17th IAA SYMPOSIUM ON VISIONS AND STRATEGIES FOR THE FUTURE (D4)
Space Resources: Technologies, Systems, Missions and Policies (5)

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COST BREAKEVEN ANALYSIS OF LUNAR ISRU FOR HUMAN LUNAR SURFACE ARCHITECTURES

Abstract

The return of humans to the lunar surface encompasses a range of possible architectures, from brief Apollo-like sorties to long-term sustainment of human presence. Any of these architecture concepts requires propellant for the crew's ascent from the lunar surface, as well as consumables to support their presence on the Moon. Oxygen and hydrogen are leading candidates for ascent vehicle propellants, due to their high specific impulse and potential for production from lunar resources, and are important consumables for the crew. Under the right conditions, the production of oxygen and/or hydrogen from lunar resources could significantly reduce the mass that must be sent from Earth to enable future human lunar missions. To assess the merits of using lunar resources, the costs associated with developing, producing, launching, operating, and maintaining lunar resource processing systems must be considered relative to the costs of delivering the needed propellant and consumables from Earth. The demand for those propellant and consumables depends upon the nature of the lunar mission, while the costs of both Earth-derived and lunar-derived propellants and consumables depend on the performance requirements and technology capabilities associated with each approach. Thus, determining which approach is more cost efficient requires modeling the performance and cost of the associated systems, across a range of possible architectures. This research proposes a model that parametrically captures the factors influencing the relevant costs of providing propellant and crew consumables on the lunar surface from Earth and/or from the Moon. The model will be used to estimate the costs of providing those resources under several scenarios encompassing different possible lunar surface architectures. Because such a model must include systems and technologies that are not fully matured, the effects of uncertainty in the model parameters will be evaluated; this will enable an understanding of the factors most contributing to the uncertainty in the results, which may merit more detailed analysis. The outcomes of this research will include a

description of the model, the results of the uncertainty analysis, and the driving factors that are most impactful. These results can inform future architecture and campaign planners in their consideration of how lunar resources best support human lunar missions. In addition, these results will identify key technology and capability requirements that can inform what investments will be most enabling to future missions.