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LUNAR HABITAT ECO-DESIGN: BRIDGING THE GAP BETWEEN MODEL-BASED SYSTEMS ENGINEERING AND LIFE CYCLE ASSESSMENT

Abstract

In recent years, the international space community has devoted efforts to returning humans to the Moon's surface. These efforts have garnered support from potential private partners interested in conducting in-situ experiments to aid in establishing a permanent human presence on the moon. Due to increased investment from both public and private institutions, along with advancements in space system reliability, there has been a surge in space activities over the past decade. While the environmental impacts of space activities are minor compared to other industries, it is crucial to monitor and account for the ecological effects. Through these efforts, design engineers can make informed decisions early in the mission planning process to incorporate eco-friendly design methods, which will contribute to environmentally sustainable space missions. Model-based Systems Engineering (MBSE) is widely used in space missions to facilitate comprehensive solutions across disciplines. The ecological Life Cycle Assessment (LCA) of an MBSE model can be used to evaluate the system's environmental impacts during its various phases on Earth, in space, and on the Moon. However, there exists a significant gap between MBSE and LCA, notably from the ontological point of view. This article aims to address these gaps by proposing a methodology for evaluating the environmental impacts of a space mission defined using MBSE. It proposes incorporating LCA goals and scopes within an MBSE tool and clearing the ontological ambiguities between the two disciplines. Also, the paper will include a sensitivity analysis of the initial requirements obtained from various stakeholders of the mission, to determine how they alter the studied system's environmental impacts.