Advanced UVOIR Mirror Technology Development (AMTD) for Very Large Space Telescopes

ABSTRACT

ASTRO2010 Decadal Survey stated that an advanced large-aperture ultraviolet, optical, near-infrared (UVOIR) telescope is required to enable the next generation of compelling astrophysics and exoplanet science; and, that present technology is not mature enough to affordably build and launch any potential UVOIR mission concept.

AMTD is the start of a multiyear effort to develop, demonstrate and mature critical technologies to TRL-6 by 2018 so that a viable flight mission can be proposed to the 2020 Decadal Review.

AMTD builds on the state of art (SOA) defined by over 30 years of monolithic & segmented ground & space-telescope mirror technology to mature six key technologies:

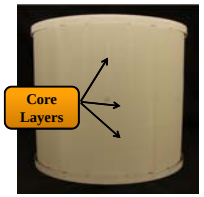
- *Large-Aperture, Low Areal Density, High Stiffness Mirror Substrates:* Both (4 to 8 m) monolithic and (8 to 16 m) segmented primary mirrors require larger, thicker, and stiffer substrates.
- *Support System:* Large-aperture mirrors require large support systems to ensure that they survive launch and deploy on orbit in a stress-free and undistorted shape.
- *Mid/High Spatial Frequency Figure Error:* Very smooth mirror is critical for producing high-quality point spread function (PSF) for high contrast imaging.
- *Segment Edges:* The quality of segment edges impacts PSF for high-contrast imaging applications, contributes to stray light noise, and affects total collecting aperture.
- *Segment to Segment Gap Phasing:* Segment phasing is critical for producing high-quality temporally-stable PSF.
- *Integrated Model Validation:* On-orbit performance is driven by mechanical & thermal stability. Compliance cannot be 100% tested, but relies on modeling.

AMTD is pursuing multiple design paths to provide the science community with options to enable either large aperture monolithic or segmented mirrors with clear engineering metrics traceable to science requirements.

1st YEAR ACCOMPLISHMENTS

AMTD derived, from Science Requirements, Engineering Specifications for 4 to 8 m monolithic space mirrors and is working on segmented primary mirror specifications

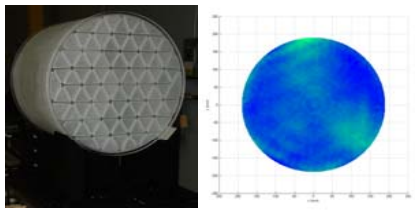
Large-Aperture, Low Areal Density, High Stiffness Mirror Substrates: AMTD partner Exelis developed and demonstrated a technique to manufacture a 400 mm thick mirror substrate via 'stacking and fusing' core structural elements to front and back faceplates; making a 40 cm 'cut-out' of a 4 meter diameter 60 kg/m^2 mirror. New process offers a lower cost approach for manufacturing large-diameter high-stiffness substrates.



Post-Fusion Side View
3 Core Layers and Vent Hole Visible

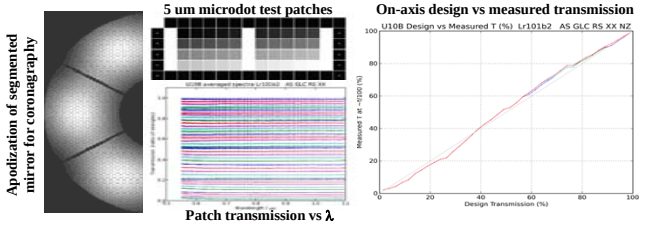
Post Slump Side View
2.5 meter Radius of Curvature

Mid/High Spatial Frequency Figure Error: AMTD partner Exelis polished the 40 cm mirror to a zero-gravity figure of 5.5 nm rms. NASA MSFC will test this mirror at 275K and generate a '2C hit map'. ITT will 'null' the deep core mirror to < 6 nm rms.



In FY14, NASA MSFC will test the AMSD ULE glass mirror at 2C and ITT will 'null' polish it to < 6 nm rms for 275K operation.

Segment Edges: AMTD Partner STScI demonstrated an achromatic microdot apodization technique to mitigate segment edge diffraction effects for high-contrast imaging.

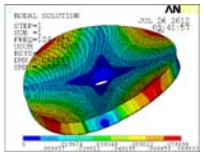


Microdot attenuation is achromatic & linear with density

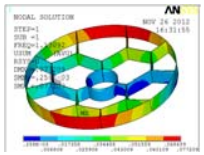
Segment to Segment Gap Phasing: AMTD is investigating the viability of various passive and active dampening and positioning technologies.

Integrated Model Validation: AMTD has developed a powerful design tool which quickly creates monolithic and segmented mirror substrate designs and analyze their static & dynamic mechanical and thermal performance. These models will be validated by test.

Support System: AMTD has expanded its substrate design tool to include launch support systems. Pre-Phase-A point designs for candidate primary mirror architectures have been produced.



Free-Free First Mode:
4 m dia 40 cm thick substrate



Internal Stress Distribution:
4 m mirror with 6 support pads

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