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James Webb Space Telescope is (almost) complete

NASA and its international partners will spend the next two years conducting tests and attaching the observatory to *JWST*'s support bus and launcher.

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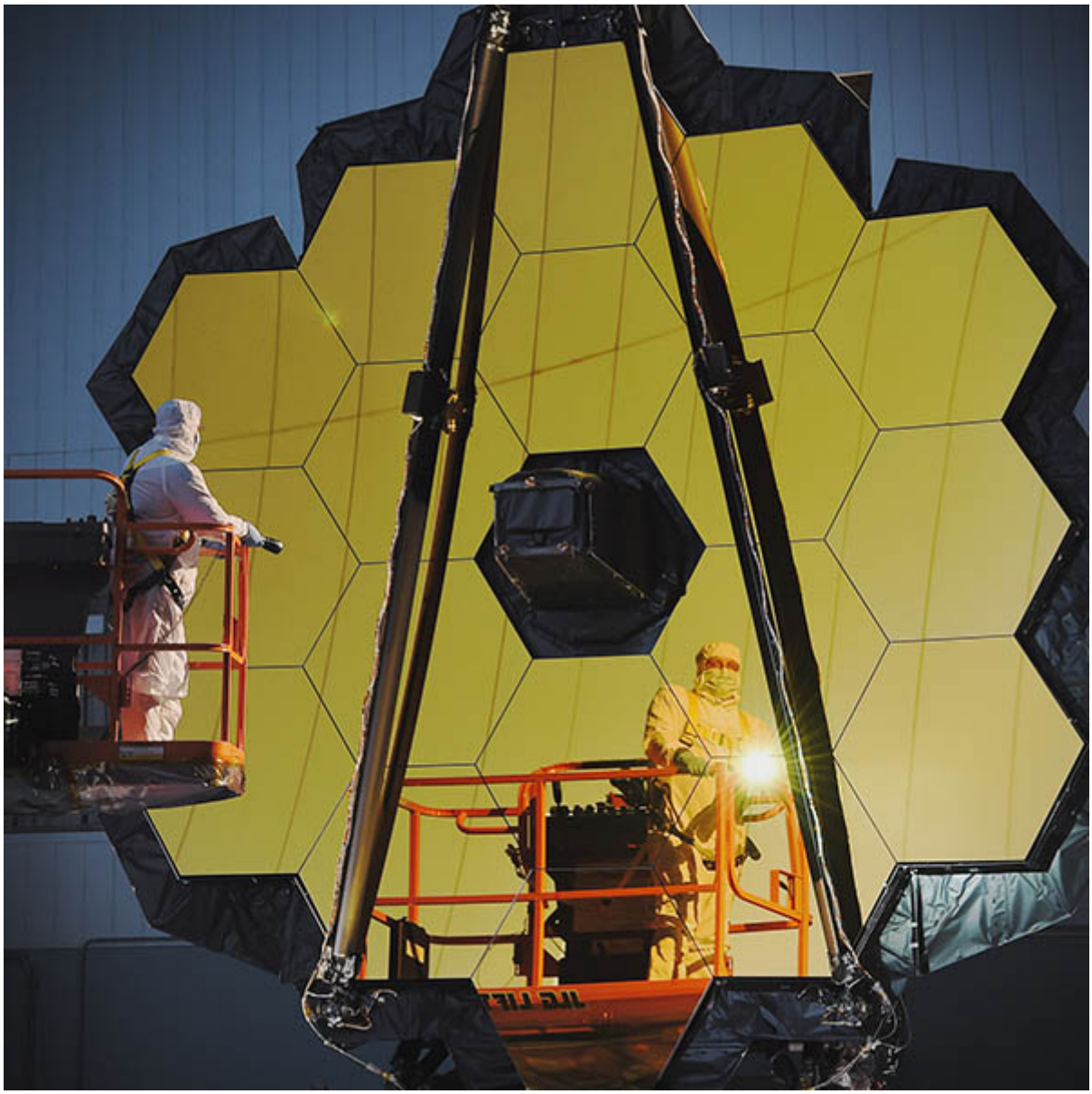
Twenty years after work began on the *James Webb Space Telescope* (*JWST*), NASA managers celebrated its completion at Goddard Space Flight Center in Greenbelt, Maryland, on 3 November. Now researchers must conduct a series of tests to prove that *JWST* can survive launch and that its mirrors will focus properly at near-absolute-zero temperatures. The telescope will then be mated to the bus carrying the solar array, sun shield, and communications and data storage components, and the assembly will be transported to French Guiana for an October 2018 launch date.

With a primary mirror that is seven times the size of the *Hubble Space Telescope*'s mirror, *JWST* is expected to be capable of probing the chemical composition of the atmospheres of exoplanets and observing the birth of stars and planets.



A NASA engineer performs a center of curvature test on the *James Webb Space Telescope*'s primary mirror. Credit: NASA/Goddard/Chris Gunn

Originally estimated to cost $1.6 billion and set to launch in 2011, *JWST* came close to being terminated by Congress in 2011 due to cost overruns. Recently, however, NASA administrator Charles Bolden said he is "very confident" that the telescope will now remain within its new cost profile, capped at $8 billion, and stay on schedule. The total cost of the project, including five years of operation, is estimated at $8.7 billion. The telescope will carry sufficient fuel to stay in orbit for at least 10 years, and possibly 12, says Bill Ochs, *JWST* project manager.

The telescope, including its four imaging and guidance instruments, will now undergo acoustic and vibrational testing at Goddard, where it was built. It will then be transported to Johnson Space Center in Houston, Texas, for a cryogenic test, and then to a Northrop Grumman facility in Los Angeles, where the bus is being assembled. A European Space Agency (ESA) Ariane 5 rocket will carry *JWST* into space.

The primary mirror consists of 18 hexagonal segments that will unfold and adjust to shape following launch. The mirror is made of beryllium and coated with a total of three ounces of gold, which is ultrasensitive to the IR light that the telescope is built to observe. Each mirror segment is so smooth that if it were scaled to the size of the continental US, the highest mountain peaks would rise just two inches.

Unlike *Hubble*, which has been serviced five times over 26 years, *JWST* is not designed to be serviced in space. The telescope will be placed in orbit around the Lagrangian 2 (L2) point, which is about 1.5 million km from Earth; *Hubble* is in low Earth orbit. By orbiting the Sun at L2, *JWST* can stay in constant contact with Earth via the NASA Deep Space Network, and its solar panels can generate energy continuously. To prevent IR emissions that would reduce the quality of imagery, *JWST*'s tennis court–sized sun shield will maintain the telescope's ambient temperature at about 50 K.

The telescope is so sensitive that "if you were a bumblebee at the distance of the Moon, we'd be able to see you both by your reflection of sunlight and by the thermal radiation you emit," says Nobel laureate John Mather, the telescope's senior project scientist. Two of *JWST*'s four instruments, a near-IR spectrograph and a mid-IR instrument, were built mainly by ESA. A near-IR camera was built by the

University of Arizona, and the Fine Guidance Sensor/Near-Infrared Imager and Slitless Spectrograph was provided by the Canadian Space Agency.

The *Transiting Exoplanet Survey Satellite*, set for launch in December 2017, will catalog small exoplanets, which could provide targets for *JWST* to examine for signs of life, such as water vapor. *JWST* also will be trained on dwarf planets in the solar system.

Developers of the telescope's instruments are guaranteed first crack at observing time, along with some "interdisciplinary scientists who have very important broad generic science programs," says Gerard Kriss of the Space Telescope Science Institute, the *JWST* ground control center. STScI will begin soliciting those proposals in January. Also in the queue will be "early release observations," which, he says, are "the kind of pictures that are meant to show we have a functional observatory and are meant to be beautiful."

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