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Making Mars Our Next Abode

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Abstract: **Today the world is trying to explore ways to colonize Mars and establishing a colony on Mars would be the dawn of intra-solar system life. Trending ideas in various STEM disciplines can be applied to make Mars more Earth like. Essential technological advances in 3D printing systems, robots, rockets, life support systems, and many more technologies promises a key to colonizing. Here, innumerous ideas are discussed and developed to create an all inclusive logic for colonizing.**

Keywords: **Terraforming, Lava Tubes, Teleoperate, Rectenna, Window period, Synodic period.**

I. INTRODUCTION

This paper suggests multiple steps and ideas to develop a sustainable habitat on Mars. The concepts of terraforming, in-situ resource utilization, human health are discussed here. The research has been developed from an amalgamation of facts studied from innumerable number of scientific work and internet open-source data. Extending the territory of Earthlings to Mars is crucial even in terms of sustaining life. By working as a world community towards implementing these ideas, would facilitate the search for a new abode.

II. THE RESEARCH WORK

SECTION 1: TRAVEL TO MARS:

What attracts us towards Mars? (1)Well Mars is the one of the closest planet to Earth**[1],[2]**. (2)It's evolution and transformation is comparable to Earth. (3)Several experiments conducted on mars reveal that the geological features are more Earth like**[3]**. (4)The exploration of Mars will help us solve present Earth based issues. (5)Martian atmosphere: young Mars had an atmospheric pressure of 1000millibars which is in par with today's Earth's atmospheric pressure however it has gradually decreased over the years**[1]**. At present atmospheric pressure on Mars is 10 millibars and human beings will require a continual support system to maintain the blood pressure. These qualities of Mars gives us a hope to colonize it. For more than 40years we have conducted robotic experiments on Mars. Now it is time for humans to explore Mars. Why should human beings be sent to Mars?**[4]** (1)Humans are highly intelligent, adaptable and capable to solve problems in real time. (2)Moreover human can conduct detailed and precise measurements of Martian surface and atmosphere with scientific equipments and instrumentation taken from Earth. (3)Population outburst and global warming issues pushes humans in search of a new home. Travel to Mars- (1)Today the travel rate is very high but it is a benefitting affair on the long run. We need to find effective ways to reduce this cost by using miniature systems, renewable energy resources. (2)Travel time has to be reduced by increasing the speed of the spacecraft in order to reduce the radiation dosage taken in by astronauts. Clearing the space debris as proposed by JAXA and re-fuelling in orbit would help boost the speed of the shuttle **[5]**.

SECTION 2: FINDING A SITE FOR SETTLEMENT:

The location of a city is crucial for its sustenance. Today the company SpaceX is planning to transport humans to Mars and many countries like UAE have a declared official project to build a city**[6]**. Initially the landing spot must be at least 25km wide and non-rocky nor super-soft. The settlement area if located at the equator would provide (1)solar energy, (2) maximum velocity to launch back, (3)may provide geothermal energy. At the poles we can extract water for (1)basic needs, (2)fuel but poles can be too cold during winters**[7]**. Caves, craters and lava tubes is seen to provide some source of (1)water and (2)protection from radiation**[8]**. Research has shown that mice, crickets could breathe argon mixtures of air for extended period of time on Earth**[9]**. Hence with efficient tools humans can inhabit caves of Mars**[10]**. The table below suggests a set of physical features on Mars where settlements can be established.

TABLE 1-SUITABLE AREAS FOR SETTELEMENTS

AREA TYPE	LOCATION	DESCRIPTION
CAVES, LAVA TUBES, SUB SURFACE HABITAT, CAVITIES, CANYON OVERHANGS	• Natural caves near Arsia Mons • lava tubes at the edges of Arsia Mons	Source Mars Odyssey-provides protection from radiation, micrometeroids may also supply minerals, gases, ices, and any subterranean life. Grant means of direct exploration, drilling and is an area of scientific interest.
CRATERS **[11],[12]**	Equatorial sites- 1.Gusev Crater(impact crater) 2.Gale Crater 3.Vallis Marineris *Hellas Planitia-southern hemisphere North west (i)Moreux Crater (ii)Hebrus Valles	1.Sources Spirit rover-had an ancient hydrothermal environment(on Earth hot springs are possible laces where life could have begun). 2.Major transition between wet Mars and dry Mars is seen. It's low altitude provides higher air pressure. Suitable landing site. 3.Landing site-4000km long. It's recurring slope predict liquid salt water below its surface. *.It is a plain located to the east of impact crater Hellas and contains large pockets of water ice. (i)East of this crater consists of rock units shows transition between different chemical times. (ii)May hold subterreanen water and fossils of life.
OTHERS **[12]**	Protonilus Mensae	Higher altitude-a part of a complex network of mesas and valleys seems to contain large amount of water ice.

Selection based on the table: Gale crater as the landing site**[13]**. Caves and lava tubes near Arsia Mons as the initial residence and any one of the craters seen in the table as the area for the first Martian City.

SECTION 3: BEFORE HUMANS LAND, ARTIFICIAL INTELLIGENCE SHALL INVADE MARS:

Section 3.1-Prediction-With the advent of quantum computer in the near future, the mission designers will be able to devise quicker and optimal missions. Although quantum computers will truly revolutionize problem solving in real world still achieving its working conditions poses a challenge.

Section 3.2-Proposal-(1)Before the arrival of humans on mars, robonauts, 3D printers, nuclear power generator and basic hardware material will form the payload to Mars.(2)A new version of robonaut i.e. R3 needs to be developed as an extension of R2. R3 will be able to endure the Martian climate. It will have extended vision ,a pair of switchable legs, capability to operate other machines, help in landing and launching on mars, be able to teleoperate and also work autonomously**[14],[15]**. R3 will basically work as a constructer on the Red Planet.(3) Next 3D printers can be employed to produce items for the colony. Robonauts will be able to fix the industrial cutters and printers in place and make objects as instructed**[16].** Initially R3 will build a tiny home in the lava tubes or caves near Arsia Mons. (4)At first basic hardware parts can be used for creating other tiny robots that are useful for construction with the 2D designs being sent from Earth.

Mars Foundation, founded by Bruce Mackenzie and NASA's 3D Printing Habitat Challenge have provided vital ideas for creating sustainable habitat. Ideas involving in-situ resource utilization from Mars Foundation-(a)to manufacture oxygen and methane-used to craft plastics. Plastics can be used to create wide range of objects like pipes for irrigation, plastic sheets can be cut from laser-jet cutters to make bigger objects.(b)Martian sand-used to make fibreglass and cement.(c)Green house grown corn and potato starch to make tiny household objects. Using Behrokh Khoshnevis's method of printing buildings i.e. "contour crafting", similar to 3D printing, is one and shade walls, thermal and micrometeorite protection shields and dust-free platforms built on the surface of Mars**[17]**.

Section 3.3-Proposal For Power Supply-Currently nuclear power is best suggested as an energy source. Radioisotope Thermoelectric Generator can be used which promises electrical power in smaller steps of about 100watts and also has a lifespan of 14 years. They work by converting heat from the natural decay of radioisotope material(plutonium-238) into electricity**[18].** Initially until humans are sent RTG can be placed in the vicinity, later it will have to be shifted to a safe distance from the colony for safety issues. Nuclear waste disposal will also have to be considered as years pass by.

Prediction-Solar energy can be used as an alternative power source. Once Space Based Power Supply(SBPS) is stabilized on Earth, it can also be implemented on Mars. Again placing the rectenna away from the colony is a necessity to reduce human exposure to microwaves**[19].** Power can be brought in through wires from grids. Bulbs and other lighting sources can be taken as a part of hardware material to support the night vision of robonauts.

Summary: Thus, the primal setup phase of a settlement is initiated. The robonauts are now currently the commanders to all other rovers and machines. 3D printers and other devices are also safeguarded from radiation by placing them in caves.

SECTION 4: THE MARTIAN HABITAT ARCHITECTURE AND ALL-EMBRACING LIFE SUPPORT SYSTEMS:

Section 4.1-With long-duration stays on the Red Planet, it is required to have a habitat where the astronauts can dwell, study and perform experiments. The main objective is to: (1) shield the humans and equipment from frequent dust storm, (2) provide a conducive environment that promotes plant life and protect humans from severe radiation (30 micro Sv) and harsh conditions (-60 degree Centigrade to 125 degree Centigrade), (3) provide breathable air for living beings and (4) offer a favourable environment for a long duration stay. The recently organised NASA's 3D habitat challenge emphasised the creation of a habitable, sustainable abode but also underlined the importance of creativity.

As the Robonauts and 3D printers will be sent to Mars before humans, the Robonauts can be instructed to work towards building a habitat while they themselves reside in the lava tubes of mars. With the help of the printers and the Martian soil, the Robonauts will create bricks, walls and other structures.

Martian settlement-A large central area will be constructed on the crater's surface and other structures will be constructed around it. It will connected to-- (1)the 3D Construction Unit-where the automaton will manufacture the required materials,(2) the Water Processing Unit-where the water from the polar caps, soil or the subsurface-permafrost is tapped and processed, making it fit for life,(3)Waste Processing Unit-where refuse from greenhouse and living quarters is collected, processed and the reusable water are siphoned off back by the greenhouse(4) Research Lab-where scientists will conduct important experiments and activities, (5) Greenhouse-where the plant life shall flourish and their growth shall be monitored. Built out of BNNT glass, the Greenhouse shall receive ample amount of sunlight and be protected from severe weather, high radiation and extreme temperatures. It will have inlets for water and gases from the Water and Waste processing units; (6) Living Area will house a wash area (outlet connected to the Waste Processing Unit), an underground, spiral staircase will lead to the gym are where the astronauts can exercise, followed by an underground quarters where they will reside. Breathable gases such as oxygen, water vapour shall be introduced through vents and these gases will spread all over the structure that add to the pressure and also help in regulating the temperature. Aquifer, if any found, shall supply water for the Living Area. The central area shall also have a vent for air supply and also provide an emergency exit.

On the surface, solar panels will be installed that will power most of the gadgets. A nuclear power plant will be installed too that will serve as a backup in case the solar panels fail due to dust storms or lack of sunlight. A waste burial site shall be constructed away from the habitat where harmful/nuclear refuse are buried. There shall also be a launch pad that will house a rocket that will transport the humans back to Earth, next to the landing site which will be an optimal distance away from the Martian habitat.

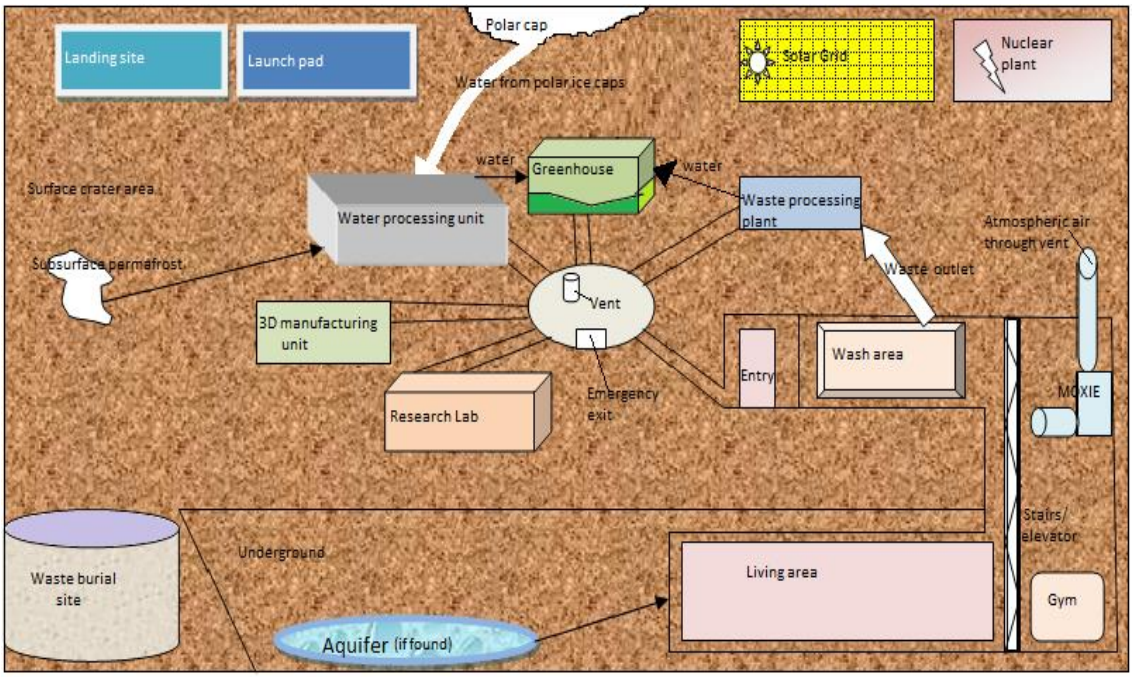

Fig: 1 Martian City Layout

Section 4.2- The key requirements to sustain life on Mars are the production of life support systems. Life support systems include the following: air, water, food, ideal temperature, pressure, possible increase in gravity, radiation shielding, power, communication system, transportation system, waste management system and additional products like clothing. The quantities required will depend on the number of crew members**[20]**. Extension in production also needs to be considered to sustain a higher population and also for a return journey back home.

(1)Breathable Air: Source-The Martian atmosphere contains generous amounts of carbon dioxide but with small and useful percentages of nitrogen, argon and water vapour. Production-Oxygen can be obtained by processing Martian air. In addition to oxygen breathable air must also contain inert buffer gas to prevent oxygen toxicity and spontaneous combustion hazard. The gases N2(nitrogen) and Ar(argon) are the potential buffer gases. MOXIE (Mars OXygen In situ resource utilization Experiment) technology that will produce oxygen from Martian atmospheric carbon dioxide (CO_2) in a process called solid oxide electrolysis**[21]**. Once this system is verified; larger MOXIE can be installed in the structures. The oxygen will be used for life support and as a rocket propellant oxidiser to energize the return trip. The carbon monoxide(CO) byproduct can be used as a propellant or converted to methane(CH4) again to act like a rocket fuel.

(2)Water: Source-(i)The atmosphere, (ii)the polar caps,(iii) a deep subsurface permafrost or an aquifer,(iv) the soil. Production-(i)The process of compressing Martian air to obtain water and then reusing the gas for power regenerators is not optimal way to obtain water. Yet may be sufficient to provide drinking water. (ii) The polar cap has two components a seasonal carbon dioxide cap and a permanent cap mostly consisting of water ice. The northern cap is thicker with a height of 4 to 6 km at its centre. Creation of artificial rivers on Mars:(similar to great man-made river in Libya) by breaking down the ice cap to tiny chunks little by little and then melting them by application of pressure**[22]**. Later on removing the contaminant; a stream of liquid water can be obtained which can be passed to the lower latitudes. A canal like structure can be dug which can contain huge closed pipes to transport water. The pipes will have to be covered by soil for radiation shielding. The water thus obtained can be used for irrigation. Once Mars is terraformed these pipes can be removed and Mars may one day see flowing water on its surface again in the future. (iii) In case of an discovery of an underground aquifer at a feasible depth of 1 km near the equator then this water could filtered and used to meet daily needs**[20].** (iv) the low percent of water present in the soil could be made use to support plant life.

(3)Food: Source- plants grown on Mars and additional supplements from Earth will provide nutrition in the initial years. Martian soil is rich in silicon(21%) and iron(13%) which is extremely beneficial for plants as suggested by PMC. Plants can be grown in greenhouses with water from the soil and manure from processed human waste. The greenhouses will have thermostat and other temperature sensors to stabilize temperature. Plants will be supplied with sufficient carbon dioxide during day and oxygen during night to maintain the Earth like conditions. Initially vegetables will be grown to serve as food for astronauts. Milk powder, sugar, oil and other protein supplements will have to be shipped from Earth. The prototype of each species of plants i.e. seeds will also have to be sent from Earth. The area of plant spread on the surface can be increased during the years of terraforming.

(4) Ideal temperature: Mars on an average has a cold climate. A summer day temperature may rise up to 20^{o} C. Highly advance temperature sensor associated with heaters and coolers will work to provide a real time temperature control within the structures to provide ambient temperature.

(5)Pressure: The location of the structures with respect to depth and the breathable air within the structure provide pressure condition similar to Earth. Yet reaching exact conditions of Earth is difficult unless a magical phenomena of formation of thick atmospheric blanket due to life on Mars occurs.

(6)Possible increase in gravity: Can be obtained with the help of rotating structures which provide increase in centripetal force. Astronauts will have to perform strength training exercises and also practice ancient ways of life enhancing practices (not suggested anywhere else) like yoga, martial arts and many more. A advance in musculoskeletal sciences is needed to deal with after effects on return. Silicon content in soil absorbed by plant tissue reaching humans can also be used to improve orthopaedic health(suggested by PMC) **[23]**.

(7) Radiation Shielding: This can be obtained with covering the structures with layers of Martian soil and also from the location of the structure(i.e. by living in caves and lava tubes) and its building material.

(8)Power: As mentioned previously nuclear power will be used and each individual system is also going to make use of solar power. Also byproducts of chemical reactions like carbon monoxide can be used as propellants.

(9)Communication System: Advance communication system to have contact with Earth is needed. The mission centre can establish contact with the family members of astronauts and also to provide medical help. Communication satellites like aero stationary satellite will to be installed around Mars to provide quick communication and allow global positional tracking on Mars. The structures will also have a mission control centre and provide local communication networks for astronauts during exploration.

(10)Transportation System: The varied Martian rovers usually solar powered will help to traverse on Mars. New rovers that are small but efficient should be developed. Transportation system for shipping construction materials are also essential. Lubrication for these vehicles can be obtained from certain seeds of plants on processing.

(11)Waste Management: Waste processing is a complex task. The waste material from the colony are varied in structure and requires resourceful processing**[24]**. The following table may help simplify the whole process.

TABLE 2-Waste Disposal Methods

TYPE OF WASTE	WASTE MATERIAL	DISPOSAL METHODS
SOLID	Miscellaneous solid body waste and dead plants and bio-degradable waste.	Are composted and allowed to decay by action of micro-organisms (that are cultured from sample taken from Earth) to produce manure and maybe biogas.
	Disease causing waste	Incinerated
	Paper, tape, clothing and non-bio-degradable waste	Recycled
	Nuclear waste	Buried far from the colony.
LIQUID	Urine	Processed by vapour compression distillation to get urea. Urea is in turn used as fertilizer.
	Brine	Can be electrolysed to produce hydrogen for a fuel cell. It can be used as a refrigerating fluid or for de-icing.
	Grey water	Is passed through a process of multi-filtration. Water obtained is reused.
	Nuclear waste	Solidified and then buried.
GAS	Exhaled carbon dioxide	Allowed to be absorbed by tiny plants within the structures.
	Carbon monoxide	Used as rocket propellant.

(12)Additional Requirements: We deal with the required hygiene products, clothing and other products like utensils. Bio-degradable clothing consisting of textile material like organic cotton, wool, tencel, soy cashmere/silk are easy to recycle and reuse. Hygiene products should preferably be organic so that the amount of effluents in the grey water can be reduced. Other accessories can be printed with the help of the 3D printers.

SECTION 5:SENDING HUMANS TO MARS:

The time taken to reach Mars depends majorly on two factors (1)relative position of Earth and Mars in their orbits and (2) the technological developments of propulsion systems. In theory, the closest distance between the two planets would be when Mars is at its closest point to the sun (perihelion) and Earth is at its farthest (aphelion). This would put the planets only 33.9 million miles (54.6 million km) apart. The two planets are farthest apart when they are on opposite sides of the star. At this point, they can be 250 million miles (401 million km) apart. The average distance between the two planets is 140 million miles (225 million km). The synodic period for the Earth to Mars trip 26 months(2years 2months) and the low-energy windows varies on roughly a 15-year cycle **[25]**.

A mission to Mars using Hohmann transfer involves an approximately 500days of stay on Mars and 18months of to and fro journey. Shorter Mars mission plans have round-trip flight times of 400 to 450 days but requiring a higher energy. A fast Mars mission of 245 days round trip could be possible with on-orbit staging. Future window periods are predicted to be in the years 2018, 2035, 2050 **[26]**.

Spacecrafts- Orion Multi-Purpose Crew Vehicle (Orion MPCV) is an American spacecraft estimated to carry four astronauts to destinations at or beyond low Earth orbit (LEO). Currently under development by NASA for launch on the Space Launch System, Orion is intended to transport astronauts to Mars around a timeline of 6 months**[27]**.

Prediction- (1)Other rockets theoretical designs like fusion rockets(a rocket driven by fusion power, and has high specific impulse, gives out less radiation but comes with a large mass of the reactor. Maybe in the future we will be able to test this technology on an asteroids or in outer space far away from Earth.)**[28]** and antimatter rockets(these rockets use the rest mass of matter/antimatter for energy. It will have high specific impulse but creating and storing antimatter yet need to be understood. The main disadvantage being the high cost, excesses of waste heat and radiation being generated.)**[29]** at present if developed would provide an easy passage medium for travel without having to wait for the window period and also reduce the radiation dosage absorbed by astronauts. With these rockets entire circuit can be reduced to a year. A crew of 3 astronauts can go to Mars develop the colony, explore Mars and return back to Earth. Then, the next team of explorers can be sent. These technological advancements will also help develop space tourism industry.

(2)Using light beams to propel spacecrafts is an expensive affair and encrypting human consciousness or memory on disks and sending them to Mars would help explore Mars but not make it a habitat. (3)Sending a crew of genetically modified explorers would also not solve the problem as we would want the explorers to return back to Earth after a certain duration of exploration. (4) The ideas of theological physics involving the usage of wormholes for inter-solar system travel may come true one day if we are able to discover real wormholes. Learn their properties and also develop the mechanism to create and maintain it with the usage of negative gravitational forces,(not suggested before). Once this has been achieved specialized spacecrafts will have to be designed for travel through wormholes.

A whole new experience for the explorers- the Martian sky displays spectacular hues of color ranging from pinkish-red around sunset and sunrise and blue at the vicinity of sunrise and sunset. During the day one can see a butterscotch(yellow-brown) color due to scattering by 1% by magnetite in the dust particles. At times of twilight Martian sky takes over a violet color due to scattering by very small water ice particles in clouds. The concept of sending humans to Mars is complex but is not an unachievable challenge.

SECTION 6: TERRAFORMING OF MARS:

Terraforming of Mars is a process of transforming the Martian environment to suite human needs. NASA suggests creation of an artificial magnetic field around Mars that will protect (1)residents from radiation (2)revive the planet's ancient oceans (3)increase the temperature. Even if we try to bring back the atmosphere of Mars, it would just be stripped away without an atmosphere. Advances in plasma physics would lead to development of inflatable structures that generate a magnetic dipole of 1or 2 tesla. Such a magnetic dipole if positioned at the Mars Lagrange Point(where the structure would be in a gravitational equilibrium) could deflect the solarwind **[30]**.

Terraforming Mars requires the thickening of atmosphere by enriching it with nitrogen and oxygen. According to the Gaia hypothesis published by the GSA, life is a powerful geologic force and possesses the power to regulate the surface temperature and chemistry of a planet**[31]**. Even terraformers believe in the potential of microorganisms. (1)Micro plants like algae and dark plants could be sown on the surface to increase surface absorption of sunlight to increase temperature. (2)Rock-eating microbes could be used to mine extraterrestrial resources. On Earth around 25 percent of the world's copper supply is obtained by mining with the help of microbes. Mining on similar lines would help use the Martian resources for the colony. Anabaena cylindrica a microbe can be successfully used for mining all rock types, including those with both high and low silica content. Anabaena cylindrica also survived up to 28 days of exposure to dry conditions similar to that on Mars.

Cyanobacteria- These are a group of photosynthetic, nitrogen-fixing bacteria that live in moist soils and water either freely or in a symbiotic relationship with plants or lichen-forming fungi **[32]**. Both cyanobacteria and other rock-dwelling microbes have survived the hard vacuum of space; proven by facilities such as Europe's BIOPAN exposure platform and the International Space Station's EXPOSE platform. And are only threatened by harsh space radiation in low Earth-orbit. A study in 2008 showed that cyanobacteria created a strong crust in the desert of Mongolia within 15 days. The crust was capable of surviving wind speeds of 10 meters per second.

Plankton- These are organisms that live in water column of large water bodies. These organisms comprise of bacteria, archaea, algae, protozoa. Plankton ecosystems play an important role in the biogeochemical cycle like the ocean's carbon cycle**[33]**. Phytoplankton by the process of photosynthesis release molecular oxygen into the water. An estimated amount

of about 50% of the world's oxygen is produced by phytoplankton. Furthermore they maintain the atmospheric carbon-dioxide on Earth. Similarly phytoplankton can be used to produce oxygen on Mars, initially in the artificially generated water and also in the melted ice once the temperature of Mars rises.

Desert plantation- Crops like beans, cucumber, eggplant, melon, pepper, pumpkin, squash, corn can be grown in the greenhouses on Mars and later on the Martian surface once it is terraformed.

During the era of terraforming, colonists can inhabit and expand the system of paraterraformed structures.

SECTION 7: BRINGING BACK HUMANS FROM MARS:

The return mission of the astronauts from Mars is an important step for a successful mission. Today, NASA is constructing Mars Ascent Vehicle(MAV). MAV poses a engineering challenge consisting of weight reduction, safe landing on Mars and launch from Martian surface to orbit **[34]**.

(i)The weight of the MAV is largely dependent on the fuel it holds. An estimated amount of 5 to 7 tons of fuel is burned during landing on Mars and another 33 tons of fuel is needed to break free from the surface gravity. Thus, carrying large quantities of fuel can be avoided by manufacturing it on Mars. Carbon monoxide a gaseous waste produced as a byproduct of nuclear power generation on Mars can be used as rocket propellant. Carbon monoxide can also be converted to Methane to act as rocket fuel. Oxygen produced by MOXIE as discussed before will serve as rocket propellant oxidiser (not suggested before). These fuel are cryogenic and need to be kept at low temperature. Also MAV has to be designed tough enough to tolerate fierce dust storms and UV radiation**[35],[36]**.

(ii) For landing MAV on Mars a Hypersonic Inflatable Aerodynamic Decelerator- a cone shaped inflatable heat shield is being developed that would act like braking system. On entering the Martian atmosphere the shield would slow down the lander and the rocket engines would ignite for a controlled landing.

(iii)By burning fuel, MAV is powered to carry astronauts into the orbit and then dock with the Earth Return Vehicle(EVR). MAV now gets into an isolated orbit. ERV on the other hand returns back to Earth while using parachutes to survive 30,000 mph plummet and descend gently to the ground(or sea) for recovery. Specialized suits or Intra Vehicular Activity suits need to be worn for the trip to the orbit from Mars. The regular space suits are too bulky, hence they can be avoided**[35],[36]**.

Fusion rockets- The alternative way is to use fusion rocket that are yet to be developed. The University of Washington and a company named MSNW are aiming at creating feasible fuel. They are investigating methods of compressing specially developed plasma to high pressure with a magnetic field, in order to create a nuclear fusion. The whole concept is to use a powerful magnet that would lead to collapsing of the lithium metal rings around the plasma material, compressing it to a fusion state for a few microseconds. Thus, the energy released heats up and ionizes the shell of lithium rings. Now the ionized metal would be gunshot at the rocket nozzle. According to the team repeating this entire process every minute would propel the spacecraft**[37]**.

Wormholes- With high advancements in technology, a wormhole could be created in the future and can be used to bring the astronauts back to Earth as discussed before.

SECTION 8: REHABILITATING MARTIANS:

Astronauts in space are affected by zero gravity, isolation and confinement due to distance from Earth, closed and hostile environment, space radiation**[38]**.

Gravity-Based on study of human body on return to Earth after living in weightlessness, certain test have been developed to monitor the changes. (1)Functional task testing(detect, minimize body balance and performance issues), (2)Fine motor skills testing(tests ability to interact with computers, distribution of fluids in the body, changes in vision- countered by compression cuffs worn on the thighs and spinal ultrasounds to monitor back pain), (3)Fitness self-evaluations(at regular intervals, accompanied with proper exercise routine and nutrition supplements**)[38]**. All these tests, including workout routines on Mars and on-flight can help counteract effect of gravity. On coming back a strict workout routine and physiotherapy will alleviate the pain.

Isolation and confinement- Various studies have been conducted around the world in a simulated Mars like environment. Devices like: (1)actigraphy(help to assess and improve sleep and alertness), (2) LED technology(will be used to align

circadian rhythms)**[38],[39]**. Behavioural issues and isolation on Mars can be countered by active interaction with crew members.

Closed and hostile environment- Enhanced air quality system can enhance the closed environment. Astronauts are likely to be carrying disease causing microbes within their body. In space these microbes mutate and hence need to be monitored**[40]**. Regular health tests: during travel, on Mars and on return to Earth will help maintain the immunity system better. The different medical conditions can be treated in space and on Mars with efficient training and coordination between the crew members. Efficient packing material for food will help retain the nutrients and self- resilient medicines help counter the diseases. These facilities will help conquer the ill effect of long duration space travel**[41]**.

Space radiation- Mutation due to cosmic rays can lead to changes in DNA and cause cancer**[40]**. Shielding, monitoring minimize risks to a certain level**[41]**. Practice of ancient techniques of yoga may help reduce the risk of cancer. The best way is to Travel to Mars at a high speed using revolutionary technology like fusion rockets in order to minimize radiation exposure. Also, it is better to send a younger generation of astronauts as they will be sustain slightly higher doses of radiation. On Earth we will have to develop best medical methods to treat cancer like destroying cancer cell without use of radiation.

III. CONCLUSION

The paper lucidly explains the steps to establish a colony on Mars. The research discusses: the need to colonize Mars, explore a site to establish a colony, determine an architecture for the structure, obtain power supply, develop life support systems and use robonauts to assist explorers. The scope also includes ways to send humans to Mars, terraform Mars and also bring astronauts back and rehabilitate them. The paper systematically gathers ideas from around the world and analyses their application to develop a colony on Mars. It also includes a whole new dimension to the already existing methods. The processes of establishing a abode on Mars is indeed though but is achievable by following the above methods. The paper involves theoretical ideas which are yet to be developed, tested and implemented, thus establishing the first colony may take a few years from now. Reaching Mars is an expensive affair, and a joint venture by all the countries-space programs; will help manage funds and also speed up development of technologies by sharing of research findings.

REFERENCES

[1] M.H. Carr, W.A. Baum, K.R. Blasius, G.A. Briggs, J.A. Cutts, T.C. Duxbury, R. Greeley, J. Guest, H.Masursky, B.A. Smith, L.A Soderblom, J.Veverka, J.B Wellman. article "History of Mars" http://www.nasa.gov/history

[2] Matt Williams by Universe Today website article "Which is the closet planet to Earth?" May 19, 2016 http://www.universetoday.com/14447/what-is-the-closet-planet-to-earth/.

[3] Michael Starobin and Mike McClare by NASA Goddard Space Flight Center "Siblings Rivalry: Earth/Mars" http://www.nasa.gov/vision/earth/environment/Sibling.Rivalry.html

[4] Joel S. Levine and Rudy Schild, "Human Mission To Mars: Colonizing the Red Planet", Editors, Cosmology Science Publishers, 2010

[5] Advanced Space Technology Research Group-JAXA, "Cleaning Up Space Junk", eng-magazine publication 2004, http://www.aero.jaxa.jp/eng/publication/magazine/sora/2004_no02/ss2004no02_02.html.

[6] Sources AL Jazeera News article "UAE seeks to build human settlement on Mars by 2117" January 14,2017 http://www.aljazeera.com/news/.

[7] Alex Moore article from Red Colony "Where will the first colony on Mars be located" Aug 2015.

[8] David, S.Leonard (2005-02-22). "Digging and Sniffing for Life on Mars". Space.com. Retrieved 2010-06-30. (PDF), USRA Reports, NASA Institute for Advanced Concepts, retrieved 2010-06-30.

[9] From Wikipedia the free encyclopaedia "Caves of Mars Project" http://en.wikipedia.org/wiki/Caves_Of_Mars_Project

[10] P.Boston, G.Frederick, S.Welch, J.Werker, T.R.Meyer, B.Sprungman, V.Hildreth-Werker, D.Murphy, S.L. Thompson.(2004),"System Feasibility Demonstrations of Caves and Subsurface Constructed for Mars Habitation and Scientific Exp ".

[11] Mars maps real time data(2017) http://nasa.gov/maps/explore-mars-maps and http://www.google.co.in/mars.

[12] The article "The Geography Of Mars" from free encyclopaedia http://en.wikipedia.org/wiki/Geography_Of_Mars.

[13] Charles Q Choi "If Humans Go To Mars, Where Is the Best place to land" article Oct 28,2015.

[14] From NASA home page "Robonauts" https://robonaut.jsc.nasa.gov/R2.

[15] From Wikipedia the free encyclopaedia "Robonauts" https://en.wikipedia.org/wiki/Robonaut.

[16] From the article " Robots could use 3d printing build mars bases astronauts arrive" http://www.iflscience.com/space/robots-could- use-3d-printing-build-mars-bases-astronauts-arrive.

[17] Bahar Gholipour, Staff Writer "3D printing on Mars could be key for Martian Colony" Space.com Oct 3,2013 "http://www.space.com/23059-3d-printing-mars-colony.html".

[18] Retrieved from NASA publication "Space Radioisotope Power Systems-MMRTG" Jan 2008.

[19] The publication from National Space Society "Space Solar Power" Oct 2007 http://www.nss.org/settlement/ssp

[20] The research paper "Mars life support systems" published in the International Journal of Mars Science and Exploration Open Access Jornals,2006.

[21] The Wikipedia article "Mars Oxygen ISRU Experiment "https://en.wikipedia.org/wiki/Mars_Oxygen_ISRU_Experiment.

[22] The article "The Great Man Made River" https://en.wikipedia.org/wiki/Great_Man-Made_River.

[23] The research paper "Silicon as a versatile player in plant and human biology: overlooked and poorly understood", https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4641902.

[24] Christopher P. McKay, Thomas R Meyer, Penelope J Boston, Mark Nelson, Taber Maccallum and Owen Gwynne, "Utilizing Martian resources for life support "http://www.uapress.arizona.edu/onlinebks/ResourcesNearEarth Space/esources29.pdf

[25] From Wikipedia the free encyclopaedia "Astronomy on Mars" http://en.wikipedia.org/wiki/Astronomy_on_Mars

[26] From Wikipedia the free encyclopaedia "Human mission to mars" http://en.wikipedia.org/wiki/Human_mission_to_Mars

[27] The article "NASA's Orion Flight Test and the Journey to Mars" https://www.nasa.gov/content/nasas-orion-flight-test-and-the- journey-to-mars

[28] From Wikipedia the free encyclopaedia "Fusion Rockets" http://en.wikipedia.org/wiki/Fusion_rockets

[29] From Wikipedia the free encyclopaedia "Antimatter Rockets" http://en.wikipedia.org/wiki/Antimatter rockets

[30] Ryan Whitwam, the article "NASA proposes building artificial magnetic field to restore Mars's atmosphere" on March 6, 2017, https://www.extremetech.com/extreme/245369-nasa-proposes-building-artificial-magnetic-field-restore-mars-atmosphere

[31] Lynn Margulis, Oona West, the research paper "Gaia and the Colonization of Mars" published in GSA Today on November 1993, http://il052-5173-3-11-sci.pdf

[32] From Wikipedia thefreeencyclopaedia"Cyanobacteria"http://en.wikipedia.org/wiki/Cyanobacteria

[33] From Wikipedia the free encyclopaedia "Planktons" http://en.wikipedia.org/wiki/Planktons

[34] Matthew Twombly, Chiquiesteban, NG Staff, the article "Would you go to Mars if you could never come back", sources: Bong Wie/IOWA state university, AMES, https://www.space.com/would-you-go-to-mars-if-you-would-never-come-back

[35] Mark Strauss, the article "Homeward Bound" http://news.nationalgeographic.com/3015/10/151002-mars-mission-nasa-return-space

[36] Richard Hollingham, the article "Bringing back a bit of mars"November,18,2014, http://www.bbc.com/future/story/20130104-brining-back-a-bit-of-mars

[37] The article "Fusion rocket able to go to mars and back in 30 days could be the to deep space travel" published by space.com on April,11,2013, http://www.huffingtonpost.com/2013/04/11/nuclear-fusion-rocket-mars-deep-space-travel_n_3059992.html

[38] Laurie J. Abadie, Charles W. Lloyd, Mark J. Shelhamer the article "Human body in Space", http://www.nasa.gov/hrp/bodyinspace

[39] James Griffiths "Mars simulation crew 'return to Earth' after 365 days in isolation" sources CNN, August 30,2016, http://edition.cnn.com/2016/08/28/health/mars-simulation--hawaii/index.html

[40] The article "How will the Mars mission physically affect the astronauts?" http://www.mars-one.com/faq/health-and-ethics/how-will-the-mars-mission-physically-affect-the-astronauts

[41] Ker Than, the article "Mutant disease may cripple missions to Mars, Beyond" sources National Geographic news, November 4,2009, http://news.nationalgeographic.com/news/2009/11/091104-space-diseases-mutants-mars.html