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ENHANCED MODEL-BASED SYSTEM ENGINEERING TO AID THE DELFFI FORMATION FLYING MISSION

Abstract

This paper presents a novel and piloting research on the application of Model-Based System Engineering (MBSE) to a formation-flying project. MBSE is a promising methodology for areas which involve multi-disciplinary engineering fields. MBSE relies on models instead of documents to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout the development and later life cycle phase. Some efforts have been made on space system modelling and analysing, however all deal with a single satellite or satellites without cooperation. We apply MBSE to the DelFFi project where two cubesats Delta and Phi fly within an autonomously controlled formation and perform in-situ characterization of low earth thermosphere. It is a challenge to deal with the new modeling task, where the system of interest includes not an independent satellite as usual but two cubesats with an intersat link, and that means more difficulty and difference in the modeling of requirement decomposition, system specification, logical architecture design, etc. Also, we explore how a space organization should start to use MBSE in practice. Considering it is a long march for the space industry to accept MBSE, we study how MBSE should be used to support the document-based approach as the first step. In addition, the research is intended to contribute to develop the MBSE methodology. We start from the original mission statement and continue to specify the mission/ system requirements, define the behavior/structure of the systems of interest (i.e.Delta and Phi) within the mission architecture, and also define the logical/physical architecture for the system based on our expertise. Then we identify and define the analysis contents, for example, relative orbit control requirement analysis or design parameter trade-off. In doing so, we capture the necessary system specification and design information with SysML language in Artisan Studio® environment, and define the executable SysML/external analytical models for parametric analysis. Secondly, during the modeling and analysing, we compare our MBSE results with that of the document-based approach and identify how the system model could be useful for the traditional design approach. Also, we record the workload of using MBSE, such as the working curve, important modeling issues and problems. Finally, we draw conclusions for the DelFFi project, present lessons-learned and experience for a space organization on how to progressively apply MBSE to a real project, and give some suggestions on the setup of an integrated development environment and its tools.