Technology Demonstration for Next-generation Segmented Large Apertures

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One of NASA's most profound and inspiring scientific goals is the search for life elsewhere in the galaxy. To achieve its goal, NASA will require an 8- to 20-m space-based optical/UV telescope. Such a telescope would seek evidence of life on other worlds by imaging Earth-like planets around nearby stars to search for spectral "biosignatures". The telescope would also conduct a sweeping range of fundamental astrophysical studies that would, by virtue of the unprecedented combination of sensitivity and image sharpness, enable a transformative advance in our understanding of the structure and evolution of the Universe.

Today's state-of-the-art space telescopes, represented by the Hubble Space Telescope and the James Webb Space Telescope, require ground-based integration and test of the complete system and launches as a single unit. This approach will limit the size of future systems to the size of ground test facilities, the capacity of launch vehicles, and the ability of precision systems to maintain performance through launch and deployment. Furthermore, this approach is neither tolerant to imperfections in the optical system, nor cost-effective to scale to larger apertures. This white paper presents a new paradigm for on-orbit telescope assembly, alignment, and phasing that breaks these constraints, mitigates performance risk, lowers cost and offers a credible path to large apertures in space.

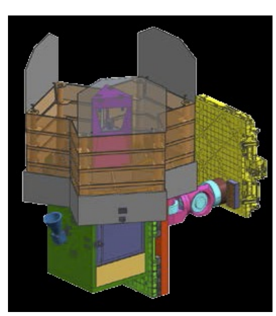
NASA and the Department of Defense (DOD) have already invested significant resources into technology required for the next-generation space telescope. Key elements of these technologies include (1) actuated hybrid mirrors (AHM) with lower areal density and cost than conventional mirror technologies, (2) diffraction-limited alignment, phasing and maintenance of the telescope system's optical performance using AHM, laser metrology and wavefront sensing and control (WFS&C), and (3) the robotic assembly of a telescope system to mechanical tolerances. We recommend the task force of the NASA Advisory Council's Astrophysics Subcommittee (APS) consider a system level demonstration of these technologies that will enable the assembly, alignment, phasing, and upgrade of large optical apertures in space.

Under NASA's sponsorship, the *Optical Testbed and Integration on ISS eXperiment* (*OpTIIX*) was initiated, as a cost-effective Class D system-level demonstration that would assemble, test, and operate a 1.45 m segmented-mirror telescope on the ISS. The telescope would be transported to the ISS as six modules and assembled using existing ISS robotic capabilities. Once assembled, active optics technologies would be used to align and phase the telescope to establish diffraction-limited optical quality. Images from the telescope would demonstrate system functionality and characterize performance. Performance results would be used to validate thermal, optical, and mechanical models developed prelaunch that will enable extension to larger systems.

Such a sub-scale system-level demonstration should be included in the roadmap to validate this new cost-effective paradigm for assembling the large apertures needed for NASA's future missions, enabling the masses of such systems to be reduced by adopting active control of the optics, and as a first step in demonstrating the robotic-assisted assembly and servicing of precision systems in space that NASA will need for a broad range of applications in the next 30 years.

Technical Objectives

- Demonstration of robotic assembly of an optical telescope
- Demonstration of segment actuated hybrid mirrors with integrated active control to provide as-needed figure correction and control
- Demonstration of diffraction-limited performance on bright stars
- Validation of models that will scale to larger apertures



OpTIIX Payload

- Six separate launch modules
- 773 kg attached mass (CBE)
- 879 W peak power (CBE)
- 1.45 m aperture (6 segments)

> 75% Strehl ratio at 650 nm

- Remote robotic assembly
- Attached to Express Logistics Carrier 3 on ISS