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Systems and Infrastructures to Implement Sustainable Space Development and Settlement - Systems (2A)

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MOVING TOWARDS A BROAD-SCOPE PARAMETRIC MODEL BASED SYSTEMS ENGINEERING APPROACH FOR LUNAR SYSTEMS : A CASE STUDY OF LUNAR BULK MATERIALS CONVEYING.

Abstract

The scale, complexity, and integration challenges inherent in designing future lunar bases make a Model-Based Systems Engineering (MBSE) approach highly attractive. However, MBSE in this context faces a key hurdle: specifications and even high-level requirements often need revision during the evolving design process. This arises from the iterative nature of lunar base design spread over many years, which inevitably uncovers unforeseen data and boundary conditions, necessitating adjustments to the system architecture and project scope. This iterative approach creates a dilemma: either the system model undergoes constant updates to reflect these changes, or the initial requirements and specifications become overly abstract, potentially compromising their usefulness in guiding the design process. The proposed solution is to utilise a much broader-scope system model that encompasses and is driven by a wider range of lunar base parameters than traditional models. This includes life cycle considerations, interactions with many other space activities, and other relevant inputs. This broader scope aims to discourage siloed development and mitigate the risks of underestimating resource demand. The methodology variation is not radical: when a need to specify an architectural element arises, it becomes a variable parameter. Designers then populate the parameter with a specification derived from available solutions. The current work utilises a bulk material conveying system as a case study. Selecting a suitable conveyance principle requires specifications for multiple parameters associated with materials properties and system demand. However, these specifications are unavailable as key details of other systems such as lunar ISRU facilities and other dependent systems are still under development, leaving the total demand uncertain. Consequently, any initial specification would be arbitrary, limiting development options and necessitating rework later. To address this, the system architecture is treated as a variable parameter. This allows for continuous refinement as the design progresses and system parameters become more concrete, enabling exploration of different architecture variations and optimisations with minimal rework. The presentation will outline the problem and then highlight the benefits of a broad-scope parametric approach to systems modelling for lunar development, using the case study of bulk materials conveying.