The ISS as a Testbed for Future Large Astronomical Observatories: The OpTIIX Demonstration Program

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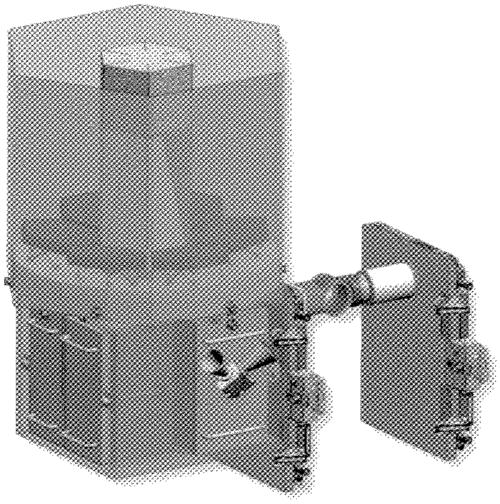
Future large (diameters in excess of ~10 m) astronomical observatories in space will need to employ advanced technologies if they are to be affordable. Many of these technologies are ready to be validated on orbit and the International Space Station (ISS) provides a suitable platform for such demonstrations. These technologies include low-cost, low-density, highly deformable mirror segments, coupled with advanced sensing and control methods. In addition, the ISS offers available telerobotic assembly techniques to build an optical testbed that embodies this new cost-effective approach to assemble and achieve diffraction-limited optical performance for very large space telescopes. Given the importance that NASA attaches to the recommendations of the National Academy of Sciences "Decadal Survey" process, essential capabilities and technologies will be demonstrated well in advance of the next Survey, which commences in 2019.

To achieve this objective, the Jet Propulsion Laboratory (JPL), NASA Johnson Space Center (JSC), NASA Goddard Space Flight Center (GSFC), and the Space Telescope Science Institute (STScI) are carrying out a Phase A/B study of the Optical Testbed and Integration on ISS eXperiment (OpTIIX). The overarching goal is to demonstrate well before the end of this decade key capabilities intended to enable very large optical systems in the decade of the 2020s. Such a demonstration will retire technical risk in the assembly, alignment, calibration, and operation of future space observatories.

The OpTIIX system, as currently designed, is a six-hexagon element, segmented visual-wavelength telescope with an edge-to-edge aperture of 1.4 m, operating at its diffraction limit, and shown in the accompanying figure.



The system is highly modular allowing its components to, be launched either on a single or on multiple vehicles and subsequently assembled on ISS with the existing robotic systems. Astronaut EVA provides a contingency. Deployment to ISS is proposed for the 2015 time frame. A 2-axis gimbal, developed at JSC, attaches the telescope to an ISS FRAM at Express Logistics Carrier 3 (ELC3) and will be zenith-pointing in our current baseline design. Existing Robonaut 2 joint designs will be leveraged in the gimbal design.

The optical telescope assembly (OTA) derives from nanolaminate active optics technologies originally developed for JPL via support from NASA and the Department of Defense. Mirror phasing will be controlled via laser metrology, developed at JPL. It is essential to demonstrate this technology in 0 g as performance of these very light optics is likely to behave very differently in this environment from that in terrestrial 1 g.

OpTIIX will employ a two-part wavefront-sensing system to control the OTA mirror systems: the Shack-Hartmann and the Phase-Retrieval Cameras. Together, these imaging systems will provide the detailed information necessary for figure control of the primary segments.

Imaging for most of the OpTIIX program will be carried out by a simple CCD camera with a multiple filter wheel. The camera will be designed and built by GSFC. As with other elements of the telescope, it will be a modular design, allowing the possibility of being upgraded during the course of the OpTIIX program. It will work at the diffraction limit of the telescope, thus offering an end-to-end demonstration of overall system performance.

Sustained operations on ISS will allow the imaging camera to be upgraded or replaced by other instruments under future Stand Alone Missions of Opportunity Notice (SALMON) issued by NASA's Science Mission Directorate.

Although the primary goal of OpTIIX is to retire technology and engineering risk in advance of the next NRC Decadal Survey in astronomy, we intend to offer observing time via an education and public outreach program.