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Return to the Moon (02)
Lunar Surface Outposts and Enabling Technologies (4)

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OPERATIONS-ORIENTED ARCHITECTURE FOR NEAR-TERM AFFORDABLE HUMAN LUNAR EXPLORATION

Abstract

Current concepts for human lunar exploration tend to be "feature-rich", involving significant new technology developments such as heavy-lift launch vehicles which may never be economically justifiable. That approach flies in the face of the last forty years of human space flight experience, which demonstrates that extensive orbital options are feasible with current technology. This paper assumes a requirement for a "minimum functional" approach to human lunar exploration: the establishment of an infrastructure, within a likely budget cap of $3B per year, using existing expendable launch vehicles. The developed architecture is based on lunar orbital logistics, and requires the initial development of only three components: a three-person spacecraft with a mass below 5000 kg, a standard orbital propulsion module, and a lunar landing stage derived from the orbital propulsion module. The paper goes into detail on the system trades and preliminary design details of each of these components, which are launched on a human-rated Delta IV Heavy vehicle. In compliance with the minimal functional design approach, the initial operational scenario requires the use of nothing more than simple docking capability between modules in low lunar orbit (LLO) to build up a vehicle capable of landing three humans on the moon, and returning them to Earth via direct entry and landing. Probabilistic risk assessments show that the ability to stockpile propulsion modules in LLO provides the capability of equalling or improving upon mission reliabilities found for the Constellation program, while providing multiple abort-to-orbit options for the crew throughout the lunar descent. Building on this architecture, the paper outlines a long-term program of increasingly ambitious lunar exploration missions along with "Flexible Path" missions in cis-lunar space, to near-Earth objects, and to the moons of Mars by continual targeted development of more advanced technologies along with two human lunar missions per year, all while remaining within the established yearly budget cap.