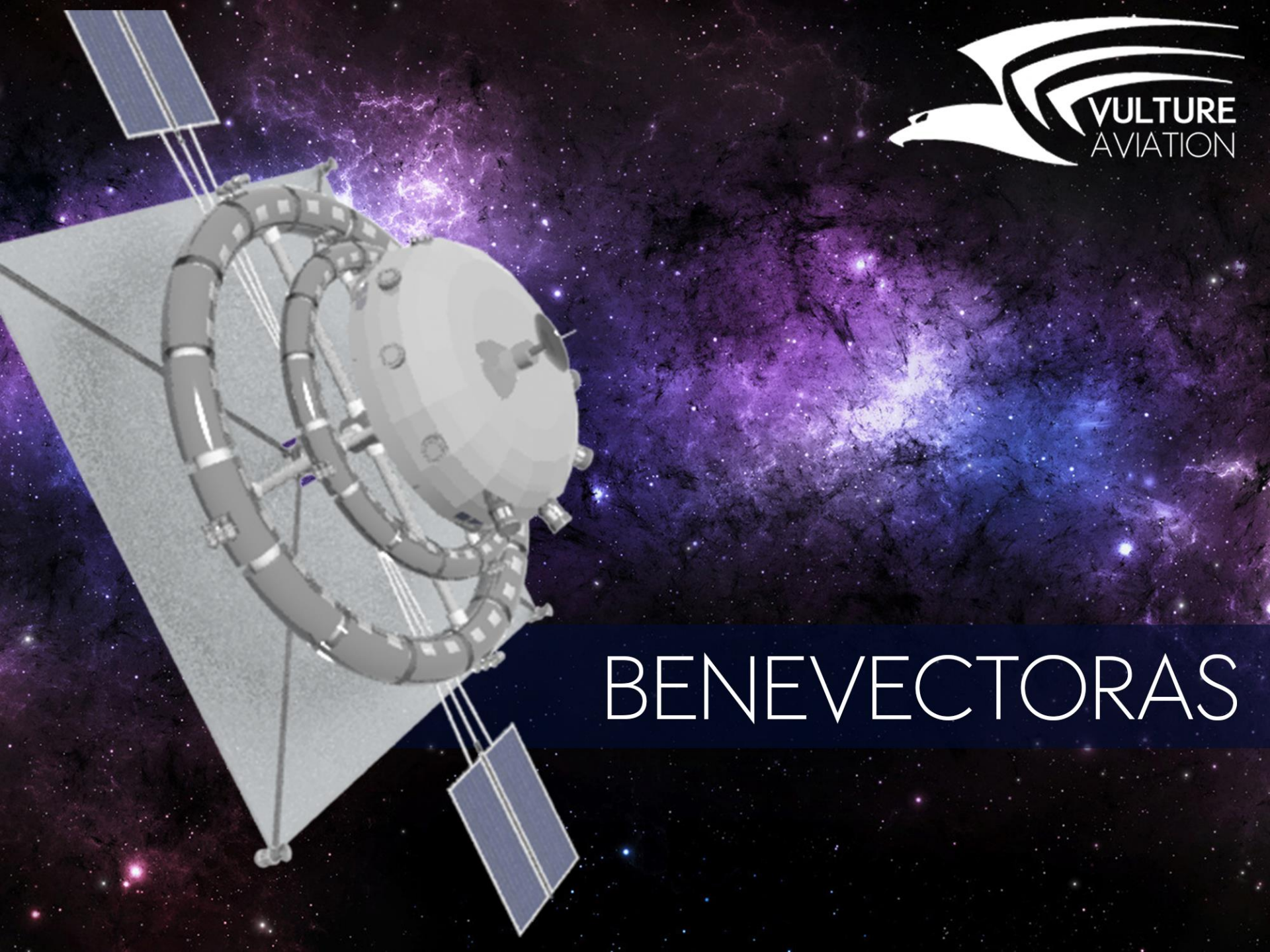

VULTURE
AVIATION
BENEVECTORAS

Presenting Benevectoras: The next evolution in space settlement design.

Fulfills the requirements of the Foundation Society.

Provides access to Mars and its settlements.

Utilizes innovative techniques to achieve a sustainable settlement.

A unique product made possible by the talented engineers of Vulture Aviation.

Salient Features:

- Vertical Farming combines aesthetic appeal with utilization of space.
- Solar sails convert harmful radiation into a source of propulsion for the settlement.
- Augmented reality training for people going to Mars.
- Ten docking stations for maximum efficiency during the eight-day window.
- Hydraulic powered temporary housing for the transient population.
- Unique sports such as Parabolic Squash and Paintball to entertain residents.
- Rapid manufacturing and prototyping with 3-D printers.
- Annual Multi-Cultural day to honor the diversity of Benevectoras.
- State of the art research facilities will analyze, document and process all minerals we extract.

Population	2500-8800
Contrcution starts	1st April 2060
Date of completion	31st December 2074
Total Cost	$ 158.518 Billion
Location	Earth to Mars Transit
Rate of Rotation	0-0.99 RPM
Gravity	0-0.9g
No. of docking hubs	10
Energy Consumption	50,000 kW

Structural Engineering

2.1 Exterior Structure Design

2.2 Interior Design

2.3 Construction Process

2.4 Solar Sail and Space Tugs

Benevectoras is the second settlement around sun and the first cycler settlement around Earth and Mars. It will act as a transportation system between the two planets. Natural views have been enabled and the residents will be able to see Earth and Mars while in orbit.

2.1.1 Exterior view of Benevectoras

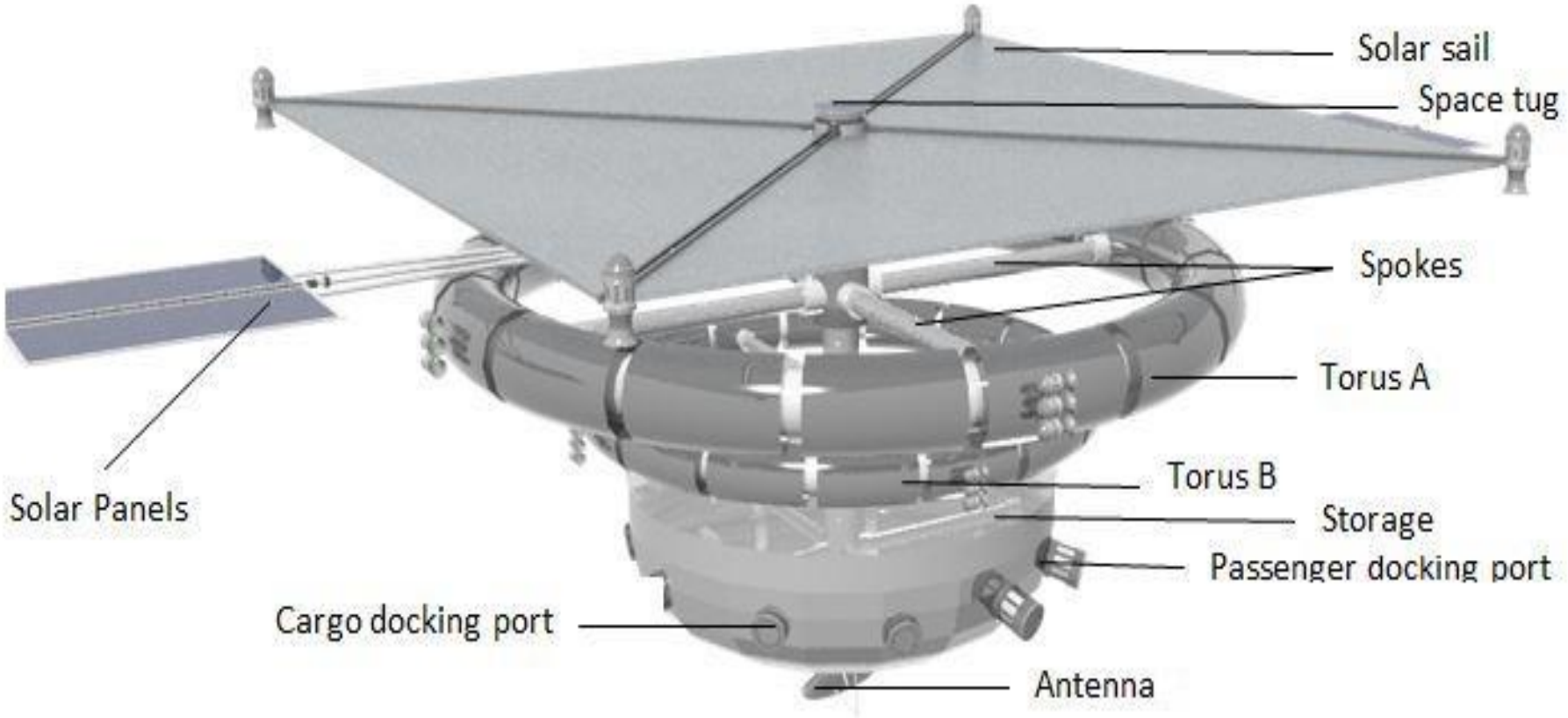


Fig 2.1: External Structure

2.1.2 Rotating and Non-rotating sections

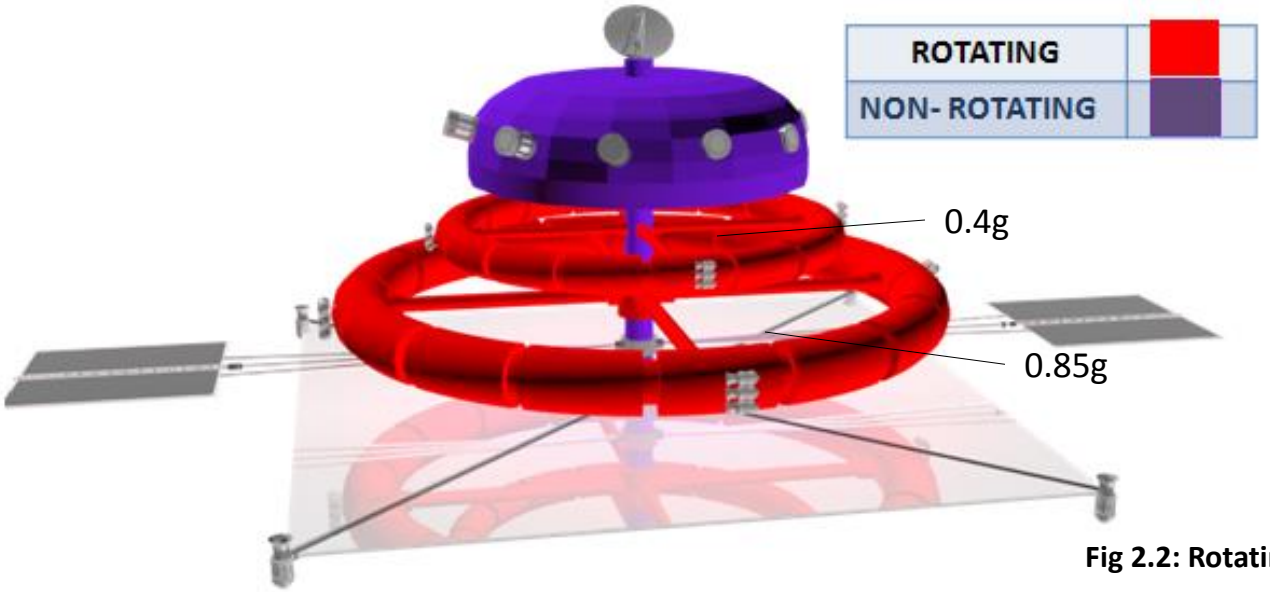


Fig 2.2: Rotating and non-Rotating sections

2.1.3 Artificial Gravity

• The rotation of both tori around the central node will provide the affects of artificial gravity to the people residing in our settlement.
•Torus A (Residential/Agricultural) will be rotating at 0.99 RPM to stimulate an Earth-like living environment while Torus B (Industrial) will be rotating at 0.85 RPM for easy cargo handling hence saving energy. Also, preventing any adverse affect on the residents such as Nausea or the Coriolis effect.
• Multiple MPD (Magneto Plasma Dynamic) thrusters will be used as a redundant plan to provide thrust to our settlement in case of any deviation from the normal rotation rate.
•The thrusters placed will increase or decrease rotation speed as needed or produce propulsion to overcome any wobbling effects that may perhaps arise overtime.
•Refer to Fig 2.2 for the sectors highlighting gravity magnitude in respective areas.

2.1.4 Docking facilities

•The docking ports are positioned in the lower compartment of the hemispherical structure beside torus B. It is placed in a zero-g environment.
•There will be five cargo docking ports, four passenger docking ports and one for emergency landings and repairs. All will have refuelling stations.
•Every docking port has an interface (with passenger ports having airlocks supplied by the sub contractor Lossless Airlocks)
•The port face consists of suction pads on its circumference and on its interiors it consists of sensors integrated with numerous small mechanical slabs.
•The sensors help these slabs to configure themselves according to the nodes of different vehicles.
•The mechanical slabs have the ability to move back and forth to form any shape.

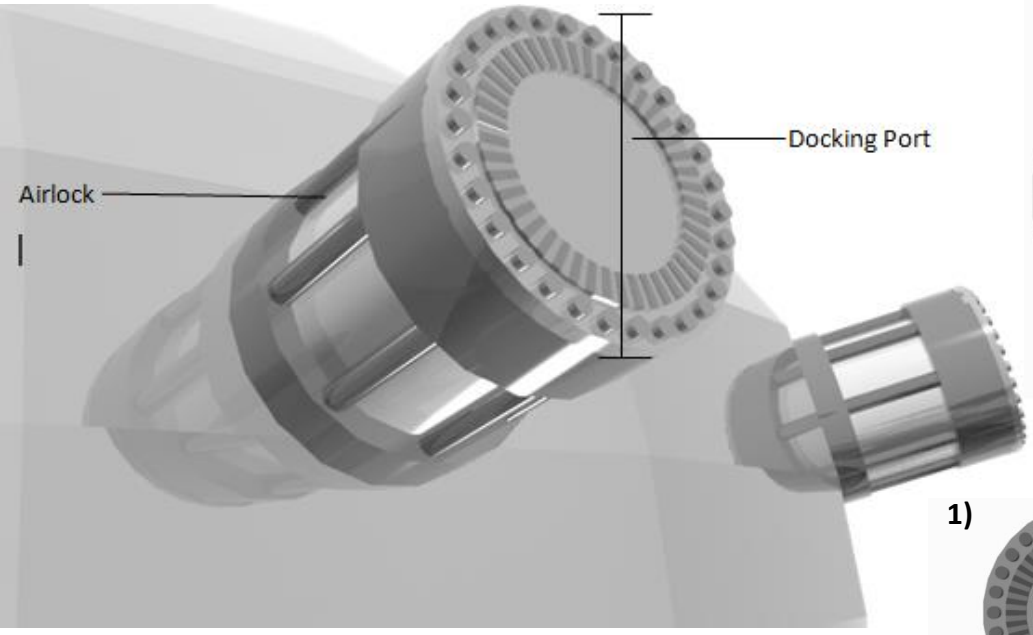
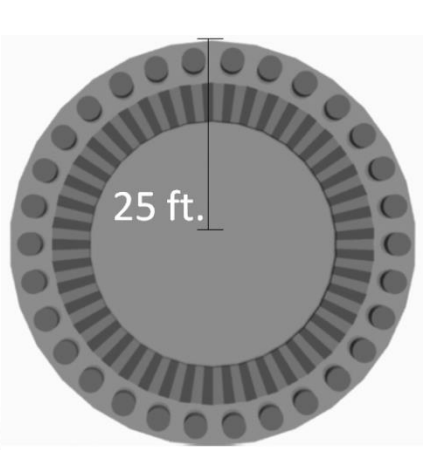
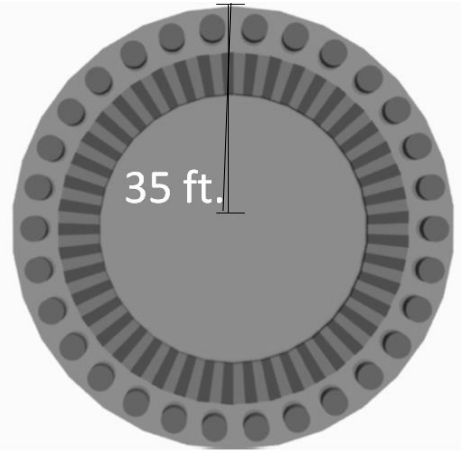


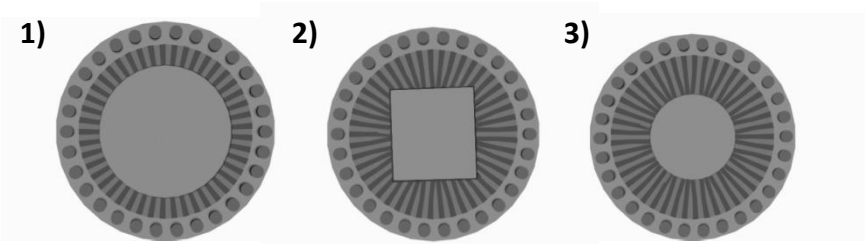
Fig 2.3: Docking Mechanism and specifications.



Passenger Docking Port



Cargo Docking Port



The docking port showing three different (more possible) configurations of the interface for docking.

2.1.5 Construction Materials

Table 2 A: Construction Materials for Structural components					
Layer	Material	Outer surface of tori (ft.)	Inner surface of tori (ft.)	Axles/Spokes (ft.)	Docking port (ft.)
1	Aluminium Alloy	3.5	3	3	4
2	Silicon Bucky structure	1.5	3	3	2.5
3	X-Aerogel	0.8	0.6	0.3	0.3
4	Boron Carbide	4	3	4	4
5	Fused Silica Glass	1.5	1	0.5	1.5
6	RXF1 Polyethylene	3	2	2	1
7	Kevlar	2.5	0.5	1	1
Total Thickness		16.8	13.1	13.8	14.3

Table 2 B:Material for windows (Only on tori) (ft.)
Electrochromic glass 8
X-Aerogel 4.2
Aluminium oxy-nitride 4.6

For material properties refer to section 3.1.4

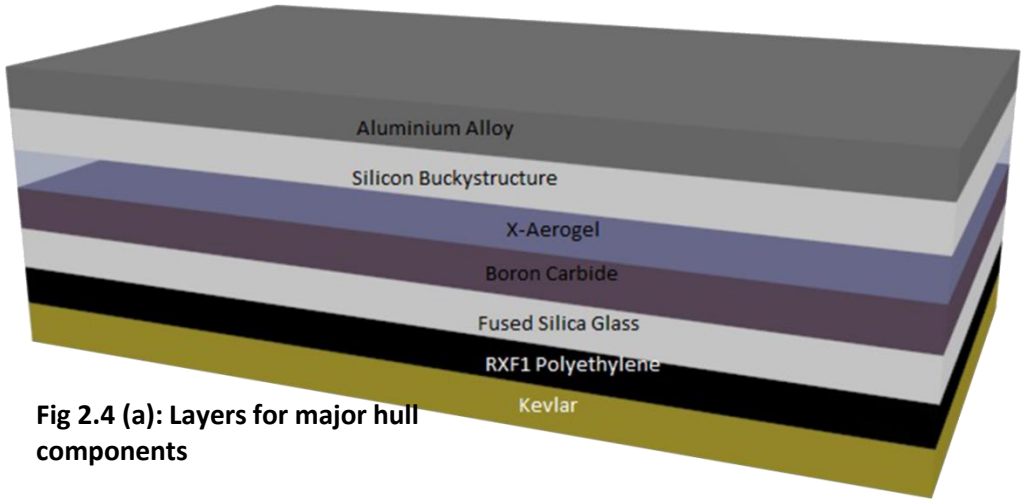


Fig 2.4 (a): Layers for major hull components

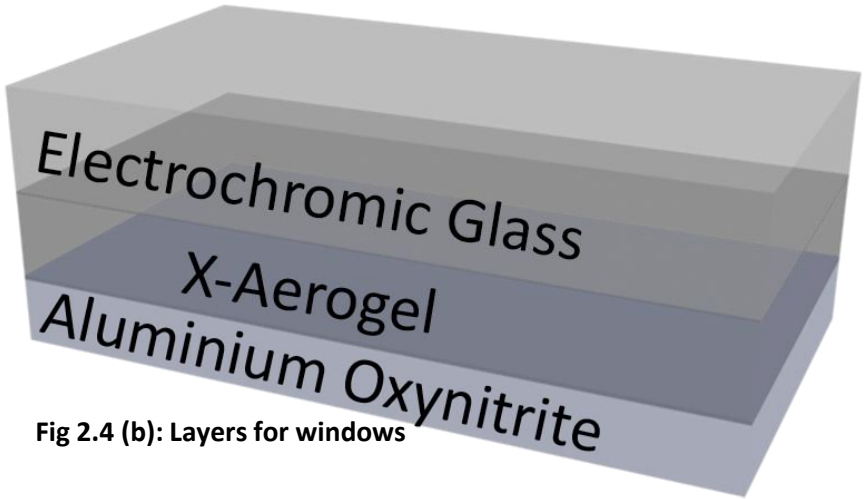


Fig 2.4 (b): Layers for windows

2.1.6 Radiation and Debris Protection

- The layers of our hull components are designed to protect the residents against debris penetration, radiations, solar flares and cosmic rays. The curved surface of the tori assists in deflecting space debris hence reducing any disastrous damage to our settlement.
- The materials used for this purpose are:

i. Boron Carbide,
ii. X-Aerogel,
iii. Aluminium oxy-nitride,
iv. RXF1 polyethylene

- Refer to section 3.1.4. for the properties of these materials.

2.2.1 Dimensions:

Table 2 C: Dimensions

Sections	Torus A [0.85g] [0. 99RPM]	Torus B [0.4g] [0.85RPM]*	Central Node/Axle [0g]	Spokes [Variable gravity]	Antennas	Docking/ Storage [0g]
Outer radius	2460 ft	1640 ft	-	-	-	-
Inner radius	251.7 ft	154.3 ft	65 ft	50 ft	400 ft	250 ft
Volume	3,076,318,372 cubic ft.	770,735,638 cubic ft.	-	-	-	95,785,588 cubic ft.
Height/Length	-	-	1450 ft	Torus A: 2208 ft Torus B: 1485 ft	-	Storage:75 ft Docking:315 ft
Down surface area	5,218,492 sq.ft.	3,600,000 sq. Ft.	-	-	-	480,286 sq. Ft.
Vertical clearance	438.4 ft	103.4 ft**	-	-	-	250 ft

*The rotational speed can be changed according to requirements by the industries hence changing the magnitude of artificial gravity.

**Two floors are built in torus B.

(2.2.2) Table 2 D: Interior allocation			
Sector	Category	Area (sq. ft.)	Percentage
Residential/Agricultural Torus (Torus A)	Residential	2,567,600	49.2%
	Educational institutions	3000	0.06%
	Commercial services	54,500	1.04%
	Emergency/Medical facilities	31,500	0.60%
	Open space/Recreation	79,250	1.51%
	Roads/streets	1,077,700	20.7%
	Miscellaneous	52,000	1.01%
	Agricultural	1,352,942	25.9%
	Total	**5,218,492**	**100%**
Industrial Torus (Torus B)	Factories	3,560,000	98.9%
	Operational services	25,000	0.69%
	Research laboratory	15,000	0.40%
	Total	**3,600,000**	**100%**
Lower Hemisphere	Docking	365,932	76.2%
	Storage	114,353	23.8%
	Total	**480,286**	**100%**

2.2.3 Cargo hold(s)

•The cargo imported to Benevectoras will be stored in a cargo hold located in a modified hemisphere. After extensive research, the engineers of Vulture Aviation have come to the conclusion of providing a zero-g environment for the storage of cargo.

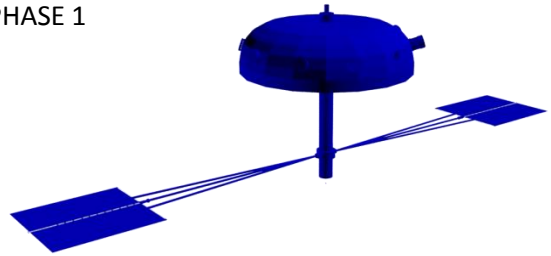
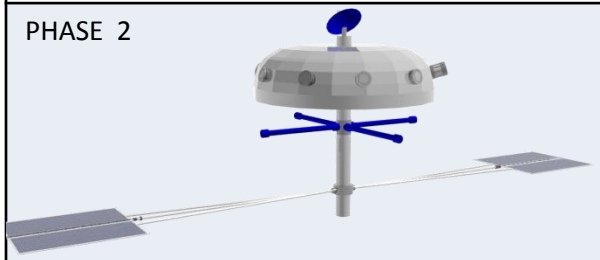
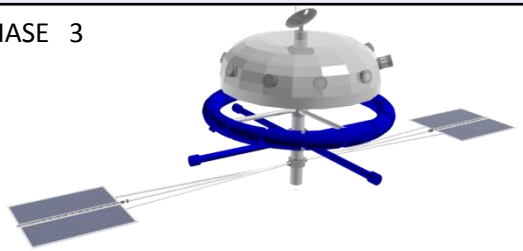
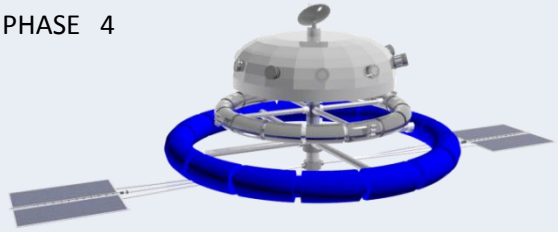
•The reason behind this is the convenience of handling bulky payload without the need for costly and space consuming mechanism. Moreover, it will also prevent the wear and tear of the mechanisms which results in a reduction in the maintenance cost. The cargo hold of Benevectoras will be able to hold 2500 tonnes of cargo.

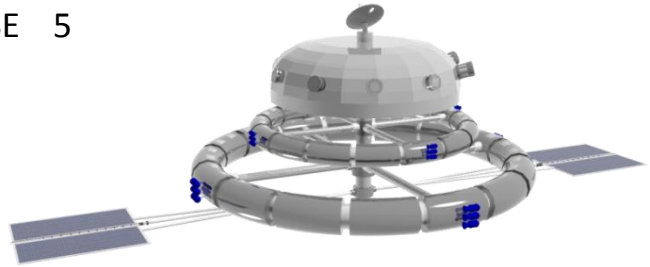
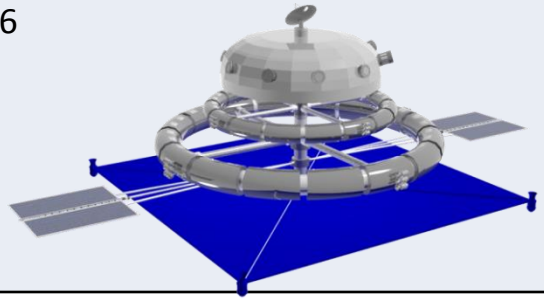
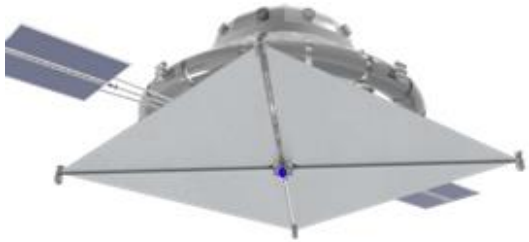
Table 2 E: Trait study (Cargo handling)					
Artificial gravity	Mobility	Ease of handling	Energy required by equipment	Equipment required	Total
Zero g	9	6	9	7	31
Micro g	7	8	5	6	26

From this study it was concluded that zero g was more feasible.

2.3 CONSTRUCTION SEQUENCE

TABLE 2 F: CONSTRUCTION PHASES

PHASE	DESCRIPTION
PHASE 1 	•The Axle and the solar panels along with the storage hemisphere and the cargo docks will be constructed at Bellivistat. •It will be transported to near earth using VASIMR thrusters. •The axle would act as the base for further construction.
PHASE 2 	•The external construction robots will construct the spokes for Torus B . •The antenna will be installed.
PHASE 3 	•Torus B will be constructed . •The second set of spokes will be constructed for Torus A. • Rotation of Torus B is initiated using thrusters and it is constructed for production of materials.
PHASE 4 	•Residential and agricultural Torus A will be constructed.

PHASE 5 	•The rotation will be initiated through thrusters to provide artificial gravity. •The permanent residents will then start living in their homes.
PHASE 6 	•The solar sail will be attached and then deployed.
PHASE 7 	•Finally, the space tug will be constructed on the central axle.

*different colours have been provided for better understanding of the construction phases.

2.4.1 Solar Sail

Benevectoras uses a solar sail as its primary mode of propulsion. The structure, functioning and control system of the sail are explained in the following sections.

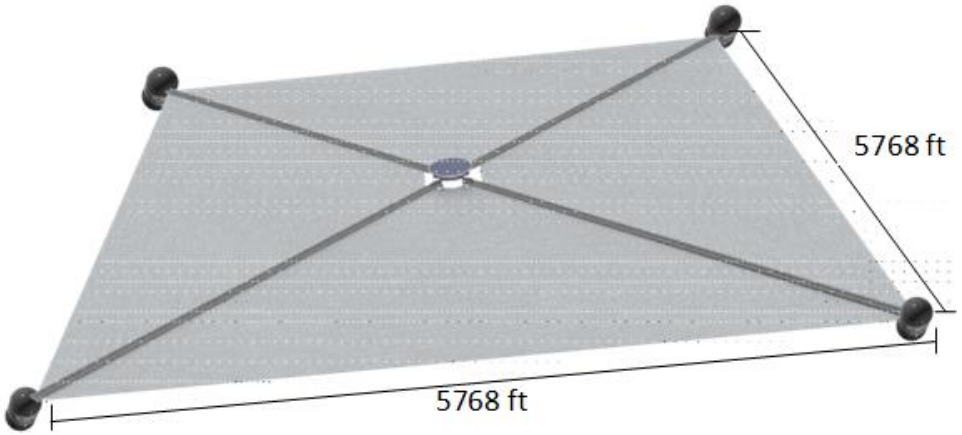


Fig.2.5: Showing Dimensions of the Solar Sails

2.4.1 (a) Attach Mechanism

The solar sail is attached to the Benevectoras on the axle.

2.4.1 (b) Trimming

The Solar sail has been provided with 4 mini MPD (magneto plasma dynamic) thrusters at the vertex's of the sail which will help in the trimming procedure and will act weight on the vertex's thereby ensuring stability. Trimming is done only when the Benevectoras needs to change it's trajectory.

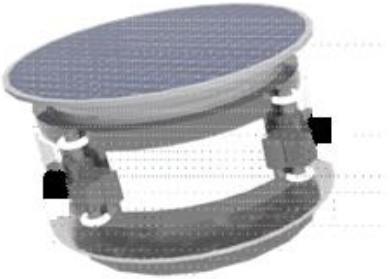


Fig.2.xxx- Undeployed stage

2.4.1 (c) Deployed and Undeployed Stages

The following pictures show the Solar Sail in their Undeployed and Deployed stages –

2.4.2 Space tug

Benevectoras has also been provided with a flat circular interface which is 16 feet in diameter. This would be the interface where a space tug would be attached to the Settlement. The space tug would provide a boost to the settlement, thereby inducing 3.234 ft/s$^{2\ of}$ acceleration. The space tugs would be got from GRUMBO AEROSPACE as they Specialize in space tug manufacture.

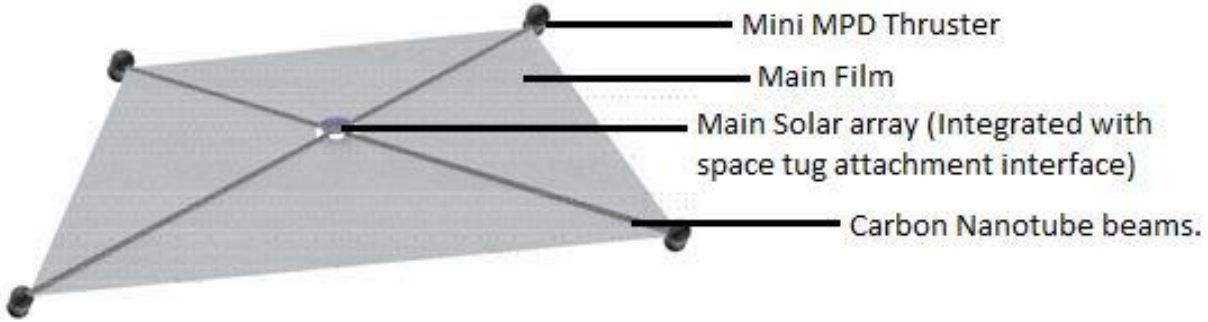


Fig.2- Deployed stage

Table of Contents:

3.1.1 Location

- Transportation becomes easier as the settlement closer to Mars.
- Settlement crosses Mars orbit but it does not enter the Asteroid Belt either.
- Our settlement uses 4S5 orbit based on derivatives of Aldrin Cycle proposed by Dennis V. Brynes.
- Our settlement will be built at Bellevistat.
- It will be Launched from near Earth,

VASIMR Propulsion system will be used for it's launching position.

Table 3 A Specifications of the Orbit	
Semi-major Axis	117290026.24 miles
Semi-minor Axis	92942838.709 miles
Distance in one Orbital revolution	6.63*10^8 square miles
Area of the elliptical orbit	3.24*10^16 square miles
Duration of one Orbital revolution	18 months
Eccentricity	0.60998

3.1.2 Sources of materials

Table 3B Construction Materials				
Materials	Purpose	Sources	Properties	Transport
Aluminum Alloy	Torus, Internal transport, Houses	Alaskol	Easy to recycle, corrosion resistance	Condor
Boron Carbide	Structure, Hull	Produced on the settlement	Radiation Shielding, Hardness	Belvo
Carbon Nanotubes	Structure, Electronics	Alexandriat	Extraordinarily tough, High tensile strength	Belvo
X Aerogel	Shock Absorbers	Alaskol	Strong, polymer, low thermal expansion	Space elevator
Kevlar	Structure, Protection, Space suits	Asteroids	Low Thermal Conductivity, High Tensile stress	Condor
Silicon Bucky structure	Main composition of torus walls	Alexandriat	Extraordinarily Strong ,flexibility	Belvo
Rxf1 Polythene	Shielding	Asteroids	Flame tolerance, Stronger than aluminium	Condor
Optical Fiber	Structure, communication	Alaskol	Flexibility, thickness	Space elevator
Sillicone	Adhesive	Produced on the settlement	It can join glass and metals, High Mechanical strength	Belvo
Perovskite	Solar panels	Balderol	Cost Efficient	Condor

3.2.1. Food production

Table 3.2.1A Food Production		
	Farming	**In-Vitro**
1. Growing	•Food will be produced in the residential torus according to the green building design which will provide 40 % of the food produced	•Animal Stem Cells brought from earth. •Specific cuts of meats are grown in an artificial environment.
2. Harvesting	• Agromatic will harvest the crops and send them down the spiral tube .The food is collected and taken for processing.	•After grown to desired size cut of meat is taken out of the artificial environment and cut accordingly.
3. Storing	• stored in dry container area before distribution	Stored in a c9PEFold container till packaging
4.Packaging	•Harvest moves through the spiral tube and is collected at the bottom. •Pulsed electric field (PEF) electroporation. •The harvest is then vacuum sealed in Mylar bags.	•The meat is collected and put through pulsed electric field (PEF) eletroporation •The meat is heat sealed .
5. Delivering	•The delivering robot takes the consumable to the consumer •Food is delivered door to door •The food is ordered using the PCD , an hour before the food is required	

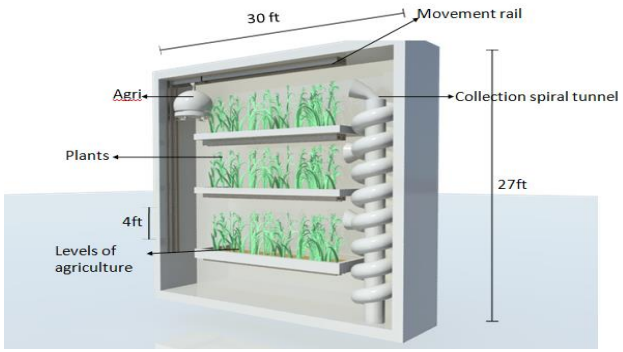


Fig 3.1 Agro-bot

3.2.2 Energy Production

Solar Cells

- Solar cells will be made of mainly 2 materials:
- Perovskite solar cells
- Graphene solar cells
- Traditional silicon cells are very expensive.
- But Perovskite cells are used because they are very cheap and cost efficient.
- Graphene cells have 15.6% efficiency.
- In particular, its transparency and conductivity mean that it solves two problems of solar cells.
- First, light needs a good conductor in order to get converted into usable energy.
- Secondly, the cell also has to be transparent for light to get through.
- Thirdly the dehydrated organic matter will be incinerated at a small thermal plant . The rising water vapour will generate electricity and later along with the co2 produce will react under sebastian process which will produce o2 and methane
- Solar panels are rotated using motors so that it always faces the sun to ensure maximum output of solar energy.

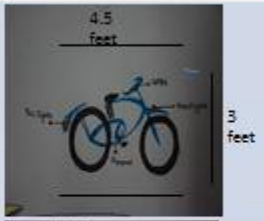
Nickel Hydrogen Battery (Backup)

- Rechargeable power source.
- Hydrogen in gaseous form in pressurised cell.
- Long Life(15 years)

Table 3 B Solar Panels configurations	
Area of Solar Panel	1325800sq. feet
Electricity produced by solar panels.	38 watts/ sq. feet
Range of power	55 – 128 watts/ sq. feet
Total energy required	50000 KW

3.2.3 Internal and External Communication System

Table 3G Communication systems		
Type of communication system	Place of use	Description
Optical fiber system	Internal communication	All PCD'S are directly connected to the In House servers through WiFi. The In House servers are connected through each other through fiber optics in multimode. The servers are in mesh topology. Bandwith is up to 4 GB/s
Wimax	Internal communication	Wimax comes with a range of up to 30 miles and a speed of 70 Mbs/s.
Laser communication system(LCS)	External communication	a pulse laser beam used to send data over a range of 1261920000 feet at speed of 622 mbps. during the time when the settlement is at the distance of 22 minutes the com server will store and relay the data

Vehicle	Capacity and units available	Features	
Cycle	Capacity-1 Units-5600+400	Self adjusting seats The paddle connected to dynamo produces energy which is used to run the cycle like a motor bike when the rider tires out	
Bus	Capacity -20 Units-150+20	Double decker open-top busses the bus will produce energy using electromagnets on the axils and PIEZO electricity at entrances and exits of the bus	

3.2.5 Atmosphere, Climate and Weather control

Table 3.2.5A Atmosphere			
Elements	Residential Sector	Industrial Sector	Regulation
Oxygen	28	20	Plants produce and regulate it.
Carbon dioxide	0.03	0.10	Human beings, animals and plants. Zeolite in industrial sector.
Nitrogen	67.5	78.94	Supplied from asteroids, regulated by leguminous plants.
Water vapours	variable	variable	Dehumidifiers
Argon	2.5	0.95	Imported from earth
Inert Gases	1.97	0.01	Imported from Earth

0.85 Atm pressure will be maintained in Residential Pressure and 0.5 in industrial atm.

Table 3.2.5.B Weather Control	
Factors	Way to control
Temperature change	• Temperature Sensor • Negative Feedback Mechanism
Breeze or wind	Heaters and coolers making pressure zones.
Humidity	Dehumidifiers.
Atmospheric composition rain	O_2 will replenished by agricultural sector "Green buildings" (according to community plan)The sprinklers will be activated at distances.

Table 3.2.5 C Climate		
Season	temperature	humidity
Spring (March-May)	77°F-82.4°F	60% – 70 %
Summer (June-September)	82.4°F -89.6°F	55% - 65%
Autumn (October-November)	71.6°F-82.4°F	45% - 55%
Winter (December-February)	64.4°F-69.8°F	45%- 60%

3.2.6/3.2.7 Water and Waste Management

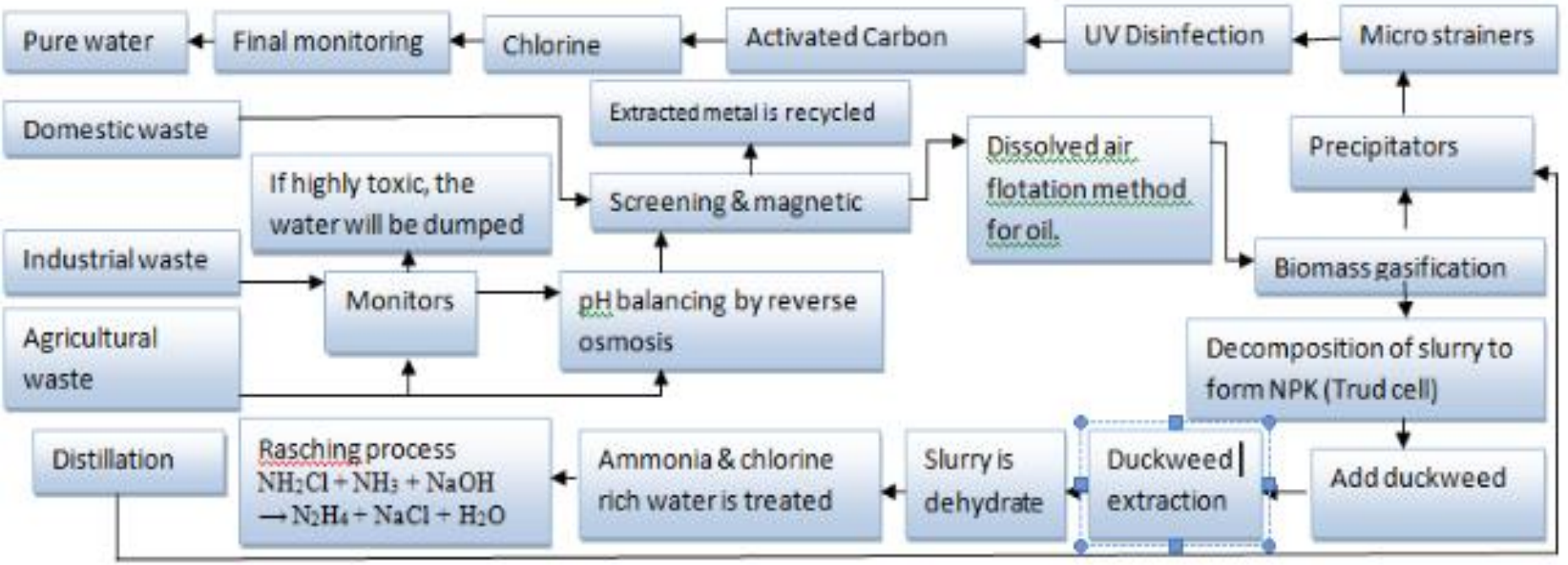


Table 3.2.6A Household Waste Management			
Waste	Per person per day/Kg	Earth to Mars/Kg	Mars to Earth/Kg
Carbon Dioxide	1.3	1140	4030
Water	2.7	23760	8370
Solid	0.22	1936	682

**36000 kg is the per day capacity of Waste Management System

3.2.8 Day And Night:

- Electro-chromic smart glass is a glass-backed Graphene used in combination with specific electrolyte for voltage-tuneable transparency/opacity in an electro-chromic window/device.
- Bio-Luminescence trees inside the settlement will glow in the dark and replace street lightning and it will save energy.
- Organic Light Emitting Diodes replacing ordinary LEDs
- Holographic images of the sky will be displayed on the ceiling.

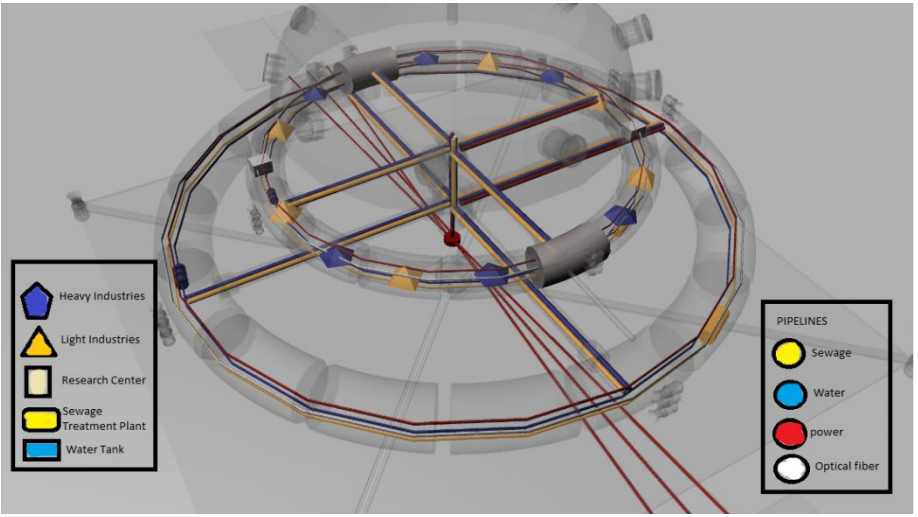


Fig 3.2.8(Roots)

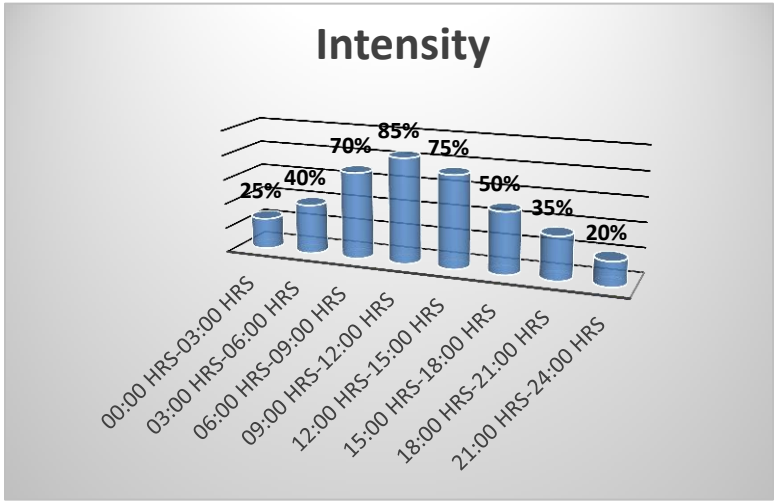
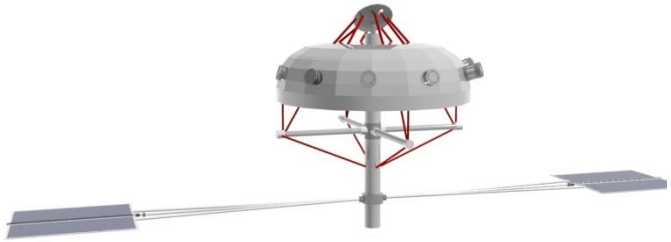
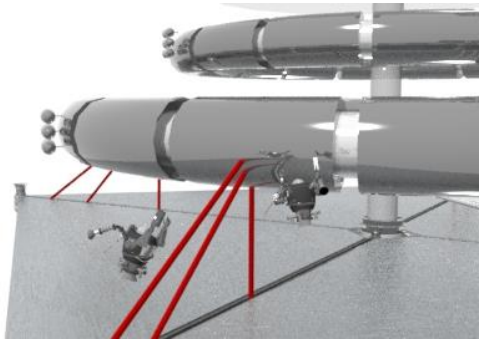


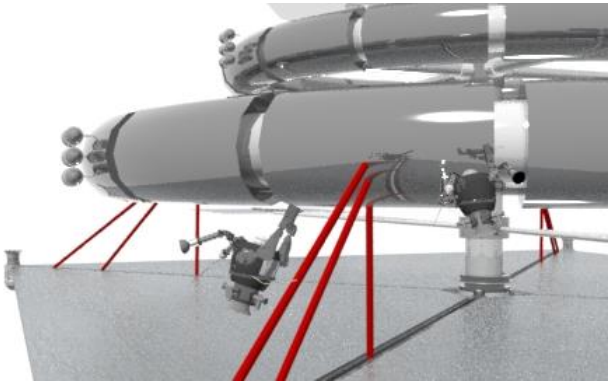
Fig 3.2.8(ii)

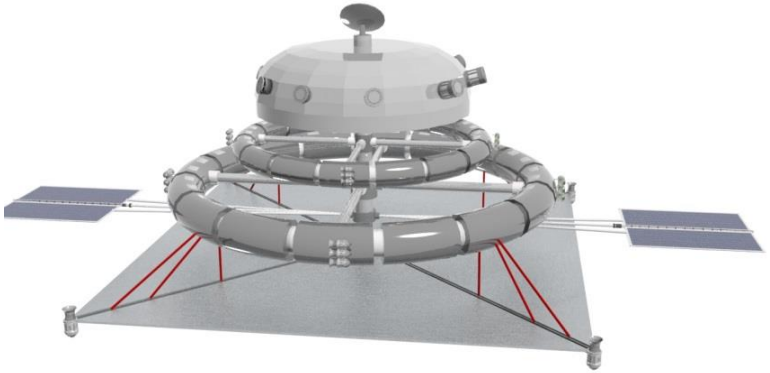
Table 3.2.8A
Lighting Methods
Organic Light Emitting Diodes
Electro-Chromic Smart Glass
Bio-Luminescence Trees
Holographic Sky

3.3. Design of Primary jigs And Machines employed for constructing the settlement



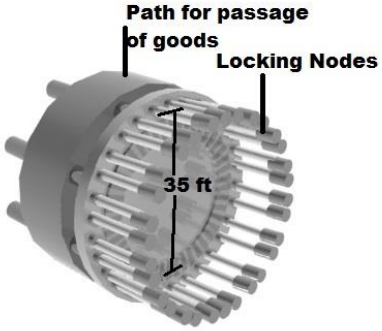




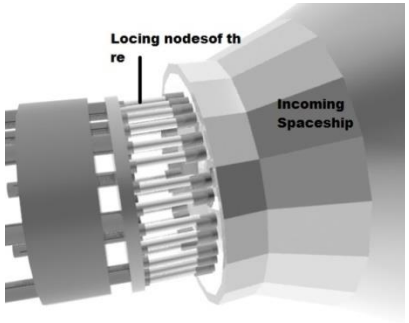


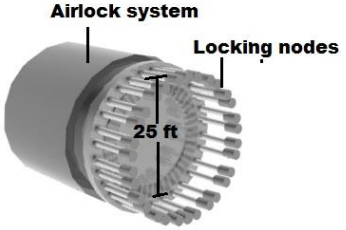
Refer to 5.1 for details

3.4 Docking mechanism



Refer to 2.1.4 for details





**15 robots per engineer during the construction phase

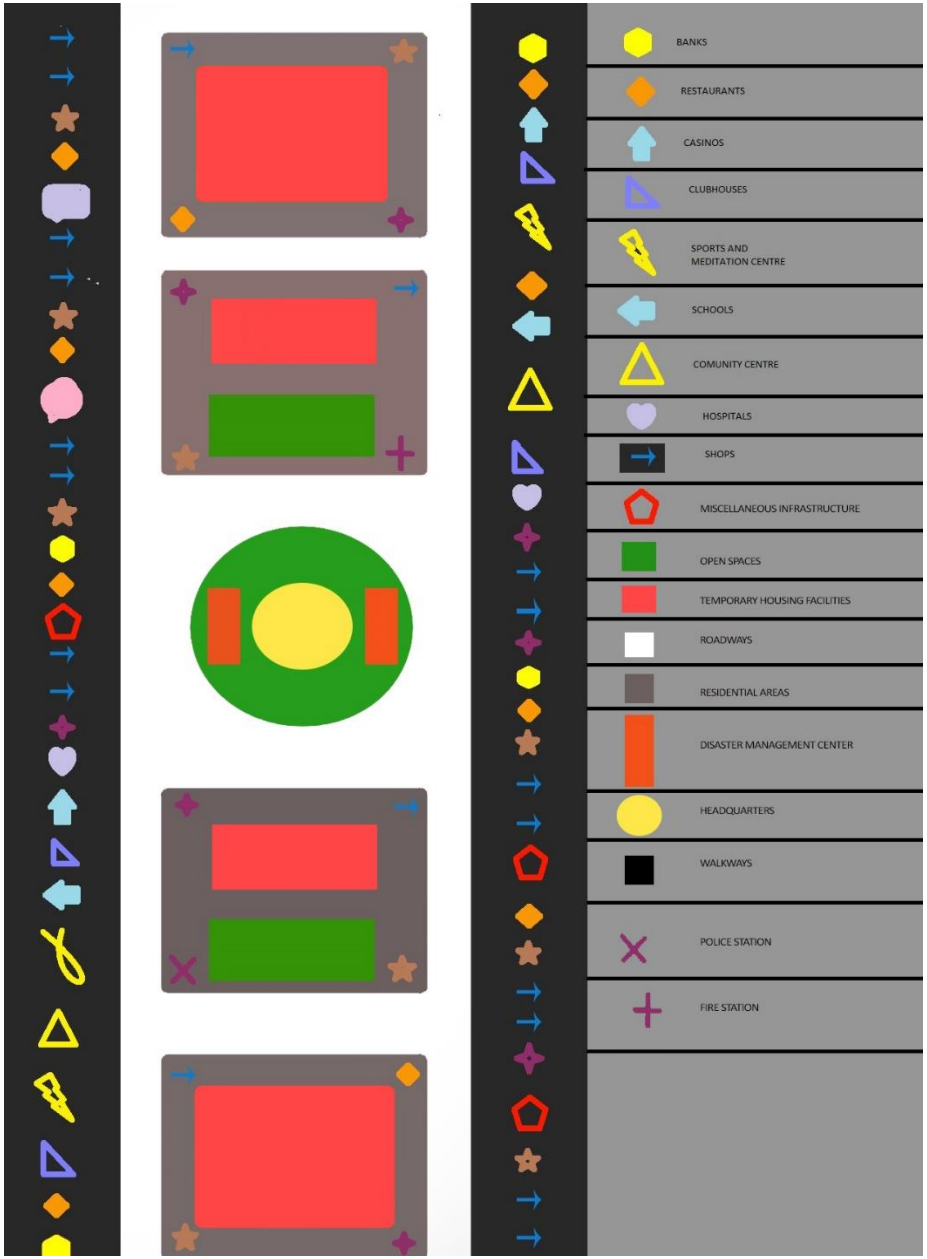
Human Factors

4.1 Environment
4.2 Housing Facility
4.3 Safety
4.4 Training

4.0.1: Overview

While designing Benevectoras, Vulture Aviation has ensured, through innovative models and mechanisms, that it will have all the luxuries offered by a major Earth city and allow a very high standard of living.

Fig 4.1



4.0.2: Natural views:

The residential torus has windows to allow sunlight to pass through, and to help combat claustrophobia by letting residents enjoy natural views of the Sun and space.

4.1.1: Community Design with Scale

Benevectoras includes a myriad of amenities, meant to ensure that residents have access to facilities ranging from entertainment and fine cuisine to education and disaster management. Subways and tunnels are present under roadways for transportation of robots.

4.1.2: Consumables and Commodities

A wide range of consumables has been chosen to ensure that residents have access to a balanced diet and a variety of foods. This is shown in the table to the right.

Replenishment of cloth and paper is summarized as follows:

Material	Cloth	Paper
Per Person Annually	12.4 kg	5644.8 sq ft
Earth to Mars	109120 kg	49674240 sq ft
Mars to Earth	38440 kg	17498880 sq ft

Items	Requirement per person per year (in kilograms)
Beans	370.407
Bread	37.598
Dried fruits	17.397
Butter	6.323
Cheese	11.335
Fish	32.763
Fruits	29.117
Lettuce	200.020
Carrots	35.125
Broccoli	88.244
Wheat	15.860
Cucumber	126.680
Milk	31.541
Chicken	9.164
Lentils	62.270
Eggs	6.926
Tea/coffee	1021.990
Sugar	5.280
Rice	44.126
Mushrooms	10.550
Vegetable oil	182.500
Ginger	36.500
Garlic	18.250
Chillies	7.300

Resource	Water	Oxygen
Usage per person per year (kilograms)	11041.25 kg	306.6 kg

4.1.3: Community and entertainment attributes

The community centre will include a library, carrom, snooker etc. Plays and performances will also be held at the cultural centre. Apart from amenities, Benevectoras will have two unique games so that residents stay entertained:

Parabolic squash
A vertical, partially curved, pointed structure will be constructed to enable the people at Benevectoras to enjoy this sport similar to squash in microgravity. For safety they will be provided with helmets, suits and in addition, no hard ball will be used for the same. Moreover the racquets will have low tensile strength. the number of players can range from 2 to 4.

Paintball
This game will comprise of 2 teams that will enter the arena through two different doors. The arenas will consist of any obstacles and both the teams will be given an objective. The team which fulfils the objective first using their paintballs wins the game. For safety helmets as well as thickly padded suits will be provided.

Table 4a

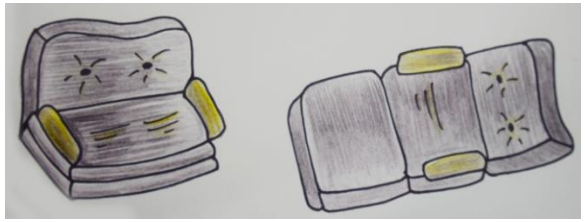
4.2.1: Furniture Requirements

These calculations are made keeping in mind the requirements of the residential as well as the transient and cycler population.

SOFA-CUM-BED-

Category Of Population	Number Required
Married	2640(total divided by 2)
Single Men	1848
Single Women	1496
Children	176

Table 4b



DESK-Workforce=1500 people

Number Of Desks For Offices	Extras	Total
1500	500 extra	2000

Table 4c

SOFA

Type Of Sofa	Quantity
1-seater	1758
(Commercial) 4-seater	550
2-seater	300
TOTAL	2608

Table 4g

CHAIR-

Type Of Building	**No of Units/Persons**	**No of Chairs**	**Total**
Married Adult House	750	2	(750*2)=1500
Office	1500	1250	1250

Table 4d

COFFEE TABLE CUM CHAIR- 2 Tables in each house.

Total Number Of Houses	Number Of Tables
1758	(1758*2)=3516
(OFFICE WORKFORCE) - 1500	500

Table 4f

CUPBOARDS-

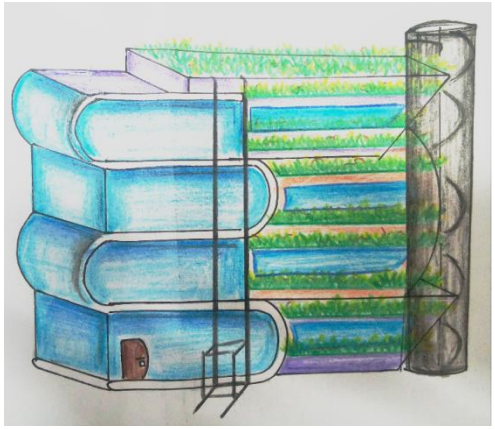
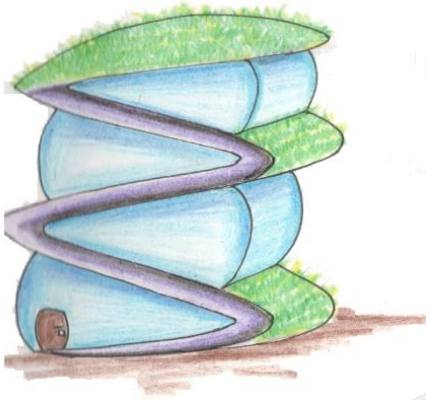
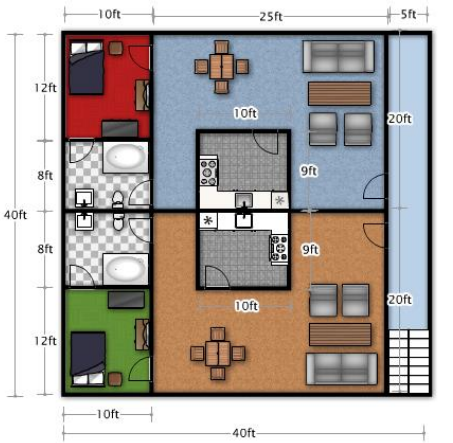
1 Cupboard for each house	2 extra in each house	Cupboards in Office	TOTAL
1758	3516	500	5774

Table 4e

4.2.2: Designs of Houses and Floor Plans

Vertical farming systems will be incorporated into house designs to capitalize on available space, and enhance their aesthetic appeal

Height of each floor is nine feet.

Design Type	External View	Floor Plan (First Floor)
Apartment Type A **300 Units** **Permanent Residents**		
Apartment Type B **770 Units** **Temporary Residents**		

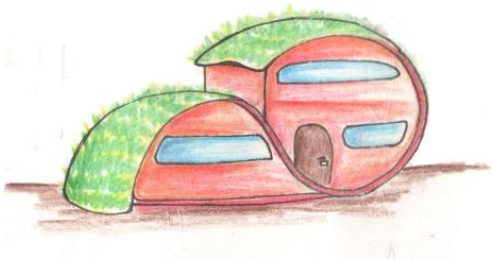
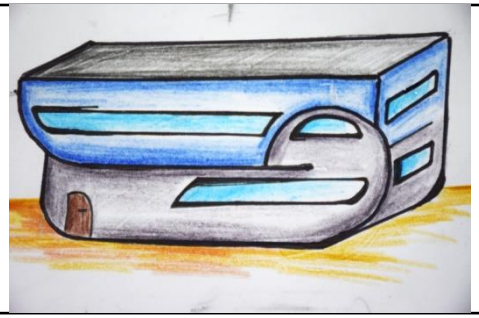
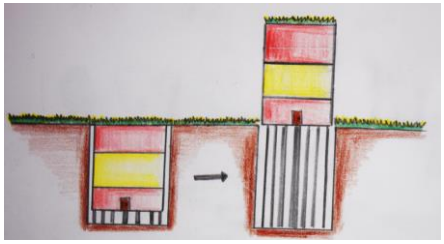
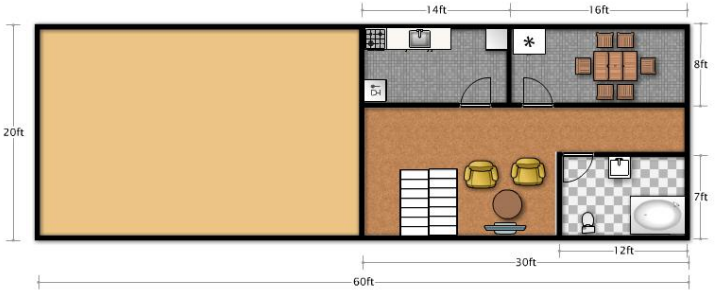
Design Type	External View	Floor Plans
Villa for Couple without Children 115 Units		
Villa for Family with Children 35 Units		

Table 4h

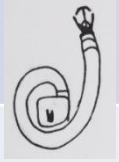
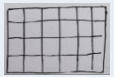
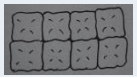
Due to a high variability in population, temporary housing systems will be present, to accommodate the temporary population of up to 6300 people.

Using hydraulic systems, these temporary houses will be raised when these people are staying at the settlementand will be retracted when they leave.





4.3: Safety Systems

Systems and devices	function	picture
tethers	Attached on the belt of the space suit, it helps to grab on things easily and long cables allow greater mobility	
Dual cluthcher tether	It is magnetised to allow greater attraction also it can be expanded and retracted on use	
Velcro pads	It is located on many parts of the settlement both inside and outside the settlement	
Handrails	It is located on many parts of the settlement to hold onto and rubberised tips for greater grip	
Foot holds	It allows to put your foot easily into it and allow people to stand in micro gravity	 
Rods and handles	It gives a greater area to catch upon and more grip also	
cages	Helps to stand on with ease	
Rings and net	Nets to catch things falling in micro g	
Padded walls	It prevents crashes and injuries in micro g	

- Boron Nitride shields against radiation and is used for the hard torus
- Kevlar has a very high tensile stress and is very tough. It will be the main constituent material of the suit
- Glass Fibres is very flexible, has high tensile strength.
- Silicon bucky structure is flexible and light. (used in fabric)
- RxF1 Polyethene is used for shielding against radiation

- We will be ordering extreme survival technology for space suit. There are going to be two types of space suit for work and for recreation. The no. of spacesuits available will be 12. they will be available in 3 sizes, small, medium and large, 4 pieces each.

Table 4i

4.4: Training people going to Mars

A combination of hands-on experience and immersive augmented reality will be used to train people going to Mars. Schools will be utilized for this purpose in the evening. Students will be divided into four classes. Guest lectures will be held by professors from universities on Earth, and on Alexandriat's University of Space Science and Technology. Obstacle training will also take place once every week. At the end of the course, a simulation will be run where the person will be required to respond to situations such as a team-mate being injured. In case the number of students surpass the current class sizes, we will hire the aforementioned guest professors to add a new class.

Module	Explanation
1. Mars 101: Introduction to climate and conditions **5 teachers, aided by instructional videos**	This will cover weather, pressure, gravity, topography, and currently available infrastructure including rovers and Aresam. Augmented reality will be used to familiarize participants to the Martian landscape. A display system will show information about the features that the participants observe.
2. Getting Around: Spacesuit Training **20 teachers**	**a)** Practice movement while wearing the spacesuit **b)** Donning and doffing between areas of variable pressures (with hands-on experience at airlocks) **c)** Responding to a partial puncture or rupture in one's spacesuit
3. A Day In The Life: Acclimatizing to the Red Planet **10 teachers, and instructional videos**	Participants will be shown a video covering a day in the life of someone on Mars, showing the kind of food eaten, job/tasks completed, standard of life etc. Participants will also try out samples of food identical or closely similar to the kind eaten on Mars.
4. Safety First: **20 teachers**	**a)** Deal with safety issues including contamination through Martian dust, Airlock failure, PLS failure, contamination and corrosion due to Martian dust, dust mitigation processes, problems caused by breathing in the Martian atmosphere, using spacesuit thrusters. **b)** Treat minor and critical health problems, including the use of first aid for emergencies.
5. Communicational Problems: **20 teachers**	Dealing with communicational issues, such as a lost uplink or a damaged snoopy cap (communicational component of spacesuit).
6. ELECTIVE: Depth Study **15 teachers**	"Analysis of Materials" will be held at the research laboratory and allow participants to learn analysis techniques such as spectroscopy. "Geology" will be held at the school where participants will be able to learn more about the topography and structure of Mars.

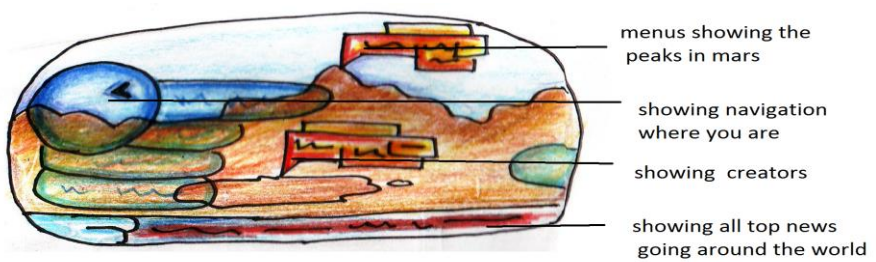
Table 4j

Training will be held at the school and at the sports center.
Due to high use of augmented reality and instructional videos/animations, a faculty will only be needed for some parts of courses and for guiding participants during hands-on experience. An approximate student to faculty ratio of 50:1 will be maintained at the school, so 126 faculty members will be needed.

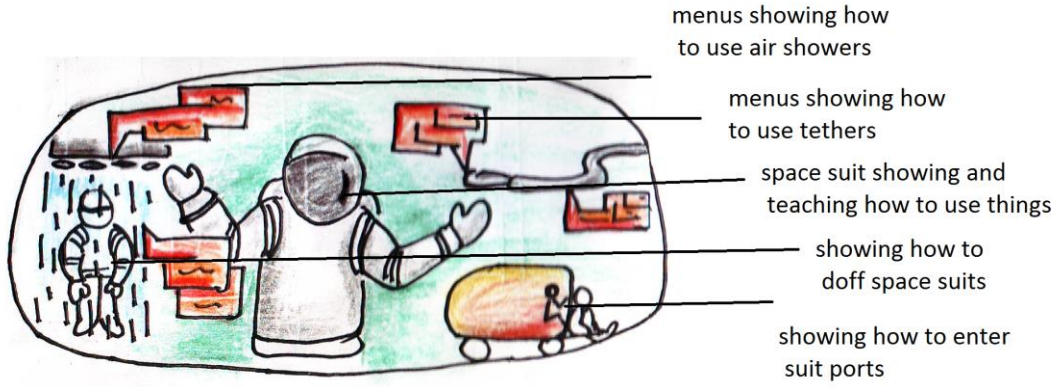
Location	Faculty Members
School	90 (refer to previous table)
Gymnasium (at sports center)	16
Obstacle Course	20

Table 4k

Augmented Reality Training Sequences and Facilities



Design of School Building



5.0 – *Networking And Data Systems*

5.1 – *Automation For Construction*

5.2 – *Automation In Operations*

5.3 – *Automation In Everyday Life*

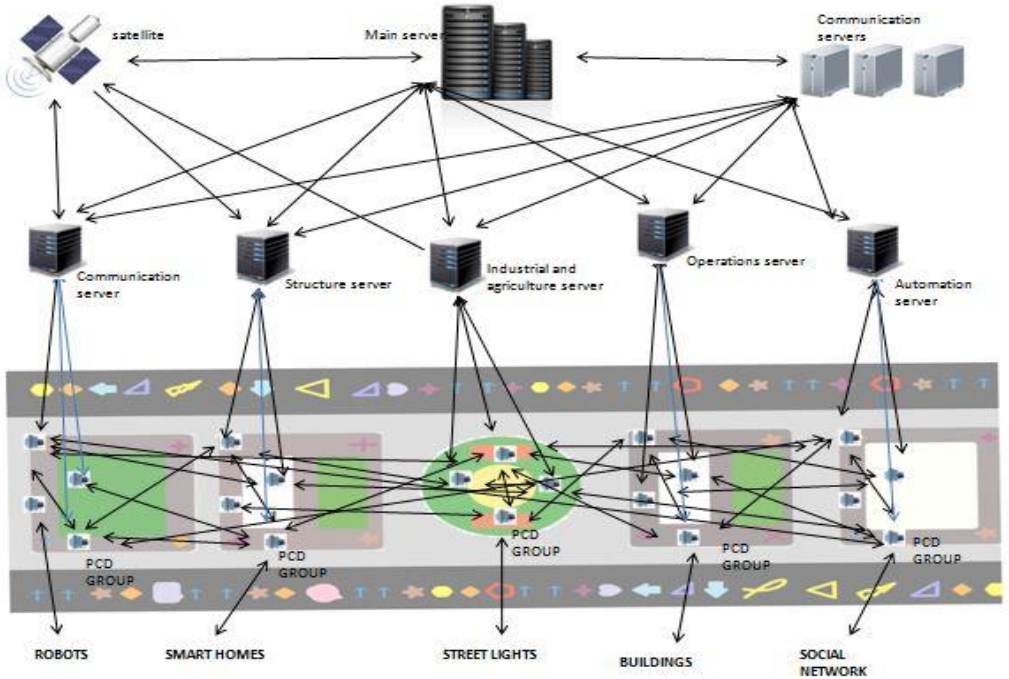
5.4 – *Deployment Of The Solar Sail*

5.0

Table 5A Server specs

	Type	Speed	Storage(each rack)	Power	Racks	Number	No of
1.	Main	20PHz	20PB	120PFlops	60(1200PB)	1	Residential
2.	Back Up	3PHz	10PB	90PFlops	50 (500PB)	3	server
3.	In-House Specs	3Phz	2 PB	60PFlops	25 (50PB)	100	
4.	Auto Sub-Server	9PHz	6Pb	75PFlops	30(180PB)	1	
5.	OPS Sub-Server	7PHz	4PB	80PFlops	30 (120PB)	1	20
6.	Industrial & Agri Sub-Server	10PHz	8PB	100PFlops	30 (800PB)	1	20
7.	Docking & structure server	8PHz	3 PB	70PFlops	30 (90PB)	1	40
8.	Communication server	8Phz	5PB	80PFlops	40 (200PB)	1	10

All servers have a state of art cooling system.



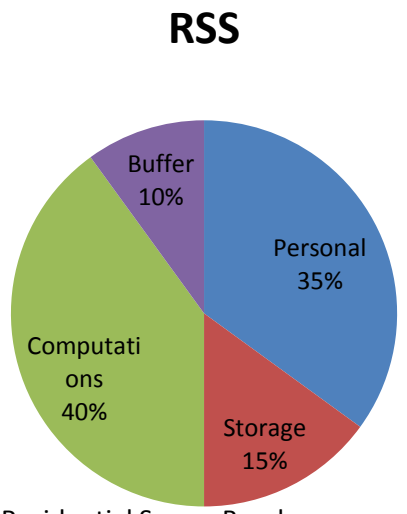
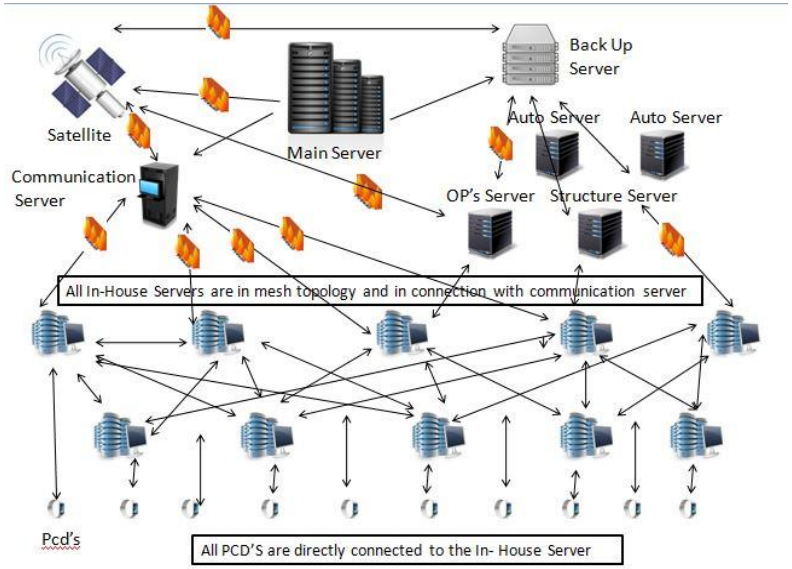


Fig. 5.1 Residential Server Breakup



- PCD is in mesh topology
- Overall in star-buss topology.
- The PCD's can communicate externally through communication server.
- Overall security is maintained by firewalls in every level

Table 5B Soft wares

SR#	Software name	Description
1.	Semi Artificial Manager	• Name is a smart, adaptive intelligent software(closed loop) that controls all other soft wares and handles all security clearance in accordance with the human ware.
2.	Smart Home Software	• A smart software technology that controls almost all the features of your smart home. Its works as a closed loop with specifications given by the resident or the user themselves. • The interactions here are voice over and from PCD.
3.	Security software	• This controls the automations of Benevectoras. With a set of protocols this adaptive software will not only control all robots but will also aid in the construction and maintenance sequence.
4.	Industrial and agricultural software	• A adaptive software that aids in day to day office, industry and research work. It is adaptive and can perform some ruined functions of the job itself e.g. – teaching, some experiments, creating lists etc. It also is linked via the PCD
5.	Communications	• A set of protocols for the communication of servers, process and the interactions between servers, server to robot, server to PCD and server to satellites.
	Operating system	• This is the operating systems for all PCDs. It allows users to have a selection of a variety of applications in the cloud. It includes the set of protocols for PCD to human, PCD to smart spectacles, PCD to smart clothes and their

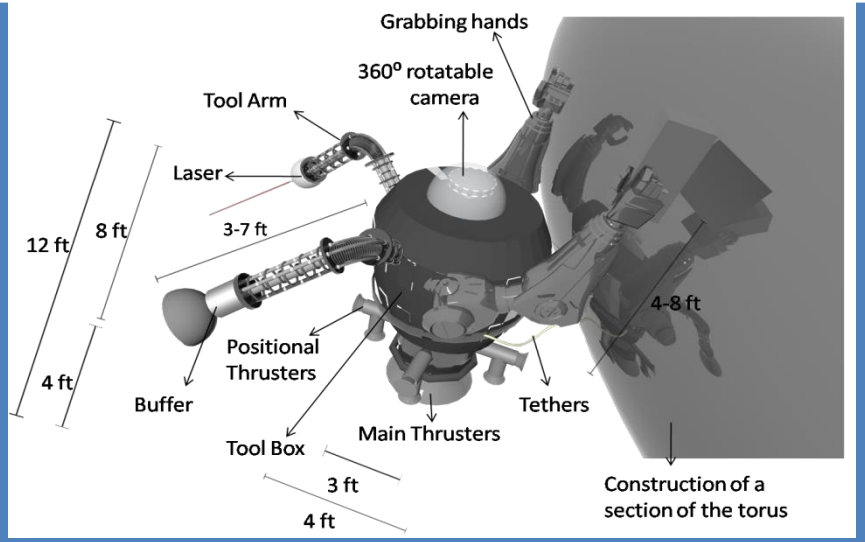
Location and size of repair maintenance and storage facilities
Location- Residential torus area 252000 sqft

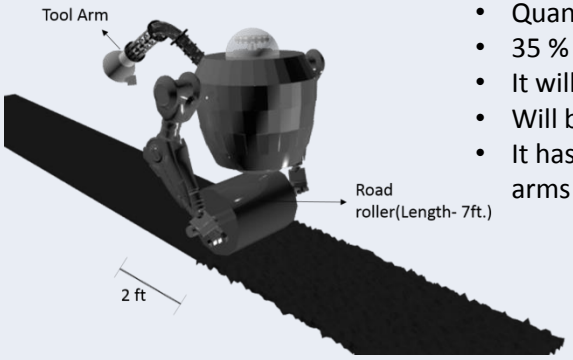
Use of power and other resources- refer to 3.2.2

5.1

Automation for exterior construction-Extro

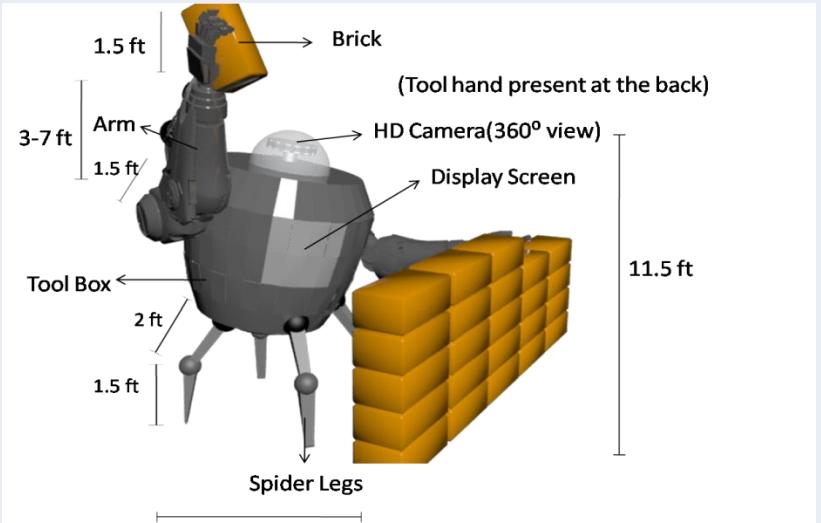
- **Quantity 110**
- **Has 4 detachable and retractable arms capable to use tools from the tools box.**
- **One main center thruster and 4 separate thrusters**
- **Human supervision would constantly observe the video being streamed by the robot.**
- **It will later be used for maintenance and repair.**





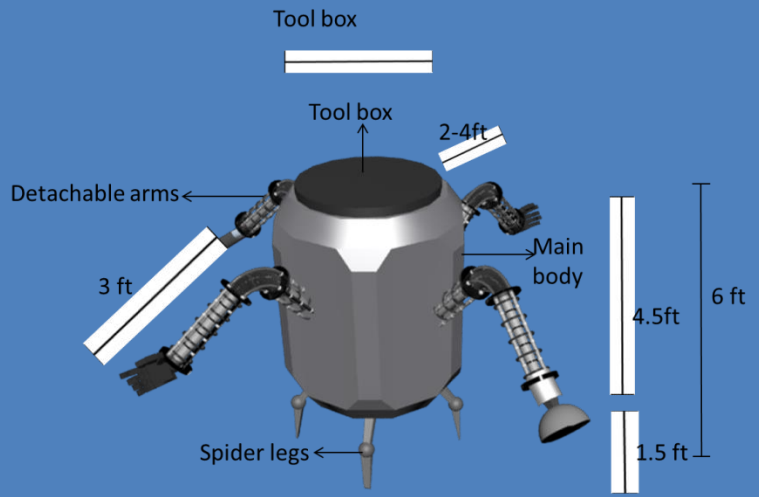
Automations for interior construction-Intro

- Quantity 110
- 35 % are made from extro
- It will make buildings
- Will be used for laying down roads.
- It has three retractable and detachable arms



Automation for internal Finishing-chamakio

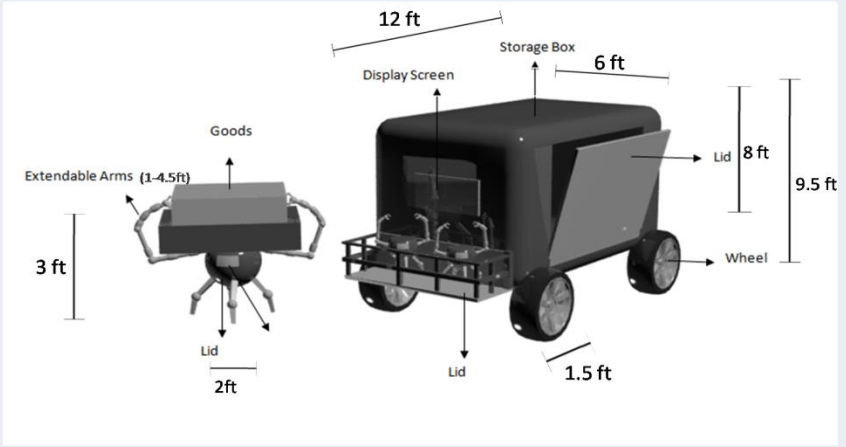
- **Quantity -250**
- **It puts the furniture and does polishing and other decorative task**
- **It uses the 3d printing technologies that is present in the settlement for furnitures**



External Transportation of humans and delivery will be produced by Vulture Aviation-Condor

Automations for Internal delivery-Belvo and Nanovo-

- Quantity-150(both)+50(Backup)
- The Nanovo is the door to door delivery robot.
- Belvo is the one which will carry goods via roads.
- Nanovo will remain in Belvo until it reaches its destination.



Internal Transportation of Humans

- Refer to 3.2.4

5.3 Contingency plans

Problem		Prevention	Contingency 1	Contingency 2
Solar Flare		Hull materials for radiation prevention	35 hour prior cautionary warning and disaster warning 5 hours prior to the flare so that all electronic devices are switched off. 35% of robots are reserved to work after solar flare activities	
Power Failure		Frequent checks for power overloading	Nickel- Hydrogen batteries	
Medical Emergency		-	Medical bots	
Fire	Class A		Water	Evacuation and depressurization/oxygen cutoff in case of major fires in a section. Sprinklers in residences
	Class B		CO2 extinguisher	
	Class C			
	Class D		Fire Extinguisher Robot	
	Class K		Water mist	
Internal Damage/ Malfunction		Monthly repair/ maintenance	Internal repair robots	
External Damage			External repair robot	Evacuation and isolation to other sections until damage is repaired, minute damages will be taken care of by the nanobots
Gas Leak		Monitoring of gas levels	Ventilation system	
Depressurization			Airlocks in each section	
Robot Malfunction		Set of predefined instructions, weekly self-evaluation	Manual takeover	System override, shutdown, repair/recalibration
Dust Mitigation		Lotus effect and aerogel	Ventilation system	
Criminal Activity		Security cameras, ban on explosive and projectile weapons	Security bot shall apprehend criminal	

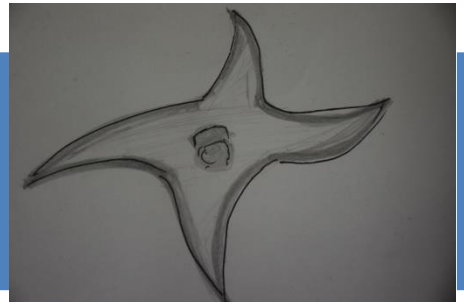
Type of residents	Security access	People Getting Clearance	Security type	Clearence Level
Admin Prime	Full settlement access. Also control clearance eligibility of other residents.	15 Major Directors and president	DNA Scan Retinal Scan, Password ,Biometrics.And a check by the SAI Heartbeat	7
Admin Clearance 1	Have access to classified information can modify most things in the settlement.	20 Mayor, , rest of the directors	DNA Scan Retinal Scan,Password . Biometrics And a check by the SAI	6
Admin Clearance 2	All information except classified information will be available. Can modify some of the crucial settings and community settings.	community workers, people selected by clearance 6,7	DNA Scan Retinal Scan Password	5
Researchers A	Access to classified information of their respective servers of the sectors.	Selected researchers	DNA Scan Retinal Scan Password	4A
Researcher B	Access to general information regarding their respective servers of the sectors.	All Researchers	DNA Scan Retinal Scan Password	4B
Management	Basic access to information of their respective sectors. Will be able to control cargo software	Store workers, management etc	Password Biometrics Heartbeat	3
Industrial Workers	Permission to access basic information regarding their appointed duties.	Industrial Workers	Password Biometrics Retinal Scan	2
Permanent Residents	Will get basic settlement information and can control community and house settings fully	Permanent Residents	Password Biometrics Retinal Scan	1A
Cycler Residents	Will get information on a need to know basis will be able to	Cycler Residents	Password	1B

5.4.1 Deployment and stowage of solar sail

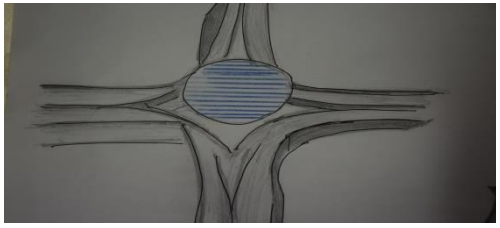
- The solar sail will be stored inside the array unit in the center.
- When the sail will need to be deployed boons made of carbon nanotubes would open up and extend outwards stretching out the sail.
- This process will be inverted when the sail needs to be stowed away.

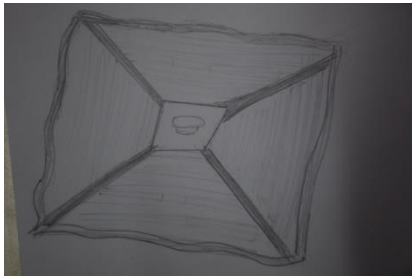
Nano botsfrom nanosolutions are used for repair

5.4.2 Trimming of the solar sail



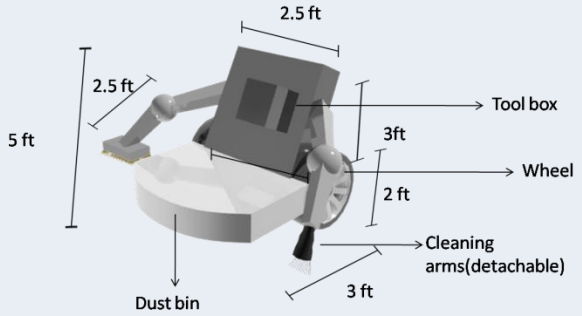
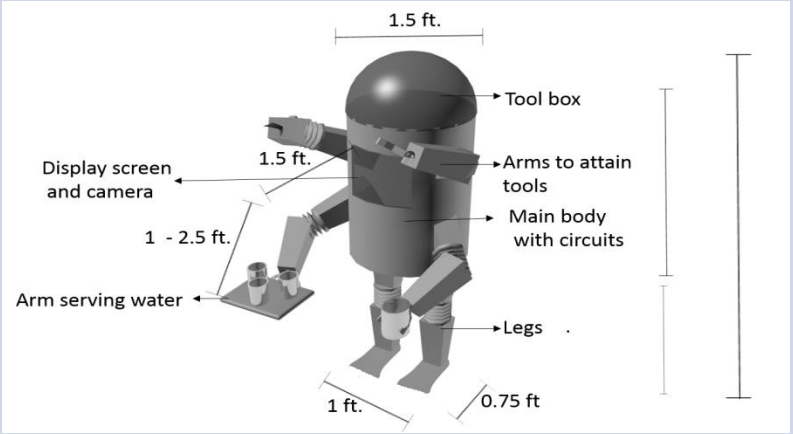
- For the purpose of trimming there are 4 micro thrusters at each corner of the sail two facing each direction.
- The appropriate thrusters will be activated to trim the sail by bending it into the shape needed to generate the thrust.





Physical location of computers and robots for critical functions-

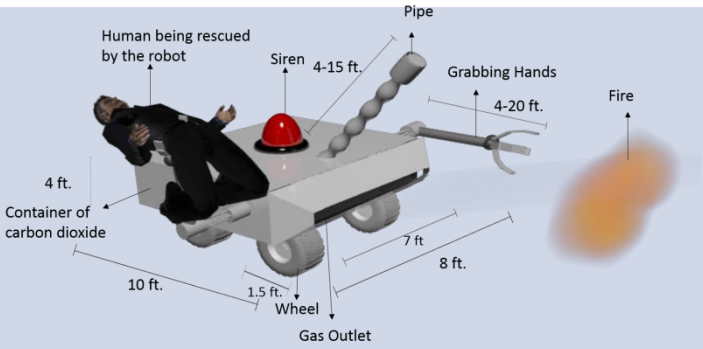
- Servers will be stored in the server building in industrial torus.
- Critical robots will be stored in the storage hemisphere..
- The server room has a state of art cooling system to keep the servers in proper form.

Enhancing liveability in the community.	
Description	Diagram
Automation for cleaning-safaio • Quantity-70 units • It is used as a lawn mower • It is used for the cleaning of the surroundings.	
Automations for convenience in Residences-Comio Quantity-1170 • It will perform different household task • It will have a holographic projector for projecting different pets • It will also provide entertainment facilities to the residents.	

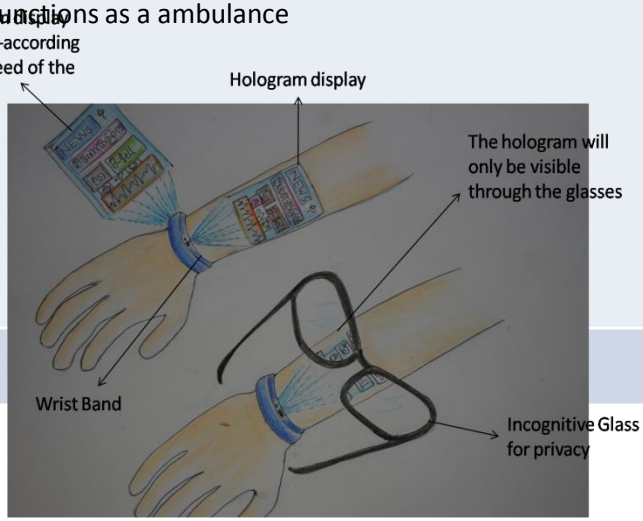
5.3

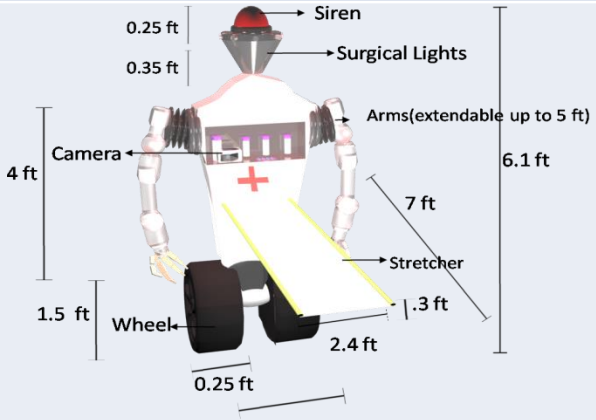
Emergency Robots

Automation for fire protection-Hugo
- Quantity- 98
- It has different compartments for different extinguishers.
- It can even carry humans in case of emergency



Health Robot:
- Quantity 150
- It carry medicines and other firt aid
- It also functions as a ambulance





PCD

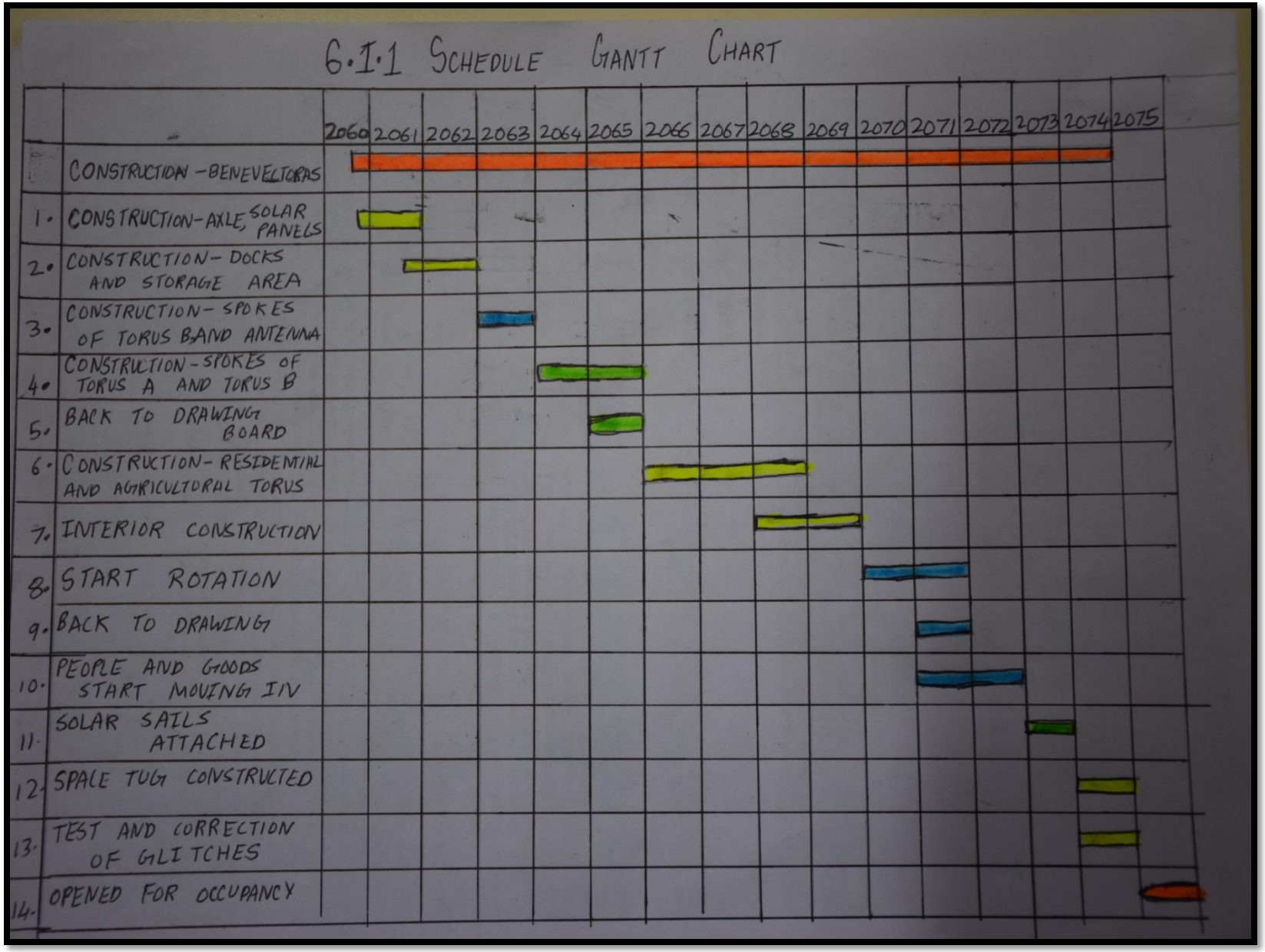

6.1.1 SCHEDULE GANTT CHART
2060 2061 2062 2063 2064 2065 2066 2067 2068 2069 2070 2071 2072 2073 2074 2075
CONSTRUCTION - BENEVELTORAS
1. CONSTRUCTION - AXLE, SOLAR PANELS
2. CONSTRUCTION - DOCKS AND STORAGE AREA
3. CONSTRUCTION - SPOKES OF TORUS B AND ANTENNA
4. CONSTRUCTION - SPOKES OF TORUS A AND TORUS B
5. BACK TO DRAWING BOARD
6. CONSTRUCTION - RESIDENTIAL AND AGRICULTORAL TORUS
7. INTERIOR CONSTRUCTION
8. START ROTATION
9. BACK TO DRAWING
10. PEOPLE AND GOODS START MOVING IIV
11. SOLAR SAILS ATTACHED
12. SPACE TUG CONSTRUCTED
13. TEST AND CORRECTION OF GLITCHES
14. OPENED FOR OCCUPANCY

Table 6A Different Phases	
Phase	Tasks
Phase 1	1.Construction of Axle and Solar Panels 2.Construction of Storage Hemisphere and Docks
Phase 2	1.Construction of Spokes of Torus B and Antenna
Phase 3	1.Construction of Spokes of Torus A and Torus B 2.Back to Drawing Board
Phase 4	1.Construction of Residential and Agricultural Torus A 2.Interior Construction
Phase 5	1.Rotation Starts 2.Back to Drawing Board 3.People and Goods Start Moving In
Phase 6	1.Solar Sails Attached
Phase 7	1.Space Tug Constructed on Axle 2.Test and Correction of glitches

Table 6B Phases with their Completion Dates		
PHASES	DURATION	COMPLETION DATE
1	2 years 9 months	31st Dec 2062
2	1 year	31st Dec 2063
3	2 years	31st Dec 2065
4	4 Years	31st Dec 2069
5	3 Years	31st Dec 2072
6	1 Year	31st Dec 2073
7	1 Year	31st Dec 2074

6.2 Costs

Table 6I Phase 1	
Materials	Cost
Aluminium Alloy	$2Bn
X Aerogel	$1.5Bn
Silicon Bucky-Structures	$2.5Bn
Rxf1 Polythene	$2Bn
Pervoskite	$1.5Bn
Graphene	$1.5Bn
Total	$11Bn

Table 6J Phase 2	
Material	Cost
Aluminium Alloy	$1Bn
Carbon Nanotubes	$2Bn
X Aerogel	$2Bn
Kevlar	$1Bn
Silicon Bucky-Structures	$1Bn
Rxf1 Polythene	$2Bn
Total	$9Bn

Table 6K Phase 3	
Materials	Cost
Aluminium Alloy	$1Bn
X-Aerogel	$1.5Bn
Kevlar	$1.5Bn
Silicon Bucky-Structures	$2Bn
Total	$6Bn

Table 6N Phase 5 Materials Costs	
Materials	Cost
Transport of People and Essential Goods	$4Bn
Total	$4Bn

Table 6M Phase 4	
Materials	Cost
Aluminium Alloy	$2Bn
Kevlar	$1Bn
X Aerogel	$3Bn
Rxf1 Polythene	$3Bn
Silicon Bucky-Structures	$4Bn
Carbon Nanotubes	$$Bn
Total	$18Bn

Table 6L Phase 7	
Operations	Cost
Test and Correction of Glitches	$2Bn
Total	$2Bn

Table 6D Housing Costs			
Houses	Cost per Unit	Quantity	Total Cost
Villas Type 1	$4Mn	35	$140Mn
Villas Type 2	$4Mn	715	$2860Mn
Apartments Type 1	$5Mn	238	$1190Mn
Apartments Type 2	$6Mn	470	$2820Mn
Apartments Type 3	$8Mn	300	$2400Mn
Total		1758	$9.41Bn

Table 6C Interior Construction Costs			
UNIT	QUANTITY	COST PER UNIT	TOTAL COST
Restaurants	10	$9Mn	$90Mn
Shops	30	$5Mn	$150Mn
Malls	2	$20Mn	$40Mn
Clinics	8	$6Mn	$48Mn
Hospitals	2	$15Mn	$30Mn
Hotels	1	$30Mn	$30Mn
Casinos	2	$6Mn	$12Mn
Schools	2	$15Mn	$30Mn
Clubhouses	4	$8Mn	$32Mn
Community Centre	2	$10Mn	$20Mn
Headquarter	1	$15Mn	$15Mn
Sports and Meditation Centre	2	$30Mn	$60Mn
Cultural Centre	1	$5Mn	$5Mn
Religious Centre	1	$5Mn	$5Mn
Emergency Centre	4	$8Mn	$32Mn
Amusement Park	1	$15Mn	$15Mn
Bank	4	$5Mn	$20Mn
Roads		$20Mn	$20Mn
Open Spaces		$15Mn	$15Mn
Misc. Infrastructure		$10Mn	$10Mn
Total			$679Mn

Table 6F Salary Expenses of Employees				
Employees	Number	Annual Salary	Years of Service	Total Salary Expenses
Researchers	200	$600,000	15	$1.8Bn
Scientists	50	$600,000	15	$450Mn
Engineers	150	$600,000	13	$1.17Bn
Technicians	100	$400,000	13	$520Mn
Managers	75	$400,000	11	$330Mn
Architects	300	$540,000	4	$648Mn
Total				$4.918Bn

Table 6H Operations	
SYSTEMS	COST
Power Generation	$6Bn
Waste and Waste Management	$3Bn
Food Production	$1.5Bn
Internal Transportation	$3Bn
Internal and external communication	$1.5Bn
Day and night cycle	$1Bn
Machines and equipments	$5Bn
Atmosphere/climate/weather control	$1Bn
External Transportation	$3Bn
Docking	$2Bn
Propulsion	$4Bn
TOTAL	$31Bn

Table 6L Final Costing Table	
Phase 1	$11Bn
Phase 2	$9Bn
Phase 3	$6Bn
Phase 4	$18Bn
Phase 5	$4Bn
Phase 6	$10Bn
Phase 7	$2Bn
Operations Costs	$31Bn
Residential Costs	$9.41Bn
Salary Costs	$9.418Bn
Automations Costs	$26.19Bn
Maintenance Costs	$27Bn
TOTAL	$158.518Bn

The final cost that will be billed to the Foundation Society is $158,518,000,000 or 158.518 Bn USD.
Note –
All costs are in USD
Economic Inflation has not been taken into account.

Table 6G Maintenance Costs	
Maintenance	Costs
Maintenance of Interior Buildings	$3Bn
Maintenance of Robots	$5Bn
Maintenance of Communication Servers	$5Bn
Maintenance of Operational Systems	$12Bn
Maintenance of Solar Sails	$2Bn
Total	$27Bn

7.1 Passenger and cargo transfer facilities

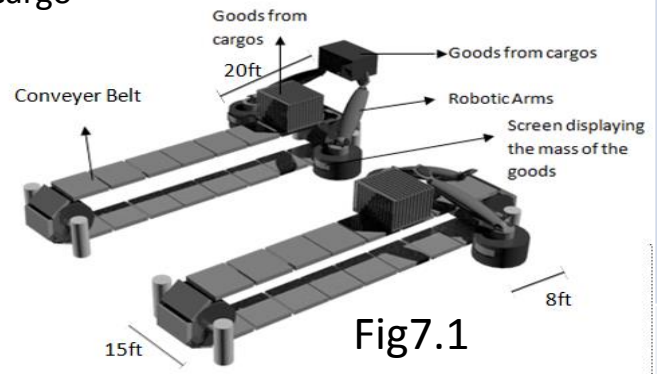
Types	Features
Cargo  Fig7.1	• Cargo ships will match speeds with the settlement and dock at one of the many cargo docks. These docks will have very low gravity. • A robot will go through the airlock and carry goods onto the conveyer belt inside the settlement. • Cranes inside the settlement will now be used to move goods the transport vehicles. • Harness and tethers shall hold the cargo to keep them in place. • Cargo will be screened and checked. It will then be assigned an RFID tag. • Goods will now be categorized. The perishable goods will be kept in cold storage until they are consumed while durable goods and Martian ores will be kept in standard storage
Passengers	• Passenger's ships will dock. Passengers will then will then be attached to the railing in the airlock by hooks and will walk to the nearest elevator which will take them to the rotating torus. • They will now be taken to the Benevectras HQ where they will be processed at residents of the settlement. • Here they will undergo a medical and security screening. An electro interstitial scanner will analyze them for contaminants • Finally a retina and thumb print scanner will be used to register all the passengers. Saliva swab will be taken for DNA. • After data is processed passengers will be given a PDC and will proceed onto the settlement.

Table 7A

•RFID tags are attached to all cargo to keep track of all goods and to classify all goods.

•The CargoMAX software will allow supervisors to manage the flow of traffic in the docks. This software will take into account the various physical characteristics of the goods to analyze the best path cargo traffic within the settlement.

•Furthermore 5 cargo docks and 4 passenger docks will allow us to completely fill the settlement in 8 days

7.2 Activities in Benevectoras

•Benevectoras will be home to people from all over the world, so there will be a cultural centre to allow residents of the world to not only share their own culture and tradition but also to explore many other different cultures and traditions.

•Residents will also be able to take part in competitive Zero G sports and other physically challenging activities in the settlement's Sports centre.

•Some of the more passive residents can take part in activities like the Zero G Yoga and Virtual reality games.

•Residents can take classes to get more accustomed to their upcoming lives on Mars.

•On their way back to Earth, the settlement will be manufacturing goods so then the residents will also take training classes to become a part of the workforce.

•Some of the more technical residents could also take part in the research being conducted on the newly uncovered Martian ores and minerals.

• A unique tradition can be that residents can use processed Martian ores to make novelty items. This can be a fun tradition for families and residents and these items can be also be sold to the temporary residents and even the people of Earth

•Finally another tradition will be the celebration of the various cultures and nationalities present on the settlement. So every 2nd February the residents will celebrate the Red Ball.

• There will be a variety of international cuisines available to the residents at breakfast, lunch and dinner.

• We will also have numerous parades, and each float shall represent a particular people and their traditions.

•Residents will wear red clothing to represent how different cultures have come to unite on Benevectoras.

•The entire show will be telecasted worldwide on Earth for high revenue as well as to increase the popularity of Benevectoras. Different companies may also use this opportunity to advertise their products on a unique platform.

7.3 Flexible future planning

•Rotating sections can be used for the manufacturing of lighter goods and materials

•Non rotating sections will be used to manufacture heavier goods.

•For this purpose our manufacturing robots will be built with interchangeable hands. Furthermore these robots are radiation hardened and magnetically shielded This allows them to interact with a wide variety of unknown materials that are surely to be found on Mars.

•Upcoming fusion powered ships will attract most of our passenger market therefore we will change the settlement's purpose in order to adapt to the new conditions.

•The ship will be repurposed to act as a cargo transporting ship only. First of all 9 of the 10 docks will now be used for the transport of cargo inside and outside the settlement.

•Furthermore all the empty houses will be repurposed into warehouses using the construction bots. These new warehouses will be more specialised than ever, allowing for an even more types of goods to be transported.

•Another point to note is that by the time Benevectoras will be transformed into a cargo ship, Aresam's construction will be close to completion. We can also use our newly increased storage capacity to transport goods to and from Aresam too.

Research Facility

•A three fold processing system which consists of automated screening, spectroscopy and selection of minerals for research or mass extraction.
•Automated Screening of raw mineral ores to check for radioactive substances and extra-terrestrial dust. Any hazardous raw ores will be ejected out in to space.
•Safe ores will be analyzed by scientists through spectroscopy and suitable minerals will be selected for mass extraction and/or further research to produce new materials.
•In case of a radiation leak or an accident, the whole research facility can be detached from Benevectoras to quarantine the settlement.
•Empty residential space can be turned into a limited research facility in times when there are less passengers aboard.