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INTEGRATING HUMAN FACTORS INTO MODEL-BASED SYSTEMS ENGINEERING FOR LUNAR HABITAT ECO-DESIGN: A MULTIDISCIPLINARY APPROACH

Abstract

Following the Artemis program, a global initiative aimed at revitalizing lunar exploration is currently underway, with a firm commitment to establishing a sustained human presence on the Moon. Recognizing the strategic importance of the lunar South Pole, the International Space Exploration Coordination Group (ISECG) has emphasized the necessity of a long-term surface habitat. However, achieving this ambitious objective requires a coordinated multidisciplinary effort, notably integrating Human Factors Engineering (HFE) with Model-Based Systems Engineering (MBSE).

This paper delves into the crucial role of integrating HFE into MBSE to facilitate early validation of system architecture and behavior in lunar habitat eco-design. HFE, characterized by iterative, non-functional, and qualitative methodologies, often faces challenges when juxtaposed with the top-down, function-oriented approach of systems engineering. Thus, a novel approach is proposed by amalgamating these facets into a model-driven framework, encompassing ergonomics, habitability, comfort, sociability, emergencies, and training considerations.

It is imperative to prioritize the physiological, psychological, medical, and day-to-day needs of astronaut crews during system design. Conventional system modeling languages typically depict astronauts as external actors rather than intrinsic components of the system. This paper advocates for a shift in this approach, drawing from ongoing projects in the concept and preliminary design phases, which are crucial for the success of a Human Factors program.

This study introduces a strategy for incorporating human factors into system models using a human-centered design approach. Additionally, it scrutinizes quantitative and qualitative attributes of the lunar habitat concept related to HFE, alongside methods for evaluating, validating, and modeling these quality attributes. The sample system undergoes analysis to identify task, resource, and data flows, followed by the construction of distinct system- and human-centered diagrams to evaluate their functional and physical characteristics. These models are then interfaced and merged to create an integrated model of the habitat, including the crew, providing new perspectives that enable systems engineers and human factors engineers to better understand the user's role during early system design processes.

By integrating astronauts as integral components within a robust system engineering approach, their influence on system performance, safety, and reliability becomes significant. Therefore, utilizing a common modeling approach facilitates comprehension of the system by various stakeholders, ensuring that human-related concerns are effectively communicated and managed.