SPACE SYSTEMS SYMPOSIUM (D1)
System Engineering Tools, Processes & Training (I) (3)

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FAST EVIDENCE-BASED SPACE SYSTEM ENGINEERING

Abstract

This paper presents the latest advances in the use of Evidence Theory to incorporate uncertainties in Space System Engineering. With Evidence Theory, uncertainties can be introduced in the form of intervals of values or propositions expressing opinions. It is, therefore, easy to model the typical uncertainties existing during the early phase of the design process, when a preliminary assessment of the feasibility of a mission is required. Evidence Theory measures the credibility of a given proposition (e.g. the spacecraft mass will be below 1000 kg) through two cumulative functions called Belief and Plausibility. They give, respectively, the lower and upper limits on the probability that the proposition is true given the current body of evidence. Each proposition is associated to one or more design solutions. Belief and Plausibility provide a quantitative trade-off among different design solutions under uncertainty. Therefore, they represent a very valuable tool for decision making during the early phase of the design of a space mission. However, the cost to compute the values of Belief and Plausibility grows exponentially with the number of uncertain parameters, because the combination of all the uncertain values for all the uncertain parameters must be considered in the computation (each combination is a focal element with associated belief content). This paper presents an innovative technique that allows for the fast computation of an approximation of Belief and Plausibility, even for problems of moderate size, with a predictable accuracy. This technique is sufficiently fast to allow for the simultaneous optimisation of the system budgets and their associated Belief values. Hence, the associated design results to be simultaneously optimal and robust against uncertainty. The underlying idea is to use a fast evolutionary process to, at first, find the design solutions with maximum Belief and minimum Plausibility, and then incrementally build the other parts of the Belief and Plausibility curves by progressively discarding the focal elements with irrelevant belief content and clustering the rest. A few representative examples will illustrate the effectiveness of the novel technique. In particular, as this research is in support to the ESA activities for the development of Concurrent Engineering, the paper will present an example of robust design optimisation of an integrated telecommunication and power system onboard a small satellite.