NDX-2 LUNAR SPACE SUIT PLSS DEVELOPMENT FOR ANALOG OPERATIONS. B. D. Badders[1], [1]University of North Dakota Department of Space Studies, Human Spaceflight Lab (brian.badders@my.und.edu)

Introduction: The effective development and use of terrestrial analogs for lunar missions is essential for the development of lunar and planetary space exploration. However, testing on Earth to determine how space suits will perform in various hostile environments can be both hazardous and costly [1].

Relevant analogous conditions to lunar missions can be simulated on Earth in order to benefit future space suit design and operation [2]. This can be accomplished with less risk and decreased cost by specifically engineering systems that utilize the advantages of the Earth environment. At the University of North Dakota, a Portable Life Support System (PLSS) is being designed that exploits the abundance of breathable air, atmospheric pressure conditions, and predictable range of operational temperatures in the Earth environment. The environmental analog testing of such a system will allow for the development of space environment coping techniques, small group dynamics in remote settings, and can help define realistic mission goals and space environment stresses.

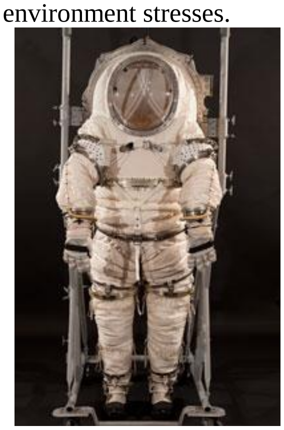

Fig. 1. NDX-2 Advanced Lunar Suit

By creating a dedicated PLSS for analog testing that is fully integrated with biomedical sensors, communication systems, temperature and pressure controls, and a power supply system, scenarios which will likely be experienced during extravehicular activities can be effectively emulated [3]. The NASA-funded Human Spaceflight Laboratory at the University of North Dakota is developing and testing the North Dakota Experimental-2 (NDX-2) Spacesuit (See Fig. 1.). As students and faculty work towards the future field testing of the space suit, a key area of concentration is the development of a new PLSS.

As the technological complexity, redundant systems, and capabilities of portable life support systems have increased, so have the costs. A life support system can be exorbitantly expensive and require tedious system checks and certification of components. These cost and time expenses have led to the use of life support systems for analog testing that have hindered the development of new generations of space suits.

Analog Components:

Oxygen supply. While they can be inexpensive (such as SCUBA diving tanks), oxygen tanks have limitations in an Earth environment. In a 1-G environment, the excess weight of the oxygen tanks adds a lot of weight to the space suit system which is already unrealistically heavy. A simple pump can be used to supply air and pressurize the suit.

Materials selection. Currently used are plastic materials with high rates of thermal expansion show little evidence of plastic deformation before failure. This is a problem because the space suit is to be tested in several difference environments including extreme hot and extreme cold. The pump must be able to behave predictably no matter what environment it is exposed to and should never become so brittle that it breaks.

Power supply. Current power supply systems are not very realistic and detract from the analog conditions. The power supply solutions used for analog missions typically consist of multiple heavy, bulky batteries. These batteries are separate from the space suit and supply the power through long cables and require a team to manage the power.

Fluid loops. The Human Spaceflight Lab currently has a liquid cooled ventilation garment (LCVG), but it is not yet fully incorporated into the life support system. Currently, the water is not in a closed loop that is cooled and recalculated, the garment uses a large water reservoir to supply cool water which is eventually discarded from the system. A feedwater loop is also needed which takes up a considerable amount of the limited space of the portable life support system.

Suitport system concept. The Suitport system concept is a driving factor as it constrains the size of each designed component. (See Fig. 2.)

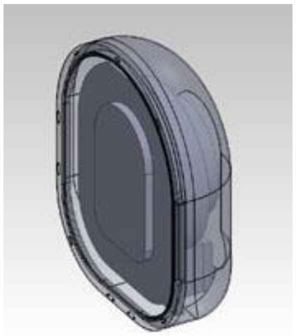

Fig. 2. Suitport System Concept Design

Conclusion: Since the Earth has a breathable atmosphere, a simple pumping system can be used to cut weight and to pressurize the suit. Materials limitations can be overcome through a more robust materials selection process and the fabrication of the components. While this is inherently more expensive than buying off the shelf components, it is a relatively simple fix. Positioning of open loop battery packs aids stability and less stress on the user while allowing for recharging capabilities [4]. Fluid loops are necessary to insure efficient metabolic functioning and must fit within the suitport design.

References: [1] Ranganathan et al. (2010) Acta Astronautica 67.1/2: 60-70 [2] Léveillé (2009) *Comptes Rendus Palevol 8.7: 637-648* [3] Léveillé (2010) *Planetary & Space Science* 58.4: 631-638 [4] Kurz et al. (2009) *Journal Of Biomechanical Engineering*131.9