
THE 23RD ANNUAL INTERNATIONAL
MARS SOCIETY CONVENTION
RISING
TOGETHER
TO MARS
AROUND THE WORLD
VIA THE INTERNET ON OCTOBER 15-18-2020
THE MARS SOCIETY

"RISING TOGETHER"

The 23rd Annual International Mars Society Convention
October 15-18, 2020

An Online Virtual Event with the World's Top Mars Leaders and Experts

	Thursday October 15th, 2020
All Times PDT	**Morning Plenaries**
9:00 AM	Dr. Robert Zubrin, President, The Mars Society
9:30 AM	Dr. Chris McKay, NASA Ames, Prerequisites to Human Activity on Mars
10:00 AM	Dr. Carol Stoker, NASA Ames, Potential Habitats for Life on Mars
10:30 AM	Dr. Michael Hecht, PI, MOXIE, Mars Perseverance
11:00 AM	Dr. Abigail Fraeman, Deputy Project Scientist, Mars Curiosity
11:30 AM	Dr. Mark Panning, Project Scientist & Co-Investigator, Mars InSight
12:00 PM	Dr. Adrian Brown: Mars 2020 and Mars Sample Return
12:30 PM	Dr. Anna Yusupova, IBMP Russia: confinement experiments

	Afternoon Sessions			
	Tech A	**Tech B**	**Settlement A**	**Medical**
1:00 PM	TA-1 Romanko et a:l Oasis Mars Project	TB-1 Gilbert: Nuclear Fuel Cycle for Mars	SA-1 Bhuiyan: Mars City Design for 1,000,000	M-1 Kir: Medicine on Mars after 2050
1:30 PM	TA-2 Lee Roberts: Underwater Mars Habitats	TB-2 Nikitaev: Seeding H2 in NTP Engines	SA-2 Haeupli-Meusburger: Mars Science City	M-2 Gardiner: Towards Healthy Living on Mars in a Time of CV19 on Earth
2:00 PM	TA-3 Anastasia Prosina: Stellar Amenities	TB-3 Tan, Rezende et al Operations of a Power Station on Mars	SA-3 Jus Ad Astra: Human Rights as a foundation for a Mars Bill of rights	M-3 Jobin: Martian Mental Health

2:30 PM	TA-4 Pelc, Suscicka et al; Evolution of a Mars Colony	TB-4 Kumar, Sharma et al: Power Generation for Mars using CO2	SA-4 Mayes: Utopian Colonies on Mars	M-4 Lordos: Large Scale Space Settlements: A New Frontier for Space Psychology
3:00 PM	TA-5 Lebedev: Alternatives to drilling using war technology	TB-5 Kumar, Adlakha et al: Next Gen power for Martian life	SA-5 Calanchi: A cultural and ecological approach to Mars Colonization	M-5 Kommareddy and Rezende: Bone Density Stabilizer for Long Term Space Travel
3:30 PM	TA-6 Tompkins: GrowMars Expanding Loop Process	TB-6 Cooper: 2032 the first humans on Mars	SA-6 Gaviraghi et al: The Martian Urban Cell as the unit for Martian settlements	M-6 Wong, Wu, McEwan: Non-invasive biomonitor for human spaceflight
4:00 PM	TA-7 Rezende, Souza et al: Deploying Greenhouse facilities	TB-7 Saranya: Sanitation in a Mars Habitat	SA-7 Nebergall: Solar System Mini-Settlements in 2060	M-7 Radstake et al: In vitro models to unravel interplay of spaceflight stressors
4:30 PM	TA-8 Kacha, Sia: deployable Martian Habitat	TB-8 Isenberg: Areomorphology by Plasma Processes?	SA-8 Tellez et al: The preservation and coexistence of human colonies on Mars	M-8 Pelc et al: Hospital on the moon
	Break / Dinner Hour (5pm - 6pm)			

	Thursday Evening Programs
6:00 PM	Dr. Vandi Verma, Rover Driver - Mars Perseverance, Curiosity, Spirit, Opportunity
6:30 PM	Dr. Farah Alibay, Systems Engineer, Mars InSight - Engineering Perseverance
7:00 PM	Reid Stowe: Mars Ocean Analogs: Learning How to explore Mars at Sea
7:30 PM	Mars Desert Research Station Panel - Dr. Shannon Rupert & crewmembers
8:00 PM	
8:30 PM	Dr. John Grunsfeld, Astronauts Can Do Great Science
9:00 PM	University Rover Challenge Panel - Kevin Sloan
9:30 PM	
10:00 PM	Mars University Panel - Kolemann Lutz

	Friday October 16th
All Times PDT	**Morning Plenaries**
9:00 AM	Dr. S. Pete Worden, Breakthrough Initiatives
9:30 AM	Nick Booth & Elizabeth Howell, Co-Authors, Book: "The Search for Life on Mars" (2020)
10:00 AM	Dean Cheng, The Heritage Foundation, China in space
10:30 AM	Michael Griffin, Former Administrator, NASA
11:00 AM	Dr. Nathan Putzig, Exploring Mars with Ground-Penetrating Radar
11:30 AM	Dr. David Poston, Space Nuclear Power
12:00 PM	Rick Tumlinson, The Spaceflight Revolution
12:30 PM	Kelvin Manning, Associate Director, Kennedy Space Center

	Afternoon Sessions			
	Tech C	**Tech D**	**Settlement B**	**Outreach & Education**
1:00 PM	TC-1 Zlindra et al: UBC Mars Colony	TD-1 Matkowski: Simulation of Evacuation in Martian Conditions	SB-1 Sobocinski: Pawns on Mars	O-1 Melton: Spread the Word
1:30 PM	TC-2 Smith: SPORE: Resource Extraction and habitable space creation	TD-2 Chase: Psychological and Physiological implications of Settling Mars	SB-2 Nebergall: Paraterraforming Hebes Chasma	O-2 Charrek: The Mars Society Education and Outreach Team Focus
2:00 PM	TC-3 Pazar: Resource Utilization on Mars	TD-3 Doug Shull: Lunar lava Tubes Show the Way to Mars	SB-3 Gaviraghi: Mars Terraforming	O-3 Burk and Crossman: Marspedia.org - 2020 Progress Report & Tutorial Demo
2:30 PM	TC-4 Cadet et al: Mars, a buildable planet	TD-4 Green: Robotic Testing for Space Suit Joints	SB-4 Shankar et al: Launch Center on Mars	O-4
3:00 PM	TC-5 Singh and Shariq: Material properties of Martian concrete	TD-5 Lofqvist: Intelligent Swarms on Mars	SB-5 Pelc, Popiel et al: A State on Mars	O-5 Hoveee: Mars Society Chapters update
3:30 PM	TC-6	TD-6 Gurrea: Mars Direct v3	SB-6 Susciicka, Torchala et al: Evaluation of Mars Colonization opportunities	O-6
4:00 PM 4:30 PM	Elon Musk - Founder & CEO, SpaceX			

5:00 PM	TC-7 Prasad: Development of Mars launch facility Using CO2	TD-7 Purewal et al: Engineering on Mars	SB-7 Soni, Trabelsi et al: Postcards from Mars	O-7 Nan Li: Why Public Education of Mars Exploration?
5:30 PM	TC-8 Rezende, Shankar et al: Operation of the main station on Mars		SB-8 Bruce Mackenzie: Mars Settlement Study Group	O-8 Secosky: How to explore Mars without leaving your chair

All Times PDT	**Friday Evening Programs**
6:00 PM	Geoff Landis, Memories of MIP
6:30 PM	Taber MacCallum - Space Perspective
7:00 PM	Dr. Peter Diamandis, X Prize Foundation & Singularity University
7:30 PM	Search for Life on Mars Panel - McKay, Stoker, Abramovich, Willett
8:00 PM	
8:30 PM	Mongolian Aerospace Research and Science Association
9:00 PM	New Space Centers Panel: Aliya Grigg, Jarek Mika, Łukasz Wilczyński, Krzysztof Kacaliński
9:30 PM	

	Saturday October 17th
All Times PDT	**Morning Plenaries**
9:00 AM	Barbara Belvisi, Founder & CEO, Interstellar Lab
9:30 AM	Sarah Baatout, How to Protect Astronauts from Radiation
10:00 AM	Jim Bridenstine, NASA Administrator
10:30 AM	Dr. Alan Stern, Exploring Pluto and Beyond
11:00 AM	Loretta Hidalgo Whitesides, Founder, Yuri's Night
11:30 AM	George Whitesides, Virgin Galactic
12:00 PM	Angela Cui and China Panel
12:30 PM	

	Afternoon Sessions			
All Times PDT	**Tech E**	**Analog Bases**	**Political**	**Mars City State Contest**
1:00 PM	TE-1 Divay et al: Challenges of Food production on Mars	AB-1 Chase: Psychological and Physiological Implications of Settling Mars	P-1 Bellant: A Prize Fund to Get Humanity to Mars?	**Team 1** The Sustainable Offworld Network (SONet)
1:30 PM	TE-2 Tellez and unger: BioColchon Space Garden	AB-2 Marsh et al: Multi-National Design of Mars Missions	P-2 Heisler: The Space Force & the Human exploration and settlement of Mars	**Team 2** NAVARRO Remy
2:00 PM	TE-3 Toro et al: Aquaponics for food production on Mars	AB-3 Tymoszuk et al: Designing a rover for an analog mars mission	P-3 Harman: Liberty in Space: The Artemis Accords and the Rule of Law	**Team 3** Southern Cross Innovations
2:30 PM	TE-4 Rodriguez at al: Mead, as a drink for colonies on Mars	AB-4 Staats et al: High Fidelity Mars habitat simulation	P-4 Gilley: The Artemis Accords; Impacts on Martian Constitutions	**Team 4** Space Generation Advisory Council
3:00 PM	TE-5 Colorado et al: Bakery for Mars colonies based on microalgae	AB-5 Rezende et al: Space analog virtual training	P-5 Kulu: Factories in Space	**Team 5** Korolev Crater SAR
3:30 PM	TE-6 You and Zottola: Reducing Percholates in Martian Soil	AB-6 Romero et al: Construction of namoga research station in the Nambia desert	P-6 Hague: a metric of solar system development	**Team 6** Dr Muhammad Akbar Hussain

All Times PDT **4:00 PM**	TE-7 Nadeem et al: Proliferation and Survival Analysis of Rhizosphere Soil Bacteria in Mars Soil	AB-7 Romero et al: African participation in solar system exploration	P-7 Chairetis: All space to all	**Team 7** Paul Meillon
4:30 PM	TE-8 Gardiner and Isenberg: Comets at Mars	AB-8 Secosky: Marspedia's Mars Atlas: Your gateway to Mars	P-8	**Team 8** Phlegra Prime
5:00 PM	**Break / Dinner Hour (5pm - 6pm)**			**Team 9** Tharsians@USCViterbi
5:30 PM				**Team 10** Nexus Aurora

6:00 PM	**Saturday Evening Virtual Banquet**
6:30 PM	Oscar Castellino- We're halfway to Mars and other music
7:00 PM	Carter Emmart- Mars Multimedia
7:30 PM	Special guest speaker
8:00 PM	Special guest speaker
8:30 PM	Special guest speaker
9:00 PM	Dr. Robert Zubrin

	Sunday October 18th
All Times PDT	**Morning Plenaries**
9:00 AM	Dr. Sarah Milkovich, Lead Science Systems Engineer, Mars Perseverance
9:30 AM	Dr. R. Aileen Yingst, Mars Exploration Program Analysis Group & Planetary Science Institute
10:00 AM	J. Bob Balaram, Chief Engineer, Ingenuity (Mars copter), NASA
10:30 AM	Anastasiya Stepanova, Dry immersion experiment
11:00 AM	Yonatan Winetraub, Co-Founder, Space-IL
11:30 AM	Mars Society South Asia / Indian Rover Challenge
12:00 PM	Dr. Robert Zubrin, Closing Remarks
	End of Convention

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THURSDAY AFTERNOON SESSIONS

TECH A-1

THE OASIS ON MARS PROJECT CAN REACH MORE 1 MILLION PEOPLE ON MARS IN THIS CENTURY

VADYM ROMANKO, VLADIMIR VOROTNIKOV
RUSLANA KOLODNYTSKA, YAROSLAV YACHMENOV

KOROLYOV ZHYTOMYR MILITARY INSTITUTE

The Oasis on Mars project can reach more 1 million people on Mars in this century
The Oasis on Mars project envisages the creation of a huge comfortable and radiation safe living space on Mars and its regular growth. The project occupies an intermediate place between the idea of terraforming Mars and projects of life in tunnels in the rock. Most well-known projects offer life on Mars as the life of sailors in a cramped submarine with exits to work in a deep-sea suit. According to the project, industrial nuclear reactors are being delivered to the glaciers of Mars from Earth. Almost all the thermal energy of the reactors is not lost, as on Earth, but is used to create living spaces on Mars. They are the basis for the creation of various ecosystems. The basis of the project is the technology of melting wide tunnels which become inhabited spaces. At the rate of 1 million cubic meters of ice per person, more than 1 billion people can live in the northern polar cap of Mars alone.

The water that is formed during the melting of the tunnels is used for 3D printing of huge cones well protected from cosmic radiation cones above the surface of the glacier. The walls of giant cones are formed of tunnels. Cone tunnels are printed using the same technology and using the same equipment as the glacier tunnels.

The use of ice melting technologies, its transportation in the form of water through pipelines and 3D printing of cones from water allow to simplify the construction process as much as possible. In addition, permanently operating reactors require constant construction and growth of the colony space.

In our opinion, the technology of creating oases on Mars, the only technology that allows us to colonize Mars, and reach a population of more than 1 million people in this century.

TECH A-2

UNDERWATER MARS HABITATS

LEE ROBERTS

EXHELIOS CORPORATION

Locating Mars habitats underwater offers several significant advantages. One atmosphere of pressure can be maintained with reduced structural stress while allowing for cuboid architecture due to minimal differential pressure. In addition to providing a heat sink for thermal regulation, adequate depths of water provide substantial shielding against GCR and solar charged particles. A large-enough body of water will also provide a habitat for agricultural production of marine life and aquatic crops. Liquid water rarely exists on the martian surface because the pressure is slightly below water's triple point, the minimum pressure required for a substance to exist in liquid form. Water harvested from regolith can be stored in liquid form by maintaining its pressure above the triple point. This can be accomplished by pooling water in reservoirs formed from existing craters covered by transparent membranes that maintain a small cap pressure on the water's surface and prevent boil off.

TECH A-3

THE FUTURE OF LIVING IN SPACE

ANASTASIA PROSINA

STELLAR AMENITIES

The time when space exploration was only a matter of government has ended. In the past few years, a number of private space companies have skyrocketed. Elon Musk claims that the first manned crew to Mars will happen in 2024 whereas NASA plans to send humans to the same destination in the middle of the 2030s.

There is a lot of interest expressed on how we will get there, yet no particular plans on HOW we will sustain our presence in the severe environment. Yet, NASA estimated that the crew behavioral health is a secondary risk in manned space missions after radiation exposure. Human factor considerations increase with the longevity of missions, in particular, their application to where future travelers will be living to support the wellbeing of the crew in an enclosed environment.

What does the future of living in space look like? Is it going to look like the promise of sci-fi movies? Or somewhat different?

Join Anastasia Prosina for a peek at what aspects need to be habitable modules to thrive in long-duration missions to Mars.

TECH A-4

EVOLUTION OF MARS COLONY ON THE EXAMPLE OF DESIGNED BASE PER 1000 INHABITANTS

JUSTYNA PELC, BEATA SUŚCICKA
PIOTR TORCHAŁA, MAGDALENA ŁABOWSKA

WROCLAW UNIVERSITY OF SCIENCE AND TECHNOLOGY

Evolution of Mars colony on the example of designed base per 1000 inhabitants
About 50 years after landing on the moon, man is going to take another step forward in the direction of the space exploration - the colonization of Mars. However, this is a very expensive undertaking requiring the use of highly advanced technology, because in addition to the transport from the Earth to Mars, it is still necessary to create a properly adapted base, which will allow man to survive and provide conditions for maintaining life, different from those currently prevailing on Mars. In order to minimize the financial outlay, the best solution is to create a self-sufficient base as soon as possible, which provides for the production of food, as well as sourcing and processing of raw materials available on Mars using high automation. In order to design the base properly, an urban, architectural and logistical analysis should be carried out in order to optimize paths and minimize human exposure to the external environment. On the basis of the Ideacity project, the concept of the base for 1000 people will be discussed, along with the evolution of its development to achieve self-sufficiency. The concepts discussed will be the ways of distribution of functional buildings, transport possibilities, taking into account the fact that part of the base is located underground and part on the surface of Mars. The aim of this paper is to present the concept of creating a self-sufficient martian base for 1000 people, together with an analysis of its evolution from the first astronauts through subsequent stages, and to present the most important functions leading to financial independence.

TECH A-5

THE ALTERNATIVES TO DRILLING ON MARS AND SOLID PLANETS: USING WAR TECHNOLOGIES FOR PEACEFUL EXPLORATION

NIKOLAI LEBEDEV

MOSCOW INSTITUTE OF PHYSICS AND TECHNOLOGY

The majority of modern concepts of the Martian colonies involve the use of drilling to protect the settlers from the solar radiation, dust and meteorites. The underground SETTLEMENTs are using tunnels for communication and transportation.

But is drilling on Mars a cheap and easy solution for settlers?
The Boring Company estimates the cost of drilling on Earth between $100 million and $1 billion per mile, promising to reduce it more than 10 times. Still the cost is going to be much higher as it requires new robots and machinery for drilling in Martian conditions. These machinery needs to be designed, constructed and transported to Mars. The cost of the transportation should be about 500$ per kilogram, with the typical weight of TBM ~100 tons. The alternative way is to use Martian lava tubes and other natural geological forms, but these landforms are tied to specific rocky regions limited in water.
Instead, one can use the ballistics and physics to make a precise shot with the penetrative warheads, accelerated by the gravitational maneuver. This technology will let us make deep holes in the soil in desired places anywhere on the surface of Mars and provide the settlers with the high temperature compound which appears after collision. This material can later be used for construction and radiation protection. Varying the type and the size of warhead results in holes of different diameter for various purposes. One missile sent to Mars can carry a pack of warheads, making the desired set of holes for future buildings.
The whole process is going to be unmanned and fully automatic, much cheaper than traditional drilling methods and provide the settlers with the shelter immediately after their arrival.

TECH A-6

GROWMARS EXPANDING LOOP PROCESS

DANIEL TOMPKINS

GROWMARS

To enable new possibilities of sustainable space exploration and to ensure mission success we propose a concept to integrate photosynthetic biological growth utilizing in-situ materials and in-situ bioderived plastic. The integration of both remains unexplored and undemonstrated in the context of a space application, in particular from a detailed balance of plant. Compared with traditional biological closed loop system design, the integration of biological life support with the production of building material is a critical keystone technology between the two well-known areas of study and practice. The material output of the process, bioderived clear plastic, enables more photosynthetic biological growth. The synergistic and exponential benefits could be profound for space exploration with essentially a seed system that expands in output capacity and function, ultimately to increase mission success and/or ensure human survival.

In the context of a deep space exploration mission, the proposed concept of an Expanding Loop Process (ELP) leverages the integration of biological growth with manufacturing. Three deep space exploration mission categories include human, biological studies, and robotic operations as outlined below are applicable to Moon, Mars, Venus and other locations where CO_2 and H20 can be extracted or derived from in-situ materials.

TECH A-7

PROPOSAL OF NOVEL APPROACH IN DEPLOYING GREENHOUSE FACILITIES FOR LIFE SUPPORT AND FOOD PRODUCTION ON MARS

JULIO REZENDE, DAVI SOUZA
SAI KIRAN PARRE, JAS PUREWAL

HABITAT MARTE

Long term exploration missions in deep space require the development of regenerative and reliable systems to work even in critical situations. Among several situations to be considered in future SETTLEMENTs in Mars, mission control still need to fill the gap between astronauts' health and the technologies to supply food demand. With Controlled Environment Agriculture (CEA) systems and automation, it is possible to build a self-sustainable and resilient habitat on Mars surface and assist in crew performance to achieve mission goals, allowing in situ food production, optimizing resource usage, and regeneration of organic waste. This motivated the development of a greenhouse concept with one big challenge: find an innovative approach to integrating life support systems, bio-regenerative, and environmental control technologies. The design combine the use of integrated farming tech associated with habitat's support protocols, since the implantation of the environment until reducing the demand for terrestrial supplies and achieving sustainability. Therefore, a detailed review will be done in Space mission planning to propose a new perception for the transportation of resources and life-supporting systems to Mars in three stages: launching, In-space manufacturing, and deployment of the structures on Mars, in the most economical and efficient way possible.

TECH A-8

DEPLOYABLE AI MARTIAN HABITAT

AASTHA KACHA

MARS SOCIETY OF CANADA

Manned mission to Mars is of a particular case of space missions due to its long-term duration. A human factor becomes here as important as technological problems are. The extreme Martian conditions requires a specific architectural design. The objective of this Investigation is to acknowledge the possibility of landing our feet on Martian soil and raise generations by fulfilling the primary need of shelter. Comprehensive analysis of this problem has been performed in the treatise by employing Artificial Intelligence, Computational geometry and deployable mechanism to design Deployable Martian Habitat, that can be used as a primary shelter.

Distinct Origami and correlation to Inflatable structure is used as the basic principal to study different deployable methods, to calculate the density, area, mass and weight in both flat and deployed state of the structure. One of the key information adopted as the base of the design standards, is from NASA Integration Design Handbook. Physical and psychological comfort of the extraterrestrial base inhabitants can be significantly enhanced by proper architectural design. Various challenges to inhabit Mars have been taken into consideration and as a result an architectural concept has been proposed. Artificial Intelligent software “Rhino Grasshopper” has been used to form algorithms and to calculate geometry, to achieve explicit deployable predictability and enabling robust structural performance after deployment. An integrated study of building technology, structural and mechanical components, ECLSS and various other stipulations for a constructive deployable Martian habitat has been proposed.

TECH B-1

ESTABLISHING A NUCLEAR FUEL CYCLE FOR MARS EXPLORATION AND SETTLEMENT

ALEXANDER GILBERT

PAYNE INSTITUTE, COLORADO SCHOOL OF MINES

The unique characteristics of nuclear power – energy density, reliability, co-production – make it an ideal energy source to support Martian exploration and settlement. This presentation evaluates the technical and policy issues related to initial and large-scale use of nuclear power on Mars. It reviews current, near, and far future technologies, from RTGs and Kilopower to thorium and fusion. Nuclear power can provide heat, electricity, hydrogen, and other energy services for visitors. The prospective availability of nuclear fuels is discussed, as are the comparative advantages of indigenous production versus imports. Recent progress in additive manufacturing (3D printing) for nuclear reactor cores and parts is evaluated to determine their application to Martian production.

There are also major policy and governance challenges. Nuclear power sources require decommissioning, waste storage, and potentially reprocessing. Near-term use by governments and private entities raise different governance and liability concerns. Martian nuclear power also presents unique concerns related to clandestine nuclear weapons proliferation. Ongoing regulatory and policy reforms to support space nuclear power provide a framework for future use on Mars.

TECH B-2

SEEDING HYDROGEN IN NUCLEAR THERMAL PROPULSION ENGINES

DENNIS NIKITAEV, DR. L. DALE THOMAS

UNIVERSITY OF ALABAMA IN HUNTSVILLE

Using the NASA Design Reference Architecture, Nuclear Thermal Propulsion engine and Mars transfer vehicle models were developed to numerically examine the effects of adding heavy noble gases into the hydrogen propellant stream (seeding) on round trip transit times (baseline of 357 days). Seeded hydrogen, up to maximum seed mass concentration (MSMC) 55.85%, increased engine and vehicle performance by reducing pressure losses, decreasing reactor power, and increasing the overall change in velocity while assuming constant vehicle volume and dry mass. The tradeoff was lowered specific impulse and increased net propellant mass, resulting in increased vehicle wetted mass. Vehicle performance increased at MSMC and provided a best case 32-day reduction in transit time vs. pure hydrogen. Vehicle performance was comparable to densified pure hydrogen at 30% seed mass concentration. When taken in combination with densified hydrogen, vehicle performance increased further by providing a 41-day reduction in transit time at MSMC.

TECH B-3

EXPLORING THE SUSTAINABILITY OF OPERATIONS OF A POWER GENERATION FACILITY ON MARS

ARVIN JOSEFF TAN, JULIO REZENDE, PHD, DAVI SOUZA

HABITAT MARTE

Literature on the technologies that enable Mars missions are numerous. However, the operations and maintenance of these technologies will also need to be addressed. As sustainability is a major consideration for any future crewed Mars mission, we attempt to explore the sustainability of operations and maintenance of a Martian facility. This research is the result of a virtual simulation mission conducted in the space analog station Habitat Marte in Brazil on July 11-17, 2020. As part of the simulation, we propose a scenario wherein a crew is stranded inside the power station facility during a week-long dust storm. In this example, we assume a two- to four- person crew will need to manage an energy matrix system, interchanging different energy sources such as solar, nuclear and bio-regenerative sources. We identify necessary technologies for constructing and supporting this facility. The ideal crew size for operations and maintenance is also evaluated, along with the necessary quantity of resources to support this crew. We emphasize that the adequacy of such small crew size heavily depends on a highly automated operations system. Even so, the availability and sustainability of life-support systems on the power station will need to be implemented to ease the life-support burden on other facilities and to support emergency situations, such as isolation during dust storms. In-situ and imported sourcing of materials are identified. Activities, functionalities, and workload are explored and defined with regards to the power station operations. We also explore the possible benefits of the findings of this simulation to the sustainability of related operations in other facilities within the habitat and on Earth. The work reported here improves upon previous knowledge by emphasizing the human factor and effects on humans of the regular operation of a Martian power station facility.

TECH B-4

ADVANCED POWER GENERATION SYSTEM FOR COLONIZATION OF MARS USING ATMOSPHERIC CARBON DIOXIDE.

RAMESH KUMAR, PRASHANT SHARMA, SHIVAM CHAUDHARY

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

As we plan to make Mars habitable, the first step for establishment of any kind of facilities over there is to create a power source capable of operating under Martian conditions. In order to tackle this problem we intend to design a power plant for Mars based on the concept of closed supercritical carbon dioxide Brayton cycle , as we know there is high concentration of CO_2 present in the Martian atmosphere (nearly 95%) thus this abundance of CO_2 will be advantageous for the sCO_2 Brayton cycle, which can be applied to a miniature nuclear fission reactor which will provide enough heat to heat up carbon dioxide above its critical temperature.

Carbon dioxide having low values of critical pressure makes it easy to compress it directly into supercritical state and to heat it up before expansion. Also, the efficiency of cycles depends on the temperature difference between the source and sink. The density of sCO_2 is high so it makes the entire turbomachinery system small thus making the plant easy to carry to Mars.

We plan to design the power plant in accordance with the Martian atmosphere in this paper.

TECH B-5

NEXT-GEN POWER GENERATION SOLUTION FOR MARTIAN LIFE

RAMESH KUMAR, PARAS ADLAKHA
HITESH DHAWAN, AAYUSHI BOHREY

DEPARTMENT OF AEROSPACE ENGINEERING, PETROLEUM AND ENERGY STUDIES DEHRADUN INDIA

The Martian environment experiences an abundance in the amount of Co2 as well as solar energy. This availability of the aforementioned resources paves the way for a new era of power generation. Scope of this paper covers the generation of power at the Martian atmosphere for supporting life with minimum cost, more weight to power ratio, higher efficiency and being environment friendly. The supercritical CO2 (S-Co2) Brayton cycle has recently been gaining a lot of attention due to its compactness, efficiency and being environment friendly for the next generation solar power. Supercritical Co2 Brayton cycle will absorb heat through direct solar plate and rise the temperature of Co2 gas. Which ultimately reaches the supercritical temperature of Co2 (304 K). Due to the property of Co2, gas near the supercritical regime will have a higher density as compared to normal gas and it will take very less amount of work. Further, the increase in temperature will improve the net work done by the plant. As compared to normal Bryton cycle, size of the plant is reduced by more than 50% hence making it economical.

Against the backdrop of energy conservation and emission reduction, the development of power generation technology has always been focusing on higher efficiency with lower cost, whereas using renewable energy source or abundant heat is one of the solutions. Since solar energy is readily available at mars, will give an exhaustive solution to the power generation need as compared to any other power source.

The sCo2 Brayton cycle utilizing solar power gives a unique cost-effective solution for Martian life in future. This paper mainly focuses on the overall system optimization from receiving solar heat to generating power.

TECH B-6

2032 THE FIRST HUMANS ON MARS, FROM DESIGN TO EXECUTION

MIGUEL COOPER

FREELANCE

This paper starts with the concept of the Mission, its structure, its timetable, and the different milestones that take place to reach the objective.

The initial architecture of the Mars Camp consists of three elements: the Marslab, the greenhouse and the Mars Rover, later two additional modules will be added.

Besides the physical wellbeing of the crew, the Psychological health is a key issue as they will visually loose contact with earth as well as communication due to the time delay, up to this day all Human Space travelers have been able to look at the Earth, their home, and to keep contact with it, this took me to another important issue, Mission Control, the crew will have to be their own Mission Control they must be able to take de appropriate decisions in time, most of the time without the Earth intervention.

Communications will be essential between the Vehicle in Mars Orbit and the Lander, in my concept the orbiter becomes the MCC for the lander, so it is important to have real data communications all times, not only when an orbital path passes over the landing site, this took me to the necessity of having a Martian communications network with three satellites. I considered also the Training of the Crew to simulate the whole experience, the preparation of the vehicle, the different tests of all the elements and a complete journey; he arrival of the components to assemble the Martian Camp, supplies, and many other issues. Not less important is the quarantine the crew must follow after their return and the handling of the Mars Samples.

I tried to create a conceptual design of the whole project, with international participation and beginning now to reach Mars by 2031.

TECH B-7

FUNCTIONAL SOLUTIONS FOR SANITATION IN A MARS HABITAT

RAVVA SARANYA

VNRVJIET, HYDERABAD, INDIA

For Human Exploration to be feasible on an inter-planetary mission, one of the major criteria is to manage the life support system. Waste management, Atmosphere Maintenance, Personal Hygiene are the key elements of a sanitation center. To transform and extract value from human waste using various technological approaches, including combustion, supercritical water oxidation and pyrolysis is very much encouraged as the resources are limited. Sustainable Sanitation acts as a catalyst for development where in waste can be converted into bio-gas, protein rich minerals, fertilizers and the recent experiment on ISS states that a water-filled garment can protect astronauts during interplanetary missions by acting as a cosmic radiation field. Atmosphere management by maintaining oxygen level, removal of carbon dioxide, maintenance of Pressure, humidity, temperature, HVAC (Heating, Ventilation and Air Conditioning), Maintenance of Indoor air quality with the left of HEPA (High efficiency Particulate air) filters and Air purifiers is very essential. Every entrance of the habitat must be equipped with an Airlock. On Mars, Dust management is one of the key issues and Spacesuits are to be made using Nanotechnology solutions for self-cleaning by dirt and water-repellent coatings which can be prone to dust accumulation. For food production, usage of Hydroponics and Aquaponics can be highly beneficial. Looking into employing some ingenious methods to plant crops on Mars (using biomass and bio-gas) can make the habitat more sustainable. Smart Sanitation using sensors can be used for molecular characterizations of waste, then to transmit and analyze the need for maintenance, repair, cleaning and waste collection throughout the habitat. By following strict sanitation protocols in every center helps in the proper functioning of the Mars habitat.

SETTLEMENT A-1

MARS CITY STATE DESIGN FOR 1,000,000 POPULATION: AN INTEGRATED MODEL-BASED APPROACH TOWARDS MARTIAN SETTLEMENTS

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Mars used to be “God of War " since ancient Roman civilization but in Bengali language planet Mars means “মঙ্গল গ্রহ” or “Peace Planet " which implies things have changed and wheel of future history will be different as we voyage around the universe. In this paper, we have designed city states on Mars for 1 million population. An integrated model-based approach can play a major role in designing intelligent and self-sustaining city states on Mars. Based on our research findings on the Hawaiian Islands and the greater Himalayan regions, we understand that an optimization-simulation-ArcGIS-GoogleEarthPro based methodology can be useful for Martian SETTLEMENTs e.g. resource allocation, technology designs, governance, workforce development etc.
Some important features of Mars City States are:
1. If one leader can manage/coordinate 1000 people, then 1000 leaders will be required,
2. Potential locations: Mount Olympus, near the ice caps and craters e.g. Jezero crater, Vallis Marinaris etc.,
3. City State#1 Olympus Town will include: I. Gateway, II. Living habitats, III. Time Capsule, IV. Greenhouses, V. Quarantine Habs, VI. Earth museum, VII. Observatories, VIII. Health Units, IX. Manufacturing warehouses etc.

Moreover, we propose various innovative strategies e.g. Mars Exploration and Governance Assessment (MEGA) Tools, analyzing human factors vs. robots, sanity agreement among the nations, culture and workforce development, aesthetics and equations etc. With proper guidelines and protocols, we envision our unique Martian city states will create an outstanding example for the entire solar system by ensuring equality, transparency and growth patterns for every citizen on Mars. In addition, Mars Citizenhubs will act as a portal for interplanetary communication and further expansion of human civilization from Earth to Mars and then towards interstellar journeys.

Keywords : মঙ্গলগ্রহ, integrated model, human factors vs. robots, resource allocation, MEGA tools, time capsule, aesthetics and equations, interplanetary communications.

SETTLEMENT A-2

MARS SCIENCE CITY – ENVISIONING A SETTLEMENT ON THE RED PLANET

SANDRA HAEUPLIK-MEUSBURGER

VIENNA UNIVERSITY OF TECHNOLOGY

The Mars Science City is the long-term vision to build a human settlement on Mars within the next 100 years. In the frame of the 2020 Mars Science City design studio at the Vienna University of Technology, master students have developed hypothetical scenarios for a future prototypical scientific city and further elaborated one part in detail. The studio was supported by several space experts and space related entities that have accompanied the studio with theme-specific lectures and workshops. Relevant themes included in the architectural design are: versatility and flexibility of space, Life cycle and renewable materials, power, food and water cycle, climate and energy design, construction phases and adaptation, as well as culture and heritage among others. The main part of the paper discusses the different typologies of SETTLEMENTs that have been developed for the concept of a scientific city on Mars. Selected projects are detailed through plans, sections, and diagrams.

SETTLEMENT A-3

THE BEST OF BOTH WORLDS: HUMAN RIGHTS AS A FOUNDATION FOR A MARS BILL OF RIGHTS

HAYDEN PENDERGRASS, JONATHAN LIM

JUS AD ASTRA

The Best of Both Worlds: Human Rights as a foundation for a Mars Bill of Rights
The inherent, inalienable, and universal attributes of human rights provide a coherent and foundational legal basis for the advancement of permanent human SETTLEMENTs on Mars - achieving social harmony, stability, and prosperity through the rule of law (ROL). ROL represents the basic concept that both governments and citizens A) Know the law; and B) Express the willingness to obey it equally - forming the social contract upon which human communities and societies can be organized, created, and governed with fairness and impartiality.

Across the wider space community, debate abounds surrounding the need for a Bill of Rights in governing anticipated human colonies on the Lunar and Martian surface – exploring liberty and freedom as essential human elements within proposed provisions guaranteeing freedom of speech, freedom of assembly, the right to a fair trial, and the right to transportation to earth. Leading technologists including Elon Musk have also contributed their views on potential political systems and governance structures, including the need for a direct democracy.

Looking into the future, ROL is central to the maintenance of social stability, order, and good governance across isolated human communities spread across the final frontier, where each decision may have a disproportionate and irrevocable effect on the survivability and unity of the community. In avoiding conflict, social stratification, and social unrest the importance of the ROL, based upon human rights, underpins the maintenance of peace and stability.

The international human rights law framework offers a multitude of benefits conducive to the advancement of prolonged human habitation and activities in outer space – including the lasting transference of universal values and ethical practices, the implementation of good governance principles, checks and balances on the use of government power, the independence of the judiciary, the presumption of innocence, access to justice, and the right to a fair trial.

SETTLEMENT A-4

UTOPIAN COLONIES ON MARS

IAN MAYES

RADICALS, ANARCHISTS AND UTOPIAN THINKERS WORLDWIDE

24 years after Christopher Columbus “discovered” North America for the Europeans, Thomas Moore wrote his renowned book ‘Utopia’ that envisioned a radically new and different society in this New World. This subsequently brought this word and concept of “utopia” into English parlance. About a hundred years after that, a group of Puritan Separatists founded the Plymouth Colony in this New World in an attempt to live out their beliefs as they saw fit, away from the interferences and restrictions of the societies that they came from. As the possibility of people living on the “New World” of Mars becomes increasingly likely, the door is similarly opened for envisioning new ways that groups of people can move out there to actualize their beliefs in new societies, free from terrestrial interferences.

In this workshop session I would like for us to take the time to envision what these new utopian colonies on Mars can be like, from social, cultural and political perspectives. I will be drawing from my own experiences with both the world of intentional communities, as well as from the world of radical political thought, to give some broad outlines as to how such utopian colonies on Mars could look like. I would also like to open up the space to hear from others about their thoughts on how new utopian colonies can be organized.

To quote Albert Einstein, "We cannot solve our problems with the same thinking we used when we created them." The time has come for some new thinking about our social structures! The time has come for some Martian thinking!

SETTLEMENT A-5

A CULTURAL AND ECOLOGICAL APPROACH TO MARS COLONIZATION

ALESSANDRA CALANCHI

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Mars colonization started much earlier than we think. Like any other colonization of the past, it began in the human imagination and SF fiction. Nevertheless, this colonization is happening now in the real world, and differently from the past it has a worldwide mass media coverage. We are now having several missions involving Mars and several countries in the world, Europe included, are actively participating in this space race. While literature and cinema have prepared generations of readers and spectators for any kind of extra-terrestrial invasions, the hard sciences have gradually built up the technology necessary to explore the outer space and to take the first steps on alien lands, and are now joining forces with the soft sciences in order to design human missions with the double aim of giving the Earth a new possibility while – obviously – making big money.

Of course, the risk of repeating the same errors of the past does exist. While our planet is being destroyed by environmental crises, overpopulation, and natural catastrophes enhanced by human intervention (pandemics included), we plan to terraform Mars, to extract mineral and gas resources, and ultimately to create human SETTLEMENTs, with no guarantees that the investors of today and settlers of tomorrow will show more respect to the environment than we have granted our own home-planet so far.

In this scenario, new economies are emerging which ought to take ethical and ecological issues into consideration in order to avoid inequalities and reproduce the failures of the past. I therefore do believe in the necessity of interdisciplinary approach and a common agenda that implies equality, sustainability, and respect for the environment and geo (Mars)-biodiversity, with a little help from literature, philosophy, and cultural studies.

SETTLEMENT A-6

THE MARTIAN URBAN CELL AS THE BASIC PLANNING UNIT OF BASES AND MARTIAN SETTLEMENTS

GIORGIO GAVIRAGHI, SERGIO DE PAULOI, STUDIO GAVIRAGHI

UFMT UNIVERSIDADE FEDERAL DO MATO GROSSO

The Martian Urban Cell (MUC) is a basic planning unit for martian SETTLEMENTs of any size that must be a functionally self-sufficient core.

The MUC must represent the basic component of Mars planning that can be isolated or in clusters and must be totally self-sufficient, modular, multifunctional or specialized, but always with a terminal a connection to a transportation grid system, above, below ground or in space. The planned population for urban cells may range from under 100 to over 10Kpeople Analyzing expansion possibilities of martian SETTLEMENTs, above ground the linear, concentric and the rhizomatic patterns , the latter appear to be the recommended one due to its flexibility and expansion possibilities, while the underground settlement may better be served by a concentric system reducing underground excavated areas with easy and compact expansion possibilities.
The MUC would be composed of above and underground facilities, including the vertical hab that will connect all areas. MUC are composed of different main components with common facilities for general functioning and specialized ones for SETTLEMENTs with specific scopes (mining, water collection etc.) they can be summarized as follows:

- Above ground facilities (SAU or surface access units, rover workshop, laboratories, storage, agricultural, mineral processing and manufacturing buildings. and connectors
- Underground facilities, connectors and vertical hab including offices, labs, health care, schools, services and residences, gardens and plazas.
- All facilities will have expansion capabilities, including the vertical hab connecting them all to a transportation termina part of the TransMars network, also described here.
- Spaceport and terminals must be considered partially underground and above ground for ease of connections with the MUC.

Each vertical hab must have an exclusive interior and landscape design to allow easy identification and to represent a particular MUC.

SETTLEMENT A-7

SOLAR SYSTEM LOGISTIC MINI-SETTLEMENTS IN 2060

KENT NEBERGALL

MACROINVENT.COM

Any solar system economy begins with human health requirements, juxtaposed with the specific challenges of deep space. These anchor points suggest the design of an affordable permanent habitat/transport/settlement system with minimal mass and maximum customization. As with the highly flexible design of SpaceX Starship, a micro-settlement for deep space and low gravity surface use is a logical next step. It closes the gaps in Starship capacity and provides the bases from which the Starship and succeeding designs can operate across the inner solar system. These bases would also be modular to allow easy expansion, safety redundancy, and “mitosis” where appropriate.

Each module would contain at least two counter-rotating centrifuge rings with cosmic ray shielding. The core would contain low gravity storage, processing and docking equipment. Tethers, skyhooks, linear accelerators, and other propellant-free methods can be optional additions. A Low Earth Orbit version would shield a starship refueling facility from orbital debris. A Lagrange version would be a marshaling ground for fleets en route to Mars and other destinations, with or without a cycler of a similar design. Other versions could operate as independent settlements in the asteroid belt. A surface version for the Moon or Mars could compensate for lower gravity where the ecosystem or industry required higher gravity levels. Using a common design in many locations will allow economies of scale and open the entire inner solar system to human habitation. Other purposes include exoplanet ecosystem simulators, epigenetic driver laboratories, and terraforming transitional ecosystems.

SETTLEMENT A-8

INTEGRATION OF COMPONENTS FOR THE PRESERVATION AND COEXISTENCE OF HUMAN COLONIES ON MARS

ARNULFO TELLEZ, GERMÁN SARMIENTO
HOLLMAN PIÑEROS, SANDRA MENDOZA

THE MARS SOCIETY CHAPTER COLOMBIA

The objects of analysis of the research team, of an environment of spatial experience, are the elements that allow:

- generation of life - human species and avoiding the extinction of the species (kinship);
- preserving the energy balance of a system and avoiding its deterioration or destruction (health);
- integration of components to adapt, conserve and reconstitute the energy of a being (maintenance);
- combination of components to group, associate people or institutions (loyalty);
- mix of aspects for rest and compensation for fatigue generated by other systems (recreation);
- merger of matters for the circulation of information (communication);
- articulation of facilitating pieces for learning and the operation and use of collective areas (education);
- recognition of aspects for the transfer of possession, accumulation of goods, values or produced tools (patrimony);
- integration of issues that contribute to the extraction, multiplication, adaptation of materials, services or supplies (production);
- elements that contribute to the dimension of transcendence (religious);
- aspects that seek to face threats to a system and guarantee its tranquility (security);
- establishment of personal or collective goals from planning and organization (political-administrative);
- integration of aspects that regulate coexistence (legal);
- and, matters that help the classification, ranking, and valuation of subsystems according to criteria (precedence)

From the 14 subsystems (kinship, health, maintenance, loyalty-solidarity, recreation, communication-transportation, education, heritage, production, transcendence, security, political-administrative, legal, merit-ranking), the needs, aspirations and proposals are characterized They must allow the levels of development of both the subjects, groups and societies. Now, from that global understanding, on the one hand, some projects are being developed aimed at the materialization of sustainable space SETTLEMENTs, and on the other hand, the global perspective is socialized to academic communities, researchers, teachers, students and the general public.

MEDICAL-1

MEDICINE ON MARS AFTER 2050

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Major challenges after establishing a permanent human colony on Mars will include long-term ability to maintain and propagate human life. Successful adaptation of humans to low gravity, high radiation, and low air pressure, will depend on fusion of highly advanced systems technology and science-based medicine. This level of self-sufficient and self-operating life and MEDICAL systems functioning independently on Mars will be necessary to maintain normal human life on Mars after 2050. Highly advanced and individualized MEDICAL monitoring devices, including wearable, implantable, or built into the individual's microenvironment, will continuously monitor multiple physiological, biochemical, and behavioral variables, and location. Using highly sophisticated algorithms and machine-learning processes, the system will be able to produce specific responses to individual patients, including alerting patients as necessary, reminding to take medicine, advising on healthy lifestyle and positive thinking. The main focus will be disease prevention rather than disease treatment. Artificial intelligence systems will analyze patterns and trends, producing highly personalized information. This information will be combined with biomedical and population data to advise decision making whenever required. Automated decision-support systems will ensure that patients will receive optimal MEDICAL care, involving disease prevention, diagnosis, treatment and management, including invasive and surgical procedures. Application of artificial intelligence based MEDICAL avatars and robotics will be essential. The role of MEDICAL professionals will change from traditional direct physical interaction of MEDICAL doctors with their patients to more monitoring roles, overseeing general effectiveness and direction of patient care. Future MEDICAL professionals will become highly knowledgeable biomedical scientists, developing new biomedical methods, utilizing nanotechnology and advanced genetic technology. To successfully sustain human life on Mars in the future, advanced MEDICAL and genetic technology will be required to make the future generations to adapt to low gravity, high radiation, and low air pressure.

MEDICAL-2

TOWARD HEALTHY LIVING ON MARS IN A TIME OF COVID-19 ON EARTH

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In Mars Society talks each year since 2014, we have presented the case for developing the opportunity for healthy outcomes from our exploration class missions to Mars by applying major changes to the food and diet before, during, and after our missions. As we move into planning for actual analog Mars missions on Earth, we must now look at applying other lessons from dietary changes. Principle among these are time-restricted feeding, whether on an intermittent daily basis, periodic daily fasting of variable duration, or extended less frequent fasts. Both studies and widespread voluntary efforts indicate the benefits of low carbohydrate, high fat, and moderate protein intake diets (also known as “ketogenic diets”) are significantly enhanced by time restricted feeding. Such measures in total or in part have been proven to reduce the occurrence of metabolic syndrome disorders among adherents. Surveys of the pandemic statistics show these major co-morbid disorders are strongly associated with the infection rate and lethality of the Covid-19 coronavirus to varying degrees in different age cohorts. We describe the enzymatic and biochemical processes that assure the continuity of health by the application of these kinds of dietary changes. What their application implies for improved resistance to disease vectors of all sorts and to chemical, radiation, and physical stressors is presented.

MEDICAL-3

MARTIAN MENTAL HEALTH: HOW COVID-19 ACCIDENTALLY INVENTED INTERPLANETARY THERAPY

JIM JOBIN

NEVADA COUNSELING ASSOCIATION

In his cosmic quest man's greatest asset - and greatest liability - is his mind. While physics and biology can teach us how to keep people alive en route to and on Mars, psychology can only guess at how to keep people sane. During the quarantine of 2020 psychotherapists were forced to use telehealth technology to do the delicate interpersonal work of therapy. This presentation adapts the lessons Nevada's top doc learned doing therapy with patients trapped in their homes and surrounded by uncertainty into solutions for treating astronauts far from home.

MEDICAL-4

LARGE-SCALE SPACE SETTLEMENTS: A NEW FRONTIER FOR SPACE PSYCHOLOGY?

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The discipline of Space Psychology has always played an important role in ensuring the success of space missions, through contributions of Organizational and Clinical Psychology to optimizing performance and preventing mental health problems in space. However, it is doubtful whether legacy approaches will suffice, in the transition from small-team, duration-restricted, Earth-directed missions, to building large, multi-generational and increasingly autonomous communities in Space. The objective of this study is to develop initial guidance on the scope and content of a new Space Psychology, which could support the establishment of large space settlements.

Anticipated challenges of large-scale space settlements were cataloged through thematic analysis of 22 finalist conceptual papers of Mars Society's Colony Design contest. Challenges were cross-referenced against various sub-domains of Psychology to identify salient principles, theories, and methods which could be integrated into a new Space Psychology.

While Organizational and Clinical Psychology will remain salient, several other sub-domains of Psychology could be integrated into Space Psychology, as we transition to large space settlements. Developmental, Educational and Counselling Psychology will be particularly important in supporting skills acquisition and identity formation in post-Earth generations. Additionally, Social, Cultural and Peace Psychology can inform efforts to ensure intergroup harmony, negotiate multilayered identities, and navigate the eventual transition from survival-orientation to self-expression, as space settlements gradually mature and thrive. These new directions for Space Psychology require extensive research, which could be advanced through large-scale analog missions, utilizing ecological momentary assessments and a multi-level research design, to investigate the aforementioned psychological processes.

Supporting human development and social cohesion in large-scale space settlements represents a new frontier for Space Psychology. This challenge can be met by drawing principles and methods from a wide range of Psychology sub-domains.

MEDICAL-5

DEVELOPMENT OF BONE DENSITY STABILIZER FOR LONGTERM SPACE TRAVEL AND ACTIVITIES ON MARS

SAI TEJASWI KOMMAREDDY, JUILO REZENDE

HABITAT MARTE

Humans are closer to becoming interplanetary species. Mars would be our best shot for pushing the evolution of our technologies further. In order to achieve that we need to deal with unpredictable challenges caused by the martian environment, reliance on advanced technology, remoteness from Earth's capabilities, and resources. The colony must fall into a nearly closed-loop system and become self-sufficient. The following are main survival goals for the establishment of habitat on mars critical infrastructure, dust storm monitoring, use of existing or active development automation technologies for systems; recycling, food production, maintenance, health monitoring. The main aim is to present on muscles and bones in space we have to use it or deal with the loss of bone and muscle density. Not using muscles as much result in a decrease in size and mass. Bones are continuously losing calcium in space even though we can control somewhat through exercises but considering the long.

The key is the development of a solution for bone density stabilizer for surviving on Mars. This can be implemented during the travel time from earth to mars as well as on mars activities. The system is essential because the early loss of bone density may cause difficulty in walking on mars and for other crew activities for astronauts.

MEDICAL-6

OPTIMIZATION OF A NON-INVASIVE BIO-MONITOR FOR EXPLORATION-CLASS HUMAN SPACEFLIGHT

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UNIVERSITY OF SYDNEY

Current health system developments for Mars based habitats are in their infancy. While research has investigated the challenges of transporting people to Mars, relatively little analysis has been performed in characterizing the challenges of maintaining human health upon arrival. Therefore, there is increasing scope to explore the design of novel ecological systems responsible for the clinical care of humans experiencing health issues such as exposure to space radiation, gravitational fields, risk of adverse cognitive or behavioral conditions and psychiatric disorders and wicked problems such as injuries and hypovolemic shock.

The goal of this study was to construct a matrix of priories based on costs and urgency of biomedical ‘issues’ that could occur within the proposed Mars Habitat environment. There is further scope to develop to investigate a particular issue from this selection, using readily-available data, including from the University of Sydney Clinical Schools, Charles Perkins Centre and other related institutions. To inform this work, we conducted a systematic review on the human health-system architecting problem associated with historical and current Martian-based mission designs. The project has demonstrated the future scope to detail a meta-heuristic framework designed for Mars-habitat inhabitants based on Martian Environment Control & Life Support Systems & Crew Health Care Systems Architecture.

MEDICAL-7

GETTING UNDER THE SKIN: THE DEVELOPMENT OF IN VITRO MODELS TO UNRAVEL POTENTIAL INTERPLAY OF SIMULATED SPACEFLIGHT STRESSORS.

**ELINE RADSTAKE, BJORN BASELET,
SARAH BAATOUT, MIEKE VERSLEGERS**

ENVIRONMENT, HEALTH AND SAFETY, RADIOBIOLOGY UNIT, BELGIAN NUCLEAR RESEARCH CENTRE SCK CEN, MOL, BELGIUM & FACULTY OF BIOSCIENCE ENGINEERING, DEPARTMENT OF BIOTECHNOLOGY, GHENT UNIVERSITY, BELGIUM

Continuous exposure to microgravity, ionizing radiation, and increased psychological stress imposes great health risks for astronauts on long interplanetary spaceflights. One of the organs affected by this spaceflight environment is the skin, which is subjected to rashes, itches, delayed wound healing and shows a phenotype similar to the ageing skin. Yet, there is still lack of understanding how the complex spaceflight environment induces these defects. Cultured primary human dermal fibroblasts were used to investigate how the exposure to a combination of spaceflight stressors affect skin cell structure and function. Cells were incubated with hydrocortisone to simulate the effects of chronic stress. Consequently, cells were exposed to X-rays to study the effects of ionizing radiation. We obtained measures for wound healing capacity, expression of dermal proteins and DNA damage repair.

We found a decreased cell migration upon wound induction and lowered expression of type I (pro)collagens, indicative for skin aging, in response to hydrocortisone, but not following irradiation with 0.1-2Gy of X-ray. Furthermore, first results show increased DNA damage after irradiation and incubation with hydrocortisone in fibroblasts, suggesting an additive effect of these stressors.

Besides hydrocortisone and ionizing radiation (low- vs. high- LET), microgravity will be used as the final simulated spaceflight stressor to which fibroblasts will be exposed. Additional endpoints will include cell survival and more detailed investigation of extracellular matrix proteins and cytoskeleton components. Altogether, the results of this PhD project will give more insights into the effects of combined spaceflight stressors on skin dermal cells, and as such, improve the risk assessment for human deep space exploration.

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MEDICAL-8

HOSPITAL ON THE MOON ON THE EXAMPLE OF THE ALLDREAM PROJECT

JUSTYNA PELC, ARKADIUSZ KOŁODZIEJ
AGATA KOŁODZIEJCZYK, HUBERT GROSS, ALEKSANDRA WILCZYŃSKA,
MILENA MICHALSKA, MACIEJ TRZASKOWSKI

WROCŁAW UNIVERSITY OF SCIENCE AND TECHNOLOGY

The publication will present the project of the hospital on the moon, designed for the Home on the Moon competition, organized by the Aldrin Family Foundation. The project was carried out by members of the BRIGHT analog moon mission, organized by the Analog Astronaut Training Center.

The hospital is intended to be a MEDICAL unit for families living on the moon permanently and to be able to serve dozens of them. The concept of the operation of such a facility in lunar conditions will be described and the factors necessary to take into account. The hospital is divided into two main parts - the MEDICAL part, which includes operating rooms, an outpatient clinic and intensive care, and the day part, where patients can recover under the right conditions. A 3D model of the hospital and a detailed 2D plan of all rooms as well as the necessary equipment will be presented. The ongoing maintenance of the hospital, related to the supply of necessary elements from Earth, will also be discussed. It will also show the operation of all the systems in the facility that enable the hospital to function in such demanding conditions.

FRIDAY AFTERNOON SESSIONS

TECH C-1

DEVELOPMENT AND TESTING OF PROTOTYPE SABATIER REACTOR FOR MARTIAN IN-SITU PROPELLANT PRODUCTION

ANDREW ZLINDRA, DAGAN SCHOEN
YASH ADNANI, FRANCIS MAYER

UBC MARS COLONY

The presence of near-surface water on Mars, in the form of ice at mid-upper latitudes, has been established and supported by the scientific community. This discovery has allowed for research into in-situ resource utilization techniques (ISRU) to grow immensely. In-situ rocket propellant (methalox) production has been proposed as a way to reduce costs of Mars-bound space exploration missions. One of the approaches currently being explored involves a reaction with carbon dioxide and hydrogen gases at high temperatures and pressure over a solid catalyst in a packed bed reactor (PBR) to produce methane and water, also known as the Sabatier reaction. As a first step to creating a prototype modular “Sabatier Fuel Plant” for use on Mars, our team designed and constructed a lab-scale test reactor based on published literature in the field. Our research is focused on testing the behavior of multiple methanation catalysts and their capacity for the continuous production of methane gas via the Sabatier reaction. Results from the test reactor will inform the design of a full-scale fuel plant on Mars. The team’s next steps are to develop a technologically and economically feasible proposal to construct and operate such a plant. The materials and methods needed to construct the reactor are detailed; along with a brief explanation of how proposed catalyst testing is linked to future fuel plant design.

TECH C-2

SPORE: RESOURCE EXTRACTION AND HABITABLE SPACE CREATION

BEN SMITH

LUNAR HOMESTEAD

The Martian surface is a hostile environment for both humans and equipment. Toxic dust, radiation, near-vacuum, thermal extremes, and meteoroid impacts require complex, difficult, and expensive engineering solutions. The Lunar Homestead Shielded Pressurized Oxygen Resource Extraction (SPORE) project's hypothesis is that Lunar mining operations conducted inside a sub-surface pressurized structure can mitigate or eliminate all of the challenges presented by the Lunar surface while also creating habitable space. With some modifications, SPORE could be the solution to Mars Homesteading as well.

SPORE mining and habitat construction will be shielded from most Martian surface threats by ten or more meters of untouched regolith. Near-vacuum and the remaining dust will be mitigated by pressurizing the work area with excess pure oxygen obtained from processing Martian rocks. SPORE will minimize the need for complex robots designed to operate on the challenging Martian surface and the need to for humans to operate in such a dangerous environment.

This presentation will cover the advantages of SPORE for Lunar settlement. Properly modifying it for Mars would require substantial time and effort. However, it can provide a starting point for people working on the settlement of Mars.

TECH C-3

RESOURCE UTILIZATION ON MARS

COLE PAZAR

COLORADO SCHOOL OF MINES – CENTER FOR SPACE RESOURCES

Resource utilization of the atmosphere, surface, and upper subsurface of Mars is of utmost importance for scientific exploration, permanent colonization, and the development of sustainable city infrastructure. This presentation demonstrates the current knowledge, systems, technologies, and processes for resource utilization on Mars. The stages of space resource utilization on Mars are: prospecting, acquisition, processing, production, and manufacturing. The six primary resource requirements to sustain human life on Mars are: water, air, metals, power, fuel, and food. For the acquisition of water, there is solid water ice readily available in the subsurface of the Martian Polar Regions, and quite abundant in specific ice-filled craters. Oxygen can be initially acquired by separation of carbon dioxide from processing the Martian atmosphere and surface ices and can later be partially acquired through biological photosynthesis. The leftover nitrogen can be concentrated and pressurized for the inert component of breathable air. Metals (iron, aluminum, silver, gold, REE's, etc.) for technology manufacturing and construction can be acquired from surface and subsurface deposits, and asteroid mining, utilizing the byproducts of mining for concrete and agriculture. Electrical power generation will be fulfilled by a combination of solar, wind, nuclear, and combustion. Fuel for plastics (syngas) and propellant (methane) can be created via. the Sabatier process, and potentially extracted from subsurface reservoirs where they exist. Food production can be enabled through resource processing of Martian soil and acquiring essential minerals for biomass growth. I address the current geologic knowledge of available Martian resources, modern advancements in space systems and robotics, state-of-the-art ISRU technologies, and the construction processes of developing this infrastructure. The costs of this infrastructure are addressed at various scales and will be funded through asteroid mining and resource supply chains going through the future Mars–Moon–Earth transportation network.

TECH C-4

MARS, A BUILDABLE PLANET

LAURENT CADET, ENGUERRAN PETITFILS

ARIANEGROUP / NANOAVIONICS

A challenging technological race is back outside the Earth's atmosphere. For many years space agencies have sent planetary flybys, orbiters, atmospheric probes, landers, rovers, sample probes to collect data on celestial bodies. Some of them are now preparing to set foot on the red planet.

Architects deploy all their imagination to draw outlines of human's colonies on Mars. Aerospace engineers and logistic officers carefully plan strategies to deploy workers and equipment 34 million miles away from the Earth. Civil engineers are also part of it. Their mission not only consists in building a new city as we have learnt to do for centuries. The point real point in here is whether we can build reliable constructions for those who will have boots on the ground far away from the blue planet.

Building is knowing what nature can do to our constructions and knowing how to face those natural conditions in order to carry out activities that we want to establish locally. This article offers a review of natural phenomenon that have been caught by space agencies' sensors. In the first part usual parameters would be studied: seismic conditions, geology, soil resistance, wind, storms, tornadoes, temperature gradient, etc. In the second part other parameters will be considered to take into account extraterrestrial conditions: gravity, atmospheric pressure, air density, solar radiations, meteorite, etc. Formatting these input data would be helpful for civil engineers to start basic designs.

TECH C-5

A CRITICAL REVIEW ON THE MATERIAL PROPERTIES OF MARTIAN CONCRETE

NAKSHATRA SINGH, DR. MOHD SHARIQ

ALIGARH MUSLIM UNIVERSITY, DEPARTMENT OF CIVIL ENGINEERING

Construction of the concrete structures on Mars and the Moon is one of the future challenges which civil engineers have to face. To carry out the construction, Martian and Lunar concrete formation is one of the major tasks which have to be performed for construction. By 2030, the goal of NASA and SPACEX like space agencies is to land the first humans on Mars and they have proposed the development of infrastructure on Mars by colonizing Mars. Few researchers performed several tests on concrete to evaluate and compare the environmental impact of Martian concrete for construction on Mars. Therefore, this paper reviews the material properties and compressive strength of the Martian concrete and compares it with the conventional concrete. This paper has also reviewed the structure stability on mars having 1/3 of earth gravity. It is discovered that the major compositions of Martian soil are magnesium, titanium oxide, and a large amount of sulfur. The effects of the magnesium, titanium oxide, and sulfur on the formation of concrete and their properties have also been presented. Experimental results showed that the compressive strength of the Martian concrete is higher as compared to the conventional concrete. It has also been observed that the Martian concrete can be re-used by heating up to 250^{o}C temperature. One of the advantages of Martian concrete is that it is not fire-resistant, therefore, fire resistance methodology is required before using in concrete construction. Therefore, structure on Mars will depend on many factors including its vacuum atmosphere, temperature cycles, regolith bearing capacity, radiation and micrometeorites attack with hyper velocities.

TECH C-6

MARS HABITAT DEVELOPMENT THROUGH COTS AND COLLABORATIVE APPROACH BY MARS HOMEBASE ORGANIZATION (BANGALORE, INDIA)

KRISHNA MANJUNATHA

MARS HOMEBASE ORGANIZATION

Mars HomeBase Organization is involved in the development of technologies related to human settlement on Mars. We are not developing either rocket or propulsion systems to transport men and materials to Mars from Earth. SpaceX/ Blue Origins and others are developing Mars rocket and we intend to use services from them. What we are working on are- all types of technologies and tools needed to live, survive and thrive on Mars once we get there! The goal of Mars HomeBase Organization is to use COTS (Commercially Off The Shelf) and Collaborative approach to develop every tools or technology, small or big needed to live and explore on Mars. The objectives of this study paper is to develop concepts for practical design for a manned Mars Habitat which is expandable in nature and can accommodate growing crew of people. The term design refers to both Habitat design and construction tools/techniques to be used on Mars taken together. This research is being attempted by engineers/technicians from the field of welding, metal work fabrication, electrical, electronics and computer engineering discipline. Our approach is "build it and feel it". Our understanding is "If we cannot weld two metal sheets on Mars, then we are going no where with human settlement on Mars!". Focus is more on Insitu Hab Assembly on Mars and tools needed. The extended goal includes development of all functionalities like development of green house, living, working facilities, MEDICAL, exploration, recycle/re use facility, social facilities like M-MAY (Music, Meditation, Arts and Yoga). The main design tasks involves development of construction technology of Habitat structure and investigating appropriate structure, materials, construction techniques and necessary tools needed for insitu construction on Mars. This paper will show some prototypes developed and discuss advantages tools used for such development.

TECH C-7

RESEARCH AND DEVELOPMENT OF A LAUNCH FACILITY AT MARS USING ABUNDANT CARBON DIOXIDE

PALLAVI PRASAD

HABITAT MARTE SPACE ANALOG STATION

This paper presents research outcomes from Habitat Marte Mission 46. The mission explored how learnings from the Perseverance Rover Mission could be utilized at the analog astronaut station Habitat Marte in order to progress towards the goal of sustainable living on Mars. The abundance of carbon dioxide on Mars (~96%) is identified as a key enabler in achieving this goal. Supercritical carbon dioxide can be used as a solvent to extract useful minerals from the martian soil and rocks. This can support the generation of liquid hydrogen, liquid oxygen and liquid methane which are excellent rocket fuel. Upon the success of Perseverance MOXIE experiment life-supporting, oxygen and water can be generated. The water generated can be used to build structural “ice” dwellings that naturally offer excellent radiation shielding, while the atmospheric carbon dioxide can provide insulation. The space inside these “ice-homes” can sustain life and provide a base for human activities.

This paper outlines the building blocks and necessary technical and scientific concepts that enable the utilization of carbon dioxide to support the development of a launch facility on Mars. The paper also includes recommendations on the employment of robotics and quantity of human involvement in the development.

TECH C-8

THE OPERATION OF A MAIN STATION ON MARS

JULIO REZENDE, VARSHA SHANKAR, DAVI SOUZA

HABITAT MARTE SPACE ANALOG STATION

Main station is considered the first module of a Mars habitat. This research explores the possible features of this facility. One of the main purposes of the main facility is to provide all elements necessary to start a habitat from the moment of landing.
It is suggested that this module enables: communication with Earth and the astronauts during Extravehicular activities (EVA); use as a dormitory, gym, dining room, kitchen and research laboratory.

Some functionalities of this facility are:

1) check and operate routines and operational protocols associated with Intravehicular and Extravehicular Activities (EVA)
2) Coordinate the daily routines of communication
3) Training and simulation (on-line content delivery, follow up meetings, Virtual and Augmented Reality)
4) Consumption of meals, food preparation procedures, waste disposal, cleaning, organization and maintenance of utilities
5) MEDICAL examinations, blood collection, accident simulation and emergency preparation. The laboratory allows for the use of multitasking laboratory tools, conducting studies and analysis of samples.

We also consider the cultivation of plants in the main station important since this would serve as experience for future large-scale greenhouse operation on Mars.
For successful operation of the main habitat it is also vital to consider the following:

1) Mental well-being and entertainment through content delivery
2) Daily Routines and scheduled activities
3) Health and safety guidelines and
4) Striving for independence and self-reliance: every member observing self-organization, maintenance, repair and alerting others.

TECH D-1

MARS COLONY BASE - SIMULATION OF EVACUATION IN MARTIAN CONDITIONS

SZYMON MATKOWSKI

MARSITY.ORG

There is one fact inevitable in the future: there will be a plenty of people on other moons and planets. Humanity is technically ready to settle down there. Brave concepts are being developed, populated with thousands of pioneers.

Safety of the people should be a top technical priority in every building or device – in any place. All: structure, MEP systems and the layout should be focused on minimizing the risk of life loss. Design of a base, or colony on other planet also should comply with this principle.

The layout of all safety egress communication (passages, corridors, staircases, lifts etc.) should not be changed or altered. The unchangeable layout of those elements is a bone system for the functional layout and all the decoration we see.
The drawback of such solution is that - once designed, the layout is frozen. Any change leads to re-examination of all safety measures – which is very expensive (even in Earth's conditions).

The layout and safety measures are influencing and also depend on critical value, which is Evacuation time. Time – which people have, to save their lives.
This entry describes research on Evacuation movement speed on Mars, possible behavior types and a sample evacuation time count in different scenarios.

Depending on the threat (decompression, fire and smoke) additional means should be provided: smoke exhaust, additional air supply, sealed safety rooms, emergency teams access routes and action plan.
For the purpose of the investigation a fragment of Twardowsky Mars Colony was used (the design won 2nd prize in 2019 competition organized by Mars Society).

The key goal is to define layout of safety premises and principles of work of MEP systems for the whole Colony and obtain safety guidelines for further Mars/Moon base design.

TECH D-2

SPACE COILGUN: A HIGHWAY TO MARS

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While space engineers are trying to make chemical rockets cheaper and more effective, the massive colonization of Mars and Solar system can only become possible with new ways of transportation. One of them can become a space coilgun - an orbital station, which can accelerate a spacecraft using the electromagnetic forces.

Such a station can change the orbit of a spacecraft using a current impulse sent to the coil. The impulse changes the electromagnetic energy of the coil resulting in the change of the momentum of the projectile travelling towards its center, where the current is turned off. The effectiveness of such a gun depends on the inductiveness of the coil and its maximum electrical current. Modern superconducting magnets can provide tens of thousands of Amperes to create a kinetic energy enough to accelerate a spacecraft weighting 100 tons to several tens of km/sec. The resulting speed is enough for interplanetary travel. The energy for impulse can be collected using solar panels and stored on board in special batteries, then released using capacitors.

The design of a coilgun requires a spacecraft to be made of ferromagnetic material or to carry an additional coil onboard. Another requirement due to high acceleration is the cargo: the ship has to be unmanned and carry sturdy materials. It is more effective to send small amounts of cargo to make a significant difference in weight between the station and the ship thus minimizing the station back momentum. The advantages of coilgun design is evident: it doesn`t require a mechanical contact essential in railgun design and thus experiences no friction.

The back momentum of the station can be compensated by switching the incoming/outgoing cargos. Coilgun can also be used to send spacecraft directly from planet surface to space on the planets with rarefied atmosphere.

TECH D-3

INDUSTRY AND SCIENCE FROM LUNAR LAVA TUBES (LLTS) SHOW THE WAY TO MARS!

DOUGLAS SHULL, MEMBER #65

NOBLE METALS EXTRACTION SYSTEMS

In this scenario, the selected LLT provides stability and safety for human habitation, and was previously set up with rugged Kevlar inflatables for:

- Habitation with crew quarters Hab (Flashline Mars “Tin Can” size or larger), Greenhouse Module and Airlock Module.
- Equipment maintenance with a Garage/Workshop Module (GWM) Science with a Laboratory/Assaying Module (LAM).
- Solar panel/clock drive package/batteries provide the initial power, augmented with a small nuclear reactor for power at night.
- Truck quality pressurized rovers, open rovers, construction vehicles (bulldozer, front end loader, backhoe) provide mobility, towing and regolith moving.

Initial Mission

The initial purpose of this base is bootstrapping the construction of equipment and factory sets, utilizing in situ resources as much as possible with the purpose of building railroad lines, railroad rolling stock, locomotives, along with additional construction and mobility vehicles. This building program is concurrent with the construction of hardened launch pads at safe distances from the base.

Follow-on Mission

The manufacture of telescopes, specialized rail cars for mounting those telescopes, for operation on the Lunar surface. These telescope sets are for sale or lease to universities, countries, states, cities, companies, individuals, etc. The telescope sets will be railed to a railroad parking area, controlled from Earth, and maintained by the base. Money earned from the lease or sale of telescope sets will defray the costs of the base, while steadily building an extensive telescope network on the Lunar surface, complementing space-based telescopes. This base is also complementary to Lunar Polar bases producing water and other volatiles. The equipment required for this base creates an economy of scale, lowering costs for parallel Mars missions while showing the way for populating Martian Lava Tubes.

TECH D-4

DEVELOPING A ROBOTIC TESTING DEVICE FOR SPACE SUIT JOINTS

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The return of astronauts to the moon to prepare for a trip to Mars will lead to an increase in mission duration and an emphasis on surface Extra-Vehicular Activities (EVAs). To make the most of these extended missions, an advanced EVA space suit system will be needed. One way to increase astronaut performance through the design of an improved space suit could be sizing the space suit to the individual astronaut. This would reverse the current trend in USA EVA space suits of modularization and size standardization. To determine the benefit of a custom-sized suit system work needs to be done to identify the potential benefits of custom sizing. This will require the development of new testing devices and methodologies similar to the work presented here.

Testing methods for pressure suit joints vary across companies and organizations. All of these methods fail to accurately capture the mechanics of a human limb actuating a pressurized joint. An improved testing system that takes into account the placement of a limb inside the joint could uncover the effect sizing has on the torque requirements of a joint. With this information joint geometry can be tailored to an individual, minimizing the effort required to perform tasks in the suit.

A novel joint testing device and methodology was created using an iterative design process. The new device improves on previous methods by accurately replicating the limb movement in a pressurized joint. The modular nature of the device allows for multiple sized anthropomorphic arms to be used to uncover the effect sizing has on the resistance to movement of a joint. With the new device and testing method, the effect of sizing on the operability of space suits can be investigated.

TECH D-5

IMPROVING THE LONGEVITY OF INTELLIGENT SWARMS ON MARS

MARTINA LOFQVIST

MOMENTUS

Significant investments have been made by governments in the development and demonstration of intelligent swarming. Much of this research has been focused on adaptive tasks and agent allocation with swarm networks as a tool to achieving complicated behaviors. Similar to how animals use swarming behavior as a method to gather information, rovers on Mars can study areas more effectively by working cooperatively.

Supervisory control where humans monitor these systems by sending high level commands is not preferable since teams on Earth would have to constantly manage these robots as well as issues relating to latency. In order to develop robotic systems that can complete certain mission tasks without human intervention, the robots need to be able to operate autonomously. Small robots operating in intelligent swarms require powerful devices.

However, computing at the edge provides limitations in terms of memory, power, and compute capacity. By examining the capabilities of constrained devices and investigating ways to compress both the data and detection models, performance can be optimized. In order for these networks of rovers to operate effectively, incorporating intelligence to the navigation and communication systems will improve the longevity of these rover swarms.

TECH D-6

MARS DIRECT V3 | AN EXPANSION OF DR. ZUBRIN'S PROPOSAL FOR A MARS MISSION WITH STARSHIP

MIGUEL GURREA

THE MARS SOCIETY SPAIN

In 2019, Dr. Robert Zubrin presented his revised version of Mars Direct based on SpaceX's Starship vehicle. For a number of reasons, Dr. Zubrin argued that SpaceX should develop a Mini-Starship in addition to their Starship system. However, Elon Musk thinks it isn't worth developing another vehicle.

This presentation would serve a dual purpose:

The first purpose is to expand on Dr. Zubrin's Mini-Starship architecture to make it simpler and more appealing to be developed by SpaceX. In this revised plan, the Mini-Starship would require little to no heat shielding, no wings and only one Raptor engine. This simplicity would make it cheaper and easier to develop.

The second purpose is to outline the architecture for the first crewed mission to Mars with this system. This plan would include what each vehicle carries, the technologies needed as well as multiple contingency plans in case things fail to make sure the astronauts are safe. These include things such as how to survive on solar power in case of a global dust storm.

In this proposed first mission, the astronauts would conduct vital science, explore their surroundings and leave behind a functioning base and ISRU machinery for future missions. All of this with the number of spacecrafts planned by SpaceX, Dr. Zubrin's mini-Starship and a few key technologies (such as ISRU machinery).

In conclusion, when added to SpaceX's plans and Dr. Zubrin's proposals, this offers a complete picture of the Mars mission architecture needed to establish human presence on the Red Planet.

TECH D-7

ENGINEERING ON MARS

JAS PUREWAL, JULIO REZENDE
DAVI SOUZA, SAI KIRAN PARRE

RESEARCHER SCIENTIST. OTHER AUHORS FROM UFRN AND SGAC

Proposal for engineering operations and protocols required in a Mars habitat. An international research collaboration was carried out with team members from India, Brazil, England and Canada during the 42nd Habitat Marte analogue virtual mission. The expectation is that the research conducted will be useful for future missions and space habitats.

For a space habitat the need for an engineering facility was deemed necessary for the maintenance and efficient functioning of the habitat and equipment. Some of the required functions of the engineering facility would be:

1) Maintenance and repair of habitat technology, vehicles, space suits etc.;
2) Health & safety checks;
3) Risk assessments and equipment testing;
4) Innovation based on experience in the new environment;
5) Providing engineering specific training.

Some activities to be developed in the engineering facility include:

1) Best working practices;
2) Adequate tools and training to allow each facility to operate independently;
3) Support of EVA;
4) Adaptation of existing technology to the new environment;
5) Determine necessary emergency and backup systems;
6) Protocol for facility and equipment testing;
7) Engineer new solutions specific to the environment;
8) Support for scientific research.

The engineering facility recommendations for the rest of the crew include:

1) Regular systems checks;
2) Report on environmental conditions;
3) Alert to any engineering issues;
4) Maintain safe working practices;
5) Prepare and share daily reports.

SETTLEMENT B-1

PAWNS ON MARS

MIKOLAJ SOBOCINSKI

GAMEDEC

In 1979 Arthur C. Clarke delivered a presentation at the 30th International Astronautical Congress, where he discussed the idea of a space elevator. Although at the time the idea seemed impossible, if not preposterous to some, he claimed that “The Space Elevator will be built about 50 years after everyone stops laughing.” Seeing the advent of board games, LARPs, serious games, games used in education, recruitment, and professional training, it is time to finish laughing at video and table-top games as indispensable for the colonization of Mars. We would like to argue for the necessity of providing the colonizers of Mars not only with computers and tablets with their video games, but more specifically with a wide variety of card games, board games, narrative games, and hybrid games. Not only do they allow for a stress-free playfulness and relaxation, but more importantly they are an integral part of human behavior encompassing the need to socialize and interact with others on a variety of plains. To name just a few advantages, one could mention: physical and mental exercises, therapy, creativity, collections, adjustment to scarcity, safety of the known and well-established worlds, familiarity, inclusivity, cooperation, competitions, simulations, creation of iterations, long-term relations with family, friends, and fans on Earth, and obviously fun. Table-top games, to a much greater degree than video games, relate to our primal need for storytelling and social inclusion that various narratives and games have provided for thousands of years. Therefore, in order to exemplify the wide spectrum of positive effects games can provide while astronauts travel to Mars and settle it, we would like to present an analysis of games and game types followed by a proposal for a set of games that every ship with colonists should be equipped with.

SETTLEMENT B-2

PARA-TERRAFORMING HEBES CHASMA

KENT NEBERGALL

MACROINVENT.COM

Hebes Chasma is an equatorial canyon roughly the size and shape of Lake Erie, just north of Valles Marineris. At the center is a volcanic black plateau called Hebes Mensa. This location shares the sedimentary qualities of Valles Marineris to the south and the Tharsis volcanic region to the northwest, giving it ideal qualities for both bringing metals to the surface and concentrating them via the action of water on early Mars. The central plateau is ideal for a spaceport. Since high walls close both ends of the equatorial canyon, it is also the ideal location for a para-terraforming project that would enclose the top of the valley. The space is extensive enough to allow engineering of multiple climates in an open airflow, while allowing isolation of zones to avoid a complete failure if a meteor or other disaster hits one region.

Mining operations would involve extensive regolith processing. Engineers would recycle the tailings and overburden to landscape the enclosed terrain and refine soil types for various biomes. This process would also strip metals and toxic reactive compounds that are better used in industry and kept from ecosystems. They may pass the soil through an agricultural phase for enrichment before committing it to the enclosed ecosystems.

Since it may not be practical to terraform all of Mars, this provides most of the benefits of interconnected ecosystems in a much smaller package. It will also provide the experience needed for other locations (craters and canyons) and development of terraforming species for low-gravity biomes.

SETTLEMENT B-3

MARS TERRAFORMING- HUMANITY BIGGEST OPPORTUNITY

GIORGIO GAVIRAGHI, SERGIO DE PAULO, STUDIO GAVIRAGHI

UFMT UNIVERSIDDAE FEDERAL DO MATO GROSSO

Speaking about Mars terraforming, most considerations are related, wrightly, to the biochemical processes by which we would be able to transform the atmosphere composition and the temperature of the planet as well as how to shield its surface from radiations being the main known challenges.
In the last fifty years many possible alternatives were suggested by the scientific community but never followed by practical experiments.
In reality we must not consider such conditions only, since, while they are of prime importance, they mask other opportunities slightly mentioned.

Terraforming Mars means a unique historic opportunity to design an entire planet, to optimum human friendly conditions, creating ecosystems, environments both physical and social, that would improve our living conditions in a new planet avoiding all past mistakes or incorrect situations generated by our planet development in its history.
All environmental, social and potential future challenges must be faced before the planning of our second home that must be designed with the best possible utilization of the different disciplines that composed our society, from technological, to social that would be applied .They range from urban planning to building design to health care system or educational as well as governance , from food production and resources utilization just to name a few.
In this paper we want to face the main ones with working proposals that would define their conditions in a human friendly designed planet, with potential applications in our own.. While it may seem early to face such issues , we must consider the final goals for Mars colonization and development at this moment, before the first manned missions that could be conditioned by such issues.

SETTLEMENT B-4

CONCEPT OF A LAUNCH CENTRE ON MARS CONSIDERING SELF-SUSTAINING ISSUES

VARSHA SHANKAR, JULIO REZENDE
KOMMARED TEJASWI, SAJJAD GHAZANFARINIA

CANADIAN SPACE SOCIETY

This research discusses the operational features of a launch center on Mars with its primary function being to enable arrival and departure of goods and people from beyond Mars. We propose a self-sustaining facility decoupled from other facilities to avoid the risk of incidents damaging other parts of the habitat. We propose the use of recycled materials and modular components while exploring technologies and human routines to support operations in the center. The plan was developed as a result of the 43rd research virtual mission at the space analog station Habitat Marte.

We propose the use of reusable rockets with a propulsion system that can withstand dust storms, radiation and low temperatures on the surface of the planet and explore a hybrid fuel system i.e. solid wax-based fuel with liquid oxidizer to support maneuverability, multiple starts and stability. A closed loop guidance system to transfer cargo to ships in low Earth orbit will allow for increased reusability of the rocket. The landing pad will be reinforced against cratering from engine plumes – either through robotic paving or metallic exhaust from nozzles during descent. Decentralized excavation of Martian regolith using robotic swarms will generate methane as fuel and water for self-reliance autonomously encouraging modular components and efficient spare part usage.

We propose that the facility contain 7 sections and related activities – a dome shaped main launch facility that opens to accommodate arrivals and departures while keeping the area clear of dust, acting as a radiation shield and a means to secure docked ships during storms. The other sections are a methane storage area decoupled from the launch site, water storage, transportation center for cargo delivery coordination, traffic control station to schedule and inbound and outbound ships, kitchen/relaxation zone and maintenance hub for robotic machinery and computer systems.

SETTLEMENT B-5

STATE ON MARS ON THE EXAMPLE OF THE INNSPACE PROJECT

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PIOTR TORCHAŁA, BEATA SUŚCICKA, ŁUKASZ SOKOŁOWSKI,
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The publication will present the concept of a state on Mars for 1,000,000 inhabitants, designed for the Mars City State Design competition organized by The Mars Society.

Organizational and legal issues related to the operation of such a base on the Red Planet will be presented. The plan to distribute this number of people on Mars will be discussed and the plans of all city-states that will make up the InnSpace Federation will be shown along with an analysis of communication both on Mars and between Mars and Earth. The principles of operation of such cities and the origins of their creation will be discussed. Economic issues and functioning of Mars as a state independent of the Earth will be shown. The main expenses and sources of income as well as the functioning of the market on Mars will be presented. Social issues will also be shown - what the everyday life of Martians looks like, what holidays are celebrated, what art looks like and what sports can be played on Mars.

SETTLEMENT B-6

EVALUATION OF MARS COLONIZATION OPPORTUNITIES DEPENDING ON ITS CONDITIONS

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Searching for an alternative planet to be inhabited by humans is currently quite a popular topic, especially considering the current state of technology development and future opportunities. Mars is the closest planet in the Solar System, located in the ecosphere, which despite the difficult conditions on the surface, is planned to be colonized. However, before this happens, the Red Planet must be better known. The first challenges that await the future colony are to choose the right location and develop technologies to facilitate the water acquisition (e.g., from ice caps on the poles or hidden under the surface of regolith). In order to enable human survival in the initial colonies, it is necessary to create a habitat to enable the everyday functioning of the first settlers and to protect them from low temperatures, a rare atmosphere whose composition is mainly carbon dioxide and where the amount of oxygen is below 1%. Lack of Mars magnetic field makes it impossible to protect against cosmic and solar radiation. Another problem is the occurrence of sandstorms, which can last for months, limiting access to natural light. A natural consequence is to design infrastructure adapted to current conditions and chosen location. Habits such as a cave system or the location of the base in a canyon, whose walls would additionally protect against difficult conditions, are considered. The aim of present paper is evaluation of Mars colonization possibility depending on conditions on this planet and also the location of the colony in accordance with the landscape. The paper presents a proposal to minimize the impact of negative factors on the lives of future Mars residents, related to, inter alia, the architecture and location of the base, food production, energy generation and transport of colonists, based on the Ideacity project proposed by the InnSpace team.

SETTLEMENT B-7

POSTCARD FROM MARS

ABHISHEK SONI, YASMEIN TRABELSI
MICHAEL DI MARIO, BERKAY YILDIRIM

THE MARS SOCIETY EDUCATION AND OUTREACH

Humans have always been skilled explorers. Our history is full of establishing new colonies and exploring unknown territories. Earth, then the Moon, and now Mars is the final frontier for settlement. Building a self-sustaining civilization on Mars is the greatest adventure in human history. Drawing parallels with the initial European settlement trips to America, the journey to Mars is a foray into ensuring the survival of human civilization. In order to take the first step on the red planet, first and foremost would be the selection of a landing site, followed by a launch window; both of which are chosen according to the mission requirements and resources. Spacecrafts and rockets are an integral element of the mission since they ensure a safe journey of the crew to and from Mars. By its very nature, the first mission to Mars is full of uncertainties. Therefore, a mission to Mars needs a robust crew selection process accompanied by a diverse set of training and skill development to encounter unforeseen anomalies using available hardware and supplies. The crew will undertake a 9-month travel through space and stay for over 500 days in a 38% 38% Earth gravity environment and an atmosphere of 96% carbon dioxide. Hence a well shielded and oxygenated habitat is indispensable for mission survival. Postcards from Mars entails the voyage details of the first Martian explorers in a memoir about the technical, social, mental, physical, psychological aspects of living on a spaceship and on Mars. It also includes how the path to human settlement was laid out by overcoming challenges using in-situ resources to generate oxygen, conducting experiments for water extraction, growing crops, and acclimatization in below zero-degree temperature. These postcards shall serve as a motivation to humans on earth in becoming a space-faring civilization.

OUTREACH & EDUCATION-1
SPREAD THE WORD

DR. JAMES MELTON

Many people are not aware of the phenomenal, real-world missions now underway to the Moon, Mars and other solar system destinations. How would you like to be the person who connects with the general public to lift their awareness and open doors to reveal the plans for a spacefaring civilization?

As strange as that may seem to those of you who have held these visions for so long, there is a world of eager listeners waiting to be enlightened. Many of these people do not even know that the greater part of our future lies in space. You can step forward and be an agent for change.

This session provides an overview on how to deliver the facts, figures and timelines that will ignite a spark to entice people to be curious about their future.

Program highlights:

- Newsletters / Articles / Speeches / Podcasts / Interviews
- Outline talking points for a 30-minute program.
- Provide PowerPoint images to support the information presented.
- Deliver facts on the Moon, Mars and space.
- Offer questions and answers to encourage follow-up action.
- Who, what, where, when, how and why?

If we are going to continue to grow as a civilization, there are certain elements that will allow success to evolve more easily. We can and must learn vicariously. It is a process that we have relied upon for years. Your experience is valuable. Sharing it is even more valuable. This is a philosophy by which we can all grow and benefit. As Francis Bacon said, “Knowledge is power.” It can pave the way for an existence of an entirely new experience in humanity.

“Only those who risk going too far can possibly find out how far they can go.” –T. S. Eliot

OUTREACH & EDUCATION-2

A MARS SOCIETY EDUCATION AND OUTREACH TEAM FOCUS: BLENDED LEARNING K-12 STEM LESSON PLANS FOR 2020 AND BEYOND

KHAOULA CHARREK, LUCINDA OFFER, ASMA AKHTER

THE MARS SOCIETY EDUCATION AND OUTREACH

This presentation will cover the recent results of the Education and Outreach team's newly developed blended-learning lesson plans for education. The plans have been updated according to modern education methods and in line with the current digital lives of students. The team has created STEM lesson plans for K-12 (5-18 years old) that aligns with curriculum in the US, UK and EU and will highlight humans to Mars, current missions, landing sites, Mars geography and aerology, atmosphere and weather, and finding life on Mars.

OUTREACH & EDUCATION-3

MARSPEDIA - 2020 PROGRESS REPORT AND TUTORIAL DEMO

JAMES BURK, FRANK CROSSMAN

THE MARS SOCIETY

James Burk, Chair of Marspedia Governing Council, TMS IT Director
Frank Crossman, TMS Chief Archivist

Marspedia is an online encyclopedia maintained by The Mars Society with volunteers. Its focus is to promote the sharing of ideas regarding human exploration and settlement of Mars. It is also serving as a knowledge repository - an archive- for Mars advocacy organization projects.

In 2020 we completed much of the Mars Atlas project, which will be discussed in a separate talk at this conference by Jim Secosky. Here we will note some significant contributions of technical articles, a current project to archive the MDRS crew reports in Marspedia, and the archiving of working documents for MarsPapers and FMARS-INTERACT. Tutorials for editing of Marspedia articles and for archiving of Mars related projects will be briefly demonstrated.

OUTREACH & EDUCATION-5

MARS SOCIETY CHAPTERS UPDATE

NORA HOVEE, JEANNINE AGUILAR

MARS SOCIETY

As in the past for previous Conventions, an update of the activities of Mars Society Chapters will be presented in a power point presentation.

OUTREACH & EDUCATION-7

WHY PUBLIC EDUCATION OF MARS EXPLORATION?

NAN LI

NATIONAL INFINITY ARTIFICIAL INTELLIGENCE TECHNOLOGY (SHANGHAI) CO., LTD.

Many people are Mars Dreamers, they are pursuing the possibilities of transforming Mars a future habitat for humanity. Many others may not be like them and would rather live on Earth forever if it is possible. And the rest may not even think about where to live in the future. If we believe that the Earth is our forever homeland, why do we still explore Mars? Why do we still explore the universe? For those who just follow the steps of the Mars Exploration pioneers, I mean us, why do we choose to do public education of Mars Exploration?

OUTREACH & EDUCATION-8

HOW TO EXPLORE MARS WITHOUT LEAVING YOUR CHAIR

JAMES SECOSKY

RETIRED FROM BLOOMFIELD CENTRAL SCHOOL
AND FINGER LAKES COMMUNITY COLLEGE

For over 25 years, I have explored Mars through NASA programs for amateurs to select places for cameras orbiting Mars to look at in high resolution. In this talk I will talk about my excitement in receiving nearly 5000 pictures from every part of Mars. There are a number of programs in which regular people can help explore the universe. I want to share my joy in investigating new vistas on my computer.

I started out as a teen with a $20 telescope from Edmund Scientific (I saved up money from mowing lawns for 50 cents/hr.) and ended up using the most powerful telescopes ever built. I've been lucky to have had the privilege of using the Hubble Space Telescope, the Mars Global Surveyor, and the Mars Reconnaissance Orbiter. I want to show you how to do it too. Some of the pictures I will show are of dunes, gullies, layers, hollows, oxbows, glaciers, volcanoes erupting under ice, and boulders rolling down slopes. Many of the pictures for this talk are found in the Marspedia article called "HiWish program."

Anyone can register for this program and make suggestions for HiRISE at
https://www.uahirise.org//hiwish/
NASA started to accept image suggestions for the Mars Orbital Camera onboard the Mars Global Surveyor in August of 2003. That Public Target program lasted until contact was lost to the spacecraft on November 2, 2006. For years HiRISE was nicknamed the "People's Camera" because NASA wanted to give ordinary people a chance to use it. It was one of several instruments onboard the Mars Reconnaissance Orbiter which arrived at Mars in March 2006. The first suggestions for HiRISE from the general public were accepted in January 2010.

SATURDAY AFTERNOON SESSIONS

TECH E-1

CHALLENGES FOR FOOD PRODUCTION ON MARS

NIKITA DIVAY, DR. JULIO REZENDE

HABITAT MARTE (MARS ANALOG RESEARCH STATION, BRAZIL)

Mars missions will require sustained in situ food production to provide sufficient nourishment for the crew. Martian environmental conditions make it necessary for crops to be grown by controlled-environment agriculture (CEA) in greenhouses. In this paper, current understanding of Martian conditions is summarized, and an attempt is made to imagine the working of a greenhouse on Mars. Considerations when selecting possible crops to be grown are evaluated. As a means to maximize use of in situ resources, opportunities to harness solar insolation to be used for plant growth and greenhouse operations are recognized. A major challenge that stands in the way is air borne dust and dust storms. To mitigate these, necessary protocols are determined. Other possible functionalities of the greenhouse beyond providing nutritional needs are explored. These considerations for space food production system are a result of Mission 44 conducted virtually in Mars analog research station Habitat Marte, Brazil.

TECH E-2

BIOCOLCHON SPACE GARDEN

ALEJANDRO SALINAS TÉLLEZ, FEDERICO GRANADOS UNGER

NATIONAL POLYTECHNIC INSTITUTE,
MONTERREY INSTITUTE OF TECHNOLOGY AND HIGHER EDUCATION

Food production for long-duration missions represents one of the greatest challenges in the space sector. The BioColchon Space Garden project was created to solve this problem, by incorporating biotechnological and agricultural techniques in the development of space technology that will enable diverse vegetable species for human consumption, to grow sustainably in microgravity conditions.

The BioColchon Space Garden system consists of a device that enables the development of diverse vegetable species for human consumption in simulated microgravity conditions. Our creation has soil-monitoring and environmental-control systems that are capable of not only obtaining precise measurements of the substrate conditions, but also of providing the vegetables with isolation from microorganisms, an automatized irrigation system, and controlled environmental conditions. Together, these systems make it easier for vegetables to grow under simulated microgravity conditions.

One of the most important milestones of the project is the growth of potatoes (Solanum phujera), corn (Zea mays) and lettuce (Lactuca sativa L.) in our system, achieving not only the successful sowing and germination of their seeds, but also their complete development. In addition to this, vegetables from the species mentioned above have participated in experiments where fully-developed plants were exposed to adverse temperature and humidity conditions, with the objective of determining their research potential in Analog Mars Missions, such as those offered by the MDRS, where our team seeks to participate.

TECH E-3

AQUAPONICS, AS A FOOD PRODUCTION ALTERNATIVE FOR COLONIES ON MARS

SANDRA TORO, LAURA SANCHEZ
LILIANA SABOGAL, MARCOS ALEMAN

THE MARS SOCIETY COLOMBIA CHAPTER COLOMBIA

The aquaponic social system for evaluating the adaptation and performance of plants and fish implemented at the SENA Agricultural Biotechnology Center, in Mosquera Cundinamarca, consists of an aquaponic module of polyvinyl chloride that works with the film technique of Nutrients. The aquaponic module consists of the following parts: a canvas culture tank with a capacity of 9000 liters; a tank internal recirculation pump and a submersible pump that circulates the water through the tubes. In the experimental NFT system, 12 rigid PVC tubes 3 meters long and 2 inches in diameter were used. 10 6 cm holes were drilled in each tube circuit. diameter at a distance of 30 cm between holes. The determination of the production volume is carried out according to different objectives, fundamentally: energy supply, water flow or available land area, admissible load capacity and profitable sales possibilities. Thus, each of the phases in the production process is being analyzed, and the requirements in terms of infrastructure and equipment necessary to obtain the desired results are determined. Likewise, sludge digesters are used in order to maximize efficiency through the reuse of solid waste. In this sense, the reuse of solid residues from crops greatly reduces anthropogenic nitrogen losses from food production, which have significant impacts on the environment. It is important to highlight that the excessive use of nitrogenous compounds in food production was responsible for 68-93% of total loss of anthropogenic nitrogen in the last decade and in the future, it is expected that the loss of nitrogen from food production will increase dramatically due to the increase in world population, which is estimated to increase from two to three billion people in the next 30 years.

TECH E-4

MEAD, AS AN ALTERNATIVE DRINK FOR COLONIES ON MARS

NATALIA RODRIGUEZ, MONICA OSPINA
SERGIO GONGORA, SEBASTIAN MORENO

THE MARS SOCIETY CHAPTER COLOMBIA

The alternative use chosen in this project for bee honey is mead, an alcoholic beverage accidentally discovered in antiquity by man, after trying a bowl of honey into which rainwater fell, fermented by environmental conditions ; resulting in a sweet, slightly acidic drink with a notable degree of alcohol, which makes it one of the oldest alcoholic beverages on record (Castells, 2010).

Work has been done since last year on the production of mead from a production approach that allows maintaining quality conditions but does not require the acquisition of highly technical machinery, but that beekeepers can carry out production in an environment with the necessary conditions for a food preparation area according to current legal regulations.
This drink has great versatility due to the fact that some additions or changes in the production process allow obtaining very different products, many alcoholic beverages can be obtained from the fermentation of honey, including wine-type sherry, sparkling wine, fruit wine and honey, and different types of mead. These products have different flavors depending on the floral source of the honey, the yeast used in the fermentation and the presence of additives. So far, trials have been carried out with honeys from the Savannah of Bogotá, Colombia, commercial yeasts and alternatives in the preparation of the must, such as the addition of hops, aromatic herbs and carbonation, identifying the variables to be controlled in the fermentation, such as pH, solids soluble and acidity and determining the maximum alcohol production capacity, which was 12%, the organoleptic characteristics generated during the fermentation and maturation processes were determined, we will continue working on the standardization of production parameters that allow obtaining quality products.

TECH E-5

BAKERY AS PRIMARY FOOD FOR COLONIES ON MARS BASED ON MICROALGAE

MARIO COLORADO, FABIO QUIMBAYA
GERMAN SARMIENTO, CARLOS SARMIENTO

THE MARS SOCIETY CHAPTER COLOMBIA

From the point of view of microbiology in the macroproject, the use of microalgae such as Haematococcus pluvialis and cyanobacteria such as Arthrospira maxima (Spirulina), have been used as food for both animals and humans. The importance of these microbes is fundamentally in their practicality to be cultivated in confined spaces. Additionally, the relative reduction of time in production cycles from the inoculation of the strains to the biomass harvest allows the generation of fresh biomass with relative speed. However, the challenge of food production in areas with little or no resources necessary for food production, such as water, minerals, and nutrients, requires innovation in materials and systems aimed at achieving establishments that facilitate production in adverse conditions. Bakery Products are considered as basic elements in the diet of the world population. There are included food products such as bakery products, pastries, biscuits and cereals for consumption at breakfast. Today part of the bakery products are obtained through the use of MMC, these have application at both industrial and artisanal levels, the latter being the ones that are commercially opening up a great path in the consumption of households in the world today (Foschino et al, 2004). One of the challenges presented by the use of microalgae and cyanobacteria in human nutrition lies in the palatability of the food or food mixtures. Therefore, from the CBA-SENA gastronomy school, trials are established on MMC-based breads, cookies and cereal bars, MMC is defined as a homogeneous mixture of flour or mixture of flours and water, which over time is fermented by the action of the BAL, responsible for the acid character of this mixture and by yeasts that are the cause of the fermentation process.

TECH E-6

REDUCING PERCHLORATES IN THE MARTIAN SOIL WITH M(BH4)2

SEOJIN YOU, MARK ZOTTOLA

BUGIL ACADEMY, SOUTH KOREA

A reliable means of generating food must be secured before we settle on Mars. However, the presence of perchlorate (ClO4-) in the Martian soil poses a challenge; its concentration of 0.5~0.7wt% by volume is capable of harming plant growth as well as human health. Therefore, an expedient way of degrading perchlorate in the soil is needed.

This project proposes a unique chemical solution—the use of borohydride (BH4-)—to reduce perchlorate. Preliminary computations revealed that the electrostatic repulsion between perchlorate and borohydride provides an insurmountable barrier for reaction. Therefore, divalent metal cations (Mg^{2+} and Zn^{2+}) were used as coordinating agents to catalyze the reaction. Our study comprised a sequence of reactions: The first one focused on the reaction between a divalent metal ion and perchlorate. Thenceforth, the complex was reacted with water to determine the relative reactivities between the metal ion with water and the metal ion with perchlorate. Following this, the complex was reacted with borohydride. Our results validated that reduction of complex perchlorate with borohydride and a metal cation is facile.

We present data on the relative stabilities of the various complexes encountered during the reaction sequence. Further, we show, from NBO analysis, a clear rationale for not only the reaction sequence proceeding but also the molecular interaction stabilizing per each intermediate.

TECH E-7

GROWTH AND SURVIVAL ANALYSIS OF RHIZOSPHERE BACTERIA ON MARS SOIL SIMULANT UNDER SEVERAL SIMULATED MARS CONDITIONS

MIAN BEHZAD NADEEM, FAISAL KHAN, NOOR MUHAMMAD

KOHAT UNIVERSITY OF SCIENCE & TECHNOLOGY

Initial Mars colonizers utmost priority will be growing plants on the hostile planet. These plants will be of vast use ranging from being an essential food source to raw material for different industrial products. Rhizosphere dwelling bacteria perform key functions in growth and development of plants. In this study, the growth and survival of rhizosphere bacteria (Rhizoplane & Ectorhizosphere) was examined for a period of 7 days in Khyber Pakhtunkhwa mountain clay & Mars Global Simulant–1 (MGS-1) both representing Mars soil. The simulated Mars environment consisted of diurnal temperatures (positive 25 °C to negative 80 °C), low soil moisture content (1%), anaerobic atmosphere (carbon dioxide dominant) and UV-C ionization radiation (253nm). These conditions were tested alone, in combination and all together for effects on bacterial growth and survival. Bacterial cells were inoculated in various volumes (1%, 20%, 40%, 60% & 100%) in 5 grams of Mars soil simulant. Cell inoculums were nutrient broth (O.D. 0.6) and cells suspended in distilled water only. Bacterial cell counts in Mars soil simulant were analyzed through optical density measurements. Isolation of bacteria was done through serial dilution from all the soils. All the tested simulated Mars conditions had a negative impact on the growth and survival during 7 days exposure. Major cause of bacterial biomass reduction was ionization radiation and soil desiccation. This work may have significant implications in deciding which bacteria should be considered to grow on Mars for an effective growth of plants.

TECH E-8

COMET SIDING-SPRING AT MARS AND POTENTIAL COMETARY PLASMA BENEFITS

WILLIAM W. "BILL" GARDINER, HOLGER ISENBERG

ANALYTECH, A DIVISION OF LABORATORY CONSULTING SOURCES, INC.

On October 18, 2014, comet Siding Spring (C/2013 A1) passed near Mars at ⅓ the Earth's lunar distance and showed an energizing effect on the upper Martian atmosphere of the whole planetary hemisphere and its magnetic field. While this effect might create concern about human Mars exploration, it provides an opportunity for insight into the true nature of effects observed around comets and how those could be actually useful for planetary expeditions to Mars and other bodies within the heliosphere.

In this context, the results of the Langmuir probe aboard the Rosetta mission to Comet 67P as presented by Dr. Franklin Anariba, electrochemist at the University of Singapore, are of interest. The known electrochemical processes may connect the comet mineralogy to the abundant water in the plasma tail of the comet.

This abundance of water in the tail of the comet and not on and in the core, is a new model for cometary behavior and explains the evident lack of water ices on comets observed by all 5 major cometary explorer missions of recent years. Implications for possible delivery of volumes of volatile gases and water to the surface of Mars in large quantities are discussed.

ANALOG BASES-1

THE PSYCHOLOGICAL AND PHYSIOLOGICAL IMPLICATIONS OF SETTLING MARS: LESSONS LEARNED FROM ANALOG ASTRONAUTS

NICOLE CHASE

SEDS USA

Not only will the journey to and the process of establishing a base on Mars be challenging from an engineering perspective, but it will also be challenging from a space medicine perspective. How will humans react to living on a different planet that has little in common with Earth? How will their bodies react to the long journey to Mars and to the differences in gravity once on Mars? These, and other questions, must be asked by researchers to ensure that not only do the humans make it safely to Mars, but that they continue to thrive once on the red planet. This study hopes to give some more discussion into how the brain and body changes both during the trip to Mars and once the brain and body are on Mars. Using data collected from numerous analog astronauts, this study will create a data model to help predict (or otherwise forecast) what future astronauts might experience psychologically and physiologically during the flight to Mars and once on Mars. Future studies will examine more specific parts of the human psyche and body that the collected data and the data model seems to point to as being absolutely crucial (i.e. combating mental health problems, etc.). In doing so, this will help bring another voice to the conversation of travelling to and settling Mars, a voice that needs to be heard and needs to be understood completely. Additionally, based upon the future results of this study along with future studies, technology can be better designed to ensure that humans can (and will) thrive on Mars.

ANALOG BASES-2

MULTI-NATIONAL DESIGN OF MARS MISSIONS

MARCO MARSH, FIONA MCALLISTER, JOHAN BERTRAND, MIRELA DE ABREU, MIRANDAH ACKLEY

INTERNATIONAL SPACE UNIVERSITY

The first analog experiment, BIOS-3, was created by the Russians to simulate the closed environment of space for life support systems. Analogs have since become integral elements for exploring space by providing a means to stress-test space mission components before a full launch. There is an enduring interest among space agencies to one-day send crews to Mars, where such missions would significantly outlast any crewed historical missions to date. Analogs as platforms for mission simulation and investigative research for both behavioral and structural elements will become a vital part of the success of future Mars missions. The goals and research interests of five major space agencies (i.e., NASA, ESA, ISRO, Roscosmos, and CNSA) concerning Mars mission analogs shared here exemplify this. While many analog studies have been collaborative efforts, objective misalignment between space agencies, funding inadequacies, and limited analog access collectively hinders the ability of all space agencies to advance toward self-imposed Mars mission targets. This paper advises a series of actionable recommendations to overcome the observed challenges and shortcomings, based on an analysis of the current goals and trajectories of the identified space agencies. Presented here is a solution with a focus on increasing international collaborative efforts in the future through a neutral entity or broker. The ISECG was identified as a suitable forum to broker forthcoming talks for designing a multi-national analog consisting of the parties identified. The core themes in future discussions should include developing a global analog assessment tool, renting private analogs, and prospective sites for a multi-national analog

ANALOG BASES-3

LESSONS LEARNED - A STUDENTS' APPROACH TO DESIGNING A ROVER FOR AN ANALOGUE MARS MISSION

JAKUB TYMOSZUK, FRANCISZEK WALESIAK
JAKUB FABISIAK, MATEUSZ SZYMAŃSKI, ALBERT PIECZUL, TOMASZ MIŚ

STUDENTS' SPACE ASSOCIATION WUT

The Students' Space Association has been participating in analogue Mars rover competitions since 2010 with its first rover design 'Skarabeusz' ('Scarab'), developed since 2008. Since then five more rovers have been designed, constructed and tested, as a response to constantly evolving competition rules. The specificity of a student project means that there is a constant rotation of team members. This causes issues with project maintenance and causes it to evolve rapidly. In this paper we aim to summarize our team's technical experiences gathered during developing systems as a part of a multidisciplinary project that is fully managed by students in their spare time.

ANALOG BASES-4

HI-FIDELITY MARS HABITAT SIMULATION PROVIDES UNIQUE EDUCATIONAL EXPERIENCE FOR CITIZEN SCIENTISTS

KAI STAATS, IURII MILOVANOV
EZIO MELOTTI, DON BOONSTRA

UNIVERSITY OF ARIZONA'S BIOSPHERE 2

Since the Apollo era, analogs have provided astronauts and researchers opportunity to study components, techniques, human health and psychology, and mission planning. Analogs vary in degree of fidelity, from the natural landscape of Meteor Crater Arizona, to the Mars Desert Research station in Utah, to the sealed bioregenerative Lunar Palace operated by Beijing's University of Aeronautics and Astronautics.

Computer software brings researchers into environments too difficult or costly to replicate, for the study of emergent behavior in complex systems and compression of long-duration missions across a multitude of parallel computational studies.

SIMOC is a scalable, interactive model of an off-world community. This hi-fidelity computer simulation incorporates NASA data in human factors and plant physiology, design parameters by Paragon SDC, and data generated in a plant study at the Biosphere 2 (ICES 2019).

Development of SIMOC was funded 2017-19 by Arizona State University's Interplanetary Initiative and is currently licensed and hosted by the National Geographic Society for integration into classrooms, world-wide.

This research grade, simulation engine provides novice and advanced users opportunity to select the number of crew, quarters, greenhouse, plants, life support, power generation and storage, and then set the model in motion for the selected duration. The fundamental goal is to design a mechanical and bioregenerative life support system for long-duration missions and isolated communities. SIMOC was used to generate data for NASA's 2019 greenhouse challenge winning team.

We propose a live demonstration and Q&A session for the Mars Society 2020 conference.

ANALOG BASES-5

SPACE ANALOG VIRTUAL TRAINING

JULIO REZENDE, DAVI SOUZA, DALMO SANTOS

HABITAT MARTE

The space analog station Habitat Marte is an initiative very connected with Quality Education, one the Sustainable Development Goals of United Nations.

The organizers developed a new category of space analog missions during coronavirus pandemics: the virtual missions.

Was observed, that COVID-19 pandemic made it difficult to carry out missions in space analog station Habitat Marte in person, considering the possibility of disease spreading if one of the participants be infected and transmit to other. In addition, respiratory allergies (runny nose and sneezing) that would occur during physical missions in Habitat Marte, could be seen as a symptom of coronavirus, creating a worry about.

In view of this scenario, a proposed innovation for the continuity of Habitat Marte was virtual missions. Missions 33-45 (March-July 2020) have already taken place according to this methodology.
In virtual missions, participants are invited to participate in remote activities related to the Habitat Marte protocols and research themes associate to space and sustainability, observing how Habitat Marte would contribute to solutions related to isolation during the coronavirus period. We realized that the actions of Habitat Marte may present guidelines for this challenging moment.

The virtual missions would also bring learnings to education in space and also collaborating to good relationship in the crew.
The research also evaluated benefits/advantages/disadvantages.

ANALOG BASES-6

CONSTRUCTION OF A NAMOGA RESEARCH STATION IN THE NAMBIE DESERT BY TRANSFORMING A BLUEBIRD CARCASS INTO ONE OF THE NOS ON THE INTERNATIONAL SPACE STATION

MARCO ROMERO, CRISTOVÃO CACOMBE
PAULO CESAR, ALFREDO CAPITAMOLO

ANGOLAN OFFICE FOR SPACE AFFAIRS

Construction of a namoga research station in the Nambie desert by transforming a bluebird carcass into one of the Nos on the International Space Station

Angola space sector had an abrupt development on the las 10 years. Nowadays little groups of Startups and Universities has sparked their interest for the NewSpace, a chapter from the Mars Society was created in Angola and several other events are requiring attention. With the ultimate aim of satisfying the demand for infrastructure and conditions for the development of the activity of education, research and development in the space sector in Africa, this article presents the strategy and concept for the reuse of an abandoned bus station and through a Systems Engineering, Robotics and Space Architecture approach transform it into one of the nodes of the International Space Station. Those nodes present similar geometry and applicability of as caravan buses.

The Namibe desert was chosen because it has the most appropriate geographic, geological, biological and climatic conditions to establish the analogous mission and also because it is aligned with the vision of expansion of the Angolan Chapter of the Mars Society.

The conceptual dimensioning was done using the Lean concepts of Project Management and the Agile Model based System Engineering and was based on the requirements for Low Earth Orbit and Martian surface readjusted to Namibe's figures.

Having presented this concept, we intend to move on to the subsequent phases of the project, which involve gathering financial and material capacity for real implementation, taking into account that from the Project presented in this article, we can see that in a 6-month interval, with a daily workload of 5 hours , distributed by a team of 18 people in more than 8 areas of knowledge, has set up an analogue research station in the middle of the Namibe desert with the capacity to receive crews of 6 to 10 astronauts while maintaining sustainable operation and maintenance costs.

ANALOG BASES-7

STRATEGY FOR AFRICA'S PARTICIPATION IN THE INTERNATIONAL SCENARIO OF HUMAN AND ROBOTICS EXPLORATION OF THE SOLAR SYSTEM

MARCO ROMERO, RUVIMBO SAMANGA
ELDRIGE DE MELO, ARMANDO TEIXEIRA

SPACE GENERATION ADVISORY COUNCIL

Strategy for Africa's participation in the international scenario of human and robotics exploration of the Solar System.

Due to its political, social and economic conjuncture, Africa has followed with relative delay the global evolution in the space sector. The main and most addressed reasons are: the prioritization of space applications to solve the main Sustainable Development Goals (SDG), the small belief or knowledge about the benefits of space and the reduced level of digital literacy and infrastructures and lack on the capacity building in different areas.

Increasingly growing and part of the 17 SDG, the implementation of Space programs requires Technical and Professional skills, Investments and Infrastructures that many countries sometimes lack or don’t have to implement in order to guarantee their sustainability. With the advent of NewSpace to complement the traditional Space, arrives a paradigm shift where the upstream and downstream of the space are increasingly decentralized and small players start having more access to space, with low costs and higher margins of failure. That brings more disruptive business models, technology and opportunities for Africa to enter in this new space race. After having studied, through bibliographic research, interviews and the identification of practical explosions, the origin of several space programs and their evolution until they obtain the human and robotic exploration capacity of the solar system, this article proposes the main strength points and respective disadvantages of some of the African countries that can guarantee medium and long-term entry into the space sector.

The analysis showed that Africa have several opportunities and benefits in joining the exploration of solar system either through its enormous human potential in Space legislation, Space Analogue Sites, System Engineering, Project Management, Astronomy, Miniaturization of Technology, STEAM, Integration in Initiatives like the Mars Society and affordable accessibility and a possible integration of the eighteenth Sustainable Development Objective into the 2030 Agenda.

ANALOG BASES-8

MARS ATLAS—YOUR GATEWAY TO MARS GEOGRAPHY AND GEOLOGY

JAMES SECOSKY

RETIRED TEACHER FROM BLOOMFIELD CENTRAL SCHOOL AND FINGER LAKES COMMUNITY COLLEGE

The Mars Society's Mars Atlas at Marspedia.org can lead you to all places on Mars and to current ideas on its geology. In this talk, Jim Secosky will walk you through numerous maps and links. There are maps showing where everything is: water, ice, volcanoes, craters, geological features, as well as successful and unsuccessful landings.

To find detailed information, one can click on a quadrangle from a list or just click a point on the main map. That will take you to quadrangle articles with dozens of pictures taken by spacecraft since the 60's and 70's. To choose the best pictures of each quadrangle thousands of pictures were examined. Most of the pictures came though the HiWish program, which since 2010 has allowed amateurs to select locations for NASA to photograph with the powerful HiRISE. All major features of the quadrangle are described and illustrated. Each quadrangle has links to special topics and to outside sources such as past Mars Society talks from other conferences. Some of the top experts on the planet can be heard through these links. In the talk, we will look at the Oxia Palus quadrangle where the pathfinder landed and where EXoMars will land. Mars Atlas is valuable for students, teachers, journalists, or anyone else interested in seeing what the planet looks like and what is significant--especially for future colonists. Each article in Marspedia contains many references. Every effort has been taken to provide the original sources of research, particularly from refereed journals. For easier reading, other sources like press releases are cited. Many references are on the internet and are just a click away.

Note: For official information on the names of Martian features go to Gazetteer of Planetary Nomenclature at https://planetarynames.wr.usgs.gov/

POLITICAL-1
A PRIZE FUND TO GET HUMANITY TO MARS FASTER?

CHRIS BELLANT, MINA MUKHAR

MARS INITIATIVE

Since the industrial revolution cash prize funds have helped push the bounds of human ingenuity. This presentation will discuss the common reasons cash prizes are created and their effectiveness in achieving the stated goal of the prize. The largest prize funds to date are examined to extrapolate how a Mars Prize Fund would work. We will then discuss how the Mars Prize Fund has been created and is being rolled out to ensure humanity gets a crewed mission to Mars in our lifetime.

POLITICAL-2

THE U.S. SPACE FORCE REPRESENTS A GRAVE DANGER TO THE HUMAN EXPLORATION AND SETTLEMENT OF MARS

EDWARD HEISLER

MEMBER THE MARS SOCIETY MEMBER THE PLANETARY SOCIETY
FORMER TEAMSTERS UNION PROJECT ORGANIZER
FORMER RAILROAD UNION REPRESENTATIVE IN CHICAGO

"Space is a war fighting domain … It is not enough to have an American presence in space; we must have American dominance in space." Vice President Mike Pence.

Former Acting Secretary of Defense Patrick Shanahan declared that "Space is no longer a sanctuary. I'm fully confident we could win a conflict in space today." Secretary of Defense Mark Esper explained: "Maintaining American dominance in that domain is now the mission of the Space Force."

China is the most likely target of the proposed space war.
The drumbeats for starting a war against China are getting louder and louder. Some politicians are now openly advocating a war with China!

What is the most obvious danger to our planet if Space Force warriors are ordered to begin combat operations against Chinese assets in outer space?

Here's what Apollo astronaut Edgar Mitchell said back in 1989 "any war in space would be the one and only. By destroying satellites in space massive amount of space debris would be created that would cause a cascading effect and even the International Space Station would likely be broken into tiny bits." Mitchell said that so much space junk would be created that we would not be able to get a rocket off the planet again for decades. "Modern society would go dark." If that should take place, we can kiss every nation's plans for the human exploration of Mars goodbye

Such a space war could quickly escalate into a direct nuclear exchange with China and possibly Russia. A world-wide confrontation would threaten the annihilation of humans and at best result in the collapse of civilization and a return to barbarism.

We have the power to stop that outcome.

POLITICAL-3

LIBERTY IN SPACE: ARTEMIS ACCORDS AND THE RULE OF LAW

ART HARMAN

THE COALITION TO SAVE MANNED SPACE EXPLORATION

You may have read NASA's "Artemis Accords," but did you understand their importance? There's ten principles, and of those, three are of the greatest interest to Mars and Moon explorers, entrepreneurs and colonists.

Why do these matter? Let's look at property rights on Earth. If you can't own, lease or control the location where you want to build a mine, house, store or even a lemonade stand, you can't do business. And if someone forces you to share what you earn with everyone else, you'll never be able to eat, and you won't even bother.

A long time ago there was a buzz about deep seabed mining. Manganese, cobalt and more. Plans to extract these abounded, but then the Law of the Sea Treaty nuked the concept by requiring splitting earnings with the world and sharing technology too. Essentially like doing business in China. So deep seabed mining in international waters quietly evaporated.

The Moon Treaty similarly declares natural resources are the common heritage of mankind. Follow that, and you'll never raise a dime to build your propellant depot or colony. And to do anything on the Moon under the treaty requires the approval of a bunch of bureaucrats who may have their own vested interests and loyalties to other states. Thankfully, most countries didn't ratify it and it takes just a year's notice to withdraw. The L5 Society helped block it in the U.S. This is why NASA is creating the Accords; to provide a true foundation for the rule of law in space. I will show why property rights, which have protections as "safety zones" in the Artemis Accords, are the fundamental basis for a successful economy anywhere in space, including on Mars and the Moon.

POLITICAL-4

THE ARTEMIS ACCORDS: IMPACTS ON MARTIAN CONSTITUTIONS

JAMES GILLEY

NICHOLLS STATE UNVERSITY

On May 15th, 2020 NASA released a revised set of guiding principles for human space activities known as the Artemis Accords. These 10 principles seek to update and clarify the larger body of space law that has essentially lain fallow since the late 1970s. While aimed primarily at more near-term moon-centric activities, these Accords could have a great deal of impact on human settlement of Mars should they achieve international normative status. This paper will examine the impact of the Artemis Accords on the wider spectrum of human space activities. In particular, attention will be focused on the impact of the Accords on the process of establishing a legal and political regime for a human Mars settlement. As we progress in our technical capabilities towards establishing a settlement on Mars, the need for a political and legal regime will become much more foregrounded. The time has come to begin preliminary planning for what such a regime and set of institutions might look like. While the particulars of the governing institutions might be best determined once on the ground realities of Martian settlement emerge, the principles about how those institutions can be crafted can be explored using current understandings of best practices of constitutional engineering. The contours of a Martian Constitution and how they bump up against current space law and the Artemis accords will be explored.

POLITICAL-5

A STATISTICAL LOOK AT MARS COMPANIES IN 2020

ERIK KULU

FACTORIES IN SPACE

The number of new space companies aiming for Mars is starting to take off. Applicable industries include surface habitats, commercial landers and rovers, ISRU technologies, human spaceflight and space tourism among others.

Factories in Space (www.factoriesinspace.com) is the largest online database of commercial entities in the emerging in-space economy and space settlement fields. The directory has over 250 entries and is growing quickly. Approximately 100 already are or promptly could become involved with Mars with SpaceX being the best-known company working towards a Mars transportation system. While most of the commercial lander, ISRU, habitat and space utilities (energy, oxygen, metals, water, food, communications) enterprises are focusing on the Moon at the moment, many of them could add Mars to their activities once launch opportunities and market arise.

Let's have a first statistical insight of which commercial entities are or aim to become active in the exploration and settlement of Mars. To leave a snapshot and to start discovering the trends and the next space boom about Mars companies over the coming decade. Part of the work entails making an attempt to establish classification for the commercial entities to be able to group them. Within the categories, comparison will be made between capabilities, development status, geographical distribution and funding where available.

As far as the author is aware, such analytical overviews and taxonomies for Mars and in general for the beyond-Earth space economy have not been published before. The aim is to make this analysis about the state of the industry a yearly occurrence.

POLITICAL-6

A METRIC OF SOLAR SYSTEM DEVELOPMENT

PETER HAGUE

In spaceflight as in any other field, measuring progress is a necessary component of making progress. We can measure mass to low Earth orbit, or to the surface of the Moon or Mars, but such metrics are limited to a single destination. I will present and discuss an alternative metric - mass value - that can compare all possible destinations with a single figure of merit.

Space policy based on such a metric would give commercial and non-government entities freedom to pursue mission objectives how they see fit and enable an acceleration of space settlement.

This is a presentation of a paper published in New Space in March 2020

POLITICAL-7

ALL SPACE TO ALL

MANOUSOS CHAIRETIS

THELLAS SA (UNDER CREATION)

The ALL SPACE TO ALL presentation, re-proposes the adoption of the Minoan lifestyle and mentality that guided humans to use space for the benefit of ALL humanity. Inspired from the Minoan 4400-1100 BC era mindset mentality, scientifically proved to be practically the original known celestial minded human existence.

It will present that Minoans successfully explored, all world they needed to progress during their era using space. They devised technology to support their quest, based on astronomy, math, physics, engineering, technicalities adapted to the human physical environment.
As the Minoan era sustained for 3.5 thousand years, in absolute peace and prosperity for the benefit of all humanity managed to spread to the all earth the art to proceed using earth space (at that era land and sea only). As known Daedalus and Icarus Myth triggered from the will of humans to achieve liberty using their technical intelligence was made while they were kept in the Labyrinth at Knossos palace.

Unfortunately, the eruption of Santorini (Thyra) volcano approximately 1600 BC, destroyed the cradle of the Minoan peaceful triumph, leaving humanity in a three thousand year struggle into the darkness of unwillingness, to progress explore/exploit/inhabit universe for the right reasons. The presentation will pass through modern available and readily available technology options critically judging the pros and cons.

The speech will show the vast room for improvements in any aspect regarding human space exodus.
Critical questions will be introduced to the audience as to touch the core of their will and produce the right answers that will lead to the right decisions.

Finally, a series of tangible proposals inspired by the vision of ASTERES organization (under creation), will be offered and any audience desired questions will be taken from the speaker.