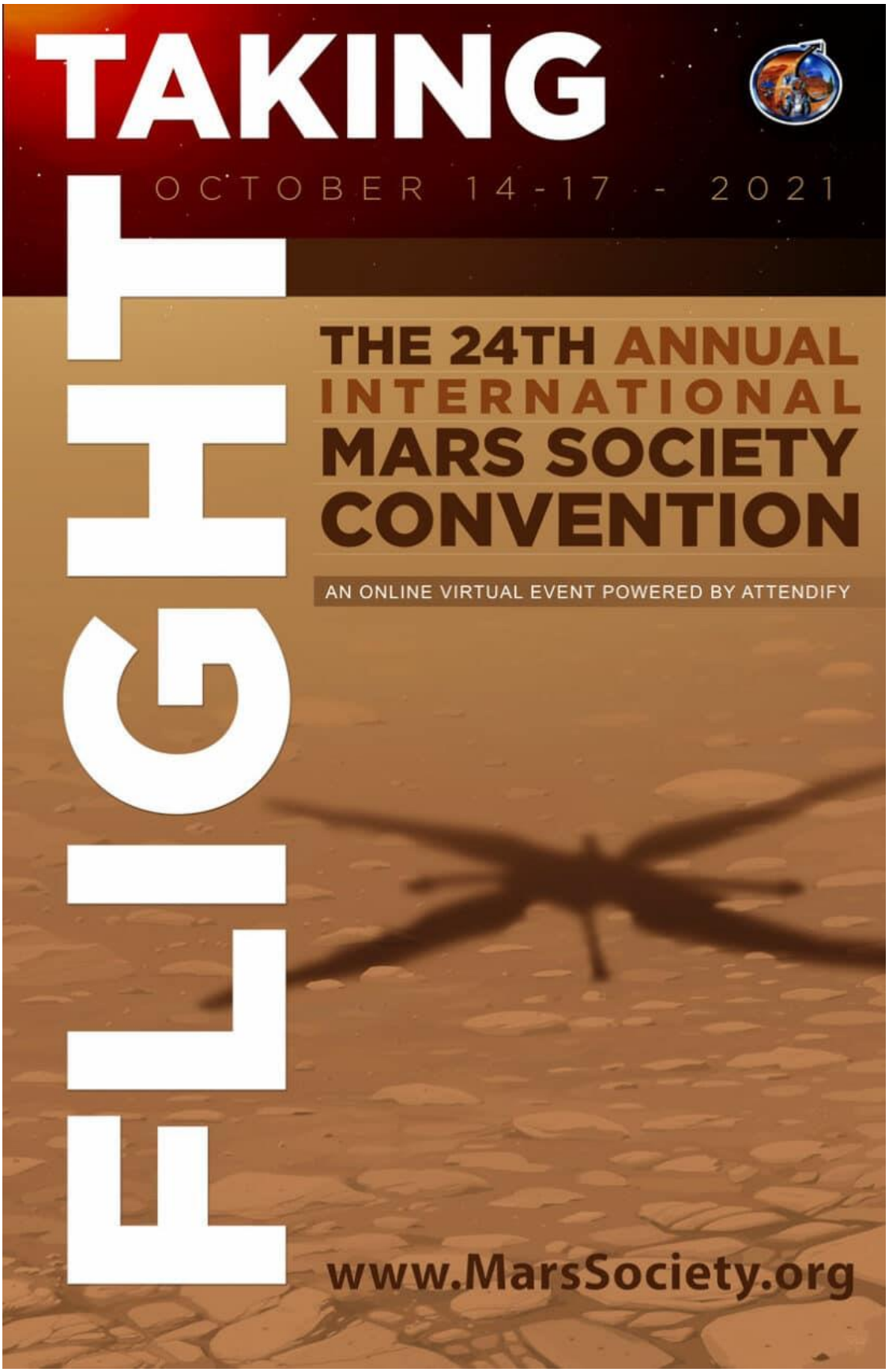
TAKING
FLIGHT
OCTOBER 14-17 - 2021
THE 24TH ANNUAL
INTERNATIONAL
MARS SOCIETY
CONVENTION
AN ONLINE VIRTUAL EVENT POWERED BY ATTENDIFY
www.MarsSociety.org

	Saturday October 16th			
All Times PDT	**Morning Plenaries**			
9:00 AM	Pam Melroy, Deputy Administrator, NASA - NASA's Path to Mars			
9:30 AM	Barbara Belvisi, CEO, Interstellar Lab - Sustainable Space Settlement			
10:00 AM	Dr. Carol Stoker, NASA-Ames - Finding Life on Mars			
10:30 AM	Dr. Paul Davies, University of Arizona - What is Life?			
11:00 AM	Dr. Chris McKay, NASA-Ames - Terraforming Mars			
11:30 AM	Dr. Steven Benner & Jan Spacek, Astrobiology Group - How SpaceX Could Find Life on Mars			
12:00 PM	Dylan Taylor, Founder, Space for Humanity & CEO, Voyager - Opening Space for Humanity			
12:30 PM	Dr. Bernard Foing - EuroMoonMars highlights, instruments, field campaigns			
1:00 PM	Dr. Charles Cockell, University of Edinborough - Engineering a Free Mars			
	Afternoon Sessions			
	Tech E	**Tech F**	**Political/Philosophical B**	**Mixed A**
2:00 PM	TE-1 Chaturvedi et al: Challenges of Mars settlement: Planetary surface perspective	TF-1 Chen: Remotely sensing Martian dusting storms from space using machine learning	PB-1 Kenyon: The Two Plots Problem: Dealing with Death and Crime in a Martian Colony	XA-1 Gerard: 20 years of European Mars Conference (EMC)
2:30 PM	TE-2 Marefat: The need for speed in Space Power Electronics	TF-2 Arora: Astronomy On Mars	PB-2 Zara: Mars, Terra nullius	XA-2 Canada: Raise your Voice - Comms, Before, During and After Mars
3:00 PM	TE-3 Baldock: Semi- Cycling and the Martian Export Market	TF-3 Collier-Wright: Overview of NEP for Human Space Exploration Missions	PB-3 Bhatt: Legal perspectives on the political economy of a Martian settlement	XA-3 Rezende: Building experiences in the Lava Cave Habitat space analog
3:30 PM	TE-4 Trevino et al: Micro Algae for Life Support	TF-4 Collier-Wright: Superconductor Magnetohydrodynamic Shielding System	PB-4 Young: Sicut in Caelo et in Marte: Implementing a Catholic Diocese of Mars	XA-4 Shull: Modify MDRS Layout to Resemble Lunar Lava Tubes
4:00 PM	TE-5 Khalid: Evaporite Minerals at Ritchey Crater using CRISM Hyperspectral Data	TF-5 Humble: A spinning toroidal gravity facility for mars.	PB-5 Dyck: Saint John's Newfoundland – historical example of settlement	XA-5 Wise/Burk/Lopin: Land Rights and a Centralized Mars Database
4:30 PM	TE-6 Shah: Martian Paraterraforming	TF-6 Collier-Wright: Superconductors as Enabling Technology for High Power Space Missions	PB-6 Sayfullin et al: Doc- reality of family crews as a technology for settling on Mars	XA-6 Kapoor: Leveraging Mars to solve immediate problems on Earth
5:00 PM	TE-7 Dyck: Large Scale Colonization Ship	TF-7 Green: Walking on Mars: A Pathway to a Martian Space Suit	PB-7 Earnshaw/Gilley: Defining Mars for the purposes of a Martian constitution	XA-7 Muscatello/Blair: The Institute for Terraforming Earth and Mars (ITEM)
5:30 PM	TE-8 Mondal: Understanding the Surface Modifications at Mars Landing Site	TF-8 August/Borri: Improved Rocker-Bogie Suspension Block	PB-8 Wood/Gilbert: Toward a Martian Trade Economy	XA-8 Harman: Who's Winning the Moon Race— and Why it Matters for Mars
6:00 PM	TE-9 Mondal: Energy Supply System Applied To Mars	TF-9 Sharp: Xenotrophic gastronomy: fine dining on Mars	PB-9 Heisler: Threat of war against China to end our exploration of Mars	XA-9 Rafi et al: Implementation of Origami-Style in Mars Engineering

6:30 PM	TE-10 Łabowska/Suścicka: Design of Xors Moon Base	TF-10 Kumar et al: Underground Mars Habitat Design	PB-10 Chairetis: Proposal for Interhuman Space Immigration Corporation ISIC	XA-10 Mackenzie: Open Discussion on New Visionary Mars Projects
	Break (7pm - 7:30pm)			
7:30 PM	**Saturday Evening Program**			
	Digital Simulations & Entertainment Panel: MarsVR & Occupy Mars game (Moderated by James Burk - Mars Society Director of IT & MarsVR)			
8:30 PM	Erik Bethke, CTO: Million on Mars game			

2021 Mars Society Convention Schedule

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Saturday Afternoon Sessions

Political & Philosophical B

Mixed A

SATURDAY AFTERNOON SESSIONS

TE-1

CHALLENGES OF MARS SETTLEMENT: PLANETARY SURFACE PERSPECTIVE

SUDHIR KUMAR CHATURVEDI, ROHAN CHANDRA, ADHITHIYAN NEDUNCHERAN

UPES INDIA

While humans are fighting against global warming on Earth but are also planning to colonize Mars for major reasons such as survival of humans as a species, exploring the potential of life on Mars to sustain humans. Truly, Mars has been the planet with the most number of robotic missions so far with the hope for future settlement of humans. All the planetary exploration missions have helped in understanding Mars to a greater extent to plan for surface visits and settlements in the future. Using in situ resources on Mars for constructing settlement will not only save launch costs from Earth but also make it faster. This would certainly require advancement in the development of basalt additive manufacturing which is commonly known as 3D printing. The process for construction of the base is also discussed using robotic technologies. However, the first Astronauts to step on Mars would require to critically inspect the quality of the habitat structure that would protect humans from extreme temperatures and radiations. We briefly discuss the challenges for building habitats and the environmental concerns. The aim of this paper is to present the major factors that will be encountered by humans to establish a settlement on Mars at some point in the future.

TE-2

THE NEED FOR SPEED IN SPACE POWER ELECTRONICS

MOHSEN MAREFAT, BABAK PARKHIDEH

THE CATHOLIC UNIVERSITY OF AMERICA,
UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE

The adoption of post-silicon substrates for power electronics is a significant pathway to higher power density and better efficiency in electronics for space systems and stationary power facilities on the Moon and Mars. The transition to Wide BandGap (WBG) technologies has been faster and smoother than many predictions. Now is the time for power system designers to take full advantage of the inherent capabilities of the new materials: Shrink the size and increase robustness and reliability.

Speed is the key design difference. While higher breakdown voltage and current capability are the first level advantage over Silicon, switching speed is the game-changer that allows smaller coils and inductors that result in significant size/weight reduction. However, fast switching characteristics (less than 10 nanoseconds for Gallium Nitride GaN) require designers' attention to nuances and the use of new techniques for fault detection and fail-safe operation.

This tutorial-style discussion aims to inform all Space Application enthusiasts of the latest developments in Power Electronics and the resulting advantages for near-term deployment.

TE-3

SEMI-CYCLING AND THE MARTIAN EXPORT MARKET

PHILIP BALDOCK

NEXUS AURORA

Before a Mars colony can reach self-sustaining sizes it will find itself with a large population completely dependent on expensive technology imports from Earth. Somehow this must be paid for. This project suggests a novel approach towards dramatically decreasing export cost from the Mars system to Earth's orbit. Using material from Deimos to make products instead of Mars itself and novel orbital manoeuvres (via L1 Halo orbit) requires around 5 times less delta v for exporting goods compared to launching from Mars' surface, aided also by lower thrust requirements (fewer engines). For the other half of successful export to Earth, cheap aerocapture at Earth's atmosphere, a large reusable nickel superalloy spacecraft (a "semi-cycler") travels with the freight to aerobrake just enough for elliptical orbital capture. Its large size permits aerobraking without the use of disposable heat shields and greatly simplifies maintenance. Inbound freight from Mars now captured in a steep ellipse and detached from the semi-cycler, this freight can then gently aerobrake without the semi-cycler over many passes until low Earth orbit is achieved. The detached aerobraking spacecraft follows a steep ellipse to Sun-Earth Lagrange point 1, loitering until the next launch window where it launches outbound to double as a cycler-style living space for Earth->Mars passengers, hence the name semi-cycler. Storing orbital energy at a Lagrange point enables minimal outbound fuel costs and launch date flexibility. Together, the semi-cycler and use of Martian Moons for source material may provide as much as 50 times lower export costs than shipping naively from the Martian surface, making an entire new industry possible. The export of thousands of tonnes of satellite components and other goods at a profit from Mars could thus enable much quicker development of a Mars colony.

TE-4

ASTRONAUT ASSIMILATION OF AND PROPAGATION OF MICROALGAE FOR LIFE SUPPORT

TERRY TREVINO, ERIN STAMPER, LARRY HARRISON, DR. KRISTEN MILLER

AMERICAN MILITARY UNIVERSITY

The purpose of the study herein described is to prove that an astronaut in a spaceship will have the capacity to keep and maintain a micro algae, Limnospira fusiformis when presented with a rudimentary set of instructions and the appropriate equipment such as is consistent with that on the International Space Station. Transport of resources from Earth to beyond low Earth orbit is costly and not practical. Utilizing materials harvested in-situ on the surface of Mars will lower logistical constraints in a resource-limited environment. Microalgae have the potential to play a major role in maximizing self-sufficiency, supporting the resupply of vital consumables, and performing other functions on long-duration space missions as well as on a future settlement on Mars.
Hypotheses: H1: A Natural Scientist or Astronaut Candidate will have the capacity to perform spirulina maintenance given a typical astronaut schedule and maintain the health of the Limnospira fusiformis.
H2 : Limnospira fusiformis will propagate in its natural genetic sequence under habitat grow lights provided in a simulated spaceship environment.
Questions:

1.) What methodologies should be presented to the subject participant to make the process seamless and simple?
2.) What frequency of communications and information exchange is necessary to maintain the health of the Spirulina?
3.) Can the subject participant maintain the health of the Spirulina?

Progress to Date: The Team are working to actively propagate the algae in a lab environment building the methodologies and will test out the system in a scheduled analog mission inside the ILMAH at University of North Dakota.

Mission Start Date: 27 September 2021. The investigation is actively sponsored by SMEs, Erin Stamper, and Larry Harrison with corporate sponsorship from their employer, Cyanotech.

TE-5

EVAPORITE MINERALS CHARACTERIZATION OF MARTIAN RITCHEY CRATER USING CRISM HYPERSPECTRAL DATA

ROCHDI KHALID, ABDERRAZAK BANNARI, HASSAN RHINANE

GEOSCIENCE LABORATORY, FACULTY OF SCIENCES AIN CHOCK, UNIVERSITY HASSAN II

Minerals such as sulfates, carbonates, and chlorides have been remotely detected on the Martian surface. These evaporite deposits are not only indicative of environmental conditions of their formation but can provide clues indicating their interaction with water. Due to its narrow absorption features, spectroscopy is a powerful technology to identify and discriminate evaporite minerals. This study aims to detect such minerals including Ca-sulfate gypsum and salt deposits on Ritchey crater using hyperspectral data acquired by Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) carried onboard Mars Reconnaissance Orbiter (MRO). To achieve this, the data were pre-processed (destriping, sensor radiometric calibration, photometric correction, volcano-scan atmospheric corrections, noise filtering, spectral-smile correction, and data projection) using the CRISM Analysis Toolkit (CAT) which was implemented in ENVI-IDL environment. Afterward, the Normalized Difference Gypsum Index (NDGI) and Salinity and Solidicity Spectral Index (SSSI) were implemented, and maps derived. Integrating the shortwave-infrared (SWIR), these indices were developed and validated for the detection of gypsum and soil salinity in arid terrestrial lands over Omongwa salt-pan area which is a natural flat salt playa (dominated by gypsum and halite crusts) in Namibia and the salty desert of Kuwait-State which is very rich in sodium chloride (halite, NaCl), calcium carbonate (calcite, CaCO3), gypsum (CaSO4.2H2O), and anhydrite (CaSO4) due to sea-level rise and the depth of the water table which is near to soil surface. Analysis of the results obtained indicates that although both the indices have mapped the evaporite minerals patterns almost similarly, the NDGI further highlights the gypsum content. While the SSSI shows greater sensitivity to evaporite mineral crusts (halite, gypsum, etc.) particularly on the slopes facing the Sun. In addition, our results show that these areas are characterized by fine-textured soils forming fine and smooth crusts.

TE-6

MARTIAN PARATERRAFORMING

KHUSHI SHAH, ADITI PANDE, SAVRI GANDHI, RICHAL ABHANG

MUMBAI AND SAVITRIBAI PHULE PUNE UNIVERSITY

With the development of space technology and deterioration of Earth-based resources, settling on Mars is the next step for humans to become a spacefaring civilization. Terraforming is a process to convert unfriendly Martian surface into an ecosystem similar to that of our home planet. But with present-day technology, it remains at best a technological challenge for the far distant future. The scaled-down process of Paraterraforming is a much more feasible alternative. Paraterraforming creates off Earth habitable environments on volatile deficient planets. This paper maps out technologies that can be used for Paraterraforming the Martian surface. Modern engineering along with automation and robotics will help create and expand this concept remotely. A paraterraformed Mars will consist of standalone or multiple interconnected dome-like structures known as World houses. The unbreachable multi-layer habitat will be built using self-repairing, radiation-resistant material implementing additive manufacturing techniques such as 3D Printing and Sintering from local regolith. With the advent of robotics, a swarm of rovers can be appointed for auto-maintenance technology. Internet of Things (IoT) and its applications will be used to monitor environmental parameters like the composition of the atmosphere, to ensure optimum living and breeding conditions for earth organisms. HVAC systems along with Waste Management & Life support systems will be present inside the habitats. The focus will also be on ISRU for tapping into Martian resources for mining CO_2 and water ice from polar ice caps which can be transported back to the habitat using the rover swarm. Nuclear technology & Radioisotope thermoelectric generators along with Solar Arrays will be used as key energy sources. The success of the world houses will lead to expanding the terraforming techniques to the entirety of the planet, thus converting Mars from a secluded barren planet to one flourishing with life.

TE-7

LARGE SCALE COLONIZATION SHIP

ROBERT DYCK

ARDECO AEROSPACE

Proposal for a very large ship to carry settlers to Mars. This ship is designed to be built in Earth orbit, and travel from Earth orbit to Mars orbit and back. It will never land on any planet, so can be purpose built for space. This isn't intended to replace SpaceX Starship, but to work with it. This started when someone sent a tweet to Elon Musk asking what's next after Starship. Elon replied the next would be twice diameter and twice length. That's 8 times volume! Starship is already the largest rocket ever launched from Earth, a rocket 8 times that size is neither reasonable nor safe. This ship is intended as an alternative to that. Starship will be used for construction, fuel, and as a taxi to carry passengers from Earth surface to Earth orbit. Another Starship will carry passengers from Mars orbit to the surface.

TE-8

UNDERSTANDING THE SURFACE MODIFICATIONS AT LANDING SITE DUE TO SPACECRAFT LANDING ON MARS

RIYABRATA MONDAL

TU FREIBERG & HABITAT MARTE

Understanding the surface modifications of landing sites during spacecraft landing on Mars' surfaces is important for scientific as well as engineering perspectives. The environmental properties of the landing site, mainly the upper layer of its regolith, and its physical interaction with the supersonic jet plumes principally determines the possible modifications to the surface. The resulting cratering and consequently ejected particle kinematics provide clues to the physical effects that might have caused to its surroundings. Also, for carrying out in situ measurements, it is important to know beforehand the extent to which the landing site might get altered by the jet plumes and to the benign shock environment. Many other aspects such as thrusters' positions, landing velocity, parachute development to reduce the speed and other important landing modules. The advancement can be made with AI by simulating the in situ conditions in a demo prototype. AI can be used to increase drag coefficient of the landing ship by increasing drag through combination of thrusters and aerofoil wings to have a velocity drag.

TE-9

RESEARCH & DEVELOPMENT OF NEW CONCEPT OF ENERGY SUPPLY SYSYTEM APPLIED TO MARS (SOLID STATE BATTERIES)

RIYABRATA MONDAL

TU FREIBERG & HABITAT MARTE

Energy is the most fundamental part for living and development. It should also be portable to be carried to space and that it is not treacherous to the rocket or the carrying vehicle. Another option that comes to the energy source is the sun, the solar energy. But as we know solar energy is not an effective way as the energy produced is not sufficient. Here I have discussed a few methodologies and prototypes that can help to advance the extraction of energy in a faster and reliable way.

Theory

As the power source is time dependent so the extra power can be stored in the batteries. So during the night this power can be utilized. Even if we look for nuclear power the energy generated at the initial stages are more in the form of heat which can be stored in batteries. The heat generated from the Kilo power plant which is distributed to the thermal fins can be directed to the rooftops of the habitat station during night to work as a room heater. Advanced batteries should be used which charge up quickly. This can be used as a hybrid power system to solar power.

Methodology

From 40W/liter with lithium-ion battery by Sony, Samsung now introduces Solid state battery which delivers 900 watts per liter and a minimum lifetime of thousands of cycles. In solid state battery layers of lithium nickel cobalt manganese oxide mixed with a sulfide solid electrolyte on top of a nanocomposite layer of silver carbon. All of this compacted in a foil of aluminum and stainless steel as a current collector.

TE-10

DESIGN OF XORS MOON BASE

JUSTYNA PELC, HUBERT GROSS, EWA BOROWSKA, PIOTR TORCHAŁA, MAGDALENA ŁABOWSKA, BEATA SUŚCICKA, ŁUKASZ SOKOŁOWSKI, MAŁGORZATA POPIEL, ARKADIUSZ KOŁODZIEJ, ALEKSANDRA WILCZYŃSKA, MICHAŁ GARUS, CYRUS SIDOR I MARCIN ZIELIŃSKI.

INNSPACE

Xors Moon Base project, which is a lunar habitat feasible within the next ten years and able to accommodate 2-3 crews at one time, will be presented by Innspace team members. The project took 4th place in the Moon Base Design Contest.

The base consists of 4 living modules and 2 additional ones covered with a thick layer of lunar regolith using 3D printing technology, which would provide additional protection against radiation.

The group will present their solution of the habitat's life support systems. A mix of specially selected microorganisms, including bacteria, cyanobacteria and microalgae, will perform the function of purifying wastewater and other waterborne pollutants. Specially selected microalgae in the form of wall panels will also provide oxygen. To better mimic sunlight, the team used lamps that emit not only visible light but also infrared light and UV-A and UV-B light.

Xors is located near Shackleton Crater at the south pole. This is one of the most interesting places on the Moon, because of the places that the Sun illuminates almost all the time, as well as those that the light never reaches. Thanks to this location at the south pole, the habitat has gained access to water, which is trapped in the form of ice on, as well as under, the Moon's surface.

The details of the project and all subsystems will be presented during the conference.

TECH F

TF-1

REMOTELY SENSING MARTIAN DUSTING STORMS FROM SPACE USING MACHINE LEARNING

THOMAS Y. CHEN

ACADEMY FOR MATHEMATICS, SCIENCE, AND ENGINEERING

The development of small interplanetary satellites that capture high-resolution imagery of planets, moons, and other celestial objects is a fascinating area of recent research. This technology enables a vast array of new opportunities in terms of monitoring objects and events on planets in the solar system. Specifically, future deployment of capable small satellites to the orbit of Mars is exciting because collecting multi-temporal imagery data of the planet allows for the study of events such as dust storms, using machine learning approaches. On Earth, recent advances in deep learning, the collection of high-resolution multi-temporal satellite imagery, and more has led to development of sophisticated natural disaster response systems. Artificial neural networks are used to analyze data in real time to assess infrastructure damage after earthquakes, extreme storms, wildfires, etc., and inform policy makers and local communities. While the study of Martian dust storms does not have the same humanitarian ramifications, it is important to understand these sometimes elusive events in a novel manner. For instance, in 2018, a storm killed NASA's Opportunity rover by coating its solar panels. Additionally, there is emerging evidence to suggest that the storms are a cause of the loss of water on Mars. In this work, once the appropriate multi-temporal high-resolution data is collected, we seek to train an automated classifier. Labels for each image, including bounding boxes and storm severity, are collected through crowdsourcing. We propose the use of a VGG-16 model, which is a stack of convolution layers with small receptive fields in the first layers. The model segments the storm in a pair of images captured in the same location but at different times and outputs a classification representing the severity of the change detected.

TF-2

ASTRONOMY ON MARS

AYANSHA ARORA

Despite the atmosphere's low density, meteors can be occasionally seen and are faintly visible. If the Martian atmosphere was as dense as earth's, they would've seemed brighter since co2 is heavier than nitrogen.

The visibility of comets is dependent on external factors. The brightest comets that we see on the earth would be fainter on mars due to orbital differences.

The seasons would be twice as long as on earth. The seasons and the respective tropical zones would be similar except the duration of the season and the temperature would vary. The summers would be less hot, and the winters will be cooler. It orbits closest to the Sun when its southern hemisphere is tilted towards it, while the northern hemisphere is tilted towards the Sun when it is farthest away.

Phobos whips around Mars three times a day, while the more distant Deimos takes 30 hours for each orbit. Both of the moons are asteroid-shaped, lumpy, heavily cratered and covered in dust and loose rocks. Phobos is the larger moon of the planet and would be visible in the Martian night sky whereas Deimos is smaller in size, and it is farther away from the planet.

Eclipses occur more frequently than on Earth. They're shorter and last just about 30 seconds. All of the sun's light will not be blocked due to the sizes of the moons. Phobos' eclipse will be more visible than Deimos' since it is farther away and smaller in size.

Sunsets are blue because the atmosphere scatters all colors except blue which is received on the surface. It isn't scattered more than the other colors due to some molecules and particles in the atmosphere which have the ability to scatter solar radiation.

TF-3

OVERVIEW OF NEP FOR HUMAN SPACE EXPLORATION MISSIONS TO MARS

MARCUS COLLIER-WRIGHT, MANUEL LA ROSA BETANCOURT, ELIAS BÖGEL

NEUTRON STAR SYSTEMS UG

Human space exploration is at the dawn of a new era. Mars is first targeted to demonstrate our ability to extend our expanse. Chemical propulsion as used thus far is not sustainable for this purpose due to the large quantities of fuel required. Other forms of propulsion offer a more compelling, feasible and sustainable alternative: Nuclear Electric Propulsion (NEP) is the key to unlock more cost-effective and sustainable manned interplanetary transportation. NEP combines the unmatched megawatt level of power of a nuclear reactor with the high specific impulse of electric propulsion. This enables cost-effective cargo or crewed missions to Mars and beyond, on a large scale. Since NEP is now considered by several space agencies, this paper presents an overview of the geopolitical and technological considerations behind different NEP programs worldwide. Amongst the various types of electric propulsion systems, Gridded Ion Thrusters (GIT) and Hall Effect Thrusters (HET) are usually the first considered for NEP use due to their low-power flight heritage. However, GIT and HET present several fundamental drawbacks at higher power levels: scalability limitation, clustering of numerous thrusters needed and lifetime and efficiency concerns. Applied-Field Magnetoplasmadynamic (AF-MPD) Thrusters, such as used as basis of the "SUPerconductor-based Readiness Enhanced Magnetoplasmadynamic Electric propulsion" (SUPREME) technology developed by Neutron Star Systems in Germany, on the other hand offer a compelling set of properties such as propellant flexibility, scalability up to several megawatts, simple design and wide range of operations. Concurrently, High-Temperature Superconductors (HTS) have now reached industrial maturity, and considering their low masses, compact volumes, and high current densities, they offer the potential to act as a disruptive technology in NEP missions. This paper reviews current concepts and programs for NEP, and underlines the possibilities offered by SUPREME for these NEP programs and concepts.

TF-4

SUPERCONDUCTORS AS ENABLING TECHNOLOGY FOR HIGH POWER SPACE MISSIONS

MARCUS COLLIER-WRIGHT, MANUEL LA ROSA BETANCOURT, ELIAS BÖGEL

NEUTRON STAR SYSTEMS UG

Mass and power are two of the most critical parameters when it comes to spacecraft. Every kilogram of mass must be optimized to minimize launch costs, while available power is typically limited. The two parameters are closely linked; more advanced and capable spacecraft are invariably larger, heavier, and require more power. For advanced propulsion systems, the power dilemma becomes fundamental, as both high thrust and high specific impulse can only be achieved with systems working on high efficiencies and high power. For certain EP technologies, such as the Applied-Field Magnetoplasmadynamic Thruster (AF-MPD), the efficiency strongly depends on the strength of the magnetic field, which is limited by conventional copper coil technology due to high mass and high-power consumption of the electromagnet. Compared to this, coils made from High Temperature Superconductors (HTS) achieve a technological leap by enabling a reduction in coil mass, and an increase in the magnetic field strength, both by a factor of 4, and a reduction in power consumption by two orders of magnitude. These improvements become critical with power levels of 20 kW and beyond. HTS have achieved a degree of technological maturity which makes them commercially viable to act as game-changers for space applications. Several applications of superconductors for space systems exist, including electric propulsion, power management systems, re-entry shielding, and radiation shielding. The use of HTS enables a reduction in mass and volume, and a maximization in efficiency, of such subsystems. This paper will discuss the status-quo and latest advancements of the HTS industry before discussing HTS in spacecraft subsystems. The latest developments for these subsystems will be presented, demonstrating the technical and economical superiority of HTS over conventional technologies, especially at high powers. Hence, their potential to act as a key enabling technology will be shown.

TF-5

A SPINNING TOROIDAL GRAVITY FACILITY FOR MARS.

STEPHEN HUMBLE

My talk is in the category of a hard science fiction engineering presentation. I present the design of a centrifuge in the form of a large torus containing enough volume to accommodate around 10 thousand people and provide an earth like gravitational environment for the inhabitants of a future Martian city.

The design I present has a major diameter of around 900 meters and a minor diameter around 64 meters and is able to accommodate facilities like housing, offices, sport areas, schools, workshops etc. I have produced a visual model of the design in OpenSCAD and have created a 3D computer animation fly through of the design in the Blender 3d animation tool to help show how it would look and to help explain how it would work as part of the presentation. I explain the design requirements, the various constraints including how the Martian environmental conditions affect building design and how these made it easier or harder.

I draw on many real-world examples and research to overcome design challenges creatively to provide as realistic and plausible design as possible.

I explain how real material properties affect the design and present realistic solutions for how the traction and suspension system would work, the thermal regulation, radiation protection, energy consumption, transport within the torus and in and out of it, the gravity quality requirements and how people may adapt to the torus, the economics of having such a structure and more.

My presentation will take about an hour. It will be condensed from a ~15000 word long technical explanation I have written on this design. I can also answer questions and discuss any aspect of the design from the audience.

TF-6

A SUPERCONDUCTOR-BASED MAGNETOHYDRODYNAMIC SHIELDING SYSTEM FOR HYPERSONIC RE-ENTRY: MEESST

MARCUS COLLIER-WRIGHT, MANUEL LA ROSA BETANCOURT, ELIAS BÖGEL

NEUTRON STAR SYSTEMS UG

This paper outlines the initial development of a novel magnetohydrodynamic plasma control system intended to mitigate shock-induced heating and the radio-frequency blackout phenomenon encountered during atmospheric entry. An EU consortium comprising universities, research institutions, and industry has been formed in order to develop this technology. The project is funded by the EU's Horizon 2020 scheme (grant no. 899298) and is scheduled to conclude in 2023 with the launch of a functional prototype for full scale re-entry testing. Atmospheric re-entry, with the combination of high spacecraft velocity and the rapid compression of atmospheric particles by the spacecraft leads to high-enthalpy, partially ionized gases forming around the vehicle, forming one of the most challenging environments a spacecraft can be exposed to. This can significantly inhibit radio communications and induce high thermal loads on the spacecraft surface. Spacecraft currently have no reliable mitigation for radio blackout, while expensive, heavy, and non-reusable thermal protection systems (TPS) are needed to dissipate the thermal loads. To solve the above issues and through using electromagnets, the boundary layer of the ionized gas layer can be displaced away from the spacecraft such that the thermal loads can be reduced, while also opening a magnetic window for radio communications and mitigating the communication blackout phenomenon. High Temperature Superconductors (HTS) have now reached a level of industrial maturity and commercial availability sufficient for them to act as a key enabling technology for the electromagnet. This paper introduces the MEESST project and the preliminary design of such a system. The latest progress and achievements of the project in terms of prototype development and numerical modelling, are summarized. The current status-quo of HTS technology is presented, and applications of the concept in various mission scenarios (crewed Mars flight, Mars cargo) are contextualized and assessed.

TF-7

WALKING ON MARS: A PATHWAY TO A MARTIAN SPACE SUIT

WILL GREEN

UNIVERSITY OF NORTH DAKOTA

Extravehicular Activities (EVAs) are when astronaut crew members leave their spacecraft or habitat to do work or explore. These EVAs are made possible with space suits. Performing EVAs on the Martian planetary surface will require advanced space suits to allow crew members to safely, easily, and frequently traverse the rugged terrain for the entire duration of the mission. While the lunar "moonwalking" EVAs have been an important and iconic part of human space exploration, most of the EVA time has been in microgravity. This gravity-free environment is very different and, in many ways, less difficult than a planetary surface. NASA's return to the moon provides the EVA community with a valuable testbed to develop new technologies and designs that will make human exploration of the red planet possible, while paving the way for further space suit advancements, including additively manufactured and Mechanical Counter Pressure (MCP) space suits. This combined with the operational experience resulting from long-term surface exploration will ready humanity for a mission to Mars. This will be a discussion on how lunar exploration can be used to build up technological and operational capabilities that will be critical for the human exploration of Mars.

TF-8

IMPROVED ROCKER-BOGIE SUSPENSION BLOCK

RILEY AUGUST, M. K. BORRI

ROBOTS EVERYWHERE LLC

The rocker-bogie suspension system (RBSS) has robust capabilities to deal with uneven terrain because of its ability to distribute payload mass uniformly with no active control required. However, a RBSS using a differential effectively puts all mass and shock forces on two semi-axles and their support, creating a weak point, and requires that the differential be in the middle of the chassis, getting in the way of other systems, while a RBSS using a balance bar leaves the mechanism exposed and requires very tight tolerances in the balance bar linkage.

Here we present a variant of the RBSS that attempts to tackle these problems with a new block design.

Our design is optimized for skid steering, reducing the need for actively driven moving parts and thereby increasing mean time between failures. The design also evenly distributes the payload mass and forces on six points, rather than two, allowing its use in higher gravity, and will continue to operate if any one (possibly two) of the four additional support points fail entirely. The design is cheap to manufacture and tolerant of field-expedient repairs as it can work with components with wide dimensional tolerances. Finally, the design does not require a differential or other parts internal to the chassis, thus providing more flexibility in payload layout. It can, however, be hybridized with the existing differential design for additional reliability.

We hope that this suspension design will help enable a "many cheap rovers" strategy for planetary exploration and field science, and later on, expedient in-situ assembly and repair within the context of permanent settlements.

TF-9

XENOTROPHIC GASTRONOMY: FINE DINING ON MARS

ALEX SHARP

The Earth has a vast ecosystem that supports the modern human diet. Mars is not so lucky. This talk focuses on the development of an artificial food chain designed around the constraints of a small to medium sized Martian colony, providing both food for people or animals and biomass for industry. It starts unconventionally using xenotrophs to convert rocket fuel and electricity into food. It then expands to include both conventional farming techniques such as greenhouse farming and aquaculture, but also unconventional applications of these techniques such as automated low-pressure farming of grasses for biomass or the concept of 'ditch farming' for growing algae without a conventional greenhouse. Finally, it explores the applications of processed foods and GM foods. Aspects of this talk are also discussed at greater length in the Mars City State Design Competition entry 'Korolev Crater', specifically the written submission which includes references.

TF-10

DESIGN OF MARS UNDERGROUND HABITAT FOR HUMAN SETTLEMENT ON MARS

MALAYA KUMAR BISWAL M, DAVID GOMEZ-FERNANDEZ

GRAHAA SPACE, BANGALORE, INDIA.

Longer crewed missions require extended presence either in interplanetary space or planetary bodies and this longer duration may be subject to censorious survival challenges. The crew may encounter the effect of cosmic radiation and microgravity along with inevitable obstacles such as regulated temperature and pressure. Its wobbling condition may lead the crew to the hazard of hypothermia and body deformation. And this defect does exist at every interplanetary proximity standing as a fundamental prospective challenge of space survivability. Hence, concerning this ultimatum of survivability, we have presented a Mars Underground Habitat (MUH) to neutralize the thermal stability between the crew and habitation module on Mars. In this paper, we technically emphasize the achievable extent of thermal stability with respect to the architectural configuration and its preferred location on Mars. In addition to this, we extended our discussion to define what internal and external factors influence thermal stability along with the habitat's significance for future crewed exploratory missions beyond Mars.

Political & Philosophical B

PB-1

THE TWO PLOTS PROBLEM: DEALING WITH DEATH AND CRIME IN A MARTIAN COLONY

MATTHEW KENYON

As Nathaniel Hawthorne wrote in the Scarlet Letter, any new colony must allot a portion of its land as a cemetery and another portion as a prison. These two plots of land are not usually the first that come to mind when planning a Martian colony, but the undeniable fact is that eventually people will die and crime will occur no matter where in the cosmos humans travel.

Several authors have mused about crime in space, but they rely on current treaties or maritime law to discuss how to prosecute a Martian crime back on earth. The reality is that the settlers on Mars will not return to earth to stand trial. Nor will they return to earth for burial. Handling these situations requires developing new institutions, which presents a unique opportunity for reform not presently available on Earth.

To give these institutions the best chance at success, we must begin preparations now by asking the right questions about future colonies, exploring potential answers to the questions, and outlining a system that adequately prepares colonists for these eventualities while being flexible enough to adjust to rapidly changing situations.

History has taught us that how institutions function now is directly related to how they functioned in the past. The Shire Reeve of the 7th century begat the Sheriff of the 21st century. People have been buried in the ground since the Middle Paleolithic era. Deciding how the Martian colony of this century handles crime and death will shape how crime and death are handled for centuries to come. These should not be the knee-jerk decisions of colonists in a crisis. We have an obligation to get things right, and that is something better not left to chance.

PB-2

MARS, TERRA NULLIUS

MAURA ZARA, ALEKSANDRA MARINOVA, TRISTAN JAMES BRUCE. SIFAT KAUR ALAG

FIRST STEPS LEGAL

Terra nullius, in international law, is a territory that has never been subject to the sovereignty of any state, or on which any previous sovereign state has expressly or implicitly renounced sovereignty. The sovereignty of this territory can be achieved by occupation, although in some cases this may be a violation of international laws or treaties.

But what happens when this Terra nullius is nothing less than another planet? The first difficulty is that the Principle of Sovereignty does not apply to outer space.

What is the legal situation regarding the acquisition of sovereignty over another planet? This study aims to highlight the difficulties in the management of this problem, with specific regard to the planet Mars.

This will be done by reflecting on the meaning of sovereignty in space law and its close correlation with the non-appropriation principle, enshrined in Article II of the Outer Space Treaty 1967. The research also looks at the current regulatory framework provided by space law, with the aim of understanding whether, in the current state, there are tools to manage the situation in the case of colonization of Mars. In this regard, a reflection on Article VI of the OST, which provides that private companies may still be viewed under space law as state actors, is dutiful.

In addition, special attention will be given to the Moon Agreement 1976, to determine if its structure could be a starting point for the specific case of Mars.

Our study concludes with a reflection on the thorniest aspects of the Martian regulation and the crucial importance of adequate legislation to avoid conflicts and ensure peaceful use of outer space.

PB-3

LEGAL PERSPECTIVES ON THE POLITICAL ECONOMY OF A MARTIAN SETTLEMENT

MUKESH CHIMAN BHATT

BIRKBECK UNIVERSITY OF LONDON, & PARADIGMS ESPACE

Current attitudes appear to presume that the inhabitants of a settlement on Mars or elsewhere will be primarily research specialized scientific and engineering personnel along with some specialized crew with broad technological training. As the settlement grows towards permanence, non-specialized personnel will grow the infrastructure of the settlement in non-specialized and non-technological ways including education for children. The establishment and development of a localized economy and market will require regulation and law that is not based on functional or occupational deontology. Governing large numbers of people will introduce differences in diversity dependent on political ideologies and (sub-) cultures. Unless terraformed, Martian society will also depend on technology for individual survival and that of the entire enclosed settlement, further relying on outside support during development whilst moving towards a self-sustaining economy and full independence. This further raises questions of the interaction between law, economy, and technology particularly with respect to aid and support, environment, safety, monitoring and surveillance. A generic decolonial and therefore flexible model of financing, political economy and governance may be introduced at the beginning of the settlement allowing for the growth of diversity in the organic manner as seen on Earth. Whereas the outer space treaty of 1967 privileges cooperation between diverse nations whilst extending national sovereign legal systems into space, models of plural society from Earth are many and varied. These can inform applications to the initial Martian society. One constant is the development of pluricetral laws ordering or transforming society. Therefore, a primary part of the model needs to be an outline of the domains of necessary law and regulation applicable to the changing circumstances of Martian society.

keywords: Mars, settlement, political economy, law, environment, technology

PB-4

SICUT IN CAELO ET IN MARTE: IMPLEMENTING A CATHOLIC DIOCESE OF MARS

CHERILYN YOUNG, OP, PH.D.

VOLUNTEER CATECHIST, CATHOLIC DIOCESE OF AUSTIN

From the Middle Ages onward, the Catholic Church has been substantially involved in the study of astronomy. Even to the current day, NASA astronauts, other countries' space explorers, and other officials involved in the exploration of space have been influenced by their Catholic faith. This presentation includes a brief history of Catholic involvement in the history of astronomy and space exploration. The case for a separate Diocese of Mars is put forward as a necessary sociological and cultural component of Martian colonization that is consistent with history and current culture within the astronomical and space exploration communities. Current and previous Catholic Codes of Canon Law and liturgical rules and guidance documents indicate how a Catholic missio sui iuris (mission territory infrastructure of the Catholic Church) and a later Diocese of Mars could be implemented successfully. The relevant factors of the use or substitution of the words "earth" and "world" in Bible translations and liturgical texts, the effects of gravity on liturgical logistics, and candles' oxygen consumption are addressed; with proposed solutions that do not violate current liturgical norms. Finally, the Roman Catholic liturgical calendar and secular calendar for 2118 are compared to the relevant months of the Martian Darian calendar of years 270 and 271 to demonstrate how the Catholic liturgical lunisolar calendar, secular Gregorian standard calendar, and Martian Darian calendar could be aligned successfully.

PB-5

SAINT JOHN'S NEWFOUNDLAND – HISTORICAL EXAMPLE OF SETTLEMENT

ROBERT DYCK

ARDECO AEROSPACE

St John's Newfoundland was the first European settlement in North America after Columbus. It was not established by any government; it was built by fishermen. The city dates its founding to the first house built for a caretaker to overwinter in 1497, so the city celebrated its 500th anniversary in 1997. What started as a fishing camp grew to a city and is now the capital of the Canadian province of Newfoundland and Labrador. Founded more than a century before Jamestown, almost a century before Roanoke. This settlement demonstrates cooperation between businessmen from various countries, and ability to build profitable business and a successful settlement without any government involvement. At a time when multiple government sponsored colonies failed.

PB-6

DOC-REALITY OF FAMILY CREWS AS A TECHNOLOGY FOR SETTLING ON MARS

NAZYM SAYFULLIN, VLADIMIR DOROJINSKY

INOCONT

The success of engineering and technological programs to ensure flights and create a life-support infrastructure on Mars should not overshadow the importance of working on even more complex problems of civilizational and cultural expansion of earthlings into the unknown territories of the Universe. The latter require advanced non-trivial R & D, including in the media sphere.

The complex of related tasks does not apply to individual enthusiasts and organizations, but to humanity as a whole. They can only be dealt with by a civil club project movement that unites strategic actors - family crews. Tens of thousands of such families as the basis of a progressive socio-cultural model will be able to become developers, builders, and testers of new forms of life activity in difficult conditions of uncertainty and unknown risks.

The objects of the project activity will be prototypes of autonomous settlements –planetopolises, - located in various natural-climatic and cultural-ethnic locations of the Earth. Providing the included observation of family crews in the format of a documentary reality show will allow you to receive valuable design and research information and serve to popularize new models of life activity.
It is necessary that the doc-reality of family crews allows participants to receive:
* scientific and methodological support for project teams;
* interactive interaction between family startups in the course of research and solving agreed vital problems based on promising technologies,
* the right to win housing and work in the planetopolis.

We invite partners to develop this harmonious technically feasible civil program for preparing future immigrants to overcome the earth's cradle. This is the key to the success of making systemically balanced decisions that would meet the basic software, functional and operational requirements for the long term.

PB-7

THE MARTIAN PAPERS:
DEFINING MARS FOR THE PURPOSES OF A MARTIAN CONSTITUTION

HANNAH EARNSHAW, JAMES GILLEY

MESA

In this paper we address the question of how a Martian state should be defined, as part of the Martian Papers project, a series of accessible papers on the problems of Martian governance to be solved in preparation for the human settlement of Mars. Humans on Mars will depend on more than just the Martian surface to thrive and achieve the same benefits of modern life that are accessible to humans dwelling on Earth. By drawing parallels with the implicit global sovereignty of Earth over objects and regions in the Earth-Moon-Sun system, we argue for the inclusion of analogous regions in the political definition of Mars, defining a Martian Zone of Sovereignty such that the entire Mars-Sun system may be governed by, and for the benefit of, the people who will one day make Mars their home.

PB-8

TOWARD A MARTIAN TRADE ECONOMY

LEET WOOD, PHD, ALEXANDER GILBERT

INDEPENDENT SCHOLAR/COLORADO SCHOOL OF MINES

Martian settlement proposals are typically viewed through the lenses of technical or political feasibility. Less frequently examined in a rigorous way is how such a grand endeavor could be rendered economically feasible. Leveraging the relatively advantageous orbital energy position of Mars compared to Earth, we propose an interplanetary trade system that could provide a sound basis for a Martian economy robust enough to plausibly create a self-sufficient settlement. Specifically, the authors posit a multilateral trade network among Mars, its moons, and Earth. Despite Mars' relative poverty of energy resources, the proposed trade system relies on the Martian settlement becoming a net energy exporter through the development, construction, and operation of space-based solar power (SBSP) satellites to serve electricity markets on Earth. SBSP satellites would be constructed on Mars, and to the greatest extent possible its moons, and then transported to Earth geosynchronous orbit. Trade in volatiles and raw materials to support the near-Earth space economy provides another pillar of Martian trade. In return, high-value, low-mass items are exported back to Mars from Earth. Such a trade system is viable because the energy cost, and thus economic cost, of transporting mass from Mars space to Earth geosynchronous orbit is substantially lower than transporting to the same destination from Earth's surface, providing a relative advantage for the Martian economy in this area. This study provides a preliminary economic analysis of such a trade system, a general description of the overall infrastructure and physical parameters of the system and discusses the potential implications of the proposed trade network.

PB-9

THE DEMOCRATIC/REPUBLICAN BI-PARTISAN RUSH TO WAR AGAINST CAPITALIST CHINA THREATENS TO END OUR EXPLORATION OF MARS. CAN IT BE STOPPED?

EDWARD HEISLER

FORMER TEAMSTER UNION PROJECT ORGANIZER
FORMER RAILROAD WORKERS UNION REPRESENTATIVE IN CHICAGO
MEMBER OF THE PLANETARY SOCIETY AND THE MARS SOCIETY

Beginning in the Trump government and escalating in the Biden administration we are witnessing a steady increase in the pro-war propaganda campaign against China. It seems like we are going down a "no exit" path to war with China.

The current pro-capitalist China government is feared and hated by many American corporations, corporate heads, and politicians much more than the old hard line anti-capitalist regimes in China. Perhaps that's because during the first three decades of "communist" rule China didn't compete on the world market. Capitalism and capitalists didn't exist in China!

China is leaping ahead in their economic development and has gross domestic product growth that the United States can only dream about. Their top-down command capitalist economy is working better than United States capitalism.

The escalating trade war with China won't help the U.S. economy. In fact, a growing trade war can sink the American economy which in turn will increase calls for a war against China because they will be blamed for any economic collapse.

That war with China could easily start in space. The federal government could claim that a Chinese satellite engaged in suspicious or threatening activity against a United States satellite and acting in "self-defense" the Chinese satellite was destroyed. Or the war could start in space due to a miscalculation, bad intelligence or human error. And such a "space war" could easily end the human exploration of Mars for decades because of the Kessler chain reaction.

We must and we can prevent that.

PB-10

PROPOSAL FOR INTERHUMAN SPACE IMMIGRATION CORPORATION ISIC

MANOUSOS CHAIRETIS

MEMBER

The proposed speech will be a presentation and proposal of how humanity can create the enterprise that will make space immigration possible for any fellow human who wants to immigrate to space, within the next thirty years. A thorough outline of the need for humanity to immigrate Mars, Moon and other celestial bodies, for exploration, exploitation of resources, as well as habitation will be attempted. The solution to the countless problems that humanity risks for itself by staying on earth to sustain its future existence will be given too. The reason for the presentation will be to attract the interest of all possible co-creators that can take part to create Interhuman Space Immigration Corporation ISIC as a peacemaking progressive interhuman entrepreneurial proposal.

MIXED A: XA-1

20 YEARS OF EUROPEAN MARS CONFERENCE (EMC)

STEPHAN GERARD

PLANETE MARS (FRENCH MS CHAPTER)

This year marks the 20th anniversary of the first European Mars Conference that was held in Paris (France).

We will review the timeline of these conferences since 2001 with facts, information, photos, and anecdotes but also the evolution of the conference year after year alongside the international Mars Society Convention in the US.

A timeline of the Mars missions and projects will be added to illustrate the choice of the annual theme.

This talk will also be based on my personal experience in attending almost all EMC editions (excepted in 2004 and 2005).

MIXED A: XA-2

Canada

Raise your voice: Comms- Before, during and after Mars

MIXED A: XA-3

BUILDING EXPERIENCES IN THE LAVA CAVE HABITAT SPACE ANALOG

JULIO REZENDE

HABITAT MARTE SPACE ANALOG STATION

Under development is a new space analog station in Brazil: The Lava Cave Habitat. Members from the space analog station Habitat Marte had developed Extravehicular Activity (EVA) in Lava Cave Habitat during the 2021 second semester. This habitat is based in a rock formation under preparation to subsidize the occurrence of space analog missions simulating a lava tube on Mars.

The coordination of Habitat Marte is just already practicing a set of experiences in Lava Cave Habitat since June, 2021:
- reconnaissance of the area;
- plan of activities;
- digging;
- camping;
- making bonfire;
- having community and psychological experiences.

Also the coordination of Habitat Marte is considering a new set of experiences in Lava Cave Habitat:
- conclude until Late 2021 the basic infrastructure in terms of walkability in the inner area of the lava cave habitat. This implies digging some parts of the cave.
- a structure of beds, furniture and utensils.
- potable water infrastructure, sewage equipment and energy supply.

MIXED A: XA-4

MODIFY MDRS LAYOUT TO RESEMBLE THE NMES CONFIGURATION WITHIN LUNAR LAVA TUBES (LLTS)

DOUGLAS SHULL

NOBLE METALS EXTRACTION SYSTEMS (NMES)

Background
The MDRS Hab currently has a direct 'airlock' to the outside environment, with separate tunnelways to the Greenhab and other modules. This configuration uses up space in the Hab for an airlock and storage of the 'spacesuits,' and allows for the introduction of regolith dust directly into the Hab. Collected samples are brought directly into the Hab.
Rovers remain outside day and night, exposing them to the harsh night and making any maintenance by crewmembers difficult or impossible.

Proposal
Create an 'airlock' outside of the entrance/exit to the Hab, connected to a tunnelway to the Greenhab. The Greenhab will have its own two 'airlocks', one on the tunnelway to the Hab, the other on a tunnelway to an Airlock Module, which will have its own two 'airlocks', one towards the Greenhab, the other opposite to the environment. In the Martian or Lunar environment, this will prevent the direct entry of hazardous dust into the Hab, as crewmembers will first leave their spacesuits in the Airlock Module, then travel through the Greenhab on their way to the Hab itself.

Next, a tunnelway/airlock combination can go to a new Garage/Workshop Module (GWM) for equipment maintenance. The GWM will have a 'vehicle airlock.' Maximum simulation gets rovers out of the frigid night, allowing crews to exit in a pressurized environment, and do vehicle maintenance in shirtsleeves.

Lastly, a tunnelway/airlock combination should go to a Laboratory/Assaying Module (LAM) from the GWM. The LAM should have a small airlock for bringing in regolith and rock samples directly from the environment.

Conclusion
This reconfiguration will allow for maximum simulation to guard the Hab from hazardous dust, place samples in a dedicated facility, and allow for the protection and care of the rovers.

MIXED A: XA-5

LAND RIGHTS AND A CENTRALIZED MARS DATABASE

MATT WISE, JAMES BURK, LENNART LOPIN

MARS REGISTRY FOUNDATION

The registry is a robust database of geological, scientific, historic, and exploratory information about the planet Mars. It is both crowd-sourced and accessible to the common human. As advances in human spaceflight bring us ever closer to the Moon and Mars, the questions of aggregate information, human settlement, and land rights become ever more pertinent. To ensure peace, equity, and human community, it's imperative that a system be established before settlement begins. The Mars Land Registry is a system whereby any human may register a land claim on the surface of Mars. This registry is a decentralized ledger which is built on the blockchain and as such is not owned nor controlled by any sovereign power or individual human.

MIXED A: XA-6

LEVERAGING MARS TO SOLVE IMMEDIATE PROBLEMS ON EARTH

BILLIE KAPOOR

ARAHANGA SPACE

The journey to Mars has two main and connected roadblocks, financial and political. With these solved all engineering and human problems can be overcome. The difficulty is that nearly all the rewards from the project are far in the future.

Arahanga Space is a project to solve this and enable a multi-party race to Mars. We are a non-state non-American team based in New Zealand. Our team is composed of women engineers and professionals from all over the globe. We propose to send some humans to Mars as quickly as possible using Mars Direct scaled up to a Sea Dragon style launcher.

We propose to fund this by creating reality/documentary shows and social media in near real time, originated as 12 different regional language streams. By presenting the drama of women doing hard engineering under pressure, and presenting it in localized ways, we can use the Journey to Mars to elevate the position of women globally and simultaneously ease racial animosity globally.

The demand for such a show, with its branding and sponsorship should handily fund the development of the full technology stack and mission costs. Additionally, it will motivate the funding of competing missions by elevating the profile of Space exploration.

The single biggest problem we face is the public's disregard for Space and academia's growing suspicion of human expansion into Space as imperialistic, colonial, sexist, etc. Arahanga solves for both bringing many stakeholders into alignment with a human Mars mission.

MIXED A: XA-7

THE INSTITUTE FOR TERRAFORMING EARTH AND MARS (ITEM)

ANTHONY MUSCATELLO

ORBCHEM, LLC

Recent success by SpaceX in launching a prototype Starship and plans for an orbital test of Starship/Super Heavy encourage optimism that people from various walks of life and not just professional astronauts will be traveling to Mars in the next several years, some of them to stay permanently on the Red Planet. Martians will turn their attention to terraforming Mars once they have established viable living facilities. At the same time the climate change crisis is causing serious concerns about the future of humanity on Earth. On first examination, the two problems seem to be opposite: Earth has too much CO2 in its atmosphere and Mars has too little to reach clement temperatures. However, both require thinking on a global level and some of the technologies needed for Mars exploration, such as in situ propellant production (ISPP), require CO2 as a starting material along with water to make methane and oxygen. Several methods have been studied over the years to obtain CO2, with one, i.e. compression, being demonstrated on Mars on a small scale by the MOXIE oxygen production experiment on the Mars Perseverance Rover. Others include freezing with cryocoolers and sorption/desorption from molecular sieves, though the latter is usually considered to be impractical. However, work on using Metal-Oxide Frameworks (MOFs) have shown promise for CO2 capture and sequestration on Earth. Thus, there is a natural synergy between Mars ISRU and addressing climate change, which can be called terraforming Earth since the Earth needs to be restored to earlier conditions. Fortunately, government and private funding from billionaires and multimillionaires to combat climate change is increasingly available. We propose to found The Institute for Terraforming Earth and Mars (ITEM) to pursue the intersection of Mars and Earth technologies to benefit both planets.

MIXED A: XA-8

“WHO’S WINNING THE MOON RACE—AND WHY IT MATTERS FOR MARS”

ART HARMAN

THE COALITION TO SAVE MANNED SPACE EXPLORATION

Starship and Super Heavy are being readied for their first spaceflight, and NASA Administrator Bill Nelson is still pushing for Artemis on the Moon by 2024, in spite of delays and contract disputes. Meanwhile, China is in a breakneck race to the Moon, partly to control the ice-rich polar craters. They continue to startle those unfamiliar with how Beijing works by their sudden ‘breakout’ with an Apollo-scale infrastructure and new generations of spacecraft and rockets.

Where is America standing in this very real race to the Moon? Does it really matter if China beats us? Could SpaceX pull it off alone if NASA or Congress lose interest?

Would delays to the Moon affect going to Mars in the early 2030s? Will bureaucrats and slothful contractors, such as for spacesuits and perhaps the Gateway stall Artemis into perpetual delays?

Little talked about is how Starship, as the (presumed sole) winner of the contract for a lander would need the Gateway, or what purpose is served by spending the extra fuel to reach the distant retrograde orbit and then to get to the surface. As we know, it makes more sense to scrap the Gateway and do a Moon-Direct flight once refueled in LEO. Scrapping the Gateway alone could free up funding for a lunar base, while reducing the complexity of lunar voyages.

I’ll review and compare the status of the space programs of the U.S., commercial space and China; how Russia fits in, where each country may be in a few years and by the end of the decade, and how the Moon remains the essential proving ground for Mars.

MIXED A: XA-9

IMPLEMENTATION OF ORIGAMI-STYLE IN MARS ENGINEERING

SUHAIL HAQUE RAFI, MD. FAHMID-UL-ALAM JUBORAJ

BRAC UNIVERSITY

This article analyses the use of Origami-style implementation in Mars engineering. With this approach, it may be possible that it will lead to significant advances in Mars rover engineering, energy supply (solar panels) as well as space and volume adjustment difficulties. The deployable architecture also takes advantage of the Origami-style structural modifications. Moreover, this Origami-style can help to design wireless communication devices and transmitters for communication on Mars. In addition, the article discusses how the Origami-style can be useful in pre-deployment stages up to the landing and stability phases. These are the main focuses of the design. Furthermore, there is a comparative analysis of how the objects can be folded and unfolded during the pre-deployment stage as well as the deployment stages. The solar plates of the satellite's wings can be folded using the technique. Considering these aspects, the objective is to analyze Origami-style structures, comparative advantages and areas for improvement. The Origami-style allows for the flexibility of volume, space, durability, and the weight and density relationship of other components. Finally, at the conclusion, the article highlights the areas of possible improvement and outlines the scope of future work and development opportunities.

Keywords: Origami-style, Mars engineering, Mars rover, energy supply, solar panel, deployable architecture, flexibility, pre-deployment stage, deployment stage, landing and stability phase, comparative advantages, development opportunities.

MIXED A: XA-10

OPEN DISCUSSION ON NEW VISIONARY MARS PROJECTS

BRUCE MACKENZIE

MARS SOCIETY, MARS FOUNDATION

What visionary programs do you suggest should be done by the Mars Society and similar organizations?

After the Blue Origin launch, several space organizations were offered major grants.

This allows them some financial security and a chance to start new programs, without worrying about the startup costs.

This is a chance for you, the audience, to suggest new or expanded programs, especially related to education, outreach, STEM, or capacity building.

We can discuss them as time permits, or afterward.

If you are interested but cannot attend, contact BMackenzie@alum.mit.edu