Thermal Model Performance for the James Webb Space Telescope OTIS Cryo-Vacuum Test

Kan Yang, Stuart Glazer, Shaun Thomson, Christine Cottingham
NASA Goddard Space Flight Center, Greenbelt MD 20771

William Burt, Brian Comber, Wes Ousley
Genesis Engineering Solutions Inc., Lanham, MD 20706

Randy Franck
Ball Aerospace & Technologies Corporation, Boulder, CO 80301

Sang Park
Smithsonian Astrophysical Observatory, Cambridge, MA 02140

The James Webb Space Telescope (JWST), set to launch in early 2019, is currently undergoing a series of system-level environmental tests to verify its workmanship and end-to-end functionality. As part of this series, the Optical Telescope Element and Integrated Science Instrument Module (OTIS) Cryo-Vacuum (CV) test, the most complex cryogenic test executed to date by NASA, has recently been completed at the Johnson Space Center's Chamber A facility. The OTIS CV test was intended as a comprehensive test of the integrated instrument and telescope systems to fully understand its optical, structural, and thermal performance within its intended flight environment. Due to its complexity, extensive pre-test planning was required to ensure payload safety and compliance with all limits and constraints. A system-level pre-test thermal model was constructed which fully captured the behavior of the payload, ground support equipment, and surrounding test chamber. This thermal model simulated both the transient cooldown to and warmup from a 20K flight-like environment, as well as predicted the payload performance at cryo-stable conditions. The current work is a preliminary assessment of thermal model performance against actual payload response during the OTIS CV test. Overall, the thermal model performed exceedingly well at predicting schedule and payload response. Looking in depth, this work examines both the benefits and shortcomings of assumptions made pre-test to simplify model execution when compared against test data. It explores in detail the role of temperature-dependent emissivities during transition to cryogenic temperatures, as well as the impact that model geometry simplifications have on tracking of critical hardware limits and constraints. This work concludes with a list of recommendations to improve the accuracy of thermal modeling for future large cryogenic tests. It is hoped that the insight gained from the OTIS CV test thermal modeling will benefit planning and execution for upcoming cryogenic missions.