WEATHER BALLOON EXTRAVEHICULAR ACTIVITY LAUNCH IN THE INFLATABLE LUNAR MARTIAN ANALOG HABITAT. D. K. Buckner[1] and P. de Leon[1], [1]University of North Dakota, Space Studies Department, Clifford Hall Room 512, 4149 University Ave Stop 9008, Grand Forks, ND 58202, denise.buckner@und.edu.

Introduction: Human habitation of Mars and other extraterrestrial bodies is a promising venture for the future of space exploration, and is an important goal of NASA and other space organizations [1]. Currently, Earth based analog habitat studies provide vital research on life support systems and essential technical functions, as these studies prepare and inform habitat design for future settlements [2]. For a Martian settlement to support sustained human presence, weather forecasting is of utmost importance; the Martian atmosphere can be volatile, and dust storms are a major concern to Extravehicular Activity (EVA) operations.

The Martian atmosphere is thin, making aircraft or UAS observations difficult, placing weather monitoring satellites into orbit is a costly and time consuming infrastructure venture, and ground based weather sensors only provide limited data. However, weather balloons provide an ideal platform for forecasting, as they are low cost, user friendly, require no fuel, traverse high altitudes, support radio based payloads for instant information downlink, and can carry a wide variety of light, low cost, accurate sensors. Further, sensor arrays can be fabricated within the habitat, and weather data transmitted to the base station immediately, creating a sustainable, real time forecasting system.

Analysis of the literature finds no prior attempts to launch weather balloons during any analog habitat studies. This poster discusses a weather balloon EVA simulated by crewmembers in the Inflatable Lunar Martian Analog Habitat at the University of North Dakota in an attempt to prove the validity of extraterrestrial weather balloon operations and prepare for sustainability and autonomy in future habitation [3].

Mission Overview: This EVA is a preliminary mission intended to explore feasibility of balloon operations and weather forecasting with a small, three member crew in a simulated Martian environment in the Inflatable Lunar Martian Analog Habitat at the University of North Dakota (Figure 2).

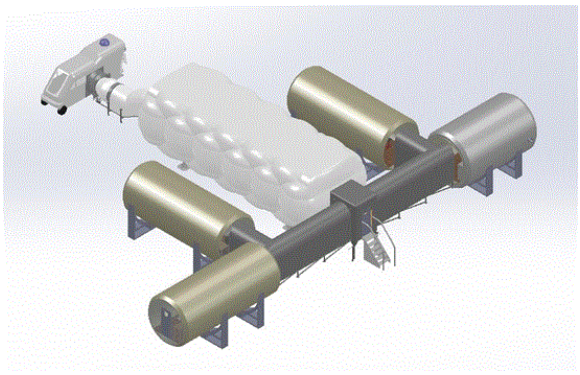

Figure 2: Inflatable Lunar Martian Analog Habitat

For this mission, the crew fabricated a sensor based payload, then launched the instruments. One crewmember stayed inside the habitat to monitor weather data transmitted via HAM radio to the ground station. Meanwhile, two crewmembers exited the habitat in spacesuits, filled a weather balloon with helium, attached the payload, initiated contact between the payload and the ground station, and re- entered the habitat to track the balloon and downlink the data.

Mission Overview: This mission was designed to simulate an autonomous weather observation operation. Hardware and software were Earth based, but could operate in the Martian environment. Procedures and human performance were other key elements.

Payload design: While inside the habitat, the crew fabricated a radiosonde to fly on the balloon; this device measures temperature, pressure, and humidity. An AnaSonde- 3M device by Anasphere was selected, as the components arrive unassembled (Figure 1).

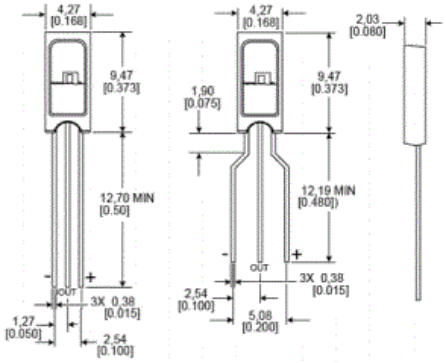

Figure 1: block diagram of radiosonde assembly

The payload consisted of this radiosonde, plus an Iridium GPS unit and Go Pro cameras to track the path of the balloon and gather images from above.

Ground Station and Communications: The ground station consisted of a 10 element diamond Yagi antenna atop a tripod sitting outside the habitat, connected to a radio receiver and PC inside the habitat. Data was transmitted from the radiosonde over HAM radio frequency. SondeWorks and CW Get software were used to decode and chart the radiosonde data.

Tool design: A number of typical tools used to fill weather balloons were altered to interface with the spacesuits and work with gloves. A tool belt was designed to hold the tools and keep them close to the crewmembers (Figure 3).

Figure 3: Crewmembers filling the balloon with modified tools

Procedural design: The procedural design for this mission was based off of balloon launches conducted on Earth. All proper notifications were made. Procedures for filling the balloon were altered to interface with the tools, suits, and communication systems. The crewmember inside the habitat communicated with the two crewmembers outside the habitat via radio headsets. Helium was used to fill the balloon, and a parachute carrying the payload was suspended beneath the balloon (Figure 3).

Overview: Important aspects of this mission include instrumentation design and fabrication, payload design, communication between the payload and ground station, specialized tools to interface between suits and Earth based balloon equipment, procedural design, communication between crewmembers, and data analysis. The crew was able to successfully fabricate the sensors, build the payload, fill and launch the balloon, and track its location. However, a radio malfunction prevented significant radiosonde data from being collected. Nevertheless, procedural design was successful and operations ran as planned.

Future Work: A second, more in depth study, is planned for a future Inflatable Lunar Martian Analog Habitat mission in 2018. Proposed mission design includes a more extensive sensor array, fully autonomous crew operations, interface with different spacesuit models, and payload retrieval methods. We believe this research is essential for life in the Martian environment, and studying operations on Earth provides important preparation for future tool and procedural design.

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References: [1] National Aeronautics and Space Administration (2015) *NASA's Journey to Mars Pioneering the Next Steps in Space Exploration.* [2] Robinson, D. K. R. et al. (2008) *Acta Astronautica, 62(12),* 721- 732. [3] States News Service. (2017) *States News Service: Space Station Takes Shape,* July 4.