

Roman Optical Telescope Assembly (OTA) integration and performance status



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PRESENTED AT:

INTRODUCTION

The Roman Space Telescope will survey the sky 1000x faster than Hubble with similar sensitivity and infrared resolution.

-- Julie McEnery, Senior Project Scientist

Optical telescope enablers

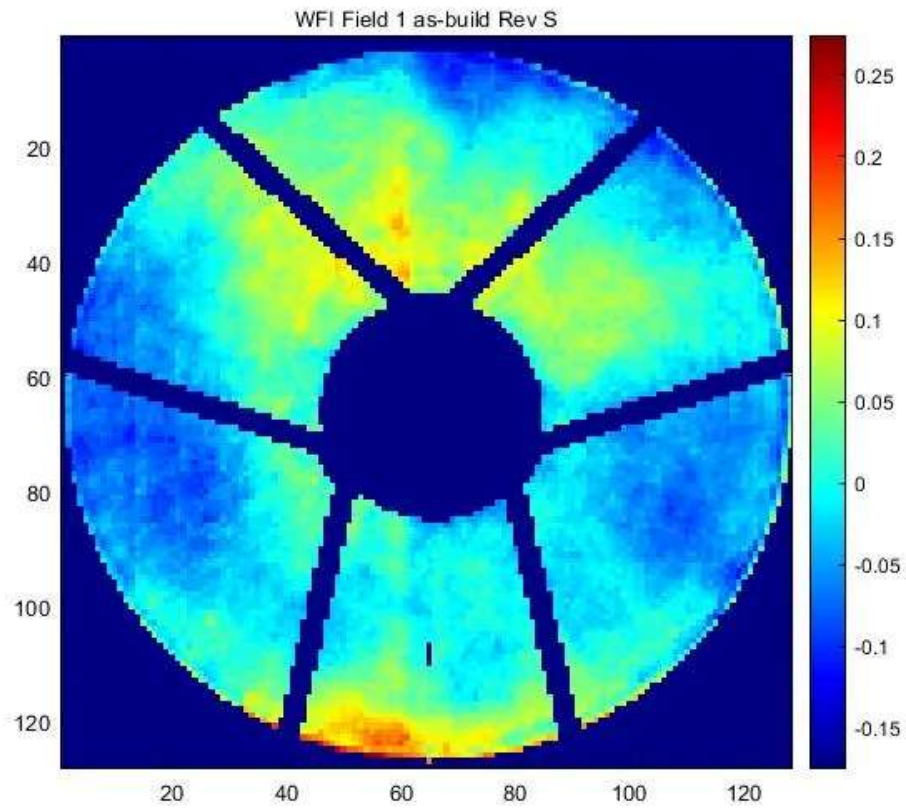
- Primary Mirror has the same diameter as the Hubble with 1/4th of the mass to enable more mass for the coronagraph and wide field instruments.
- ~ 70 nm wavefront error performance.
- Low thermal expansion materials with under 20 millikelvin temperature control.
- Exquisite thermal control and ultra-low CTE materials enable extreme optical stability with no settle time needed. Under 80 picometers wavefront error immediately following most extreme pointing direction changes.

Build status

- Assemblies complete
- Integration in process
- System test facility in renovation
- System test equipment procurement and build in process

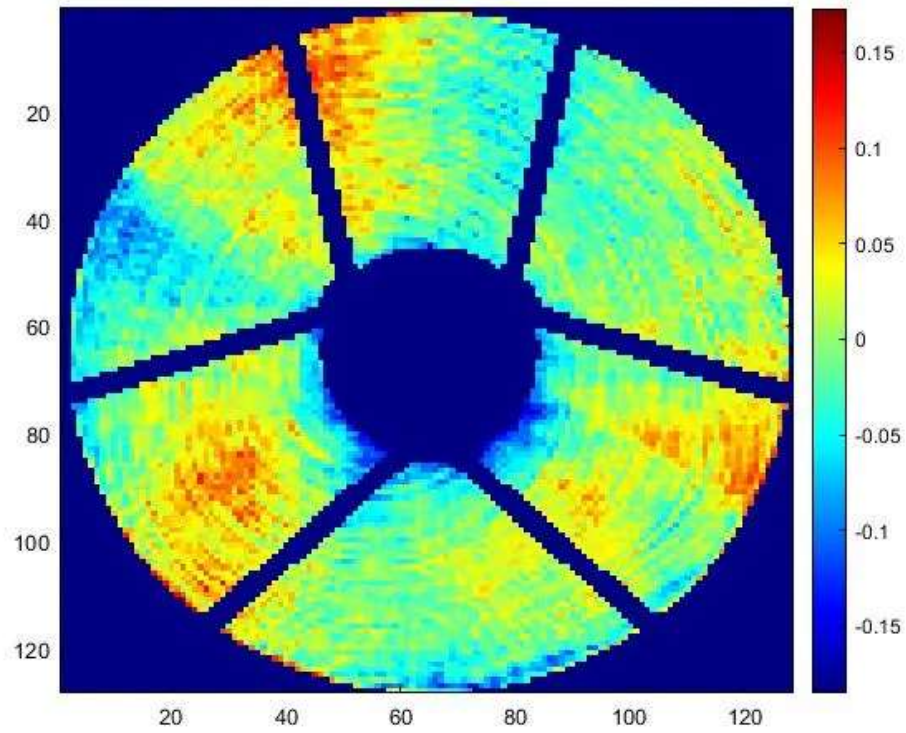
PREDICTED WFE

Predicted Wide Field image wavefront error map with ~ 70 nm telescope fabrication and alignment error



Predicted Coronagraph collimated beam wavefront error map with under 70 nm fabrication and alignment error.

CGI Field 1 as-built Rev S



TELESCOPE TAKING SHAPE!



Forward Optical Assembly complete

As shown above the Forward Optical Assembly completed and contains the Primary Mirror, the Secondary Mirror, and the supporting metering structure with actuated secondary mirror in 6 degrees of freedom with additional redundant fine focus actuation.

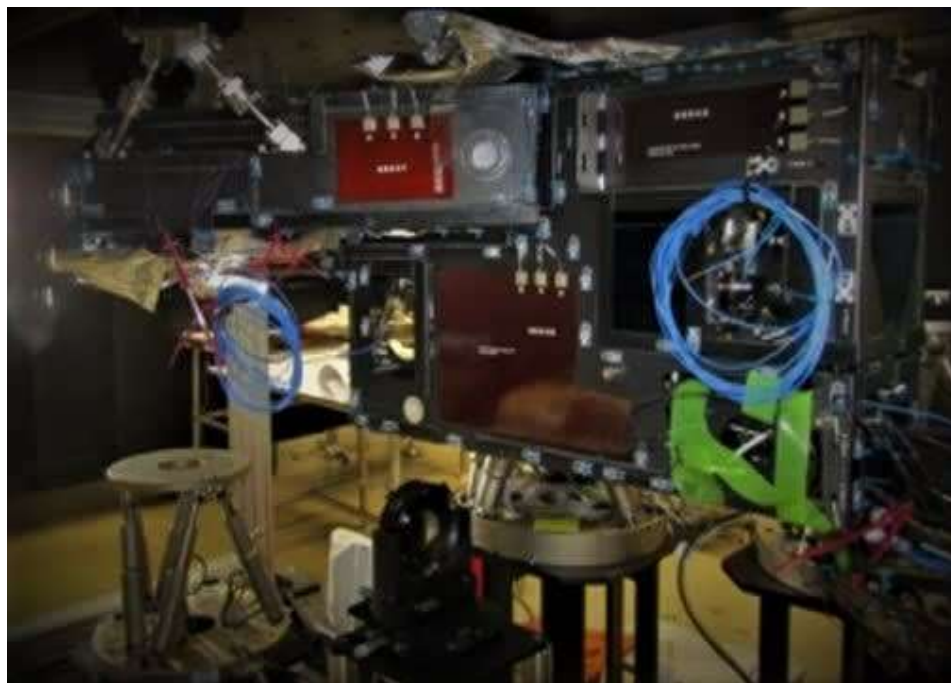
Pictures of the other assemblies display in the images window in the lower right.

Currently the team is integrating the Pick-Off Mirror Assembly (POMA) for the Coronagraph Instrument (CGI) into the Forward Optical Assembly and continue to install the extensive wiring for the tight thermal stability control.

Here is the POMA structure prior to integration with the Forward Optical Assembly and the flat mirror.



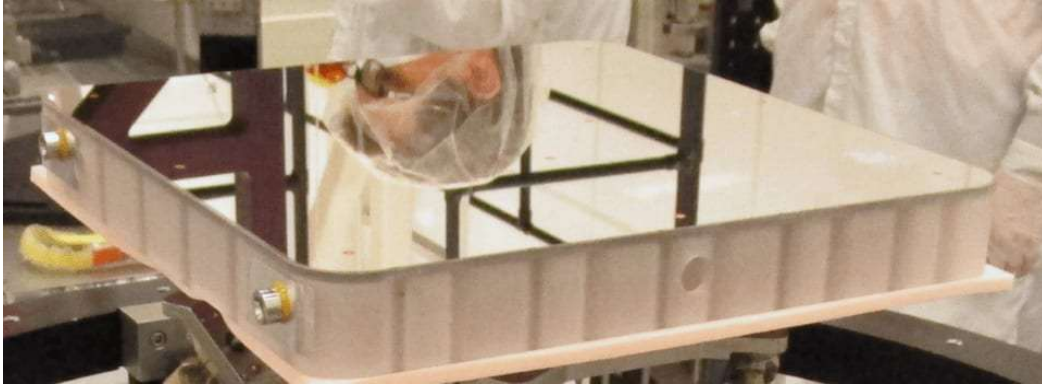
The Tertiary Optical Mirror Assembly (TOMA) completed with 3 powered mirrors installed to generate a low WFE collimated beam for the CGI and an actuated flat mirror to finely align the pupil position into the CGI.



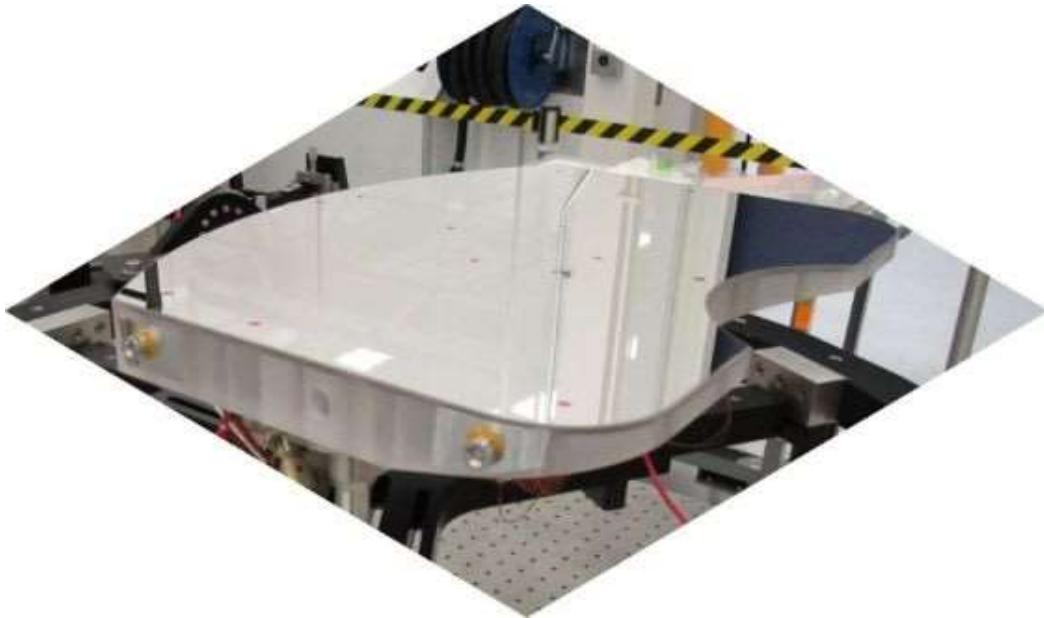
After the TOMA is integrated, the arrowhead-shaped Aft Optics Structure installation begins to enable installation of the two fold mirror assemblies.



The first fold mirror for the wide field image has tip, tilt, and piston actuation:



The second fold mirror has a mouse bite to pass the wide field beam as it passes underneath to the Wide Field Instrument:



Finally the 0.6-meter wide Tertiary Mirror assembly will install to generates the wide field image.

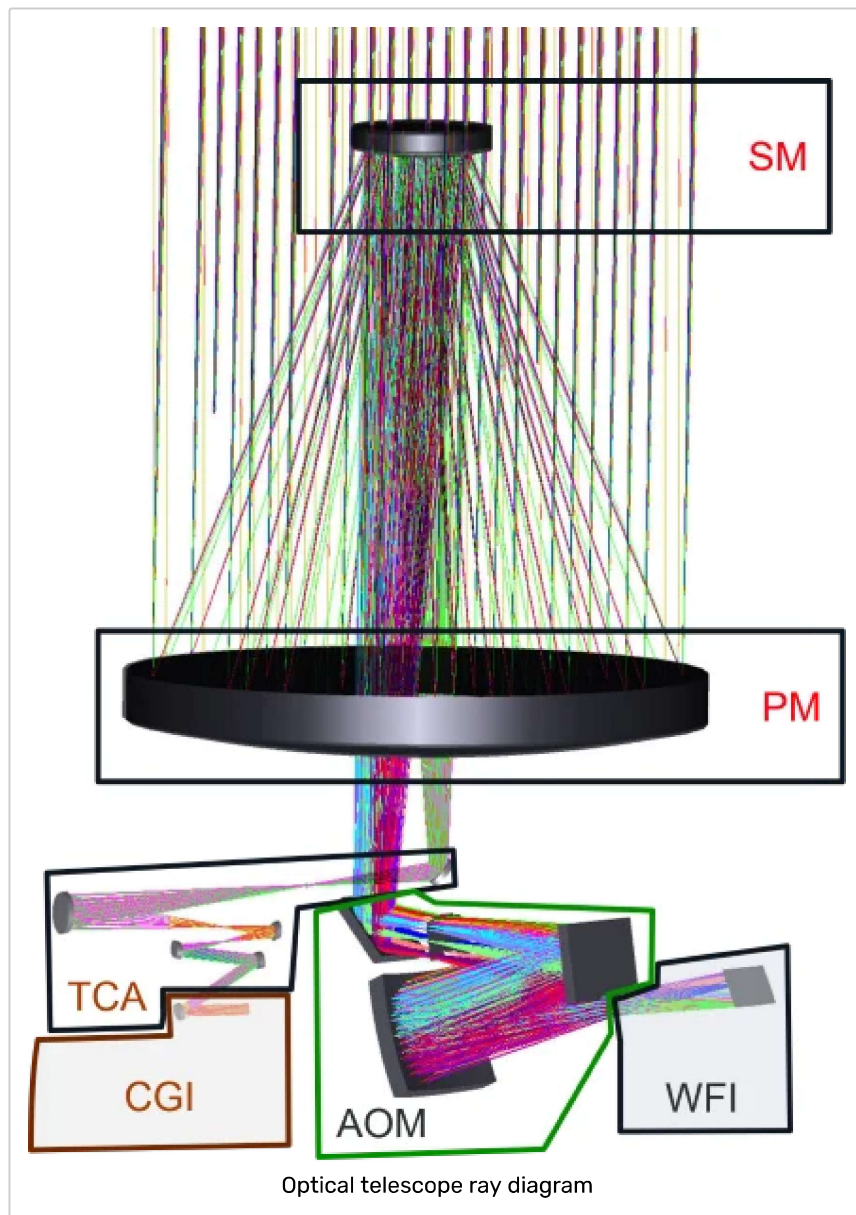


All the assemblies and structures have already been tested for strength, vibration, and thermal cycling. Pictures to the right show preparation for the environmental testing for the Integrated Optical Assembly.

Meanwhile the Telescope Control Electronics box shown below is currently under Electromagnetic Interference testing.



Here is the ray trace through the optical telescope. The Tertiary Collimator Assembly (TCA) includes the POMA and the TOMA.



Meanwhile the test facilities are in construction. The pressure tight enclosures for optical test equipment at the image plane are under construction. Electrical and thermal test equipment under construction and under test. The vacuum chamber is under renovation to vibration isolate the telescope, optical test equipment, and auto-collimating flat mirror for a double-pass optical test at cold operating temperatures. The new full-aperture auto-collimating flat is complete and waiting for integration into the hanging system.

The vibration facility has been expanded to test the Roman optical telescope. The facility itself is currently being tested for readiness and characterization.

The telescope is taking shape and approaching system-level test!

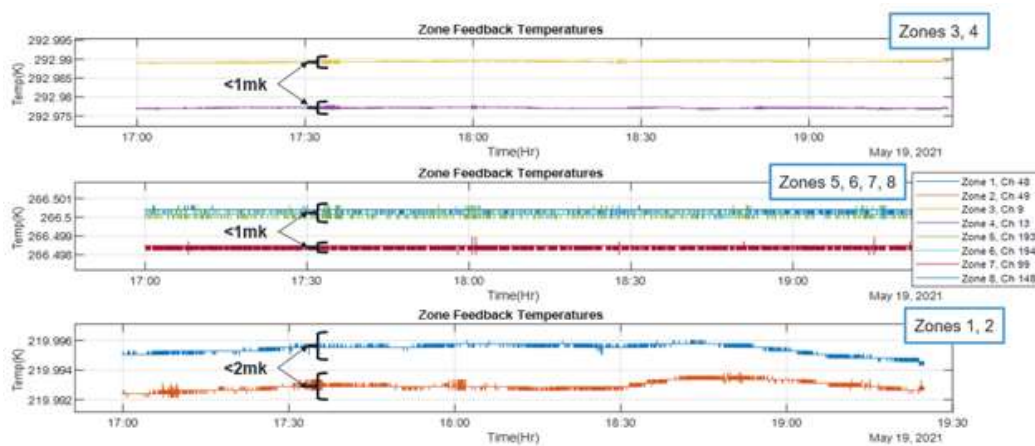
TEMPERATURE STABILITY DEMO

The Roman Space Telescope (RST) mission has multiple observing programs that rely on very stable optical behavior of the telescope, including:

- **Weak gravitational lensing:** One of the observing methods used by the Widefield Instrument. A stable and repeatable point spread function is necessary to observe transient gravitational micro-lensing effects caused by mass moving between the observatory and the target
- **Exoplanet coronagraphy:** The complex “masking” process used to block starlight and directly image exoplanets relies on maintaining optical stability while repeatedly slewing between target and reference stars

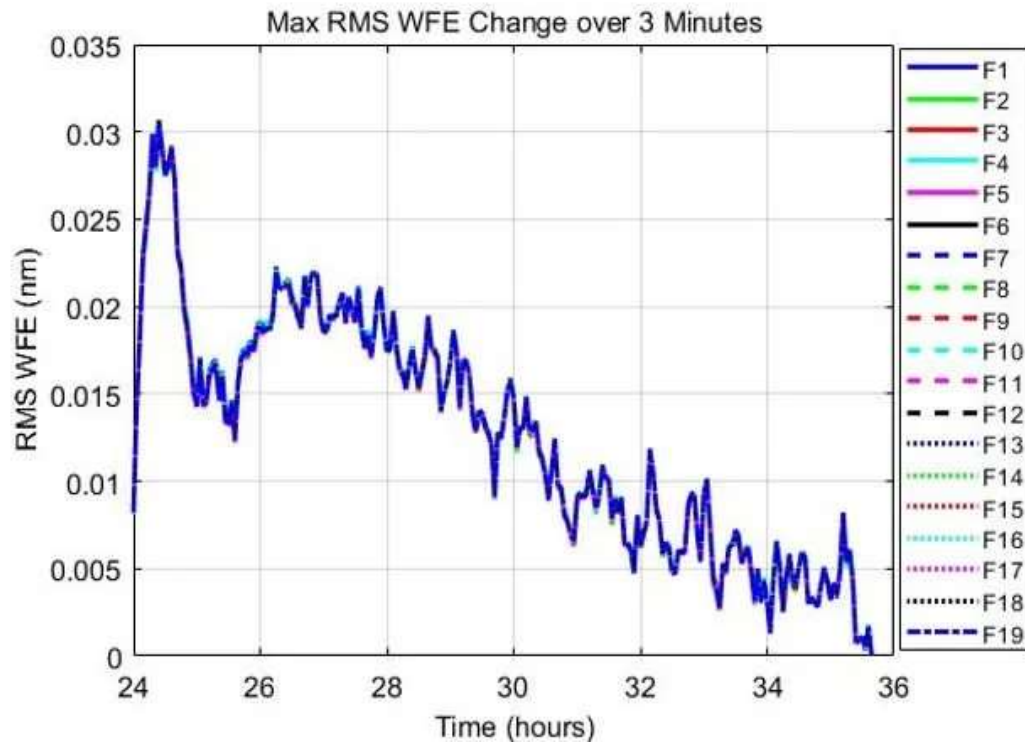
Demonstration of Integrated Thermal Control System (DITS):

- A test using flight-like electronics, sensors, and heaters together with thermal simulators in a flight-like (temperature and vacuum) environment
- Showed excellent correlation between predicted and measured temperatures and duty-cycles, validating thermal controller models
- Demonstrated control < 1 milliKelvin with ~ 100 mK variable environment

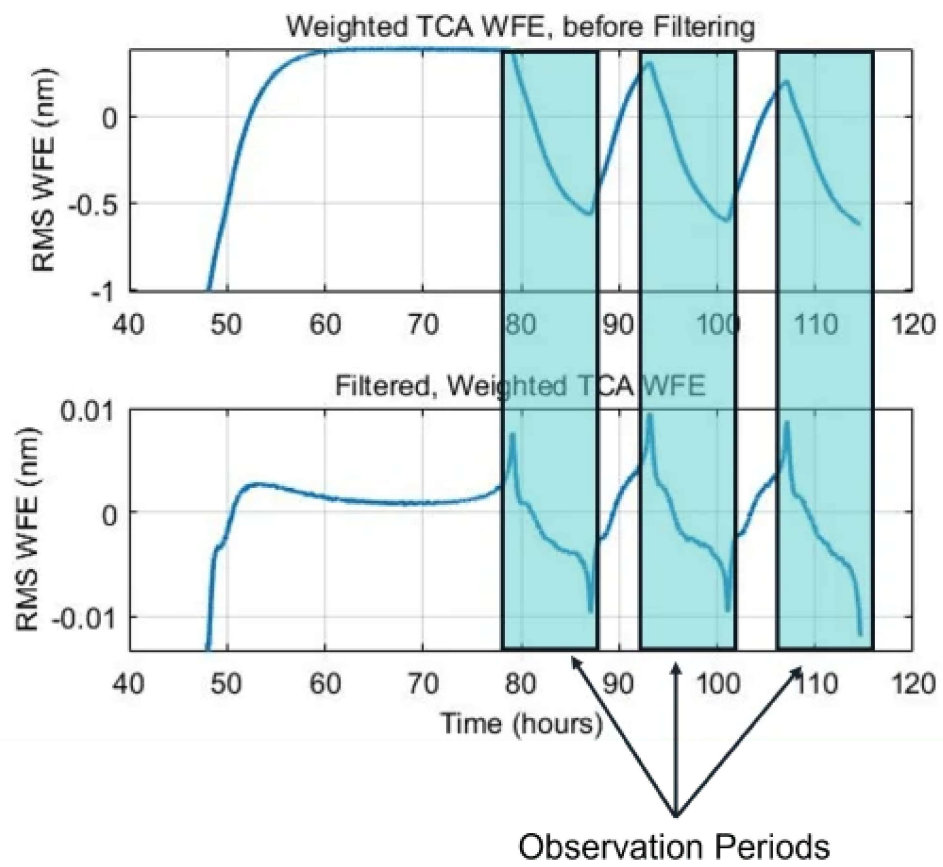


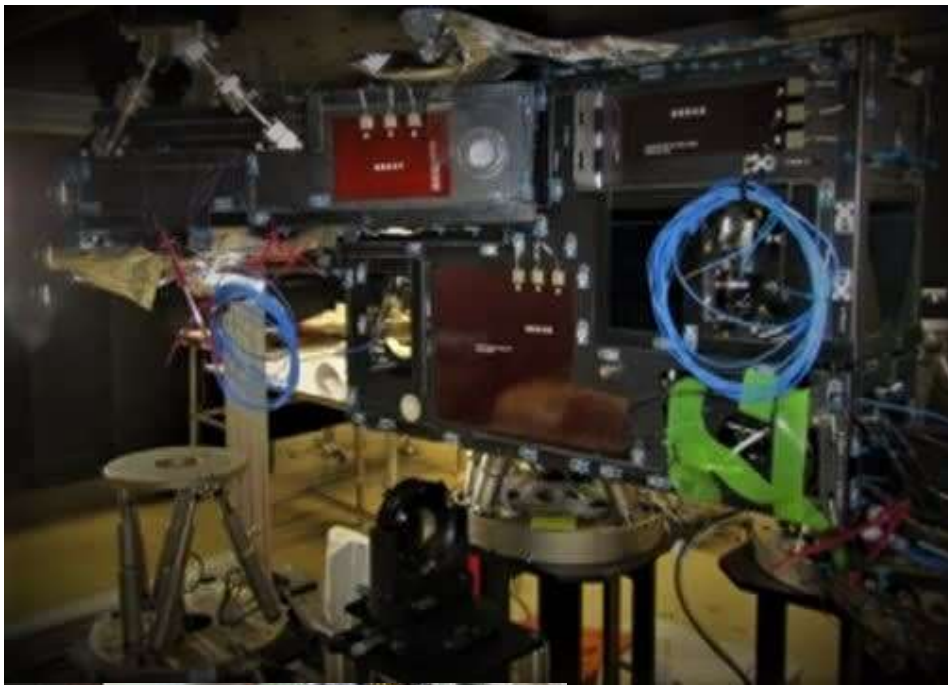
OPTICAL STABILITY

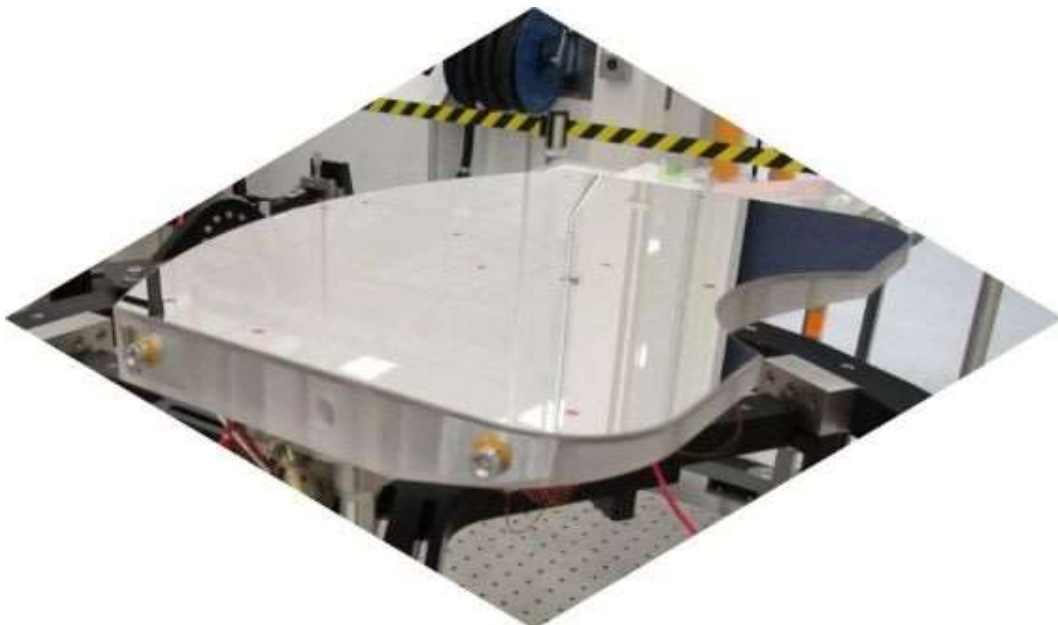
With temperature stability demonstration and finite element modeling, an early optical stability predictions after an instantaneous slew between two extreme pointing directions for the Wide Field images are below.



Here is an early WFE stability prediction for the Coronagraph Instrument that uses multiple slew cycles.











DISCLOSURES

The design, build, assembly, and testing of the Optical Telescope Assembly was supported by the National Aeronautics and Space Administration under Contract Number 80GSFC19C0021.

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TRANSCRIPT

ABSTRACT

The OTA for the Nancy Grace Roman Space Telescope includes the primary mirror, secondary mirror, and aft optics for guiding light into the Wide Field Instrument and the Coronagraph Instrument. The telescope is taking shape integrating the tested optical mirror assemblies. The assemblies have been thermal cycled to the cold temperatures for infrared operation, load tested to launch loads, vibration tested, and optically tested. Pictures and descriptions of the integration and test progress are provided, along with performance results measured at these levels of assemblies with predictions for system-level performance.

REFERENCES

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Peter Miller, Nicholas Ferry, Brian Martens, Dave Smith, Perry Voyer, Tony Whitman, "Roman Space Telescope – Demonstration of Integrated Thermal Control System Test for the Optical Telescope Assembly," Proc. SPIE 12188-54 (2022)

Tony Whitman, Peter Miller, Joshua Abel, J. Scott Smith, Brian Martens, Perry Voyer, Dave Smith, Erin Schiele, Nicholas Ferry, Alice Liu, "Roman Space Telescope Optical Stability," Mirror Tech Days (2022)

SCREEN TIME

