SPACE SYSTEMS SYMPOSIUM (D1)
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MODEL-BASED THERMAL DESIGN UNDER UNCERTAINTY FOR THE JAMES WEBB SPACE TELESCOPE

Abstract

The validation of spacecraft thermal system models is usually performed through a series of thermal vacuum and balance tests, which provide experimental data at prescribed temperature levels. The process of correlating the thermal model to the experimental data becomes a parameter adjustment problem, which is a search for a set of parameters that fit to the model within a level of goodness deemed appropriate for mission success and which relies on engineering expertise and intuition. One could improve this process by automatically looking for the best-fitting model parameters through an optimization of specific figures of merit. In this approach, the model parameters are, in fact, tuned to the test data and not to the flight conditions in which the real system will find itself after launch. This paper describes a methodology to rigorously quantify input model parameter uncertainties upstream of the model and to propagate them through the model to determine their influence on specific output quantities of interest. A variance-based global sensitivity analysis is used to identify and rank the critical system parameters, based on their contribution to the variance of the quantities of interest. These input parameters can therefore be targeted by additional research through optimal parameter inference experiments in order to reduce their variability. By so doing, one incorporates uncertainty in the model early in the project life-cycle and updates the model iteratively as new parameter information becomes available. This process increases one's knowledge about the system, especially when important design decisions are to be made, and can potentially reduce mission costs related to resources (e.g., mass or power) and processes (e.g., design, verification and validation). As a case study, this paper presents results from the latest test campaign of the James Webb Space Telescope "Core" thermal system.