IAF SPACE SYSTEMS SYMPOSIUM (D1)
Systems Engineering Modeling and Analysis (5)

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SYSMLV2-BASED MODEL-DRIVEN APPROACH FOR ASTEROID LANDER SYSTEM DESIGN AND ANALYSIS

Abstract

The focus of this study is to design and analyze an asteroid lander space system to demonstrate Model-Based Systems Engineering (MBSE) approach to construct a dynamic and comprehensive model illustrating interfaces between elements, components, subsystems, and systems. Recent asteroid landers include MASCOT and MINERVA-II landers onboard the Hayabusa-2 spacecraft to study the Ryugu asteroid. Philae lander (Rosetta mission) on the 67P/Churyumov–Gerasimenko comet is yet another example. The main challenges faced in the asteroid or comet lander missions are: constrained mass and power budget, prolonged cruising time (several years), tumbling of the lander after deployment, risk of high lander touchdown velocity and others. We initially developed a detailed model of the lander, including system architecture, mission operations concept, and dynamic budget analysis, using CATIA MagicDraw software based on SysML v1. However, we have observed significant issues in the extensibility and interoperability of the current software. While we can accomplish all the goals of our study, we believe it can be done more effectively. We will experiment with the recently released SysMLv2 standard and API to implement an effective MBSE approach. SysMLv2 standard is UML-like text based therefore it is easier to manipulate with the standard text-based tools as well as the new API to utilize SysML files as a database, which will connect together all models. These models will include system description (e.g. requirements, interfaces, state machines) as well physical models (parts, Attitude Control Models, trajectories etc.). We will evaluate suitability of SysMLv2 files as the single source of truth for the MBSE approach. We will demonstrate how to design and analyze a detailed lander system architecture illustrating all the interfaces between requirements, elements, components, and system budgets. In this study, concept of operations is developed for the entire lander mission to understand the sequence of events during cruise, deployment, descent and landing. A comprehensive budget analysis is also performed to determine safe margins in terms of power, mass, volume, data, and link using MBSE approach. Analysis is updated upon any modification to the overall design parameters. Further analysis is conducted for attitude control, structure, and power to verify concept feasibility. The configuration of the lander is tracked using version control system. We will present a comparison of the effort that is required with the currently established MBSE toolset (MagicDraw, ValiSpace, 3DExperience) and their interfaces to the representation of physical models in SolidWorks, MATLAB and Python.