The JWST Observatory: Status and Path Forward

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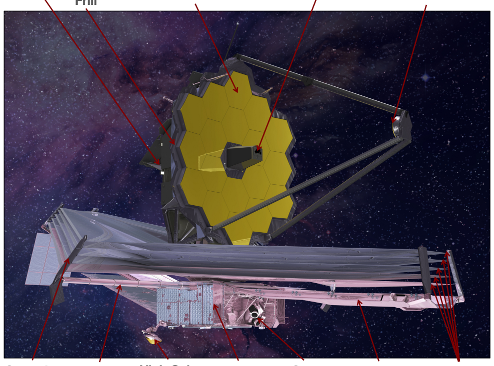
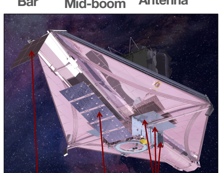
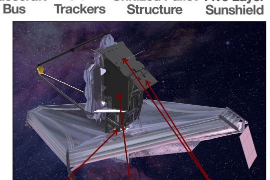
JWST Observatory Overview

The James Webb Space Telescope (JWST) is a large (6.5 m) segmented aperture telescope equipped with near- and mid-infrared instruments (0.6-28 microns), all of which are passively cooled to ~40 K by a 5-layer sunshield, while the mid-infrared instrument is further actively cooled to 7 K. The extensive integration and test program developed and verified two primary elements: the telescope and science instruments, called OTIS, and the spacecraft and the sunshield, called the Spacecraft Element. The two elements were recently joined to form the complete JWST Observatory. We describe the Observatory integration process, the Observatory-level testing plans, and reference the on-orbit performance estimates.

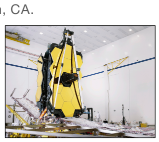






Observatory Integration

The JWST OTIS, in its stowed configuration, was lifted with an overhead crane (*left*) to move from its stand to a position over the Spacecraft Element, with the sunshield structures deployed and the membranes folded (*middle*). OTIS was then slowly lowered onto the Spacecraft Element, and when nearly connected, there were a few precise movements to avoid contact with cryocooler hardware in the core area. OTIS has six pads that connect to the SCE -- four on the bottom corners of the telescope support structure and two at the base of the instrument electronics compartment. The expected positions of the OTIS and SCE were verified using optical metrology such as laser trackers. Once the OTIS and SCE super elements were mechanically attached, final mechanical and electrical connections were made to complete the Observatory integration (right). Functional electrical testing was completed to ensure all electrical connections were made. Finally, soft structure closeouts and insulation were applied to the Observatory. These activities took place in a high bay clean room at Northrop Grumman's Space Park facility in Redondo Beach, CA.

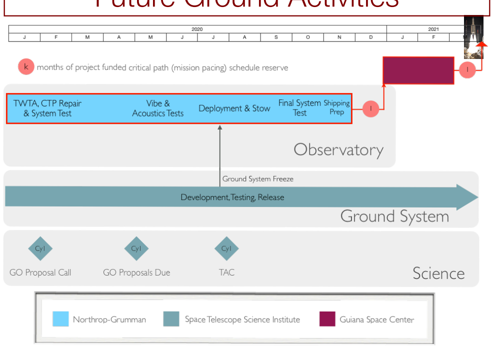


Deployment Testing

Shortly after integration, OTIS was deployed using its deployable tower assembly with offloading support by a specialized overhead crane and counterweight system. The sunshield was then deployed and tensioned as part of the Spacecraft Element post-environmental testing and Observatory pre-environmental testing. Laser trackers were used to measure key metrology points on the Observatory, such as fiducials on the spreader bars, to ensure the correct deployment shape was reached. The top sunshield layer is visibly sagging in the image below, which is as expected at room temperature and in one gravity. The on-orbit sunshield shape at ~70 K and zero gravity will be similar to the rendering at left.

The sunshield is now being folded back to its stowed configuration for the Observatory environmental test program. Additional offloaded testing of the membrane tensioning system to simulate zero gravity ensured the cable lengths are correct. Sunshield modifications to the tensioning system and corner interfaces have been completed, along with repairs necessitated by handling. The momentum trim tab, solar array, and radiator shades have all be removed from the Observatory for offline testing and updates as needed, which are taking place in another facility at Northrop Grumman.

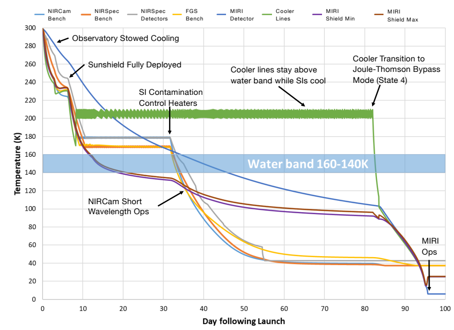
Future Ground Activities



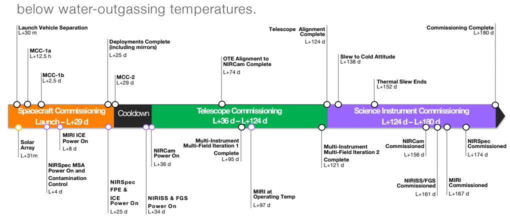
The final testing flow above is aimed at verifying the new OTIS to SCE interfaces and Observatory interactions. The Traveling Wave Tunable Amplifier (TWTA) and Command and Telemetry Processor (CTP) exhibited anomalies as part of the Spacecraft Element testing and will be replaced. An electrical Comprehensive Systems Test (CST) will be carried out before the Observatory vibration and acoustic testing program, which will be taken to the acceptance levels. Following these environmental tests, an Observatory deployment and CST will confirm the Observatory is ready for launch. The sunshield membranes will be folded, the Observatory will be stowed, and the Observatory will be shipped down to the launch site, Kourou, French Guiana, and prepared for launch on an Ariane 5 rocket.

Commissioning Plans

The post-launch commissioning process for JWST will take the payload from its stowed launch configuration to its fully deployed, cooled state, with the telescope aligned and the instruments configured, with their observing modes checked out and ready for scientific observations. The commissioning process is scheduled to be completed within six months after launch. A detailed sequence of commissioning activities has been developed, with all constraints, pre-requisites, and resulting products well-defined. The image at right shows the JWST Observatory in its stowed configuration for launch, which will deploy to its operational configuration over the first 12 days after launch.



A key input to commissioning planning is the timeline for the cooling of the payload's components to their cryogenic operational temperatures, as shown schematically above. The cooling time constants are long. In addition, heaters are employed when appropriate to prevent contamination of sensitive surfaces. For example, see the temperature plateau for the science instruments from day 10 to day ~32 where the instruments are held above water-condensing temperature until the surrounding sources of water (e.g., the composite structure supporting the science instruments) cool below water-outgassing temperatures.



A high-level schematic of the commissioning timeline is shown above, with some key activities and milestones noted (MCC = Mid-Course Correction; ICE, MSA, and FPE are instrument subsystems). There is substantial overlap in the commissioning phases above: 1) day 0-29: spacecraft checkout and deployments, 2) day 29-36: cooldown to temperatures at which NIRCam can start operations to support telescope alignments, 3) day 36-124: alignment and phasing of the 18 primary mirror segments and alignment of the secondary mirror (with many internal SI checkouts in parallel), 4) day 124-180: commissioning of the instruments' observing modes with an aligned telescope.

Performance Estimates

JWST performance estimates continue to meet requirements with margin. The current performance estimates can be found on JDox at https://jwst-jdocs.stsci.edu. The Observatory performance is sensitive to many factors, including stray light from contamination, thermal performance of the sunshield, short term line of sight jitter from the reaction wheels and cryocooler, and longer term optical thermal distortion from temperature changes on the telescope. These JDox estimates are built upon a comprehensive Observatory test program that not only verifies functionality, but also provides inputs to integrated models used to predict the in-flight scientific performance.