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Author: Mr. Arukshan Pavalachandran
The University of Sydney, Australia

EVALUATING THE FEASIBILITY AND IMPACT OF MODEL-BASED SYSTEMS ENGINEERING IN A STUDENT-LED LUNAR ROVER TEAM

Abstract

The high complexity of student-led space robotics projects, such as lunar rovers, demands a structured approach to design, integration, and management. Model-based systems Engineering (MBSE) offers a systematic methodology for modelling system requirements, functional interactions, and physical components while ensuring efficient subsystem communication and collaboration. Although MBSE is widely used by organizations in the aerospace industry, its feasibility and effectiveness in student-led teams remain underexplored.

This study investigates the implementation of MBSE within the Sydney Interplanetary Rover Initiative (SIRI) - a multidisciplinary student-led lunar rover team consisting of forty members across six subsystems. The objective is to determine how MBSE can streamline system modelling, requirement tracing, and inter-subsystem integration to enhance project management and improve design efficiency.

The research follows a case study approach, applying the Arcadia method within MBSE to evaluate its effectiveness in the multidisciplinary student-led lunar rover team, SIRI. Using SysML-based modelling, in tools such as Capella, the study systematically models the rover's system through Arcadia's structured four-phase approach: Operational Analysis, System Analysis, Logical Architecture, and Physical Architecture.

The process begins with Operational Analysis, where stakeholder needs and mission objectives are modelled, followed by System Analysis, which identifies key system functions and their interactions using block definition diagrams (BDD) and internal block diagrams (IBD). The functional and behavioral relationships between subsystems are defined in the Logical Architecture phase. This logical model is translated into a detailed hardware/software implementation in the Physical Architecture phase, ensuring design traceability and compatibility between subsystems.

To assess the impact of MBSE, the study employs both quantitative and qualitative methods. Performance metrics such as design iteration time and error reduction are analyzed by comparing traditional document-based engineering workflows with the Arcadia-driven MBSE approach. Additionally, team feedback, through surveys and structured interviews, is collected to evaluate the feasibility and effectiveness of implementing MBSE. Simulation-based verification is used to validate the accuracy of system models, ensuring their alignment with real-world design and operational constraints.

The expected outcomes of this study include (1) a structured framework for implementing MBSE in student-led multidisciplinary teams, (2) empirical evidence of its benefits in reducing design conflicts and improving requirement traceability, and (3) recommendations for best practices in adopting MBSE for future student aerospace projects. By demonstrating the feasibility and advantages of MBSE in a student-led environment, this research contributes to the broader discourse on systems engineering education and its role in preparing students for complex aerospace projects.