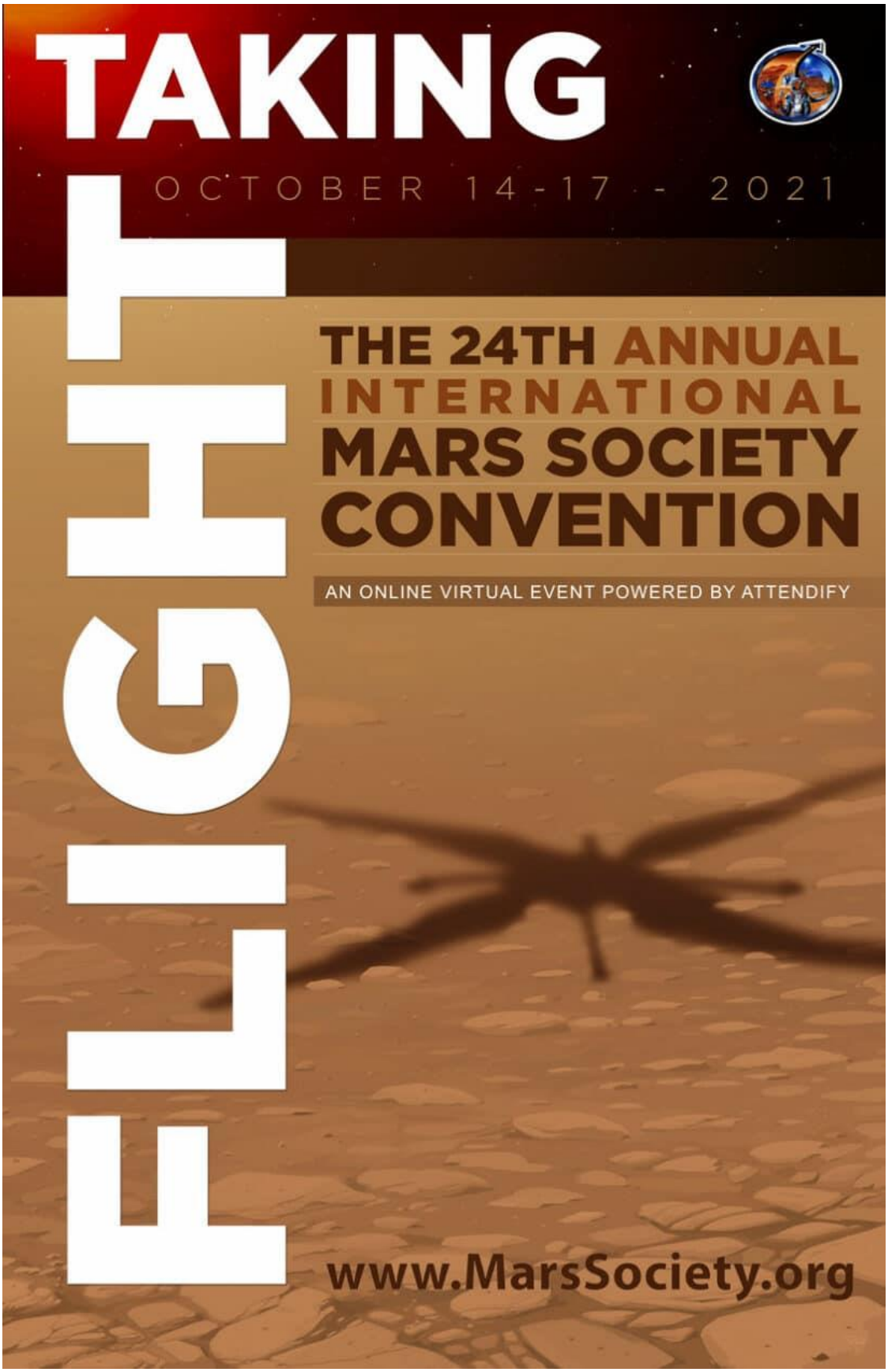
TAKING
FLIGHT
OCTOBER 14-17 - 2021
THE 24TH ANNUAL
INTERNATIONAL
MARS SOCIETY
CONVENTION
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	Friday October 15th			
All Times PDT	**Morning Plenaries**			
9:00 AM	Maria Antonietta Perino, Thales Alenia Space - ExoMars Mission Update			
9:30 AM	Jim Green, NASA Chief Scientist - Ingenuity and the future of Flying on the Red Planet			
10:00 AM	Teddy Tzanetos - NASA-JPL Ingenuity Mars Helicopter Operations Lead - Mission Update			
10:30 AM	Dr. Katie Stack Morgan, NASA-JPL Perseverance Deputy Project Scientist - Mission Update			
11:00 AM	Dr. Michael Hecht, NASA-JPL, Principal Investigator - MOXIE Project Update			
11:30 AM	Penelope Boston, Director, NASA Astrobiology Center - Mars & Astrobiology Review			
12:00 PM	Dr. Greg Autry, Arizona State University - COMSTAC duties; commercial spaceflight			
12:30 PM	Patrick Rennie & Fabrizio Bernardini, British Interplanetary Society - Engineering for Mars			
1:00 PM	Anastasiya Stepanova, IBMP Moscow, Researcher - Preparation of humans for deep space flights			
	Afternoon Sessions			
	Tech C	**Tech D**	**Analog Missions**	**Political/Philosophical A**
2:00 PM	TC-1 Greenbaum: Mars Aquaponics System	TD-1 Chaturvedi et al: In- Situ Resource Utilization technology for sustainable development	AM-1 Marques-Quinteiro: How Antarctica teams deal with unexpected events	PA-1 Tirto Pamangin: International Development of Space Science and Industry
2:30 PM	TC-2 Schulze: Food: Morale & Sustainability	TD-2 Nebergall: Insight – From First Landing to Cities	AM-2 Burk: MDRS Crew 261's Innovative Mars Analog Experiments	PA-2 Ravibhanu : Space Archaeology: Humans as a Multiplanetary Species in 2050
3:00 PM	TC-3 Mezilis: A Brief History of Sound on Mars	TD-3 Nebergall: FlexSail – Solar Sails and Tech Revolutions	AM-3 Popovaite: Machine Learning to Study Behavior in Space Analogs	PA-3 Lixiong: Seek Democracy on Mars
3:30 PM	TC-4 Clarke et al: The Challenge of Mars EVA suits	TD-4 Mor: Communication Technologies in Mars Missions	AM-4 Stowe: Mars Ocean Analogs: Voyages at Sea to Provide Human Factors Data	PA-4 Plata: Martian Countries: Why They are Inevitable
4:00 PM	TC-5 Rodriguez et al: Restoration of Essential Atmosphere Exploits Megastructure	TD-5 Kannan: Data Networking in Mars Missions	AM-5 Souza: Endurability to Habitability: BRIDGES for human spaceflight	PA-5 Blaisdell: Tokenization and Space Economies
4:30 PM	TC-6 Greenbaum: Mars Research Operations Habitat	TD-6 Rupali: Indian Mars Programme	AM-6 Kędzierski: Improved cycloidal gear design in Mars rover analogue	PA-6 Quintana: International Exploration, Terraforming and Colonization
5:00 PM	TC-7 Bonime: The Initiative for Martian Hemp Industrialization (I. M.H.I.)	TD-7 Ahmed: Antenna System Design for Mars Missions	AM-7 Trolese: A Low- Cost & Off-the-Shelf Analogue Research Hab in Extreme Environments	PA-7 Brünnemann: Intercultural Competence for Space Exploration
5:30 PM	TC-8 Secosky: Water, water, water on Mars	TD-8 Aggarwal: Satellite Communication Channels for Mars Missions	AM-8 Staats: Data analysis of the first hermetic seal of SAM habitat at Biosphere 2	PA-8 Gilley: The Martian Papers: A framework for thinking and discourse on Martian Governance
6:00 PM	TC-9 Hago/Hatfield: A thermochemical approach to convert CO2 and water to sugars	TD-9 Kumari et al: From Earth to Mars : from simulation to experiment approach.	AM-9 Rezende: Physical preparation of analog astronauts in Habitat Marte	PA-9 Bhuiyan: Mars City State Design for 1,000,000 Population

6:30 PM	TC-10 Chaturvedi et al: Challenges of Mars settlement: Planetary surface perspective	TD-10 Nudurupati et al: Study of Thermal & Pressure Gradients in Martian Atmosphere	AM-10 Rezende: Mining in space analog habitats	PA-10 Rathod: Habitat on Mars - Architectural Design for Future Settlements
	Break (7pm - 7:30pm)			
7:30 PM	**Friday Evening Program** IS THERE LIFE OUT THERE? Current Biological Research at the Mars Desert Research Station (MDRS) Shannon Rupert, Director, Mars Desert Research Station			
8:30 PM	MDRS Crew 245 - Mars Analog Experience at MDRS (Moderated by Ron Craig - Host, Red Planet Live podcast)			

2021 Mars Society Convention Schedule

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Analog Missions

Political & Philosophical A

TECH C: TC-1

MARS AQUAPONICS SYSTEM

Carl Greenbaum

Independent Researcher

A sustainable, nutritious food supply is essential for long-duration missions on Mars. A small-scale aquaponics system has been designed to demonstrate the capacity to integrate vegetable, fruit and fish protein production in a nearly closed-loop system suitable for operation on the Martian surface with minimum crew attention.

In an Aquaponics system, fish waste is filtered and nitrified to eliminate toxicity and make nutrients available to the plants. The plants absorb the nutrients, and the clean water is returned to the fish tank. In addition to fruits and vegetables, duckweed is grown as a high protein fish food. Tilapia grow to over 500 grams in about 8 months with an astonishing food conversion ratio of 1.6-1.8:1. Crops grown include typical salad components like lettuce, spinach, tomatoes and cucumbers as well as eggplant, blueberries and strawberries.

MARS EXPERIMENTAL AQUAPONICS LONG-DURATION SYSTEM (MEALS) lacks the diversity to serve as the sole food source but can enhance the menu available with “Farm to Table” freshness and provide psychological benefits of living plants and fish. The design goal is to produce 25% of the food for a crew of 6.

Once the system reaches steady state, inputs are nearly zero. The system grows its own food, supplemented by table scraps, the fish reproduce on their own and only fruit and vegetable seeds and occasional nutrients are input-plus electrical power for lights and pumps. Feeding and water quality monitoring and adjustments are automated.

A demonstration MEALS should be constructed, evaluated, and perhaps integrated into the Mars Desert Research Station (MDRS) to supplement GreenHab. Valuable insights will be gained into system performance and the degree of automation achievable. The ability to study different levels of fish and plant densities will inform the design of larger systems.

TECH C: TC-2

Food: Morale & Sustainability

David Schulze

Earth

The current Mars missions outlined will result in extremely poor health, a complete breakdown of morale among participants and absolute mission failure, due to poor choice in dietary options.

No one can survive three years on 'MREs' alone.

In order for colonization to succeed where there are no indigenous, no wild turkeys, no corn, and a completely hostile environment, the mission will require farms, dairies, ranches, orchards and vineyards be taken with them.

All of these facilities were established and produced well before the mission left our orbit.

A ship that will stay in orbit around the new planet, growing fresh food for the colonists below during the entire mission sequence.

That means a much larger crew roster, and a much, much larger ship.

A ship too large to launch from the surface of the planet.

It also changes the design parameters of the ship, and allows for much greater flexibility in that design, to maximize options and meet needs previously constrained by Max-Q stresses.

Our next real, productive, step into space, isn't an under-resourced leap by a few, out into the unknown.

Our next step is a space dock at our front porch, in orbit, where the real building begins.

Reusable and plentiful booster rockets make that possible.

Realization of the realities faced by colonists demands a hard look at how we intend to proceed.

TECH C: TC-3

A Brief History of Sound on Mars

Jason Achilles Mezilis

Zandef Deksit Inc. (CEO) / NASA-JPL (Independent Contractor)

I am a Los Angeles based musician and audio recording engineer by trade. During 2017-2021, I was afforded an exciting opportunity to assemble an engineering team serving as independent contractor for the EDLCAM Microphone system onboard Mars 2020 Perseverance. This microphone was to be flown with the rover on a groundbreaking mission to finally capture the true unadulterated sounds of the Red Planet. Working with supervisor David Gruel @ NASA/JPL, our team assisted in evaluation and final selection of flight hardware and sent the microphone capsule on its way.

The story that follows is a first-hand tale of impossible dreams, tough failures, and ultimate triumph as is par for the course in the hard world of space development. Beginning with the early proposals of this mission back in the mid-90's with Carl Sagan and the Planetary Society, our story channels throughout multiple Mars lander attempts…loss and reinvigoration of spirit, and the ultimate capture of the first Martian winds heard by the public during the NASA/JPL press conference on Feb 22nd, 2021.

We will discuss hardware selection, various testing procedures, and predictive analysis vs. actual audio returned from the surface. The two onboard microphone systems are contrasted for early "lessons learned", and of course we will discuss all the recent cool stuff we've heard on Mars (including the helicopter!).

Finally, we will discuss how audio capture will ultimately affect day-to-day life on the Red Planet. Our future colonists will be working in a harsh, desolate environment and awareness of their surroundings will be essential towards productivity and mental health as they journey outside, able to hear the sound of their footsteps crunching through the Martian terrain, their tools operating on the surface.

TECH C: TC-4

The Challenge of Mars EVA suits

Jonathan Clarke, James Waldie and Braid MacRae

Mars Society Australia, Human Aerospace Pty.Ltd

The crewed exploration of Mars will be fundamentally different to any previous human activity in space. EVAs will be essential to Mars exploration. Unlike Apollo EVAs or those in support of the ISS and Mir, long duration sojourns on Mars will involve small teams (most likely four to six astronauts) performing hundreds of EVAs over a year or more (two to three per person per week) and, with the assistance of pressurized exploration vehicles, working at distances of up to 100 km from the Mars surface station.

Present and historic EVA suits are unable to support Mars exploration. They are too heavy, over-pressurized, lack cooling systems that will work on Mars, exhausting, poorly fitted, insufficiently durable, and too dangerous. Most of these issues have been recognized for over 30 years. Meeting these demands will be challenging for space suit designers, especially current space suits have not fundamentally changed since the late 60s. Long established requirements with respect to length of time the suit will support EVAs without replenishment, consumable reserves, thermal management, and acceptable suit pressurization levels will need to be critically examined and modified, along with expectation of support equipment the astronauts are expected to carry.

Human Aerospace is researching the application of MCP technology to meet the requirements of Mars EVA suits. The technology promises suits with lower mass, more flexible and with great dexterity than conventional gas pressure suits. Numerous issues remain to be solved, however, including the maintenance of adequate compression across the entire body, fluid loss, and the time needed for donning and doffing the suits. Human Aerospace is also investigating two other applications of MCP technology to spaceflight. These include an in-flight zero-gravity countermeasures suit and the descent and post-landing orthostatic intolerance garment.

TECH C: TC-5

Restoration and Maintenance of Essential Atmosphere Exploits Megastructure

Gary Rodriguez, Timothy Cash, and Joshua Sparber

MegaScale GeoMagnetics LLC

The inhabitants of Earth are witnessing a migration of the magnetic poles that is most likely a precursor to a weakening, and reversal of its magnetic field. For the first time in our experience, the Magnetic North Pole has departed the upper reaches of the North American Continent and crossed the Bering Straits into the Eastern extremities of the Asian Continent (Russia). A pending magnetic reversal poses potential problems because the charged particles that form the van Allen Belts are corralled by Earth's Magnetic Field, preventing the Solar Flux from eroding the van Allen Belt's constituent particles upon which we depend to protect the upper reaches of the Earth's atmosphere.

This concern has urgency in this century due to an exemplar in our neighborhood, where Mars' magnetic field is hugely diminished due to the solidification of its once-molten magma interior. As a result, the bulk of the Martian atmosphere has been swept into interplanetary space, and the gravitation grip of the Gas Giants.

A number of researchers in our orbit have studied this problem and posed several models in support of a solution. We view this problem soberly, and as more urgent than most problems which challenge contemporary civilization, and our limited mega-technology – which seems limited to toxic pollutants. Proposed solutions had consistently exceeded today's economic, and technological reach – until now.

Our informal, multi-disciplinarian study group has discovered an ad hoc solution which is astonishing, and exciting. It is ironic that the problem may have once been solved, yet urgently requires that entrenched establishmentarianism yield control to more agile thinking. Further, the proof-of-concept can be retrofit, and tested through integration of existing, foundational infrastructure – before replicating the Terran solution on Mars in an implementation, and process that is nearly identical.

TECH C: TC-6

Mars Research Operations Habitat

Carl Greenbaum

Independent Researcher

A Mars Crew Habitat for Research Operations Meals & Exploration (CHROME) complex has been designed to meet the following goals:

- Support crews of 6-12
- Enable multidisciplinary research
- Produce a significant fraction of crew nutrition from a nearly closed-loop aquaponics system
- Harvest subsurface ice for potable water, Oxygen (breathing and propellant) and Hydrogen (methane production)

The design is an extension of the Moon Base Design that was awarded 2nd place in the Moon Society Design Contest. The notional site location is Deuteronilus Mensae, identified in a Nature Astronomy paper as a suitable landing site and source of near surface water.

A four-section inflatable habitat provides crew quarters, research space, an aquaponics facility for production of vegetables, fruit and fish and a water harvesting and processing facility. All habitat sections have radiation and micrometeorite protection with 2m of regolith plus polyethylene layers to retain the regolith during Martian storms and add additional radiation protection. Habitat airlocks will incorporate dust and perchlorate mitigation areas.

Site preparation and surface mobility will be provided by a Martian version of the NASA Chariot rover prototype originally developed for lunar operations. This rover will be supplemented by the “LANCE” bulldozer blade also developed for the Chariot. If shirtsleeve rover operations are desired and launch cargo volumes permit, the design exists for a pressurized Chariot cabin.

Power is supplied by flexible solar panels some of which are installed across the N-S oriented, low angle cylindrical section habitat structures. Electrodynamic dust shields mitigate solar panel performance degradation. High energy-density backup batteries are included.

Food production will be based on the Mars Experimental Aquaponics Long-Duration System (MEALS).

Water will be harvested using microwave heating. The sublimated water vapor will be liquified in the habitat by compression and heating to habitat pressure and temperature.

TECH C: TC-7

The Initiative for Martian Hemp Industrialization (I.M.H.I.)

Cameron Bonime

The Initiative for Martian Hemp Industrialization (I.M.H.I.)

The Initiative for Martian Hemp Industrialization (I.M.H.I.) exists to advocate the research, cultivation, and utilization of Cannabis sativa (hemp) in space exploration to sustainably produce food, textile fibers, building materials, graphene, biofuel, bio plastics, soil remediation, soil amendments, medicine, and thousands of other resources across industries as the foundation for a self-propagating Martian society.

If the potential viability of hemp's versatility is actualized in cosmic colonization efforts, a subsequent renaissance of industrial horticulture technology and techniques will maximize yields and prosperity in civilizations on Earth, Mars, between, and beyond.

The key reasons why we need to grow hemp on Mars is the quality, quantity, viability, and versatility of terrestrial cannabis sativa (hemp) biomass yields, and the singularity of potential innovation and utilization within this solar system and others.

TECH C: TC-8

Water, water, water on Mars

Jim Secosky

Retired from Bloomfield Central School and Finger Lakes Community College

In this talk I will show many pictures from various cameras that show evidence of past rivers, lakes, and an ocean on Mars. Many images will be from HiRISE. Most of these probably formed billions of years ago.

Early evidence for rivers was first found in Mariner 9 photos from 1971. A feature, later named Nirgal Vallis, had the curves of rivers on Earth; Warrego Valles in the Thaumasia quadrangle displayed branched channels (dendritic drainage pattern). Also, huge streamlined shapes indicated great floods in the past--floods that may have been as large as any that the Earth has experienced.

Past lakes have been proposed for over two hundred craters including Gale Crater, Jezero Crater, Columbus Crater, Holden Crater, Ritchey Crater, Hellas Basin, and Argyre Basin. Some portions of Valles Marineris may have contained lakes. The Eridania Lake may have held 9 times as much water as all of the Great Lakes combined. Besides showing features which usually form in water like deltas, many proposed lakes contain mineralogical evidence for water in the form of clay and hydrated sulfates that require water for their formation.

An ocean on Mars has been debated for decades. Much evidence supports its existence, including observations suggesting tsunamis struck the ocean and left marks on the landscape.

Some of the photos and information for this talk can be found in Marspedia articles: https://marspedia.org/Rivers_on_Mars and https://marspedia.org/Oceans_on_Mars.

TECH C: TC-9

A thermochemical approach to convert Martian CO2 and water to sugars

Wilson Hago and Randal Hatfield

Hago Energetics, Inc.

Hago Energetics was a participant in the NASA Centennial CO2 Conversion Challenge. The Challenge aimed to find practical solutions to generating food for microbes in order to facilitate in situ plant growth on Mars. In this talk we will describe our thermo-chemical approach that we submitted to this Challenge as well as lab results that were generated during implementation of approach.

TECH C: TC-10

Challenges of Mars settlement: Planetary surface perspective

Sudhir Kumar Chaturvedi, Rohan Chandra, and 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 most number of robotic missions so far with the hope for future settlement of humans. All the planetary exploration missions has helped in understanding Mars to a greater extent to plan for surface visits and settlements in the future. Using insitu 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.

TECH D: TD-1

Resource Utilization technology for sustainable development

Rupali, Abhai Kaushik, and Sudhir Kumar Chaturvedi

UPES Dehradun

Mars is quite similar to earth but it is a freezing barren land, which primarily has 95.32vol% 〖CO〗_2and only 0.13vol%O_2, volcanoes and wind blows here with full wrath. To colonize advanced technology is required to protect humans from the harsh Martian environment. This could be one of the most expensive space missions because of several primary and secondary reasons. According to some reports the gear ratio for mars is 226:1. Also for missions, dependence on the earth's resources can lead to degradation. That's why there is the need for technology that can reduce the mission cost and also be a sustainable option.

In situ resource utilization technology can help to reduce the dependence on the indigenous resource but right now it is in the developing stage. With the intent to utilize the local resources, an adequate layout to implement ISRU technology is designed. The development of ISRU technology is categorized under five main stages and substages. The first stage is site selection for the acquisition of resources. This will be done first by orbital resource evaluation and then by surface resource evaluation, after this mapping and scaling these all three steps will be carried out by mass spectroscopy, stereo terrain imaging, using highly advanced rovers, high-resolution cameras, Raman Laser etc. The second stage is the preparation stage. It includes leveling of land, construction of the launch and landing pad and roads using rovers' with autonomous technology which can work despite dust storms and harsh climatic conditions efficiently. The third stage includes the setup of mining units, energy units, and assembling of different machines and instruments. The fourth step includes the acquisition of resources from regolith and atmosphere which include multiple steps.

TECH D: TD-2

Insight – From First Landing to Cities

Kent Nebergall

MacroInvent.com

Insight is a surface outpost design that finds the most efficient way to fill the gap between the first landings and settlement. The facility starts with four repurposed Starships and encloses them for both radiation protection and as a lab for manufacturing with hybrid local/imported materials. This is the rapid development factory to create systems with greater mass ratios of local materials over time. From here, the starship port may be expanded to 1000 residents. This would then create the first small “towns” on the moon, Mars, or (with the addition of a centrifuge) asteroid surfaces.

This concept expands on my StarPort Logistics design from the 2020 Mars Society Conference and updates a small outpost concept from the 2021 Moon Society Conference. It also starts with the “everything is as hard as possible” baseline to avoid scope creep and failure if there are setbacks on the surface.

TECH D: TD-3

FlexSail – Solar Sails and Tech Revolutions

Kent Nebergall

MacroInvent.com

Solar Sails are at the same stage of engineering development as electric motors were in the 1830's. Each attribute of solar flux has been examined in isolation, such as photon, proton, plasma, and electrodynamic systems. This talk recommends designing a simple baseline system that converges multiple propulsion methods into optimized systems, as is currently done with electric motors. Many convergences can come from this solution space. Once a baseline design is created, AI genetic algorithms can "flight test" and refine the designs in simulation to adjust proportions and geometry. Once a base design is refined, a second AI evolution pass would design fleet systems that flock like birds to optimize performance. These could fly as a protective shield around Mars crewed fleets, provide space based solar power, deploy rapid reaction probes for interstellar comets, and be used in NEO asteroid mining. In the long term, fleets of solar energy management vehicles can provide orbital Carrigan event protection and Martian solar wind protection for terraforming.

This talk is also a case study in how technology revolutions happen, and how to accelerate the creation and democratization of technical solutions.

TECH D: TD-4

Communication Technologies in Mars Missions

Ayush Mor and Sudhir Kumar Chaturvedi

UPES Dehradun India

The idea of using nuclear reactors for propulsion dates back to the earliest days of the U.S. space program. In the 1950s and 1960s, scientists with what was then called the Atomic Energy Commission developed a series of nuclear rockets. The program was conducted in collaboration for NASA and developed working prototypes. But it was cancelled in the early 1970s, after it became clear the missions for which it was needed, to travel to Mars and the moon, were unlikely to go forward.

Nuclear electric propulsion systems use propellants much more efficiently than chemical rockets but provide a low amount of thrust. They use a reactor to generate electricity that positively charges gas propellants like xenon or krypton, pushing the ions out through a thruster, which drives the spacecraft forward. Using low thrust efficiently, nuclear electric propulsion systems accelerate spacecraft for extended periods and can propel a Mars mission for a fraction of the propellant of high thrust systems.

Nuclear thermal propulsion technology provides high thrust and twice the propellant efficiency of chemical rockets. The system works by transferring heat from the reactor to a liquid propellant. That heat converts the liquid into a gas, which expands through a nozzle to provide thrust and propel a spacecraft.

It’s a potential technology for crew and cargo missions to mars and science missions to the outer solar system, enabling faster and more robust missions in many cases.
Space nuclear propulsion systems could enable shorter total mission times and provide enhanced flexibility and efficiency for mission designers.

TECH D: TD-5

Data Networking in Mars Missions

Lokash Kannan and Sudhir Kumar Chaturvedi

UPES Dehradun, India

The Indian Deep Space Network (IDSN), commissioned during the year 2008, at Byalalu village near Bengaluru, forms the Ground segment for providing deep space support for India's Space Science Missions like Lunar mission-Chandrayaan-1, Mars Orbiter Mission (MOM) etc., Indian Space Science Data Centre (ISSDC), located at the IDSN campus, is the primary data center for data archives of Indian Space Science Missions. IDSN complex comprises Deep Space Antennas of 18 m and 32 m capable of supporting interplanetary missions. It also houses an 11 m antenna facility to support earth bound scientific missions. The 32 m antenna was indigenously realized with the collaboration of ECIL, Hyderabad, BARC, Mumbai and other Indian Industries. DSN32 consists of a Servo system for precise antenna pointing and tracking with a speed as low as 0.1 milli-deg/sec. The timing system of the antenna consists of an active Hydrogen maser for a highly accurate and stable clock. This facility is built on the earthquake resistance site.

Considering the long-time preservation requirement, for catering to the needs of all ISRO space science missions, a hierarchical storage management is used. At present, ISSDC is supporting MOM apart from AstroSat and Megha-Tropiques. Presently, ISSDC is involved in the following major activities: Recently, ISSDC has released the MOM data sets belonging to the First Year of Martian Orbit. MOM Long Term Archive (LTA) is hosted to the general public and has received overwhelming response. ISSDC has hosted 1603 products acquired during the First Year of MOM operations in Martian Orbit from all the five instruments of the satellite.

TECH D: TD-6

Indian Mars Programme

Rupali and Sudhir Kumar Chaturvedi

UPES Dehradun India

Today India is among the space elite nations. The nation which was once barely able to crawl is touching the orbit of another planet just after seven decades. All credit goes to the Indian space research organization. The success of the Chandrayaan-1 in 2008 encouraged the ISRO scientists to embark on an interplanetary mission to Mars. The objective of the paper is to understand the mission objectives, problems, bus systems, technology, and the results produced by MOM. Mission was full of challenges like time limitation, design the system that can survive in mars environment as the mars environment is cool and capable of operating in EBN, MTT, and MO environment, power system as mars is away from the sun and is receiving very less amount of solar rays, communication system was also the major challenge as it takes almost 42 minutes to receive back the signal, design autonomous system so that MOM can self-diagnose and can make the decision itself during a signal delay, navigation system and propulsion system as the target was to use the minimum amount of fuel due to budget constraint. To send and receive the information ground communication system was also developed named as Indian Deep Space Network. Where two antenna systems collect radio signals working at 20Kw power and are still receiving the information from MOM almost after 8 years. By designing MOM using indigenous technology and within such a small budget ISRO had done a commendable job.

TECH D: TD-7

Antenna System Design for Mars Missions

Syed Uzair Ahmed and Sudhir Kumar Chaturvedi

UPES Dehradun, India

The Space exploration organization has been facing an issue with Mars exploration and a way to start a society on a completely different planet. The most important thing we need is communication & navigation, and it's only possible with an antenna and a satellite.
Currently, the Mars rover relies on indirect or relay communications. The rover sends its data to a satellite which is revolving around the Mars and is a very much larger satellite antenna, named the Mars Reconnaissance Orbiter, which then send its data to earth at high transmission rates and the distance it covers is unbelievably huge, the frequencies of transmission are in X-Band which near the 8 GHz, with radio wavelength close to 1.5 inches, the band is so high because there are many rovers present on the surface of Mars, a rover has accessibility to gather information like, measurements, pictures, and video, etc.

When enough of these antenna elements are used in an array, which is 256 elements, this will result in greater power, and this array is equal to 12x12 inch of chessboard and this will fit nicely into the required volume on the rover. This may solve the problem of so many things and delay communication. We don’t need to waste time in building satellites, when you have direct connection, and much more resources are saved and may get reused.

TECH D: TD-8

Satellite Communication Channels for Mars Missions

Sarthak Aggarwal and Sudhir Kumar Chaturvedi

UPES Dehradun India

Making humans a multiplanetary species seems to be a natural course of action with our advancing technology, curiosity, and the will to find answers to questions that cannot be answered by what we see from Earth. The only way to achieve that goal is to have a consistent, redundant, and efficient communication system to fulfill our requirements. The approach to achieving this has two parts. The first part is to make the channel consistent by addressing blackout points where the Sun eclipses Mars from Earth, due to which LoS communication is not possible. Installing communication nodes at all possible Lagrange Points between the Earth, the Sun, and Mars will solve this problem.

Till now, we have used electromagnetic waves for communication, which poses issues in terms of degrading signal quality with increasing distance, low precision, and limited bandwidth for data transfer. Using Infrared Lasers for communication can solve these issues. Laser communications are one of these enhancements and will provide significant benefits for missions, including bandwidth increases of 10 to 100 times more than radio frequency systems. It also reduces the size, weight, and power needs, making it easier and more cost-effective to place these modules in their target orbit, due to their smaller size and lower maintenance requirements. NASA's Laser Communications Relay Demonstration (LCRD) mission showcases these abilities which can revolutionize space communications.

TECH D: TD-9

From Earth to Mars: from simulation to experiment approach

Anita Kumari, Smriti Arora, and Sudhir Kumar Chaturvedi

UPES Dehradun India

Microbes withstand a wide range of environmental conditions such as : light intensity, total salinity, water availability, oxygen abundance, pH, temperature, x-ray, gamma-ray and UV rays upto an extent. There are studies conducted by NASA and other international bodies on climate of Mars and extant life. Mars environment is oxidising, extremely cold, gets intense UV radiation and presently dessicated. Oxidants appear to be hydrogen peroxide which damage DNA and would be deleterious to most organisms. Therefore, we suspect very few life forms to exist on current Martian climate. However, microbes are so diverse that some of them might be present on Mars. A recent study conducted using some microbes taken from earth to Mars called as MARSBOx (Microbes in Atmosphere for Radiation, Survival, and Biological Outcomes Experiment). In this mission, spores of fungus Aspergillus niger, and bacteria namely *Salinisphaera shabanensis*, Staphylococcus capitis subsp. capitis, and Buttiauxella sp. were exposed to a martian atmosphere. The experiment had two sets of conditions that the microbes were exposed to one with UV and another without. Microbes showed differential survival to UV. However, pigmented fungi showed prospective survival on Mars. Such experiments may be more elaborated by using microbial consortia isolated and grown from marine environments, rocks or deep vents in laboratories. These may be mixed in different proportions for e.g if pigmented fungi survive better, they could be mixed in higher proportion. Using such simulations, the consortia that survives harsh martian climate can be hunted and sent to Mars to see real life survival.

TECH D: TD-10

Study of Thermal & Pressure Gradients in Martian Atmosphere

Abhay Kaushik Nudurupati, Rupali, and Sudhir Kumar Chaturvedi

University of Petroleum and Energy Studies [UPES], Dehradun, India

“The extension of life beyond Earth is the most important thing we can do as a species' ' stated by Elon Musk, with a purpose to colonize Mars has been a contemporary challenge for organizations. Yet, new findings from the lone robots on Mars procured sufficient data for the preliminary research to be performed in view of future colonies and their sustainability. Purposing the same, this study composes a scrutinized behavioral structure of temperature and pressure gradients within Martian atmosphere, proposing and verifying the effects caused by such gradients. A digital work in combination with the simulations encompasses the structure and details of environment, terrain, soil and atmospheric composition along with the changes caused proportionate to their variation. The system level design and analysis were performed iteratively to obtain average changes over a justified period to validate on software’s including COMSOL Multiphysics, Autodesk Fusion 360, and MATLAB. The results from the study would act as a forerunner for the establishment of colonies and added experimentation providing a headway pursuit in the field of Martian sciences and colonization.

A Martian environment comprising high concentration of Carbon Dioxide, would create noticeable changes in the pressures across a section of atmosphere above a terrain.

A simulated chamber in the COMSOL Multiphysics work space creates a constrained environment with an estimated plane area of 100 meter square. With a halogen source inserted in the space at a proportionately higher altitude would alternate the radiation and temperature effects by the sun at an approximate distance of 250.7 Million kilometers.

Analog Missions: AM-1

Team adaptation in space analogue contexts: How Antarctica teams deal with unexpected events that threaten performance

Pedro Marques-Quinteiro, Jan B. Schmutz, Mirko Antino, and Walter J. Eppich

ISPA- Instituto Universitário, Lisboa, Portugal

Team adaptation - how teams modify relevant team processes to deal with unexpected threats to performance and wellbeing - makes or breaks mission success in isolated, confined, and extreme work environments such as space, the polar regions, and underwater stations. Yet we are only beginning to understand these adaptation processes, what drives them and what prevents them to maintain effective teamwork under adverse conditions. The current study adopted an event-based approach to study team adaptation in Antarctica, as a space analogue context. Specifically, we tested how different characteristics of adaptation triggers - events that happen during a mission that disrupt group functioning and threaten performance and wellbeing - moderate the relationship between team processes adaptation and team performance. Participants were 56 individuals (21 teams) who reported 87 adaptation events during one Antarctic Summer Campaign. Using hierarchical linear modeling (HLM), we found that the adaptation of transition (as planning and organizing behaviors) and interpersonal (as relationship management) processes leads to higher performance when teams deal with internal triggers (e.g., equipment malfunction; conflict). Likewise, our results suggest that interpersonal processes lead to higher performance when teams must solve external triggers (e.g., sudden weather change; aggressive wildlife) that are highly complex. The findings of this study help to clarify how team adaptation triggers the relationship between team processes adaptation and team performance, in isolated, confined, and extreme work environments.

References:

Landon, L. B., Slack, K. J., & Barrett, J. D. (2018). Teamwork and collaboration in long-duration space missions: Going to extremes. American Psychologist, 73(4), 563–575.

Maynard, M. T., Kennedy, D. M., & Sommer, S. A. (2015). Team adaptation: A fifteen-year synthesis (1998–2013) and framework for how this literature needs to “adapt” going forward. European Journal of Work and Organizational Psychology, 24(5), 652-677.

Analog Missions: AM-2

Innovative Mars Analog Experiments

James Burk

MDRS Crew 261 - Transatlantic Mars Society

James Burk will be the commander of MDRS Crew 261, composed of professional analog astronauts from the US, Canada, France and Belgium. As part of the preparation for MDRS Crew 261 (Dec 2021), our crew held a call for experiments across the space analog science community. We selected 10 experiments which run the gamut of the disciplines of medicine, chemistry, biology, robotics, sociology, psychology and human factors challenges for a human Mars mission. James will present our roster of experiments and our plan for executing them during our mission in December.

Analog Missions: AM-3

Machine Learning Algorithms to Study Behavior in Space Analogs: Leadership Example

Inga Popovaite

PhD Candidate at the University of Iowa Department of Sociology and Criminology

Research shows that a perfect leader in space or space analog environment should combine both agentic and communal behavioral traits (Landon et al 2017, Nicholas and Penwell 1995). In this talk I propose a novel and unobtrusive way to study leadership in space analog environment using advanced computational techniques. I use Commanders' reports from the MDRS crews and structural topic modeling to investigate agentic and communal aspects of their leadership. My data consist of 824 reports written by 76 commanders during 2009-2016 field seasons. I show that both female and male commanders are agentic, but female commanders are more communal than male commanders (controlling for other sociodemographic characteristics).

Analog Missions: AM-4

Mars Ocean Analogs: How Voyages at Sea Provide Valuable Human Factors Data For Mars Missions

Reid Stowe

Mars Ocean Analogs (MOA)

Reid Stowe has been into long duration Mars psychology since the 1980's when he led a multinational sailing expedition to Antarctica. That led to publishing an article titled "Seafarers of Today Provide a Role Model for Spacefarers of Tomorrow" and The Mars Ocean Odyssey, the longest continuous non-stop without re-supply sea voyage in history. 1,152 days and nights living between the stars set the bar for long duration space analogs.

A sailing voyage at sea in a vessel about the same size as a rocket to Mars has many similarities to a space voyage. The crew of multinational men and women are cramped together in about the same size living quarters, always moving, floating in a life and death, isolated, high performance environment. Crew interaction in a dangerous environment is very different than in a safe habitat on land where one can walk out on a whim.

With the experience of long voyages he began an analog program that provides psychological training at sea. Stowe took a Mars Ocean Analog team all the way to Starbase, Tx, signed one team off and another team on right under the starship prototype being developed to go to Mars. There, next to the launching pad for humanity to become a multi-planet species, the analog astronauts felt the reality of the mission to Mars.

Reid will discuss what he has learned from four three-week Mars analog missions at sea and what is being done to make future analogs better for the individuals who participate and better able to contribute to the overall knowledge of human factors relevant to sending humans to Mars.

Analog Missions: AM-5

Endurability to Habitability: A study to create a Biologically Reliable Integration and Design for Ground Environment and Space (BRIDGES) for human spaceflight

Davi Souza, Eran Shileikis, Sai Tarun Bandemegala, and Bailey Burns

(#1) Federal University of Rio Grande do Norte; (#2) Independent; (#3) University of North Dakota; (#4) Paragon Space Development Corporation

During the modern space age, one of the most difficult challenges to overcome is sustaining life in space. In this work, the authors used the critical factors that impact human life to design a model based system that addresses solutions for possible gaps in current ground-based space analogs and ISS studies about closed ecological environments. Past industry research is leveraged on this effort to create a modular and scalable method named BRIDGES. The modularity of BRIDGES offers a unique decomposition of a complex system to isolate and manage critical pieces of both biological life and the environmental control and life support system (ECLSS). BRIDGES also addresses the scaling concerns encountered in these same areas as human spaceflight habitats and its capabilities expand during the assembly process. The design of an ECLSS based on failure prediction, detection, and diagnosis can support not only systems operation, but can also provide meaningful information for reliability and its analyses to assist habitat management - simplify maintenance and optimize resources and consumables. Sensor specifications, locations, and frequency of data acquisition will be the immediate focus to determine the degree of time sensitivity required for autonomous or human response to adverse conditions. In summation, the integration of systems capabilities such as controls, automation, and situational awareness can directly contribute to studies on the deep interconnection and dependencies between the built environment and the natural environment before reaching the Moon and Mars. Future work will leverage model based systems engineering (MBSE) for habitat monitoring and feedback loops to ensure the safety of the crew by detecting faults or other issues in the system which can support studies in analog settings.

Analog Missions: AM-6

Improved cycloidal gear design in Mars rover analogue

Jakub Kędzierski and Hubert Gross

Rzeszow University of Technology

The rising popularity of space exploration in recent years has resulted in the significant development of technology. One of its branches has peaked in the development of technology, so called "robotics". It's related to the construction of manipulators and their drives which use mechanical transmissions.

Gears used in Mars rover manipulators and positioning systems are extremely important for the space industry. Gears provide not only increased torque but also precision positioning of devices or arm members, which is represented in already used designs such as the Perseverance rover and the Discovery space shuttle.

In the analog Mars rover project, a two-stage cycloidal gear was designed for the robotic arm structure and prototyped using 3D printing. The gearbox was designed to provide high torque in the arm drive, high precision positioning, high resistance to harsh terrain conditions (such as dust, impact resistance of components, overloads), and at the same time have compact size and low weight. A gear ratio of 100:1 and a torque of 58 Nm (the torque for which the FEM strength analyses were performed) were obtained. The mass of the whole structure according to the analysis (for the model made of metal) was 1038g, which is much lower than the structures found on the market with similar parameters. The load-sensitive elements were made of 42CrMo4 steel, while the less critical elements were made of 7075 alloy. All bearings were replaced with sliding sleeves made of polymer resistant to high pressure and friction forces. After preliminary testing and analysis (motion, FEM) the results meet the needs of the robotic arm of the analog Mars rover.

Analog Missions: AM-7

Design for a Low-Cost & Off-the-Shelf Analogue Research Hab in Extreme Environments

Enrico Trolese and Patrick Rennie

Mars Society UK

ENRICO TROLESE: Architect, Mars Society UK, British Interplanetary Society, Moon Village Association. London, United Kingdom.

PATRICK RENNIE: President, Mars Society UK, Systems Engineer, Reaction Engines Ltd.

A Hab design is proposed which maximizes value by taking advantage of Earth-based logistical infrastructure. By fully utilizing intermodal container volumes and a flat-pack assembly, an inexpensive Hab concept may be conceived and easily transported across the world with minimum risk.

Another innovation of this concept is to utilize the intermodal containers themselves and employ a square-edge philosophy, which accepts the benefits of being an Earth-based unpressurised analogue station, and also enables the use of COTS furnishings.

The modular nature of the design also allows sections of the Hab to be individually updated (removed from the hab, taken to a warehouse, re-fitted and then re-installed) while allowing the possibility to attach other modules, expanding the Hab, if the budget allows for it.
Despite being about 83 m2, approximately 75% the size of MDRS, this station can support a crew of up to 6 people, and it is composed of a main unit on 2 floors, that includes individual sleeping spaces, living quarters, workstations, food prep, and storage.

A separate Technical & Sanitation unit contains the bathroom, individual storage for the crew members, technical space for water storage, electric power generator and other electrical and mechanical equipment. Finally, a 3rd smaller unit contains the Airlock, where all the crew suits are stored, together with equipment needed for external operations.

An inexpensive, modular, and transportable Hab is key to “opening space for everybody”, and this design is envisaged to enable the wider Martian community to consider establishing their own facilities across the globe.

Analog Missions: AM-8

A data analysis of the first hermetic seal of SAM–a hi-fidelity, hybrid physicochemical and bioregenerative human habitat analog at the Biosphere 2

Kai Staats, Trent Tresch, and John Adams

University of Arizona

SAM is a Space Analog for the Moon and Mars. This hi-fidelity, hermetically sealed habitat analog and research center is composed of a living quarter for four crew, workshop, dual airlocks, and greenhouse with temperature, humidity, and carbon dioxide level controls. SAM incorporates a half-acre indoor/outdoor Mars yard with scaled crater, synthetic lava tube, and gravity offset rig for use in sealed pressure suits.

SAM leverages the world class expertise and facilities at the University of Arizona's Biosphere 2 and the Controlled Environment Agriculture Center (CEAC). As with other analogs, SAM welcomes research teams from around the world in an effort to inform near-future, long-duration human habitation of the Moon and Mars.

With the close of June 2021, a six months refurbishing of the 1987 prototype for the Biosphere 2 Test Module was completed. A crew of five were sealed inside for four hours. This was the first hermetic seal of this iconic vessel in three decades.

The paper summarizes the data and findings pertaining to this closure, with review of the internal atmospheric pressure, CO2, O2, humidity and temperature data, including the effect of activation of a CO2 scrubber built by Paragon SDC for NASA.

Analog Missions: AM-9

Physical preparation of analog astronauts in Habitat Marte

Julio Rezende and Fernando Oliveira

Habitat Marte space analog station

The space analog station Habitat Mars has created new protocols aimed at preparing analog astronauts to participate during in person missions. From in person mission 77 (July 2021) physical preparation activities were put into practice. Some warm-up activities developed were: Stretching the dorsal; Stretching of the pectoral muscle; Quadriceps muscle stretch; Triceps muscle stretch.

Exercises with elastics were performed to simulate the exercises performed in low gravity developed aboard the International Space Station - ISS. Dumbbells and mats were also used to implement exercises with weights and body weight.

Some specific exercises performed: Ventral plank (this exercise strengthens abdominal and lower back muscles); Elastic squat (exercise for grouping the lower muscles, muscles most affected by microgravity; dumbbell exercise for the muscle in the front of the arm (biceps); and Advance with elastic to develop the entire lower group.

A survey was also applied before the mission and after the mission in order to assess the initial conditions, as well as the benefits generated from the practice of workouts.

Analog Missions: AM-10

Mining in space analog habitats

Julio Rezende

Habitat Marte

One of the main topics about In Situ Resource Utilization on Mars and the Moon is related to mining. This research presents some challenges related to how to learn to mine on a small scale, also identifying equipment just available to be used in analog habitats on Earth.

According to Cashman (2021), both surface and underground mining have three main steps:
1. Extraction: This involves drilling, blasting, or digging to remove materials from the mine site.
2. Material handling: This includes sorting and loading materials to either go to a waste area or the processing site.
3. Material processing: The final step involves grinding, separating, crushing, refining, and smelting mined ore or other goods at an off-site plant to turn them into finished products.

In terms of mining on a small scale, normally, the exploration considers taking soil and rock samples and transporting them to a laboratory. For this research it is proposed an analog mission using portable x-ray fluorescence (XRF) and spectrometer devices to analyze rock and soil in situ. This methodology provides effective and fast results, the heterogeneity of samples in some mineral deposits.

Also to mine in some special places in the World it is necessary to identify the legal aspects related to environmental licenses, but also portable tools and equipment for it.

This research presents some of the equipment and necessary challenges in terms of engineering to be used in space habitats.

There are a lot of challenges in engineering to create a small mining plant to extract minerals under a space analog simulation following protocols to analog missions also observing how the use would be adapted to future space missions on Mars and Moon.

Political & Philosophical A: PA-1

International Cooperation in The Development of Space Science and Industry

Desmarnov Tirto Pamangin

Peter the Great St.Petersburg Polytechnic University (SPbPU), Russia

Outer space exploration is a very huge task that all countries in the world should cooperate with one another to achieve. Therefore, international cooperation in the development of space science and industry is needed. Furthermore, it would bring a bright future for all countries in the world. Many countries already possess great capability in terms of material engineering, high tech & electronics manufacturing, and generating power and energy. It is time for all of us, members of planet Earth, to cooperate to have an integrated system of space industry. Eventually, this cooperation would also enlarge the GDP and will create more employment opportunities in the world.

Political & Philosophical A: PA-2

Space Archaeology in Mars: Anthropological aspect of Humans as a Multiplanetary Species in 2050

Aravinda Ravibhanu, Majda Aouititen, Lucinda Offer, and Nick Thomson

South Asian Astrobiology & Earth Sciences Research Unit: Eco Astronomy Sri Lanka

Since 1960, the Homo sapiens sapiens race has explored Mars and now we are closer to making humans a multiplanetary species. Addressing the next logical step in the series of Mars exploration, it is quite obvious, going to be a permanent settlement of earthen in the Red Planet, where crews that go to Mars can stay and build a new society with it all hierarchy similar to these we have already established in Earth; still, it may differ due to the new environment. Also searching anthropogenic activities of Mars via space archaeology to interpret current anthropological aspects is absolutely important. Therefore, we're aiming to illuminate and clarify the results of human behavior interaction with technology; we will highlight the particular technical assemblage on MARS for a better understanding, and to promote the inclusion of heritage planning in future space missions and planetary exploration, specially for studying culturally significant sites and spacecraft on the red planet Mars. Our methodology consists of applying 46 numbers of historical log entries via NASA science Mars exploration program and proceeding to the space analysis, images sites by using the catalog of Mars orbiters. Based on these data, it appears that non-compliance with consensus issues could lead to serious crises in the future when it comes to comparing the future results scenarios with the United Nations Universal Declaration of Human Rights. Mars colonization or human settlement must inspire us all to make Earth a better place, much more, it is the perfect timing for us to boost our technology, scientific understanding, and worldwide cooperation – is there anything we cannot achieve? Considering "Humans as a Multiplanetary Species", it shows how important tto have establish a sustainable settlements aspect correspondence to archeological and anthropological point of view.

Political & Philosophical A: PA-3

Seek Democracy on Mars

Wang Lixiong

Writer, scholar, best known for political prophecy fiction

What type of the social political system adopted by the Martian society determines success or failure of the colonization of Mars. The differences between the Earth and Mars decided that we cannot duplicate the Earth system but have to be innovative. However, innovation cannot be tested and learned after landing on Mars, it must be completed, and well understood and used well before the first martian immigrants. Therefore, the whole process of design and experiment must be completed in advance. This process will take several years, and this is the ideal mission for the Mars Society. It's recommended to Mars Society to initiate a call for proposals and competition on the social political system in Mars. The community experiments, follow-up and monitoring has to be conducted after the review, and finally, to provide the best plan for Martian society. This is the greatest benefit to the planet and generations!

Keywords: the social political system, Mars, Earth, the Mars Society, recommendations, experiment.

Political & Philosophical A: PA-4

Martian Countries: Why They are Inevitable

Doug Plata

The Space Development Network

This presentation proposes that there are relevant factors which will inevitably lead to multiple, independent political entities on the Moon and Mars. It is proposed that there will be an initial international public / private base but that people will, by default, start to organize themselves according to people groups for the typical reasons – language, religion, and political perspectives. Doug will suggest a possible timeline for when we would expect which groups to separate and approximately when. He also will stress why we need to establish mechanisms early on in order to prevent disputes and conflict between people groups in the more distant future.

Political & Philosophical A: PA-5

Tokenization will solve the Space economies two largest problems

Grant Blaisdell

Copernic Space

Owners of space assets like satellite data have no scalable commercial interface with end users, while users are left to fend for themselves in a complex market without a home to streamline acquisition and management of assets they need. Early stage space ventures can't get VC investment and are usually left with gov't grants, while even mature companies can't leverage contracted revenue for operational capital and are forced to lose equity and time to fundraising. Copernic Spaces's CEO will speak about how applying tokenization models will solve both issues.

Political & Philosophical A: PA-6

The Case for International Cooperation in the Exploration, Terraforming and Colonization of Mars and the Solar System

Danny Quintana

Global High Seas Marine Preserve

The need for international cooperation today is greater than at any time in history. Civilization is in transition. We evolved from empires to nation states. Civilization is evolving from nation states to multinational corporations that transcend the power of governments. Global environmental and economic problems are massive. International cooperation is essential for the survival of complex life. Covid 19 fostered international cooperation out of necessity. The pandemic had to be brought under control. There are numerous examples of beneficial international cooperation. From research on pandemics, airline travel and international trade regulations, international law is fast replacing war. The effort is underway to explore the cosmos. Multinational corporations are creating new markets for space tourism. Several nations are engaged in exploration activities on Mars. No nation or group of nations is trying to conquer the planet by military means. The United States withdrew its troops from Afghanistan. Russia's attack on Ukraine did not generate economic benefits. China has not attacked Taiwan. Space exploration is the single most difficult endeavor and adventure humans have ever undertaken. Exploration of Mars, terraforming and the eventual colonization is an adventure so massive, expensive and dangerous, international cooperation will vastly improve the chances of success. Going it alone has political as well as scientific dangers. When, not if there is an accident involving a loss of life, space exploration might be set back for decades. Thus this has to be a joint human effort by all nations. International cooperation in space exploration will demilitarize the global economy, lessen the chances of a nuclear war, the destruction of civilization from zoonotic viruses, and clean the global environment.

Political & Philosophical A: PA-7

Intercultural Competence for Space Exploration

Karin Brünnemann

4 CEE, s.r.o.

Intercultural competence for space exploration focuses on reducing risks for space missions, optimizing mission outcomes, and enhancing crew well-being. Aspects of intercultural competence in missions include communication styles, approaches to risks, concepts of time, aligning values, building trust, and developing teams. It also includes knowledge about different styles relating to leadership, followership, negotiation, problem solving, decision making, and conflict & crisis management. We must also consider cultural influence on ethnomathematics, attitudes towards change, social responsibility, and intercultural aspects of digitalization and artificial intelligence.

Some risks originate in culture. In 1999, NASA lost its Mars Climate Orbiter due to undetected cultural differences and with it, almost 200 million USD and several years of research. In today's missions, there are increased risks of misunderstandings, stress, suboptimal decisions, loss of crew motivation and conflict based on cultural differences among the crew, mission support, and mission control. People from different cultures are used to, and prefer, different management styles, they communicate in different ways, and display behaviors, ways of thinking, and emotions based on their specific cultural background. Space missions are always multinational; however, national culture is only one aspect we must consider. Organizational culture, professional culture, gender culture, and other facets play significant roles. To avoid suboptimal performance in (analog) missions, commanders, crew, and mission support should be trained to work across all these different cultures.

During space missions, we have very limited resources, be it physical, financial, or human. Hence, we must look for the best way to deploy these. Collaborating in a multicultural team will thus not only lead to avoiding mistakes and conflict but will produce better outcomes. Combining different perspectives, ways of thinking, and approaches will enhance problem solving capabilities and solution quality. Ignoring the need for intercultural competence during space missions thus borders on negligence.

Political & Philosophical A: PA-8

The Martian Papers: A framework for thinking and discourse on Martian Governance

James Gilley and Brendan Lauer

Nicholls State University

Mars presents interesting opportunities and challenges when it comes to establishing a human presence. Apart from technical issues of occupying Mars, the political and institutional problems are both major solvable issues. Yet up to this point in time, these problems have been underserved by those interested in the project of making Mars a permanent human settlement. To help solve this problem, a new framework driving discussions about the human side of Martian settlement must be created, because the first Martian will be humans with human problems. Built in the model of the Federalist Papers, the authors of this work propose and have been creating a series of short and accessible papers for a general audience to provide the background information and discussion as the prelude to the writing of a Martian Constitution and the formation of a Martian governance structure. This presentation will explore the purpose of the Martian papers, as well as outline the initial work that has already been conducted focused on arguments for Martian Sovereignty and Independence. The time has come to bring the human and social elements of Martian Settlement to the foreground, as the gap between these discussions being hypothetical and becoming real and vital to the success of human space settlement is drawing ever smaller.

Political & Philosophical A: PA-9

Mars City State Design for 1,000,000 Population: An Integrated Model-based Approach towards Martian Settlements

Marufa Bhuiyan

Everest Innovation Lab LLC

Mars used to be the “God of War " since ancient Roman civilization but in Sanskrit or Bengali language planet Mars means “মঙ্গল”(Moṅgol) meaning good, welfare, blessings etc. It implies that history and meaning can change as we voyage from the East to West, but it will be unique this time as we explore our universe both in real-time and imaginary time. In this paper, we have designed city states on Mars for a 1,000,000 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 Earth, we understand that an 0ptimization-simulation-ArcGIS-GoogleEarthPro based methodology can be useful for Martian settlements e.g. resource allocation, technology designs, governance, workforce development etc. Some important features are: 1. If one leader can manage/coordinate 1000 people, then 1000 leaders will be needed, 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. Spaceport, II. Living habitats, III. Time Capsule, IV. Greenhouses, V. Quarantine Habs, VI. Earth museum, VII. Observatories, VIII. Health Units, IX. Manufacturing warehouses etc. 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 and growth patterns for every citizen on Mars. 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.

Political & Philosophical A: PA-10

Habitat on Mars - Architectural Design for Future Settlements

Yash Suresh Rathod

MIT ADT University

With the rise in technology, the carbon emissions have skyrocketed in the past decade. The Earth surface temperature has come to 1 degree Celsius which was below 0-degree Celsius back. We have a limited carbon budget, which will be exceeded in the coming years. The resources are depleting, some species are coming to extinction. All these points boil down to the growth and growth is inevitable in a way.

The real questions arise, when we say that are we supposed to limit our-selves to Earth? There are trillions of Galaxies out there in deep space. Humans being a part of the Milky Way Galaxy. And with our solar system, it gives a lot of new directions to unleash space exploration. There are infinite resources in our solar system. We are in a quest to colonize Mars and seek a new way of living and exploring.

The thesis is done in regard to having a self-sustaining habitat on an extra- terrestrial ground. Mars being the most habitable planet after Earth, has to have a different architectural language. The project consists of formulating a settlement for the first hundred people on Mars which includes study of demographics, site selection, study of material and climate.

The study signifies about who are the 1st 100 people to go on Mars and how a permanent settlement will be created in regard to the extreme environment. The study also talks about architectural spaces for the Martians for their psychological well-being and how the settlement is a self-sustaining settlement.