SPACE SYSTEMS SYMPOSIUM (D1)
System Engineering Tools, Processes and Training (2) (6)

Author: Dr. Jian Guo
Delft University of Technology (TU Delft), The Netherlands

Prof. Eberhard Gill
Delft University of Technology, The Netherlands

INCORPORATING UNCERTAINTY IN MODEL-BASED SYSTEMS ENGINEERING OF SPACE SYSTEMS

Abstract

The design of spacecraft is a challenging task due to the complexity and multidisciplinary nature of space systems. This implies that the spacecraft engineers should consider all relevant aspects of the space product life cycle from design, manufacturing, operation until the end-of-life disposal. To make such a design, Model-Based Systems Engineering (MBSE) is a particularly suitable tool. MBSE significantly differs from traditional design approaches by using models to simulate system performance to appropriately augment the use of expensive and time-consuming prototypes or teams of engineers making multiple performance calculations for each scenario. This approach provides system designers with fast, flexible, and efficient tools that can be used throughout system development and test and evaluation. Recently, MBSE has raised significant attention from the space community. For example, the European Space Agency (ESA) is investigating the opportunity to utilize MBSE for the further development of its Concurrent Design Facility (CDF).

On the other side, uncertainty is an issue that attracts increasing interests in spacecraft development, especially in the early stage of the development process. In the traditional way of designing the system using prototypes, it is almost impossible to catch uncertainty in the early stage. However, MBSE could possibly allow spacecraft designers to identify, consider and remedy design issues with significant uncertainty early in the development process before they become too costly to address.

The paper presents an effective methodology, that explicitly considers technical and non-technical uncertainties, to enable the design, development and assessment of alternative system concept architectures for spacecraft, in the early stage of the development process. The paper consists of three main parts. The first part provides an overview of MBSE technology and its applications in the space community. Then the spacecraft system modeling methodology using the MBSE technology is described, using a small satellite as example. Emphases of this part are the uncertainty modeling and the integration of technical and non-technical uncertainty models into existing MBSE infrastructure. In the third part, a model-based system and uncertainty analysis is implemented. The results show the effectiveness of incorporating uncertainty in MBSE of space systems.