate docking facilities, each containing 2 dry docks, 1 large-spacecraft hanger, 2 medium-spacecraft hangers, 4 small-spacecraft hangers and multiple cargo storage areas will be made available for use. Each of the hangers will contain dust-decontamination and loading/unloading facilities.

The docks have been placed in order to minimise damage if a spacecraft deviates from its plotted route. As craft enter lengthways into the non-rotating volume, deviation in three of the four possible entry vectors will result in only collisions within empty space. Divergence in the fourth direction will result in an impact with the heavily protected hull of the industrial sector of the station, the inoperation of which will not result in disruption of critical functions.

In order to dock, spacecraft must position themselves so that they are stationary relative to the settlement. If the ship is small enough or manoeuvrable enough, it can navigate its way directly into the hanger using its own retro-thrusters. Should the vessel be too large and awkward, *Erebus*-class space tugs (Refer to *Section 3.3.3*) can be utilised to guide them into the hanger, where magnetic clamps secure their position. Automated services within the hangers then clean the vessel of extraterrestrial material and residue before the vessel is unloaded. If required, the vessel can then be transferred into a dry-dock for maintenance.

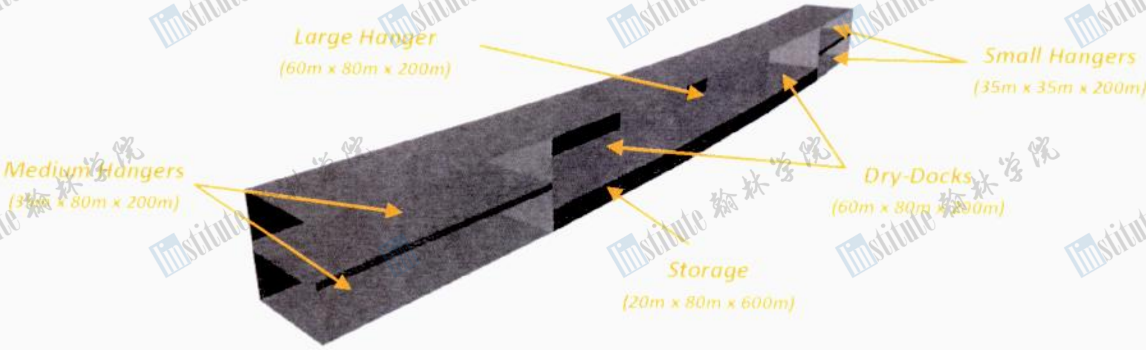

Figure 2.8: Cutaway view of docking facilities

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3.0 Operations & Infrastructure

"The engineer's first problem in any design situation is to discover what the problem actually is."

– Anon.

3.0 Operations & Infrastructure

The operations and infrastructure on board *Bellevistat* will ensure that the residents and transient population aboard the space station have access to all the luxuries and comforts of Earth, whilst still providing a fully functional business enterprise for the Foundation Society. The settlement will possess the necessary systems and infrastructure so as to make certain that the highest standards of living and safety are available for all of its occupants. Food production, hygiene, communication systems, transport, and power generation are of paramount importance in the running and maintaining of any settlement. To accommodate the large influx of incoming and outgoing space vehicles, numerous docking facilities will be located around the perimeter of the station. *Bellevistat* aims to be self-sufficient and will consequently mine the majority of its materials from the moon and nearby asteroids. Mining, extraction and purification equipment will be fabricated on orbit before they are required for construction of the settlement.

3.1 Construction Materials Sources

3.1.1 Orbital Location & Justification

Within any two-body system, there are five points that are considered ideal for the orbital position of a space station. These are known as Lagrangian or Libration points. Within these regions, the gravitational effects of the two bodies are balanced, which means that a minimum of station keeping is required.

Of these five points, the location chosen for the placement of *Bellevistat* will be the Earth-Moon L_4, the newly designated 'rust-belt' of space. It will provide stability greater than L_1, L_2 or L_3 and is situated within the Moon's orbit, allowing the transportation of supplies, residents and materials between the settlement and lunar colonies. This point is mainly outside of the Earth's shadow, enabling it to reap the full benefits of solar power.

The settlement will be constructed at the Earth-Moon L_1 so as to negate any possible effects of the theorised Kordylewski Cloud during construction. Once the settlement is complete, it will be relocated to L_4. As it will be sealed completely from the outside, the completed *Bellevistat* space settlement will not experience any negative effects due to the Cloud.

3.1.2 Construction Material Sources

Material	Source	Natural Composition	Application	Transportation to Bellavista*
Aluminium	Lunar crust Stony meteorites	Diaspore $HAlO_2$	Dual-Phase Steel, Vitreloy	A & B
Argon	Earth	Argon Ar	Atmospheric composition	A & B
Carbon	C – Type Asteroids	Calcite $CaCO_3$	Dual-Phase Steel, HD Methylene diphenyl diisocyanate, HD Polyethylene, HD Polyurethane, Lucite, RTV-3145, Shear-Thickening Fluid, Atmospheric composition, Polyanine	A & B
Chromium	C – Type Asteroids	Chromite $FeCr_2O_4$	Dual-Phase Steel	A & B
Copper	Earth Crust	Azurite $Cu_3(OH)_2(CO_3)_2$	Vitreloy	A & B
Hydrogen	Lunar Ice Vulture's L_5 Comet	Water H_2O	HD Polyethylene, HD Polyurethane, HD Methylene diphenyl diisocyanate, Lucite, RTV-3145, Shear-thickening fluid, Polyanine	C
Iron	Meteorites	Haematite Fe_2O_3	Dual-Phase Steel	A & B

Manganese	Meteorites C – Type Asteroids	Manganese *Mn*	Dual-Phase Steel	A & B
Molybdenum	M – Type Asteroids	Molybdenite MoS_2	Dual-Phase Steel	A & B
Nickel	M – Type Asteroids	Garnierite $(Ni, Mg)\ SiO_3 \cdot n\ H_2O$	Vitreloy	A & B
Niobium	Earth Crust	Niobium *Nb*	Dual-Phase Steel	A & B
Nitrogen	Earth Crust C – Type Asteroids	Nitrogen Gas N_2	HD Methylene diphenyl, diisocyanate, HD Polyurethane, Atmospheric composition, Polyanine	A & B
Oxygen	Lunar Ice Vulture's L_5 Comet Oxides	Water H_2O Oxygen O_2 Various	HD Methylene diphenyl diisocyanate, HD Polyurethane, Lucite, RTV-3145, Shear-Thickening Fluid, Atmospheric content	A & B
Phosphorus	M – Type Asteroids C – Type Asteroids	Apatite $Ca_5(PO_4)_3[F, Cl, OH]$	Dual-Phase Steel	A & B
Silicon	Lunar Crust S – Type Asteroids	Zirconium silicate $ZrSiO_4$	Dual-Phase Steel, RTV-3145, Shear-Thickening Fluid	A & B
Sulphur	Earth Crust M – Type Asteroids	Iron pyrite FeS_2	Dual-Phase Steel	A & B
Titanium	Lunar Crust	Titanite *CaTiSiO*	Dual-Phase Steel, Vitreloy	A & B
Uranium	Earth	Uranium *U*	HNS Polymer	D
Zirconium	Earth Crust S – Type Asteroids	Zirconium silicate $ZrSiO_4$	Vitreloy	A & B

* Key: A= Grumbo Jumbo Mk II-a (40m x 40m x 150m); B= Grumbo Jumbo Mk II-b (40m x 40m x 150m);
C= *Poseidon*-Class Water Transport (40m x 40m x 150m) D = Grumbo Jumbo (30m x 30m x 90m)

Table 3.1: Construction Material Sources

3.2 Community Infrastructure

3.2.1 Agricultural Production

Meat to be consumed by residents aboard *Bellevistat* will be 'grown' using in-vitro techniques. Rather than growing the entire animal for slaughter and distribution using conventional techniques, which results in wastage of non-edible parts (i.e. bones), only the meat is grown. This method involves harvesting muscle cells and other cells needed for the growth of the meat, including fat cells for energy, blood cells to deliver nutrients and nerve cells so as to send messages. In-vitro meat production requires less space to grow the same amount of meat and is more cost efficient. Because no live animals are killed, this system of meat growth may be acceptable for ethical vegetarians or vegans. It also allows for the production of meat from carnivorous animals, which conventionally is more expensive. Traditionally produced meat will also be available for residents who prefer not to eat in-vitro meat, or for meals which require traditionally produced meat. This will be produced in the agricultural section of *Bellevistat* and the livestock will live in as natural an environment as possible.

Crops will be grown using zeoponics, where plants are cultivated in an environment rich in zeolites, which contain nutrients. Zeoponic plant production has advantages above geoponic and hydroponic in that there is less usage of resources such as water, minerals and fertilizers. Zeoponic methods also do not require soil, which reduces the amount of resources needed to be transported to the station, as well as maximising the usage of space. Such food as grains, fruits and vegetables will all be grown zeoponicly which will therefore help to emulate Earths lifestyle. All plants will be grown within a six-floor Agricultural Complex (AC) located beneath the storage floor of the living areas (Refer to *Figure 2.2.1*), which will provide easy access and limit excessive transportation. An automated system will harvest and pack the produced food before it is transferred to either the storage or distribution centres, depending on demand. Three weeks worth of contingency food will be kept in storage at all times. The current occupancy of *Bellevistat* will be utilised so as to determine the productivity the zeoponics will be in order to minimise wastage.

3.2.2 Electrical Power Generation & Distribution

Bellevistat will require a large amount of electricity to power its various systems and facilities. Approximately 65% of the required power will be derived from solar, with the remainder being generated by nuclear, with any excess being stored in multiple Superconducting Magnetic Energy Storage (SMES) devices. These twin systems will produce approximately 1.44 GW.

Solar power has been allocated such a large percentile of the electrical generation due to its easy and ready availability in space. Given the lack of an atmospheric barrier and problems such as weather and day/night patterns in space, electricity generated from a solar array in outer space will be nearly six times that of what the same array could expect to generate on Earth. Power will be provided to the station through twin *Solaris* solar farming facilities placed in mirrored-geostationary orbits. The facilities will utilise fourth generation photovoltaic cells, with each farm consisting of approximately 3000 hectares of photovoltaic arrays. The cells will be arranged in a low aperture parabola so that any solar energy that is not absorbed will be reflected onto an attached water grid that will power a solar thermal generator. This enables minimum energy loss. Energy generated by the two solar farms will be beamed back to the station through microwaves.

Nuclear power on *Bellevistat* will fulfil a secondary energy production role. Power from the nuclear reactor will be used to provide electricity to the space station's critical functions, including atmospheric controls, waste and water management and robotic control. This energy will be provided by a small conventional fission reactor, called *Megatron*. Unlike most conventional reactors, however, *Megatron* will be fuelled primarily by thorium (as opposed to uranium) due to its abundance, its higher levels of safety and fact that it produces far less transuranic waste. The nuclear power facility will be located within the utility section of *Hephaestus*, providing virtually complete safety from impacts. In the event of a malfunction of the nuclear reactor, personnel can be evacuated to *Solinvictus* or *Balaat*, whose solar radiation shielding will provide protection from nuclear contamination.

Twelve small SMES devices will provide the station's electrical storage system. An SMES device stores an electrical charge within a magnetic field and is one of the most efficient forms of electricity storage that experiences high levels of reliability. They will be located throughout the utility sections of *Hephaestus*, *Solinvictus* and *Balaat*, providing redundancy in the case of emergency. In the event of power interruption, the four primary and eight auxiliary devices will allow for up to 32 days of continued standard living conditions, which will give ample time for repair of the cause of energy failure.

From substations located near *Megatron*, the *Solaris* receivers and the SMES devices, electricity will be distributed along urban and industrial grids. Several substations will be located throughout the station at points requiring large amounts of electricity such as the docking areas.

3.2.3 Internal & External Communications

Personal and residential internal communications will be provided by the availability of the Individual Communications Device (ICD). A wireless communications device for residents and transients, the ICD provides a portable access point to the Custom Living Environment Management system (Refer to *Section 5.2.1*). Central servers will act as digital switchboards for the system, and will feature an override system to alert residents or workers of any emergency situation. In the instance of a system wide crash or similar problem, emergency-standard landline phones are also located throughout the station at regular intervals. The switchboard for this landline as well as monitoring of the Household PC (Refer to *Section 5.2.3*) can be found at the Human Control Centre (Refer to *Section 5.2.2*)

External communications between the settlement and outside locations, such as approaching spacecraft and the surface of Earth will be carried out through laser communications. The communications network will involve an exchange of laser pulses between the settlement and the communiqué destination via two overlapping rings of four geosynchronous orbiting communication satellites, which will provide redundancies in the case of unexpectedly high dust accumulation within the Kordylewski Cloud. Laser transmission has been chosen over traditional S-band radio waves due to its greater data holding capabilities and transmission rates (up to 1000 times greater).

3.2.4 Transportation Systems

3.2.4.1 Internal Transportation Systems

Figure 3.1: Artists impression of Maglev trains

Magellan has opted to use Electro-Magnetic Suspension (EMS) powered Magnetically Levitated (Maglev) trains and lifts in order to fulfil the requirements of intra-ring transit. EMS provides both suspension and propulsion through the use of attraction forces generated by electromagnets. Within each of *Balaat* and *Solinvictus*, two tracks each carrying five three-car trains travelling in alternating directions will be located beneath the surface within a specified transportation route. Stations will be located every 800m within each ring. The nature of Maglev transportation ensures against any possible collision and eliminates the problem of pollution before it begins. Trains located upon the same track will act in synchronicity with one another so as to prevent bottlenecks and collisions from occurring. Each three-car train will be capable of carrying 320 people or 720 m^3 of cargo. Lower levels will be accessible by a series of EMS powered lifts. Walk paths and bikeways are situated throughout the living areas for individual usage, so as to encourage personal fitness within *Bellevistat*.

3.2.4.2 External Transportation Systems

For transportation between *Hephaestus* and the rotating rings, a unique Maglev system has been designed by Magellan. The Inter-Ring Transportation System (IRTS) involves linking an EMS Maglev train to tracks on both rings simultaneously. Each connection will be maintained independently. When 'docked' (i.e. physically connected for loading) at one ring (e.g. *Balaat*), the connectors linked to the track on that ring will remain stationary, whilst the engine connected to the other ring (e.g. *Hephaestus*) will be travelling at the exact speed in opposite direction of that ring (e.g. *Hephaestus*). Once the train is loaded and undocked, it will (in relation to the previously docked ring) accelerate in the opposite direction, until it is travelling at a velocity of 0 ms^{-1} relative to its destination ring. This trip will take less than half a minute whilst experiencing forces of less than 0.5 G, excluding loading and unloading times.

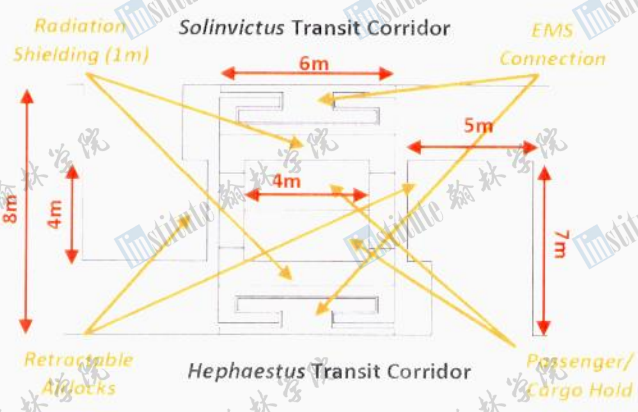

Figure 3.2: Cross-Section of IRTS Train

Due to the high speeds involved and therefore large distances travelled, all IRTS trains on each track will travel in tandem. In order to schedule different times for inter-ring travel, three tracks will link each of *Balaat* and *Solinvictus* to *Hephaestus*. They each contain three IRTS trains of similar carrying capability to the standard Maglev trains used for mass transit for up to movement of 5760 people or 12 960 m^3 of cargo in each direction per hour. Transport between *Solinvictus* and *Balaat* will be achieved via stations on *Hephaestus*.

3.2.5 Meteorological Controls

3.2.5.1 Atmosphere

Due to the great diversity of different sectors of *Bellevistat*, atmospheric composition for separate sections will be strictly monitored and maintained for maximum output and performance. Within the majority of habitable areas, the atmospheric composition will be of similar nature to that of the Earth's.

Sector	Nitrogen	Oxygen	Carbon Dioxide	Argon	Other
Freight Docking	0%	0%	0%	0%	0%
Residential Docking	78%	20%	0.03%	0.9%	<1%
Agriculture	88%	11%	0.06%	0.9%	<1%
Industrial	71%	28%	0.03%	0.9%	<1%
Commercial	71%	28%	0.03%	0.9%	<1%
Residential	71%	28%	0.03%	0.9%	<1%
Storage	88%	10%	0.07%	0.9%	<1%
Average	**78%**	**21%**	**0.04%**	**0.9%**	**<1%**

Table 3.2: Bellevistat Atmospheric Composition

3.2.5.2 Climate

Bellevistat will simulate the four seasonal changes of Earth, each season with their own climate and weather differences so as to lend the illusion of living on Terra. To achieve sufficient differentiation, each of the four thematic zones will experience different climates appropriate to their settings.

Thematic Zone	Seasonal Event	Temperature Range	Daylight
Southern France	Summer	20°C - 32°C	15 hours
	Autumn	18°C - 29°C	12 hours
	Winter	15°C - 26°C	11 hours
	Spring	20°C - 27°C	12 hours
Ireland	Summer	20°C - 30°C	16 hours
	Autumn	18°C - 26°C	14 hours
	Winter	15°C - 18°C	12 hours
	Spring	20°C - 28°C	15 hours
China	Summer	20°C - 32°C	15 hours
	Autumn	20°C - 32°C	13 hours
	Winter	20°C - 32°C	11 hours
	Spring	20°C - 32°C	13 hours
Ultra Modern	Summer	23°C - 28°C	14 hours
	Autumn	20°C - 25°C	13 hours
	Winter	18°C - 22°C	11 hours
	Spring	20°C - 25°C	13 hours

Table 3.3: Climate Settings of Sectors

3.2.5.3 Weather Control

Weather will be simulated by a series of water-vapour dispensers combined with temperature and humidity control. To increase rainfall, the water vapour is dispersed in large amounts, allowing it to condensate on its own, therefore effectively simulating a realistic rainfall pattern. The temperature controls the amount of water evaporating, the formation of ice crystals and the simulated wind drafts within the settlement.

3.2.6 Household & Solid Waste Management

All substances will be recycled so as to maximise usage of materials. Waste will be transported to a waste depositary via vacuum tubes, where it will be sorted by an automated system depending upon the type of waste. These will then be recycled using conventional techniques for that type of material, with organic waste being put through Magellan's Organic Waste Management System before being redirected into station systems such as water management, atmospheric systems and plant growth.

Industrial and non-organic solids will be recycled as appropriate for that material type and formed into other compounds that can be further made into commercial goods (e.g. thermoplastics will be sorted, melted and remoulded). Waste that cannot be recycled will be jettisoned into space into a decreasing-radius solar orbit to be eventually consumed by the Sun.

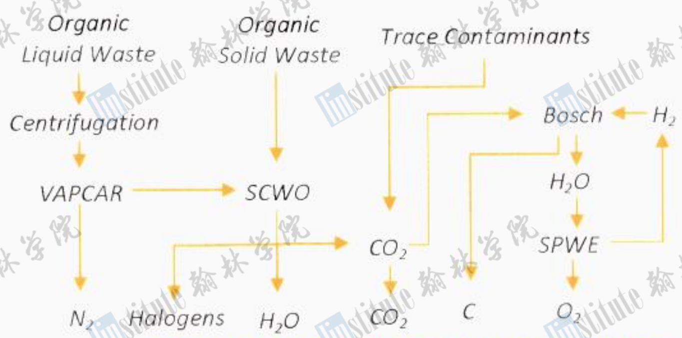

Figure 3.3: Organic Waste Management System

Process	Function
Vapour Phase Catalytic Ammonia Removal (VAPCAR)	Turns NH_3 into N_2 and H_2
Super Critical Wet Oxidation (SCWO)	Oxidises organic substances into CO_2 and H_2O
Bosch	Adds H_2 to CO_2, producing H_2O and C
Solid Polymer Water Electrolysis (SPWE)	Separates H_2O into H_2 and O_2

Table 3.4: Processes Utilised in Organic Waste Management System

3.2.7 Water Management

Water is one of the substances which humans are dependent upon. *Bellevistat* will require a total of 436.38 ML of water per day. This will be gathered from ice entombed within the lunar crust as well as from the ice-rich comet that is available for harvesting from Vulture, situated at Earth-Moon L_5. A water mining and purification base will be set up on location before the water is transported to the station in *Osiris*-class transports. Water will be stored and circulated in the hull so as to prevent stagnation. It will be contained in one of the inner layers of hull and segregated to reduce loss from small penetrations. When required, water will be then returned into the water grid, put back into the settlement systems or returned to the residential area as rain. Sewerage and waste water will be purified as part of Magellan's Organic Waste Management system. It will then be treated with vitamins and minerals for the health of occupants and returned to the hull storage. This will all be contained within the utilities areas within each of the sectors.


Figure 3.4: Residential Water Routing

Stage	Process
1	Ion Exchange
2	Granular Activated Carbon
3	Sediment Filter
4	Reverse Osmosis
5	Five Micron Carbon Block Filter
6	*Ultra Violet Disinfection*
7	One Micron Sediment Filter
8	Ozonation
9	Storage and Recirculation

Table 3.5: Nine-Stage Water Purification Process

3.2.8 Day/Night Cycle Provisions

As the days and nights within space are not as defined as on Earth, a sophisticated system utilising holograms and lighting will simulate a traditional day/night cycle for the residents. The ceiling, including both transparent sections and opaque support structures will be coated with a 20mm film of clear glass. This will act like a lens, projecting an image overlay through the spectrum to replicate the natural sky and clouds of Earth. It can darken so as to simulate 'night' as required. A *lunetta* purchased from LightWorks will redirect natural light to the settlement when it passes behind into the Earth's shadow. The cycle will be monitored by automated systems through the use of power and light input sensors.

3.2.9 Movement of Exports

Figure 3.6: Movement of Exports

3.2.10 Infrastructure Routing

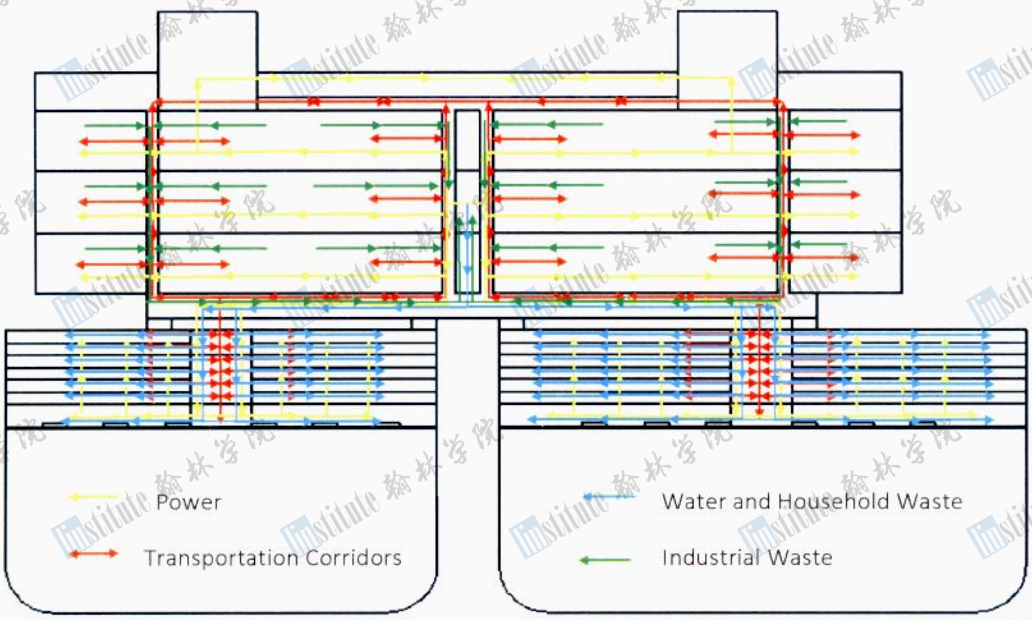

Figure 3.7: Infrastructure Routing
(For Uses and Sizes of areas shown, refer to Section 2.2)

3.3 On-Orbit Infrastructure

3.3.1 *Solaris* Solar Farms

The twin Solaris Solar Farms have been designed so as to attain the maximum output of solar energy that can be harvested from the Sun. They will be located in geostationary orbits in direct opposition to one another so that in the case of one passing behind the Earth's shadow, power will continue to be generated by the other. They will be able to rotate upon their axis so that the solar cells always face the Sun. Energy that they generate will then be beamed using microwave through the series of *Hermes* Communication Satellites unless they are in direct line of sight with the settlement.

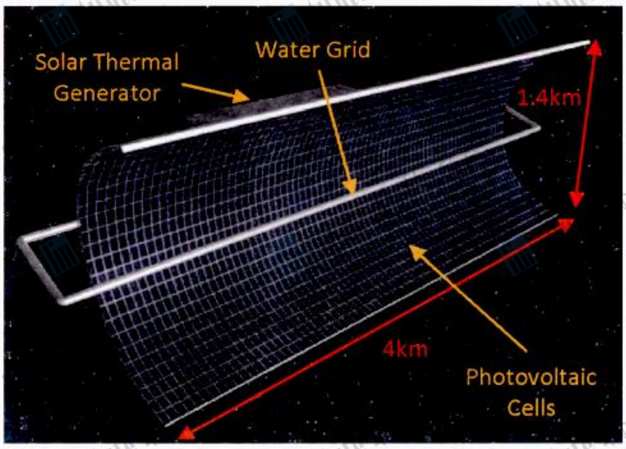

Figure 3.8: Artist's Impression of Solaris Solar Farm

The solar cells to be utilised in the farms will be purchased from *ZAP! Industries*, before they are shipped to the Earth-Moon L_1. Here the solar cells will be assembled into solar panels, sourcing additional materials from settlement pre-construction mining operations. Once completed, the farms will be relocated to their final orbital positions by the *Erebus*-class space tug (Refer to *Section 3.3.3*).

3.3.2 *Hermes* Communications Satellites

To facilitate communications between *Bellevistat* and other extraterrestrial creations, a series of communication satellites will be employed. Six *Hermes* Communications Satellites will be located in a 10km radius from the settlement, within a similar Lagrangian orbit to the settlement itself. These will ensure a failsafe backup, as well as relieving congestion and confusion of signals direct to *Bellevistat* itself. They will effectively be handlers for long distance signals (i.e. Earth-based), and will also direct links for incoming and outgoing spacecraft.

Eight additional *Hermes* Communications Satellites will be located within geosynchronous orbits, so as to make possible communications between *Bellevistat* and other settlements/Earth. They will be located 32 271 km away from one another so as to enable overlap for redundancy purposes, as well as for extended range and the elimination of 'black spots' in their coverage. The *Hermes* Communications Satellites will be constructed concurrently with the settlement at Earth-Moon L_1.

3.3.3 Spacecraft Requirements

Name (Dimensions)	Number required	Location	Purpose	Construction Details
Erebus-class Space Tug (10m x 10m x 30m)	40	Dock; surrounding space	Guides and manoeuvres large ships into dock	Constructed in *Hephaestus* Industrial Sector
Grumbo Jumbo (30m x 30m x 90m)	20	Earth – LEO	Reusable Launch Vehicle; transportation of personnel and temporary and permanent residents between Earth and Low Earth Orbit	Constructed on Earth. Included in contract.
Grumbo Jumbo Mk II-a (40m x 40m x 150m)	10	Mining location – *Bellevistat*	Transportation of ore to *Bellevistat* for the refinement	Constructed in *Hephaestus* Sector or on-site. Included in contract.
Grumbo Jumbo Mk II-b (40m x 40m x 150m)	14	Settlements – *Bellevistat*	Transportation of refined metals and manufactured goods to the buyers	Constructed in *Hephaestus* Industrial Sector or on-site. Included in contract.
Grumbo Jumbo Mk III (30m x 30m x 90m)	20	LEO – HEO (L_1, L_4, L_5)	Transportation of personnel and temporary/ permanent residents between *Bellevistat* and other orbital locations	Constructed at Earth-Moon Lagrangian Point 1. Included in contract.
Iris-class Rapid Response Unit (20m x 20m x 60m)	25	Standby in case of emergency; on-site	Performs search and rescue as well as transport for external repair and maintenance crews.	Constructed in *Hephaestus* Industrial Sector
Poseidon-Class Water Transport (40m x 40m x 150m)	6	Vulture's L_3 comet/lunar crust – *Bellevistat*	Transportation of water as a liquid at 4°C	Constructed in *Hephaestus* Industrial Sector

Table 3.6: Space vessel requirements & specifications

3.4 Agricultural Requirements

Bellevistat will be virtually independent from imports from Earth in regards to crops, grain and animal feed due to its Agricultural Complex (AC). The AC will consist of six ten-metre floors that run beneath the living space on both rings, and will provide ample area for agriculture. Each floor will be subdivided laterally, allowing different types of crops and livestock to be grown on the same floor as well as providing contingencies and quarantine in the case of a disease break out or emergency. As the majority of meat will be grown using in-vitro methods, only limited area on the outer agricultural floor will be sectioned off to grow actual livestock.

Throughout the various recreational gardens within the living sectors, as well as in backyards, space will be effectively utilised by choice of decorative plants decided upon other benefits as opposed to simply aesthetic reasons. Plants grown will include herbs and vegetable- and fruit-producing trees and plants. Each resident will be encouraged to keep their own personal 'veggie patch' or 'herb garden' for private usage.

Any excess food that is produced that is not required for contingency storage will be exported to other space stations, which have already expressed interest in purchasing of provisions from *Bellevistat*.

	Production Method	Production Location	Area Required
Meat (Livestock)	Intensive livestock farming	AC, Sixth floor	58 800 m^2
Meat (In-vitro growth)	In-vitro growth	AC, fourth-sixth floor	25 000 000 m^2
Crops (Animal feed)	Zeoponics	AC, Third floor	43 400 m^2
Crops (Human consumption)	Zeoponics	AC, First-third floor	17 100 000 m^2
	Private traditional gardens	Residential/recreational areas	184 000 m^2

Table 3.7: Area Delegation of Agricultural Complex (AC)

3.5 Innovation Materials for Residential Applications

To conserve resources, a number of innovative techniques will be employed in the construction of the interior of the settlement. Specialised materials will be used because of their superior qualities in comparison to conventional materials, as well as due to their ease of construction. The external surfaces of all interior constructs will be built using Contour Crafting (Refer to *Section 5.2.2*) so as to conserve resources, costs and time.

Name	Material	Application	Justification
Extrudawood	Reinforced recycled thermoplastic composite	Housing Walls, Floors, Fences	High tensile and compression strengths, ultraviolet protection, does not decompose, high thermal insulativity
Dual Phase Steel	Heat treated alloy with a ferrite and martensic microstructure	Surfaces, Kitchen Equipment, Furniture Frames	High strength, durable material; allows for wide application and longer lasting products than conventional materials
Fibre optics	Glass made primarily from silica and including fluoro-zirconate, fluoro-aluminates and chalcogenide	Lighting, Heating, Signalling	Faster and cheaper than conventional wires; allows signals to be sent at the speed of light without the factor of drift
Zincalume	Steel galvanised with Zinc 55.2%, Aluminium 43.2% and Silicon 1.6%	Roofing	Both durable and strong; thermally efficient, corrosion resistant, weather tight, easy to maintain

Table 3.8: Innovative Materials for Residential Applications

MAGELLAN

AUSTRALIA

4.0
HUMAN FACTORS

"Don't tell me that man doesn't belong out there. Man belongs wherever he wants to go - and he'll do plenty well when he gets there."

- Wernher von Braun

4.0 Human Factors

As *Bellevistat* is to be the second major space settlement, the psychological factors are integral to maintaining the mental health and wellbeing of each resident. A compromise must be reached between a community reminiscent of Earth and one exhibiting the awe of space living. In order to achieve this, 'ceilings' of 150m high will be placed within each of the four residential sectors, contrasting the beautiful vistas of space and zero-gravity recreation facilities within the settlement. *Balaat*, the largest of the four sectors, will contain an ultra-modern theme, whereas the three segments of *Solinvictus* will host distinct Irish, French and Chinese districts, and will be named *Tara*, *Sallavecu* and *Laotzu* respectively. Chevron mirrors within the residential sector and specialised viewing areas will provide residents with natural sunlight and views of the surrounding space, as well as helping to meet their daily D_3 requirements.

4.1 Community Design

4.1.1 Healthcare

Due to the restricted physical nature of human living in a space environment, a significant demand for leading healthcare is required. *Bellevistat* will employ a number of defence protocols to restrict the spread of infectious disease within the settlement. The modular design of the station will enable entire sections of the community to be easily quarantined, localising the spread of any infection. This innovative design also allows for swift local access to health care, with one hospital facility located within each of *Balaat* and *Solinvictus*. These medical facilities will be provided with advanced medical equipment, employing over 230 professionals, with 400 hospital beds and the capacity to deal with a hospitalised total of 2% of the entire settlement's population, including transient population, in the event of a serious medical emergency. A range of private physicians will also be in service on the station, reducing strain on the hospital system.

The *Bellevistat Pathogenic Laboratory* will be at the forefront of innovative medical research and development, housing the facilities to analyse countless strains of numerous diseases. This laboratory will allow researchers to develop new antibiotics and vaccinations for the population of *Bellevistat*.

Figure 4.1: UV Lighting Above Doorways

Low levels of UV lighting in many of the station doors will destroy the majority of biological agents, while at the same time offering residents an essential vitamin D supplement. This effective disinfectant will allow for simple extermination of skin carried and airborne pathogens and, in combination with the variety of other techniques, minimise disease within the settlement.

4.1.2 Education

With the expected influx in childhood population, education will be considered as one of the highest of priorities. The settlement will host one primary school and high school within each of the living rings, with a university/vocational school located within *Balaat*. A common curriculum will be taught throughout the schools, allowing for a consistent learning environment throughout the settlement. The introduction of an Easy-Learn system will enable students to view the entire learning programme from their HPC (Refer to *Section 5.3.3*). This innovative syllabus allows for a user-based learning experience and an underlying freedom not available by conventional learning. With the entire education syllabus available online, the high school and university learning will be designed as tutorials and lectures, with contact hours not required. Optional pathways will be made available for those choosing to take apprenticeship and traineeships, with vocational education offered after the mandatory Grade 10 education level. This compulsory education will commence at the age of 6, with students graduating from primary school after seven years of education (aged 12), before obtaining a further five at high school.

4.1.3 Entertainment & Recreation

The high density design of *Bellevistat* results in a major requirement for parks and other recreation facilities. These facilities, located in all four residential areas will account for approximately 27.2 percent of floor space and will include parks, live theatres, sporting venues, cinemas and restaurants that tie in with the appropriate theme for that sector. The settlement will also accommodate a wide variety of conventional sports and leisure activities, all available to the general public (Refer to *Section 4.5*). 12.5 percent of the floor space will be allocated to roads and paths.

The introduction and development of several space and zero-gravity orientated activities will also be possible on the settlement. Hosted on the outer edge of *Hephaestus*, facilities including outer-space viewing decks, a zero-G arena and space explorations will be available for residents and tourists to enjoy an experience that is truly 'out of this world'. Tours of nearby space and space walks will be subcontracted out to TRUE/GRIT.

Internal	External
Shopping	Stargazing
Dining	Zero-Gravity Sports
Conventional Sports	Space walks (TRUE/GRIT)
Theatres/Cinemas	Space exploration tours (TRUE/GRIT)
Parklands	Lunar tours (TRUE/GRIT)
Bellevistat Tour	

Table 4.1: Recreation Options

A variety of fine dining and cuisine options will also be available throughout the settlement, with grants offered by the administrative body to entice private enterprise and the development of dining and recreation options. *Bellevistat* will also play host to a wide variety of specialist pursuits, with nightclubs, malls and specifically constructed stargazing areas available for all citizens.

4.1.4 Distribution of Consumables & Supplies

With over 98% of essential products grown or manufactured onsite the settlement, distribution of food and other produce will be completed by means of the Maglev lift system operating in and around the settlement. The food harvested from the lower agricultural section will be transported directly to retailers and grocers, much the same way as on Earth, with costs of food being determined by supply and demand. In order to optimise the use of space and energy, specific varieties of plants and livestock will be used, although the majority of meat will be grown using in-vitro methods (Refer to Section 3.2.1).

Product	Variety	Quantity	Predicted Wholesale Price	Space Required
Dairy Cattle	Holstein-Friesian	680	**Milk**: \$0.8/L	28,600m^2
Beef Cattle	Santa Gertrudis	650	**Meat**:\$290/head	
	Braford	300	**Meat**:\$260/head	
Chicken	Orpington	900	**Eggs**: \$1.02/Dozen **Meat**: \$3.60/head	225m^2
Fish	Mackerel	3600	**Meat**:\$8/kg	Lake & Fisheries (1,100m^2)
	Perch	2300	**Meat**:\$6.40/kg	
Pork	Tamworth	750	**Meat**:\$210/head	11,750m^2
Sheep	Merino	800	**Meat**:\$260/head **Wool**: \$29/kg (clean)	16,000m^2

Table 4.2: Livestock Quantities

Food	Servings per Person/Day	Mass per Day
Grains	3 Servings	800g
Dairy	2 Servings	350g
Meats	2 Servings	740g
Fats and Oils	1 Serving	12g
Fruit	2 Servings	120g
Vegetables	5 Serving	320g
Total		2.3kg

Table 4.3: Agricultural Supplies

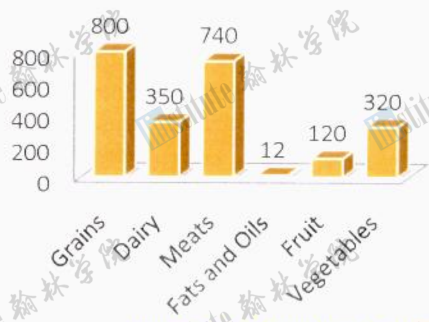

Figure 4.2: Agricultural Supplies

4.1.5 Community Design

Figure 4.3: Sectional Community Map of Balaat

4.2 Residential Design

Class	Capacity	Quantity	Area (Average)	Cost
Single	1	1,175	400m^2	$375,000 – $550,000
Townhouse	2	2,683	480m^2	$545,000 – $930,000
3 Bedroom	≥ 4	2,720	630m^2	$1,095,000 – $1,320,000
4 Bedroom	≥ 5	1,673	800m^2	$1,440,000 – $1,860,000
5 Bedroom	≥ 6	83	1024m^2	$1,500,000 – $1,920,000
Luxury	Varied	180	1024m^2	$2,400,000 – $6,000,000
Hotel Suite	2-8	75 unit/hotel	80m^2 (per unit)	$3,165/night (exc. transport)

Table 4.4: Residential Designs

4.2.1 Permanent Residents

Despite being located on the forefront of space, residents aboard Bellevistat will not be forced to compromise on luxury or comfort, with all dwellings offering spacious, liveable environments, essential to maintaining psychological health. *Bellevistat* will be capable of supplying five styles of permanent dwellings within each of the four themed areas, tailored to different demographics and family dynamics. Within these classes, a wide variety of individual styles will be offered, enabling residents to design a house their own. While differing in design, all residences will be based on the concept of open space and relaxation, with large, spacious rooms providing residents with a homely retreat.

This variation is crucial to the psychological aspects of living in such a community, with the possession of a home and the ability to change its look and feel a necessity. Each house, with the exception of the single apartments will be built on approximately 450 m^2 lots, with multiple levels allowing for optimum land usage. This sizing will also allow for residents to develop a garden or backyard to their desire, with those living in apartments having available spacious patios and decking, with views across the settlement.

Figure 4.4: Floor Plan of 3-Bedroom House (Balaat) (Dimensions in metres)

The anticipated demographics of the settlement suggest an expected influx in children, resulting in a need for three, four and five bedroom dwellings. This expansion has been taken into account in the settlement design, with a surplus of such houses being constructed in the first phase of building before the arrival of citizens. With the first phase of building only expanding into 70% of the residential sector, space will be available for future development as the demographic changes.


Figure 4.5: Artist's Impression of Luxury House (Balaat)

In order to minimise the labour-intensive nature of construction, construction robots will make use of contour crafting technology (Refer to *Section 5.2.2*). This fabrication technology will enable construction and alteration of dwellings to be completed efficiently, whilst at the same time, reducing manpower required on construction, as well as quantities of necessities such as water.

4.2.2 Transient Residents

Transient residents will not have to compromise on luxury and relaxation whilst staying at *Bellevistat*, with a variety of recreational and adventurous activities and a vast number of accommodation options to cater for all requirements. Throughout the space settlement, seven hotels will provide temporary housing for up to one thousand transient guests. Each hotel, along with a gym and pool, will have a unique activity or place to visit that is individual to the hotel. These will include movie theatres, dance studios, games rooms and other forms of recreational activities. To accommodate for all guests' needs and budgets, rooms available will range from the 8 sleeper Penthouse to the 3 bedroom deluxe to the single/double standard. Each guest, upon booking into the hotel will gain access to the TRP (Temporary Residential Package), which allows access to the pools, spas, cinemas, bars, gym and internet access along with free cleaning services and the exclusive *Bellevistat* space tour.

4.3 Work Environments

4.3.1 Space Suits

There will be two distinct space suit designs used in Bellevistat for both maintenance and industrial purposes. The lighter Space Activity Suit, or Bio-suit, will be mechanically counter pressurised with a gas-pressurised helmet. This pressure will be achieved by use of elastic fibres, strung around a spine like core, creating a resting pressure of approximately 3.3 psi. The Bio-suit will be applied by means of electrospinlacing, a process in which a multifilament fibre of polymer is electrically charged before being projected towards the skin by an electrically induced field. The Bio-Suit has many advantages over the conventional gas pressurised design, the most notable revolving around the manoeuvrability and the functionality of the suit. The suit is light weight, even with the pressurised oxygen cylinder required for the helmet attached, provides the advantage of manoeuvrability and precision. The concept of a single-use spray-applied suit offers greater convenience than a traditional design, with the use of such technology meaning that individual suits are not required, and suits being capable of being recycled into essential atmospheric gases after usage. This convenience is coupled with added safety, with a breach in the layer of the suit resulting only in bruising and damage to an isolated pocket of flesh tissue, in contrast to fatal decompression of the entire suit. The disadvantage associated with such a design is the amount of electrical energy required to apply it, a cost outweighed in convenience and safety.

Suit Type	Specifications	Applications
Bio-Suit	**Mass**:12kg **Cooling**: Evaporation of sweat **Fitting**: Electrospinlacing	Docking Sections of *Hephaestus*
Gas Pressurised Space Suit	**Mass**: 45kg **Cooling**: Ice filled heat exchanger	Space walks Asteroid mining External Maintenance

Table 4.5: Spacesuits Required

4.3.2 Internal Movement

Moving predictably in areas of low gravity is critical to the safety and well being of residents. It is therefore essential that these areas continue to maintain the level of movability practised in others.

This is achieved in large, open areas, such as *Bellevistat's* docking bays, by the use of a hydrogen peroxide powered jet pack. The use of hydrogen peroxide as a propellant provides a simple method of chemical expulsion, when reacted with the silver catalyst. Although on earth, the use of hydrogen peroxide expulsion is limited due to the running time, a controlled release of H_2O_2 allows for a 6L pack to last for up to 4 hours within zero-gravity, dependent upon usage. As the jet is required only to provide an initial motion and a slowing force with minimal gravity acting against it, this device is the most practical option to optimise industrial work or repair. In smaller areas, with little manoeuvrability, the use of permanent magnetic boots on the metallic floors will allow workers and residents to move safely and predictably. Bars and rails will also be installed in areas of low gravity to aid in safe movement.

4.3.3 Devices

Workers at *Bellevistat* will make use of several important devices, the most notable being the Individual Communications Device (Refer to *Section 5.1.4*). Utility belts and tools will also be available for those engaging in physical work and maintenance in low gravity, specifically designed for use in spacesuits. Forklifts and hydraulic trolleys will be required by workers so as to transport goods and services through the settlement through utilisation of the Maglev rail system.

Field Of Work	Occupation	Number Of Workers	% of Workers	Equipment Required
Transport	Driver	240	1.33	Vehicle manuals, logbooks
	Steward	84	0.47	Vehicle manuals, logbooks,
	Mechanic	360	2.00	Tools, space suits, ICD
General Maintenance	Cleaner	360	2.00	Cleaning Equipment, ICD, trolley
	Maintenance	672	3.73	Tools, space suits, ICD, forklift
Medical	Specialists	148	0.82	Specialty devices and tools
	Nurse	504	2.80	Medical Equipment, ICD
	Surgeon	84	0.47	Operating tools
Education	Teacher	21	0.11	Teaching resources, stationary
	Professor	20	0.11	Teaching resources
	Tutor	28	0.16	Teaching resources, stationary
	Lecturers	24	0.13	Teaching resources
	Child Care Worker	12	0.07	Young children's teaching resources
Hospitality	Domestic Carer	200	1.11	Varied
	Waiter	360	2.00	ICD
	Cleaner	295	1.64	Cleaning equipment
	Cook	250	1.39	Kitchen utensils, food supplies
	Shop Employee	1080	6.00	Varied
	Manager	216	1.20	ICD
	Cashier	360	2.00	Computer, ICD
	Performer	43	0.24	Props, other visual aids
Specialty	Technician	365	2.03	Computers, software, tools, tool belts
	Engineer	1300	7.22	Tools, monitoring systems, tool belts
	Researcher	2600	14.4	Researching tools/devices, carry cases
	Scientists	2500	13.9	Scientific implements, tool belts, ICDs
	Manufacturer	1190	6.61	ICDs, tools, tool belts
Robotic Activities	Supervisor	707	3.93	ICDs
	Maintenance	915	5.08	Repair tools, trolley

Law	Law Enforcers	20	0.11	Protective suits, tasers, ICDs
	Justices	6	0.003	Bench, gavel, ICD, stationary tools
Administration	Office Clerks	120	0.67	Computers, software tools, ICDs, stationery
	Secretaries	240	1.33	ICDs, computers, stationery
	Accountants	107	0.59	Calculation tools, ICDs, stationery

Table 4.6: Major Categories of Work & Required Equipment

4.4 Thematic Sectors

In order to ensure the maximum comfort for residents aboard *Bellevistat*, the settlement will be broken into four separate sections, each with a specific theme and lifestyle choice. *Balaat*, *Tara*, *Sallavceu* and *Laoztzu* will have the styles of ultra modern, Ireland, Southern France and China respectively, with the modular design of the settlement enabling for effective development. These styles will be seen, not only in architectural or structural aspects of the settlement, but dining, recreation and almost all services and lifestyle choices on offer. The employment of these four clearly defined styles will enhance the quality of life for the residents of the settlement as well as add variety to an otherwise sterile environment.

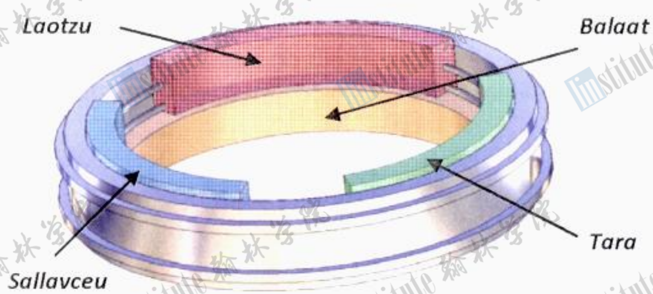

Figure 4.6: Designation of Thematic Sectors

Sector	Theme	Floor Space (Dimensions)
Balaat	Ultra-modern	10 050m x 350m
Tara	Irish	2500m x 425m
Sallavceu	Southern France	2500m x 425m
Laotzu	Chinese	2500m x 425m

Table 4.7: Designation of Thematic Sectors

4.4.1 *Balaat*

The major residential sector of the settlement, *Balaat*, will be styled with an ultra-modern theme. This section of the settlement, three times larger than the others sectors, will house the largest population, and in turn have the most aesthetically pleasing design. The use of slick angles and modern design of art deco will produce an environment with clean cut futuristic features. The use of glass and metal will produce a comfortable style of living within residential, commercial and public buildings of this sector.

Figure 4.7: High Density Offices in Balaat

4.4.2 *Tara*

Tara, one of the three smaller residential sections of the settlement and a component of *Solinvictus* will have an Irish theme. Having a more niche market, it will incorporate the use of simulated traditional materials and historical design features which will be clearly noticeable in both residential and commercial areas. The lifestyle and recreational aspect of the community will also follow this traditional Irish trend.

4.4.3 *Sallavceu*

Styled after a Southern French theme, *Sallavceu* is another one of the three smaller sections of the settlement. The use of seemingly traditional materials and the replication of Southern French aspects, including lifestyle and commercial infrastructure, will provide a psychologically pleasing environment. Residents of *Salleveceu* will be able to enjoy a realistic and enjoyable lifestyle.

4.4.4 Laotzu

In true Chinese style, both architecturally and life-stylistically, *Laotzu* will provide a traditional and simple way of living whilst still maintaining modern luxuries. The incorporation of modern and traditional Chinese culture as well as the current comforts of earth will provide a height of luxury in everyday living.

4.5 Maintaining Health

4.5.1 Physiological Health

The relatively confined living environments of space have resulted in an unprecedented demand for physical activities and recreation options. The residents of *Bellevistat* will be presented with numerous such opportunities, with the establishment of various sporting facilities and recreation options, including tennis courts, basketball courts, swimming centres, sporting fields and open spaces all available to the general public. Emphasis will be placed upon healthy living, with the size of the settlement enabling transportation to consist primarily by walkways and bike paths, with communal bike depots available for resident's parking.

Various sporting teams will be established between the community sections, with matches played weekly. These recreation options will include conventional sports, as well as space-exclusive activities, with zero-gravity sporting arenas available for the general public. Parks and recreation areas will constitute approximately 15% of the settlement, with over $5 million spent annually to maintain to the quality of the communal area

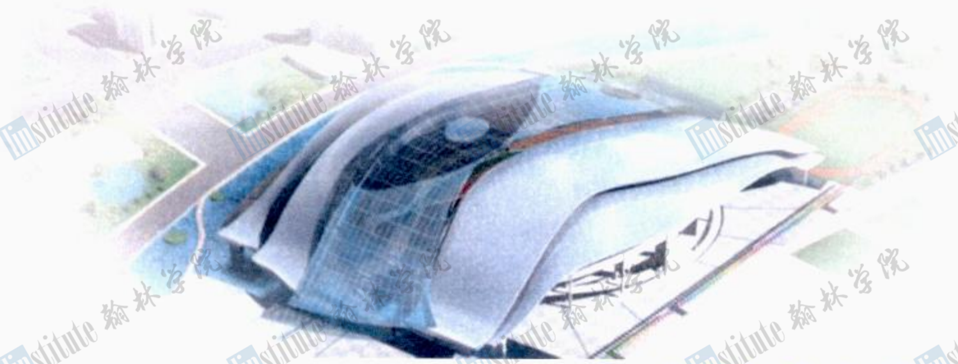

Figure 4.8: Balaat Sport and Leisure Centre

Other options allowing for socialisation between residents will be developed by individual members of the community, with privately organised groups including yoga, martial arts, athletics and meditation predicted to be available to all community members. These groups will comprise the majority of physical recreation options (Refer to *Table 4.1*), with the privately owned leisure centres available to all residents.

The centre of amateur leisure will be the *Bellevistat Recreation Centre*, located in *Balaat*, which will include a gymnasium, squash courts and sports halls all available for hire. The centre will also encompass other mental activities, including bridge clubs, chess groups and monthly poker tournaments. In order to encourage this community involvement, many of these activities will be subsidised by the major body, with admission into such public centres being free.

In order for those working in areas of low or zero gravity to maintain an appropriate body mass and muscle content, medical examinations will be conducted every three months with forced leave after every year of service. These examinations will carefully monitor the vestibular system, ensuring an accurate concept of balance is retained, reducing the effects of Space Adaptation Syndrome on the otolith organs. These assessments will also examine the plasma concentration in the blood, attempting to control the unpleasantness associated with shifts in fluid throughout the body as a result of low gravity living. The most vital physical consideration, however, will be effect of low gravity on the skeletal support and muscle systems. X-rays will be taken to determine the loss of bone tissue and change in muscle fibres. These X-rays will include an examination on the kidneys to determine a risk of calcium kidney stone formation from the breakdown of bones. To reduce the risk of bone loss, exercises will be undertaken every three hours of work for 15 minutes, with an emphasis on exercising the femur, lower vertebrae and hip, as well as individually determined regions of muscle loss. These exercises will complement a required dietary supplement, with the intention of ensuring maximum safety to all aboard *Bellevistat*. Pneumatic pressurised boots will be used by all workers to maintain constant stress on the feet, ensuring that strength and control is preserved.

4.5.2 Psychological Health

The comparative isolation and confinment of space living has resulted in the need for an in-depth analysis into the psychological effects of those living aboard Bellevistat. Of the 148 medical specialists aboard the settlement, over 20 will be trained in psychological assessment, enabling an accurate profile of residents to be formed. The most common disorder predicted from research undertaken at *Alexandriat* is insomnia or other similar sleeping disorders, particularly afflicting newly arrived residents. The loss of Circadian regulation will inevitably result in an interruption to sleep patterns, with new residents advised to remain aware of such effects for at least 3 days after arrival.

To reduce the effects of psychological distress on residents, it is necessary to ensure that a balance between Earth comforts and space living is reached. Several aspects of living reminiscent of life on Terra will be found throughout the settlement, with a natural bird population serving not only as a homely comfort, but also capable of removing foodscraps and other waste. Residents will also be able to own pets as they can on earth, with housing design accomodating this requirement, as well as the desire of many to manage a personal garden. These similarities will be complemented with specific space only activities, including stargazing and spacewalks, highlighting the awe of space, while retaining conventional luxuries.

Physiological Condition	Symptoms	Cause	Prevention	Treatment
Space Adaptation Syndrome	Dizziness Nausea Disorientation Lack of balance	Alteration between microgravity and 1-G	Pneumatic boots	Transdermal Dimenhydrinate Patches
Asthenia	Dehydration Fatigue Slurred speech	Disturbance to sleep patterns/ loss of Circadian rhythm	Adequate sleep	Sleep Fluid Prochlorperazine
Loss of Skeletal Muscle & Bone Tissue	Loss of body mass Loss of Strength	Lack of mechanical stress	Frequent exercise during low gravity activities	Novel Selective Androgen Receptor Modulators Bisphosphonate Raloxifene (for severe cases only)
Lack of Erythrocytes (Anaemia)	Dyspnea Fatigue	Decrease in red blood cell construction	Iron supplements Epoetin alfa	Vitamin C Vitamin B-12 Epoetin alfa
Hatzfeldt Syndrome	Irregular sleep patterns Irrational behaviour	Disturbance to sleep patterns	Regular exercise	Behavioural therapy
Insomnia	Inability to obtain quality sleep	Anxiety Disturbance	Regular exercise	Benzodiazepines (for severe cases only)
Depression	Anxiety Pessimism	Poor sleep quality Poor diet	Community involvement	Selective serotonin reuptake inhibitor
Claustrophobia	Panic attacks over space	Confined living environment	Community involvement	Sport and Recreation

Table 4.8: Prevention and Treatment of Physiological Disorders

MAGELLAN

AUSTRALIA

5.0

AUTOMATION DESIGN & SERVICES

"Science-fiction yesterday, fact today."

– Otto O. Binder

5.0 Automation Design & Services

Magellan has spared no expense in allocating automated systems and devices to enhance liveability and productivity in *Bellevistat*. Various computing hardware and software has been developed solely for operation of the settlement. Almost all robots aboard *Bellevistat* will be variants of Magellan's modular F1M8 robot, taking advantage of specialist knowledge in this area, or will be subcontracted to other companies. These robots are not only autonomous, but have the ability to group task leading to greater effectiveness in duties. Potential hazards have been methodically addressed with contingency plans in place for virtually every situation. *Bellevistat* will boast the safest space venture due to the meticulous nature of all systems and devices, without any hindrance to residents regarding all facets of lifestyle.

5.1 Construction Automation

The construction of *Bellevistat* will be a costly, timely and potentially dangerous operation. In order to minimise the risk to human life and increase productivity whilst reducing labour intensity, the majority of construction tasks will be performed by automated devices overseen by workers. Building phases will bear no hindrance to the materials industry on Earth, as all materials are to be harvested from other celestial bodies with the assembly of the settlement completed in orbit.

Automation for Construction	Description	Purpose	Location	Quantity
Asteroid Mining Robot (DIGGER) (20m x 5m x 1.5m)	Borehole drilling/road head mining robot	Mines metallic ores from asteroids	On-site asteroid mines (C, S, M types)	60
Lyell Mining Facility (80m x 150m x 150m)	Semi-permanent structure	Mines metallic ores from asteroids & collects ore from DIGGERs	On-site asteroid mines (C, S, M types)	6
Grumbo Jumbo Mk II-a (40m x 40m x 150m)	Mining cargo transports	Transport refined metals to settlement	Transit	10
Refining process/ Girder extruder/ Hull sheet manufacturing Factory (300m x 500m x 200m)	Fully automated refining & manufacturing factory requiring no assistance	Refining factory for raw asteroid materials which forms into alloy beams with packing onto cargo transports/extrudes metals into long framework parts/construct sheets of hull from elemental & compound materials	On-site Construction (Earth-Moon L_1)	1
Frame Placement & Arc Welding Robot (7m x 5m x 3m)	Moderately small robots which group task to build the structural frame	Constructs & welds structural frame	On-site Construction (Earth-Moon L_1)	300
Hull-Sheet Placement Robot (10m x10m x 2m)	Individual robots that attach the sheeting	Places & secures hull sheeting with RTV-3145 adhesive	On-site Construction (Earth-Moon L_1)	200
Utilities Installation Robot (3m x2m x 2m)	Adapted F1M8 robots	Installs utilities & transport corridor infrastructure	On-site Construction (L1)	300
Contour crafting Machinery (Refer to *Section 5.2.2*)	Gantry machinery	Contour layered materials build houses & buildings	On-site Construction (Earth-Moon L_1)	100
Interior Furnishings Robot (IRF-F1M8) (0.7m x 0.6m x 1.4m)	Adapted F1M8 robots	Installs finished surfaces & furniture using innovative materials (Refer to *Section 3.5*)	On-site Construction (Earth-Moon L_1)	200

Table 5.1: Designation of Automation Requirements for Construction

The refining process factory, girder extruder factory and hull sheet manufacturing factory are three separate industrial operations that will be conducted within the same housed vicinity. Once construction is completed, the facility can be retrofitted for the settlement in the industrial sector of *Hephaestus*. The automated mining equipment and machinery can also be utilised in later industrial operations (Refer to *Section 5.5*).

5.2 Facility Automation

5.2.1 Automation Systems for Repair & Safety Functions

Despite the first-class construction of settlement structures and furnishings, accidental damages are inevitable. Contingency plans have been designed to deal with any feasible scenario, the responses of which includes automated and structural features.

The Internal Quick-Response Robot (IQR-F1M8) is primarily designed to clear and repair damaged furnishings of residential facilities, as well as minor/moderate structural damage. With the ability to group task with multiple units, the IQR-F1M8 (0.5m x 0.4m x 1.0m) features laser cutting implements, storage capacity for materials, welding equipment, wiring capability, extendable work platform and interface capabilities with other automated systems. These capabilities allow the IQR-F1M8 to 'interact' with its environment providing a more effective method of restoration.

In the event of an impact with the settlement which creates multiple hazards such hull breach and damage, atmospheric contamination and fire, all systems work simultaneously to ensure the safety of the residents. A key automated process is the formation of the sealant resin (Refer to *Section 2.1.2*). Once formed, the resin provides a temporary breach repair, until EERR-F1M8s (Refer to *Section 5.2.3*) can permanently repair the hull.

Hazard	Primary Response	Secondary Response
Fire	Alarms sound, fire sprinklers activate	Residents evacuated to safe distance
Hull Breach	Polyurethane resin forms sealing breach	EERR-F1M8 deployed to repair breach
Atmosphere Contamination	Alarms sound, sector evacuated	Contaminated gases are discharged & replaced
Hull Damage	Alarms sound, sector evacuated	EERR-F1M8 deployed to repair damage
Data Storage Damage	Backup data devices with settlement system files & programmes activate	System data is continuously transmitted to other settlements & Earth
Solar Flare	All external structures & devices are radiation shielded	EERR-F1M8 deployed to survey potential damage to settlement

Table 5.2: Backup Systems and Contingency Plans

Operation	Requirement	Robots/Automated Systems	Computers
Power Generation	Power Allocation	N/A	Directs power storage
	Reactor Activities	Control Rod	Monitor power input/output
Settlement Control	Navigation	N/A	Coordinates movement
	Maintaining Orbit	N/A	Manages rotational equilibrium
Structural Monitoring	Hull monitoring, repair & dynamic positioning	Emergency External Repair Robot (EERR-F1M8)	Sensors hull status & alerts on breach
Communication	Satellite positioning	N/A	Monitors location
	Encryption & Data Security	N/A	Encrypts data transfers & restricts access
	Communication Logging	N/A	Records all sent/received packets
Cargo Handling & Docking	Control Cargo Storage & Docking Procedures	Mechanical arms & chutes	Logs & coordinates docking & storage activities
Agriculture	Growth Monitoring	N/A	Monitors agricultural growth
	Packaging & Processing	Agricultural Packing Robot (APR-F1M8)	Manages processing facilities
	Transporting Processed Food	Chutes/delivery systems	Coordinates delegation of processed food

Water Management	Water Purification	N/A	Monitors water purification systems
	Storage Management	N/A	Logs & manages storage usage
Waste Management	Cleaning Public Toilets	Self cleaning toilets	Monitors/cleaning schedule
	Separate collected waste into waste types	Automated sorting system	Monitors waste delegation & alerts of breaches
Industrial Processes	Mining Ores & Transporting Materials	Mining/transportation robots (MTR-F1M8)	Manages schedule
	Processing & Storing Ores	Automated refining systems	Monitors progress/safety
Climate Control	Controlling Gas Ratios in Atmosphere	N/A	Sensors monitor atmosphere
	Changing Seasons	N/A	Preset programming initiates seasonal changes
Safety & Security	Monitoring all Critical Areas	N/A	Monitors restricted access/records data
Community Repair & Maintenance	Internal Repair	Internal Quick-Response Robot (IQR-F1M8)	Scans for internal damages
	Community Maintenance	Community Maintenance Robot (CMR-F1M8)	Monitors community upkeep
	Household Upkeep	Domestic Task Robot (SCRUB-F1M8)	Preset programming by home-owners

Table 5.3: Automation Requirements for Settlement Operations

5.2.2 Physical Locations of Critical Functions

Within the settlement, computing hardware rooms will house networking facilities and data storage devices. These critical functions are located in utility corridors beneath the residential level and are accessible to repair robots, as well as engineering specialists if required. All rooms are shielded as to protect hardware from electromagnetic radiation, and temperature and humidity is controlled to maintain optimum performance.

The Human Control Centre (HCC) is the commanding centre for all computing data which can override external control in critical circumstances. It houses full human support for all communication systems. Storage facilities for robots are adjacent to these rooms and are accessible via restricted elevator shafts from the residential level. Robots that are housed include spare domestic robots, residential repair robots and contour construction robots. These facilities allow for the robots to be repaired and stored when not in use.

All computing hardware rooms are equipped with a terminal server, which are specialised computers used to upgrade or repair the network. These external computers are Household PCs (Refer to *Section 5.3.3*), which act as terminals to remote sources. They are either hard-wired or wirelessly connected to the network creating a fully operation service to all residents.

Magellan Electronics Systems Group's research on data storage has led to the development of new Solid State Disc (SSD) memory devices. Advantages of SSDs include the ability to recover data, withstand harsh conditions and short latency times. The settlement's system and programming data is continuously backed up in real time, being transmitted to Earth and other space settlements. Thus data can be instantaneously restored in the unlikely event of an accidental memory failure.

5.2.3 Emergency External Repair Robot

Due to the nature of the space, the hull is exposed to impact and other threats of destructive nature. Despite safety measures designed to evade these hazards, we have implemented a contingency. An Emergency External Repair Robot (EERR-F1M8) has been designed to repair any hull damage that may be incurred. Tasks of the EERR-F1M8 include repairing hull punctures and removing contaminates such as H_3 build up from solar winds or a build up of dust.

The EERR-F1M8 (3m x 4m x 0.7m) uses eight articulated arms that attach to the hull and function independently in pairs to reposition. This durable robot has payload capacity as well as numerous attachments that can allow for different tasks that may be encountered. Using cooperative programming between different events the EERR-F1M8 can group task to complete repairs more rapidly. The EERR-F1M8 is powered by a radioisotope thermoelectric generator allowing a long practical working life without need for recharging. The generator can be replaced once depleted.

To ensure that the EERR-F1M8 can function during phenomena such as solar flare activity, the protective shell and internal components are radiation hardened. These high-energy subatomic particles can cause damage and a range of techniques such as coating computing hardware with a borophosphosilicate glass layer or silicon oxide are employed to negate their affects.

5.2.4 Security Measures

Figure 5.1: Artist's Impression of IAR-Ring

Security of personal data and restricted areas in the settlement is vital in ensuring the safety of all residents. Biometrics, specifically intrinsic physiological traits and behavioural traits, will be used to secure all devices and systems to which a resident may have access. All aboard *Bellevistat* will have a certain level of clearance depending on their role within the settlement. This system is to ensure the protection and function of all sectors in the settlement, namely robotic and computing control. The three major levels of security have been selected to provide sufficient precautions against illegal access, allow authorised personnel access and to protect all residents while not baring any unnecessary hindrance to everyday activities. All personal identity data, stored in the database, is protected with disc encryption to prevent possible identity theft. These security protocols will be employed in such procedures as computer and robotic facility access, residential premise entry and personal device access (Refer to *Section 5.3.3*).

IAR-Rings will be supplied to all patrons aboard Bellevistat. These rings are designed, with a unique electronic chip device installed, for each resident or transient so as to ensure that a redundant method of personal identification will always be available. The electronic chip will contain personal identification and will allow access to the personal desktop and higher-level security systems in the settlement dependent upon their security clearance. The chip can only be accessed and changed by qualified *Bellevistat* personnel. The IAR-Rings are designed to appeal to both sexes and all ages; with each one able to be personalised at the owner's disposal. The transient populace will be issued with an IAR-Ring upon arrival, which will be redeemed upon departure to be modified, repaired (if needed) and issued to the next arrivals.

The utilities sector for the most part controls all robotic systems as well as the computing network throughout the settlement. To ensure the upmost safety for the settlement, security personnel constantly monitor these crucial systems. All entries are recorded so as to prevent an abuse of security privileges by high authorities.

	Level 1 – Low	***Level 2 – Medium***	***Level 3 – High***
Access	Residential Access	Non-essential Functions	Critical Functions
Clearance	Residents & Transients	Settlement Personnel	Specialist Personnel
Biometric Safety Measure	Fingerprint authentication	Pass code Fingerprint authentication	Retina & Iris Recognition Pass code Fingerprint authentication

Table 5.4: Settlement Security Protocols

5.3 Habitability & Community Automation

5.3.1 Automation Systems to Enhance Liveability, Productivity & Convenience

While the settlement is primarily industry focused, the comfort and productivity of residents is imperative. The development of the Personal Climate Control (PCC) system provides the population with the ability to access a control system through their Household Personal Computer (HPC) (Refer to *Section 5.3.3*) and Individual Communications Device (ICD) in order to modify and control certain aspects of their environment freely. This includes functions such as air temperature control, air conditioning, humidity and other relevant atmospheric processes inside their accommodation.

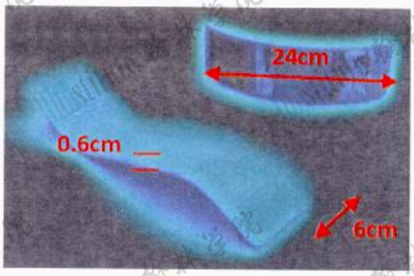

Figure 5.2: Artist's Impression of ICD Operating at Night

The ICD is a small, wireless communications device, which offers the populace the ability to connect to available communications facilities or networks anywhere in the settlement, increasing the convenience and speed for everyday life. Utilising 100 MB/s of wireless networks transmitted throughout the entire settlement, the ICD opens a communication network and can link to their home HPC, enabling control over household robot tasks. It can even access the Earth's Internet, employing OrbitLink Communications infrastructure.

Figure 5.3: Artist's Impression of Scrub-F1M8

Delegation of household chores and cleaning of the main sectors are given to the Domestic Task Robot (Scrub-F1M8). It will clean all surfaces, mop, scrub, vacuum, wash, sweep, dust and polish. Creating this system of control minimizes the necessity to waste human productivity on household maintenance as opposed to necessary occupation.

Problem	Solution	Justification
Temperature fluctuations	Climate control	Residents can control their personal home climate
Internal Communications	HCC	Monitors & controls wired & wireless settlement communications
Control of household	Electrical application controls	Controlling of all electrical applications through the CLEM
Household tasks	Scrub-F1M8	Allows energies for more productive activities
Communication	ICD	Wireless communication & internet access device
CLEM Access	HPC	The CLEM network is accessible through a HPC or ICD

Table 5.5: Automations to Increase Liveability, Productivity & Convenience

5.3.2 Automation to Perform Maintenance & Reduce Manual Labour

To maintain settlement functionality, utilising the balance of both man and machine is vital. Hence the settlement will employ numerous automated systems in completing many simple routine tasks to reduce manual labour. Automated robots, performing tasks such as internal repairs on structures and other residential estates would perform the general maintenance of the settlement. In addition, they will also locate and repair any mechanical or structural flaws in the residential sectors.

Having automated services to perform routine tasks in or around residential area's will save human resources and increase productivity. Monotonous tasks such as household cleaning will be completed by the Scrub-F1M8, while maintaining the high standards of the community's appearance will be completed daily by fleets of Community Maintenance Robots (CMR-F1M8). The CMR-F1M8 (0.6m x 0.7m x 1.2m) features cleaning capabilities and in conjunction with the IQR-F1M8 can commit to large-scale restoration projects. Residents can control authorised automated systems through the PCC system for personal benefit. To further enhance productivity, the ability to customise settings can be applied to any personal automated device or system, thus saving time and effort.

Despite the use of robotics in cleaning and maintenance duties, automation in most other occupations that traditionally require large amounts of manual labour is also imperative. Simple yet time consuming tasks for humans, such as food growth and production, waste management and industrial processes are almost completely automated (Refer to *Table 5.3*).

To significantly reduce labour intensive construction processes, contour crafting will be employed. Primarily used to construct modular buildings, the gantry structured automated machinery squeezes layers of semi-liquid construction material. This solution of regolith and various other materials is laid according to pre-programmed plans of the building. Contour crafting is a relatively swift process, and with multiple gantries operating, many buildings can be constructed in a short period of time.

5.4.3 Access to Computing & Robot Resources

The primary access for computing use by residents will be through a Household PC (HPC). HPCs (50cm x 90cm x 3cm) are installed in personal dwellings, and are multi-touch variable transparency glass monitors that are hard-wired to the *Bellevistat's* Metropolitan Area Network (MAN) across a 10GB/s grounded fibre optics cable. The HPC terminals also offer residents access to the CLEM system where as they can control and customize almost every function in their personal environment.

Throughout the settlement, a wireless connection between the ICD and HPC offers a phenomenal communication portal. This connection will also be able to connect to resident's personal PCC system, so control of robots and automatic systems are accessible from any point in the entire settlement. Further, there is a connection to Earth's Internet through the use of OrbitLink Communications and laser beam connections. This network will then be transferred through a strict firewall and anti-virus system to ensure the private server remains secure and stable. Within the hotels, there will be PC rooms for access by the transient population.

Information confidentiality for residents and transient population is paramount in the settlement and several contingencies have been prepared in the case of a privacy breach. Any classified personal data will only be stored physically in secure drives. This data will remain encrypted and will not be available to any personnel unless they provide an authorized AIR-Ring and have access to the designated HPC.

Figure 5.4: Bellevistat's Metropolitan Area Network

5.4 Interior Construction Automation

Figure 5.5: Interior Furnishings Robot

Aboard *Bellevistat* the construction of interior furnishings of houses will require advanced robots in order to establish the installations and maintenance procedures. The Interior Furnishing Robot (IRF-F1M8) constructs the inside main frames. The Utilities Installation Robot (UIR-F1M8) installs and maintains the main computer and electrical wiring, plumbing and lighting of fixtures. The last robot, the Furnishing and Upholstery Robot (FUR-F1M8) constructs and distributes the furniture and also maintains the upholstery. These robots are all automated with the ability of group tasking, needing little human control. However, authorised personnel in the main computer and robot control sectors will monitor these robots. It is estimated that WITH the assistance of these robots interior construction will take approximately 12 months.

Robotic System	Tasks	Location	Quantity
IRF-F1M8 (0.7m x 0.6m x 1.4m)	Interior Furnishings Robot. Installs finished surfaces & furniture using innovative materials (Refer to *Section 3.5*)	Onsite Construction (L_1)	10 000
UIR-F1M8 (0.4m x 0.4m x 0.6m)	Utilities Installation Robot. Installs and maintains plumbing fixtures, computer and electrical wiring, lighting fixtures.	Onsite Construction (L_1)	1000
FUR-F1M8 (0.7m x 0.6m x 1.4m)	Furniture & Upholstery Robot. Constructs and places furniture and maintains upholstery	Onsite Construction (L_1)	1000

Table 5.6: Automations to Increase Liveability, Productivity & Convenience

5.5 Mining Automation

The refining and manufacturing of mined ores from surrounding asteroids is one of the primary industries of the settlement, providing the Foundation Society with multiple business opportunity. To ensure the productivity of the mining operation is at a maximum, asteroid mining will be fully automated. This includes both construction material mining and post-construction mining.

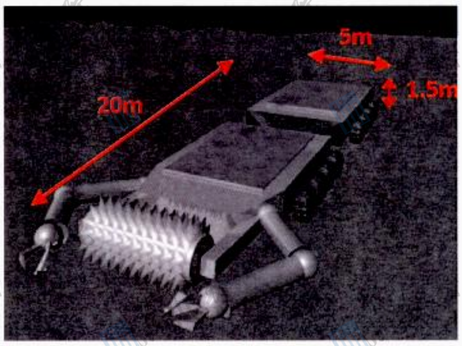

Figure 5.6: Automated Mining Robot

In the construction phase of the settlement, mined materials from asteroids will be processed and refined on-site before being transported to the construction location. To continue the productivity of the mining operations during the changeover period between construction and settlement operation, the initial automated systems and machinery will still be utilised. Such methods will enable minimal interruption concerning mining efforts.

The *Lyell* Mining Facilities (Refer to *Section 2.4*) will be the primary mining facilities, in addition to providing human control facilities for control and monitoring of secondary mining robots. The Asteroid Mining Robot (DIGGER) is pre-programmed to operate on the various types of asteroids and mine various ores. These robots use borehole and road head mining techniques so as to mine metallic ores from asteroids and return to the *Lyell* Drilling Rig. DIGGERs are fully automated, requiring no human controllers. However DIGGERs will be monitored by the three personnel aboard the *Lyell* Drilling Rig.

All mined ores will be transported to the settlement by the use of cargo transports, Grumbo Jumbo Mk II-a. These craft are manned by four maintenance and controller personnel to ensure the safe passage of materials. All mining operations are externally monitored by analysts in the HCC (refer to *Section 5.2.2*).

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6.0 COST

"No cost is too heavy for the preservation of one's honor."

– Mahatma Gandhi

6.0 Scheduling & Cost

Stage	Description	Cost ('000 000 USD)
1	Award contract	-
2	Develop Final Design	1
3	Develop Computer Programs for *Bellevistat*	2
4	Design Robots and operations for *Bellevistat*	3
5	Using a Space tug pull asteroid to L_4 construction site	-
6	Begin Mining Raw Materials on Earth	10
7	Ship Materials and specifically designed F1M8s to Asteroid	2000
8	Mining Facilities are set up on asteroid	13000
9	Workers are sent to asteroid to oversee construction of mining facilities	1000
10	Solar cells are manufactured	25000
11	Mine asteroid and assemble initial construction components	10000
12	Construct initial stages of *Bellevistat* and *Hephaestus*	22000
13	Solar cells are transported to location and solar farms Solaris are manufactured and deployed	3000
14	Begin storing power generated from solar farms in multiple SMES storage devices	8000
15	Construct temporary accommodation within *Hephaestus*	2000
16	Ship all workers and engineers to oversee construction of main settlement	10000
17	Construct port facilities on exterior of ring	15000
18	Construct entire industrial ring	35000
19	Nuclear power station construction as back up power source	6000
20	Construct the first stage of the residential section and agricultural sector	35000
21	Move all workers to residential sector and convert back temporary sector	22000
22	Complete all industrial sectors and bring zero gravity online	4000
23	Begin refining materials as first Industrial section is fully operational	15000
24	Develop all remaining automations and robots including EERR	20000
25	Attach chevron mirrors to exterior of *Bellevistat*	10000
26	Construct MDS Rails Between the two rings	18000
27	Complete all testing in industrial sector and introduce airlocks	2000
28	Employ contra-rotating mechanisms on separate rings	75000
29	Begin large scale manufacturing and bring all industrial sectors online	12000
30	Construct final stages of residential and commercial sectors	27000
31	Perform interior design and generate communities and themes inside the residential sector	56000
32	Install computer interfaces into residential and agricultural sectors	3000
33	Install all internal transport and operations into residential sectors	25000
34	Implement dust prevention systems within port facilities	6600
35	Complete all testing and air locks in agricultural and residential sectors	11000
36	Pressurise residential and agricultural sectors	12000
37	Complete town planning and interior design on final residential sections	42000
38	Complete commercial sectors and prepare business for operations	9000
39	Install and check all security and maintenance functions	4000
40	Transport all residents to *Bellevistat*	8000
41	Populate entire space station and allow tourism industry to begin	13000
	TOTAL	**$581,616**

Table 6.1: Construction Costs

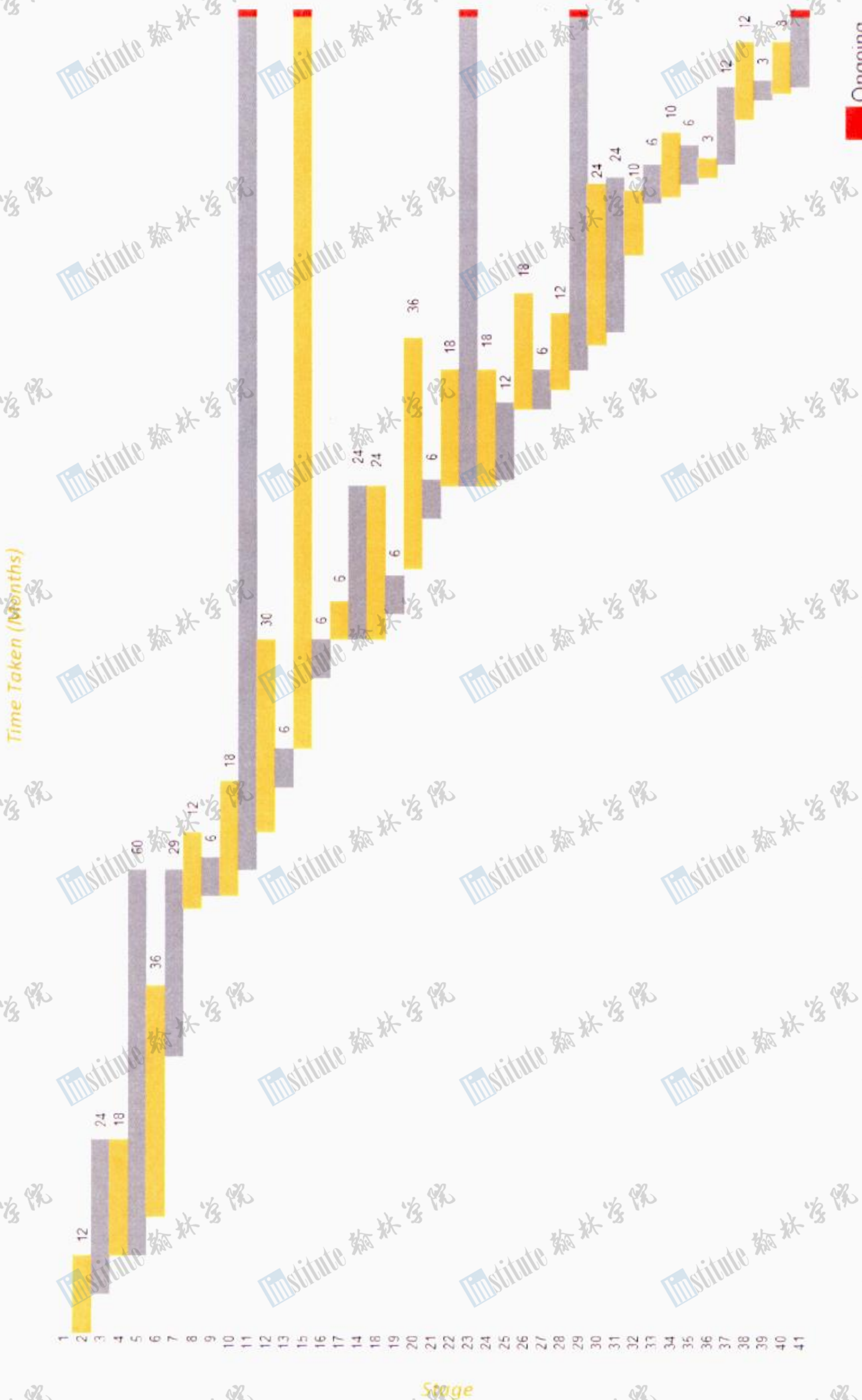

Figure 6.1: Gantt Chart Depicting Time Taken for Settlement Construction

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7.0 BUSINESS DEVELOPMENT

"The greatest gain from space travel consists in the extension of our knowledge. In a hundred years this newly won knowledge will pay huge and unexpected dividends."

— Wernher von Braun

7.0 Business Development

With the initial success of *Alexandriat*, the first Foundation Society settlement located within Earth's orbit, continuing business opportunities have expanded predominantly in the harvesting, refining and manufacturing raw space materials for commercial sales to Earth and existing and future space settlements. *Bellevistat* will host a variety of commercial and industrial endeavours that will generate substantial profit margins for the Foundation Society. The space station has been designed with commercial and industrial expansion of paramount importance – hence, both of these sections will be able to grow and evolve with the imminent success of the space trade.

7.1 Major Business Pursuits

Three major business pursuits will be engaged upon within *Bellevistat*, in the forms of harvesting and refining of extraterrestrial materials, space manufacturing and tourism.

Harvesting, refining and manufacturing operations will operate within *Hephaestus*, the stationary outer ring, whilst elements of tourism will be accessible throughout the entire space station. Industrial processes will be conducted under the influence of zero-gravity, which will cut running costs by allowing the machines to work at a heightened level of efficiency. It is economically viable to operate industries in space because of the minimization of costs in comparison to Earth-bound industries. The majority of the industrial work being done by automated systems so as to streamline the industrial and refining processes. Within the vacuum of space, mineral-rich asteroids are abundant and can be efficiently mined and refined for a fraction of the cost of their Earthly cousins, without the issue of environmental degradation.

Harvesting and refining are not the only endeavours that *Bellevistat* will encompass, as it plans to be a major tourism destination for wealthy customers wishing to vacation in space. Figures taken from *Alexandriat* predict that tourism on *Bellevistat* will be very successful, with predictions of it contributing up to 15.5 billion USD to *Bellevistat's* annual income. Natural views of Earth and the lure of zero-gravity will enable *Bellevistat* to draw multitudes of tourists, as will expeditions exploring the unique mining, refining and manufacturing capabilities of *Bellevistat*. It is predicted that this enhanced tourism industry will provide an influx of cash into the space settlement to help provide financial growth for the Foundation Society.

7.2 Extraterrestrial Materials Harvesting & Refining

The establishment of sufficient harvesting outposts to begin the collation of rare minerals and ores will be one of the major goals of the *Bellevistat* Space Settlement. A small asteroid will be captured upon the initial stages of the construction of the *Bellevistat* and placed into the orbit of the space settlement with mining outposts constructed to begin harvesting of space materials. The capture process will be contracted out to Vulture, as Magellan does not specialise in that particular aspect of asteroid mining. The asteroid will be replaced after its purpose has been fulfilled and new ore deposits are required. The asteroid will be captured from its location and transported to *Bellevistat*; the ideal size of the asteroid would be approximately one kilometre in diameter. This placement of the asteroid will reduce the cost of travelling to potential mining outposts and the cost of delivering the goods back to *Bellevistat*.

Bellevistat will export both refined and raw materials back to Earth, targeting all business demographics whilst fulfilling each business' individual requirements. *Bellevistat* will pioneer an experimental one-way delivery vehicle to transport the exports to Earth. This vehicle, named the Asteroid Transportation Utility Vehicle (ATUV) will be constructed completely from the mined materials. Triangularly shaped, it will contain rudimentary airspeed and direction control systems for piloting purposes during re-entry. Reusable engines will be attached so that it can travel in a transfer orbit to an intermediate station situated within a low Earth orbit. Once the vessel arrives at this checkpoint, the engines will be detached and sent back to the settlement on the next available Grumbo Jumbo Mk III (Refer to *Section 3.3.3*). From here, the ATUV will be launched towards Earth at the appropriate using external infrastructure, so as to minimise material consumption. Upon re-entry, it will navigate towards its designated landing area where it will touchdown and deploy parachutes.

The ATUV will have a payload of approximately 257 000 kg. As the ATUV is a single-use vessel, its hull has been designed so that it is able to be deconstructed and reused, maximising material yield per vehicle. Its components will be robotically manufactured within *Hephaestus*, before being formed together within the dry-docks surrounding the settlement. The ATUV will be comprised of a metallic core structure (which can be adapted depending upon availability of material between) and an outer layer of ceramic heat-shields. These will be comprised of reinforced carbon-carbon and high-temperature surface insulation tiles.

Due to the nature of the ATUV, it will be controlled remotely, and as such will remain in communication with *Bellevistat*, the intermediate LEO station and an Earth control base.

7.3 Space Manufacturing

The biggest commercial venture that will be undertaken by *Bellevistat* will be the manufacturing of raw space materials into exportable goods for economical gain, making up 73.2 percent of annual revenue for the settlement. *Bellevistat* will house industrial facilities used for the refining of raw materials into metals used to manufacture spacecraft and other contrivances. These facilities will allow for manufacturing and assembly within zero-gravity so as to provide increased efficiency and cost-effectiveness, maximising dividends. Launch vehicles, Lunar Landers, inter-planetary craft and service and utility vehicles will be constructed and serviced within the dry-docks of the settlement and will provide expansion capabilities for humankind.

The manufacturing industry of *Bellevistat* will also provide materials and products that will be utilised for the creation of future settlements throughout the void of space. When necessary, specific sectors will be able to work together to produce construction robots and components for these settlements that can be assembled and positioned. It will provide pre-existing infrastructure that will ease the costs of other large projects.

Vehicles and goods required for other projects will be able to be constructed within the confines of *Bellevistat*. These will include solar power and communications satellites, as well as vehicles required for use on lunar terrain.

7.4 Tourism

Harvesting, refining and manufacturing are not the only endeavours that *Bellevistat* will undergo, as it is planned to become a major tourism destination for wealthy customers wishing to go on vacation in space. It has been anticipated that tourism aboard *Bellevistat* will be very successful as multitudes have shown interest in holidaying on *Alexandriat*. We foresee the settlement as a major success in the tourism industry, and therefore will be providing a resort and activities to attract potential adventurous customers. Resorts will be located in the residential sections of the settlement and will house public parks, restaurants and other amenities for use by both vacationers and permanent residents. Along with all these activities are the resort facilities, which will include a connection to Earth's internet and pools.

Activity	Price
Space Walk	$300 per person per 20 minutes
Space Shuttle Rides	$400 per person
Zero G Ball Games	$100 per person
Play Zero G Ball	$350 per person
Universal Telescope	$50 per person
Tour of Facility	$75 per person
Movies	$20 per person
Gyms	$30 per person
Restaurants	N/A
Parks	Free

Table 7.1: Cost of Activities about Bellevistat

The most appealing attraction *Bellevistat* will have to offer is its magical views of Earth. As *Bellevistat* translates to 'beautiful view', it is only fitting that the views of Earth are provided free to all residents from designated lookout spots within *Hephaestus*.

Visitors will also be encouraged to view the industrial operations of the settlement including mining, refining and harvesting of the materials. Vantage points will be constructed at safe distances from the actual operations whilst still providing accurate views of the facilities. For a closer look at the industrial operations, the comprehensive tour of *Bellevistat* will take visitors through a tour of a specific industrial sector, showing them the different stages which result in the final manufactured products. The Space Walk and Space Shuttle rides will also give the tourists an outside vantage point of the settlement and give them the chance to explore space first hand.

Zero-G ball games are games which are played in micro-gravity and will add to the entertainment value, as they are expected to appeal to all demographics. They are able to be viewed by both residents and visitors to the settlement and it is an activity which is only undertaken on *Bellevistat*. Residents and visitors are also able to play Zero-G ball games and participate in competitions.

Visitors will be able to utilise an internet connection to Earth through their resort facilities to communicate with Earth. Visitors will also be provided with a ICD for their personal use for the duration of their stay on the settlement.

Through this enhanced tourism industry it is hoped that the influx of economy due to tourism will provide beneficial cash flow into the space settlement to help provide financial growth for the Foundation Society.

7.5 Leasing of Facilities & Future Subcontracting

A large portion of the industrial sector will be able to be leased out to prospective companies who require the particular environment of space for the manufacturing of their product/s. Various businesses have already expressed interest in purchasing construction space upon *Bellevistat*, including Tanks-A-Million and Lossless Airlocks, which Magellan predicts will gain 9.68 billion US dollars per annum for the Foundation Society.

The presence of these companies will provide long-term revenue for the Foundation Society as well as providing expansion for the space manufacturing industry, and will ultimately ensure a financially stable future.

Bellevistat will prove to be a necessary stepping stone in the effort to colonize space, as it will be able to subcontract out specialized equipment to companies interested in building space settlements. These settlements will require equipment similar to that of cranes, bulldozers and mining equipment as well as space craft to move goods. This specialized heavy machinery will be constructed in advance from the mining of materials on *Bellevistat* and will aid in the construction of the settlement whilst providing a stable future for its residents.

7.6 Business Pursuits & Goals

All of these pursuits will be aimed at ensuring the economical sustainability of *Bellevistat* by providing a steady source of income to the Foundation Society. This will combat the price that will be incurred during the construction of the settlement. Along with these endeavours, a series of other ideas will be implemented to create income throughout the production in the early stages of construction.

These will include the entire space settlement to be built in parallel so to dramatically cut down the time expenditure outlaid and ensure that it will be completely functional in a shorter amount of time, thus, enabling it to be generating maximum revenue sooner. The settlement's residential section has also been planned to be built in sections in an effort to enable earlier settlement of workers and residents into *Bellevistat*. This will attain income before the entire settlement is complete and will also give workers a safe place to live whilst the entity of the project is completed.

The major contributors to the financial success of *Bellevistat* will undoubtedly be the harvesting and refining of raw materials for exportation to Earth and future space settlements, the manufacturing of space materials and vehicles for use in future space industry and the growing space tourism industry which is booming amongst the wealthy on Earth. All of these endeavours coupled together will provide a predicted gross income of 175.5

billion US dollars per annum (net income of 60.65 billion US dollars per annum) into the new space settlement and will also ensure its requirement in future expansion into space.

Bellevistat is a major stepping stone into the colonization of space and will play an important role in the construction of future settlements. It will establish itself as a major asset to the Foundation Society and over time will generate enough revenue to pay for itself, provide adequate pay and facilities for its workers and ensure the financial stability of the Foundation Society.

Sub-Contractor	Job
BOREALIS: Vulture Aviation (through Litigation Limiters)	Harvesting of Earth-Moon L_5 comet
Flechtel Constructors (through Litigation Limiters)	Set up of refining and prospecting outposts on the asteroid
LightWorks	Purchase of *lunetta* for redirection of sunlight
Orbitlink Communications	Augmentation of standard communications channels between *Bellevistat* and Earth and other settlements
TRUE/GRIT	Recreational and tourism activities of settlement and surrounds
ZAP! Industries	Provides wire harnesses, fiber optics and systems for distribution of electrical power and electrical signals on the settlement; creation of solar cells
CRUX: Dougledyne Astrosystems (through Litigation Limiters)	Manufacture and install communication satellites allowing *Bellevistat* to communicate with Earth
	Manufacturing and installing solar power satellites to generate power
ORION: Rockdonnel (through Litigation Limiters)	Asteroid retrieval
	Supply of Lunar landing craft for mineral harvesting

Table 7.2: Subcontractors Utilised in Construction and Operation of Bellevistat

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8.0
Compliance Matrix

"An easy task becomes difficult when you do it with reluctance."

– Terence

8.0 Compliance Matrix

Section Heading	Requirement	Meeting of Requirement	Page Number
2.0	Room for 18,000 residents plus 1,000 visitors	*"...18,000 residents and 1000 transient population will be able to live comfortably within the luxurious confines of the settlement..."*	9
	Allow for natural view of space	*"...enjoying the beautiful vistas of Earth from the limitless freedom of space."*	9
	Overall exterior view of settlement, with major visible features	Refer to *Figure 2.1*	9
2.1	Purpose of each volume	*"...two innermost rings* Solinvictus *and* Balaat*...will house the residential, commercial and agricultural sectors...surrounding these rings will be the industrial sector, dubbed* Hephaestus*..."*	9
	Construction materials of major hull components	Refer to *Table 2.1*	10
	Rotating and non-rotating sections	*"...entirety of* Hephaestus *will remain stationary...[in] zero-G...1G at ground level of living area... outer floors housing agriculture and storage will experience a gravitational force less than 1.05G..."*	11
	Natural light	"...Chevron mirrors will be utilised to allow natural views and lighting of space whilst keeping ionising radiation out..."	11
	Supplying and maintain artificial gravity	*"...simulate gravity through rotation and the forces that it applies... need to rotate on their axes at a rate of 0.748 RPM... same centripetal velocity [125ms^{-1}] in opposite directions... dual connection that the IRTS uses can be utilised to create rotation of segments of the settlement..."*	11
	Pressurised and non-pressurised sections	*"...excepting only the mass-transit tracks, the entirety of* Solinvictus *and* Balaat *will be pressurised..."* *"...numerous port facilities...transportation routes...both of these regions will remain without pressure... stations that connect* Hephaestus *to the outer rings will remain pressurised...as will the rest of* Hephaestus*..."* *Refer to* Figure 2.1	13
	Radiation and debris protection	*"... Non-Explosive Reactive Armour (NERA)...first line of defence against impacts...Layers of polyethylene will be utilised to protect against radiation from the Sun and solar flares...Water will also be circulated in the interior of the hull as further prevention against radiation..."*	10

	Layout of interior land areas	*"The two rotating rings,* Solinvictus *and* Balaat *will specifically house agricultural and storage regions, as well as a conglomerate 'living' floor...Commercial, residential and recreational sectors will be integrated together...the outer ring,* Hephaestus, *will house all sectors of the settlement that are required to be within zero-G...includes heavy industrial, research, the port facilities and specific recreational areas"*	12-13
2.2	Use of micro-gravity and unpressurised facilities	*"...zero-G environment will aid in manufacturing because of the decreased weight of the materials, making them easier to transport as well as through the utilisation of unique techniques that are impossible whilst under the influence of Earth-like gravity... numerous port facilities...transportation routes...both of these regions will remain without pressure so as to eliminate air friction..."*	14
	Vertical clearance of each area	Refer to *Figure 2.4* and *Figure 2.5*	13-14
	Show total area of "down surfaces" and volume of settlement and uses of these areas	Refer to *Table 2.2*	113
	Drawings showing dimensions of areas designated for specific uses	Refer to *Figure 2.4* and *Figure 2.5*	13-14
2.3	Procedure in which settlement is to be constructed	Refer to *Table 2.3*	14-15
	Images of construction process	Refer to *Figure 2.6*	15
	Structural construction on an asteroid captured for harvesting of materials	Refer to *Figure 2.7*	16
2.4	Systems to minimise transfer of asteroid surface materials onto settlement	*"...mining facility will be purged of dust every two weeks...consists of running a series of electromagnetic pulses throughout the station...in between the fortnightly purges, the atmosphere will be extensively filtered so as to remove large amounts of dust before it has the chance to settle..."*	17
	Locations on settlement where ore refining operations will be conducted	*"...materials will be transported to sections of Hephaestus, where they will be refined into both base and alloyed metals..."*	16
2.5	Multiple (at least three) widely separated port facilities for redundancy	*"...A number of length-orientated docks will operate completely independently from one another, and will be further subdivided into 1km lengths with a separation gap of 10 meters. Twelve facilities will be located around the entire circumference of the settlement to*	17

		increase the number of exit routes for residents in the event of an accident. Thus, a total of 20 separate docking facilities... each of the hangers will contain dust-decontamination and loading/unloading facilities..."	
	Location of port facilities so as to avoid damage to pressurised volumes if deviation of vehicle flight paths occurs	*"...as craft enter lengthways into the non-rotating volume, deviation in three of the four possible entry vectors will result in only collisions within empty space. Divergence in the fourth direction will result in an impact with the heavily protected hull of the industrial sector of the station, the inoperation of which will result in minimal disruption of routine activities on the settlement..."*	17
	Community infrastructure	*"...settlement will possess the necessary systems and infrastructure so as to make certain that the highest standards of living and safety are available for all of its occupants..."*	19
3.0	Conduct of business	*"...providing a fully functional business enterprise for the Foundation Society..."*	19
	Accommodation of incoming/outgoing space vehicles	*"...to accommodate the large influx of incoming and outgoing space vehicles, numerous docking facilities will be located around the perimeter of the station..."*	19
3.1	Identify an orbital location for *Bellevistat*, and reasons for selection	"...the location chosen for the placement of *Bellevistat* will be the Earth-Moon L_4...situated within the Moon's orbit, allowing the transportation of supplies, residents and materials between the settlement and lunar colonies..."	19
	Identify sources of materials and equipment to be used in construction and operations	*Refer to* Table 3.2	19-20
	Infrastructure required for food production	*"...meat to be consumed by residents aboard Bellevistat will be 'grown' using in-vitro techniques...crops will be grown using zeoponics, where plants are cultivated in an environment rich in zeolites..."*	20-21
	Infrastructure required for electrical power generation and distribution	*"...required power will be derived from solar, with the remainder being generated by nuclear, with any excess being stored in multiple Superconducting Magnetic Energy Storage (SMES) devices..."*	21
3.2	Infrastructure required for internal and external communications	*"...internal communications will be provided by the availability of the Individual Communications Device (ICD)......external communications between the settlement and outside locations, such as approaching spacecraft and the surface of Earth will be carried out through laser communications..."*	21-22
	Infrastructure required for internal transportation	*"...opted to use Electro-Magnetic Suspension (EMS) powered Magnetically Levitated*	22

	systems	*(Maglev) trains and lifts in order to fulfil the requirements of intra-ring transit...within each of* Balaat *and* Solinvictus*, two tracks each carrying five three-car trains travelling in alternating direction will be located beneath the surface within a specified transportation route...stations will be located every 800m within each ring..."*	
	Define Rights-of-Way	*"...trains located upon the same track will act in synchronicity with one another so as to prevent bottlenecks from occurring..."*	22
	Infrastructure required for atmospheric/climate/ weather control	*"...atmospheric composition will be of similar nature to that of the Earth's...will simulate the four seasonal changes of Earth, each season with their own climate and weather differences...weather will be simulated by a series of water-vapour dispensers with adequate temperature and humidity control..."*	23
	Infrastructure required for household and industrial waste management	*"...waste will be transported to a waste depositary via vacuum tubes, where it will be sorted by an automated system depending upon type of waste...will then be recycled using conventional techniques for that type of material..."*	23-24
	Infrastructure required for water management	*"...[water] will be gathered from ice entombed within the lunar crust as well as from the ice-rich comet that is available for harvesting from* Vulture*, situated at Earth-Moon L_5... stored and circulated in the hull so as to prevent stagnation..."*	24
	Specify required water quantity and storage	*"...*Bellevistat *will require a total of 436.38 ML of water per day... contained in one of the inner layers of hull and segregated to reduce loss from small penetrations..."*	24
	Infrastructure required for day/night cycle provisions	*"...a sophisticated system utilising holograms and lighting will simulate a traditional day/night cycle for the residents...lunetta purchased from LightWorks will redirect natural light to the settlement when it passes behind into the Earth's shadow..."*	24
	Define transportation corridors	*"...within each of Balaat and Solinvictus, two tracks each carrying five three-car trains travelling in alternating direction will be located beneath the surface..."*	22
	Diagram map to show movements of exports from source(s) to port facilities	Refer to *Figure 3.6*	24-25
	Diagram to show the location of infrastructure within the settlement	Refer to *Figure 3.7*	25
3.3	Table or chart describing space-based infrastructure	Refer to *Table 3.5*	26

	and vehicles required for settlement operations		
3.4	Account separately for production of feed and facilities for animals	Refer to *Table 3.7*	27
3.5	Designs and materials of furniture, interior finishing of residences, plumbing and kitchen equipment	Refer to *Table 3.8*	27
4.0	Traditional community attributes	*"...community reminiscent of earth...four residential sectors...*Balaat *will contain an ultra-modern theme, whereas the three segments of* Solinvictus *will host distinct Irish, French and Chinese districts, named* Tara, Sallavecu *and* Laotzu *respectively..."*	29
	Natural sunlight and views	*"...Chevron mirrors within the ceiling of the residential sector and specialised viewing areas will provide residents with natural sunlight and views of the surrounding space..."*	29
4.1	Consideration of psychological factors	*"...psychological factors are integral to maintaining mental health and wellbeing...compromise must be reached between a community reminiscent of Earth and one exhibiting the awe of space living... achieved through having 'ceilings' of 150m high within each of the four residential sectors..."*	29
	Medical Facilities	*"...*Bellevistat *will employ a number of defence protocols to restrict the spread of infectious disease within the settlement...sections of the community will be able to be easily quarantined...one hospital located within each of* Balaat *and* Solinvictus*...advanced medical equipment..."*	29
	Education	*"...the settlement will host one primary school and high school within each of the living rings, with a university located within* Balaat*...common curriculum will be taught throughout the schools, allowing for a consistent learning environment..."*	29
	Public areas designed with open space	*"...located in all four residential areas will account for approximately 27.2 percent of floor space and will include parks, theatres, sporting venues, cinemas and restaurants..."*	30
	Entertainment, parks and recreation	*"...facilities, located in all four residential areas will account for approximately 27.2 percent of floor space and will include parks, live theatres, sporting venues, cinemas and restaurants that tie in with the appropriate theme for that sector..."*	30
	Variety and quantity of consumables and supplies	Refer to *Table 4.2*	30
	Maps and illustrations of	Refer to *Figure 4.3*	31

	depicting community design, location of amenities, with a distance scale		
4.2	Interior and exterior house designs	Refer to *Figure 4.4* and *Figure 4.5*	31-32
	Number required of each residence design	Refer to *Table 4.4*	31
	Transient Residence	*"...seven hotels will provide temporary housing for up to one thousand guests..."*	32
	Area of residences in square meters	Refer to *Table 4.4*	31
4.3	Spacesuit designs	*"...two distinct space suit designs used in* Bellevistat *for both maintenance and industrial purposes...lighter Space Activity Suit, or Bio-suit will be mechanically counter pressurised with a gas-pressurised helmet...second suit, appropriate for more intensive or hazardous environments is a traditional gas pressurised suit has been adapted to fit with greater ease and cost and weigh less than other gas pressurised suits..."*	32
	Predictable movement and safely in areas of low gravity	*"...achieved in large, open areas, such as* Bellevistat's *docking bays, by the use of a hydrogen peroxide powered jet pack... In smaller areas, with little manoeuvrability, the use of permanent magnetic boots on the metallic floors will allow workers and residents to move safely and predictably...bars and rails will also be installed in areas of low gravity to aid in safe movement..."*	33
	Designs for systems, devices and vehicles considering enhancement of productivity for inside and outside including sizes	*"...workers...will make use of several important devices, the most notable being the Visual Communications Device...utility belts and tools will also be available for those engaging in physical work...forklifts and hydraulic trolleys will be required by agricultural workers so as to transport goods..."*	33
	Chart or table of major categories of work being done in and around the settlement	Refer to *Table 4.6*	33-34
	List tools required to do tasks	Refer to *Table 4.6*	33-34
4.4	Different neighbourhoods to suit a variety of preferences for architectural design and lifestyle choice	Refer to *Table 4.7*	34
	Identify location and sizes of different neighbourhoods	*"...*Balaat, Tara, Sallavceu *and* Laotzu *will have styles of Ultra-Modern, Ireland, Southern France and Chine respectively, with modular design...enabling effective development..."*	34
	Design and show design style	Refer to *Table 4.7* *"...major residential sector of the settlement,*	34

	examples from at least 3 different neighbourhood types	Balaat, *will be styled with an ultra-modern theme...use of slick angles and modern design of art deco...* Tara, *one of the three smaller residential sections of the settlement and a component of* Solinvictus *will have an Irish theme...historical design features... Styled after a Southern French theme,* Sallavceu*...replication of Southern French aspects, including lifestyle and commercial infrastructure...true Chinese style, both architecturally and life-stylistically,* Laotzu *will provide a traditional and simple way of living whilst still maintaining modern luxuries..."*	
	A variety of activities, entertainment, and recreational options	*"...tennis courts, basketball courts, swimming centres, sporting fields and open spaces... space-exclusive activities, with zero-gravity sporting arena..."* Refer to *Table 4.1*	30, 35
4.5	The encouragements of physical fitness and mental stimulation of citizens	*"...recreation options will include conventional sports, as well as space-exclusive activities ... Parks and recreation areas will constitute approximately 15% of the settlement, with over $5 million spent annually to maintain to the quality of the communal areas..."*	35
	Examples of pastimes available for residents	*"...groups including yoga, martial arts, athletics and meditation available to all community members ... including bridge clubs, chess groups and monthly poker tournaments..."*	35
5.0	Computer systems	Refer to *Table 5.2*	38
	Robot designs	*"...robots aboard* Bellevistat *will be variants of Magellan's modular F1M8 robot..."*	38
5.1	Use of automation for construction	Refer to *Table 5.1*	38-39
	Automation for transportation and delivery of materials and equipment, assembly of settlement and interior finishing	Refer to *Table 5.1*	38-39
5.2	Automated systems for settlement maintenance	Refer to *Table 5.3*	39
	Physical locations of computers, servers & robots for critical functions	*"...critical functions are located in utility corridors beneath the residential level and are accessible to repair robots, as well as engineering specialists if required..."*	40
	Robots required for emergency external repairs	*"...Emergency External Repair Robot (EERR-F1M8) has been designed to repair any hull damage that may be incurred...tasks...include repairing hull punctures and removing contaminates such as* H_3 *build up..."*	41
	Means for authorized personnel to access critical	*"...three levels of security have been selected to provide sufficient precautions against illegal*	41

	data and command computer and robot systems	*access, allow authorised personnel access and to protect all residents..."* Refer to *Figure 5.1* and *Table 5.4*	
	Automation systems to enhance liveability in the community, productivity in work environments and convenience in residences	Refer to *Figure 5.2, Figure 5.3 and Table 5.5*	41
5.3	Use of automation (robots) to perform maintenance and routine tasks and reduce requirements for manual labour	*"...monotonous tasks such as household cleaning will be completed by the SCRUB-F1M8...maintaining...community's appearance will be...Community Maintenance Robots (CMR-F1M8)...simple yet time consuming tasks for humans like food growth and production, waste management and industrial processes are almost completely automated...to significantly reduce labour intensive construction processes, contour crafting will be employed..."*	42
	Access to community computing & robot resources from individuals' homes and workplaces	*"...primary access for computing use by residents will be through a Household PC terminal (HPC)...hardwired into* Bellevistat's *Metropolitan Area Network..."* Refer to *Figure 5.6*	43
5.4	Automated systems for finishing of interiors of residences and other buildings	*"..the construction of interior furnishing of houses will require advanced robots...the Interior Furnishings Robot (IRF-F1M8)...the Utilities Installation Robot (UIR-F1M8)...the Furnishing Upholstery Robot (FUR-F1M8)..."* Refer to *Table 5.6*	44
5.5	Automated systems for mining and transporting asteroid ores to refining facilities	*"...Lyell Mining Facilities...will be the primary mining facility...Asteroid Mining Robot (DIGGER)...uses borehole and road head mining techniques... Grumbo Jumbo Mk II-a...manned by four maintenance and controller personnel..."*	44
	Total costs that will be billed to the Foundation Society	*"565,800 million USD"*	46
6.0	Durations and completion dates of major design, construction and occupations tasks, depicted in a list, chart or drawing	Refer to *Figure 6.1*	47
7.2	Harvesting and transportation of extraterrestrial materials from a nearby asteroid	"...small asteroid will be captured upon the initial stages of the construction of *Bellevistat* and placed into the orbit of the space settlement with mining outposts constructed to begin the harvesting of materials...	49
	Design and manufacture vehicles to harvest the raw	"...*Lyell* mining facility will be fully equipped for the mining of asteroids...Asteroid Mining Robot	17-18, 61

	materials from the asteroids surface	(DIGGER) is pre-programmed to operate on the various types of asteroids and mine various ores..." Refer to *Figure 2.6* and *Figure 5.6*	
	Design one-way vehicles made from asteroid materials for transporting the raw materials from the asteroid and also space-manufactured products to Earth	*"...the Asteroid Transportation Utility Vehicle (ATUV) will be constructed completely from the mined materials. Triangularly shaped, it will contain rudimentary airspeed and direction control systems for piloting purposes during re-entry...* payload of approximately 257 000 kg..."	49-50
7.3	Space manufacturing of products, spacecraft, lunar landing and inter-planetary landing applications	*"...launch vehicles, lunar landers, inter-planetary craft and service and utility vehicles will be constructed and serviced within the dry-docks of the settlement and will provide expansion capabilities for humankind..."*	50
	Manufacturing facilities for future large projects	*"...manufacturing industry of Bellevistat will also provide materials and products that will be utilised for the creation of future settlements throughout the void of space...produce construction robots and components for these settlements that can then be assembled and positioned..."*	50
	Space manufacturing of vehicles for lunar construction projects	*"...able to be constructed within the confines of Bellevistat...include...vehicles required for use on lunar terrain..."*	50
7.4	Accommodate for tourism on *Bellevistat*	"...will be providing a resort and activities to attract potential adventurous customers...views of Earth are provided free to all residents from designated lookout spots..." Refer to *Table 7.1*	50
	Observation stations for tourists to observe mining, refining and manufacturing operations	*"...vantage points will be constructed at safe distances from the actual operations whilst still providing accurate views of the facilities... comprehensive tour of Bellevistat will take visitors through a tour of a specific industrial sector, showing them the different stages which result in the final manufactured products..."*	51

MAGELLAN

AUSTRALIA

9.0

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"Astronomy compels the soul to look upward, and leads us from this world to another."

– Plato

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