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ABSTRACT

Validation of Cielo, an Integrated Modeling Tool, Using a Thermo-Opto-Mechanical Testbed

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The Space Interferometer Mission (SIM) Planetquest is a large optical interferometer intended for making micro-arc-second measurements of the position of stars. SIM requires stability of optical components to tens of pico-meters per hour. Since it is difficult and costly to measure system performance on the ground, an integrated thermal, mechanical and optical modeling process is developed that allows predictions of the system performance at the required high precision. A Thermo-Opto-Mechanical (TOM3) test-bed has been built, Figure 1, to validate the models and demonstrate that the performance requirements can be met within given margins, see [1].

The current state of the art in thermal, mechanical and optical modeling involves three disparate computational models, several analysis codes and tools to transition results between these models. At JPL the commercial off the shelf (COTS) tools are the Siemens/UG CAE tools using I-deas as the main pre- and postprocessor, TMG for thermal analysis, NX/Nastran, for structural analysis. CODE V or the in-house code MACOS are used for optical analysis. MATLAB scripts are used to fill gaps in the COTS tools, see [1] for a detailed description of the current process . Each analysis code requires a different model. Although it has been shown in [1] that the commercial tools are capable to predict the performance within the given margins, the current process can be improved in terms of accuracy, reliability and speed. JPL has developed Cielo, an in house finite element tool capable of multi-physics simulations using a common finite element model, for thermal, structural and optical aberration analysis. The new tool increases accuracy by allowing finer meshes and by using double precision in all analysis steps. The code is scalable for parallel processing to get acceptable run times for large models. The common model reduces turn-around time for design changes significantly making parameter studies more feasible.

The new Cielo code is verified following the methodologies outlined in [2]. Results from theoretical problems and results from tests are compared against simulated results from Cielo and COTS tools. The TOM3 testbed experimental results and the computational results from COTS tools were used to validate Cielo's common model and computed results, see Figure 2.

The goal of the model validation is to demonstrate that the optical path difference (OPD) can be predicted within the required margin. The measured OPD (in the nanometer range) should be met by the simulated OPD within a factor of 2. The surface

emissivities in thermal analysis and the coefficients of thermal expansion (CTE) in structural analysis are the most uncertain parameters. The modeling and analysis shows that the OPD happens to be most sensitive to these two parameters. Parameter studies, sensitivity analyses, and better measurements of emissivities and CTEs are necessary to make more accurate predictions.

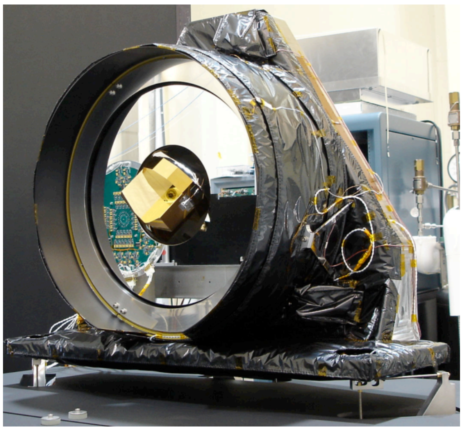

Figure 1. Siderostat of theTOM3 testbed

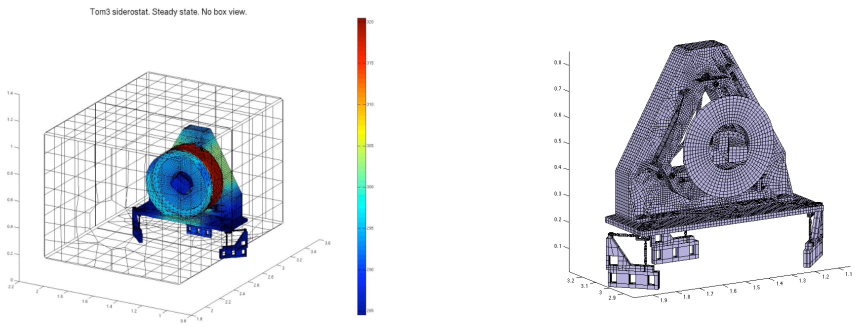

Figure 2. Common finite element model of the SIM TOM3 testbed

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