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Strategies & Architectures as the Framework for Future Building Blocks in Space Exploration and Development (1)

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A NOVEL PLANETARY RESOURCE CLASSIFICATION FRAMEWORK TO ADVANCE SUSTAINABILITY IN LUNAR EXPLORATION MISSIONS

Abstract

The space environment is often seen as an infinite frontier and not as a finite resource. When terrestrial resources are evaluated on various measures – including availability, recoverability, accessibility – quantifying resource reserve estimates are integral to the evaluation. However, no current framework exists to characterize planetary resources on the basis of mission resource metrics. In this investigation, a space resource classification framework is proposed in response to the current, heightened interest in resource recovery and utilization in planetary resource-focused missions. The preceding study presented at IAC 2020 outlined numerous gaps in planetary sustainability approaches and the basic methods to be leveraged to assess the long-term impacts and overall sustainability of space exploration missions. This paper builds on the preliminary outline and presents a novel framework for planetary resource classifications that expands "planetary sustainability" beyond the concepts of mission longevity or mission assurance; moreover, the framework is inspired by a systems engineering approach to evaluate the long-term viability of space resource extraction efforts with respect to availability, recoverability, accessibility, and sustainability. The resource classification framework incorporates availability, recoverability, and accessibility metrics, a composite sustainability metric, and associated risk scores for each metric. Existing industrial resource and risk classification methods guide framework development, while existing space sustainability concepts and resource use proposals inform metric development. Finally, the framework relies on existing lunar geologic data to articulate the resource and risk benchmarks for each metric. The investigation unveils how resource classification benchmarks are integral to sustainable mission design and illuminates how to implement planetary sustainability through a quantitative approach early in the space systems engineering lifecycle. By addressing gaps in current resource use and mission design approaches, the proposed framework is a systems engineering approach to safeguarding the sanctity of the space environment while providing a quantitative method to evaluate resources in space.