Technology Development for Large Stable UVOIR Space Telescopes

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AMTD demonstrating technology to make mechanically stable 4-meter or larger mirrors.
PTC will demonstrate technology for achieving thermal wavefront stability.

STRATEGIC ASTROPHSYCIS TECHNOLOGY

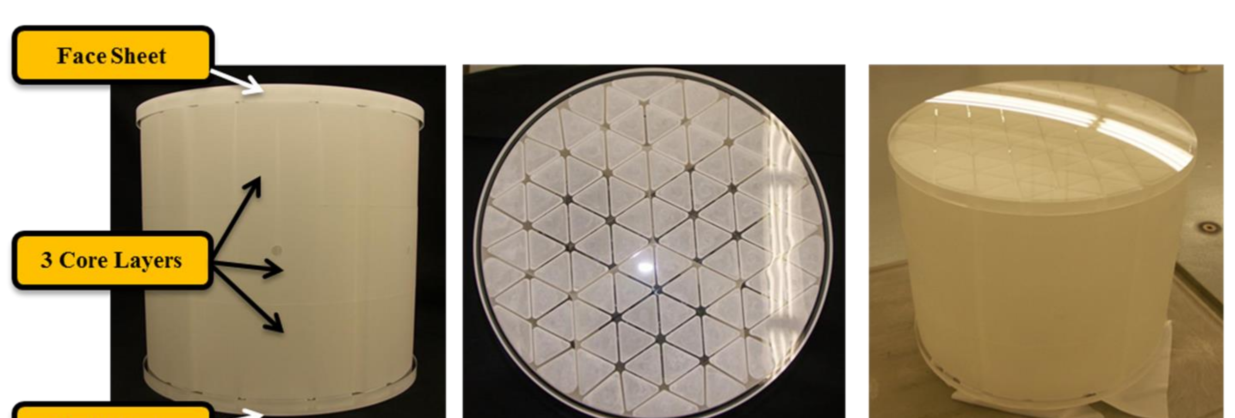
Astrophysics missions such as HabEx (Habitable Exoplanet Imaging Mission) and LUVOIR (Large UV-Optical-IR Survey Mission) require large ultra-stable space telescopes – to collect sufficient light with appropriate angular resolution and wavefront stability. To meet this need, Strategic Astrophysics Technology (SAT) Program invests in precision large optics technology. SAT places a premium on the ability to develop scalable manufacturing techniques of suitable and affordable mirror sizes. Keys to advancement are reducing areal density of optics, production times, and cost; manufacturing ultra-precise, low-mass structures to reduce launch volume; operating at wavelengths (900 – 2000 Å); and mechanisms and methods for improving thermal and dynamic stability, and wavefront sensing and control.

NASA MSFC has two funded Strategic Astrophysics Technology projects to develop technology for potential future large missions:

- Advanced Mirror Technology Development (AMTD)
- Predictive Thermal Control (PTC)

AMTD PHASE 1: Stacked Core Technology

AMTD-1 demonstrated 'stacked-core' process by making a 43 cm 'cut-out' of a 4 meter diameter 40 kg/m^2 mirror. Process offers a lower cost approach for manufacturing large-diameter, thick, high-stiffness mirror substrates.



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

Post-Fusion Top View *Pocket Milled Faceplate*

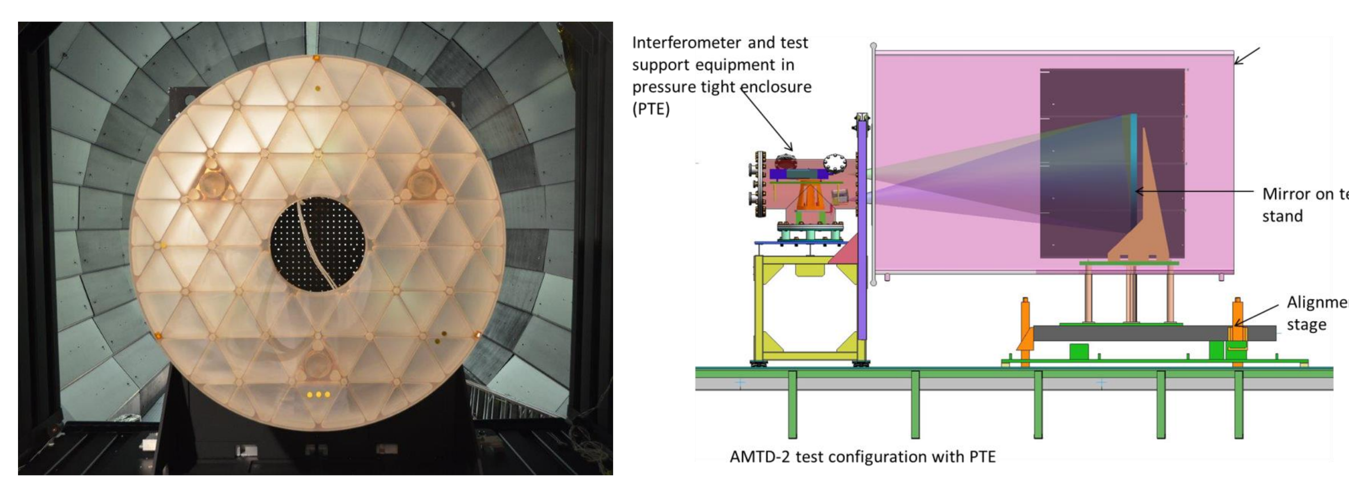
Post Slump: *2.5 meter Radius of Curvature*

ADVANCED MIRROR TECH DEVELOPMENT

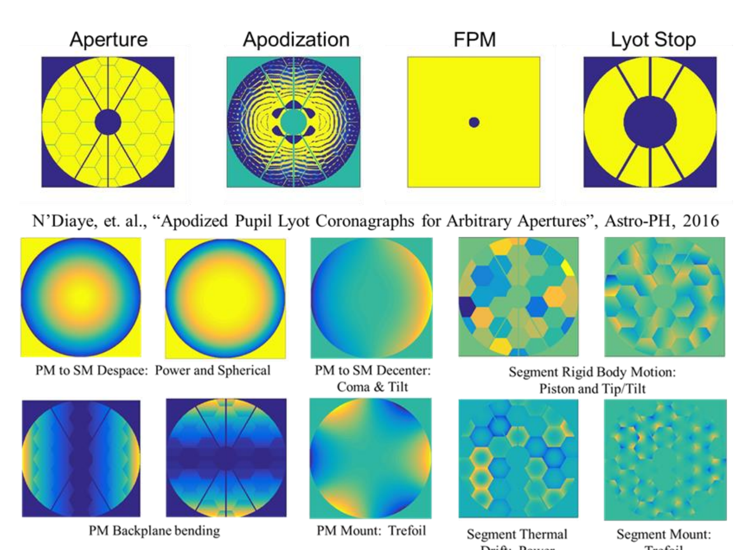
AMTD is maturing towards TRL-6 critical technologies required to enable 4-m-or-larger monolithic or segmented UVOIR space telescope primary-mirror assemblies for general astrophysics and ultra-high-contrast observations of exoplanets. AMTD uses science driven systems engineering to derive telescope level engineering specifications from driving science requirements then develop technological solutions that maximize science return for the minimum cost and risk.

AMTD Phase-2 is demonstrating lateral scalability of the stacked core process by making a 1.5 m diameter x 200 mm thick ULE$^{(C)}$ mirror that is 1/3rd scale of a full size 4-meter mirror.

AMTD-2 characterizes the mechanical and thermal performance of the 1.5m ULE$^{(C)}$ mirror and of a 1.2-meter Zerodur$^{(R)}$ mirror to validate integrate modeling tools.



Additionally, AMTD has developed integrated modeling tools to analyze the interaction between optical telescope wavefront stability and coronagraph contrast leakage.

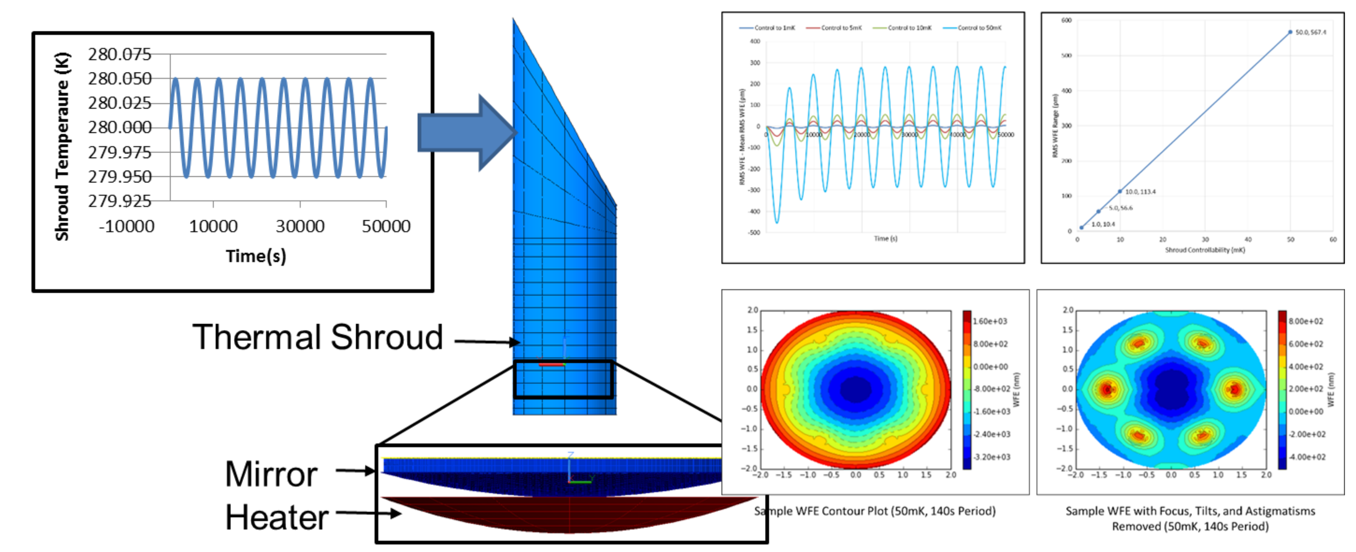


4.5-5.5 λ/D Segments	Aberration	WFE (pm) for 1x10^{-10} Photometric Noise	WFE (pm) for 5x10^{-11} Systematic Noise
	Piston	670	29
	Tip / Tilt	230	26
	Power	1,200	130
	Astigmatism	1,900	190
	Trefoil	11,000	330
Global			
	Power	22,000	22,000
	Spherical	24,000	9,600
	Coma	69,000	55,000
	Trefoil	62,000	12,000
	Hexafoil	120,000	12,000
Back Plane/Mount			
	Bend About X	1,500	330

PREDICTIVE THERMAL CONTROL (PTC)

PTC will develop technology to enable high stability thermal wavefront performance by using integrated modeling tools to predict and actively control the thermal environment of a 4-m or larger UVOIR space telescope.

PTC uses linear system theory to predict how a Space Telescope's wavefront error responds to a given temporal thermal input.



Model Predictive Control (MPC) places a physics-based model into the control loop to determine control variables (heater power levels) based upon state variables (temperature measurements). MPC uses a system of equations based on the governing physics to back solve for the desired temperature distribution. MPC takes into account the interdependency between all control zone's temperatures and all control zone's heater power.