Uncertainty and Design Margins in Space Systems Design

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Abstract

A method for propagating and mitigating the effect of uncertainty in conceptual level design via probabilistic methods is described. The goal of this research is to develop a rigorous foundation for determining design margins in complex multidisciplinary systems. The current deterministic method of uncertainty mitigation in complex multidisciplinary systems is reviewed. As an example, the investigated method is applied to the conceptual design and development of a composite overwrapped pressure vessel. For the pressure vessel example, margins for mass, schedule, cost, and risk form a set of tradable system-level parameters. The variables involved in the design and development of the pressure vessel are classified and each is assigned an appropriate probability density function. To characterize the resulting system, a Monte Carlo simulation is used. Results of this simulation are combined with the risk tolerance of the decision maker(s) to guide in the determination of margin levels. This procedure is repeated until the decision maker is satisfied with the balance of system-level parameter values. Application of this method to the pressure vessel example yielded important differences between the calculated design margins and the values typically assumed in conceptual design. The ultimate goal of this research will be a method for propagating and mitigating the effect of uncertainty that can be applied to any complex multidisciplinary engineering system.