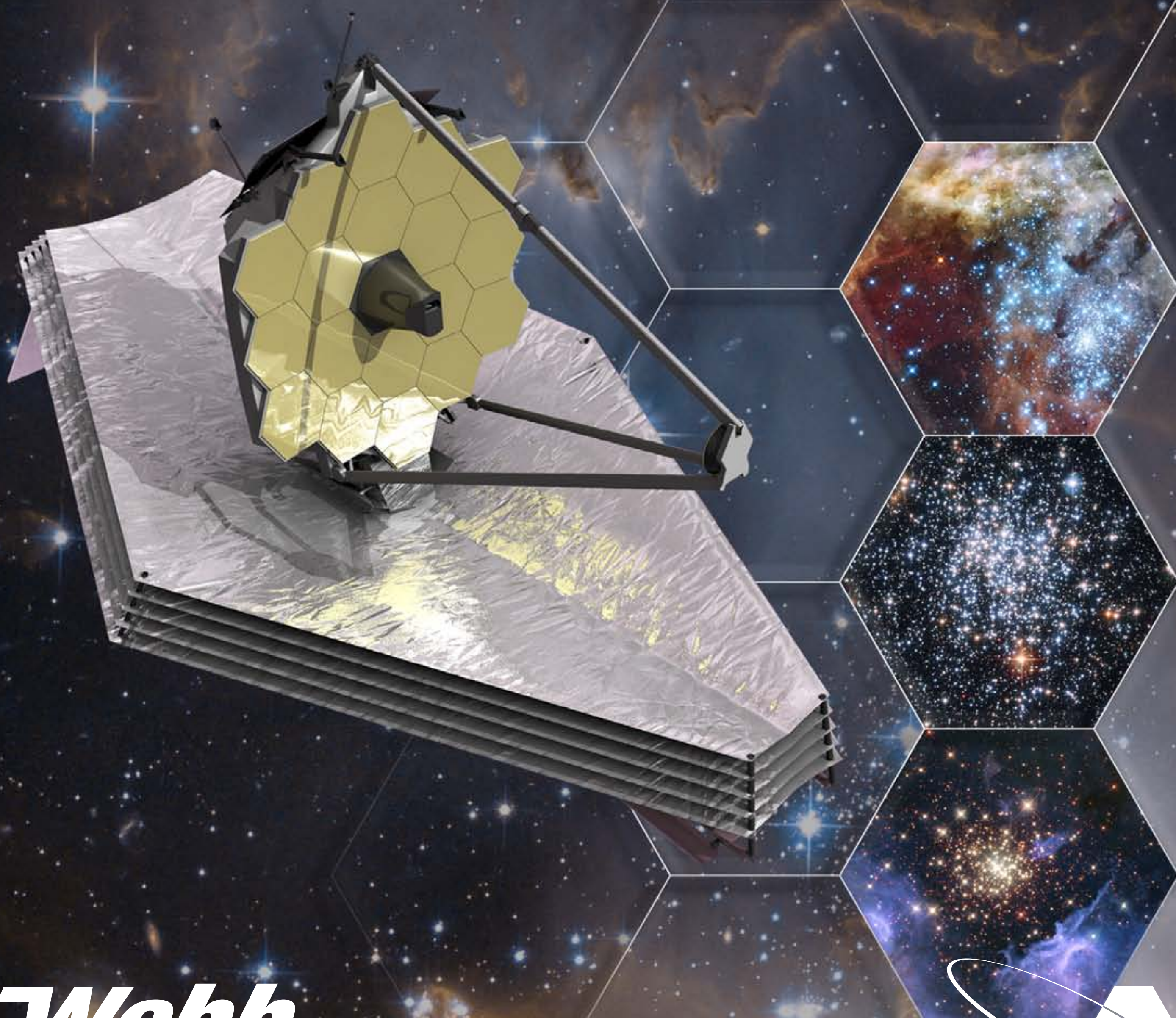
National Aeronautics and Space Administration



Webb Update

Summer 2014

jwst.nasa.gov

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Issue #17, Summer 2014
James Webb Space Telescope

Cryo-Verification Test of the Complete ISIM Begins!

By Randy Kimble

During this summer of 2014, a milestone event in the JWST test program is underway: the first of two cryo-verification tests of the complete Integrated Science Instrument Module (ISIM). Pump-down for this critical test began a few weeks ago in Goddard's largest thermal-vacuum chamber, the Space Environment Simulator (SES). We expect the test will continue for about 110 days.

As described in the December 2013 Newsletter, last year the ISIM team successfully executed a "risk-reduction" cryo-vacuum test, termed CV1-RR. CV1-RR demonstrated the capability of the extremely complex test configuration to support all the necessary thermal, optical, electrical, and operational functionality required for verification of ISIM performance against its requirements. It also provided the team with invaluable logistical experience developing and executing a wide array of test procedures. That initial test incorporated only two of JWST's four Science Instruments (SI's), however, and so did not constitute a formal verification test for the complete ISIM system.

The current test, designated CV2, examines the full flight ISIM assembly: all four Science Instruments (FGS/NIRISS, MIRI, NIRCam, and NIRSpec) along with their associated warm electronics boxes in the ISIM Electronics Compartment (IEC), connected with the flight harnesses across the flight Harness Radiator. The MIRI is cooled to its 6K operating temperature with a non-flight Cryocooler mounted outside the SES chamber, but all of the cold-region cooling hardware is flight or flight-like.

CV2 is one of two formal verification cryo-vacuum tests for the complete ISIM element. The final cryo-vacuum test, CV3, scheduled for 2015, will occur after the rest of the ISIM-level environmental test program—gravity sag, vibration and acoustics, and Electromagnetic Interference/Electromagnetic Compatibility testing. One of the key objectives of the ISIM verification program is to demonstrate the stability of the optical and thermal system across the vibration and acoustics environment of launch, so optical measurements of focus, pupil alignment, and wavefront error made during CV2 will provide crucial pre-vibration data for comparison with the post-vibration data to be collected in CV3.

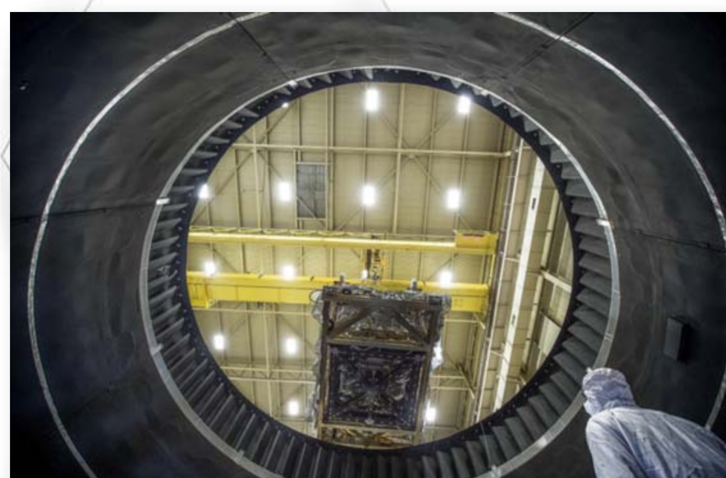

Figure 1. The ISIM approaches its summer destination in GSFC's SES chamber, as viewed from inside the He-cooled shroud that takes the ISIM to its flight operating temperature of ~35-40K. The flight ISIM components are enclosed within the support structure and thermal-control shroud visible here. Credit: NASA/Chris Gunn

CV2 is the first opportunity to assess the health and functionality of the ISIM as a whole at its cryogenic operating temperature. As such, CV2 has a rich array of thermal, electrical, and operational test goals, in addition to the detailed suite of optical tests that will be executed using the OSIM telescope simulator. CV2 will provide critical data for validating the thermal, optical, and structural models used to predict JWST's overall in-flight performance. In addition, CV2 will gather data to investigate and close out Problem Reports or Problem Failure Reports from earlier tests and provide final verification of some instrument-level requirements that we decided would be more easily addressed in ISIM-level testing than in instrument-level testing.

Pre-test preparations for CV2 in Goddard's JWST clean room culminated in lifting the ISIM into the SES chamber on May 29th, 2014 (see Figures 1 and 2). After closeout operations and a brief electrical functional and continuity check, pumpdown for CV2 began in the early morning of June 17th. The first week of vacuum operations saw the completion of a warm System Functional Test of the various ISIM and SI systems as well as a preliminary outgassing measurement for the full-up ISIM. Cooldown then began on June 23rd. The cooldown of the ISIM to its flight operating temperature is a carefully controlled process that manages the temperature of all the various systems against a complex set of rate-of-change, temperature-delta, and temperature gradient requirements. During cooldown, the team began accomplishing CV2 test goals that did not require stable operating temperatures.

At the time of this writing (July 9, 2014), the cooldown process is nearly complete, with stabilization of the instruments at their flight temperatures expected within the next few days. Next, the team will begin roughly two months of testing of all aspects of ISIM performance at temperature, followed by an equally carefully controlled warmup procedure. An exciting summer is expected for all!

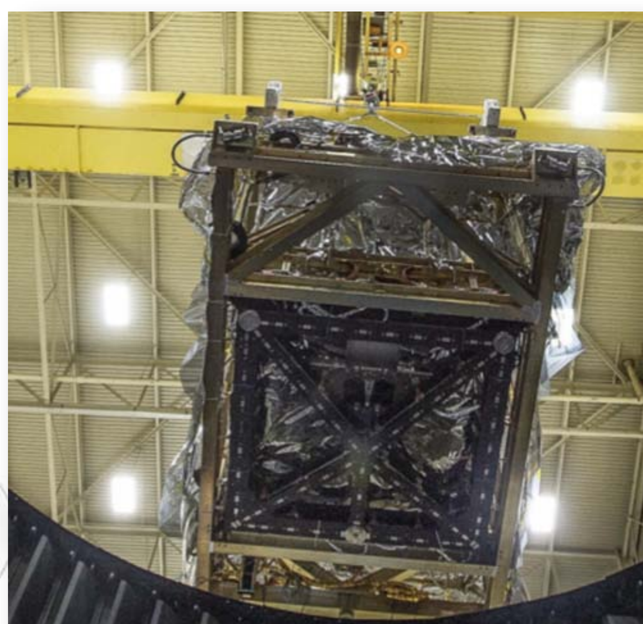

Figure 2. In this zoomed-in view of the arriving ISIM, one can just make out some of the Science Instrument apertures; they are visible through the dark rectangle located just above the vertex of the black, X-shaped support fixture. The silver-colored triangular element that cuts across that composite instrument field of view is an alignment target for the telescope simulator used in ISIM cryo-testing; that target was removed before pumpdown. Credit: NASA/Chris Gunn

Community Plans JWST Science with Transiting Exoplanets

By Charles Beichman, NASA Exoplanet Science Institute

The JWST Transit Workshop brought approximately 50 experts to Caltech in March to discuss observations of transiting exoplanets with JWST. The meeting drew together exoplanet observers and theoreticians, instrument team experts, JWST project personnel, and STScI operations experts for an intense three-day summit and brainstorming session to generate ideas for observational programs and to distill lessons from previous missions. Table 1, below, provides the meeting agenda and links to individual presentations. See also:
http://nexsci.caltech.edu/committees/JWST/agenda.shtml.

Transiting exoplanets are planets whose orbits are inclined so that they pass in front of their host stars, blocking the star's light at regular intervals. Photometry of these events yields a planet's radius, which combined with radial velocity measurements, yields the planet's mean density and important constraints on its bulk composition. Carrying out spectroscopic transit observations can provide information on atmospheric composition, vertical structure, and even planetary rotation! Observations of secondary transits, where the star blocks the light from the planet, provide additional information about the planet's temperature and atmospheric properties. Monitoring a full orbital phase curve can reveal information on planetary winds and global circulation.

Among the major conclusions of the workshop were the following:

- A large sample of exoplanets orbiting bright stars will be available for study with JWST from ground- and space-based surveys, including Kepler, the Transiting Exoplanet Survey Satellite (TESS), and ESA's CHaracterizing ExOPlanet Satellite (CHEOPS) .
- A complete multi-wavelength dataset at spectral resolutions of R>1000 in either primary transit or secondary eclipse will require between 2 and 4 separate observations per object using various JWST instrument modes. Each transit observation will require between 5 and 20 hours.
- A survey of 100-200 gas and ice giants with a range masses (0.05-5 M_{Jup}) orbiting stars with a broad range of spectral types and metallicity could lead to a breakthrough in our understanding of the formation and evolution of planets (Figure 3a). Transit observations might reveal, for example, an enhanced carbon-oxygen (C/O) ratio compared to the host star's which might be indicative of a core accretion formation mechanism. Transit signals are strong enough that a single transit/instrument mode should provide adequate sensitivity in almost all cases.
- The study of a few 10s of mini-Neptunes or super-Earths (5-15 M_{Earth}) would explore a species of planet not found in our own solar system in a variety of stellar environments. In many cases, observations of these smaller planets could be accomplished in a single transit/per mode for planets orbiting M stars.
- Intensive observations of one or two terrestrial-sized planets (1-5 M_{Earth}) preferably located in the Habitable Zone of their host stars, might only be possible with filter photometry and might require coadding many tens of transit observations. But such observations would offer the promise of characterizing the atmospheres of a planet much like our own (Figure 3b).

A white paper summarizing the workshop's findings has been submitted to PASP (Beichman 2014, submitted) and will be available on astro-ph shortly.

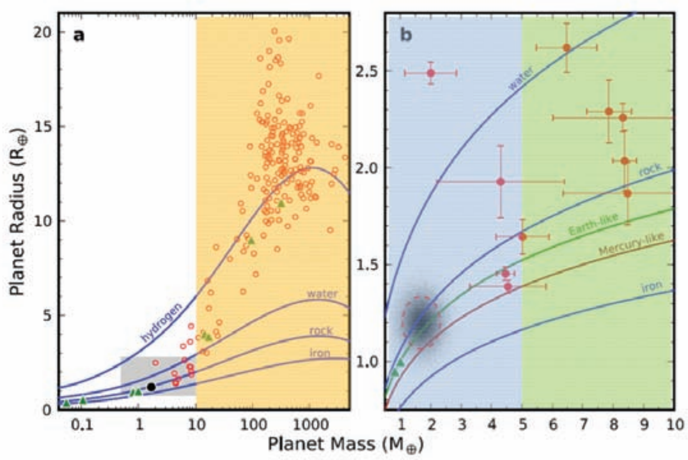

Figure 3a. Observed planet radii and masses denote different bulk compositions. Shaded areas denote different classes of object that JWST might observe using transit spectroscopy (Howard et al, 2013, Nature, 503, 381)

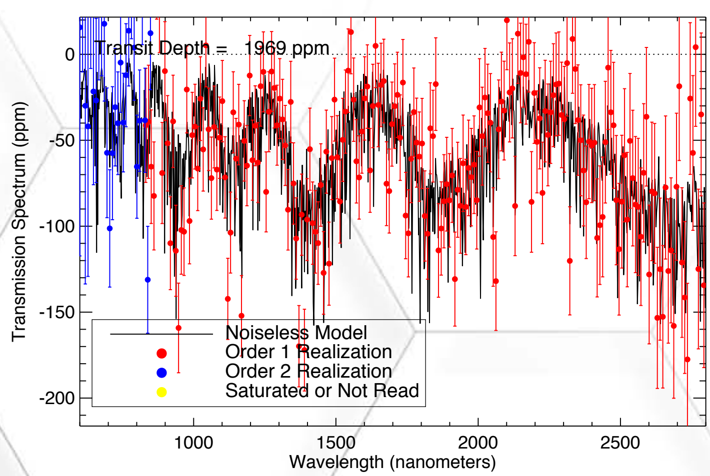

Figure 3b. A simulated NIRISS grism spectrum of an Earth-sized water world with a hydrogen-rich atmosphere in the habitable zone of a J=7.2 mag M5 star. This R~2000 spectrum required coadding 50 transits each with a noise floor of 20 ppm.

Table 1. Meeting Agenda

Day 1		Day 2	
Key Science Opportunities		**Targets for JWST**	
Spectroscopy of Giant Planets	J. Fortney	Ground RV/transits	J. Bean
Spectroscopy of Super Earths (pdf)	E. Kempton	Kepler and K2	S. Howell
Atmospheric Dynamics and Weather	H. Knutson	TESS (PDF)	D. Latham G. Ricker
Roles for High Precision Photometry	D. Deming	M Stars as JWST targets	C. Dressing
Transit Best Practices		CHEOPS	D. Ehrenreich
HST best performance and best practices (pdf)	D. Sing	GAIA	A. Sozzetti
Hot Jupiter Transit Spectroscopy with HST/WFC3	A. Mandell	Challenge of stellar variability	P. McCullough
Kepler best performance and best practices	J. Christiansen	Precursor data needs (pdf)	D. Ciardi
Spitzer best performance and best practices	S. Carey I. Crossfield	**Instrument modes for transits**	
Lessons from Spitzer spectroscopy	J. Bouwman	NIRSPEC	P. Ferruit S. Birkmann
Frontiers of Precision Exoplanet Atmosphere Characterization with HST"	L. Kreidberg	NIRISS	R. Doyon D. Lafreniere
JWST Operations for Transit Observation	M. Clampin J. Stansberry	NIRCam	T. Greene
Detector Problems and Features		MIRI	T. Greene P. Lagage
HgCdTe/ASIC	M. Rieke	**Day 3**	
Silicon detectors	M. Ressler	**Data Processing Challenges and Requirements**	
H2RG Readout for Efficient Coadds of Bright Images	R. Smith	What is the smallest planetary atmosphere JWST will characterize?	D. Deming
Challenges in measurement repeatability	M. Swain	Laboratory testbeds	G. Vasisht
		Data simulations	S. Birkmann
		Pipeline data processing challenges	P. Deroo
		Engage the Community	
		Science Timeline for JWST	J. Lee

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JWST Status

By Eric P. Smith, NASA Headquarters

The James Webb Space Telescope Program remains on schedule for its October 2018 launch and within its budget guidelines established in 2011. Proactive management within NASA and its industry, international and non-profit partners and stable funding from Congress have enabled the program's solid performance. The budgets proposed by the U.S. House of Representatives and Senate for the Government fiscal year 2015 are in line with the funding defined in the 2011 replan and will keep JWST on pace for its 2018 launch.

This year's major new activity has been the manufacturing of spacecraft components. The spacecraft bus is the final major component undergoing development. The bus follows both the telescope optics and four science instruments, which are in storage or undergoing testing at the Goddard Space Flight Center (GSFC).

The JWST project has begun its second major cryogenic vacuum testing of the science instruments, the so-called `CV2' test (figures 4 and 6). This test is designed to complete some instrument verifications, to test instrument fixes deemed necessary following last year's CV1 test, and to establish the initial measurements needed prior to next years vibration/acoustics/electromagnetic test sequence of the science payload. The instruments will undergo a third `CV3' test for final science instrument verifications in the late summer of 2015.

In July, the engineering structure representing the center section of the primary mirror backplane and the deployable secondary mirror support tower (figure 5) arrived at GSFC where it will serve to refine the process for placing mirror segments within the structure. This delivery sets the stage for next year when the flight integrated backplane and secondary mirror support tower arrive at GSFC and are populated with the flight mirror segments.

Figure 4. The Integrated Science Instrument Module (ISIM) with its four science instruments installed: the near-infrared camera (NIRCam, University of Arizona and Lockheed-Martin), the near-infrared spectrograph (NIRSpec, European Space Agency and Airbus), the mid-infrared instrument (MIRI, European Space Agency and JPL), and the fine guidance sensor/near-infrared imager and slitless spectrograph (FGS/NIRISS, Canadian Space Agency and COMDEV). Image credit: NASA/Chris Gunn

The full five-layer engineering sunshield structure is currently undergoing rigorous deployment testing at Northrop-Grumman Aerospace Systems at their Redondo Beach Space Park facility (figure 7). This "engineering model" or prototype sunshield is full scale and was manufactured with the same material and processes that the flight sunshield will use. Its deployment testing is only a small part of the extensive set of reviews and tests that NGAS and NASA conduct. During the years 2014-2016, representatives from other NGAS organizations (i.e., not the JWST project) , will conduct at least three reviews per year on the various deployments of the mission (e.g., telescope, sunshield, and spacecraft) with NASA participation. These tests precede major tests or reviews to ensure that the deployments in particular are ready for their next level of testing and/or integration into the flight system. Construction of the flight sunshield membranes has begun; the first layer is complete and the second is underway.

Any space project must expect its share of technical challenges. JWST's current challenges include construction of the Mid-InfraRed Instrument (MIRI) cryocooler and the pace of manufacturing the composite structure covers for the sunshield. The cryocooler has proven harder to build than we anticipated. The initial composite structure for the sunshield did not have the required strength to withstand launch loads, a fault related to excess water's contacting the composite material during the lay-up procedure.

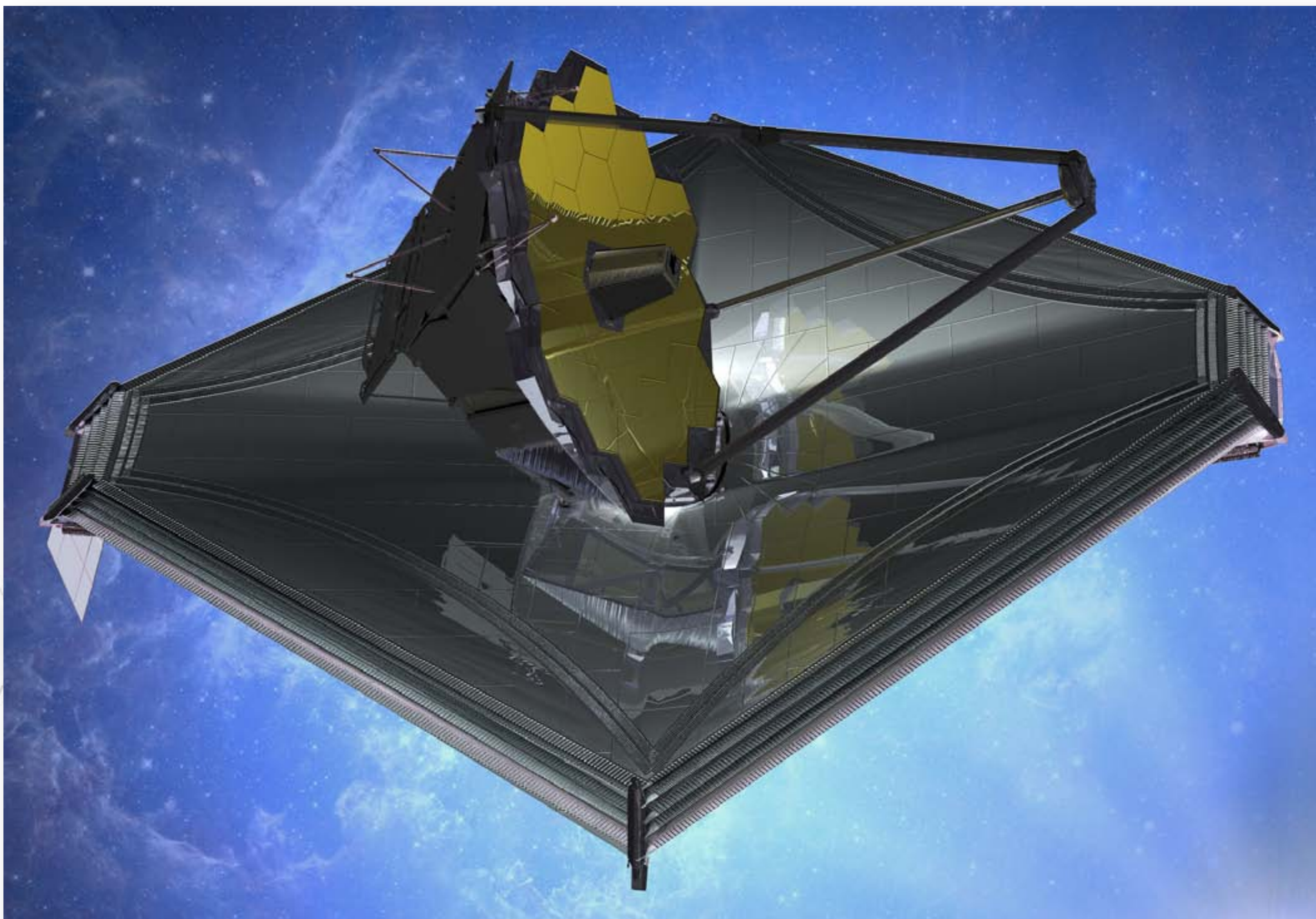
Even with these challenges, the project remains in good overall health and continues delivering and testing flight hardware. To date, cryocooler construction challenges have been met within the project's budget and schedule reserves. The challenges with the sunshield composite structure manufacturing have meant that the project will need to consume about two months of funded schedule reserve, for the first time since the replan in 2011. In 2011, JWST was replanned with 13 months of funded schedule reserve to its October 2018 launch date. Over the previous four years we have not needed to use any of this reserve. Now, with the use of two months of funded critical path schedule reserve, the project schedule remains one month ahead of plan.

Figure 5. The telescope primary mirror backplane center section engineering structure undergoing deployment testing of the secondary mirror struts at the Northrop-Grumman Aerospace Systems (NGAS) facility in Redondo Beach, CA. Credit: Alex Evers/Northrop Grumman.

Figure 6. The ISIM, covered for protection during transportation, being lowered into the Space Environment Simulator thermal vacuum chamber at the Goddard Space Flight Center for its CV2 testing. Credit: Amber Straughn

Figure 7. The 5-layer sunshield engineering model in its unfolded configuration after a deployment test at NGAS. Credit: NASA/Chris Gunn

Would you like a colloquium at your university on JWST? How about a talk at a conference you are organizing? Or a public lecture about JWST? Please email: jwst-science@lists.nasa.gov



Editor: Marc Kuchner; Graphics: Jay O'Leary; Layout: Maggie Masetti