Mission Overview of the American Public University System Analog Research Group's First Space Analog Mission: 11 Days at the Inflatable Lunar/Mars Analog Habitat

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Abstract

From September 30, 2021, through October 10, 2021, the American Public University System (APUS) Analog Research Group conducted an eleven-day space analog mission simulating a mission to the Moon and/or Mars. The mission took place inside the Inflatable Lunar/Mars Analog Habitat located at the University of North Dakota in Grand Forks, North Dakota. This was the first mission organized and operated by the student-run and faculty-advised APUS Analog Research Group (AARG) titled "ARG-1I." This mission was centered around a research program that conducted experiments across six disciplines: psychology, botany, habitat architecture and design, remote education, extravehicular activity operations, and spacesuit design. Each research project was developed to further the current knowledge of human exploration in space. This paper serves as a mission overview of AARG's first analog mission emphasizing the documentation of crew operations, research overview, and lessons learned.

Keywords: space, analog, psychology, botany, research program, education, management, extravehicular activity, moon, Mars

Resumen de la misión de la primera misión análoga espacial del American Public University System Analog Research Group: 11 días en el Hábitat Análogo Inflable Lunar/Marte

Resumen

Desde el 30 de septiembre de 2021 hasta el 10 de octubre de 2021, el Grupo de Investigación Análoga del Sistema Universitario Pú-

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blico Estadounidense (APUS) llevó a cabo una misión análoga espacial de once días que simulaba una misión a la Luna y/o Marte. La misión tuvo lugar dentro del Hábitat Análogo Inflable Lunar/Marte ubicado en la Universidad de Dakota del Norte en Grand Forks, Dakota del Norte. Esta fue la primera misión organizada y operada por el APUS Analog Research Group (AARG), dirigido por estudiantes y asesorado por profesores, titulado "ARG-1I". Esta misión se centró en un programa de investigación que realizó experimentos en seis disciplinas: psicología, botánica, arquitectura y diseño de hábitats, educación remota, operaciones de actividad extravehicular y diseño de trajes espaciales. Cada proyecto de investigación fue desarrollado para promover el conocimiento actual de la exploración humana en el espacio. Este documento sirve como una descripción general de la primera misión analógica de AARG y enfatiza la documentación de las operaciones de la tripulación, la descripción general de la investigación y las lecciones aprendidas.

Palabras clave: espacio, cosa análoga, psicología, botánica, programa de investigación, educación, administración, actividad extravehicular, Luna, Marte

美国公立大学系统模拟研究小组首次太空模拟任务概述：在充气月球/火星模拟居住舱进行的11天太空模拟任务

摘要

从2021年9月30日到2021年10月10日，美国公立大学系统（APUS）模拟研究小组（AARG）进行了为期11天的太空模拟任务，模拟了前往月球和/或火星的太空飞行任务。该任务在位于北达科他州大福克斯的北达科他大学的充气月球/火星模拟居住舱内进行。这是由学生管理和教师指导的APUS模拟研究小组所组织和操作的第一个任务，名为"ARG-1I"。该任务是一项在六个学科中进行实验的研究项目的核心，这六个学科分别为心理学、植物学、居住舱架构和设计、远程教育、舱外活动操作、以及宇航服设计。每个研究项目的开发都是为了进一步加深关于人类探索太空的当前知识。本文是AARG首次模拟任务的概述，强调了对机组操作、研究概况和经验教训的记录。

关键词：空间，模拟，心理学，植物学，研究项目，教育，管理，舱外活动，月球，火星

1. Introduction

1.1. Purpose

The purpose of this paper is to summarize the APUS Analog Research Group's (AARG) Fall 2021 analog mission to the University of North Dakota's (UND) Inflatable Lunar/Mars Analog Habitat (ILMAH). Partnerships, logistics, operations, outcomes, and recommendations will be discussed to provide a thorough overview of the project management, goals, and objectives of the mission. Individual research project will be discussed to provide an overview of mission research objectives and preliminary results. However, complete research findings will be published in future articles.

1.2. Background

1.2.1. Space Analog Research

As modern space agencies prepare to send astronauts to the Moon and Mars, preparation for these complex missions requires extensive and multidisciplinary studies to ensure future missions can be safely and effectively accomplished. While it is difficult and sometimes impossible to simulate lunar and Martian conditions on Earth, it is possible to create facilities and scenarios that are analogous to what astronauts may experience on other planetary surfaces. These types of facilities paired with simulated scenarios are called space analog missions.

Space analog missions are designed to test exploration technologies, human impacts, and operational procedures before they are implemented into spaceflight doctrine.

1.2.2. The APUS Analog Research Group

The APUS Analog Research Group is a student-organized and faculty advised Moon and Mars analog research and mission planning organization. The mission of AARG is to provide students with research experience, team skills, and unique experiences that improve job marketability, while contributing to the field of space study's total body of knowledge through impactful research.

AARG is a first of its kind endeavor. Operating within a fully online school and the first fully online chapter of the American Institute of Aeronautics and Astronautics (AIAA), AARG is at the forefront of remote research and education. The students and faculty prepared for ARG-1I fully through online communications prior to the mission.

1.2.3. The Inflatable Lunar/Mars Analog Habitat

ARG-1I took place at ILMAH located at UND in Grand Forks, North Dakota. This multi-purpose research station was the result of a National Aeronautics and Space Administration (NASA) grant to the UND Space Studies Department in 2015 (UND, n.d.). This grant allowed for the expansion of their original habitat to include five modules.

These modules include a plant production module, extravehicular activity (EVA) and maintenance module, research module, human performance module, and a habitation module (UND, n.d.). Each module is connected via an exterior tunnel system. In addition to the modules, ILMAH includes an electric exploration rover that is integrated into both the habitat and the EVA suits (de León & Nelson, 2020). The EVA suits are trainer suits designed to be analogous to future suits that could be used on the surface of the Moon or Mars. They contain limited life support infrastructure to allow up to four-hour 'spacewalks' in Earth terrestrial environments (de León & Nelson, 2020).

UND completed nine missions using ILMAH prior to the initiation of ARG-1I. UND recognized ARG-1I as ILMAH mission ten, or ILMAH-X. ARG-1I and ILMAH-X are used synonymously.

1.3. ARG-1I Mission Overview

The ARG-1I mission was scheduled for 11 days starting September 30, 2021 and ending on October 10, 2021. The simulated mission location was the surface of the Moon and/or Mars. Crewmembers experimented with operational limitations and opportunities coincident with both destinations. The crewmembers for this mission consisted of two APUS faculty and two APUS graduate students, all from the Space Studies department.

In addition to daily attention to individual research performed by each crewmember (see section 3), the crew executed six EVAs (see section 2.2), conducted a simulated emergency EVA rescue of an injured crew member (see section 2.2.1), and conducted a meeting with the Mars Society analog crew executing a concurrent mission (see section 2.4).

2. Mission Execution

2.1. Schedules and Daily Operations

Pre-mission, a baseline crew timeline was developed collaboratively between the ARG-1I crew and the University of North Dakota faculty. APUS students and faculty were ultimately responsible for the timeline development and the integration of mission control operations. UND allowed AARG extensive autonomy in mission operations development and served primarily as an advisor throughout the mission planning process.

During the mission, execution changes were made to adapt to real time events and progress. A consistent daily routine was established as much as possible to give the crew a sense of normalcy. The NASA International Space Station (ISS) mission timeline was used as a model for the ARG-1I mission timeline.

Generally, the crew awoke at 7:00am each day and were given one hour of personal time before breakfast scheduled at 8:00am. Midday meal was scheduled to start as early as 12:00pm and as late as 1:00pm depending on the morning activities. The evening meal was scheduled to start as early as 6:00pm and as late as 7:00pm. A dedicated pre-sleep personal time was allotted to start at 10:00pm, and the crew sleep period began at 11:00pm.

During the workday between meals, the crew were scheduled for their individual research, EVAs, exercise, as well as meal preparation if required. After the evening meal the crew were asked to complete surveys, write social media posts, and write journal entries. For the rest of the evening the crew sometimes participated in a group movie or game or shared their personal life experiences during 'story time' (see section 2.3.2).

Maintaining a plan during the mission was a helpful tool. When changes were needed to the EVA schedule due to weather conditions, for example, it was helpful to have the timeline available to evaluate new options and recover the EVA goals.

2.2. Extravehicular Activity (EVA)

The research goals for the mission included six EVAs to execute a set of tasks in support of a Ph.D. research project for a student at the University of North Dakota. As a result, the ARG-1I crew were trained on the use of the airlock equipment and Extravehicular Mobility Unit (EMU) suits.

The EMU suits at the ILMAH were designed and built by the Human Spaceflight Laboratory of the University of North Dakota. The suit consisted of integrated leg, torso, boots, gloves and helmet units. A backpack unit which emulated a Portable Life Support System (PLSS) found on NASA EMU suits, opened like a refrigerator door, exposing a large opening. To don, or put on, the suit, the crew member climbed through the opening feet first, then inserted arms into the suit arms. Before closing the backpack, a 2-way radio was installed, and a communications check was completed to verify the settings were correct. Finally, the backpack was closed, and the crewmember was ready to go EVA. EVAs were always performed in pairs of two crew members for safety considerations. Additionally, one crew member remained inside the habitat, positioned at the communication station, to answer calls and questions from the EVA Crew.

Prior to the mission, students and faculty at UND conducted EVA training with the ARG-1I crew to ensure safe operation of both the EMU and habitat systems. Over the course of the ARG-1I mission, the APUS crew completed six nominal EVAs. Each crew member performed three.

2.2.1. EVA Rescue Scenario

An additional EVA was added early in the mission to support an opportunity to demonstrate a search and rescue mission. Contingency situations can arise in space as well as the surface of the Moon and Mars. Developing a response to these situations as well as demonstrating and practicing them is part of normal operations. An example of a situation that could be encountered is one of crew rescue. The team developed a scenario where a habitat in the vicinity of ILMAH, one being operated by a different space agency, experienced a rapid depressurization that resulted in survival of only one crew member. The survivor experienced symptoms of decompression illness and shock but was able to don an EVA suit and attempt to make their way to the ILMAH for rescue.

As part of the scenario, the ARG-1I crew received a distress call and subsequently developed a time-critical response to rescue the crew member using ILMAH's pressurized rover. Two crew members responded with one serving as the rescue EVA specialist and the other as the rover operator. The two departed ILMAH and navigated to the injured crew member's location. An EVA from the rover was conducted the rescue EVA crew member assisted the injured crew member in returning to and entering the rover. All three then safely returned to the ILMAH.

The demonstration of this rescue scenario evaluated one approach and procedure for responding to an emergency of this nature. Several lessons learned from this exercise included the need for standard communication protocols to ensure a timely and accurate response and procedures for docking a suit-port style EVA suit with an injured or incapacitated occupant.

2.3. Health and Wellness

2.3.1. Meal Planning and Preparation

The crew conducted three different formats for meal preparation during the mission, each being tested for a third of the mission duration. The first third of the mission focused on community meals. The second third focused on individually packaged meals. Then at the end of the mission, a hybrid meal plan was adopted.

For community meals, the crew took turns cooking and cleaning for breakfast, lunch, and dinner. Meals were created from bulk dehydrated ingredients and required preparation. This type of community meal preparation was time consuming, but it gave the crew a reason to sit together and eat, which provided a relaxing atmosphere and improved communication among the crew.

During the second third of the mission, the individually packaged backpacking meals were efficient and resulted in time savings. When backpacking meals were utilized, the crew had more time to accomplish research and other mission objectives. The downside is the improved crew communication of community meals was lost.

The crew agreed they preferred a hybrid meal plan where the backpacking meals were used for breakfast and lunch while community cooking was used for dinner. These lessons learned are further discussed in section 5.3.

2.3.2. 'Story Time'

The crew anecdotally reported their crew cohesion and unity within the isolated environment improved their crew task effectiveness and personal well-being. To foster crew cohesion, besides the communication during mealtime, the crew sat together for a 'story time.' During story time a selected crew member would talk about their life journey. Doing so made it easier to communicate with each other throughout the mission. Opening themselves up to tell their stories made them feel closer to each other and helped them understand one another, building crew empathy and cohesion.

Because AARG is a fully online organization, story time was an important moment for the crew. Prior to the mission, the crew was limited to weekly video teleconferences and text-based discussions. These conversations quickly allowed the crew to shift from a virtual team to a high-performing crew.

2.4. 'Hello World'

'Hello World' was a video conference collaboration between the ARG-1I crew and the Mars Society's Mars Desert Research Station Crew 228. The Mars Desert Research Station is located in Hanksville, Utah, and is one of the most active analog research facilities in the world (Mars Society, n.d.).

In future Martian colonies, it is plausible that multiple habitats will be operated simultaneously by various space agencies. 'Hello World' was a meeting between two analog habitats both simulating a mission to Mars. The meeting was themed around Space Week, and the crews discussed multiple space topics such as the benefits of human spaceflight, future collaborations between analog habitats, and the Mars Society Convention. This video conference was a primer to expand analog research from a single facility and to begin researching how multiple habitats can live and work together on the surface of Mars.

3. ARG-1I Research Program

The AARG research program consisted of two parts: crew member research and AARG sponsored research. Each crew member was expected to complete their own research project while additional studies were sent with the crew from non-crew student researchers.

3.1. Arthrospira Platensis

The crew investigated the viability of growing Arthrospira Platensis, more commonly known as Spirulina, in an analog habitat setting. There are many reasons for studying Spirulina in an analog setting. First, Spirulina can potentially be used as a substrate growth medium for microgreens in space environments as it may aid in nitrogen uptake and perchlorate leaching from Martian regolith. Second, Spirulina efficiently removes carbon dioxide from the environment, replacing it with oxygen (Posten, 2009). Finally, Spirulina may be used as a supplemental source of astronaut nutrition. These properties suggest that Spirulina may be an important component of future space exploration endeavors (Romano, et al., 2021).

Two experiments were performed with Spirulina during the ARG-1I mission. The first involved testing the extent to which Spirulina could be grown using only commercial lab equipment available in a typical analog habitat. The second involved using dried spirulina as a growth aid for microgreens.

3.1.1. Spirulina Growth

Due to transport delays, the Spirulina sample was subjected to hypoxic conditions for 120 hours prior to arriving at the habitat. The sample arrived severely stressed and suffering due to over-acidification.

The initial 10 samples were slowly revived over the first two days of the mission, by exposing them to a 300 nm

LED light source and increasing the wavelength every 4 hours to a maximum of 660 nm. The spirulina samples showed growth and replication after 30 hours and the algae bloom strengthened sufficiently for harvesting by the seventh day of the mission. The first harvest yielded 3 grams of dried Spirulina. A second harvest was performed post mission, eight days after the first harvest, yielding 4.1 grams.

Microscopic evaluation of the Spirulina samples enabled accurate measurements of the number of spirulina rods, an important measurement of sample growth. Individual rods measured over 200 micrometers in length, and many grew to over 300 micrometers during the mission.

3.1.2. Spirulina and Microgreens

The second experiment involved growing micro greens from seeds to early-stage development to full growth. The seeds of seven types of microgreens were grown in a soil mixture composed by mass of 65% Martian Simulant Regolith, MGS-1S, which is very high in sulfates, 33% of a composted naturally occurring material, and 2% of dried Spirulina.

Initially, the substrate, including the regolith and the compost, were mixed with the Spirulina. Four days into the experiment, the substrate dried out due to the variability of the greenhab environment in the analog, which significantly stressed the seedlings. As a means of increasing the chance of the microgreens' survival in the harsh soil substrate, the astrobiology team added a layer of compost on top of the seedlings, providing a source of water, temperature balance, and nutrition. Successful growth was then achieved.

In summary, the first spirulina experiment produced dried samples totaling approximately 7.5 grams harvested from 2 liters of the active culture. The second experiment recorded substantial microgreen growth using dried spirulina as a substrate additive in a mixture of soil and synthetic Martian regolith. Both results point to potential significant beneficial uses of Spirulina in an analog setting and as a potential addition to an environmental control and life support bioregenerative sub-system helping to manage oxygen, carbon dioxide, nitrogen, and perchlorate concentrations within the habitat (Soreanu et al., 2021). Additionally, the preliminary results suggest that A. platensis can serve as an additional source of nutrition to the crew and as a fertilizer for leafy crops.

3.2. Habitat Design Case Study

ILMAH was used as a case study in surface habitat design. Habitat design requires simultaneous consideration of different human factors requirements and operational accommodations, as documented during recent deep space habitat testing performed by NASA as part of the NextStep-2 Phase 2 program (Gernhardt et al., 2020). Using a series of survey templates as well as developing sketches of each living volume, the crew evaluated all the living spaces individually. The template questions covered all aspects about how the design of each of the modules in the habitat support efficient and safe operations. They also attempt to assess how efficiently the spaces are laid out and utilized. Data was collected on the Core Habitat Module, Exercise Module, Geology Lab Module, Plant Module, EVA Module, and the connecting tunnels.

The opportunity to evaluate the design of a habitat from the perspective of a crewmember living and working within it provides unique benefits (Häuplik-Meusburger and Bishop, 2021). The results from the case study will be a resource to use during maturation of future habitat design. The ILMAH design distributes activity spaces very well. As a result, traffic issues are at a minimum and no issues were noted with having adequate room to effectively accomplish the tasks of the mission. Additionally, it was noted that the habitat has space available for growth in many areas such as payload systems and science equipment.

3.3. Space Suit Evaluation

During the crew's EVAs, the EMU suit's form, fit, and function were evaluated using engineering system test and evaluation principles. Benchmarks for operational availability were established for both spacesuits, and internal environmental suit data was collected for later evaluation.

3.4. Student Remote Learning and Data Latency

Research on reception, application latency of information, and feedback related to student learning was performed by the crew. Long duration missions will require the occupants to receive information to comprehend, implement, and monitor taskings for their effectiveness. Many of these tasks will be technical in nature and possibly beyond the scope of knowledge, skills, and abilities of the astronauts. This will force the solution providers to not only scale the level of information to perform the task, but possibly increase the scaffolding and monitoring to ensure task success.

This study targeted remote learning for students at the K-12 levels. Throughout the mission, the success of guiding engineering students virtually was evaluated as they investigated subjects related to structural, electrical, and mechanical engineering. Latency was introduced to determine if there was any effect on learning styles. The students were very responsive to the virtual instruction. No issues were noted for this age group and no extra scaffolding was required. This study will be expanded in future missions to determine if older age groups, closer to the age range of most astronauts, experience any difficulties.

3.5. Changes in Facial Emotion Recognition

The objective of the facial emotion recognition study was to determine if analog astronauts simulating a mission to the Moon experience changes in their ability to accurately identify human emotions via facial recognition. This study was derived from a series of head-down bed-rest studies that used a head-down posture to simulate the effects of microgravity on the human body. During these studies, it was determined that microgravity may change the way astronauts recognize others' emotions (Basner et al., 2012; Masserotti Benvenuti et al., 2013; Moore et al., 2017).

The analog astronaut crew completed daily emotion recognition tests consisting of 72 faces for the week before the mission, during the mission, and the week following the mission. The 72 faces were divided into categories, and each test collected data on the accuracy of facial emotion recognition for happiness, sadness, disgust, anger, fear, and neutral. Each test displayed different faces within its category and utilized the FACES database, a validated set of 1,026 images of men and women of varying ages (Ebner et al., 2010).

Preliminary results show varying changes in the accuracy of how the crew recognized emotion throughout the course of the study. Each crewmember experienced a significant change in their identification of at least one emotion after they entered the habitat. These changes in facial emotion recognition may impact emotional and behavioral responses. If the identified emotions are biased toward negative valence emotions, the astronauts may become more likely to experience social interactions negatively, emotion dysregulation, declines in emotional health, increases in crew conflict, and/or impaired ability to perceive danger (Basner et al., 2012; Masserotti Benvenuti et al., 2013; Szanto et al., 2012).

Additional studies are needed to determine to what degree facial emotion recognition changes, the causal factors that lead to the changes, and if there are any measurable behavioral changes because of the changes in facial emotion recognition.

4. Public Affairs and Outreach

The crew integrated closely with a mission support team comprised of both students and faculty to ensure the mission was broadcast both in real time and post-mission using blog posts, social media, and AIAA Newsletters. The crew sent daily reports consisting of a mission summary and photographs to mission support to disseminate.

4.1. Blog Posts

Using the information sent to mission support from the crew, daily blog posts were published on the AARG website summarizing each mission day. These blog posts can be viewed on the ARG-1I mission website here https://apusarg.wixsite.com/.

In addition to the internal blog posts, the AARG faculty advisor published a series of three articles in the American Military University Edge blog summarizing the mission for the greater APUS community.

4.2. Social Media

AARG maintained a Twitter, Facebook, LinkedIn, and an Instagram page and posted periodic updates during the mission. These social media sites were advertised to APUS Science, Technology, Engineering, and Mathematics students prior to the mission.

4.3. AIAA Newsletters

Following the mission, the APUS AIAA chapter president interviewed the crew members and AARG program manager about their experiences planning and executing the ILMAH mission. These interviews were published in the AIAA chapter's newsletter and were made available to all AIAA members.

5. Recommendations for Future AARG Analog Missions

Following the mission, interviews were conducted with the crew to discover and record lessons learned and crew perspectives. A 30-minute individual interview was conducted by the program leadership with each of the crew members. Additionally, a group interview was conducted that lasted two hours. Five key trends were discovered from the debriefs.

5.1. Research Preparation

Recommendation: Researchers should allocate ample time and resources pre-mission to test and practice experiments before executing them during the mission.

Due to the online nature of AARG, the ability to test research methods and equipment prior to the mission was a difficult program constraint. While the crew felt they were able to accomplish their research goals, considerable unplanned efforts were required due to insufficient attention to details during the mission planning phase. They recognized that preparation before the mission is key to ensure successful research inside the habitat. It was recognized as beneficial to conduct a test run of the study in a controlled environment outside the habitat before bringing it into the habitat. This allows the researcher to ensure all the required materials are present and that the methodology is validated and requires little deviation, potentially saving time for the crew.

Conducting a test run of the study before entering the habitat allows the researcher to identify risks of research failure prior to the mission. Any risks should be mitigated to the maximum extent practicable before the project enters the habitat. These efforts will also aid in development of a more reliable mission timeline. During the mission, things such as material changes, shipping delays, and poor internet connection negatively impacted research.

5.2. Mission Schedule

Recommendation: Crews should dedicate adequate time to developing and reviewing a detailed plan pre-mission to ensure everyone is aware of expectations.

Pre-mission preparation can be an extremely busy period for the entire crew. It became challenging to have all the crew provide input to and review the mission timeline. As a result, the coordination of the timeline expectations was not fully accomplished nor was the timeline fully developed when the mission started. Additionally, the crew generally expressed that the mission was initially overscheduled but agreed to accept the challenge of meeting all the goals. As the mission progressed, the challenge became harder due to EVAs, research, and food preparation taking longer than expected. The crew requested additional flexibility to achieve their research tasks instead of hard scheduling tasks hour by hour.

To improve autonomy, the mission timeline was updated to include only events that were significant crew evolutions, such as EVA. Items such as when to exercise and when to work on research were removed from the timeline, and the crew was able to fill in their own schedule around those larger events.

While the crew requested additional autonomy during the mission, it was assessed that if research is better prepared based on section 5.1, and the EVA schedule is better managed and coordinated with the research team, the schedule could become a more accurate pre-mission product.

5.3. Food Preparation

Recommendation: Use dehydrated, prepackaged meals, such as backpacking meals, for morning and mid-day meals. In the evening, the crew should cook a meal using provided ingredients and come together to have a community meal.

The crew experimented with options for how to prepare meals. Cooking all three meals each day was a time-consuming approach from the point of view of planning as well as preparing. While designating a crew member to cook each of the crew's meals, breakfast, lunch, and dinner, increased crew cohesion, it became a cumbersome and time-consuming task. Also, sometimes crew members had to be reminded to cook or got delayed, delaying the entire crew's schedule. To keep cohesion while offering additional time and flexibility to the schedule, it is more practical to eat dehydrated meals individually during breakfast and lunch and eat a prepared group meal together each evening.

5.4. Adaptability and Flexibility

Recommendation: Crew members should be prepared to adapt to changing plans and be flexible in how to work around them to accomplish mission goals.

The crew responded positively to the dynamic schedule of the mission and enjoyed the additions such as the EVA rescue, addition of a fifth crew member, and the 'Hello World' teleconference with MDRS. The crew's flexibility and willingness to adapt to planned events allowed them to take advantage of these additional opportunities which greatly enhanced the overall mission experience

5.5. Expectations Management

Recommendation: Given that crew members bring differing backgrounds and familiarity with conditions expected in manned lunar and Martian missions, analog mission constraints and limitations should be documented in writing for all to reference.

Each crew member entered the habitat with slightly different expectations for what was appropriate for a Lunar/Mars simulation and how the analog would be managed. Protocols for hygiene, phone calls, and internet access needed to be carefully and clearly defined in writing prior to the mission. The lack of a clear plan understood and endorsed by all can result in less than a complete and accurate experience for the crew members during the mission.

Despite the mixed expectations, the crew thought the mission was an excellent personal and professional growth experience and had an extremely positive outlook on their accomplishments and their time in the habitat.

6. Conclusion

ARG-1I was a first of its kind analog mission organized by the American Public University System, a fully online university, in partnership with the University of North Dakota's Human Spaceflight Laboratory. Two APUS faculty members and two APUS graduate students spent eleven days inside the Inflatable Lunar/Mars Analog Habitat at the University of North Dakota.

During their stay, research was conducted regarding extravehicular activity contingencies, spacesuit design, botany, psychology, remote education, and habitat architecture and design. In addition to the AARG research program, valuable lessons were learned with respect to mission operations and planning and analog research program development. The mission was viewed as an overwhelming success by all stakeholders.

These lessons will be utilized to continue to refine AARG processes and procedures and improve the quality and efficiency of future space analog missions.

7. Sources of Funding

The mission's Spirulina research project was sponsored by Cyanotech, a for-profit health and human nutrition supplement company that focuses on microalgae agriculture. Cyanotech provided the project with the spirulina that was grown in the habitat.

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