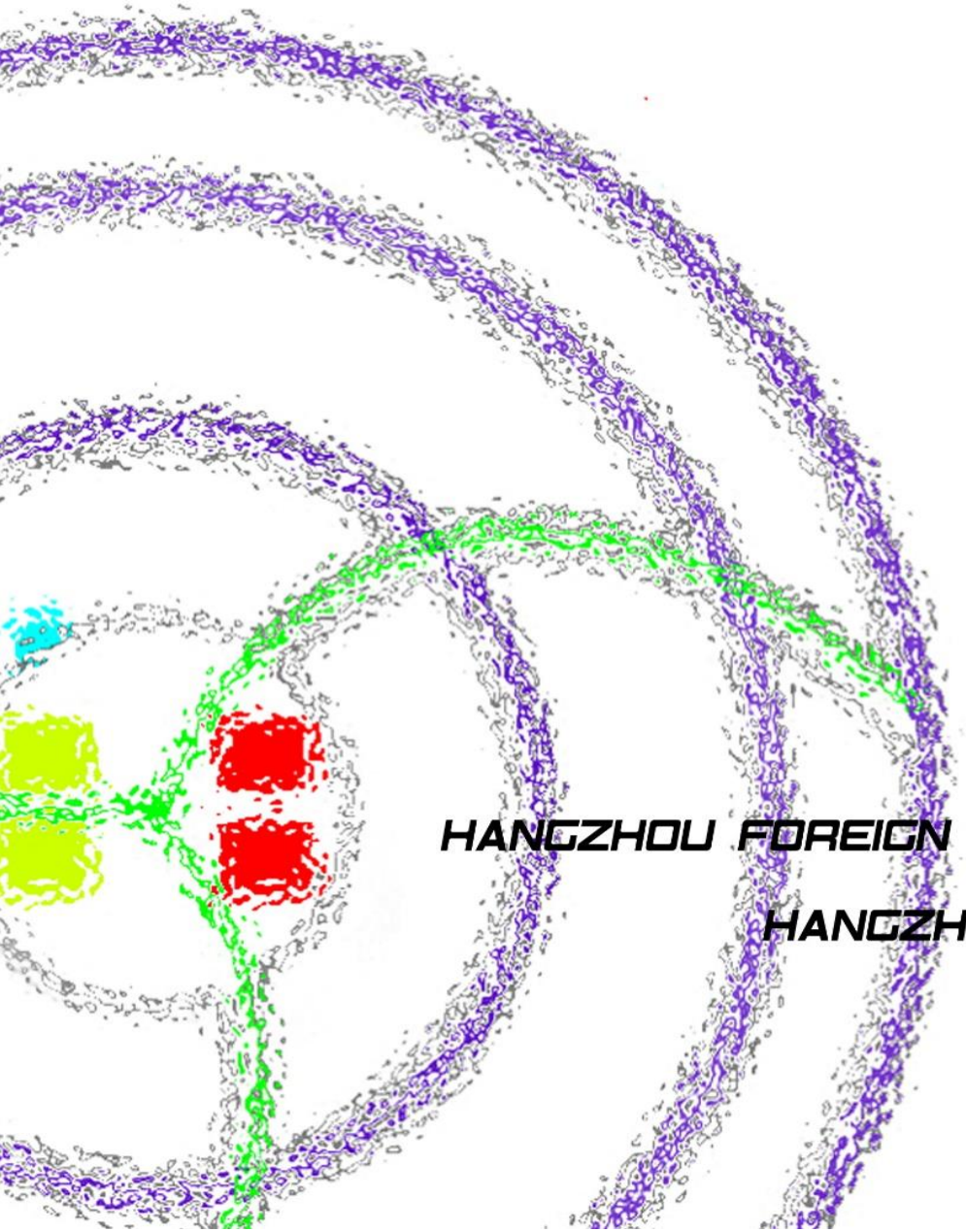
NORTHDONNING HEEDWELL PRESENTS

BELLEVISTA



HANGZHOU FOREIGN LANGUAGES SCHOOL

HANGZHOU, ZHEJIANG, CHINA

20th Annual International Space Settlement Design Competition
Proposing Team Data 2013

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Names, [grade levels], and (ages) of 12 students currently expecting to attend the Finalist Compe
(we request that participants be at least 15 years old, and not older than 19)

Chen Ziqi	[11] (17)	Zhang Dawei	[11] (18)
Feng Xinyi	[11] (17)	Bao Ziyu	[11] (16)
Liu Yushu	[11] (17)	Xu Qing	[11] (16)
Zhao Zhigen	[11] (17)	Ji Kangyu	[11] (17)
Lin Chengyuan	[11] (17)	Cai Tianyuan	[11] (16)
Liu Weidi	[11] (17)	Zhao Yunfan	[11] (17)

Names of two adult advisors currently expecting to attend the Finalist Competition:
JOHN TAYLOR AMANDA HARRIS

I understand that if our Team qualifies for the International Space Settlement Design Finalist Competition Aug. 2-5, we will pay for our own travel to/from Nassau Bay, Texas, USA.

Neil Cooper — Responsible Teacher/Advisor Signature
15/4/13 — Date

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Executive Summary

Executive Summary

We Northdonning Heedwell here proudly present our design of the space settlement, Bellevistat, in respond to the Request for Proposal by Foundation Society dated Jan. 3rd 2033. Northdonning Heedwell believes that the design addresses all the requirements exhaustively and presents compelling features through viable technology. Bellevistat will continuously generate considerable amount of profit for the Foundation Society by the mass-production of silicon buckystructure as well as by exploitation of the ores on the Moon and on asteroids, as carrying its primary mission of manufacturing after industry being launched. Beyond that, Bellevistat will provide its residents with a refreshing yet enjoyable environment of living, with comprehensive and human-oriented community design as well as convenient automation support. Moreover, Bellevistat will be highly self-contained in all aspects, including power generation, food and consumable production and orbital operation, except for the need of import of some raw materials for production.

Some of the salient features of Bellevistat are stated below,

•*Unique design* adapted in the docking system minimizes the energy lost and maximizes the efficiency.
•*Different residential, agricultural, and manufacture needs are satisfied* by the settlement design, in the form of a Centra connected to 3 concentric Tori providing 3 different gravities, 0.5g, 0.8g, and 1.0g.
•*An incredibly multifunctional personal terminal, Linka* connects all the residents with the Bellevistatian Network.
•*Versatile robots* designed for Bellevistat improve productivity of residents by widely replacing human labor by automated machines.
•*The trustworthy and efficient computing system* manages the Bellevistat and provides a comfortable living experience for the residents.
•*An advanced Security hierarchy System* protects the residents from malicious use of their information.
•*A comprehensive contingency plan* provides reliable solutions for possible accidents.
•*Efficiency in using and recycling materials* enables Bellevistat to be highly self-contained.
•*Three-shift day/night cycle design* keeps both resource consumption and labor output relatively constant over the day.
•*The well rounded safety procedure and the reliable repair facility* available protect visiting ships and the visitors on board.
•*Discarding of path and roads between neighborhoods* helps construct a close-knit community with harmonious relationships between humans and nature built by the lawn.
•*A perfect integration of traditional house designs and cutting edge technology, the hotel* guarantees costumers optimal enjoyment.
•*Mensal and annual events*, such as sport days and Earth day exhibitions, render visitors a sense of involvement.

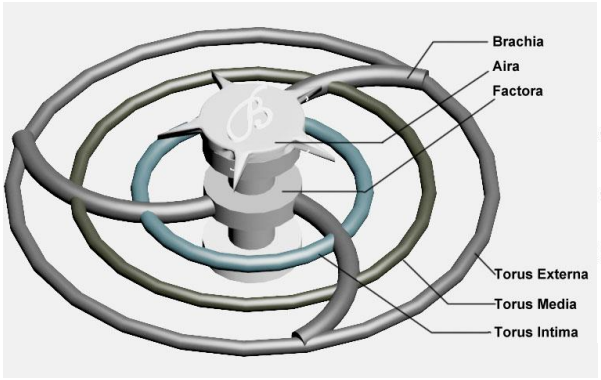
Bellevistat is surely to become another great step towards the human era of space, and we at Northdonning Heedwell again sincerely wish our design meet your desire and bring benefits for the entire human race.

Visitor's

First Impression

Structural Design

1. Structure and Operation



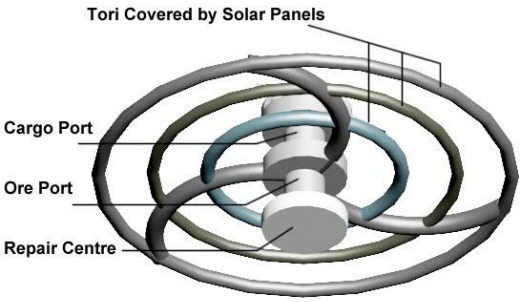


FIG 1.1

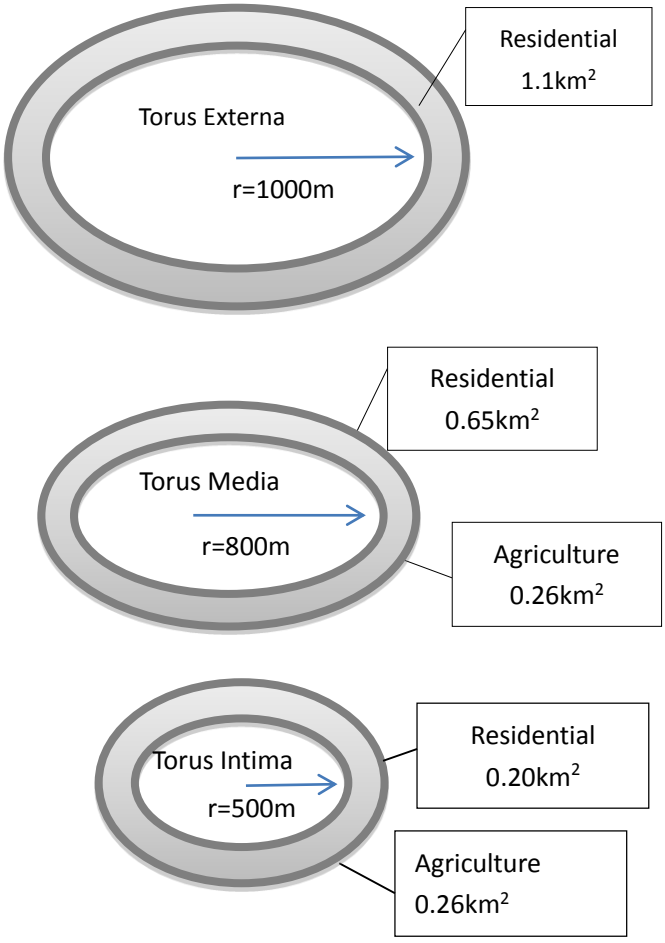


FIG 1.2.1

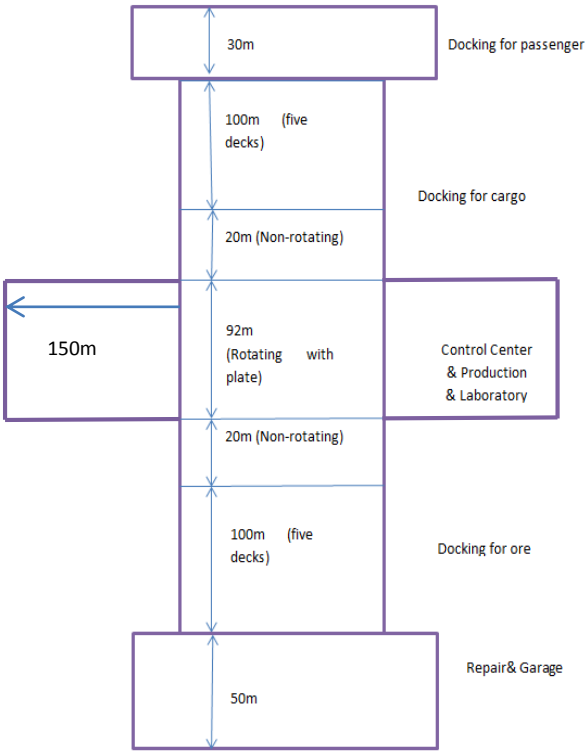


FIG 1.3

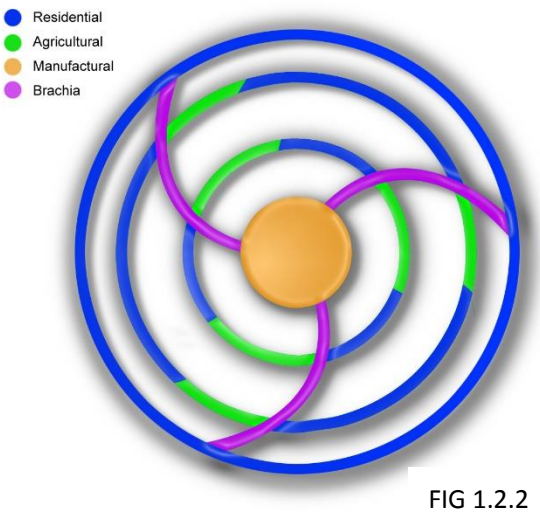


FIG 1.2.2

Dimension for major structures

	Gravity	Radius	Length (m)	Rotation	Vertical clearance (m)	Area (km^2)	Volume (m^3)
Torus Externa (Residential)	1g	1000	6283	Rotated	130	1.1	83395697
Torus Media (Residential)	0.8g	800	5026	Rotated	130	0.65	66711248
Torus Media (Agriculture)	0.8g	800	Same as Above	Rotated	Same as above	0.20	
Torus Initima (Residential)	0.5g	500	2733	Rotated	130	0.25	36275734
Torus Initima (Agriculture)	0.5g	500	Same as above	Rotated	Same as above	0.26	
Factora (Manufacture)	0 to 0.25	250	NA	Partly	50	NA	17601715
Centra (Control center /manufacture)	0g	100	NA	None	100	NA	
Centra (Docking/Control center/Manufacture)	0 g	100	NA	None	NA	NA	11309733
Solar Panel	NA	NA	NA	Rotated	NA	3	NA

TABLE 1.1

Interior allocation

	Area(km^2)	Volume($m^{3)}$	pressure
Agriculture*[1]	2000000	33834631	Varied
Residential	2000000	152548047	0.8-1.0atmp
Industry *[2]	7854	1036725	Varied
Buckystructure Production(single story)	4645	696750	0.6atmp
Docking port for passenger (single deck)	15393	461814	0.8atmp
Docking port for cargo (single deck)	7854	785398	0atmp
Storage	16597	829850	Varied
Others (control center/ observatory)	7854	722566	Varied
Total	4060197	190915781	NA

TABLE 1.2

Gravity Generation

The gravity is provided by the centrifugal force once the rotation starts. The level of gravity varies between different zones, according to their distance from the center. This is illustrated with the chart below.

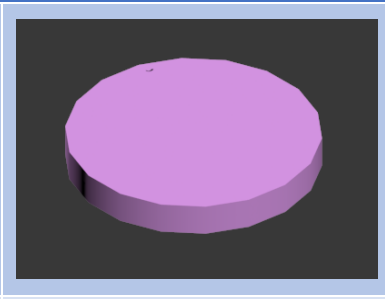
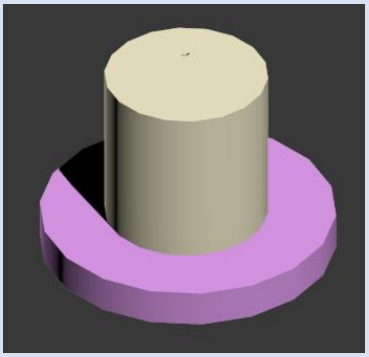
Area	Gravity	Tangential Velocity(m/s)
Centra	0~0.25g	25.81
Torus Initima	0.5g	43.67
Torus Media	0.8g	88.12
Torus Externa	1g	104.53

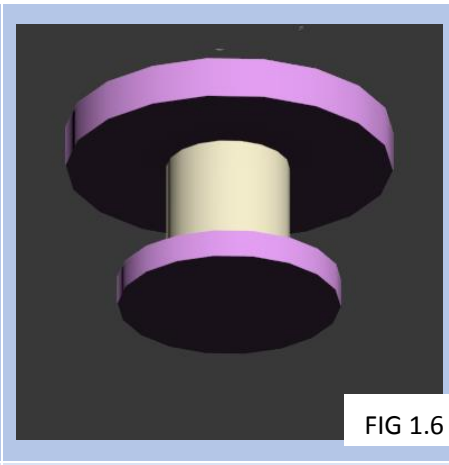
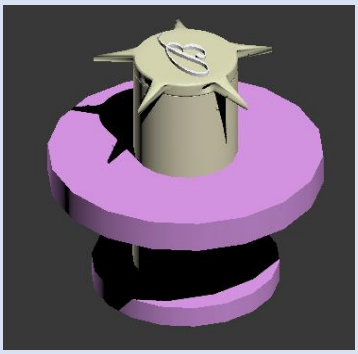
TABLE 1.3

The installation of 12 ion propellers on the brim is the second latest step in the construction. After the installation is finished and every aspects have underwent quality inspection, the ion propellers will continuously provide angular impulse to the Bellevistat. The propellers will stop working when the tangential velocity reaches 200m/s, which produces 2g on the external surface. High speed rotation will continue for 1 month to ensure the quality of soldering and connection. If it works fine, the propeller will reduce the tangential velocity to make the gravity 1g. After that the inner decoration will start.

If a serious smoldering defect, which requires the immediate suspension of rotation, happens during the operation of the Bellevistat, the power of ion propeller is not enough. Thus 3 powerful hydrazine propellers are also installed. These propellers are regularly refueled. If the emergency occurs, the rotation can be stopped in 30 minutes.

Construction Process

Step	Time /year	Construction Process	
1	0.75	The Repairing Center is assembled at Alexandriat and transferred into the orbital as a rudimental dock which enables the construction material to be stored.	 FIG 1.4
2	0.75	Centra is constructed by six External Construction Robots, which move along the six Rail Ways assembled simultaneously by the six construction robots.	 FIG 1.5

3	1.25	Factora is assembled at Alexandriat and transferred into the orbital and connected with Centra.		 FIG 1.6
4	1.75	The Aira is assembled at Alexandriat and transferred into the orbital to connect with Centra.		 FIG 1.7
5	0.25	The three Brachia are constructed simultaneously by overall twelve External Construction Robots (four construction robots each),	The ion thrusters at the three Brachias are constructed and turned on as soon as the Brachias are assembled.	 FIG 1.8
6	0		The ion thrusters are turned on and start the rotation.	NA

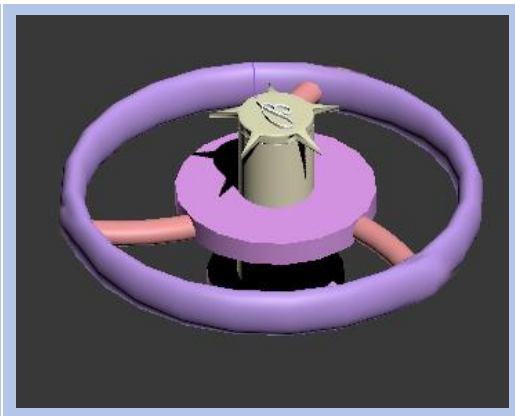
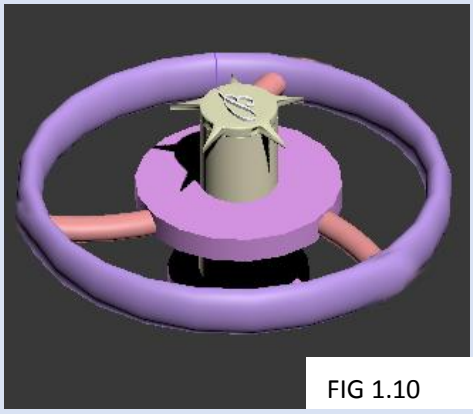
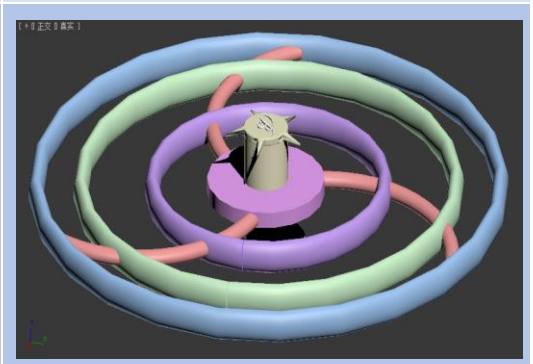
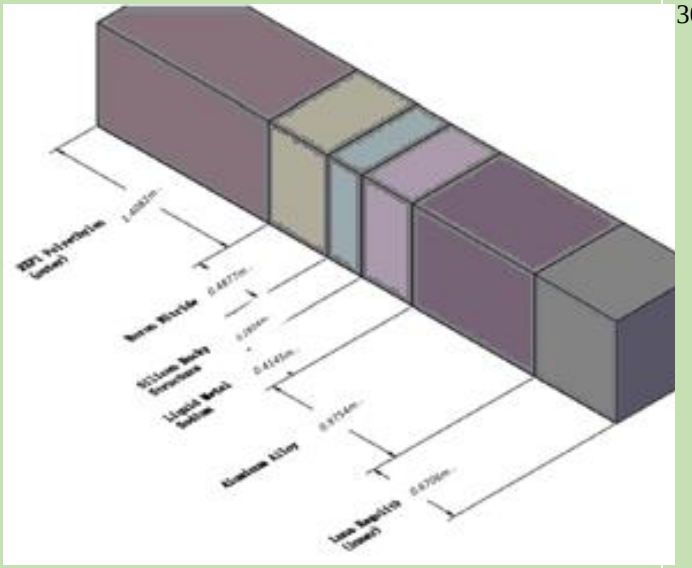
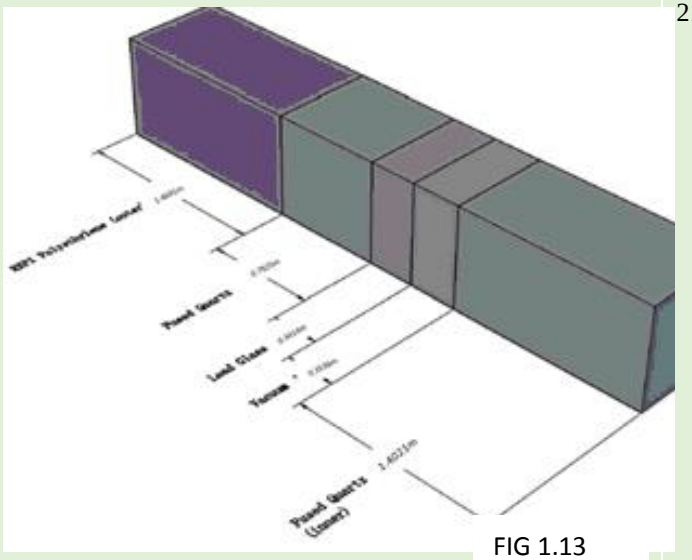
7	1.75	which move along the twelve Rail Ways assembled simultaneously by the twelve construction robots; Each Torus (each 0.67 radian) are constructed concurrently by overall twelve External Construction Robots (four construction robots each), which move along the twelve Rail Ways assembled simultaneously by the twelve construction robots. Solar panels which are paved over the surface of each Torus are constructed concurrently with the construction of Torus.	The construction of the first-section Brachia (sections that are between Factora and Torus Intima); The construction of the three arcs of Torus Intima.	 FIG 1.9
8	2.5		The construction of the second - section Brachia (sections that are between three Torus Medias and Torus Intima); The construction of the three Torus Medias.	 FIG 1.10
9	3.75		The construction of the third-section Brachia (sections that are between Torus Medias and Torus Externa); The construction of the three arcs of Torus Externa.	 FIG 1.11
10	8	Internal construction.		NA

TABLE 1.4

Construction Material

	Composition		Volume(m^3)
Wall layer	RXF1 Polyethylene 1.41 m (outer) Boron Nitride 0.49 m Silicon Bucky Structure 0.28 m Liquid Metal Sodium 0.41m Aluminum Alloy 1.01 m Luna Regolith 0.67 m (inner)	 FIG 1.12	30871372
Windows & Observatory Glass	Electro-chromatic Smart Glass 0.006m (outer) Fused Quartz 1.10 m Lead Glass 1.93 m Vacuum 0.99 m Fused Quartz 1.1 m (inner)	 FIG 1.13	2155522

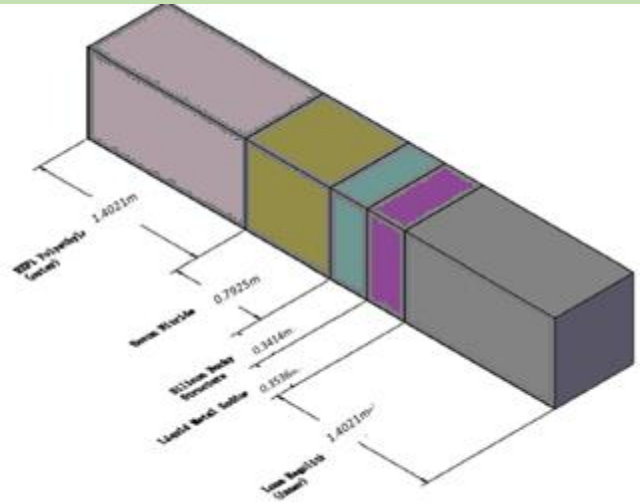
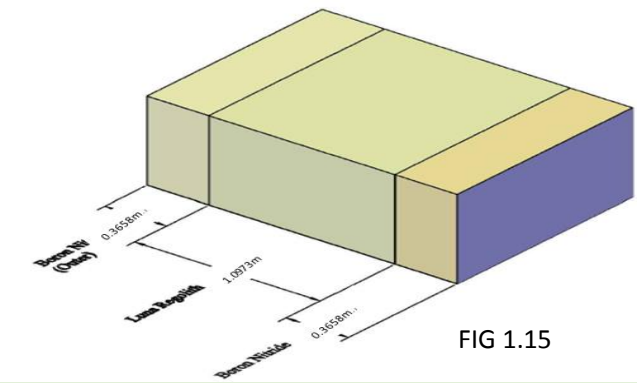
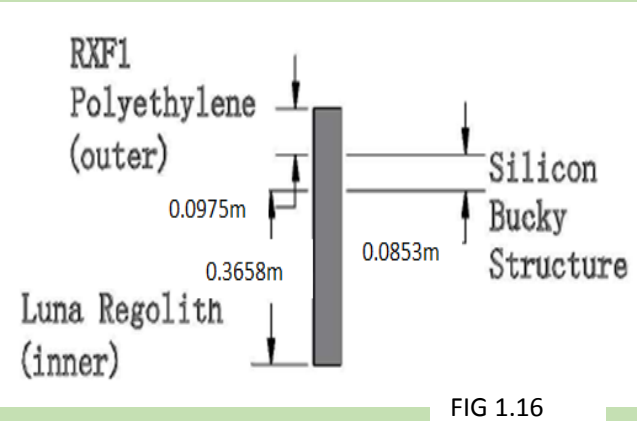
Rotating Hub Layering	RXF1 Polyethylene 1.47 m (outer) Boron Nitride 0.79 m Silicon Bucky Structure 0.34 m Liquid Metal Sodium 0.35 m Luna Regolith 1.4m (inner)	 FIG 1.14	62800
Internal Separation wall & floor	Boron Nitride 0.37m (outer) Luna Regolith 1.1m Boron Nitride 0.37m(outer)	 FIG 1.15	1086330
Shuttle Layer	RXF1 Polyethylene 0.10 m (outer) Silicon Bucky Structure 0.06m Luna Regolith 0.37 m(inner)	 FIG 1.16	1845523

TABLE 1.5

Docking

* All above are set in the environment of 0 gravity and 0 pressure

Docking at Aira	**Passenger Linersto land on Aira with magnificent exterior design. (refer to *HF*)** **Passengers move into Aira through an airlock. (refer to *HF*)** **Refuel service provided at Aira once the Passenger Liners are docked.**

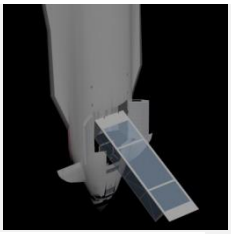


FIG 1.17 cm=15m

Docking for Cargo and Ore	1: The ships are instructed to enter the docking ports from one of the two ends of the track.

2: Corresponding modules clasp, robotic arms in the modules open the cabin door of and perform loading/unloading of standard containers when the module move along the track.

3: Module unlock the ships to leave the port when reach the other end of the track.

4. Robotic arms transfer the containers to/from the lift or to storage area via other robots. Module ready for docking again.

**if the cargo arrive in non-standard container, it shall be transferred into standard containers stored in the modules for delivery's sack.*

If one ship comes into the port from① and leave the port from ②, the next ship will enter the port from ② and leave from ①; Vice versa.

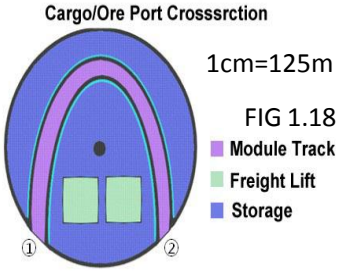


FIG 1.18

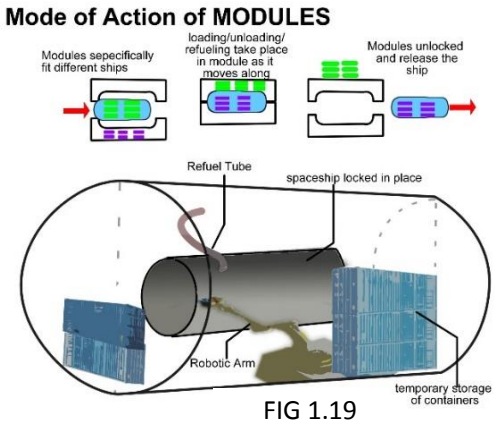


FIG 1.19

1cm=15m

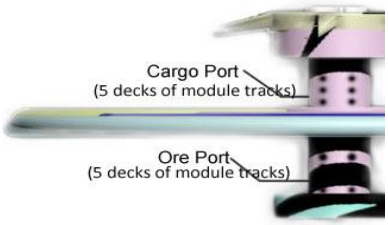


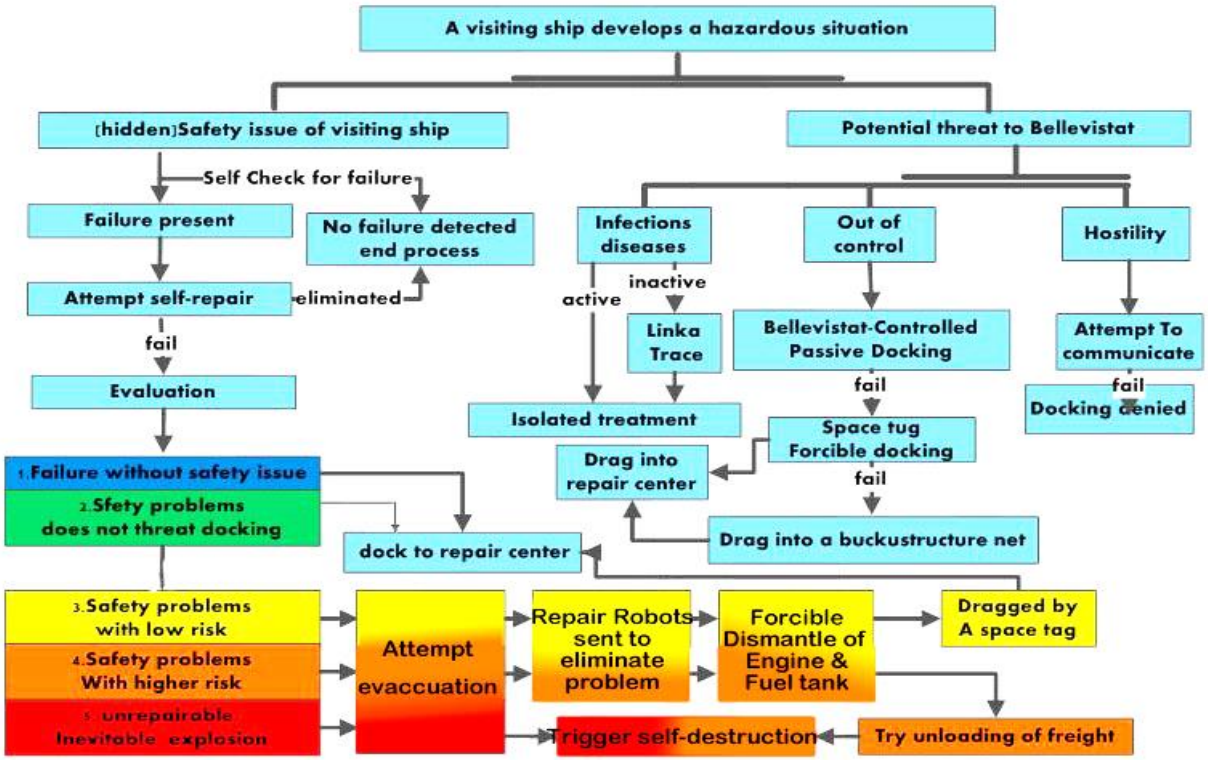
FIG 1.20

1cm=400m

Docking at Repair Center/Garage	Slightly Damaged Ship	Ship park itself among the repairing robots. Robotic arms fix it in place.
	Ship dragged by a Tug/a net	Tugs drag the ship/net through a tunnel. Robotic arms grab the ship/net and fix it in place. Tugs detached from its load.
	Space Tugs	Specific docks designed for tug will hold it in place and refuel.

TABLE 1.6

Safety procedure for a visiting ship



Transport and Delivering

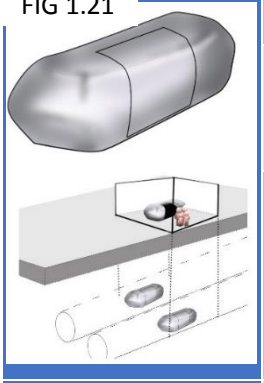
Internal Transport and Delivery			
Underground Maglev Personal Rapid Transit Taxi (PRT) FIG 1.21 	Main features	Used in travelling a distance greater than 100m For up to 4 people or robots/freights	
	Dimensions	Interior: 4.0m×2.0m×2.0m Exterior: 5.0m×2.5m×2.5m	
	Speed	Maximum 20m/s	
	Numbers	500 transits running in the settlement May be transferred between habitable volumes to meet demand patterns ***(refer to Day/night)***	
	Advantages	Driven by central computer, no congestion; Respond upon calls made by Linka quickly, shafts found every 50 meters. Shared public resource, maximizes transport capacity while need no parking	
Bicycles	Introduction	Prepared for people who prefer to ride to work/exercise	
	Advantages	Quantity dependent on need Sold at stores and manufactured on-board No need for fuel, No pollution, Healthy lifestyle	
Inter-torus Ferry	Main features	Deliver PRT Connect PRT tracks of different tori.	Deliver large-scale equipments and subassemblies Among gravities and Factora

 FIG 1.22			
	Dimensions	6.0m×6.0m×3.0m	20m×20m×20m
	Speed	Maximum 10m/s	Maximum 4m/s
	Numbers	4×3	2×3
	Advantages	Able to connect to the maglev rails Allow PRT directly driven into the ship lift Directed by operation server Efficient route designed	Able to deliver giant amount of cargoes and supplies at one time For emergency transportation of robots needed repairs
Freight Lifts	Main features	Used to deliver shipping containers (ores and goods) which are captured by Docking Modules Between dockings and the central transportation station	
	Dimensions	55m×50m×20m	
	Speed	Maximum 3m/s	
	Numbers	4 (2 for ores, 2 for goods)	
	Advantages	Lubricated by a silicon buckystructure to prevent friction Elevators launched by pop-up springs, saves energy Deal with large amount of containers on a single mission.	
Panorama Lift	Main features	Connects Aira and Factora, transfer passengers from incoming shuttles to the PRT taxis of the tori	
		provide a 360-degree view of both the settlement and the space for the 20 passengers onboard	
		Rotates when reach Factora, providing a gradual change of gravity from 0-g to 0.2g and then transfer passengers into PRTs.	
	Dimensions	10m diameter, height 3m	
	Speed	Average 1m/s	

TABLE 1.7

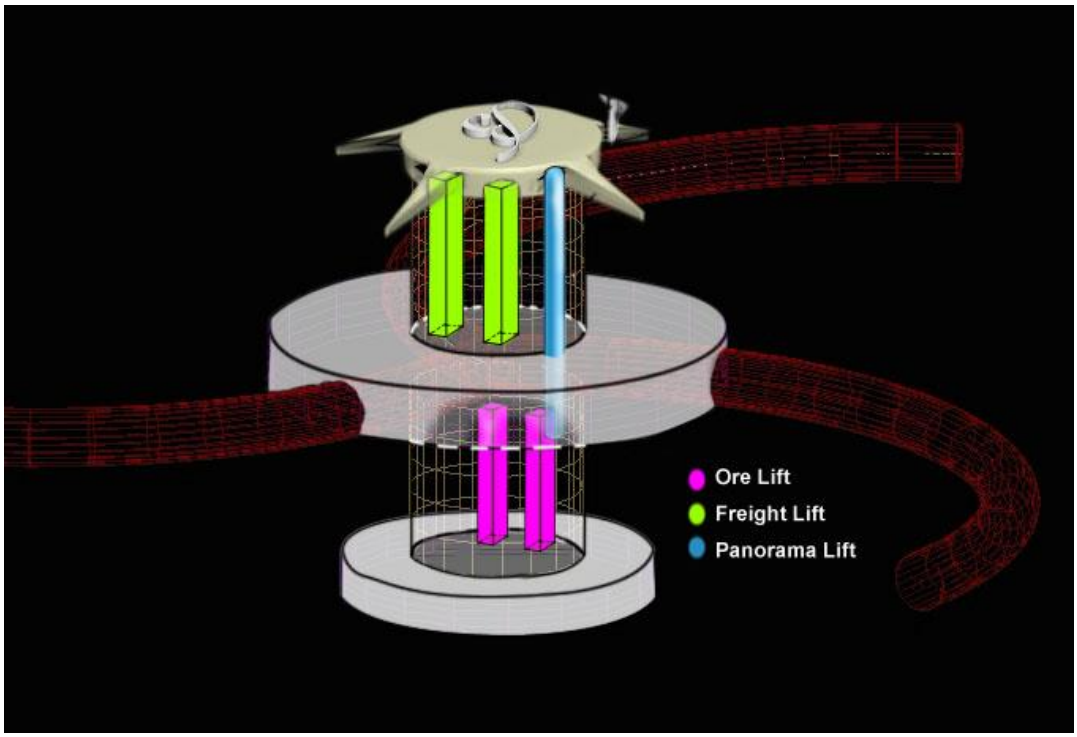


FIG 1.23

1cm=250m

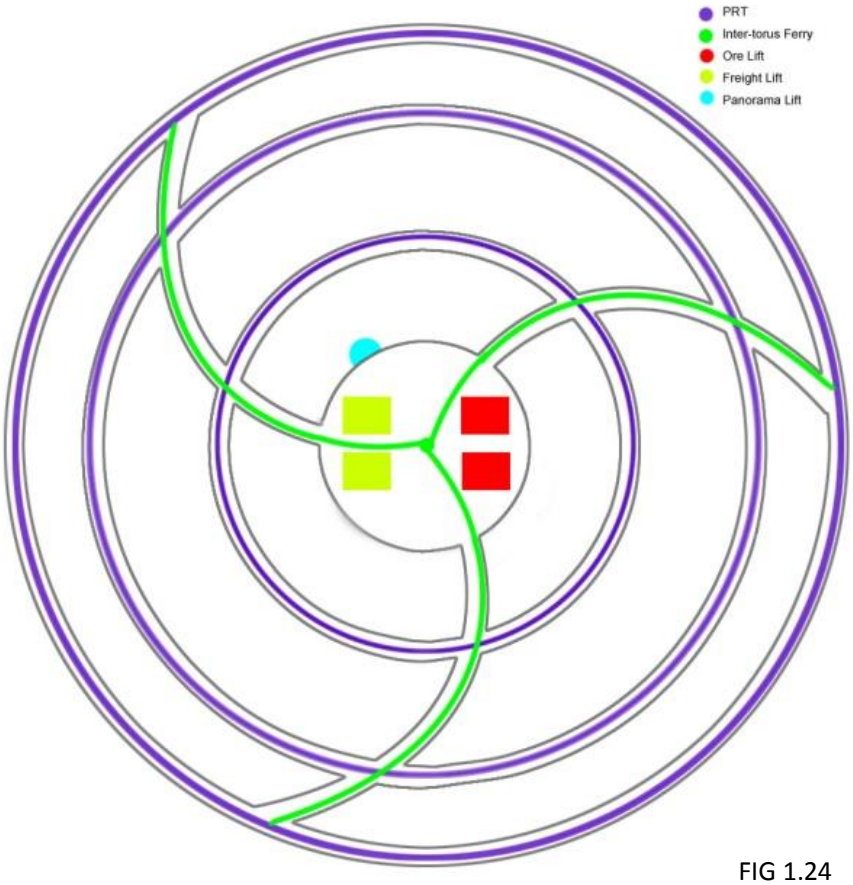


FIG 1.24

1cm=200m

Expansion of dock facilities of ore and cargo

Although the space left allows 10 decks of docking port to be built in total, due to economic concerns, only 5 docking decks will be built in first 10 years .And after 10 years, the docking decks will expand according to the turn volume.

Repair services for visiting shipss

Spaceships docking to Bellevistat will be checked by CT Scanners placed insides the docking module. If any potential failure/danger is identified the ship will be transferred to the repair centre.
Rescued ships will be dragged into the repair centre by space tugs and starts emergency repair immediately.

Phase	Emergency	Fix	Upgrading
1	Quick identification of threats	Thoroughly check with scan/ camera Human diagnosis with camera if needed	Robotic upgrading
2	Robotic removal of dangerous parts e.g. engines, fuel tank, explosive/poisonous cargo etc.	Computer decide a fixing procedure based on a digital model Human evaluation if needed	Modules 3D printed if needed
3	Temp control & Standing-by fire service	Robotic fixing	
4	Transfer of freights	Modules 3D printed if needed	
5	Go to 'fix'		

TABLE 1.8

Costs of materials

Material	Unit cost	Volume	Total cost
Lunar Regolith	-	6802017 m^3	-
Silicon Buckystructure	-	2238188 m^3	-
RXF1	$ 3.0 / kg	25240805 m^3	$ 75.7 b
Boron Nitride	$ 7.5 / kg	2990915 m^3	$ 47.1 b
Aluminum	$ 2.0 / kg	6302128 m^3	$ 34.0 b
Electro-chromatic Smart Glass	$ 8.0 / 0.006 m^3	2532 m^3	$ 3.38 m
Fused Quartz	$ 5.0 / kg	825116 m^3	$ 9.01 b
Lead Glass	$ 4.4 / kg	711579 m^3	$ 9.38 b
Vacuum	-	416303 m^3	-
Liquid Sodium	$ 1.0 / kg	2469283 m^3	$ 2.2 b
TOTAL			$ 177.4 b

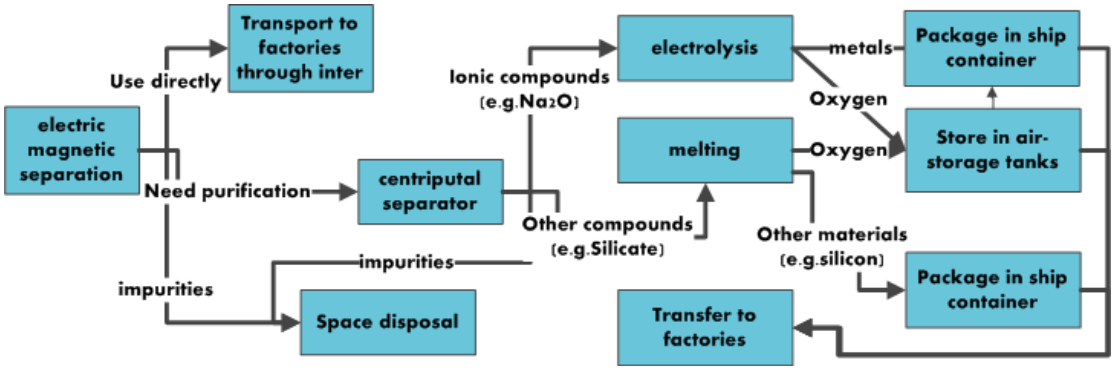
TABLE 1.9

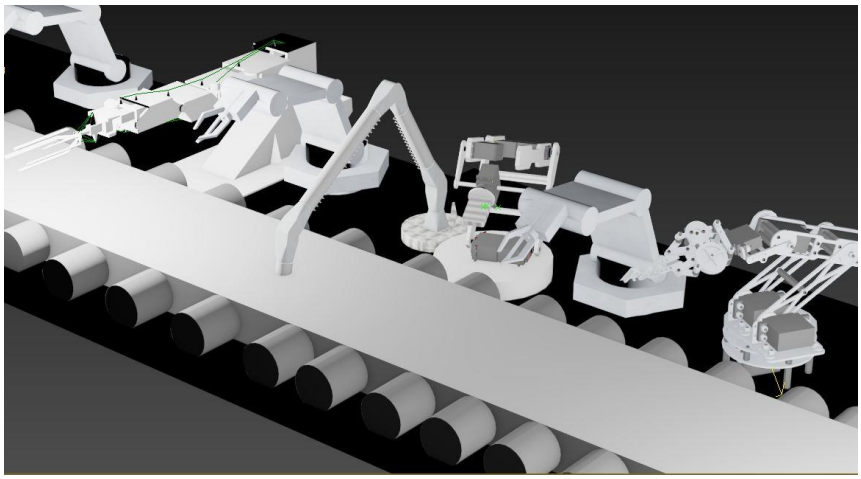
Materials from Moon and Asteroid

Chemical composition of the lunar surface regolith (derived from crustal rocks)			
Compound	**Formula**	**Composition (weight %)**	
		Maria	**Highlands**
Silica	SiO_2	45.4%	45.5%
Alumina	Al_2O_3	14.9%	24.0%
Lime	CaO	11.8%	15.9%
Iron(II) oxide	FeO	14.1%	5.9%
Magnesia	MgO	9.2%	7.5%
Titanium dioxide	TiO_2	3.9%	0.6%
Sodium oxide	Na_2O	0.6%	0.6%
Total		**99.9%**	**100.0%**

TABLE 1.10

Refinery Process





1cm=2m

FIG 1.25

Expansion of manufacture

Although the space lefted allows a manufacture center of more than 15000000m^3 to operate, due to economic concerns, however, only about half of the volume will be constructed and functioned as manufacture in first 10 years. The remaining will be leasing for other uses (such as scientific experiments) .And after 10 years, the manufacture center will expand according to the demand.

Paper Management

Paper Management		
Bellevistat has minimum reliance on paper as most office documents are on electronic media. We also provide alternative media for other conventional uses of paper, and their management is summarized below.		
Printing	**Packaging**	**Cleaning**
Rich Mineral Paper (RMP) will completely replace conventional office paper	A combination of RMP and thermoplastic starch will replace paper and plastics	Conventional tissues will be made out of agricultural waste including straw
Advantages		
-Made of powdered $CaCO_3$ from mining waste and glue, no water or other chemicals needed. -Perfectly mimics conventional paper's touch. -Non-flammable, waterproof. -Easy to recycle. -Low cost	-Easy to recycle -Thermoplastic starch is porous -RMP is waterproof. -Low cost.	-Make use of agricultural waste. -Low cost.
Recycling Process		
Separated from municipal waste by robots, cleaned, shredded, and is ready for remanufacture	Separated from municipal waste by robots, hydrolytic breakdown to form starch and thermal plastic monomers, ready for synthesis of renewed packaging	Break down in the sewage and undergoes standard waste management process***refer to waste management***

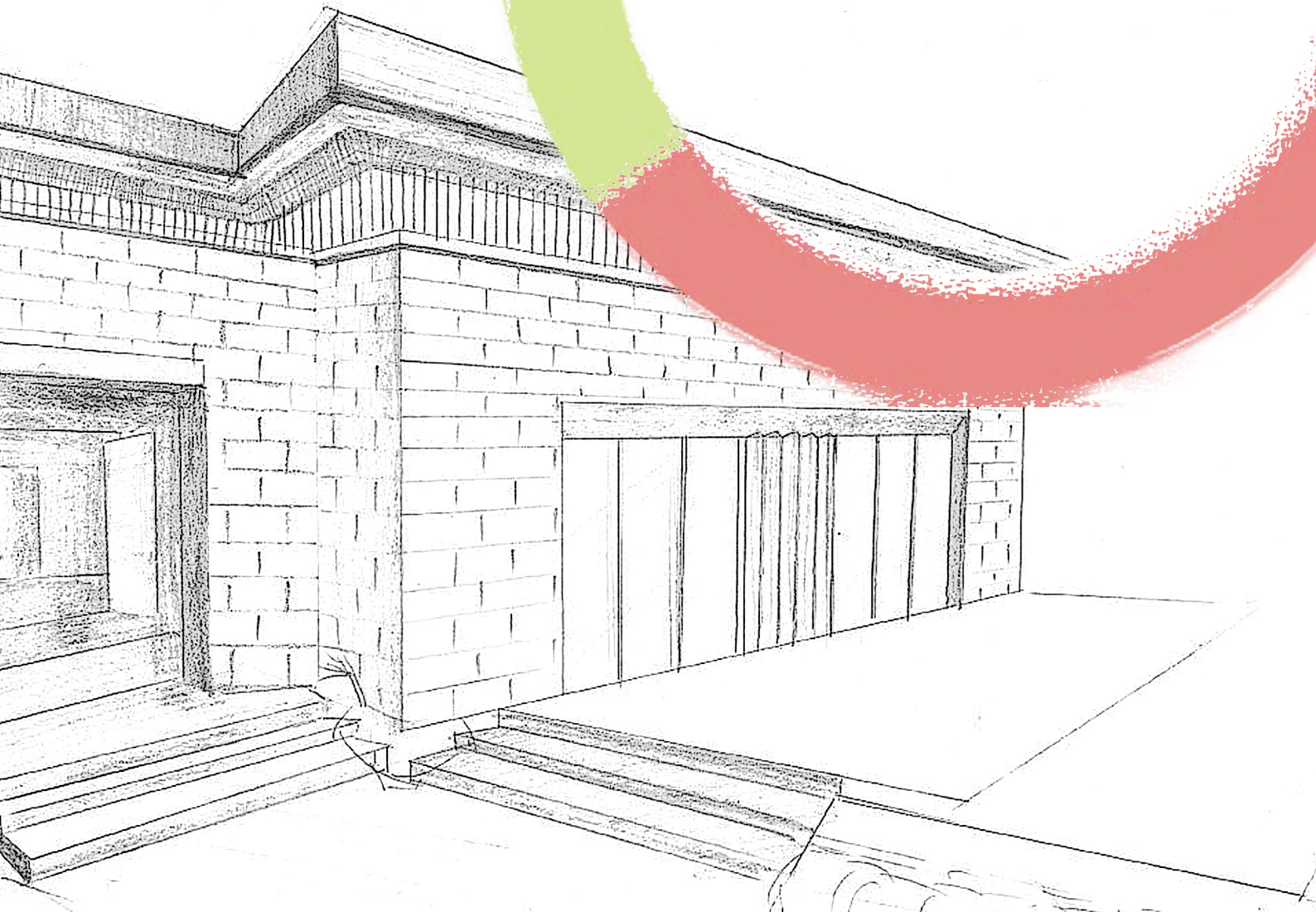
TABLE 1.11

One-off costs of operation

Delivery facilities			**Docking facilities**	
PRT	$ 50.0 m		Aira	$ 3.00 b
Underground Maglev Channel	$ 120 m		Cargo Port	$ 1.50 b
Inter-torus Ferry	$ 70.0 m		Ore Port	$ 1.50 b
Freight Lifts	$ 180 m		Repair Center	$ 1.70 b
Panorama Lifts	$ 80.0 m		Garage	$ 0.60 b
Waste reclaimmation	$ 20.0 m		Quantum Network	$ 20.0 m
Solar panels	$ 100 m		**TOTAL**	$ 8.94 b

TABLE 1.12

Settlement Community



2. Settlement community

Category	Units
hotel	2
stadium	4
cinema	4
theatre	2
Grocery store	60
clinics	80
Hospital	8
banks	20
Club	4
casino	4
Shopping mall	4
Tourist info center	4
Community center	20
restaurants	40
Fire station	4
school	8
library	8
Public restroom	200
museum	1

TABLE 2.1

Category	Units	Cost
Hotel	2	$ 14.0 m
Stadium	4	$ 10.0 m
Cinema	4	$ 20.0 m
Theatre	2	$ 10.0 m
Grocery store	60	$ 65.0 m
Clinics	80	$ 100 m
Hospital	8	$ 40.0 m
Banks	20	$ 80.0 m
Club	4	$ 10.0 m
Casino	4	$ 10.0 m
Shopping mall	4	$ 20.0 m
Tourist info center	4	$ 5.00 m
Community center	20	$ 25.0 m
Restaurants	40	$ 60.0 m
Fire station	4	$ 15.0 m
School	8	$ 20.0 m
Library	8	$ 20.0 m
Public restroom	200	$ 20.0 m
Museum	1	$ 20.0 m
TOTAL		$ 564 m

TABLE 2.2

FIG 2.1

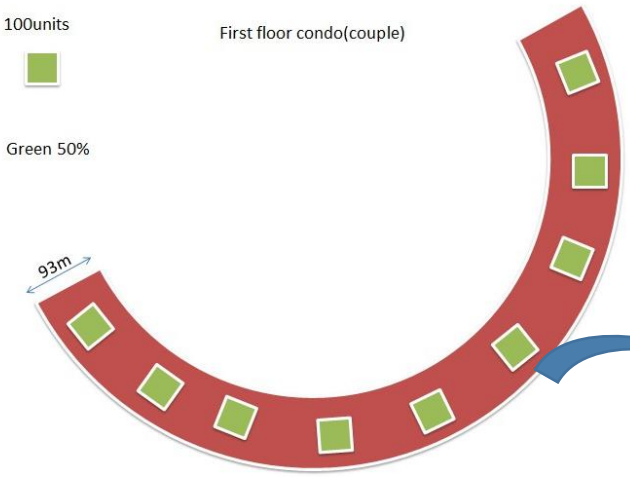


FIG 2.2

(Detail of green area)

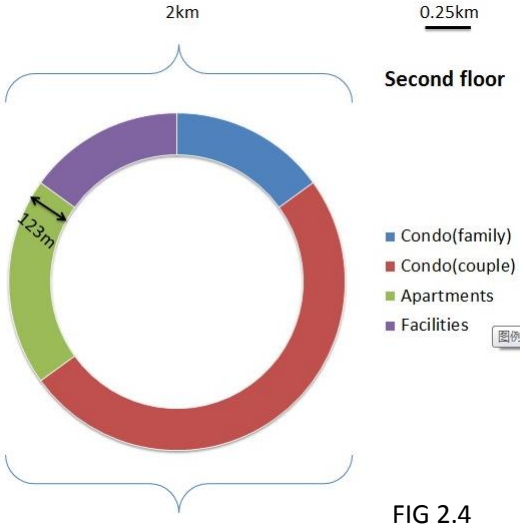


FIG 2.4

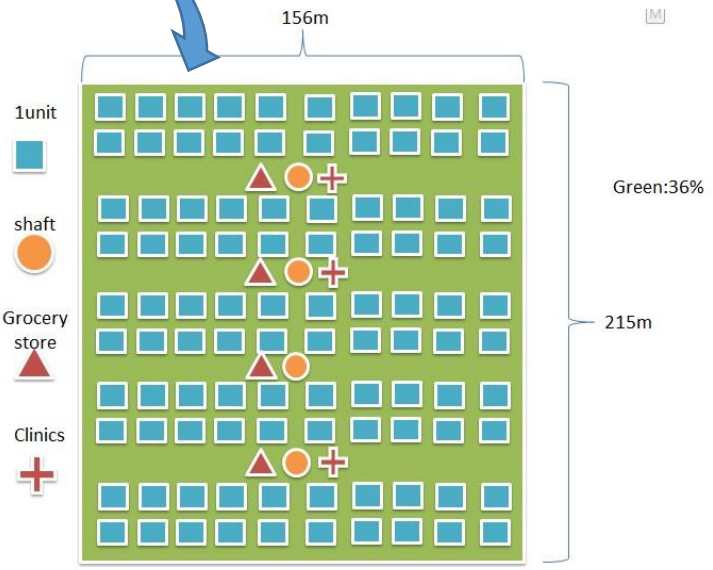


FIG 2.3

Apartment

FIG 2.5

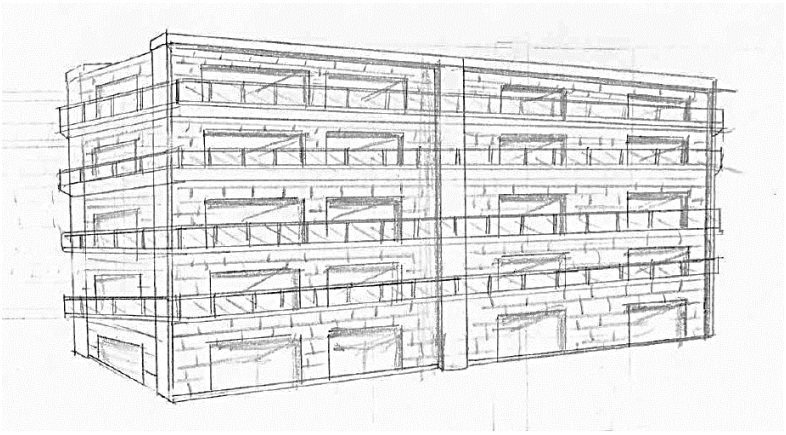


FIG 2.6
1cm=20m

Houses for Couple

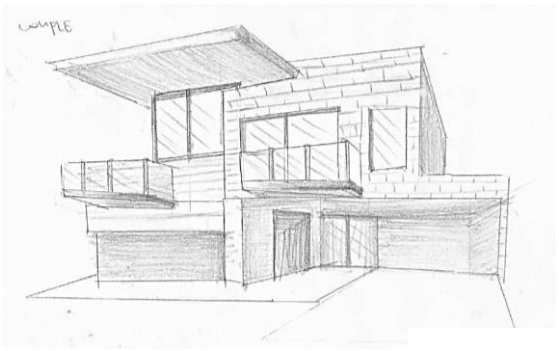


FIG 2.7
1cm=5m

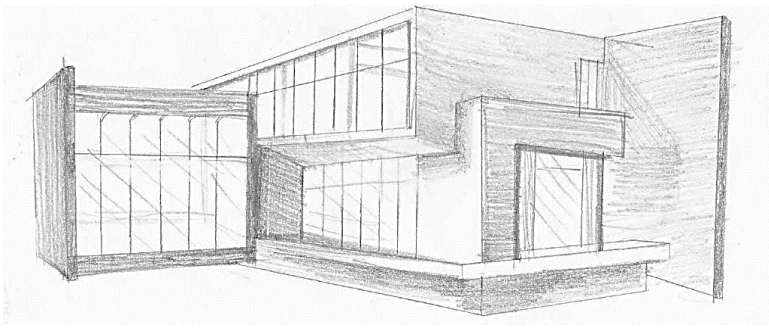


FIG 2.8
1cm=5m

Family

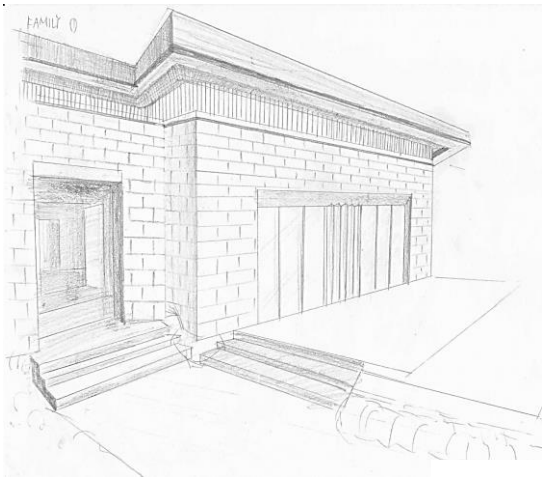
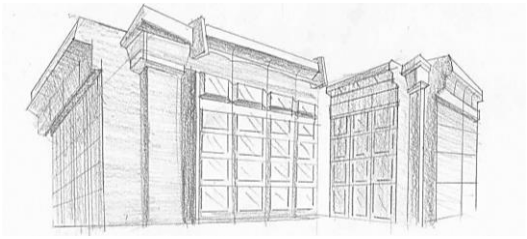


FIG 2.9
1cm=5m

FIG 2.10
1cm=5m

otel



Dave's Hotel FIG 2.11

Aimed to provide world-class accommodation competitive to the counterparts on Earth, Dave's hotel is open to both visitors and residents, who at here will enjoy the most privileged service.
Dave's Hotel integrates its cordial house-like appearance perfectly with the highly-advanced technology only to render customers the most luxurious experience ever.
The sheer variety of entertainment facilities such as grandiose theaters, shopping malls, fitness centers and so forth guarantees the optimal enjoyment.

Social involvement of new comers:

A number of tourist information centers can provide visitors with information of recreational activities, upcoming events and other assistance.
Inter-residential communication day is held on a monthly basis with the aim of deepening understandings between residents and tourists.
Sports event held annually to build friendship between tourists and residents while improving health conditions.
"Earth Day" exhibition held to propagate and inform important events on Earth, deepening residents understanding of the current world.

Appliances

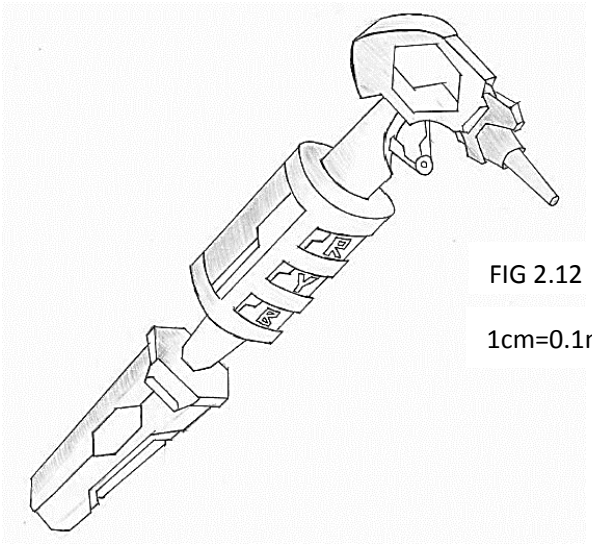
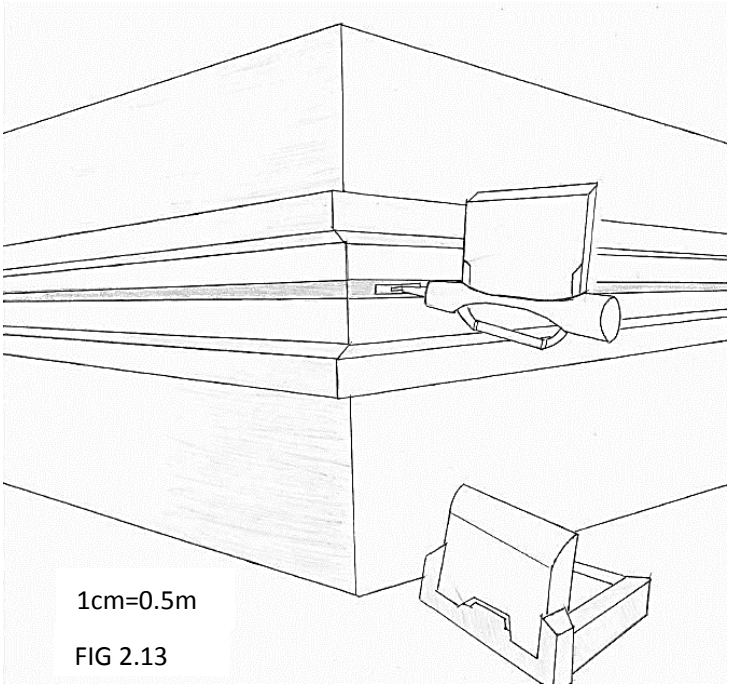


FIG 2.12

1cm=0.1m



1cm=0.5m

FIG 2.13

Multifunctional "wall": acts as a conveyor belt to send people anywhere in the house while providing entertainment.

Aira

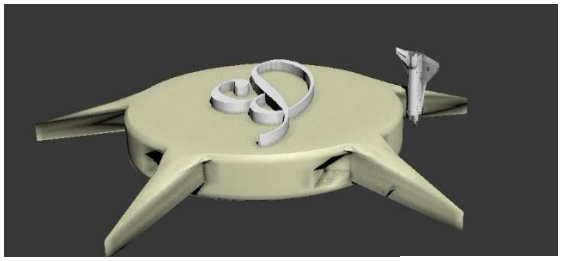


FIG 2.14

Aira is an extraordinarily designed passenger airport which plays an extremely important role in welcoming new comers to the settlement. The inner decorations look familiar to those on Earth's airports in order to minimize discomfort. When passengers are ready, the unconventional panorama lift will render the view of outer space and, most excitingly, the residential areas in the rings, which creates a sense of being involved.

Airlock

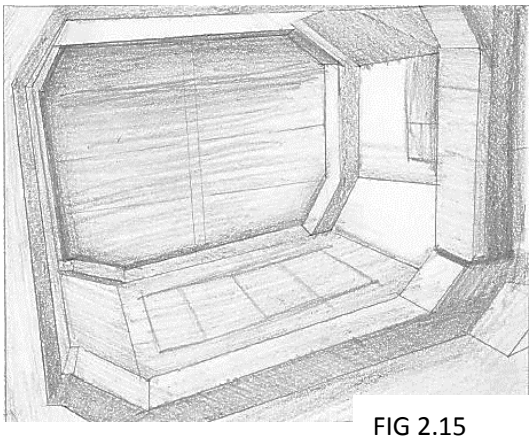


FIG 2.15

Airlock: enable people to enter pressurized places from space (unpressurized places).

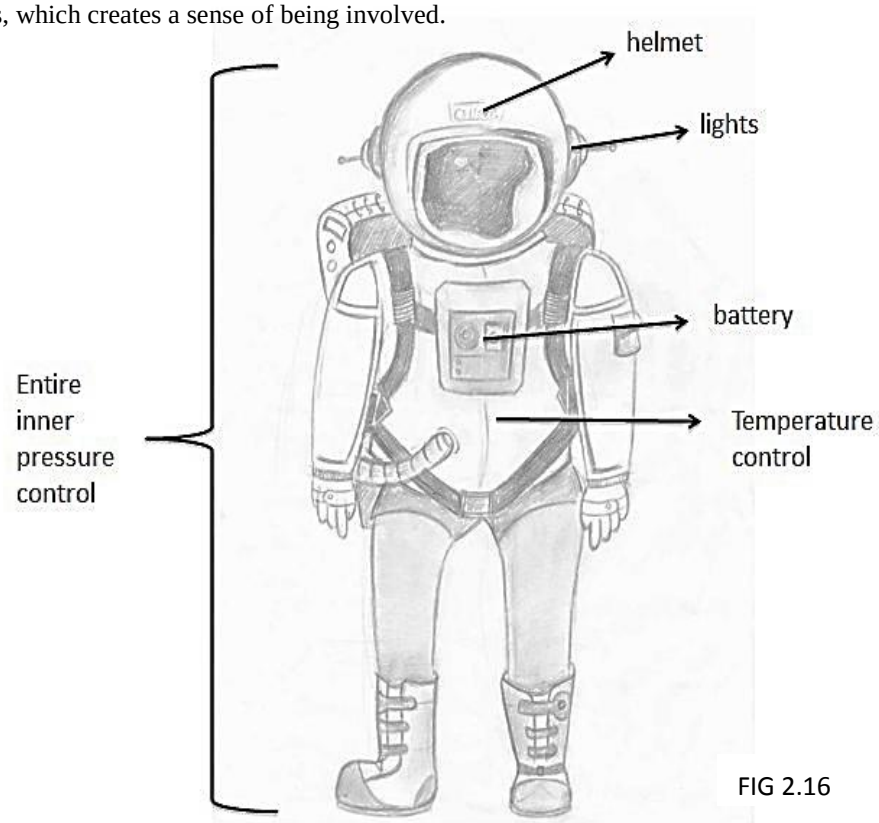


FIG 2.16

Atmosphere

Gas	Source	% in industrial areas	% in residential areas	% in agricultural areas
O_2	1) Extraction of lunar ore gives off oxygen 2) Transferred from agricultural area 3) Produced by AIP system and greens in residential area	5%	24.4%	15%
CO_2	1) Combustion of carbon from asteroids 2) Transferred from industrial area	0.4%	0.4%	25%
N_2	Liquefied nitrogen from earth	83.4%	75%	60%

TABLE 2.3

Season	Temp/℃	Humidity/%	Mechanism
	Bellevistatian climate zone		Sensors connect to control computer monitors the temperature and humidity. When air pass through the ventilation system, dust is removed and air is cooled/heated and humidified under control of the monitor. Specific compositions may be transferred between residential and agricultural volumes via pipes.
Spring	15-20	50	
Summer	20-25	60	
Autumn	15-20	40	
winter	10-15	30	

*Three climate zones with different combination of temperature and humidity are made optional in the three habitable volumes, including Bellevistatian (shown in the chart), Mediterranean Climate and Monsoon climate (all without precipitation)

TABLE 2.4

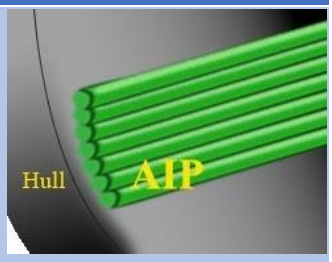
Alga in Pipe System (AIP)		
Features	A series of pipes containing chlorella attached to inner hulls of habitable volumes.CO_2 and fertiliser separated from waste pumped into the pipes.	
Functions	Chlorella provides single-celled protein and is harvested as a main protein source.	
	Quick growth of chlorella gives efficient control of atmosphere composition.	
	Water inside pipes controls heat.	

FIG 2.17

TABLE 2.5

Power management

Electricity Generation
Solar Panels: 700 MW±50MW 3 km^2 solar panels paved over the surface of the tori.
Plasma Gasification output with Fuel Cells: 2.5 MW normal output, with an maximum capacity of 10MW×2 days with stored gas in case of any power fail

Electricity Distribution	
Sector	**Distribution(MW)**
Industrial	240
Superconductive rotation	184
Automation & Control	100
Operation & Infrastructure	100
Residential & Commercial	30
Total	**654**

TABLE 2.6

Food Production

Growing	**Crops**	The crops are initially grown in a hydroponic system with AC-electric field to stimulate root growth. Then, crops are transferred to the aeroponic system and planted densely with optimal water and nutrient supply, intensive sunlight, tailored air composition and low gravity.
		The agriculture robots of operation server supervise the growth and accordingly alter the growing conditions for each group of crops to maximize the yield.
	Proteins	In-vitro meat production with stem cells, along with chlorella (an alga that grows rapidly and is rich in single cell proteins) grown in AIP system, support the 3-D printing of proteins and give rise to a variety of meat products. Additives and flavors are added in the printing process.
Harvesting	Automated robots harvest the food and deliver it to food-processing plant. Various harvesting technique would be applied to the harvesting process by equipping the automated robots with specified harvesting tools.	
Storing	The food-processing plant receives crops and printed proteins from robots. The storage section in food center keeps enough food for sustaining people's lives up to two weeks.	
Packaging	Through aseptic processing and vacuum packing, foods are sorted out and packaged in different containers/starch packages (***refer to paper***) Containers maintain interior temperature in a suitable range and is equipped with Nano sensors, which will display alarming red light when the food inside deteriorates.	
Delivering/Selling	Food packaged is distributed to restaurants and supermarkets directly by robots.	
Range of food products	Main products of the Hydroponic-Aeroponic system are Quinoa and vegetables. 3D protein printing mimics all meat product Fruits and fish are collected from residential area on regular basis as a supplement	

TABLE 2.7

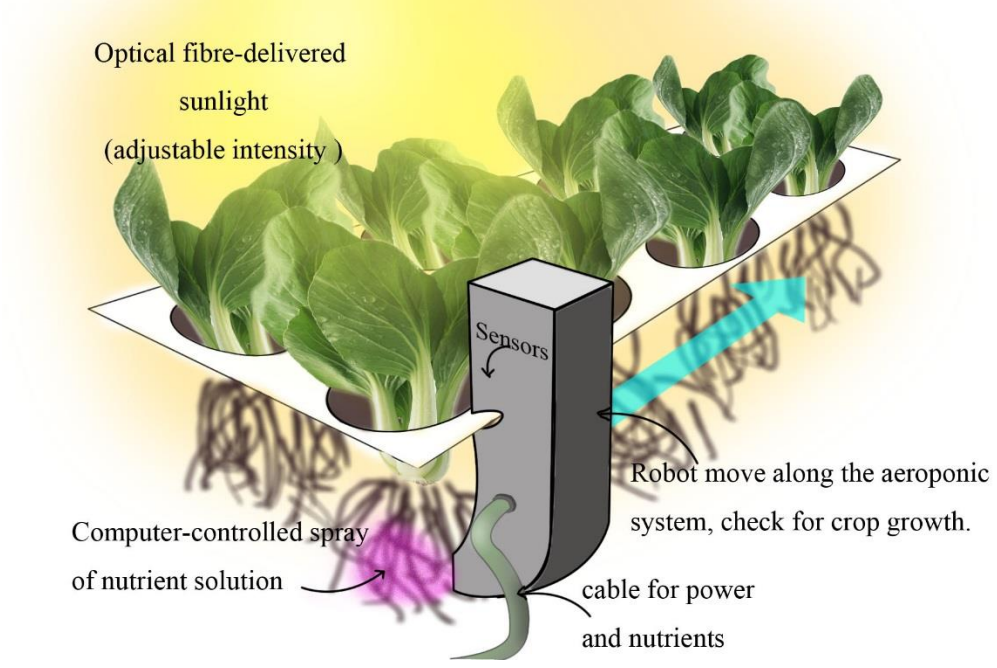


FIG 2.18

Water & waste management

Water Distribution	
Water is synthesized on settlement.H_2 from the lunar dust left by solar winds and O_2 obtained by extraction of ores. The H_2 in nascent form will readily react with O_2 to give water in demanded quantities. Most of the water (more than 95%) will be recycled but H_2 will be regularly imported from the moon.	
Sector	**Daily Distribution/m^3**
Residential	600
Industrial	4000
Agricultural	1000
Other	400
Total	6000

TABLE 2.8

*Due to the high efficiency of water reclamation, the total amount of water on the settlement is a lot less than the daily consumption.

Waste Management

A total of 50 tones industrial waste and 10 tone of municipal waste will be produced every day. In addition, 6000 tons of water will need to be recycled each day.

A resource reclamation plant located in the 0.2G torus will be in charge of carrying out the recycling process summarized in the flow chart below. Automation will help in classifying and transporting the wastes.

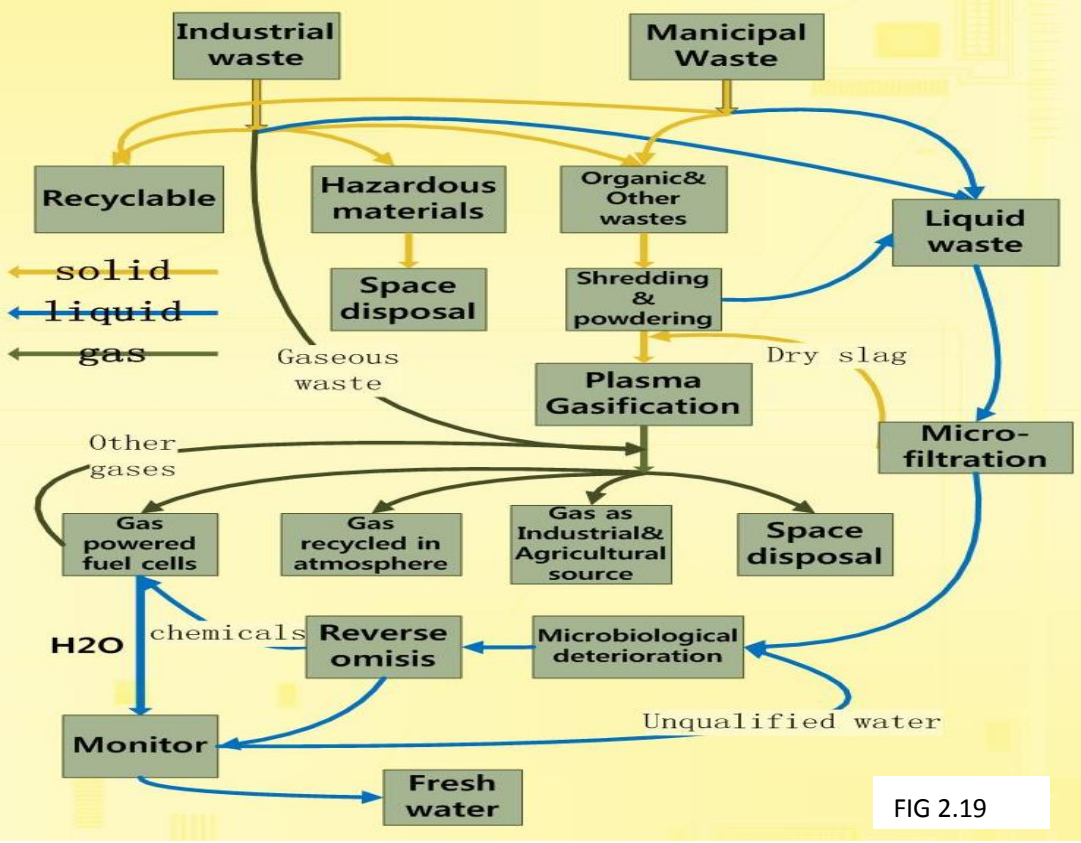


FIG 2.19

TABLE 2.9

External Communication

External Communication	
Mechanism	The external data exchange is achieved by a quantum teleportation network connecting other ships and Geo satellites. Employing and upgrading the existing satellite network achieve communication with the Earth.
Advantages	1) High speed 2) Low power requirement 3) Extremely secure 4) High stability, can run in a solar flare 5) Renting and upgrading existing satellites saves initial cost. 6) Existing GEO satellites can provide good coverage and enough back-up.

FIG 2.20

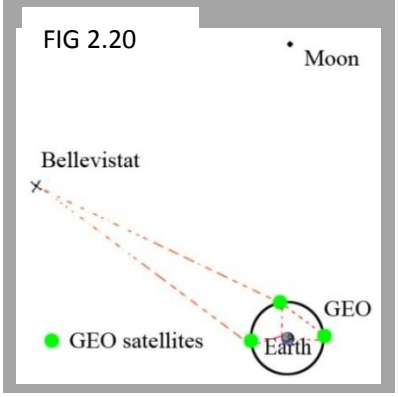


TABLE 2.10

Day/night Cycle

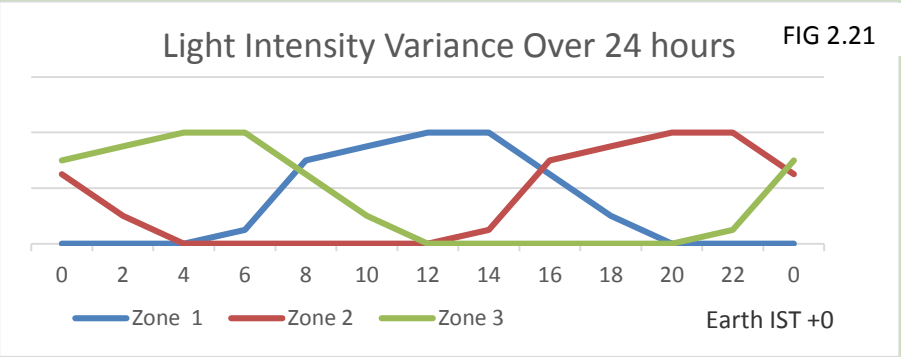
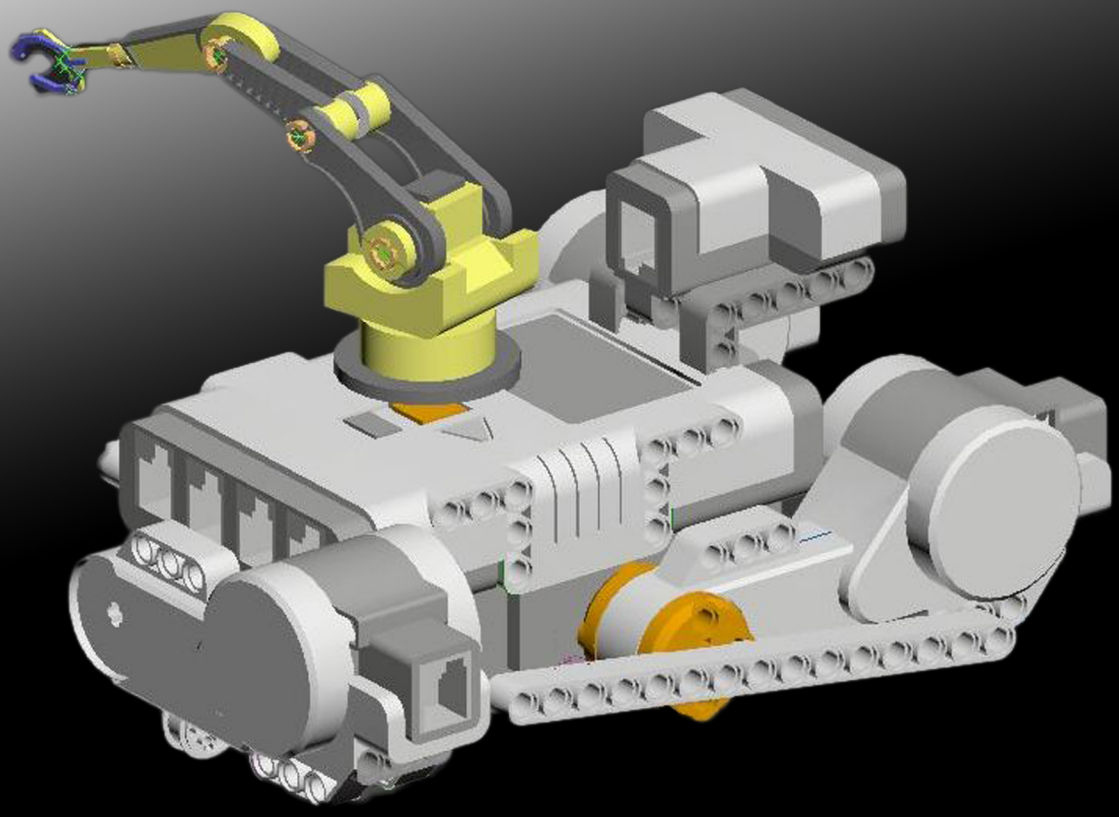
Day/night Cycle Provision	
Mechanism	Bellevistat employs three identical systems of simulation of daylight run with an 8 hour time difference through the optical fiber network.
Advantages	1) Three 8-hour differences fit the three shifts of labor, allow all individuals on-board to have a pleasant working and resting environment. 2) Difference in time and hence diverged residential schedules stabilizes the variances/reduces the maxima in consumption of public resources e.g. power, transportation etc. 3) Optical fiber delivers natural sunlight collected on the exterior. 4) Intensity of light controlled by programmed open/close of fibers.
Day/Night Pattern	

FIG 2.21

TABLE 2.11

Automation



3. Automation

Computation Systems

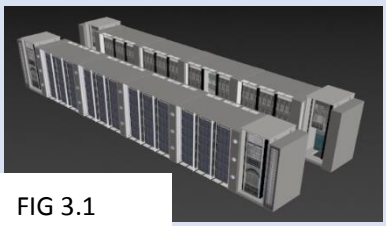
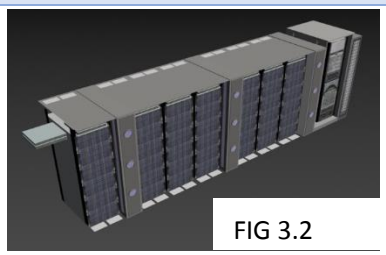
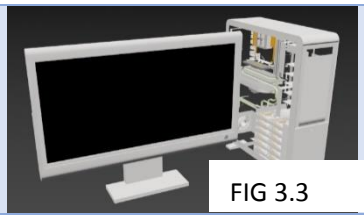
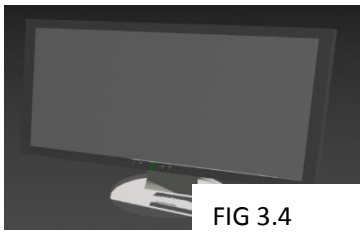
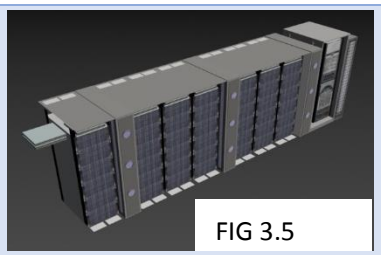
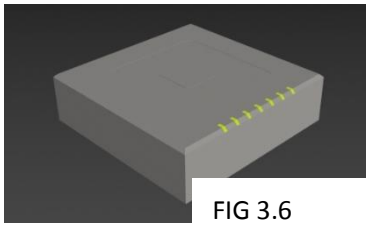
	Amount	Processor	Memory	Storage	Pictures
Center	2	78GHz 80-core	1TB of 10GHz DDR8L	500PB	 FIG 3.1
Department servers	12	48GHz 16-core	240GB 8000MHz DDR6L	10PB	 FIG 3.2
Advance department computers	48	48GHz 8-core	120GB 6000MHz DDR6L	Cloud & 100TB	 FIG 3.3
Normal department computers and personal computers	10,000	10GHz 8-core	32GB 6000MHz DDR6	Cloud & 50TB SSD	 FIG 3.4
Network servers	2	48GHz 64-core	240GB 8000MHz DDR6L	Virtualization	 FIG 3.5
Routers	20	10GHz 4-core	32GB 6000MHz DDR6	Virtualization	 FIG 3.6
Gateways	500				
Network relays	40				

TABLE 3.1

Advance department computers featured with high basic frequency processors are used to tackle huge amount of calculations departments might encounter, while, with more cores, the center servers are able

to tackle thousand sets of different data and calculations simultaneously. All devices would connect to the Internet through WiMax (1GB/S Internet connection and 50GB/S local network connection) provided by routers within the settlement, while inter-server communication and the communication between LAN and Wan of routers and the Internet server would use InfiniBand (600GB/S). InfiniBand is a type of communications link for data flow between servers and I/O devices that supports for up to 64,000 addressable devices

Name	Number	Unit cost	Total cost
Center servers	2	$ 68,700	$ 137,400
Department servers	12	$ 25,400	$ 304,800
Personal computers	10,048	$ 1,200	$ 12,057,600
Network servers	2	$ 42,000	$ 84,000
Routers	20	$ 8,000	$ 160,000
Gateways	500	$ 100	$ 50,000
Network relays	40	$ 485	$ 19,400
Linka	12,000	$ 200	$ 2,400,000
External construction and repair robot	20	$ 50,000	$ 1,000,000
Garden robot	50	$ 22,000	$ 1,100,000
Internal repairing robot	100	$ 17,000	$ 1,700,000
Medical robot	150	$ 36,000	$ 5,400,000
Office robot	400	$ 9,700	$ 3,880,000
Coordinate mapping system	1	$ 650,000	$ 650,000
Thermal Infrared Sensor	12,300	$ 30	$ 369,000
TOTAL			$ 29.312.200

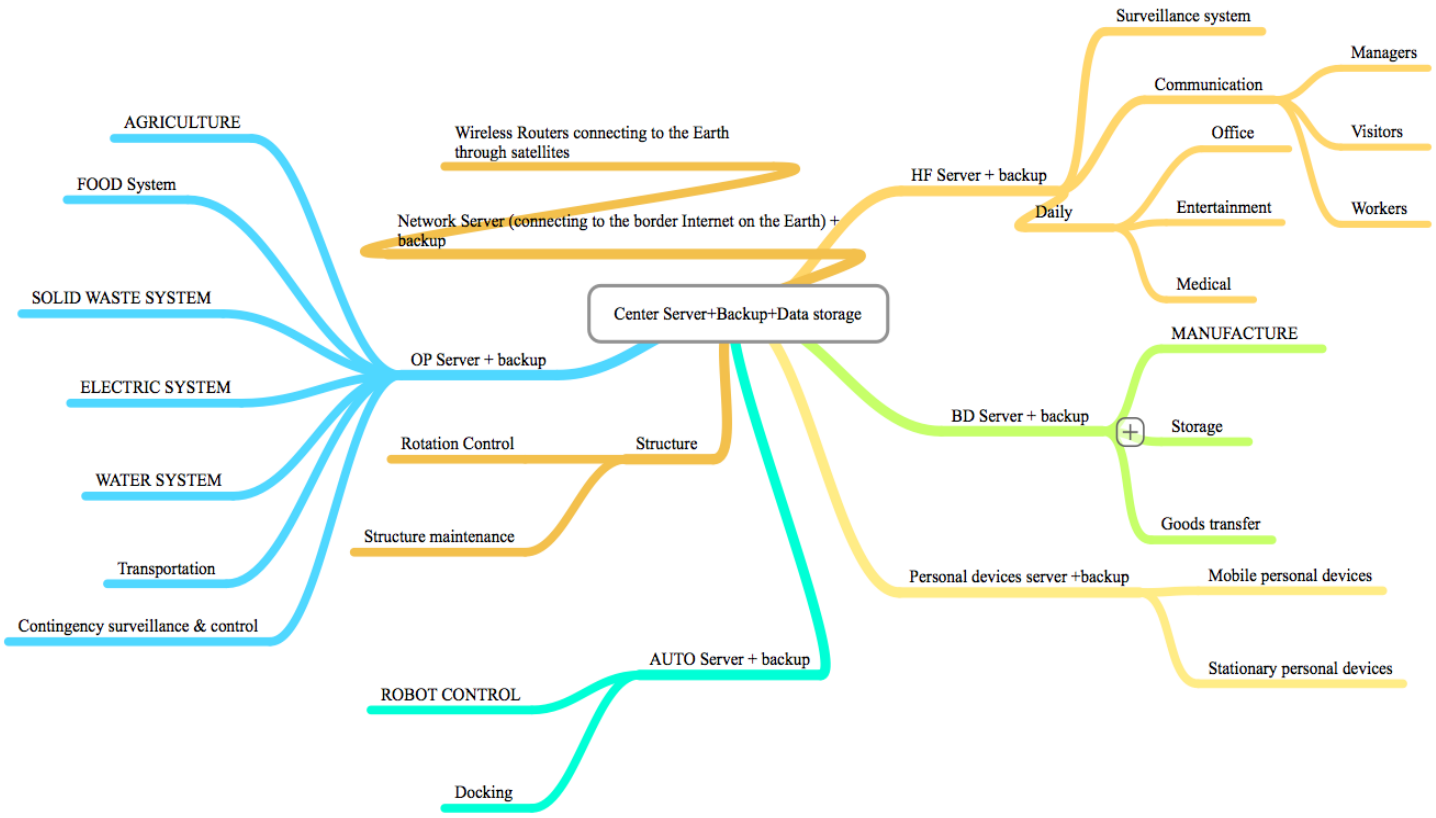
TABLE 3.2

Computation system features

Feature	Description	Affected devices
Evolvability	Cloud-based app, and thus the computers and other personal devices, would evolve literally as much as by self-correction as by crowd sourcing.	Personal electronic devices and workplace computers.
User Customization	Device interfaces will be keyed to neurological mapping information and data-mined user behavior preference for optical user experience.	Personal electronic devices and workplace computers.
Privacy protecting	Personal devices are partitioned to keep individual privacy from leaking, since individual decides which file to synchronize with cloud.	Personal devices.
Cloud calculation	Calculation tasks that cannot be tackled by personal computers would be outsourced to spare advance computers by the cloud calculation feature of the network system.	Restricted amount of personal devices and all of the workplace computers.
Cloud storage	People store most of their files on cloud storage, which is provided by main server within the 500PB disk.	All personnel.

File virtualization	Allow department servers to access isolated storage capacity on other servers and perform seamless file migrations among them.[2]	Department servers and center servers.
Liquid nitrogen cooling	This efficient coolant could cool computers and servers to ensure safe and solid performance.	Servers and advance computers.
RAID backup	All data would be backup instantaneously through local network with speed up to 50GB/S.	Department computers and servers.
Eyeball & thought control	Devices can be controlled through eyeball and thoughts. Sensors installed on devices would detect eyeball movement, and with specific demand, residents could buy a complementary helmet and control the computer system using thoughts. Conventional mouse and keyboard are history.	All computer devices including Linka.

TABLE 3.3



Security hierarchy

Level	Security Check	Application
Alpha	Linka bio-check (DNA, blood test) and retina scan and nail bed scan. **All three required.**	The center server and its backup unit. Two people need to log in simultaneously to access.
2	Linka bio-check (DNA) and **either** retina scan or nail bed scan.	Department computation systems; unscheduled robots administration; settlement Internet control.

3	Retinas scan **or** nail bed scan **combined with** one of Level 4.	Sub-department computers and routine administration of department owned robots.
4	Voice recognition, fingerprint scans, facial recognition. **Only one of those required.**	Personal robots, stationary and mobile personal devices such as Linka and personal computers.

TABLE 3.4

Contingency Plan

Contingency	Affected area	Detection method	Short-term solution	Long-term solution
Hull breach at an interface with a hole equivalent to 15 centimeters diameter in each volume	Between two separate habitable volumes of residential and commercial.	Coordinate mapping system on the outer most wall of the settlement. (Robots of any type would be supervising at any time.)	Close the nearest isolated valves. Time: 3 min	External repairing robots bring ingredients and metal plates to fill the laceration. Time: 1 h
Internal explosion without a hull breach resulting in a large release of heat and toxic gas	Habitable industrial area	Robots and TIRS (Thermal Infrared Sensor) installed in the settlement. (Robots of any type would be supervising at any time as mentioned in the robot chart.)	Close the nearest isolated gates and release dry powder to quench any fire and prevent further explosion. Time: 5 min	Internal repairing robot will bring ingredients to repair. Time: 30 min
Fire	Anywhere inside the settlement	TIRS (Thermal Infrared Sensor) installed throughout the settlement would detect the sudden temperature change.	Affected compartment would be segregated and the fire extinguish machine installed automatically extinguish. Time: 2 min	Fire source would be reported through fire extinguish machine directly to the main server. Any defects would be repaired immediately. Time: 30 min
Power failure	Any electronic devices	Power supply fluctuation would be detected by main server and backup server	The backup one would replace affected power supply till the problem is solved. Time: 15seconds	Robots would repair or replace the affected devices and log the problem. Time: 1 h
Network failure or invasion	Any electronic	Main network server would switch to the	Backup system would replace the	Server would report the

	devices	backup one. If invasion occurs, security hierarchy requirement for affected part would be updated.	main server to continue service, and directive would be sent to repair the problematic device. If invasion occurs, security-check grade for affected part would be updated. Time: seconds	problem automatically and instantly after the incident happened. Robots would repair or replace the affected devices and log the problem. Time: 6 hours
Space debris	Exterior hull	The advanced coordinate mapping system and the optical telescopes can detect space debris.	The External Maintenance Robots would put polymer composites and aluminum alloy layer to fill the crevices Time: 2 weeks	Comprehensive maintenance plan six months would be drafted. Multiple workers and hundreds of robots are used. Time: 6 months
Biological infection	Area with human presence	There will be a physical examination before visitors leave the earth and leave the spaceship. The people with of infection or have 3-5 days absenteeism will be sent to the hospital.	Affected peoples who are suspected have infection diseases will be isolated until they are treated. Patient would be sent to hospital by special route as soon as possible. Time: 15 min	There would be a biological examination for all residents in contact with patients. Time: 1 days
Asteroid	Exterior hull	Radio can detect, track and recognize hundreds of asteroids.	Space tugs will tug the asteroids away from the settlement. Time: 2 months	Marking the asteroids detected and tracking them by radars and telescopes to predict the route of asteroids. Time: 1 year
Robots function error	Robots	The error would be detected automatically by computation	Robots would power off start self-correction	Center server would log the error and the

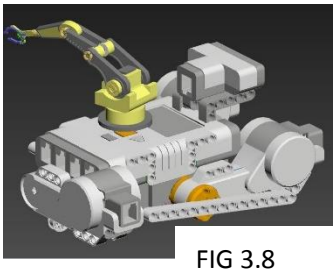
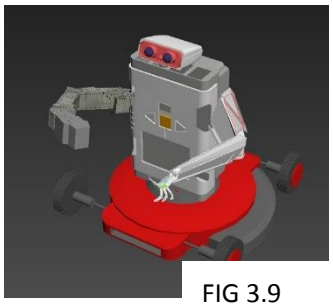
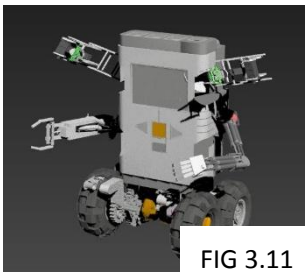
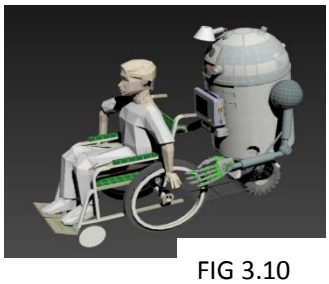
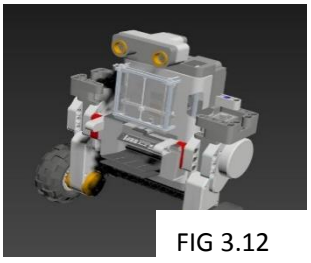
		system.	procedure automatically. Time: 10min	same type of robots would be corrected wirelessly. Time: 1 h

TABLE 3.5

Linka

Amount 12,000	Processor 4.8GHz Quad-core	Memory 16GB 3300MHz DDR5	Storage 16GB of 3300MHz DDR5
Software features		**Hardware features**	
Instant voice, video or text message chat		Holographic display	
Thousands of apps available online		Locator	
Streaming holographic movie and music display		Vibration meter	
Record any health information including DNA safe check		Biological information detector including DNA check, fingerprint collector, etc.	
Schedule arrangement and other personal affair arrangement to ensure perfect efficiency and comfort		Fingerprint collector	
Self-correcting and evolvability with artificial intelligence		Sensors: Three-axis gyro, accelerometer, proximity sensor, ambient light sensor	
Functions as security checker		Mic and speakers	
Contingency guide. When contingency such as fire accidents happens, Linka can provide instructions and exit route for users.		Projectors installed enable users to share screen and make presentation at any place	
Voice recognition			
Act as a credit card and make payment			
Access data on cloud everywhere through Linka			
Remote control house services such as robot setting room temperature, preparing bathing waters, and others			
Linka disk can be partitioned to keep private storage safe from synchronizing with servers			
Reserve for restaurant and hospital and others			

TABLE 3.6

<table>
<tr><th>External construction and repairing robot</th><th>Garden robot</th><th>Internal construction and repairing robot</th></tr>
<tr><td>20</td><td>50</td><td>100</td></tr>
<tr><td rowspan="2">-External construction and reparation
-Move through railways or ion thrusters
-CNT (carbon nanotube) layer on the robot exterior permits the hydrogen filled composites that prevents doses of electrons and protons generated through solar flare
-Grit-blasted screen provides thermal protection
-Every needed tool and material can be stored inside the body
-Are able to construct railways while moving along
-Several robots can combine to make a working platform
-Other construction tools can be installed on the surface part as well
-Used as external mobile devices for human factor
-Ion thruster ensures flexibility
-Size: 10m×7m×3m (length×width×height)
 
FIG 3.8</td><td>-Settlement cleaning
-Plant caring and grass mowing
-Identify and track the suspects
-One hand for trimming plants and another hand for other flexible works
-Base part works as garbage collector and grass mower
-Arms are extensible
-Size: 0.8m×0.8m×1.8m
 
FIG 3.9</td><td>-Have multiple tools to repair
-Display in the front provides information of reparation work load and other information
-Multiple and changeable hands installed for faster work speed and multiple functions
-Fix not only devices on the settlement but also other robots
-Arms are extensible
-Size: 0.8m×0.5m×1.5m
 
FIG 3.11</td></tr>
<tr><td>Medical robot</td><td>Office robot</td></tr>
<tr><td>150</td><td>400</td></tr>
<tr><td>-Enable, X-rays and shadow less lamp
-Provide blood test, standard health check, and more
-Provide common medicine
-Take care of patients and help in rehabilitation process
-Size: 0.8m×0.3m×1.5m
 
FIG 3.10</td><td>-A combination of printer, 3D printer, duplicator and scanners
-3D printer installed is able to print almost any required commodities including food. Materials from the moon could be used for 3D printing
-Provide drink for staff
-Size:0.8m×0.8m×1.8m
 
FIG 3.12</td></tr>
</table>

Robots of any type would be supervising at any time.

TABLE 3.7

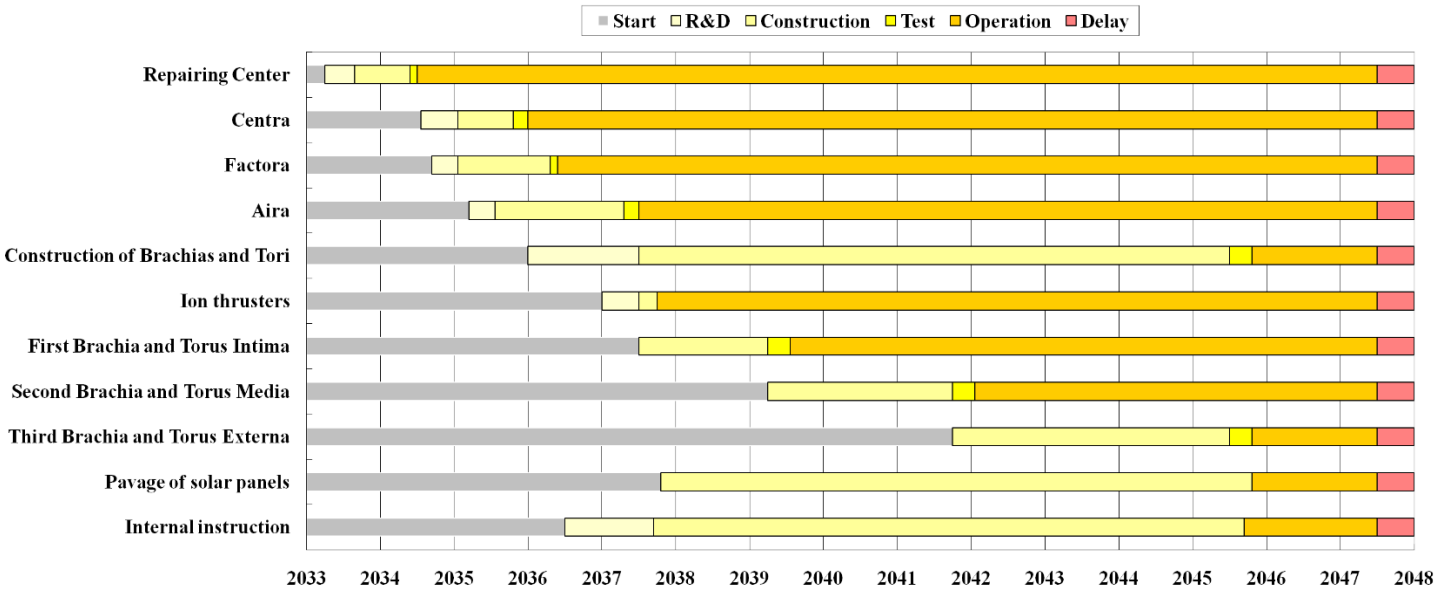
Any robots move in super quiet to ensure the tranquility of the settlement.

TIRSs (Thermal Infrared Sensor) are installed not only on the settlement, but also on every robot.

Schedule and Cost

4. Schedules and Costs

Schedule



The construction of Bellevistat will be completed before May, 2046, including the time periods needed for testing and possible delays.

Costs

Running costs of employees needed for construction

Employee	Annual salary	Phase1-4	Phase5-9	Total Expenditure
Engineers	$ 90,000	30	25	$ 28.8 m
Managers	$ 110,000	30	35	$ 44.0 m
Architect	$ 80,000	40	30	$ 32.0 m
Constructors	$ 50,000	20	100	$ 44.0 m
Analyst	$ 70,000	30	30	$ 25.2 m
TOTAL		$ 49.2 m	$ 124.8 m	$ 174 m

TABLE 4.1

Running(maintenance) costs of operations

Name	Starting year	Average annual cost	Total cost until 2046
Delivery facilities	2036	$ 100 m	$ 1.0 b
Docking facilities	2035	$ 1.0 b	$ 11 b
TOTAL			**$ 12 b**

TABLE 4.2

Running(maintenance) costs of automation

Name	Starting year	Average annual cost	Total cost until 2046
Personal computers	2040	$ 30,000	$ 180,000
Gateways	2042	$ 500	$ 2,000
Linka	2042	$ 800	$ 3,200
Robots	2034	$ 356,500	$ 4,278,000
Thermal Infrared Sensors	2035	$ 1,800	$19,800
TOTAL			**$ 4.5 m**

TABLE 4.3

Revenue

	Starting year	Average revenue/year	Total revenue until 2046
Ore mining and extraction	2040	$ 8 b	$ 48 b
Buckystructure	2040	$ 500 m	$ 3.0 b
Services for visiting ships	2042	$ 600 m	$ 2.4 b
Space leasing	2040	$ 250 m	$ 1.5 b
Tourism	2045	$ 2.5 b	$ 2.5 b
TOTAL			**$ 57.4 b**

TABLE 4.4

Costs by phase

	Construction	Operations		Automation		Human factor		TOTAL
		One-off	Maintenance	One-off	Maintenance	Labor	Building	
Phase 1	$ 10 b	$ 2 b		$ 0.5 m		$ 10 m		**$ 12.0 b**
Phase 2	$ 12 b	$ 1.4 b	$ 0.5 b	$ 1.3 m	$ 360,000	$ 15.2 m		**$ 13.9 b**
Phase 3	$ 15 b	$ 0.8 b	$ 0.6 b	$ 1.2 m	$ 370,000	$ 11.5 m		**$ 16.4 b**
Phase 4	$ 14 b	$ 4 b	$ 1.1 b	$ 1.8 m	$ 500,000	$ 12.5 m		**$ 19.1 b**
Phase 5	$ 0.4 b	$ 0.54 b	$ 0.8 b	$ 0.7 m	$ 200,000	$ 4.5 m		**$ 1.75 b**
Phase 6								
Phase 7	$ 28 b	$ 45 m	$ 1 b	$ 5.2 m	$ 600,000	$ 26 m		**$ 29.1 b**
Phase 8	$ 43 b	$ 50 m	$ 2 b	$ 5.3 m	$ 800,000	$ 28.5 m		**$ 45.1 b**
Phase 9	$ 55 b	$ 55 m	$ 3 b	$ 6.1 m	$ 950,000	$ 29.8 m		**$ 58.1 b**
Phase 10		$ 50 m	$ 3 b	$ 6.9 m	$ 720,000	$ 36 m	$ 564 m	**$ 3.0 b**
Total		**$ 8.94 b**	**$ 12 b**	**$ 29 m**	**$ 4.5 m**	**$ 174 m**	**$ 564 m**	
TOTAL	**$ 177.4 b**		**$ 20.94 b**		**$ 0.034 b**		**$ 0.738 b**	**$ 199.1 b**

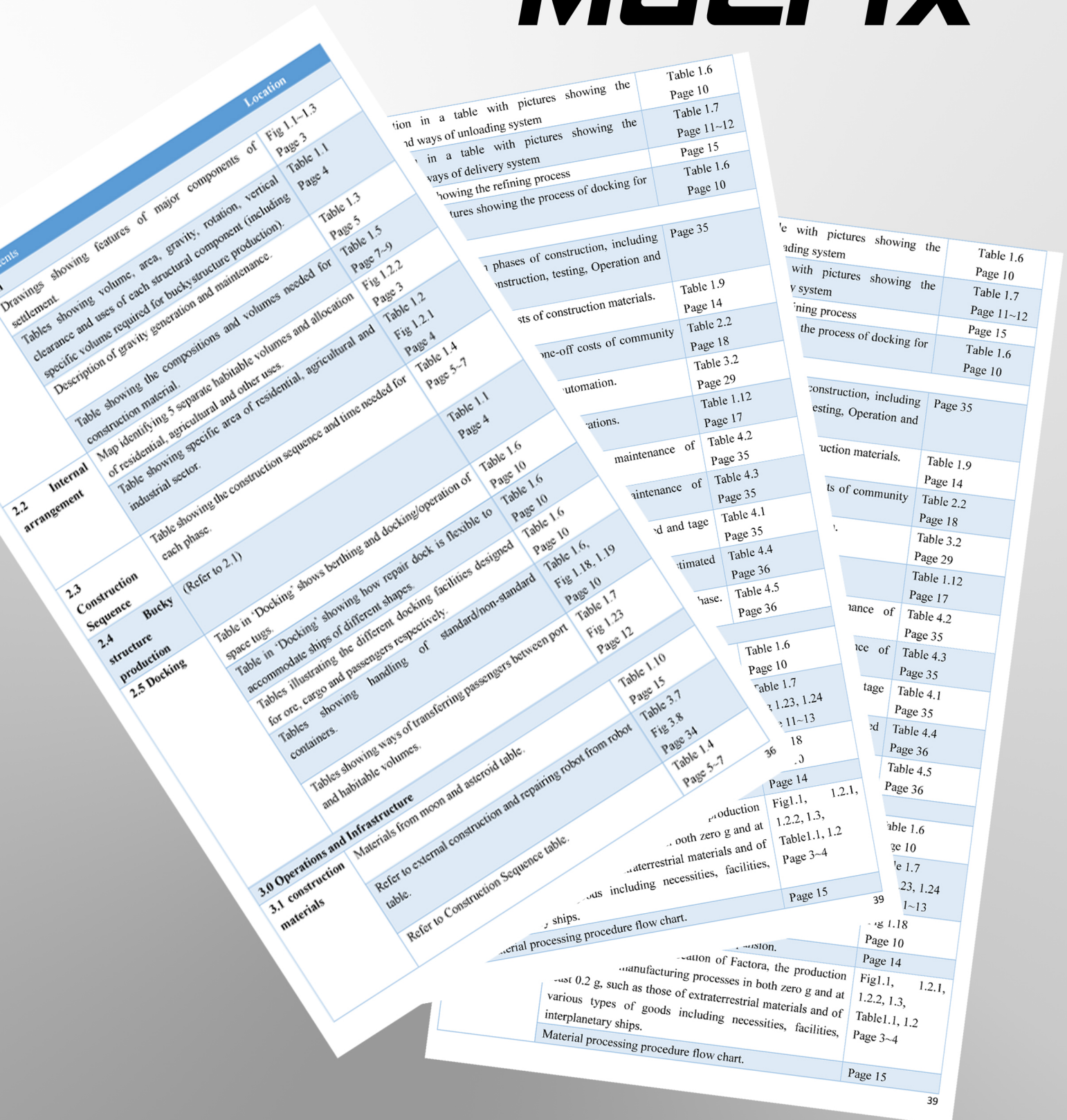
TABLE 4.4

From 2033 to 2046:

One-off costs:	
Construction costs	$ 177.4 b
Operations facility costs	$ 8.94 b
Community buildings costs	$ 0.564 b
Automation costs	$ 0.029 b
Total one-off costs:	**+ $ 186.9 b**
Running costs:	
Human labor costs	$ 0.174 b
Costs of operations	$ 12 b
Costs of automation	$ 4.5 m
Total running costs:	**+ $ 12.2 b**
Revenue:	**- $ 57.4 b**
Total costs	**= $ 141.7 b**

TABLE 4.5

Compliance Matrix



	Location
Drawings showing features of major components of settlement.	Fig 1.1~1.3 Page 3
Tables showing volume, area, gravity, rotation, vertical clearance and uses of each structural component (including specific volume required for buckystructure production).	Table 1.1 Page 4
Description of gravity generation and maintenance.	Table 1.3 Page 5
Table showing the compositions and volumes needed for construction material.	Table 1.5 Page 7~9
Map identifying 5 separate habitable volumes and allocation of residential, agricultural and other uses.	Fig 1.2.2 Page 3
Table showing specific area of residential, agricultural and industrial sector.	Table 1.2 Fig 1.2.1 Page 4
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(Refer to 2.1)	Table 1.1 Page 4
Table in 'Docking' shows berthing and docking/operation of space tugs.	Table 1.6 Page 10
Table in 'Docking' showing how repair dock is flexible to accommodate ships of different shapes.	Table 1.6 Page 10
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Tables showing handling of standard/non-standard containers.	Table 1.6, Fig 1.18, 1.19 Page 10
Tables showing ways of transferring passengers between port and habitable volumes.	Table 1.7 Fig 1.23 Page 12
Materials from moon and asteroid table.	Table 1.10 Page 15
Refer to external construction and repairing robot from robot table.	Table 3.7 Fig 3.8 Page 34
Refer to Construction Sequence table.	Table 1.4 Page 5~7

2.2 Internal arrangement	
2.3 Construction Sequence	
2.4 Bucky structure production	
2.5 Docking	
3.0 Operations and Infrastructure	
3.1 construction materials	

tion in a table with pictures showing the d ways of unloading system	Table 1.6 Page 10
in a table with pictures showing the ways of delivery system	Table 1.7 Page 11~12
howing the refining process	Page 15
tures showing the process of docking for	Table 1.6 Page 10
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ations.	Table 1.12 Page 17
maintenance of	Table 4.2 Page 35
aintenance of	Table 4.3 Page 35
d and tage	Table 4.1 Page 35
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hase.	Table 4.5 Page 36
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both zero g and at raterrestrial materials and of ds including necessities, facilities,	
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erial processing procedure flow chart.	

e with pictures showing the ading system	Table 1.6 Page 10
with pictures showing the y system	Table 1.7 Page 11~12
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the process of docking for	Table 1.6 Page 10
construction, including esting, Operation and	Page 35
uction materials.	Table 1.9 Page 14
ts of community	Table 2.2 Page 18
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nance of	Table 4.2 Page 35
ce of	Table 4.3 Page 35
tage	Table 4.1 Page 35
d	Table 4.4 Page 36
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	e 1.7 .23, 1.24 1~13
	g 1.18 Page 10
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ation of Factora, the production manufacturing processes in both zero g and at ast 0.2 g, such as those of extraterrestrial materials and of various types of goods including necessities, facilities, interplanetary ships.	Fig1.1, 1.2.1, 1.2.2, 1.3, Table1.1, 1.2 Page 3~4
Material processing procedure flow chart.	Page 15

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Compliance matrix

SOW section	Contents	Location
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2.1 External Configuration	Drawings showing features of major components of settlement.	Fig 1.1~1.3 Page 3
	Tables showing volume, area, gravity, rotation, vertical clearance and uses of each structural component (including specific volume required for buckystructure production).	Table 1.1 Page 4
	Description of gravity generation and maintenance.	Table 1.3 Page 5
	Table showing the compositions and volumes needed for construction material.	Table 1.5 Page 7~9
2.2 Internal arrangement	Map identifying 5 separate habitable volumes and allocation of residential, agricultural and other uses.	Fig 1.2.2 Page 3
	Table showing specific area of residential, agricultural and industrial sector.	Table 1.2 Fig 1.2.1 Page 4
2.3 Construction Sequence	Table showing the construction sequence and time needed for each phase.	Table 1.4 Page 5~7
2.4 Bucky structure production	(Refer to 2.1)	Table 1.1 Page 4
2.5 Docking	Table in 'Docking' shows berthing and docking/operation of space tugs.	Table 1.6 Page 10
	Table in 'Docking' showing how repair dock is flexible to accommodate ships of different shapes.	Table 1.6 Page 10
	Tables illustrating the different docking facilities designed for ore, cargo and passengers respectively.	Table 1.6 Page 10
	Tables showing handling of standard/non-standard containers.	Table 1.6, Fig 1.18, 1.19 Page 10
	Tables showing ways of transferring passengers between port and habitable volumes.	Table 1.7 Fig 1.23 Page 12
3.0 Operations and Infrastructure		
3.1 construction materials	Materials from moon and asteroid table.	Table 1.10 Page 15
	Refer to external construction and repairing robot from robot table.	Table 3.7 Fig 3.8 Page 34
	Refer to Construction Sequence table.	Table 1.4 Page 5~7

	Refer to tables showing handling of standard/non-standard containers.	Table 1.6, Fig 1.18, 1.19 Page 10
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3.4 paper management	Table of paper management giving alternatives of paper and their management.	Table 1.11, Page 16
3.5 repair service	Table showing the services provided by Repair center.	Table 1.8, Page 14
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	No.2 floor plan. (couple)	Fig 2.5, Page 19
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	Depiction in a table with pictures showing the equipment and ways of delivery system	Table 1.7 Page 11~12
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	Table listing the types and the one-off costs of community facilities.	Table 2.2 Page 18
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	Table showing the running costs of maintenance of operations.	Table 4.2 Page 35
	Table showing the running costs of maintenance of automation.	Table 4.3 Page 35
	Table showing the number of employees required and tage 36he labor costs.	Table 4.1 Page 35
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