MODELING APPROACH FOR THE TERRESTRIAL PLANET FINDER CORONAGRAPH MISSION

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The TPF Coronagraph will rely heavily on modeling and analyses throughout its mission lifecycle, and as such the methods by which models are developed, validated, and implemented are a key task for the Project. Current modeling activities on the project can be separated into 3 broad areas: predictions of on-orbit performance, analytical tool development in support of specific Coronagraph needs, and verification and validation of the analyses.

The first task includes activities such as a) the development of performance models that flow down requirements from the science to sub-system levels, b) the mechanical CAD models that ensure the overall design is compatible with launch and flight configurations, c) the thermo-mechanical-control-optical integrated models which use detailed engineering models to simulate the end-to-end contrast performance of the instrument from thermal/jitter environmental disturbances and which verify the requirements defined by the performance models, d) the science models which propagates the wave-front error through the optical system and controlled deformable mirror to predict contrast and ultimately science capability, d) straylight models, and e) launch and orbit trade models.

Analytical tool developments include a) diffraction modeling capabilities that can accurately predict contrast to orders of -10 or better using the JPL tools MACOS [Ref. 1] and SPICA [Ref. 2 ?] , b) fully integrated modeling tools which can simulate under a single computational code the thermal, mechanical, control and optical performance of the flight system – this task includes a completely upgraded IMOS [Ref. 3] with embedded thermal radiation and conduction capabilities, a NASTRAN native input format for the model description, scalability to very large problems with very efficient numerics, seamless interface to optical analysis codes, and eventually full end-to-end sensitivity and optimization capabilities, c) optical error modeling tools and processes that establish sensitivities between optical perturbations and contrast.

In terms of verification and validation activities, the modeling process and approach for integrated analysis and optical error modeling are being validated on a representative test case problem. Accuracy of the analytical diffraction predictions is verified through a variety of ways. First through verification of 1-D propagation problems for which there are derivable solutions, then through comparison of a baseline problem using several codes, including SPICA and MACOS, and possibly a commercial diffraction code. Finally the HCIT testbed will be modeled and analytical contrast predictions will be compared to the actual testbed measurements. Similarly, a performance model is being developed for the HCIT in a manner identical to the Coronagraph flight performance model, and verification of the HCIT testbed performance prediction would then serve as a validation of the performance modeling capability for the flight system.

References

1. "MACOS: Modeling and Analysis for Controlled Optical Systems User's Manual, Version 2.4.1", D. Redding, L. Needels, K. Wallace, M. Levine and S. Basinger, NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena California, April

2. SPICA reference?

3. "Integrated Modeling of Optical Systems (IMOS) User's Manual, Release 5.0", L. Needels ed., NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena California, JPL publication 98-12 Rev. A, February 2000.