Paper ID: 5341
student

SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration - Part 2 (2B)

Author: Mr. Arthur Guest
Massachusetts Institute of Technology (MIT), United States

A MINIMALIST APPROACH TO CREWED LUNAR EXPLORATION

Abstract

I. Introduction In the 2004 Vision for Space Exploration, President George W. Bush laid out a new direction for U.S. space exploration that included returning humans to the Moon by 2020 [1]. To this end, NASA began work towards establishing a program to develop a sustained human presence on the lunar surface. The reasoning for this program, as laid out in the Global Exploration Strategy [2], includes objectives ranging from exploration preparation and scientific knowledge to economic expansion and public engagement. The architecture for the lunar exploration program will require two interconnected systems to be developed: the lunar transportation system, which delivers crew and cargo to the Moon and returns crews back to the Earth, and the lunar surface system, which includes all assets required to allowed sustained crewed operations on the surface. The choice of assets for the lunar surface system will not only determine what objectives can be met and how well, but also, determine the overall cost of the architecture. Current plans for the lunar surface system involve a robust choice of assets that lead to high performance [3]. By taking a minimalist approach to the architecture, and reducing the complexity of the system, can lead to the same or slightly lower performance for significantly lower cost and risk.

II. The Continuous Presence Concept One publically released concept for the lunar surface system involves developing a continuous presence outpost at the lunar South Pole [3]. Continuous presence is achieved by enabling crew durations of 180-days and rotating the crews every six months. This concept develops a lunar outpost by delivering and assembling multiple habitation modules on the lunar surface, similar to the outpost shown in Figure 1. In order to deploy this outpost, large assets must be offloaded from their respective landers, transported across the lunar surface, and assembled together. Not only does this architecture include complex operations for deployment, it requires two types of mobility assets to be developed and deployed. One mobility asset transports crew across the lunar surface and the other, more robust, mobility asset is used to transport and assemble the 10-mt habitation modules.

III. The Minimalist Continuous Presence Concept One architecture that allows for continuous presence with fewer elements is to deploy a outpost using an inflatable module similar to that proposed for Mars DRM 3.0 [4]. Instead of having multiple large habitation modules offloaded and assembled, a single integrated habitation element is offloaded and place next to its respective lander. To ensure that an equal amount of pressurized volume is available for the crew, a simple inflatable module is developed and transported to the Moon. This module has a low enough mass that it can be transported across the lunar surface to the main habitation module using the same mobility asset used to transport crew. Once connected, as shown in Figure 2, the amount of pressurized volume available is similar to the original continuous presence concept. The internal fittings for the inflatable module are delivered separately and outfitted in-situ by the crew. This architecture provides similar performance to assembled continuous presence architectures, while reducing the number of unique elements that have to be developed by not requiring the more robust mobility asset. This approach also reduces the risk of the architecture by reducing the number of complex operations required during deployment.

IV. The Minimalist Medium-Duration Concept While the final set of objectives for the lunar exploration architecture have not been developed, the overall themes have been laid out in the Global Exploration Strategy. One set of objectives is related to preparing for human Mars surface missions. This

set of objectives can be almost completely satisfied without requiring continuous presence lunar missions as shown in Figure 3. Instead of developing an outpost that is capable of supporting crews for 180 days, it may be more beneficial to produce several medium-duration mission of approximately 60 days each. These outposts would not require any assembly or transporting and therefore produce a more minimalist set of assets. This would allow for the overall costs and risks of the architecture to be greatly reduced while achieving only slightly less performance.

V. Conclusions Current plans for the lunar surface system include developing a single continuous presence outpost consisting of several large habitation modules that are offloaded, transported, and assembled. Taking a minimalist approach of reducing the number of unique elements developed and the number of operations that have to be completed can improve upon this type of architecture. Two feasible architectures include a continuous presence outpost consisting of a single habitation module and a secondary inflatable module and a medium-duration outpost that does not require assembly. These architectures provide the same or slightly diminished performance for reduced cost and risk. The paper will outline the alternative architectures in detail and compare and contrast both the performance and the cost to baseline continuous presence architectures.

VI. References [1] Bush, G.W. "A Renewed Spirit of Discovery: The President's Vision for U.S. Space Exploration". January 14, 2004. Washington, DC. [2] NASA et al. "Global Exploration Strategy: The Framework for Coordination". May 31, 2007. [3] NASA. "Exploration Systems Mission Directorate Lunar Surface Systems Concept Study: Lunar Surface Systems Overview". June 6, 2008. Washington, DC. [4] NASA. "Addendum to the NASA Mars DRM". SP-6107-ADD. June 1998. [5] Drake, B.G. "Reducing the Risk of Human Missions to Mars Through Testing". TM-2007-214761. July 2007