Mars Desert Research Station
Crew 84 Summary Report

Crew 84 is an internationally formed team composed of various backgrounds and skill-sets, all excited to expand Mars Desert Research Station experiments for enhancement of knowledge for future missions to Mars. As the crew was assigned by Mission Support, MDRS was their initial personal interaction. The crew developed as a productive team to effectively conduct Mars simulation and conduct scientific and technical experiments.

Crew 84 was led by Commander Judah Epstein, a Texan who is a veteran at MDRS. He is a worldwide adventurer and technically an engineer, currently in training as a geologist. The Executive Officer and Design Journalist, Mike Neal, is from New York and is applying his experience in human factors and design studies at MDRS towards his graduate thesis on Martian design. Barbara Burtscher is a renowned astrophysicist in Switzerland who is a science teacher and astronomy instructor through various scientific programs such as Swiss Astronomy Day and NASA Space Camp. Lara Vimercati is the Crew Biologist from Italy, yet spends most of her time on worldwide adventures and recently completed fieldwork graduate studies at SETI and NASA Ames. Kelly Rickey is the Crew Engineer from California and is a mechanical engineer working at NASA JPL. Zak Wilson is also Crew Engineer. Zak is from Colorado and has studied mechanical engineering in USA for undergraduate and England for graduate studies.

The crew's Martian Simulation began with excitement as on the first day while on EVA away from the HAB, the engineers experienced a very close encounter with a pack of wild dogs. The crew continued with an exciting expedition rotation of productive field research, extensive laboratory analysis, exercise competitions, inter-galactic Table Tennis tournament, planetary observations, engineering maintenance and repair, subzero Fahrenheit temperatures, dinosaur bone discoveries, and Martian EVA adventures.

Although each day in Martian Simulation was a unique adventure, there was a sort of regularity to the schedule. The crew awoke at 07:30am each morning for oatmeal breakfast (except for the one early morning sunrise EVA to explore for ice deposits). And as astronauts to Mars would do to maintain muscle balance in zero or lower gravity, the crew did morning exercises such as stretching, pushups, and situps. During the day activities were conducted such as morning EVA, afternoon EVA, engineering maintenance and repair, scientific laboratory analysis, and of course lunch. The evening began with dinner and then report writing. Afterwards evening exercise was conducted and was often competitions that turned into fun team-building activities. Crew-members then worked diligently on additional tasks such as research, journalism, and laboratory analysis.

Along with the participation in the ongoing Mars Society experiments of Food Study and Environmental Contamination sampling, measurements, and analysis, Crew 84 has conducted several unique and innovative experiments relevant to our crew's diverse skill-sets.

Crew 84 conducted the following experiments within the constraints of simulation through ExtraVehicular Activities (EVAs) and in-Hab analysis:

- Sample hyper-saline evaporates in the surface/undersurface to collect, culture, and analyze halophiles.
- Astronomical observations with a concentration towards spectroscopy of planetary nebulas
- Investigation of assembly of structures using solar panel approximations
- Examination and analysis of the setup and design of the HAB and EVA activities in regards to efficiency, human factors, and personalization in a confined space and limited resources
- EVA Mobility Study through recreational activity analysis of Table Tennis tournament in spacesuit
- Water exploration through analysis of soil samples
- Greenhouse germination and growth analysis with combinations of various sands, clays, and soils with clean and greywater.

Engineering

The time at the Hab was mostly smooth for the engineers, Kelly Rickey and Zak Wilson. They grew familiar with the power systems, plumbing, and ATVs, participated in several EVAs to help collect biological samples, and made repairs to the spacesuits. They even added another project to the rotation, which consisted of putting together mock solar panels in order to simulate what astronauts may experience when putting together power systems on another world.

The engineers acquired several valuable skills during this mini construction project. They learned how to handle power tools and small objects in spacesuit gloves, communicate effectively with malfunctioning radios, and plan assembly as much as possible indoors before the EVA in order to ensure efficiency. This planning included a review of solid mechanics and solar radiation concepts to determine the most efficient layout for the panels.

There were several engineering-related issues that occurred over the course of the rotation: a leaking sink, leaking water tank, frozen water pipes, malfunctioning radios and EVA packs, generator problems, and malfunctioning scientific equipment. Fortunately, they were able to solve most of these problems. The circuit of the malfunctioning EVA pack was re-soldered and repaired. The engineers also troubleshot the scientific machinery and it is now working properly. The leaking water tank will be fixed shortly. Originally, the engineers were given an incorrect procedure for filling it; however, they now understand what must be done to refill and a sign has been posted to make the process clear to future crews. Finally, the generator would not turn over after one of the oil checks. They determined one of its battery cables was loose and were able to restart it after several minutes.

Unfortunately, a few radios are also still inoperative. Furthermore, the frozen water pipe problem still remains; although the pipe heater appears to be working, it is not doing enough in this extremely cold weather. Depending on which pipes are frozen, the downstairs sink and shower cannot be used, nor can the toilet be flushed.

The most memorable challenge Zak and Kelly faced occurred during their first EVA. While they collected samples for the biologist, they encountered a pack of stray dogs. The animals did not attack but boldly walked up to the two and stared at them for several long minutes. Eventually, the dogs slowly walked away and the engineers made it home safely. The following day, they were told that these dogs have been known to attack and were extremely dangerous. Upon learning this, they felt very grateful.

Journalism

Mike Neal, the Executive Officer and Crew Design Journalist focused on examination and analysis of the setup and design of the HAB and EVA activities in regards to efficiency, human factors, and personalization in a confined space and limited resources. Mike utilized specialized audio equipment to collect data in regards to his human interaction studies. He discovered new techniques while on EVA such as the benefit of switching from internal radio audio to external ambient sounds. As a conglomeration of his MDRS studies and data collection, he is creating an audio program to be aired on Public Radio International.

The Crew Design Journalist realized that preparing to live on Mars necessitates testing the limits of design in areas of domestic functions, social dynamics, closed systems, mobility, etc. When Mike arrived to the Mars Desert Research Station, he had done so with a basic understanding of the theoretic approach to living in a confined and resource scarce environment. Through first-hand observation and interviews with the crew as they performed their duties and experiments, Mike was able to examine these theories through a far less abstracted lens. The Design Journalist was privileged with a tiny peak into what life might be like on Mars, how it would be different than living on Earth, and how the design and function of the habitat and its systems and operations would itself contribute to or impede that existence.

An additional role that Mike Neal supervised was the Food Study. As Crew 84 members had several dietary restrictions, yet were big eaters which consumed quite a large amount of food, the role of Food Study Coordinator was quite a challenge to balance the strictness of the Food Study constraints along with crew survival.

In Mike's role as Food Study Coordinator, he was able to examine the consumption patterns and meal dynamics of the crew, an interesting look into the importance of the dinner table in situations of isolation and unfamiliar surroundings. While the study was in no way one of deprivation, our meals were often quite large, it was again a test of what can be taken away from the Earth lifestyle, and still feel human. Through food constraints and respective personal reactions, the crew learned of the sensitivity of the subject of food. There are such strong reactions to food; it is perhaps one of the most difficult aspects of the simulation to fully maintain.

Astronomy

Crew Astrophysicist, Barbara Burtscher, arrived prepared at the Mars Desert Research Station with her arsenal of advanced scientific tools and equipment. Sensors she transported and utilized included pH, conductivity, soil moisture, UVA, UVB, temperature, barometer, magnetic field, Geiger counter, light sensor, spectrograph to analyze soil samples, and a sensor to measure light pollution. In addition, she utilized her 8" telescope Meade LX200 GPS with a CCD-camera ST-7XME. Unfortunately, the declination motor was damaged during transportation from Switzerland, thus severely limiting the use of the telescope.

Despite the damage to the tracking of the telescope, Barbara successfully completed observations of the sun with a sun filter and H-Alpha filter to track the solar protuberances. Another obstacle encountered with EVA day-time telescope observations was the difficulty in viewing the computer screen output because of the brightness of the sun compiled with the visibility of the spacesuit helmet. Barbara and her EVA team rigged up a system to block the light to the computer screen, yet not interfere with the telescope view.

While viewing the telescope output on the computer monitor during the day proved to be challenging, viewing worked surprisingly well with the spacesuit helmet while observing directly through the telescope with the ocular. And while utilizing the "Tellrad", locating objects worked well, even with the spacesuit constraints.

Another challenge to astronomy observations utilizing the telescope in the spacesuit was concerning the large spacesuit gloves. Barbara found it difficult to utilize the touch-pad on the computer as the pad wouldn't react to the touch from the glove. Again this challenge was solved by taping a pen on the glove to act as a pointer device.

The Crew Astrophysicist also specialized in observing the starry sky during the night with observations of planetary nebula with a special filter for spectroscopy in the filter wheel of the CCD camera. This enabled calculation of the expansion speed of the nebulas utilizing the redshift of the spectra.

Challenges encountered during the evening included extreme difficulty in tracking through following objects with the crosslines of the searching telescope because of the freezing of the spacesuit helmet. This issue completed obstructed viewing and made the observations impossible or dangerous at best.

Unfortunately during the first days at Mars Desert Research Station, the moon interrupted almost all observations of galaxies and nebulas. Each night near the Hab, Barbara measured the light pollution from a constant location and azimuth directly up the zenith. Even without light from the moon or influenced measurements due to cloud cover on some nights, the Martian sky was not as clear as was expected. A possible explanation is dust in the air which obstructed direct sight to the stars.

Finally, the Crew Astrophysicist found it very beautiful to go outside with the spacesuit to look up to the starry sky, observing the Milky Way, galaxies, nebulas, and planets; and dreaming of one day going on a real mission to Mars.

Biology

Biological studies and analysis were a major part of the research conducted by Crew 84. Such research was led by the Crew Biologist, Lara Vimercati. Research consisted of numerous EVAs for data collection, mostly through soil sampling, and then respective laboratory analysis of the samples. While on EVA in the field, proper sterilization techniques were always utilized and environmental data collected at each sample site, such as soil moisture, GPS, time of day, UVA and UVB radiation data, presence of radioactivity, temperature, pH, and electrical conductivity.

Environmental Contamination

The ongoing MDRS Environmental Contamination study was continued by Crew 84. This study measured the soil for environmental impact potentially caused by the Hab and its inhabitants on the surrounding local Martian terrain. At sample sites on specified azimuths from varying distances based on a geometric series, measurements were taken of penetrometer soil compactness, pH values, and E.coli presence. This is a very relevant simulation study, as it is important to measure the levels of contamination that Earthlings will bring to a new planetary environment.

Procedures involved in this study included EVA with sterile sampling tubes, penetrometer, GPS, and long-distance survey measuring tape. At each field site, the samples were collected along with GPS coordinates, distance from previous sample site, and soil compactness from the penetrometer. Upon return to the Hab, further analysis was conducted. pH measurements were taken of each sample site and all soil samples proved to be highly alkaline. Furthermore, each sample was distributed into five separate sterile vials with 10 mL of distilled water for E.coli analysis. After placing in the incubator to maintain constant temperature, each vial was analyzed at 24 hours, 48 hours, and 72 hours for evidence of E.coli contamination.

Various results were observed and are further discussed in the Final Science Report. But it was found that contamination is not dependent upon distance from the Hab and that there is no linear relationship between distance and contamination.

Greenhouse

In addition to laboratory work in the Hab, the MDRS Greenhouse was also necessary for biological studies. White, red, green, and black soils were collected from three separate locations and seeds of lentils, carrots, and lettuce were planted in these soils to verify whether or not the soils could support plant germination and growth.

Significant results from Greenhouse studies included:

- Germination of the seeds planted in the four different clays was observed during the last days of the second week of Crew 84's rotation. This indicates that clays found in this area do not inhibit germination, but they do slow the germination. This is realized since the same seeds in a hydroponic culture germinated during the first week.
  This study suggests that the optimal germination condition is simply plain water. Therefore, this would likely be the same solution as on a future base on Mars. After germination the seeds could be transferred to other soils, such as Martian regoliths, whose composition is similar to the area around the Hab.
- Seeds planted in a combination of 50% clay and 50% sand did not show any germination after one week, clearly not providing any better condition for seed germination as would have been expected.
- Seeds planted in grey water and those planted in a combination of 50% clay and 50% sand and watered with grey water did not show any germination after one week. This shows that grey water from the Hab significantly slows down or inhibits the process of germination of those plants generally grown to provide food.

Further work should be focused to see if plants which germinated in clays are able to build roots and grow, and how fast this process would be compared to the one in classic soils used for these plants.

Water / Ice Exploration

As discovery of water on Mars, especially significant sources, is a key for further understanding potential Martian life-forms and for establishment of Earth inhabitants; Crew 84 participated in exploration for ice deposits and existence of water on analogue Mars.

To search for early morning ice deposits, the team braved the extreme negative temperatures at the coldest time of day to obtain the best results. Unfortunately after warming up the ATV rovers, all expeditioners experienced frozen helmets and could no longer properly view the surrounding area. Obviously this would affect the crew's safety for driving the ATV rovers, and the crew-members would not even be able to notice ice deposits even if in plain view. Therefore, after hypothermic conditions, the crew returned to the airlock and the Hab to retrieve the keys for the V'ger pressurized rover. On this first EVA, the crew did find ice just outside the Hab, but it was runoff from the Hab and was therefore not relevant to our studies as the water was contaminated for proper biological studies.

The second continuation EVA consisted of the same scientific purpose of ice deposit exploration. The crew explored to the North and the East of the Hab. Unfortunately no ice deposits were found. But many interesting geological formations were observed. Additionally, dry streambeds and dry water flow areas were discovered for return after potential precipitation. And GPS coordinates were taken of an area to return to search for groundwater exploration on a cliff outcrop.

The team later returned to this outcrop discovery South-East of the Hab to search for evidence of water in the vertical cliff outcrop. Although the crew experienced difficulty in drilling into the hard soil of the cliff, the team was able to take some interesting measurements. It was discovered that soil moisture increases with depth, even in desert regions. As the team measured deeper into the bottom edge of the base of the cliff, proportionally increasing levels of soil moisture were discovered. Therefore evidence of groundwater is probable. Data discovered from this type of research on a Mars analogue can potentially be utilized correspondingly in Martian exploration for water sources and inherent potential life forms.

Microbiology

The major component of the biology research conducted by the Crew Biologist, Lara Vimercati, at MDRS was focused towards microbiology. Research consisted of exploration for unique soils and respective sampling for microbiata with a focus on extremophiles such as halophiles. Labwork consisted of microbiata culturing, DNA extraction, and spectrophotometry.

Several EVAs were conducted to search for unique soils for sampling sites. Red, white, and black soils were discovered and collected. Additionally, sandy and salty soils were sampled at different areas depending upon dry or moist soil humidity content. Samples were also collected at various depths, from surface to undersurface. During collection, environmental data was collected at each sample site, including; GPS, time of day, UVA and UVB radiation data, presence of radioactivity, soil moisture, electrical conductivity, temperature, and pH.

For analysis of the microbiology samples, extensive labwork was conducted in the Hab. The salty samples were hypothesized as MgCl2. After spectrophotometry analysis of the salty samples compared with pure MgCl2 and NaCl salts, it was confirmed that the samples collected were MgCl2.

Next, the Crew Biologist cultured the halophilic microbiata potentially living in the collected soils. Both liquid (2M NaCl + 10g yeast extract) and solid cultures (2M NaCl + 10g yeast extract + 2% agar) were prepared in duplicates for each sample and they were stored in the incubator at 37 C°. As no growth was detected in 2M NaCl + 10g yeast extract, a further attempt of growth was tried sprinkling the soil collected from the salty basin on plates containing agar and LB medium. Although the sample from the undetermined salty basin did not show any growth in these conditions; the red clay, white clay, and undersurface soil all showed microbiata growth in LB + agar. Contamination can be excluded as growth was only discovered around soil particles.

DNA extraction was also performed to determine possible presence of DNA in the samples. Discovery of DNA would prove the existence of micro-organisms in the regolith samples collected around the MDRS area. Gel electrophoresis and a PowerSoil DNA Isolation Kit were utilized for the DNA extraction process of the collected soil samples. As a control method, a sample of microbiata actively growing in the incubator

was also analyzed. Unfortunately, none of the samples or control showed any DNA bands, even though the samples showed growth in the laboratory. Therefore, it is hypothesized that the kit's reagents were no longer functional as the kit was stored in Hab temperatures of -10 C°, while the kit protocol suggests to store at 15 – 30 C°.

Nevertheless, extensive microbiology results were established from Crew 84 at MDRS. Halophiles were cultured and found to grow in certain media. They grew only in LB medium, but not in halophiles medium. Moreover, surface and undersurface samples grew, but only when placed in agar and LB medium. They did not grow from the soil extract plate.

Furthermore, spectrophotometry of salts and clays were analyzed. Spectrophotometry of clays determined the composition and the similarity despite differing color values. In regards to successfully culturing salts, it was discovered of the necessity to find the best environment. This was explored through successful growth in LB medium with agar, but unsuccessful growth in halophiles medium.

Conclusion

Crew 84 was excited to participate as Marsonauts at the Mars Desert Research Station and proved to be an effective and efficient team at conducting scientific fieldwork. The crew successfully performed research and analysis while in Martian simulation in regards to Environmental Contamination, halophile collection and analysis, astronomical observations, microbiata culturing and DNA extraction, EVA engineering construction, human factors studies, food studies, water and unique soil exploration, spectroscopy of planetary nebulas, and greenhouse germination techniques. The crew performed their duties through ExtraVehicular Activity (EVA) fieldwork, extensive laboratory analysis, and proper engineering maintenance and repair. Crew 84 was further able to combine a productive scientific expedition into an exciting and adventurous journey that has forged an everlasting experience into each crew-member. On behalf of Crew 84, we would like to thank the Mars Society for allowing the crew the opportunity to participate as Marsonaut researchers at the Mars Desert Research Station!

Judah Epstein, Commander / Health & Safety Officer
Mike Neal, Executive Officer / Design Journalist
Barbara Burtscher, Crew Astrophysicist
Lara Vimercati, Crew Biologist
Kelly Rickey, Crew Engineer
Zak Wilson, Crew Engineer