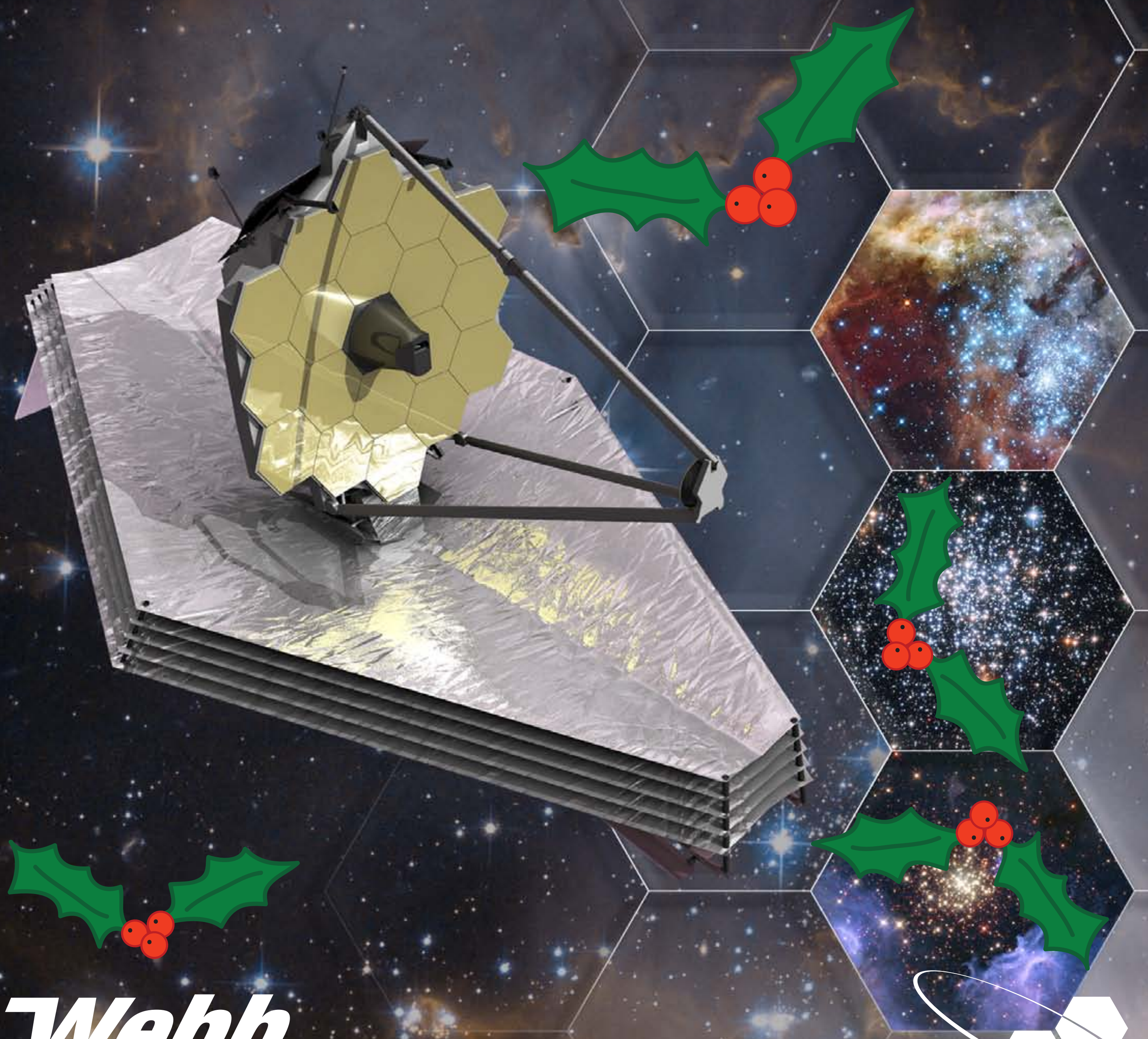
National Aeronautics and Space Administration



Webb Update

December 2013

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James Webb Space Telescope

JWST Backplane Update

By Lee Feinberg

The composite backplane that holds the 18 primary mirror segment assemblies forms the backbone of JWST's primary mirror. The backplane is the largest single structure on JWST and also the largest precision metrology structure that has ever been built for a NASA program. The structure has to hold mirrors during launch and provide optical quality stability for up to two weeks at a time at the operating temperature of ~50K. Given this groundbreaking size, temperature, and precision, the numerous backplane accomplishments this past year are truly significant.

The past year began with ATK of Magna, Utah delivering and successfully cryo-cycling the Primary Mirror Backplane Support Structure (PMBSS) composite Wings at the XRCF chamber in MSFC, Huntsville, AL. During cryo-cycling, the hardware is taken between room temperature and the operating cryogenic temperature and back, in order to demonstrate that it will maintain its stability. While the wings were cycling at the XRCF, ATK was completing the manufacturing and final integration of the Backplane Center Section (CS) to the Backplane Support Frame (BSF). The completed CS/BSF was then shipped to the MSFC facilities for its turn at cryo conditioning and also for a cryogenic optical measurement of the alignment of the interfaces between the Optical Telescope Element (OTE) and Integrated Science Instrument Module (ISIM). This work was started in October and completed in early November. The CS/BSF was then shipped to Northrop Grumman in Redondo Beach, California on November 13th where it will undergo spacecraft adapter interface testing, bond testing, and static load testing which are all due to be completed by the summer of 2014. The shipment of the Backplane to and from the XRCF was accommodated by the use of the 'mini STTARS' shipping container and the United States Air Force C5 cargo transport.

ATK engineered and fabricated the more than 10,000 individual parts of the PMBSS at its facility in Magna, Utah, under a contract with observatory contractor Northrop Grumman. Measuring approximately 24 ft. tall by 19.5 ft. wide by more than 11 ft. deep when fully deployed, and weighing only 2,180 lbs, the PMBSS supports the 18 mirror segments and instruments.

Figure 1: Wings that each will hold 3 primary mirror segments

Figure 2: Center Section Integrated to the Backplane Support Frame (CS/BSF)

Figure 3: Shipment of the PMBSS using Mini STTARS on the C5

How many times can you fold a membrane? Status of the JWST sunshield.

By Mark Clampin

The James Webb Space Telescope employs an array of five membranes, each approximately the size of a tennis court, to achieve its nominal operating temperature of ~40K. In simple terms, the membranes perform the function of a sunshade, keeping the telescope optics and science instruments shielded from the sun during science operations. JWST will be the first space mission to employ this approach, known as passive cooling, to achieve cryogenic operating temperatures below 50K. The top four membrane layers are made of 25 μm thick kapton and are coated with aluminum. The bottom layer (Layer 1), which faces the sun, is a 50 μm thick kapton membrane. The sun facing sides of layers 1 and 2 are coated with a proprietary silicon film to provide protection from the sun's ultraviolet radiation.

The immense size of these membranes requires that they be folded and stowed during JWST's launch, and then deployed with exacting alignment tolerances once in space. This presents some unique engineering challenges not usually encountered with flight hardware. For instance, how is the tennis-court sized membrane correctly folded? How are the membranes deployed, and then tensioned to achieve their correct three-dimensional shape? To answer these questions and validate the concept for stowing and deploying these large swathes of material, the JWST project has constructed five full-size membrane layers. These layers are engineering versions of the final flight membrane design and are known as the template membranes.

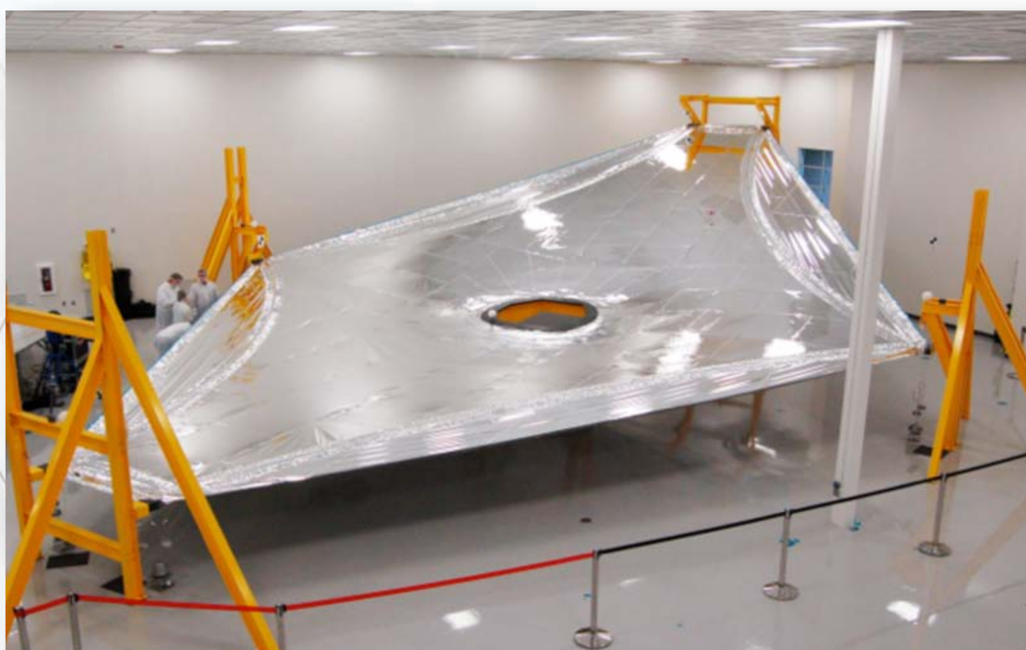


Figure 4: Template layer 3 mounted on the shape test fixture at Mantech. The membrane is tensioned via four catenary cables. The purpose of the test is to measure the three-dimensional shape of the membrane.

The template membranes are manufactured at Nexolve/Mantech in Huntsville. They are assembled from a set of gores cut from patterns and seamed together into their final shape via a proprietary spot welding process. Following completion they are installed on a mounting fixture. Figure 4 shows template layer 3 mounted on the fixture, with the catenary cables tensioned to give the required three-dimensional shape, which is different for each membrane layer. The shape of each membrane under tension is accurately verified with lidar measurements. Each sunshield layer was shipped to Northrop Grumman's Space Park in California, mounted in unique, specially-designed 3x7x51 foot long shipping crates.

Following arrival of the five membrane layers at Space Park, testing has begun on JWST's Integrated Validation Article (IVA). The IVA is a detailed mockup of the JWST observatory design to accurately represent the sunshield sub-system structures, interfaces and deployment envelopes. Figure 5 shows template membranes layers being installed onto the IVA following delivery at Space Park. The IVA is designed to simulate the sunshield deployment hardware, including the pallets on which the membranes are folded and restrained during launch. Mockups of the telescope backplane and the spacecraft bus permit detailed assessment of clearances during deployment of the membranes.

Currently, all five membrane layers are installed on the IVA, and are undergoing testing to validate the approach for folding all five-membrane layers. Figure 6 shows a view of the IVA with folded membranes stowed on the fore sunshield palette. Once folded, the layers are pinned to the pallets with quick release pins, so the process of folding has to ensure that the holes line up across approximately 50 layers of material. Extensive testing is required to show that the folding process is repeatable, since the flight membranes will undergo several full-scale deployment tests during observatory integration, and so the folding process has to be repeatable. The final element in the fold and stow sequence is installation of the covers, which protect the sunshield layers during launch, followed by deployment testing to show the covers retract into their stow positions. The sunshield team will then be ready to begin the process of validating the membrane deployment concept with initial pullout of all five layers with simulated mid-booms. This will be the first step in validating the process of sunshield deployment and exercising the systems that will make this complex deployment a reality.

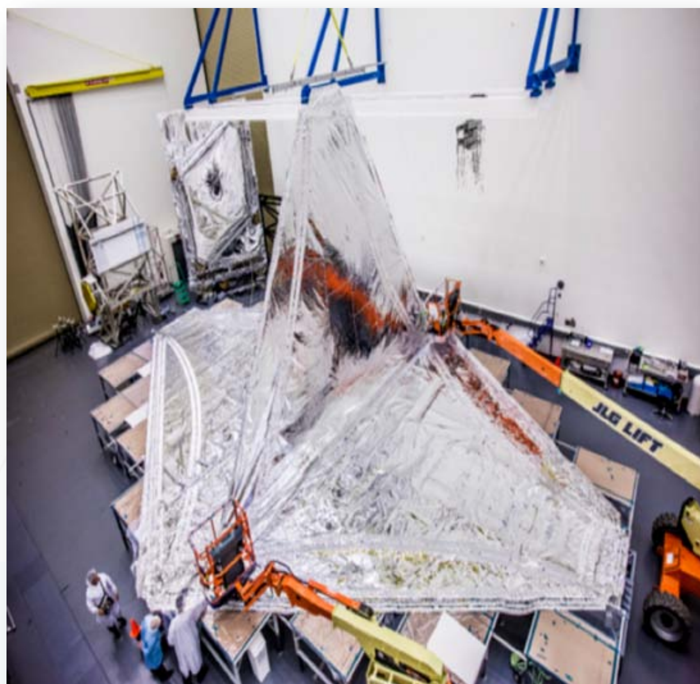


Figure 5: Template membranes being installed onto the IVA at Northrop Grumman's Space Park Facility. The engineers seen standing at the lower left illustrate the sheer size of each membrane layer.

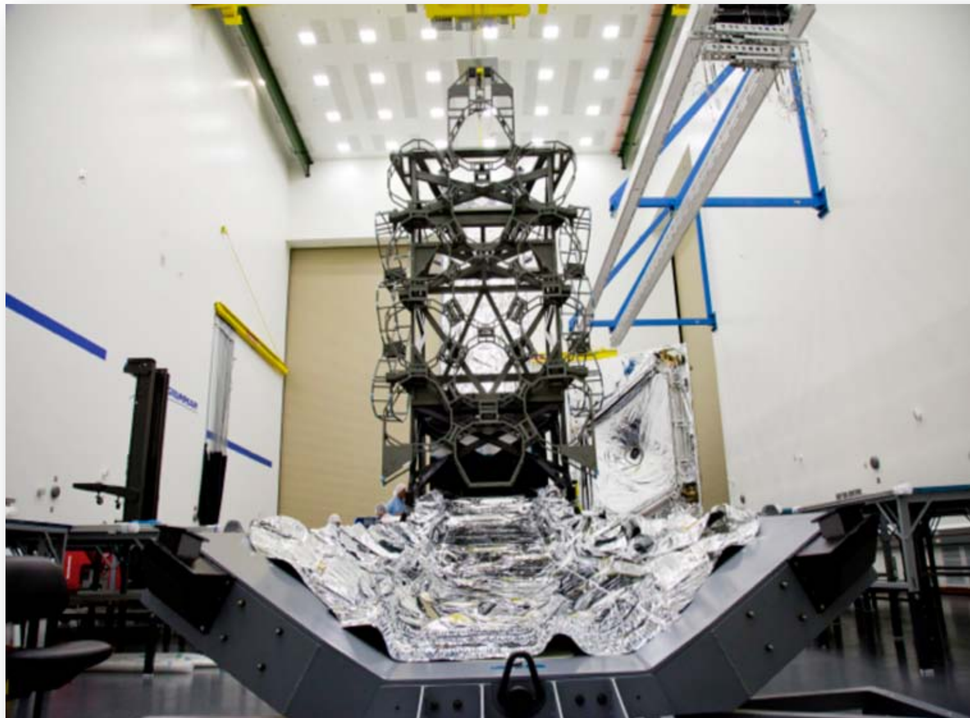


Figure 6: A view of the IVA showing the fore-sunshield palette, with membranes folded and stowed. The IVA also features a mockup of the primary mirror backplane, the skeleton structure which is used to assess envelope clearances during deployment testing.

ISIM Completes Highly Successful First Cryo-Vacuum Test

By Randy Kimble

The first cryo-vacuum (CV) test of the Integrated Science Instrument Module (ISIM) has recently been completed in Goddard's Space Environment Simulator, GSFC's largest vacuum test chamber. After 73 days under vacuum, with most of that time at cryogenic temperatures, the chamber and test article were brought back up to room temperature and atmospheric pressure on November 11th, marking the culmination of a highly successful test campaign.

This first cryo-vacuum test of the ISIM as a system has been designated CV1-RR, indicative of its primary purpose: "risk reduction". As described by Matt Greenhouse in his April 2013 Webb Update article (wherein a number of useful diagrams and references can be found), the formal cryo-verification program for the ISIM will be carried out in two cryo-vacuum tests with the full JWST Science Instrument (SI) suite; those tests, CV2 and CV3, will bracket ISIM's room temperature environmental test program (vibration, acoustics, Electromagnetic Interference/Compatibility) and are scheduled to occur in 2014 and 2015.

In order to ensure that those future verification tests can be executed with the greatest efficiency and likelihood of success, the JWST program chose to conduct a precursor risk-reduction test – CV1-RR. The test configuration for CV1-RR included the ISIM structure, the first two SI's to be delivered and mounted to that structure (the MIRI and FGS/NIRISS), the ISIM Electronics Compartment (IEC), the Harness Radiator, and the full-up set of thermal, electronic, and optical Ground Support Equipment (GSE) required to cool the system to the flight operating temperature and to test it thoroughly under flight-like conditions.

At a top level, the principal goals of CV1-RR were: 1) to demonstrate that the test configuration, which included a large amount of new GSE, is able to support the requirements of the ISIM verification program (i.e., reduction of hardware risks before CV2); and 2) by dry-running critical test procedures, to learn how to most efficiently formulate and execute them and analyze the results (reduction of procedural/operational risks before CV2). Both of these goals were well accomplished in CV1-RR.

The ISIM and IEC, in their thermal-control-panel cocoons, were installed into the SES chamber on August 10, 2013 (Figure 7), and configured for pump-down (Figure 8), which began August 29. After a functional test in vacuum at room temperature, the system was cooled over the course of three weeks to the flight operating temperature plateau (~40-43 K for FGS/NIRISS, 6-7 K for MIRI). A wide variety of tests were then conducted at those flight temperatures, including thermal balance and heat load tests, electrical checkout of the SI's with the ISIM electronics, noise susceptibility, and optical alignment and performance tests.

In general, the flight and test hardware performed beautifully during CV1-RR. The extremely complex thermal GSE demonstrated controlled cooldown and warmup and stable thermal control; SI + ISIM electronics systems performed well together in primary, redundant, and cross-strapped configurations; the

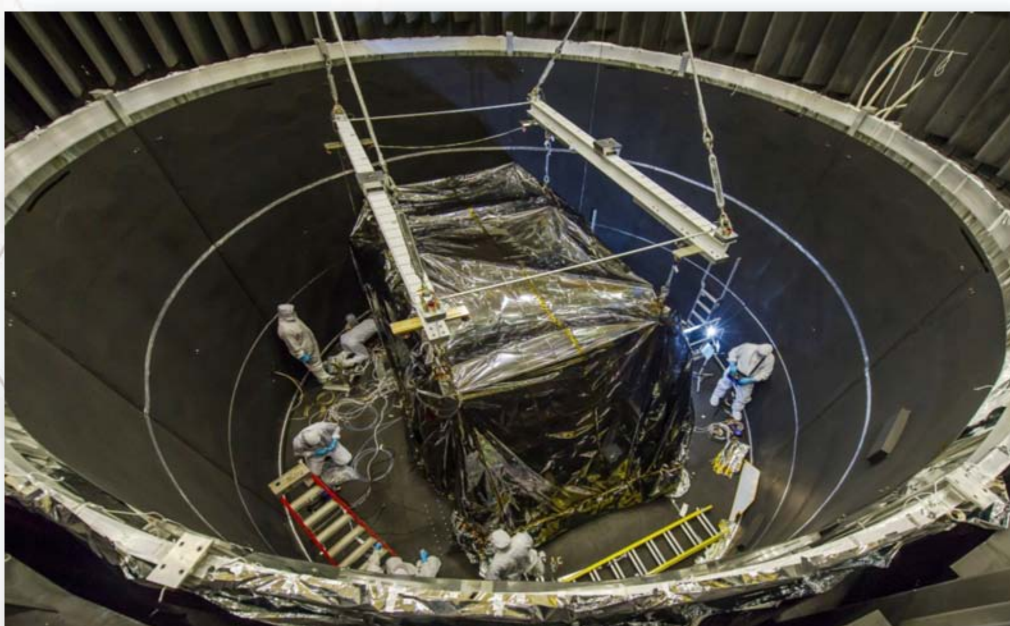


Figure 7: The ISIM and IEC, having just been lifted into the upper, Helium-cooled shroud of the SES chamber. The OSIM telescope simulator is located below the floor visible in this image in the lower, Nitrogen-cooled portion of the chamber; it feeds its JWST-like optical beam upward into the ISIM Science Instruments.

jitter and stray light environments were shown to support the optical testing needs; the OSIM telescope simulator was exercised thoroughly with the MIRI and FGS/NIRISS, confirming their alignments and carrying out a number of performance tests; the Onboard Script System that will conduct ISIM operations in flight was significantly exercised. In addition, the test team (ISIM, SI, Cryocooler, STScI, and facilities personnel) gained invaluable experience in the logistical aspects of planning and executing tests and analyzing the results.

There are of course issues to follow up on between now and CV2 – we will work to improve the reliability of the SES's Helium cooling system, which experienced some brief dropouts that interrupted the test timeline; a previously known intermittent loss-of-communication issue with the FGS/NIRISS needs to be resolved; aspects of the ground system and data handling will be improved. And many other small lessons were learned, which was the point of the CV1-RR exercise. Overall, CV1-RR superbly demonstrated the basic viability of the ISIM cryo-vacuum test configuration and plans and has positioned the team well to follow up with successful execution of CV2 and CV3.

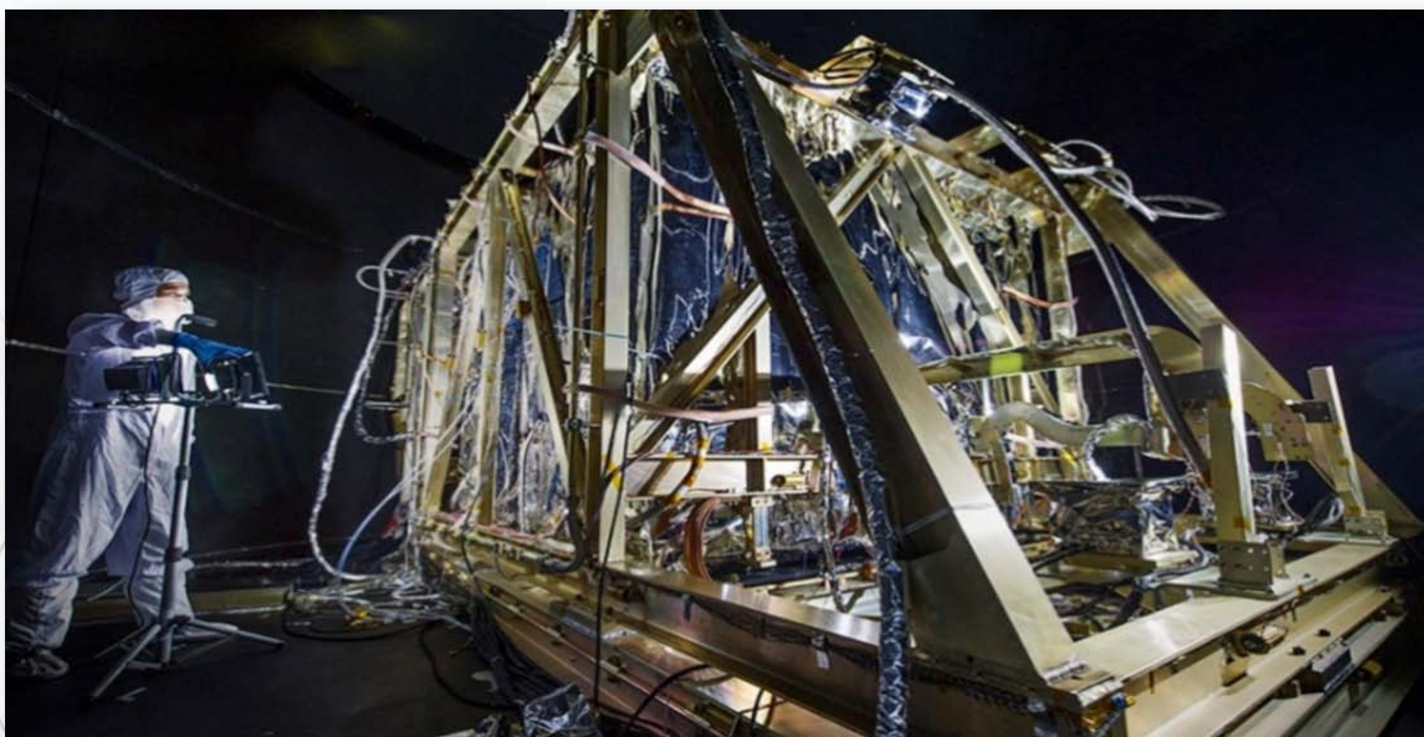


Figure 8: The ISIM cryo-test configuration, with its assorted cooling loops and electrical harnesses, seen shortly before pumpdown. The flight ISIM hardware is located inside the blanketed thermal control panels in the center of the image, visible through the support and handling structure.

James Webb Space Telescope Programmatic Status

By Eric Smith

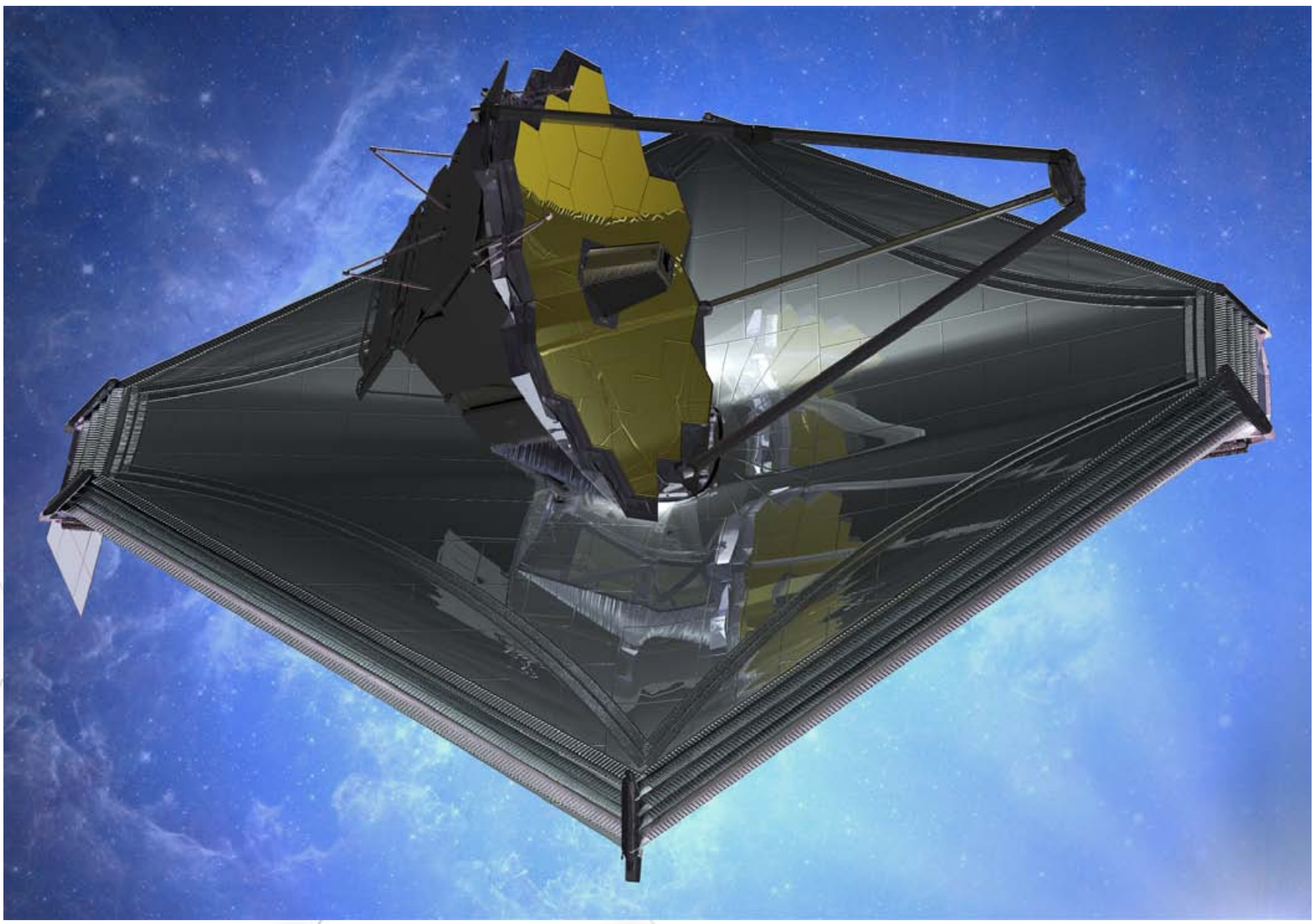
The JWST program continues to remain on track for its October 2018 launch and is performing within its 2011 replanned budget guidelines. Fiscal 2013 was a major year for instrument deliveries. By September all the flight science instruments had arrived at the Goddard Space Flight Center (GSFC) and were either already integrated into the ISIM (MIRI and the FGS/NIRISS) or getting ready to enter the integration and test flow for ISIM (NIRCam and NIRSpec). Primary mirror segments continued to be delivered to GSFC as well. Currently 15 of 18 segments are in storage at GSFC and the remaining three segments will be arriving in early December. As we enter fiscal 2014 we are preparing for the spacecraft critical design review, the final gate to pass before all elements of JWST will be in fabrication or integration and test.

Of course the shutdown of the Federal government at the start of October has many folks wondering what the impact on JWST might be. Webb saw two major tests affected by the shutdown. Starting in late August the first major cryogenic thermal vacuum test of the ISIM began with the aforementioned MIRI and FGS/NIRISS instruments. Some of the testing had been started when the order to shutdown came. A skeleton crew was permitted to remain on center to keep the chamber functioning, but no additional testing was permitted until the shutdown was lifted. Another test, this time of the center section of the telescope backplane, at the Marshall Space Flight Center's X-Ray and Cryogenic Facility (XRCF) was stopped just as it was about to begin. The critical path (or pacing path) for the project's schedule runs through this backplane. Thus the three weeks lost to the shutdown do represent a loss of schedule reserve. Fortunately, the project had 14 months of funded schedule reserve heading into the shutdown so there's no movement in the launch date.

The ISIM test was concluded on its original schedule meaning that any activities not completed as a result of the shutdown will have to be completed in one of the other ISIM cryo-tests (in 2014 or 2015). The project made sure that its contractors were funded prior to the shutdown, so activities were largely able to continue at places like Northrop-Grumman, Ball Aerospace, ATK, and the Space Telescope Science Institute. These are the readily evident and preliminary effects of the government shutdown. It may be some time until the magnitude of second order effects and change in risk posture are fully understood.

As we head into fiscal 2014 the program has major activities planned in the area of the science instruments, as well as sunshield and spacecraft manufacturing. The new near infrared detectors for NIRCam will be installed into that instrument and then NIRCam itself will be integrated with the ISIM. NIRSpec too will be mounted onto ISIM. A second ISIM cryo-test with all four flight instruments in the late Spring of 2014 will clearly be of great interest to the science community. We've already started manufacturing the flight sunshields and this activity will continue through the year. Finally, many elements of the spacecraft that will carry Webb's 6.5m diameter primary mirror and science payload into space will be manufactured. We are sure to face challenges as we build many of these unique items. Our current technical challenges include finishing the build-up of the cryo-cooler system needed to cool the MIRI detectors, and final design tweaks to several spacecraft components to ensure they meet system requirements. Finally, insuring that all elements of the program continue to remain within their replan budgets will also require the collaboration, ingenuity and creativity of all players on the Webb team. Their recent successes have built confidence that the team will tackle these challenges as well.

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



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