Successful Secondary Mirror Installation on the Vera C. Rubin Observatory

The mission: capture the universe like it has never been seen before. The Vera C. Rubin Observatory, formerly known as the Large Synoptic Survey Telescope (LSST), is under construction at Cerro Pachon, Chile. The program team recently announced the successful installation of the 3.5-meter secondary mirror on the Simonyi Survey Telescope.

The observatory will use the largest digital camera ever made. That combined with power of its large optics will allow the observatory to see things that previous telescopes could not. Scientists expect to learn things about the universe that they never anticipated. Moog positioning systems provide the precise mirror alignments required to take these high-quality images.

Discovering the Unknown

The Rubin Observatory, funded by the U.S. National Science Foundation (NSF) and Department of Energy, is designed to perform a 10-year survey of the Southern Hemisphere by imaging the entire visible sky every 3-4 nights. Its powerful telescope is expected to discover billions of stars and galaxies that have never been viewed before as well as millions of unknown objects within our solar system. It will help reveal the nature of dark matter and dark energy. The repeating images allow the detection and investigation of objects such as supernovae and asteroids that change brightness or position over time.[1]

The Mirror Technology and Moog Positioning Solution

This revolutionary project has been decades in the making. The telescope's novel three-mirror design includes an 8.4-meter primary mirror, a 3.5-meter secondary mirror, and a 5.0-meter tertiary mirror. The secondary mirror, which will be the largest convex mirror in any operating telescope, requires precise alignment. In 2013, Moog was selected to design and build a hexapod to provide this positioning as well as a similar system for the telescope's camera. The secondary mirror hexapod corrects for misalignments caused load shifts, temperature changes, and wind effects. It is also used to refocus the camera after a new filter is installed.

The secondary mirror and its cell assembly weigh more than 5,000 kg. The custom hexapod Moog designed and built can move this massive structure in very small, precise amounts to improve the alignment between the different optics, which allows the telescope to take better pictures. Its smooth and controlled motion protects the telescope from unnecessary vibration. Due to space constraints, our engineers used an unconventional actuator arrangement that still has the high stiffness to meet natural frequency requirements, will not backdrive under load, and will not shift position when the load transitions from tension to compression. Moog's hexapod control software allows the pivot point for all rotational moves to be located at the secondary mirror vertex although this location can be shifted to other locations for testing and diagnostics. The software also performs all the kinematic computations required to provide appropriate position commands to each of the hexapod's actuators.

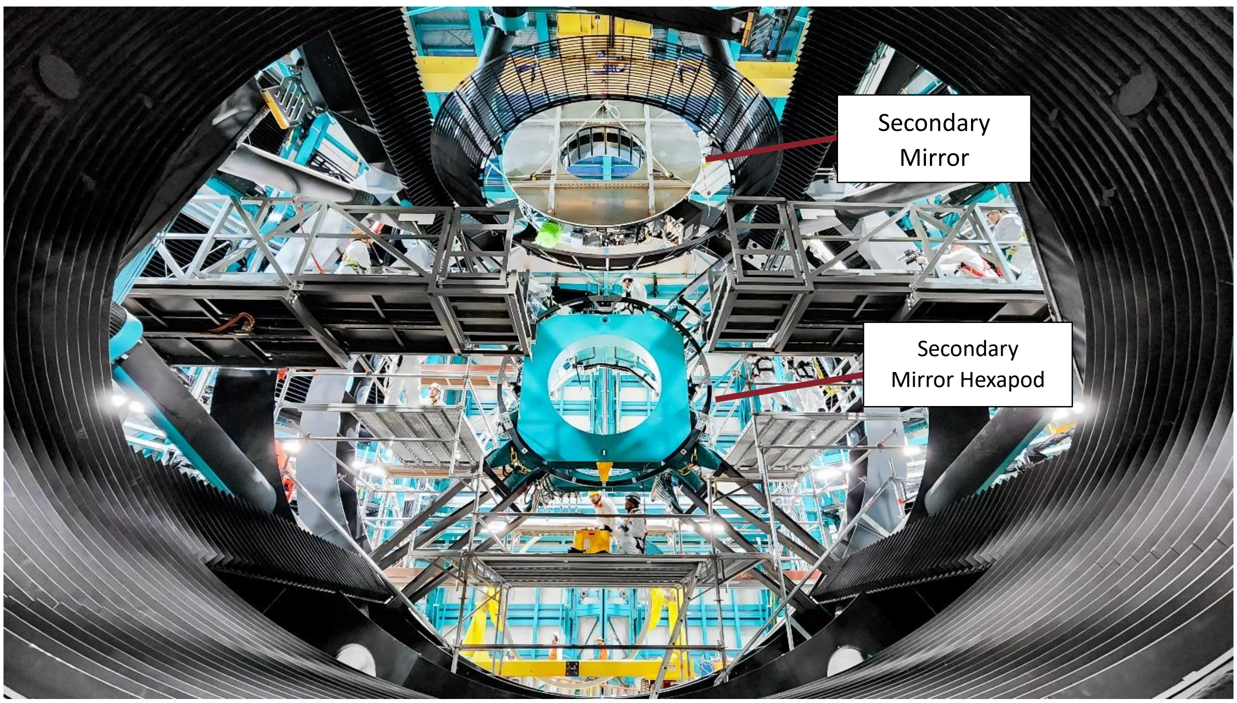

Figure 1: Secondary mirror of the Vera C. Rubin Observatory being installed on the secondary mirror hexapod provided by Moog. Credit: Rubin Observatory/NSF/AURA/F. Munoz Arancibia

Leveraging Moog Expertise from James Webb Space Telescope

The design and build for the hexapod highly leveraged the work Moog did for the primary mirror on the James Webb Space Telescope (JWST). While there were unique requirements for both programs, the hexapod actuators were very similar and used identical drivetrain components including the motors, harmonic drive gear reducers, and roller screws. Much of the hexapod control software was able to be reused as well. Moog's successful heritage from JWST was a major factor in our selection to participate in the Rubin Observatory.

Moog Precision Motion Control for the Camera

The Rubin Observatory also includes a 3.2-gigapixel camera, the largest digital camera ever built, to capture its images. Like the secondary mirror, the camera requires a hexapod to facilitate precise optical positioning relative to the primary and tertiary mirrors. Moog utilized identical actuators for the camera hexapod which facilitates maintenance and minimizes the need for spare components.

Figure 2: 3.2-gigapixel camera arriving at the Rubin Observatory (left, credit: Olivier Bonin/SLAC National Accelerator Laboratory) and camera hexapod and rotator system built by Moog (right)

The camera also requires a rotator to de-rotate its images. Because the rotator operates while the telescope is imaging, its motion must be incredibly smooth and accurate to avoid degrading the image quality. That is why we incorporated a separate rotator mechanism using curved linear guide bearings and helical gearing with the hexapod. The rotator incorporates two drive motors, biased against each other to eliminate backlash, along with a complex control scheme to achieve the necessary tracking smoothness.

Moog delivered the two hexapods and rotator in 2019, and following additional performance verification tests, they have been awaiting their call to duty. The successful installation of the secondary mirror onto Moog's hexapod represents a significant integration milestone for the program.

Unlocking the future potential

The completed installation of the secondary mirror onto our hexapod and the upcoming installation of the camera onto our hexapod and rotator are the last major steps for our equipment before the telescope is fully assembled and begins its functional alignments and checkouts.

First light of the observatory is expected in April 2025, and Moog's precision motion systems will play a critical role in the discoveries that will soon follow.

Interested in speaking with Moog? Contact us at space@moog.com

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