James Webb Space Telescope completes second month of commissioning, accomplishing many key steps

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The newly launched James Webb Space Telescope (JWST) has completed the second month of its six-month-long commissioning period, bringing the joint NASA, European Space Agency (ESA) and Canadian Space Agency (CSA) telescope several steps closer to becoming a fully operational space-based astronomical observatory.

The JWST was launched on December 25 on an Ariane 5 rocket from the Guiana Space Centre in French Guiana. It has so far completed among the riskiest steps of its deployment, including unfolding its sunshield, unfolding its secondary mirror and primary mirror wings, and successfully entering its orbit at the Sun-Earth Lagrange point 2 (L2). Each operation could only be attempted once, and if any had failed, the telescope would have been unusable.

One of the highpoints of this process was the precision with which the JWST was launched on the Ariane 5. In order to reach and maintain its orbit at L2, a point of gravitational stability that is perpetually behind Earth relative to the Sun, 1.5 million kilometers (930,000 miles) away, the spacecraft has a limited amount of onboard propellant, which ultimately caps the lifespan of the telescope. Pre-launch calculations estimated that the JWST would have enough fuel to last 10 years in such an orbit.

These estimates were extended to “around 20 years” after the launch, Bill Ochs, the JWST project manager, said in a January press conference, thanks to the efforts of the Ariane 5 launch team to make the telescope’s launch as perfect as possible.

Now, the telescope’s operators at the Space Telescope Science Institute in Baltimore, Maryland, are carefully aligning the JWST’s primary mirror. Unlike the single mirror which gathers light for the Hubble Space Telescope, the primary mirror on the JWST consists of 18 hexagonal gold-plated segments, a design originally developed in the 1930s by Italian astronomer Guido Horn d’Arturo.

When properly aligned, the segments combine into a single mirror 6.5 meters in diameter, more than seven times the size of Hubble’s mirror. This alignment process is achieved using 132 motors, seven for each segment and six for the secondary mirror. Each motor is designed to move the mirror segments, as well as change the curvature of each segment, in increments as small as 10 millionths of a millimeter. The motors at the same time represent 132 points of failure for the telescope, and the time that was taken to meticulously plan out every motion of these motors is one of the reasons that commissioning the JWST was designed to take several months.

Such precision is necessary, however, if the JWST is to focus on targets further away—and thus further back in time—than even Hubble is capable of observing.

The first phase of this alignment was completed on February 18, which involved ensuring that every segment located and imaged target star HD 84406. Full alignment and calibration are expected to take a further five months.

One further major hurdle remains: The telescope must finish cooling. The JWST is designed to observe in the infrared parts of the electromagnetic spectrum, wavelengths of light that are longer than those of visible light and associated with the heat emitted by matter. In order for the telescope’s optics to clearly see infrared light from its targets, the infrared light emitted from the telescope itself—the substructure, the mirrors, the electronics—must be minimized.

The first step was to deploy the sunshield, which consists of five layers of Kapton, a very thin and light polymer, coated with reflective metals. It reflects heat from the Sun, as well as that reflected from the Earth and Moon, creating a hot side of 110 degrees Celsius (230 degrees Fahrenheit) and, just six feet away, a cold side of ?223 degrees Celsius (?370 degrees Fahrenheit), where the telescope and its instruments live.

The telescope itself, however, was not launched at -223 degrees Celsius but at about 27 degrees Celsius (about 80 degrees Fahrenheit, a typical tropical temperature on Earth) and has been passively cooling since the sunshield deployed. As a consequence, the entire structure of the telescope has been shrinking slightly, as most things do when they become colder. The JWST was designed for this, built ever so carefully larger than its final shape, and it must first completely settle into its final, cooled state before it can be fully operational.

Once the JWST is ready for science operations, it will have many targets of study. One will be the Milky Way's central supermassive black hole, Sagittarius A*, joining many other observatories including the Event Horizon Telescope (EHT), as part of a decades-long effort to understand the colossal supermassive object at the heart of our galaxy.

One of the many difficulties of studying Sagittarius A* is that from our vantage point on Earth, nearly half a galaxy's worth of gas and dust lie in the optical path, not to mention the much denser and hotter material that makes up the galactic core. Sagittarius A* itself also flares up about once an hour, making it difficult to image. It is expected that the combined abilities of the EHT, which provided the first imagery of a black hole in 2019, and of the JWST, which is designed to view through clouds of gas and dust, will be able to much more accurately characterize the black hole.

The JWST is also slated to join a survey of nearby galaxies involving the ground-based Atacama Large Millimeter/submillimeter Array (ALMA) in Chile and the Hubble Space Telescope. Astronomers are planning on using Webb's ability to view infrared wavelengths of light—complementing ALMA's capabilities to view microwave radiation and Hubble's ability to observe visible light—to observe through clouds of gas and dust in other galaxies and deepen humanity's body of knowledge about galactic formation.

This work will also follow up on the extraordinary observations of the Spitzer Space Telescope (primary mission 2003-2009; Spitzer Warm Mission 2009-2020) and the Herschel Space Observatory (2009-2013), two of the most powerful infrared telescopes ever built. The findings of both those telescopes forced a reappraisal of our understanding of the Universe, including the importance of thermal radiation in stellar and galactic formation.

While the JWST does not observe at the same wavelengths as its predecessors, designed as a complement and not a replacement, it will no doubt continue the trend of such discoveries when fully operational.