# System Engineering for Spaceborne Optical Interferometers

*Riley Duren*
Jet Propulsion Laboratory,
California Institute of Technology

**Abstract**

There are a number of major spaceborne optical interferometry missions with reasonably near-term launch dates (ranging from 2006 to 2013). These include the Space Interferometry Mission (SIM), Space Technology 7 (ST-7), the Laser Interferometric Space Antenna (LISA), and potentially the Terrestrial Planet Finder (TPF) and its sister project, Darwin. Many other missions exist in various stages of planning. The majority of these projects are currently (and appropriately) in "technology-development mode", meaning their focus is on proof-of-concept in the laboratory along with flight-qualification of selected low-heritage components. These projects will each undergo a profound metamorphosis in the coming years as they transition into "flight-project mode", where the focus will change to producing a robust, integrated flight SYSTEM on-time and within-budget. Such transitions are likely to prove challenging given some cultural issues that exist in both the interferometry technology and flight-project implementation communities. More importantly, spaceborne optical interferometry truly represents uncharted territory. We are learning as we go and as such, no one yet knows the "right way" to implement such missions. However, this paper is based on a collection of lessons-learned based on related missions including the Shuttle Radar Topography Mission of 2000 (a radar interferometer with some interesting parallels to optical interferometers), SIM (currently in phase A), and StarLight, a formation-flying stellar interferometry mission that merged with the TPF technology development program just prior to entering phase C/D. The time is ripe for a discussion of the unique system engineering challenges associated with the upcoming missions as they approach definition and implementation phase.

To first order, optical interferometry missions differ from "standard" deep-space science missions in several key respects: they are highly distributed systems, they are sensitive to small, cross-coupling error sources, and their operation is very complex. This leads to three unique challenges in the area of system engineering: performance modeling/simulation, validation and verification (V&V), and system robustness. Performance modeling for interferometers requires a heightened awareness of issues such as errors in the interfaces between constituent models, calibration and characterization testing (and/or modes of operation), and removal of systematic errors. V&V for optical interferometers requires a greater emphasis than usual on things such as requirements validation and model validation and on planning for performance verification (true end-to-end testing is very difficult, resulting in a critical need for a carefully formulated piecewise verification story-board). Finally, ensuring the flight interferometer is robust, both in terms of performance and functionality/operability, places increased demands on performance sensitivity and fault tree analyses. This paper will not describe the principles of interferometer design. Rather, it will elucidate the challenges associated with "flight-project mode" and suggest mitigating system engineering techniques. Finally, while many of the concepts presented will be applicable to all spaceborne interferometers (including those employing heterodyne techniques such as Interferometric Synthetic Aperture Radar and Very Long Baseline radio Interferometry), the emphasis will be in those operating at visible and infrared wavelengths (both white-light stellar interferometers and gravity-sensing laser interferometers).