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Space Habitat Design

by

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Executive Summary:

We have chosen Mars, the fourth planet from the sun in the inner solar system as an appropriate host for our project. It would be a hybrid idea in which large maneuverable spaceships would be manufactured and sent to Mars where they shall land and be stationed to support 25000 persons. The spaceships will have residential units in the form of capsule living units. Recreation units will also be provided on board.

The utilization of resources has been done to the fullest as many metals, vital life supporting gases and other materials will be extracted on Mars through various processes mentioned like Zirconia electrolysis, Sabatier processes, metallurgy etc.

Spaceships have their own unique propulsion systems and design for the portion to be used by the citizens. An effective transport system of monorails and escalators will be put in place. Microwave access and fibre optic transmission systems which will be extremely reliable will be used for the communication systems. The communication devices inbuilt in the Mars orbiters of NASA and ESA will function as the communication satellites for the settlement on Mars. Microwave relay link connections supported by the spaceships would be enough to handle exchange of terabits of information.

The ten spaceships used will have their own internal pressurization system and an air conditioning system which will use methane as a coolant, methane being available on Mars.

Nuclear energy and solar energy will be used for power production for the entire city composed of the spaceships. For the use of solar energy special photovoltaic cell units will be mounted on the rooftops of the spaceships. They will have several other advantages such as production of heat while power production which will be extremely valuable to the human settlement on Mars. Hydrogen polymer electrolyte membrane fuel cells would also be used aboard spaceships for backup supply. Moreover it gives of valuable water as a byproduct. Transmission of energy between spaceships will also be done through our self-developed technology which will convert the electric energy at source to ultraviolet radiations, transmit it through optical fibres and vice versa at the receiving end of the electrical energy.

The spaceships for their journey to Mars and landing there would use specially designed Liquid Air Cycle engines or LACE.

Food growth on the planet will be done through the usage of red soil found on Mars which will be suitable for growing certain food crops. Apart from that the major part of the growth of food will be done through the techniques of tissue culture or micro propagation where conditions like optimum light, temperature could be provided in in-spaceship structures meant for food growth. Oxygen would also be provided through Zirconia electrolysis and the Sabatier reaction.

We have also taken care of the need of certain elements and compounds of human need on Mars by usage of resources

such as dry ice on poles of Mars and the nickel magnetite ores of the metals and iron oxides found on the surface of Mars.

Advantages of the Plan:

The survival of Life outside Earth in a spaceship is very advantageous. Artificial conditions can easily be created in a spaceship which is optimum for humans. They can be modified to what is most suitable for the humans. The various things that can be produced artificially are- Artificial pressure system, atmosphere, temperature control, etc. An artificial pressure system can be installed which can maintain a pressure of 1 atmosphere. Thus it won't cause any interference in the normal functioning of the human body. It will be suitable for the human body. The problems like hypoxia which we face when we go at places of different altitudes won't be faced by the people living on those spaceships. They will be completely fit and fine.

The atmosphere of Mars is very different from that of Earth. It contains ninety five percent Carbon Dioxide (95% CO_2), three percent Nitrogen (3% N_2), one point six percent Argon (1.6% Ar) and traces of Oxygen and water vapours. The atmosphere is also quite dusty. Humans cannot sustain in such type of atmosphere. For human beings to sustain in mars the concentration of various gases like 20.95% Oxygen (20.95% O_2), 78.09% Nitrogen (78.09% N_2), 0.3% Carbon Dioxide (0.3% CO_2), 0.93% Argon (0.93% Ar), traces of Hydrogen and other noble gases can be maintained in the artificially prepared atmosphere inside the spaceships. The water vapour content in the atmosphere can also be maintained. To let their volume remain constant Oxygen Cycle, Carbon Cycle, Nitrogen Cycle, etc. can be setup in the spaceship.

Along with this large heaters can be installed in the spaceships to maintain a temperature of around 15 degrees during chilly climate and air conditioners can be installed to reduce the temperature inside the spaceships during hot climate. Thus a favorable temperature (around 15 degrees) is maintained for humans and they can live with comfort.

Another advantage of using spaceships is that there is less risk to the life of the workers involved in building the habitat as the spaceships can be constructed on Earth and then they can be taken into space. While creating a habitat directly on any planet involves great risk to the life of those workers. This is because the conditions of Earth are quite different from other heavenly bodies. And those conditions may prove to be very harmful for human life. For example there are many dust storms on the surface of Mars. And if the workers are employed to work and during the same time a dust storm comes then it may lead to the loss of several lives. Hence constructing spaceships on Earth and then taking them to Mars is a safe technique which doesn't cause any risk to the Life of workers involved in the construction of the habitat.

Mars is suitable for creating a habitat because of its proximity from earth. It won't take that much time to reach Mars as much it would take to reach any other planet. Therefore it will be easy for humans to go and settle there. While if it's on some other far off planet then it would take many years to reach there. Moreover resources from Earth can be transported to Mars when required without much difficulty. While if a planet which is much far away from Earth is chosen then it will be very difficult to transport anything between Earth and that planet. It will remain cut off from Earth.

The presence of Water on the surface of Mars is beneficial for setting up of a habitat as water is essential for the sustenance of Life. Without water life cannot exist. Mars has two permanent polar ice caps. The polar caps at both poles consist mainly of water ice. Frozen carbon dioxide(Dry ice) accumulates as a thin layer of about one meter thick on the north cap when it is winters in the northern hemisphere, while the south cap has a permanent dry ice cover of about eight meters thick. The volume of water ice in the south polar ice cap is too large. If it is melted, the water produced would be sufficient to cover the entire surface of the planet to a depth of 11 meters. This much water is enough to support life.

A highly developed communication as well as transport system will be present on the spaceships. The whole spaceship will be Wi-Fi enabled. There won't be any problem to the residents in contacting any person in the entire spaceship.

Mars is also rich in various mineral resources that if utilized to the fullest will be extremely beneficial. The most abundant being Iron Oxide because of which Mars is known as The Red Planet. Several other minerals like Nickel, Magnesium and Silica are found in Mars.

Now the technology of making spaceships is already available on Earth therefore it won't be a difficult task to build spaceships to be sent on Mars.

In the spaceship there will be various sources of recreation for the people. There will be shopping complexes, parks, movie theatres, etc.

All the technology is available now in this application and simply depends on the will and the pull of economic gain and the ability to forget research and apply knowledge

Space ships will be manufactured in earth's orbit and sent to Mars where there will be stationed. Artificial conditions necessary to support human life can be created within the spaceships can be created.

In the spaceships slight rotational effect will be provide for to strengthen artificial gravity.

<u>These are the details of the planet along with the assumptions:</u>

- The Martian day (or **sol**) is very close to Earth's. A Mars solar day is 24 hours 39 minutes 35.244 seconds. (See timekeeping on Mars.)

- Mars has a surface area that is 28.4% of Earth's, only slightly less than the amount of dry land on Earth (which is 29.2% of Earth's surface). Mars has half the radius of Earth and only one-tenth the mass. This means that it has a smaller volume (~15%) and lower average density than Earth.

- Mars has an axial tilt of 25.19°, compared with Earth's 23.44°. As a result, Mars has seasons much like Earth, though they last nearly twice as long because the Martian year is about 1.88 Earth years. The Martian North Pole currently points at Cygnus, not Ursa Minor.

- Mars has an atmosphere. Although it is very thin (about 0.7% of Earth's atmosphere) it provides some protection from solar and cosmic radiation and has been used successfully for aerobraking of spacecraft.

- Mars has methane in its atmosphere. The oxidation of methane in the presence of very little air will lead to the formation of carbon and water vapours.

- Recent observations by NASA's (National Aerospace and Space Administration) Mars Exploration Rovers, ESA's (European Space Agency) Mars Express and NASA's Phoenix Lander confirm the presence of water ice on Mars. Mars appears to have significant quantities of all the elements necessary to support Earth-based life.[1]

The reasons for choosing Mars as a sustainable habitat host are the same as mentioned above.

Other physical characteristics are shown below.

Equatorial radius	3,396.2 ± 0.1 km 0.533 Earths
Polar radius	3,376.2 ± 0.1 km 0.531 Earths
Surface area	144,798,500 km^2 0.284 Earths
Volume	1.6318×10^{11} km^3 0.151 Earths
Mass	6.4185×10^{23} kg 0.107 Earths
Mean density	3.9335 ± 0.0004 g/cm^3
Equatorial surface gravity	3.711 m/s^2 0.376 *g*
Escape velocity	5.027 km/s
Equatorial rotation velocity	868.22 km/h (241.17 m/s)

THE DESIGN DETAILS:

This section has been divided into various sections:

The city design and architecture would be as mentioned below:

In order to accomplish the maximum utilization of the space available on board the spaceships the living and residential units for the people will be in the form of capsule shaped houses where the different rooms of a house will be shaped in the form of capsule like structures and integrated together.

Power generation would be done in the following ways:

- Solar power is a candidate for power for a Martian colony. Solar insolation (the amount of solar radiation that reaches Mars) is about 42% of that on Earth, since Mars is about fifty two 52% farther from the Sun and insolation falls off as the square of distance. But the thin atmosphere would allow almost all of that energy to reach the surface as compared to Earth, where the atmosphere absorbs roughly a quarter of the solar radiation. It is for this reason also that the solar energy power generation units will have to be built as separate structures outside the spaceships which would transmit their collective electrical energy to all other spaceships. As an alternative a large number of photovoltaic cells would also be planted on the roof of the spaceships to create some sort of direct supply of electricity.

- Nuclear power is also a good candidate, since the fuel is very dense for cheap transportation from Earth. Nuclear power also produces heat, which would be extremely valuable to a Mars colony. The nuclear power generation units could be small in size and be an integral part of the spaceships thus allowing each spaceship its own independent energy supply unit. Since small amounts of nuclear fuel are required, therefore storage of fuel would not be a problem.
- Heating requirements could be lowered if the colonists use domes to trap solar heat, especially for greenhouses.
- Special modified walking tiles would be used all over the spaceship that would generate electricity when they would be pressurized upon by the movement of our feet.

Transmission of energy would be done through our own devised technology as described below:

- The energy generated by the individual power generation units of the spaceships will be transmitted from one spaceship to another during need of transmission of energy generated from spaceships with surplus supply to spaceships with deficient supply. The energy generated by one of the spaceships will be used to light many micro size carbon arc lamps each of whose light emitting apertures will be connected to an optical fibre. The carbon arc lamps will emit ultraviolet radiations of high frequency which will consequently be highly energetic and have high directivity. The ultraviolet radiations will be transferred through the optic fibres. Numerous optic fibres will constitute an optic cable. The other spaceship which will receive the energy from the other spaceship will be connected with the other end of the cables containing optical fibres in them. The receiving end will have a photodiode that will convert the ultraviolet radiations received into electrical energy which will then be distributed all over the spaceship through a normal wiring system. The photodiodes will essentially be semiconductor devices with p-n junction structure in a forward bias status.
- Polymer electrolyte membrane fuel cells would also be used as a backup for power in case of failure of the other power generation systems aboard the spaceships. The advantage is that it would produce extremely useful water as a byproduct.

Food growth will be done through the following methods:

Moreover even food crops can be gown inside them under man man-made favourable conditions through techniques of micro propagation and tissue culture. The method would be practiced inside special greenhouses, built preferably on the top two floors of the spaceship. It would make the growth of the crops enhanced as favourable conditions like suitable temperature, bright light water supply and carbon dioxide could be easily provided. The greenhouses' temperature would be regulated by the heat energy released from the nuclear power generation units built inside the spaceships. The heat thus provided would be of great help during the extreme winter conditions on Mars where plant growth outside would be impossible due extreme sub zero temperatures. When the plantlets grown through the tissue culture will mature they could be treated mechanically in food processing plants inside the spaceships to be made ready for human consumption.

The human solid excreta and metabolic wastes would be biologically treated so as to form a nutrient medium which would be nutritious enough to support the crops or plants in their initial stages.

The advantages of the following technique would be that:

1. The will quickly produce mature plants and crops
2. The production of numerous plants in the absence of any seeds or agents of pollination would be possible
3. Entire crop varieties can be regenerated through few genetically modified cells of a crop.
4. The production of crops in such sterilized conditions will produce a cleaner and disease free variety of crops suitable for human consumption.
5. The energy released in the form of heat from nuclear energy production will be utilized in greenhouses

Thus the amount of waste produced from biological sources could be reduced and we would be less burdened in the field of waste disposal as human metabolic wastes would be biologically treated to prepare the nutrient medium

Mars' red soil can also be used for growth of crops like vegetables, rice, groundnut, potatoes etc.

Large volumes of food can be reduced to a small size by dehydrating them. They could be stored in their powder form. Thus the people will consume the food as they would have done it on earth. The water produced by hydrogen fuel cells used to run the spaceships alongside solar panels will be injected into the food products before consumption. Iron abundantly available at Mars can be used to maintain the spacecraft infrastructure. Observations from NASA's Mars Reconnaissance Orbiter have revealed possible flowing water during the warm months on Mars

The spaceships and their skeletal design would be as follows:

Around ten ships of dimensions 150m X 100m X 25m (one hundred and fifty metres into hundred metres into twenty five metres) will be built that could easily support 25000 (twenty five thousand) people. Each spaceship would accommodate around 2500 (twenty five hundred) people. Around each spaceship will have 8 (eight)levels with 5 (five) levels meant for sustaining people and two would be meant for the commercial purposes and the last would have systems sustaining all the life support systems and the systems required for the operation of the spacecraft. Each level will enclose an area of over 12,500 (twelve thousand five hundred) square metres. The area of 12,500 (twelve thousand five hundred) square metres would be used for the residential purposes and for sustaining people, this would be kept in the form of floors and the remaining 2500 (twenty five hundred) square metres would not be in the form of floors as the machinery would be huge and it would be kept so as it occupies the least space and the efficiency is increased. On landing the spaceships monorail systems could be developed between them to connect them.

TRANSPORT

Transport between the spaceships would be enhanced by the monorail systems between the spaceships and elevators within the spaceships.

The transport system of the ship would be accomplished in 2 ways

a. Monorails
b. Elevators

MONORAILS

There would be 2 (two) parallel rails which would have small compartments running on them in opposite directions. This would be branched wherever needed (branches would be taken out or rails would be made out of different rails to increase the efficiency and the extent of the monorail system). The system would be highly branched so that the citizens don't have any difficulty in reaching the desired place. The 2 (two) parallel rails would have ovals around them which would actually be oval rails so that if one desires to stop at a point he would not be stopped on the main rail so as not to stop the other compartments coming from behind. The compartments would be stopped on the oval. The ovals would have 4 (four) rails coming out of it 2 (two) on each side of the main rails (two rails on each side of two rails which would have compartments running on them opposite to each other) to accommodate any extra compartments. If there are compartments more than that of the capacity of the oval it would automatically be sent to another oval via main rail (the main rails would be used to move the extra compartments from one oval to the other if both the sides of the oval are filled that is ovals on both sides of the opposite rails are filled). The compartments sent from one oval to the other oval would actually be empty from within that is no passenger would be seated in those compartments. There would be compartments of different capacities (the number of passengers a compartment of the monorail system could hold) probably the minimum capacity would be 2 (two) passengers and varying in even numbers the maximum capacity would be 6 (six) passengers. This monorail system would be carried on a different floor (probably the floor beneath the residential floors and the commercial floors of the ship) in the ship. Monorail system would be quite extensive inside the ship. It would pass through each and every corridor in the in the respective floor of the ship whose corridor pattern would be similar to the corridor pattern of the other residential, commercial and the floors containing other machinery and the area restricted to the common people each and every oval of the ship would have an elevator so that the people using the ship do not have to waste time to go up to the elevator. The distance between two consecutive ovals of the monorail system of the ship would range between 40-50 (forty to fifty) metres for the convenience of the architecture of the ship and the people residing in the ship.

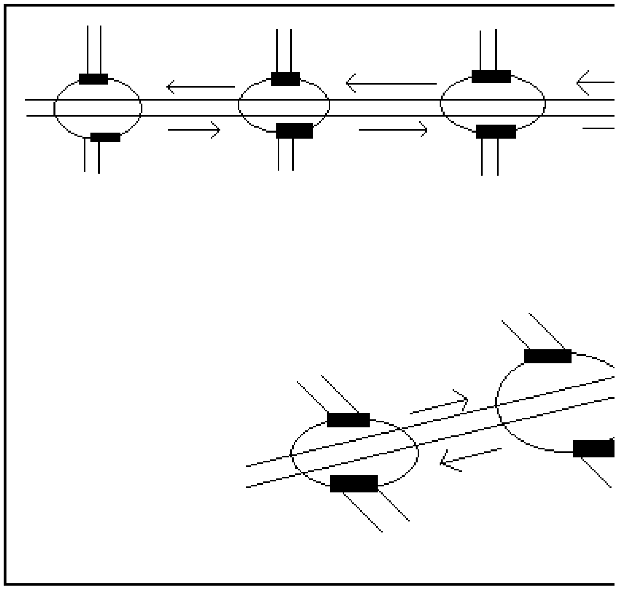

DIAGRAM SHOWING THE SYSTEM OF MONORAILS BETWEEN AND INSIDE THE SHIPS

The monorails would work on electromagnets so that there is least friction (friction would be there only due to air molecules present). The monorails would be highly energy efficient (the monorails would consume very less energy that would be in the form of electricity) as they would run on air and actually would not touch the surface of the rails (the friction between the rails and the compartments would not be present). This would increase the efficiency of the monorail system and would decrease the energy consumed by it during working. The monorails would be used only if a person has to travel long distances horizontally or the distance parallel to the ground is more than the person can travel by foot and if the horizontal distance is not much elevators can be used to travel vertical distances and a person can travel short distances by foot which could again be used to produce electricity through energy tiles (this mechanism is explained in energy production, energy tiles). The different ships on Mars would be joined through monorails which would be the only method of transportation from one ship to another. The monorail would be made inside a tunnel which would join different ships. Some special monorail compartments would be made that would serve as ambulance. The monorail systems would be designed in such a way that the entire system of monorails would be enclosed in tubular capsules.

ELEVATORS

Elevators would be present at very short distances in the ship these would go from the top floor to the bottom floor covering each and every floor of the ship the elevators would be highly capacitive so that around 16 people could be accommodated in a elevator at one time so as to avoid any waiting or any discomfort. The elevators would be used very frequently in the ship. The elevators would complement the monorail system of the ship. The transport of the ship would be incomplete without the use of elevators or without the use of monorails. The elevator system would expand itself up to a maximum size of over 40 (forty) elevators. Low energy consuming escalators would also be put into place inside the spaceships in cases of distances between two points on a spaceship being very large. Thus journey from one point to another on Mars would be made even more comfortable. The elevators would complement the monorail system of the ship. The transport of the ship would be incomplete without the use of elevators or without the use of monorails. The elevator system would be extensive with a total functional system of around 40 (forty) elevators. Low energy consuming elevators would be put into place inside the spaceships. Thus journey from one point to another on Mars would be made even more comfortable with the combination of the elevators and the monorails.

ENERGY TILES

Energy tiles designed indigenously will be used for auxiliary power generation aboard the spaceships and will be very useful in case of an emergency. The flooring of the ship would be done by specially prepared tiles which would produce electricity. When people would walk on the tiles, the tiles would convert the energy obtained by the foot and the mass of the person to electrical energy. The tiles would be six inch thick and would be made keeping in mind the design of the ship and would be manufactured assembled in the ship or we can say that a dual flooring would be present in the ship and between the two layers some machinery would be placed that would convert kinetic energy to electrical energy that will stored and used for various purposes of the ship that is lighting of the residential and the commercial areas. The shape and the dimensions that is the length, breadth and the height would be made and adjusted such that the production of energy which will be in the form of electrical energy is maximized.

INTERNAL PRESSURE MAINTENANCE

Pressurization of the internal cabins of the individual spaceships will be achieved by the design of an airtight fuselage (fuselage of the spaceships will be made airtight by the normal airtight technology used in today's commercial airliners). Engineered to be pressurized with a source of compressed air and controlled by an environmental control system (ECS). The most common source of compressed air for pressurization is bleed air extracted from the compressor stage of a gas turbine engine, from a low or intermediate stage and also from an additional high stage; the exact stage can vary, depending on engine type. By the time the cold outside air has reached the bleed air valves it is at a very high pressure and has been heated to around two hundred degree Celsius- 200 °C or three hundred and ninety two (392 °F). The control and selection of high or low bleed sources is fully automatic and is governed by the needs of various pneumatic systems at various stages of flight.

The part of the bleed air that is directed to the ECS, is then expanded and cooled to a suitable temperature by passing it through a heat exchanger and air cycle machine known as the packs system. In some of the larger rooms hot trim air can be added downstream of air conditioned air coming from the packs if it is needed to warm a section of the cabin that is colder than others.

At least two engines provide compressed bleed air for all of the ship's pneumatic systems the space similar to an airplane with, to provide full redundancy. Compressed air is also obtained from the auxiliary power unit (APU), if fitted, in the event of an emergency and for cabin air supply on the ground before the main engines are started. The ship will have a fully redundant, duplicated electronic controller for maintaining pressurization along with a manual back-up control system.

All exhaust air is dumped into space via an outflow valve, usually at the rear of the fuselage. This valve controls the cabin pressure and also acts as a safety relief valve, in addition to other safety relief valves. In the event that the automatic pressure controllers fail, the pilot can manually control the cabin pressure valve, according to the backup emergency procedure checklist.

SPACESHIP DESIGN

The space ship will be of around 8 floors, 3 metres being the height of each floor. There would be 5 residential floors, 2 will be for commercial purposes and for entertainment and 1 will be the control panel. The corridor pattern for each floor will be the same. There will be elevators connecting each floor and there will be a monorail rail system in the lowermost floor which would act as a transporting mode between the interconnected ships(more than 2 ships of the same kind will be connected).The area of each floor will be around 12500 square metre and one ship would accommodate around 2500 people.

The body of the ship will be manufactured from titanium metal and carbon alloys. Super high frequency aerials and photovoltaic cells will occupy the roof of the ship. The spaceships will have a command centre for their own use which will handle the functioning of all the systems of the spaceship such as lighting and air conditioning and temperature control. The wires and other devices used in the spaceship will gradually be replaced by devices made by materials available on Mars.

CAPSULE ROOMS

We are going to use the capsule beds for the people so as to maximize the area available to us. A capsule rooms measures not more than 1m*1.2m and the height of the capsule being around 50 cm. This technology has been recently invented in Japan. There will be a common dormitory where all the capsules will be placed. The living rooms and the dining rooms will have foldable tables and retractable seating arrangements so as save as much space as possible without compromising with the needs of the people.

Each spaceship will have its own common kitchen which will be used by its residents so as to avoid the need of having a separate kitchen for each person. Thus the space saved by the usage of this idea will be meant for use by recreation centres and other entertainment spots within the spaceship.

There will be a huge water tank situated towards the rear side of the spaceship near the propulsion system of the spaceship.

The spaceships will have retractable gears used for landing on Mars.

LIGHTING

There will be a very exquisite lighting system. We will use the newly invented Super Light Emitting Diodes (L.E.Ds). They will be connected to the auxiliary power system of the spaceship which will comprise of the polymer electrolyte membrane fuel cells that will produce water as a byproduct. The surface and the paint of the ship would be manufactured and would be such so that the maximum amount of light energy is reflected back and the least amount of light energy is absorbed. This would enable us to produce maximum lighting by the utilization of least amount of energy (the energy utilized in the process of lighting would actually be in the form of electrical energy).

Propulsion of the spaceships will be done as described below

For the propulsion of the individual spaceships as the move to Mars highly sophisticated and efficient Liquid Air Cycle engines would be integrated with the spaceship body for use. Liquid Air Cycle Engine (LACE) is a type of spacecraft propulsion engine that attempts to increase its efficiency by gathering part of its oxidizer from the atmosphere. In a liquid oxygen or a liquid hydrogen bipropellant rocket the liquid oxygen needed for combustion is the majority of the weight of the spacecraft on lift-off, so if some of this can be collected from the air on the way, it might dramatically lower the take-off weight of the spaceship.

The communications systems on Mars would be as follows:

Mars already has communication satellites in the form of inbuilt communication systems in the various Mars orbiters put into space by NASA (National Aerospace and Space Administration) and ESA (European Space Agency). So normal technology of electromagnetic radiations such as microwaves can be used for intra planetary communication on Mars. Mars' orbiters have been providing hundreds of terabits information and transmitting it to receivers on earth so they should be able to easily handle the telecommunication systems that shall be operational when colonization of Mars takes place. Most satellite communications systems operate in the C, X, K_a, or K_u bands of the microwave spectrum. These frequencies allow large bandwidth while avoiding the crowded UHF frequencies and staying below the atmospheric absorption of EHF frequencies. Microwave communication is thus a suitable candidate for communication on Mars. The frequency of the waves would range between 3 and 30 gigahertz (GHz). Super high frequency or SHF aerials would be mounted on top of the spaceships which would transmit the microwaves. Alongside would be small receiver dishes which would receive the incoming microwaves. The spaceships would be stationed on the surface of Mars and configured in such a way that they would be in the line of sight of the communication satellites in Mars' orbit. This would be done to improve quality of communication through microwaves. Moreover the super high frequency (SHF) aerials used would have high directivity. The receiver would be parabolic having a diameter of not more than four (4) metres. A backup plan would also be put in place in cause of a failure of the microwave communication system. Contemporary methods of communication of data and voice through fibre optic cable being laid between adjacent spaceships would be done which could ensure uninterrupted high quality communication between the spaceships. It would certainly be a reliable dependable backup in case of an emergency or failure of a few spaceships' communication link with the communication satellites.

Utilization of the resources available on Mars would be done in the following ways:

The following methods of resource utilization would make the environment on Mars a suitable one for planetary habitability.

- Some early Mars colonies might specialize in developing local resources for Martian consumption, such as water and/or ice. Local resources can also be used in infrastructure construction.
- One source of Martian ore currently known to be available is reduced iron in the form of nickel-iron meteorites. Iron could then be extracted through certain metallurgical processes. Iron in this form is more easily extracted than from the iron oxides that cover the planet. This iron thus retrieved could be used for the repair and maintenance of the spaceships and other machinery used on the surface of Mars. Carbon could be produced through combustion of methane (which is available on Mars) in the presence of little amount of air.
- Upon reaching Mars, we again have a world with resources that can be used to expand our capabilities. The Martian atmosphere, consisting mostly of carbon dioxide, can be processed to release oxygen for life support or propellant use. Carbon monoxide, which could be a moderate performance rocket fuel, is the by product. By combining this oxygen with a small amount of hydrogen, water for a variety of uses could be produced for only a fraction of its mass if brought from Earth. One good aspect of atmosphere utilization is that no mining is involved. Simple gas handling equipment can be used, providing a much more reliable system.

The environment of the settlement of the spaceships on Mars will be kept similar to that of Earth as shown below:
Temperature control inside the spaceship:

In order to keep the system eco friendly we would use biogas powered air conditioners that would not require electricity.
The methane is used to power a small refrigerator to cool water by the evaporation and condensation process of the ammonia (NH_3).
The cold water is pumped from the bottom to the top of the unit where the cold water tank of the spaceship is located, A 100 W (hundred watt) Photovoltaic Panel is used to power This DC Pump and A DC Fan Cooler Inside The Unit .The Air is chilled by cold water and a DC Fan Cooler is used To blow The fresh air inside the Apartment. The Solar-Methane Air Conditioner can be used to cool apartments, single family homes, offices, businesses, schools, hospitals, retirement centers, green houses or other remote structures - without electricity!

Life support technologies routinely deal with the conversion of CO_2 to other compounds, including methane. This process was discovered nearly one hundred years ago and is still used in many chemical plants today. A direct application of this technology to the Martian atmosphere would allow for the production of oxygen, methane, and water by bringing only a small amount of hydrogen. Thus, large quantities of propellant could be leveraged from minimal import mass. As described earlier, a rocket engine using methane and oxygen could be developed for use in Martian spacecraft. This could enable another large cost savings for the space program by utilizing those materials available at Mars.

Water is available at the poles of Mars in the form of ice. It is likely, and almost certain, that water is available elsewhere on the planet, perhaps as a permafrost layer or bound as a mineral hydrate. There is every reason to believe that a process can be developed to make it available for human use. It is likely that one could even extract enough water to produce both hydrogen and oxygen propellant for the launch back to orbit and even the return trip to Earth, thus reducing the size of the spacecraft leaving Earth for Mars. Highly specialized systems that would allow the process of tele robotic mining at Mars could also be a good idea as the operations of mining would not be controlled from an extremely distant place like earth but from a nearby spaceship which could coordinate the entire mining operations on Mars.

The two moons of Mars, Phobos and Deimos, may also be rich in water. Processing at the extremely low gravity present on these bodies will require some innovative equipment. While early exploration scenarios suggest it would be difficult to bring this promise to fruition, future operations on or near Mars could easily make use of the potential within these bodies. Many asteroids are believed to be of similar composition and are also likely targets for utilization once we have honed our ability to operate highly complex equipment at distances so remote that teleoperation is not feasible, but this dream could be turned into a reality if we choose operation of the systems from nearby stationed spaceships on Mars.

The carbon dioxide (CO_2) that makes up 95 % (ninety five percent) of the atmosphere of Mars can be a valuable starting material for the manufacture of critical products. Unlike lunar resources, CO_2 can be had by merely compressing the atmosphere. Carbon dioxide itself can be used to support plant growth at an advanced outpost. Both carbon and oxygen are important elements which have many possible uses at an outpost. There are several well understood chemical reactions that we can use to produce oxygen, methane, water, and perhaps other materials.

Oxygen can be produced by passing CO_2 through a Zirconia electrolysis cell at 800 to 1000 (eight hundred to thousand) degree Celsius. Twenty to thirty percent (20% - 30%) of the CO_2 dissociates into oxygen and carbon monoxide. Separation is accomplished by electrochemical transport of oxide ion through a membrane. A prototype reactor using this chemistry has been run for over 1000 (thousand) hours. Using such a scheme, we could bring a small unit to the surface of Mars which would then continuously make oxygen for life support, propellant use, or further processing. The only additional item we would need to supply is the power to run it: a 12kW (kilo Watt) unit would produce about one metric ton of oxygen per month.

This oxygen can be converted into water if we also bring a small supply of hydrogen. Since the molecular weight of hydrogen is 2 (two) and the molecular weight of water is 18 (eighteen), we can leverage 2 kg (two kilograms) of hydrogen into 18 kg (eighteen kilograms) of water. The mass savings would, at some manufacturing rate, pay back the mass of the oxygen production unit. After that, we would get water for only the price of getting the hydrogen to Mars. To overcome that problem to we can prepare hydrogen by the electrolysis of water produced from the fuel cells used for power generation by the spaceships. If this is practiced on a large scale for around twenty five thousand people then the daily demand for oxygen for all the twenty five thousand people can be easily met.

$2CO_2 \rightarrow 2CO + O_2$

Zirconia electrolysis is presented by the above shown reaction

$O_2 + 2 H_2 \rightarrow 2 H_2O$

combustion of hydrogen is a simple reaction as shown above

If we choose to produce hydrogen by simple chemical reactions, there are other things we can do with it in addition to making water. A chemical reaction which converts CO2 into methane (CH4) was discovered in 1899. This is known as the Sabatier reaction. Along with the CO2, hydrogen is passed over a finely divided metal catalyst at an elevated temperature. Methane and water vapour are produced. By taking this water vapour and splitting it to obtain oxygen and hydrogen (which is recycled), we can completely convert the imported material into 4 times its mass of fuel. We also get the oxygen we need to burn this fuel in a rocket engine, fuel cell, or internal combustion engine. When combined with the production of additional oxygen via the Zirconia process described above, only 4 kilograms of hydrogen can be converted into 72 kilograms of a rocket propellant mixture.

$CO_2 + 4H_2 \rightarrow CH_4 + 2H_20$

Sabatier Reaction – the above shown reaction would be useful in generation of water vapours too.

$2H_20 \rightarrow 2H_2 + O_2$

Electrolysis of water is widely known.

$CO_2 + 2H_2 \rightarrow CH_4 + O_2$

Net Reaction

Other well known reactions have been practiced for decades which can also accomplish similar conversions. Fischer-Tropsch chemistry is practiced in the petrochemical industry in a variety of ways. It converts carbon monoxide and hydrogen into methane and water. The Bosch reaction can convert CO2 and hydrogen into carbon and water. The carbon could, perhaps, be used for advanced material production at an outpost once fabrication facilities are available.

Eventually, we will obtain water from the environment of Mars. We would then not need to make water from imported hydrogen. Indeed, we could turn the situation around and use this water as a source of hydrogen, thus continuing to utilize the chemical processing capabilities we have developed. For instance, it would be even more favorable to produce methane from the atmospheric CO2 and water derived hydrogen. This would require the production of much less water than if we switched the space transportation system to a hydrogen-oxygen propellant system. It is also much easier to liquefy methane than hydrogen.

With a large amount of hydrogen available, and a ready supply of CO2, we may consider going the next step and developing the ability to produce a large variety of products. If ethylene were produced from hydrogen and a carbon source, polyethylene can be made using technology available today. This material, or other carbon-based polymers, can then be extruded or molded to form habitats, furniture, pipes, and a variety of useful items. The petrochemical and natural gas industries can contribute a great deal of expertise in this area.

Note: An important inter-Martian trade good during early colonization could be manure. Assuming that life doesn't exist on Mars, the soil is going to be very poor for growing plants, so manure and other fertilizers will be valued highly in any Martian civilization until the planet changes enough chemically to support growing vegetation on its own.

Key Learnings:

The creation of this entire report had been something more than just writing a report. It was a process of learning about things which we would have never thought of. This opportunity would not have been within our reach only through the medium of school teaching. Space Habitat Design Challenge (SHDC 2011) provide that opportunity by which we could think of new frontiers and apply our own creative mind in development of technologies and solutions that would make possible the living of the human race in outer space.

During the process we learnt some important aspects of food production on the commercial scale which are practiced in the world today. The technology of tissue culture for growth of food crops and plants has been quite popular and an effective idea.

The idea behind the technology used by us for transmission of energy is a novel idea which struck our mind on learning about electromagnetic spectrum. We learnt as to how conversion of electrical energy into electromagnetic radiations and vice versa can take place.

City design and design of the internal space of the spaceships was also a modification of a not so known concept of capsule hotels. The pressurization system for the internal environment of the spaceships was an important thing to be designed. During the design process we learnt about the internal pressurization systems in the cabin of today's modern commercial airplanes and airliners. Similar was the case with the temperature control systems of the spaceships. We wanted to use a non-polluting and less energy consuming air conditioning system for the spaceships and it was then that we came across the idea of using biogas as a suitable substance for the air conditioning system. We learnt a lot about how the original mechanism could be tweaked a bit to play to our benefit in life in outer space. We wanted to ensure the utilization of resources available on Mars for this purpose and came about learning a lot about the possible uses of Martian resources.

During the process of figuring out resource utilization, we learnt about many different and not so known chemical reactions such as the Zirconia electrolysis and the Sabatier reaction. These chemical reactions if used properly could yield various vital life supporting gases which would be instrumental for life in outer space and it was only during the process of research for the creation of the proposal report that we came across this branch of chemistry.-

While designing the transport system we came across the advantages of using the monorails and the elevators aboard our spaceships.

All in it was a valuable learning experience.

SPECIALITY OF MONORAIL SYSTEM

The compartments would be controlled by a computer that would control the entire system of the monorails and would have no manual drivers. There would be self operated booths near the ovals of the monorail system where the person who has to travel would enter his destination and the number of persons and would then have to swap his ID Card and the expenses would be entered into his ID Card which could be paid later on or could be paid through money existing already in the account of the Card holder through the Card itself. The monorail compartment would take you to the oval where the elevator would take you to your desired floor from where the desired place would be nearest compared to other elevators.

Both the systems of the ship would be so effective that the travel to the farthest place in a ship would take less than 5 (five) minutes if the total journey is taken into account with all the favourable conditions available.