**A Hi-Fidelity Space Analog for the Moon and Mars at Biosphere 2.** Kai Staats[1] and John Adams[2], [1]University of Arizona (kstaats@arizona.edu), [2]University of Arizona (jadamsb2@arizona.edu). Biosphere 2, 32540 South Biosphere Road, Oracle, Arizona 85623

With NASA, SpaceX, Blue Origin, and a growing number of public and private space agencies around the world working to return humans to the Moon and then on to Mars, the need for hi-fidelity, human-in-the-loop habitat analogs is imperative for the success of these complex, long duration missions. The intent is to learn the minimum complexity required to recycle air, water, and waste using a combination of physicochemical and bioregenerative systems while reducing reliance on food rations with in situ cultivar production for long-duration, off-world missions.

While a rich history of human habitat analogs includes Bios-3, Biosphere 2, Lunar Palace 1, NEEMO, HERA, SIRIUS, HI-SEAS and MDRS, no analog, historic or in operation today performs in such a way as to closely approximate a sustained, long-duration habitat on the Moon or Mars.

The challenges encumbered are not unlike those managed on the International Space Station, but exacerbated by the introduction of food cultivars in a hybrid physicochemical and bioregenerative life support system and further restrained by the inability to resupply within hours of a launch pad. These include maintaining a hermetically sealed pressure vessel, recovering from a rapid pressure loss, managing excess heat, mitigating a build-up of humidity, carbon dioxide and trace gases; recycling human waste and inedible biomass, and managing the diverse, dynamical human and plant microbiome which can affect the quality of air, water, and human occupant heath.

A Space Analog for the Moon and Mars (SAM) is a hermetically sealed research facility located at the renowned University of Arizona Biosphere 2. SAM integrates the 1987 Biosphere 2 prototype *Test Module* with an adjacent, attached pressure vessel composed of a workshop, kitchen, common area and living quarters with support for 1-4 crew members. A CO2 scrubber built by Paragon SDC provides mechanical life support. A functional airlock leads to an adjacent half acre Mars yard where pressure suits and tools, rovers, and drones can be tested. The Test Module provides soil-based and hydroponic grow environments; controlled lighting, humidity, heating and cooling. The Mars yard is modeled after a crater selected by NASA as the first human landing site and will include varied terrain and select obstacles, a massive synthetic lava tube with skylight for subterrain exploration, and a gravity off-set rig to provide the experience of exploring on foot in reduced gravitational fields.

As a hi-fidelity research station open to visiting teams from around the world, SAM is guided by five principal lines of research:

- The transition from physicochemical to bioregenerative environmental control and life support systems (ECLSS), and the continuously shifting balance of these two as humans enter and exit, and crops are planted, consumed, and harvested.
- The transformation of simulated regolith (crushed basalt) to fertile soil. This builds upon on-site operation of the Landscape Evolution Observatory (LEO) located at Biosphere 2. The intent is to learn how to rapidly develop fertile soil from perchlorate ladened regolith.
- Crew arrival, departure, and EVA evaluation of tools, construction and repair, data collection, and communication while encumbered by pressure.
- A study of the evolution of the microbial community of a transitional, hermetically sealed space occupied by humans and plants.
- Computer models that accurately describe a functional, sustainable, long-duration hybrid ECLSS. In particular, SIMOC will be programmed to model SAM and eventually, learn to manage SAM's life support systems through the application of machine learning.

Construction of SAM began on January 20 with first closure and tests to be conducted by the close of May. Visiting teams will be received in early 2022.

*Given that SAM is under construction, we ask for an opportunity to share a brief history of the Biosphere 2 as it relates to closed ecosystem habitation, the research objectives and current status of SAM, and early data and findings for pressure regulation, CO2 levels, model development and validation.*