Mars Desert Research Station
Mission Plan

Crew 218 – The Next Giant Leap
Dec 20th, 2019 – Jan 4th, 2020

Crew Members:

Commander and Crew Astronomer: Dr. Cesare Guariniello
Crew Scientist and GreenHab Officer: Dr. Jonathan Buzan
Crew Engineer: Luz Maria "Luz Ma" Agudelo Urrego
Health and Safety Officer and assistant GreenHab Officer: Shefali Rana
Crew Geologist: Pat Pesa
Crew Journalist: Benjamin "Ben" Durkee

Mission Plan:

"The Next Giant Leap" is the third all-Purdue crew at MDRS. The enthusiasm and interest raised by the first two experiences of Purdue students and alumni at the station, as well as Purdue's honored tradition in the field of space exploration, made us eager to participate once again. Therefore, we organized a crew with one veteran of MDRS and five rookies.
Crew 218 will perform various research tasks, mostly related to human factors and logistic support of human exploration of Mars: some of them will be performed in the habitat, while others require Extra Vehicular Activities (EVA), thus adding realistic difficulties to the task. As usual, the combination of excursions and life inside the habitat will provide crew members with the opportunity to both working on their research and identifying potential difficulties of working with space suits and living in close quarters in a small habitat.

The main objectives of "The Next Giant Leap" analog Martian mission are:

- Keeping the highest level of fidelity and realism in the simulation. Earth analogs cannot reproduce Martian gravity and atmosphere, but the crew will keep every other aspect into consideration. This includes safety and research protocols, definition of roles and daily schedule (with ample space for personal time), EVA protocols and difficulties, communication protocols, fruitful collaboration with the program director and mission support, and adaptation to limited resources and environmental difficulties.
- Performing research in the fields of engineering, earth sciences, human and environmental factors, and crew operations on Mars
- Completing outreach projects and keep the public involved. Public relations and outreach began before the mission and will continue after it and includes outreach to the general public about analog missions and their importance, outreach to students about the crew research, and media release through the Mars Society, Purdue university and other media channels.
- Continuing the fruitful collaboration of Purdue crews with the MDRS program.
- Following the mission, supporting MDRS with useful results for future crews.

Crew Projects:

1.

Title: Decision Making in support of autonomy for crew EVAs
Author(s): Cesare Guariniello
Objectives: Comparison of decisions made by crew during EVAs with decisions based on an Artificial Intelligence machine

Description: Continuing a research project started last year, during EVAs, events will be suggested to the crew (not simulated, for reasons of safety. It will be up to the astronauts to keep their decisions realistic), and the discussion and decision recorded and compared to the "best decision" made by a trained AI. When events such as loss of communication, unexpected environmental difficulties, or crew member injury occur, the crew must decide whether to continue the EVA, modify the primary objective, proceed to secondary objective, or abort the excursion based on safety of the crew, current status of the mission, achieved partial goals, and potential further acquisition of data.
Rationale: Due to the distance between Earth and Mars, increased autonomy of the crews is fundamental. Support from Earth will be limited and time-delayed, therefore astronauts on Mars will need to be able to perform decisions autonomously. Intelligent and adaptive algorithms can provide a key support to astronauts, especially in situation of distress.
EVAs: 3-4 medium to long EVAs

2.

Title: Mars surface weather
Author(s): Jonathan Buzan
Objectives: Move the first steps towards autonomously generating reliable weather information in the area surrounding MDRS
Description: Currently, the MRDS does not have an active weather station besides the one used by the robotic observatory. Analog astronauts rely on weather forecast information provided daily by mission support. However, the nature of the location sometimes causes conditions that can substantially differ from what expected (which is based on distant weather stations). The first step toward generating reliable weather observations is the training of personnel on the usage of hand-held weather monitor and visual identification of weather conditions. For hand-held instrumentation, we will be using the REED Instruments LM-8000 6-in-1 Multi-Function Environmental Meter (Air velocity/temperature, Ambient Temperature, Humidity, Contact Temperature and Light). This device will be carried on EVAs and we will record weather observations every 30 min. The visual identification will be a north-south-east-west identification of horizontal conditions, and a vertical observation of atmosphere above. Our aim is to encourage regular observations of weather, as these are the first steps towards the installation of a permanent weather station at the MRDS complex.
Rationale: Mars presents a challenging environment for weather forecasting. With limited satellite coverage, astronauts will rely on in-situ data to make command decisions for EVA activities. Rugged terrain can cause higher variability and dust storms can cause hazards. Sustained human presence on Mars will rely on local weather stations and personal observation to plan daily activities.
EVAs: 3-4 EVAs

3.

Title: Subsurface structure on Mars
Author(s): Pat Pesa
Objectives: Demonstrate the use of instrumentation for structural analysis of potential locations for building on Mars
Description: Several sites in the MDRS area will be analyzed using seismometric measurements to determine shallow subsurface rock structure. A line of geophones will be set out and record data after small impacts gathering information on how vibration waves travel through the sub-surface. Applications of this data will be better understanding of non-invasive structural testing of Martian surface for building and development.
Rationale: The first missions to Mars will make use of the spacecraft and of lava tubes and existing structures as habitat. Sustained human presence, however, will also perform building operations. Before these operations can take place, the astronauts will have to perform structural analysis of potential sites for construction.
EVAs: 3-4 EVAs

4.

Title: Detecting radio signal strength
Author(s): Ben Durkee
Objectives: create a heat map of the signal strength on the 437 MHz band around the Hab
Description: To develop this, I will be going on EVAs to survey the environment around the Hab with a USB GPS unit and a custom-built antenna tuned to 437 MHz connected through an RTLSDR (Realtek Software-Defined Radio) USB adapter, both connected to my laptop. On my computer, I will be running a program created in Python which scans signal strengths in tandem with GPS coordinates to collect the data. Once it is all collected, I will compile and run it through some custom code to map the data with Google's Maps API and create a heatmap of the region. This part of the process will occur during night hours, when internet capability is increased, since interacting with the API will require internet upload and download. If time permits, once the initial heatmap has been created, I will overlay it with a more detailed map of the geography around the Hab to make it more intuitive to use.
Rationale: Communication on Mars will be of vital importance, whether it is surface-to-orbit or surface-to-surface. Being able to identify locations of stronger signal can mark the difference between being able to communicate or not.
EVAs: 3-4 short EVAs

5.

Title: EVA workload analysis
Author(s): Shefali Rana
Objectives: Evaluate performance, effort, and workload on different type of EVAs
Description: The research will use NASA TLX questionnaire covering performance, physical and cognitive workload, effort and temporal strain. Team members will assess their perceived level of workload in 2 types of EVA: simpler and short duration vs. intense and longer duration.
Rationale: Due to the restricted amount of storage available during space travel and limited resources in a Martian habitat, reducing and reusing as much waste as possible is vital. A closed-loop environmental control and life support system is a must for long-distance space travel, and once at destination, it is imperative to reuse as many resources as possible
EVAs: at least 2

6.

Title: EMU (Extravehicular Mobility Unit) ergonomic assessment
Author(s): Shefali Rana
Objectives: Provide personal assessment of the EVA suits
Description: The research will use questionnaires covering assessment of anthropometry, mobility, dexterity, posture and fatigue of the EVA suit.
Rationale: EMU are worn by astronauts for a long time. Adequate ergonomics and comfort support better performance
EVAs: at least 2

7.

Title: Environmental Stresses over MDRS habitat and Crew Members and projection over Martian Terrain
Author(s): LuzMa Agudelo
Objectives: Assess the impact of environmental factors on crew performance in and outside the habitat
Description: Environmental conditions are a fundamental aspect for designing a Mars habitat and plan a mission over Mars terrain. Continued exposure to environmental stresses increases limitations on human

activity as well as malfunctions on the habitat structure and instruments. Data collection and observations over temperature, humidity, and radiation inside the MDRS habitat are proposed to understand the climatological heat stress generated, plan the crew's occupational capacity to perform sustained labor under environmental heat stress safely, design the habitat infrastructure and generate a system model projection over Martian terrain
Rationale: Environmental conditions are among the most important factors affecting human performance
EVAs: 2

8.

Title: Messier and other space objects for outreach
Author(s): Cesare Guariniello
Objectives: Continue astronomy outreach by showing the majesty of some of the most spectacular deep sky objects
Description: Project already started before rotation at MDRS and is the continuation of astronomy work from previous season. Goal is to observe (and later filter and color) planetary nebulas and other interest objects
Rationale: Get people interested not only in the utility but also in the beauty of space
EVAs: None

9.

Title: Reliability and maintenance
Author(s): Shefali Rana
Objectives: Assess the importance of training vs. intuition and personal skills
Description: The project requires the simulation of a failure mode on an EVA vehicle. Two team members (one with knowledge of repair method, the other without) will describe the repair method. Record repair time, and repair success/ failure
Rationale: Astronauts on Mars mission will have a mix of detailed training on various operations and need to face and solve unexpected events.
EVAs: 1-2

10.

Title: Medical readings in preparation for future crew-wide project
Author(s): Cesare Guariniello
Objectives: Test medical instrumentation to be used in a future project
Description: Crew commander volunteered to wear a Zephyr sensor to monitor heart rate, breathing rate, body temperature, and level of activity of crew members, 24/7 for a few days during the rotation. Comparison will be made between different daily activities, as well as beginning vs. end of the mission.
Rationale: Medical evaluation is one of the most important tasks that astronauts undergo. This will provide useful information for crews at MDRS about the most stressful and tiring activities.
EVAs: None specifically

11.

Title: Collection of clay, shale, and hematite samples
Author(s): Cesare Guariniello
Objectives: Continue the past activity of sample collection for evaluation of potential In-Situ Resource Utilization material

Description: Continuing research from the past two years, samples will be collected to be studied in terms of mineralogy and geotechnical properties
Rationale: ISRU will be important to reduce the amount of material transported to Mars
EVAs: 3-4

12.

Title: Media and outreach
Author(s): Ben Durkee
Objectives: Advertising MDRS and our activities to the general public
Description: Before the mission began, a dedicated Instagram account and Facebook account have been created for MDRS Crew 218. Crew journalist will post on these daily after COMMS time if there is sufficient bandwidth remaining. If necessary, he will update these during the window of extended internet access. Additionally, he will record a few videos of the mission (Hab tour, Christmas festivities, maybe more) to upload after the mission concludes for more public exposure
Rationale: We want to involve as many people as possible and share our enthusiasm!
EVAs: None specific