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Author: Mr. Carlos Ortega-Miguez
Technische Universität München, Germany

Mr. Andreas Hein
Technische Universität München, Germany

A METHODOLOGY FOR RAPID PRELIMINARY SPACE MISSION DESIGN USING SYSML

Abstract

The preliminary design of a space mission is a challenging task due to its multi-disciplinary nature. Various methods have been proposed to support this phase of design. The system model is an important aspect where the relevant information for the systems engineer is represented. Nowadays, most of the major space agencies use spreadsheet-based system models for that purpose. However, this approach has severe limitations when models get more and more complex.

This paper presents a methodology for applying Model-Based Systems Engineering (MBSE) in Rapid Mission Architecture (RMA) studies, using the SysML language. This early mission formulation phase corresponds to low Concept Maturity Level (CML) studies, where initial feasibility and candidate mission architectures that define the trade-space are assessed. Typically around 15 different mission concepts may be proposed, or even more. A trade-off analysis is then carried out from which only a few concepts are selected. These resulting mission architectures are then to be analyzed in detail within the next design phases. Therefore, a crucial aspect of the introduced methodology is the modeling of a mission architecture trade-space generated during the RMA study.

The goal of this work is to provide a tool that, using SysML, allows modeling the mission objectives, the brainstormed system elements such as a variety of payload instruments, platforms or trajectories that fulfill the objectives, the traceability matrix between objectives and system elements, or the functional aspects among others. Moreover, this tool enables combining the proposed subsystems in order to generate a trade-space of mission architectures. Further relevant aspects like their associated mission life-cycle costs and schedules can be as well modeled. The outcome is a set of models; each representing one candidate architecture.

In addition, the tool provides an infrastructure for modeling trade-off analysis by considering the defined measures of effectiveness and performance. This constitutes a key feature that easies the decision making process during the RMA study.

Finally, the methodology is applied to two case studies that demonstrate its benefits: a solar system planetary exploration mission and an interstellar flight. They were performed in the context of team design sessions, showing in turn that rapid preliminary mission design can be conducted with the presented methodology.