NASA SBIR 2016 Phase I Solicitation

S2.03 Advanced Optical Systems and Fabrication/Testing/Control Technologies for EUV/Optical and IR Telescope

Lead Center: MSFC

Participating Center(s): GSFC, JPL

This subtopic solicits solutions in the following areas:

- Components and Systems for potential EUV, UV/O or Far-IR mission telescopes.
- Technology to fabricate, test and control potential UUV, UV/O or Far-IR telescopes.

Please note: an emphasis regarding mirror systems is the mirror substrate support structure. The Technical Challenges contains information on specific technologies which need developing for each area.

Proposals must show an understanding of one or more relevant science needs, and present a feasible plan to develop the proposed technology for infusion into a NASA program: sub-orbital rocket or balloon; competed SMEX or MIDEX; or, Decadal class mission.

This subtopic matures technologies needed to affordably manufacture, test or operate complete mirror systems or telescope assemblies. Traditionally, this subtopic matured technology from TRL3 to TRL4. Now, there is an additional opportunity to propose in Phase II for an effort larger than a traditional Phase II for the purpose of maturing demonstrated component level technologies (TRL4) to demonstrated system level technologies (TRL6) by using them to manufacture complete telescope systems. A requirement of this option is that there must be an identified NASA program that will fly the developed new technology system.

An ideal Phase I deliverable would be a precision optical system of at least 0.25 meters; or a relevant sub-component of a system; or a prototype demonstration of a fabrication, test or control technology leading to a successful Phase II delivery; or a reviewed preliminary design and manufacturing plan which demonstrates feasibility. While detailed analysis will be conducted in Phase II, the preliminary design should address how optical, mechanical (static and dynamic) and thermal designs and performance analysis will be done to show compliance with all requirements. Past experience or technology demonstrations which support the design and manufacturing plans will be given appropriate weight in the evaluation.

An ideal Phase II project would further advance the technology to produce a flight-qualifiable optical system greater than 0.5 meters or relevant sub-component (with a TRL in the 4 to 5 range); or a working fabrication, test or control system. Phase I and Phase II mirror system or component deliverables would be accompanied by all necessary documentation, including the optical performance assessment and all data on processing and properties of its substrate materials. A successful mission oriented Phase II would have a credible plan to deliver for the allocated budget a fully assembled and tested telescope assembly which can be integrated into the potential mission; and, demonstrate an understanding of how the engineering specifications of their system meets the performance requirements and operational constraints of the mission (including mechanical and thermal stability analysis).

Successful proposals will demonstrate an ability to manufacture, test and control ultra-low-cost optical systems that can meet science performance requirements and mission requirements (including processing and infrastructure issues). Material behavior, process control, active and/or passive optical performance, and mounting/deploying issues should be resolved and demonstrated.

Introduction

The 2010 National Academy Astro2010 Decadal Report specifically identified large light-weight mirrors as a key technology needed to enable potential Extreme Ultraviolet (EUV), Ultraviolet/Optical (UV/O) and Infrared (IR) to Far-IR missions.

The 2012 National Academy report “NASA Space Technology Roadmaps and Priorities” states that one of the top technical challenges in which NASA should invest over the next five years is developing a new generation of larger effective aperture, lower-cost astronomical telescopes that enable the discovery of habitable planets, facilitate advances in solar physics, and enable the study of faint structures around bright objects.

Finally, NASA is developing a heavy lift space launch system (SLS) with an 8 to 10 meter fairing and 40 to 50 mt capacity to SE-L2. SLS will enable extremely large space telescopes, such as 12 to 30 meter class segmented primary mirrors for UV/optical or infrared wavelengths.

Technical Challenges

To accomplish NASA’s high-priority science requires low-cost, ultra-stable, large-aperture, normal incidence mirrors with low mass-to-collecting area ratios. Specifically needed for a potential UVO mission are normal incidence 4-meter (or larger) diameter mirrors with 5 nm RMS surface figure error; and, active or passive alignment and control of normal-incidence imaging systems to achieve diffraction limited performance at wavelengths less than 500 nm (< 40 nm RMS wavefront error, WFE). Additionally, potential Exoplanet mission, using an internal coronagraph, requires total telescope wavefront stability on order of 10 pico-meters RMS per 10 minutes. This stability specification places severe constraints on the dynamic mechanical and thermal performance of 4 meter and larger telescope. To meet this performance requirement requires ultra-stable mirror support structures. Finally, specifically needed for potential IR/Far-IR missions are normal incidence 8-meter (or larger) diameter mirrors with cryo-deformations < 100 nm rms.

In all cases, the most important metric for an advanced optical system (after performance) is affordability or areal cost (cost per square meter of collecting aperture). Current normal incidence space mirrors cost $4 million to $6 million per square meter of optical surface area. This research effort seeks a cost reduction for precision optical components by 5 to 50 times, to between $100K/m^2$ to $1M/m^2$.

Development is required to fabricate components and systems to achieve the following Metrics:

- Areal Cost < $500K/m^2$ (for UV/Optical).
- Areal Cost < $100K/m^2$ (for Infrared).
- Monolithic - 1 to 8 meters.
- Segmented > 4 meters (total aperture).
- Wavefront Figure < 5 nm RMS (for UV/Optical).
- Cryo-deformation < 100 nm RMS (for Infrared).
- Slope < 0.1 micro-radian (for EUV).
- Wavefront Stability < 10 pm/10 min (for Coronagraphy).
- Actuator Resolution < 1 nm rms (UV/Optical).

Finally, also needed is ability to fully characterize surface errors and predict optical performance.