SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Near-Earth and Interplanetary Communications (1)

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STATISTICAL RISK ESTIMATION FOR COMMUNICATION SYSTEMS DESIGN: DEVELOPMENT OF AN OPTIMIZATION FRAMEWORK

Abstract

The design of a spacecraft is an evolutionary process that starts from requirements and evolves over time across different design phases. During this process, a lot of changes can occur. They can affect mass and power at component level, at subsystem level, and even at system level. Each spacecraft has to respect overall constraints in terms of mass and power; it is important to be sure that the design does not exceed these limitations. Current practice in system design deals with this problem allocating mass/power margins to single components and to each of the subsystems. However, a statistical characterization of these fluctuations in mass and power is missing. The consequences are the generation of excessively risky designs which do not fit the mission constraints, or excessively conservative designs which imply an inefficient utilization of resources.

Hence, the objective of this research is to develop a mathematical approach to quantify the likelihood that a space communication system would meet the spacecraft and mission constraints while the design matures. Due to the complexity of the problem and to the different expertise and knowledge required to develop a complete risk model for all the different subsystems, the research is focused on risk estimation for a specific subsystem: the spacecraft communication system. Communication constitutes a key design driver in a lot of different spacecraft, and it is also the core in the design of commercial satellites applications. Moreover, the current research aims to be a "proof of concept", which can then be further expanded to the different subsystems, as well as to the whole spacecraft design process.

Particularly important in this analysis is the development of optimization frameworks to compare multiple possible design architectures, and to select the one that minimizes design objectives, like mass and power consumption, while minimizing the risk associated with these same metrics.

The articles is structured as follows: an overview of the model to perform statistical risk estimation is described, and the mathematical framework for optimization is detailed and applied. Finally, results are presented.