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UNCERTAINTY MULTIDISCIPLINARY DESIGN OPTIMIZATION OF SPACE SYSTEMS IN THE PRESENCE OF NEW ATTRIBUTES

Abstract

Over the past few years, the emphasis on space systems has changed from performance to new attributes such as economics, flexibility and responsiveness. Many innovative space system architectures have been proposed according to these new attributes. For example, the concept of Operationally Responsive Space (ORS) focuses on the cost and responsiveness of future space systems while System F6 program aims to improve the flexibility through spacecraft fractionation. The introduction of new attributes results in new uncertainties, not only on technical aspect, but also in economics, market and policy domains. Therefore, it is necessary to incorporate new and existing uncertainties into the development of innovative space systems. A considerable research has been done to address the uncertainty problem in the design of spacecraft subsystems. However, the work concerning uncertainties in space system architectures is very limited, possibly due to cross impacts of uncertainties caused by the multidisciplinary nature of space systems.

This paper investigates the problem of optimizing space systems in the presence of uncertainties related to new attributes. More specially, the paper discusses utilizing Uncertainty Multidisciplinary Design Optimization (UMDO) technology to solve this problem. The paper consists of three primary parts. The first part provides an overview of UMDO technology, including theory architecture and implementation procedure. An emphasis of this part is the integration of new attributes into existing UMDO infrastructure, which is done by modifying conventional UMDO problem formulation. Then issues related to uncertainty system modeling and uncertainty analysis are discussed in detail in the context of the modified UMDO formulation. The focus of this part is the uncertainty classification and quantification of new attributes or new architectures. Some techniques are of special interest to be utilized here, which include the Generalized Information Network Analogy (GINA) and the Multi-Attribute Tradespace Exploration (MATE). In the final part, a case study is presented. Due to the revolutionary architecture and the involvement of new attributes, the fractionated spacecraft is chosen to demonstrate the efficiency of UMDO in the spacecraft conceptual design. The results obtained through UMDO and conventional MDO are compared, which indicate that UMDO is a reliable and robust technology for the design of innovative space systems.