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MULTIDISCIPLINARY THERMAL DESIGN OPTIMIZATION FOR THE JAMES WEBB SPACE TELESCOPE

Abstract

The James Webb Space Telescope (JWST) is a space infrared telescope being developed to provide insights into the evolution of the early universe. The technological challenges posed by the scientific requirements necessitate systems engineering approaches that cope with the large size of the telescope and the consequent impossibility to test it fully assembled, given the limited dimensions of currently available vacuum chambers. It becomes therefore crucial to develop models that can accurately predict the performance of each subsystem, both individually and when interacting with the others, in a space-like environment. These models must be verified and validated by test measurements. This paper presents a model-based systems engineering methodology developed to verify and validate engineering performance models by comparing test measurement data with model predictions. This methodology is based on the formulation of a constrained minimization problem whose solution represents the optimal performance parameter set. Implementing this methodology has several advantages. First, the solution of the minimization problem removes the thermal model's deficiencies, also providing formal error estimates. Second, the computation of the derivative matrices is entirely automated. This allows pre-calculating and storing their values, which can be used for multiple executions of this type of analysis during several test campaigns. When a new model becomes available, the derivative matrices can be updated quickly. Finally, the rapidity with which the analysis can be performed during a project's verification and validation phases could enable reductions in cost and schedule margins. This represents a crucial commodity when testing complex large-scale systems under time and budget constraints, such as JWST. As a case study, this paper will present results from the latest test campaign of the JWST "Core" thermal system.