

**NASA's Detailed Response  
to the  
James Webb Space Telescope Independent Comprehensive Review Panel Report**

NASA appreciates the insightful recommendations of the Independent Comprehensive Review Panel (ICRP) for the James Webb Space Telescope (JWST) project. In response, NASA has identified the following actions that have been taken or are underway. NASA agrees with the ICRP recommendations and summarized below are detailed responses grouped under the headings cited in the ICRP report.

Baseline Funding (Recommendations 1-4)

1. Develop a new baseline cost and schedule plan-to-complete that incorporates adequate contingency and schedule reserve in each year.
  - NASA is currently developing a new baseline estimate for JWST. Starting with the current status in the development phase, this baseline will be developed based on a new bottom-up, requirements-driven, joint cost and schedule confidence calculation. The bottom-up approach will be similar to that which has been done since the award of the prime contract in 2002 as part of the annual budget submittal except that the prime contractor team (along with some of the key subcontractors) will be directly involved in the development of the new baseline. The baseline will include an Estimate At Complete (EAC) for the in-house work developed by the technical lead for each in-house Work Breakdown Structure (WBS) element, and the contractor EAC for each out-of-house WBS element. NASA will use these inputs along with an analysis of the cost and schedule implications of threats and liens (a joint cost-schedule confidence level calculation) to establish a new baseline with adequate reserves in each year.
2. Include a realistic allowance for all threats in the yearly budget submission.
  - The joint cost and schedule confidence level (JCL) calculation will be based on current hardware status and the remaining work-to-go, liens, threats, and risks.
3. Budget at 80 percent confidence, and require 25 percent reserves in each year through launch.
  - NASA agrees and will plan for reserves consistent with an 80 percent cost and schedule confidence level including adequate reserves in each year.
4. Commission a new ICE, reconcile the new plan with it, and update the plan appropriately.
  - NASA agrees in principle, but the Agency has moved beyond independent cost estimates (ICE) which provide an estimate of the life cycle cost with no insight into an appropriate phasing of funds for each year to an approach where the project creates an integrated cost-schedule-risk model (a JCL) that can be assessed by the Standing Review Board-- independent technical, cost, schedule and risk experts, -- and Agency management. This approach enables the Board's assessment to focus on the executability of the project's plan and agreement or disagreement with the project's own assessment of its risks and how well their plan can accommodate risks that are realized.

In establishing the new baseline, the project will factor in the current status of the flight hardware. The plan will incorporate the technical progress achieved to date with over 74% of the JWST hardware design completed and ready for fabrication, in fabrication, test, or delivered. Examples of the hardware status are as follows: (1) the Integrated Science Instrument Module (ISIM) flight structure completed fabrication and has undergone two cryogenic tests at operating temperatures, and will be delivered to ISIM Integration and Test in May 2011; (2) the Near-Infrared Spectrograph (NIRSpec) and Mid-Infrared Instrument (MIRI) flight instruments are fully integrated and are in environmental acceptance testing in Europe; (3) the primary mirror segments have been through cryogenic testing, the Engineering Development Unit (EDU) and five of the flight segments have completed fabrication process and have been optically coated; (4) the flight tertiary and fine steering mirrors have completed the fabrication process and have been optically coated and are undergoing final environmental testing prior to Optical Telescope Element (OTE) integration; (5) the OTE flight structure is in final assembly; (6) 5 percent of the spacecraft bus subsystems have been through CDR with flight build pending the new baseline; and, (7) the sunshield flight membranes are in assembly. Additionally, two special cryogenic tests were successfully performed for design verification: (1) a one-third scale sunshield and (2) a full scale observatory core area (top of spacecraft bus to bottom of ISIM). The final section of this document provides additional information on JWST technology advances made in 2010.

The new baseline, along with the results of the Standing Review Board's independent review of the project's plan and its joint cost and schedule confidence calculation, will be reviewed by the Agency and, if approved, will be included in next year's annual budget request.

#### Independent Analysis Capability (Recommendations 5-6)

5. Establish the Office of Independent Program and Cost Evaluation (IPCE) as the recognized Agency estimating capability, responsible for validating the most probable cost and schedule estimates.
  - NASA agrees: IPCE is the Agency's lead for cost estimating policy, the development of tools and methodologies, and independent Program/project assessment. IPCE is working closely with the JWST project to enhance their use of all IPCE capabilities.
6. Hold IPCE accountable for developing ICEs for major milestone reviews, reporting directly to the Agency Program Management Council (PMC) and not simply acting as a support organization to the SRB.
  - NASA agrees. NASA will revise its NASA Space Flight Program and Project Management Requirements (NPR 7120.5d) so that the Associate Administrator can direct IPCE to develop an ICE to support consideration of a project approaching a key milestone in addition to the normal Standing Review Board assessment.

In 2008, at the time of the JWST Preliminary Design Review/Non-Advocate Review (PDR/NAR) and Confirmation Review, the Agency did not have in place a strong, robust independent analysis capability. The Agency had begun requiring projects to be budgeted at a 70 percent cost confidence level in 2006, but did not add the requirement for a joint cost and schedule confidence level until 2009, when the methodology was robust enough to put into practice. The JWST confirmation budget would have benefited from a JCL because it would have explicitly factored schedule risks and properly phased reserves into the approved cost estimate.

The Agency is continuing to improve its capability and processes in budget estimation and monitoring, assessing and reporting internally and to OMB and Congress. The Agency now requires all projects with a Life Cycle Cost (LCC) over \$250M to develop a JCL as part of the confirmation process and for independent analysis, assessment and reporting on the JCL calculation at the time of the Agency Confirmation PMC. The Agency will evaluate changing its policy to require an 80 percent joint cost and schedule confidence level for complex, high priority projects and is continually improving independent review processes to increase rigor at decision gates. As an example, in a recent review where the Standing Review Board chair and the programmatic assessment team could not reach agreement on the risk in the project's plan, the programmatic assessment was presented independently to the decision authority for consideration.

The NASA Science Mission Directorate (SMD), in the context of changing the management structure for JWST (see below) is moving rapidly to provide the kind of rigorous, independent assessments of cost and schedule performance that the ICRP correctly noted were lacking. Working with IPCE, SMD has arranged for experienced personnel to be dedicated to JWST cost and schedule analysis for the duration of the JWST development. These personnel will report to the new JWST Program Director at NASA Headquarters.

#### Project Management (Recommendations 7-12)

7. Restructure the JWST Project Office at GSFC to ensure that the Project is managed with a focus on the LCC and LRD, as well as on meeting science requirements appropriate to the Implementation Phase.
  - NASA has put a new Project Manager and Business Manager in place, as well as additional resources staff, to improve the management and focus of the Project Office.
8. Fund all existing deferred work in FY 2011 to get the Project back on track.
  - NASA's ability to implement this recommendation is tied to a final enacted FY 2011 appropriation from Congress. The new baseline being developed will include scheduling of completion of the previously deferred work as part of the overall set of tasks to be accomplished.
9. Implement a threats and liens system that is consistently applied across all elements of the Project.
  - NASA agrees, and this is being implemented by the Project. The liens and threats system employed by the project is uniform across the hardware and software elements, regardless of which entity (government, industry or international partner) is performing the work.
10. Assess and track the likelihood of threats at the GSFC management level to more clearly delineate the process for transitioning from threats to liens.
  - NASA agrees and this is being implemented for JWST and other projects at GSFC. Goddard is developing a uniform definition for and approach to defining threats and liens.
11. Manage and assess contingency in terms of its adequacy to cover unknown and as yet unrecognized threats using the industry standard process of assessing the dollarized Earned Value (EV) of existing threats.

- NASA agrees and will use this type of assessment as one factor in determining adequate contingency levels for JWST. In addition, and where appropriate, NASA will use knowledge from previous missions to assess the adequacy of its contingency posture for JWST program elements.

12. Accelerate the spacecraft element schedule to more closely bring development into alignment with other Project elements.

- NASA will evaluate the spacecraft development schedule along with the other elements of the project in developing the new baseline and will bring all elements into alignment with the new baseline schedule.

NASA is in the process of implementing the ICRP's recommendation for a project-level system to identify and quantify threats and risks and will use this information to develop and maintain an adequate reserve posture for JWST. In parallel with Headquarters, the Director of the Goddard Space Flight Center (GSFC) will dedicate personnel to perform analogous cost and schedule assessments at the project level.

#### Program Management (Recommendation 13)

13. Move the JWST management and accountability from the Astrophysics Division to a new organizational entity at Headquarters having responsibility only for the management and execution of JWST.

- NASA agrees and has implemented these changes. The management of JWST at Headquarters has been reorganized accordingly. JWST is now a stand-alone program, with an experienced Program Director reporting to the NASA Associate Administrator for programmatic oversight and to the Associate Administrator for the Science Mission Directorate for technical and analysis support. A similar approach proved successful in the past with both the Hubble Space Telescope and the Mars Exploration Program at critical junctures in their execution. As noted above, the JWST Program Director will have the support of a dedicated cadre of experienced cost and schedule analysts.

#### Governance and Accountability (Recommendations 14-16)

14. Revise the wording of the Agency's Center responsibilities document, NPD 1000.01a, to correctly and unambiguously reflect clear lines of authority, accountability, and responsibility for program execution.

- NASA agrees and took action in 2009 to clarify Center responsibilities. Revisions to Agency governance documents to reflect this direction are under review. This inconsistency and lack of clear understanding of the role of the Center Director began in 2005, when NASA's program/project governance paradigm was changed in response to the CAIB findings about independence of the technical and programmatic authorities and the need to establish an independent path by which the Agency's engineers could raise issues related to safety or performance. The policy, established in 2005, created two clear reporting lines with Headquarters Mission Directorates responsible to implement programs and projects through program offices at Centers, and Center Directors responsible to provide skilled personnel and institutional resources to these projects and assure that activities at their Centers are implemented

in accordance with accepted professional standards and NASA requirements. This policy was clarified by Administrator Bolden following his confirmation in 2009 affirming that both Center Directors and Mission Directorate Associate Administrators report directly to Office of the Administrator. The Center Director has a unique role as the only person who can ensure proper planning and execution of activities requiring constructive integration across Programmatic, Technical and Institutional Authorities. The Center Director is therefore responsible and accountable to the Administrator for the safe, effective and efficient execution of all activities at his Center.

15. Assign management and execution responsibility for the JWST Project to the GSFC Director, with accountability to the Science Mission Directorate Associate Administrator at Headquarters.

- NASA agrees that the GSFC Director is responsible for the management and execution of the JWST Project and accountable to NASA Headquarters but not to the Science Mission Directorate Associate Administrator but to the NASA Administrator. NASA has implemented requisite changes at both GSFC and Headquarters. Administrator Bolden made it clear that the Center Directors are responsible for work that is done at their Center on projects and programs, including management. Changes to the Agency's governance documents to reflect this direction are in the process of being implemented through the Agency policy process. NASA has reorganized the JWST project at GSFC to report directly to the Center Director. In order to have fresh but experienced management to lead the JWST project through its critical integration and test phase, a new JWST Project Manager at GSFC was brought on board. In addition, a new business manager was assigned to the JWST Project at GSFC to place added emphasis on cost, schedule and risk performance assessment. These changes were made in addition to the naming of a new Integration and Test Manager at JSC (reporting to the Project Manager) as a result of the Test Assessment Team report.

16. Ensure that the Project Office, the Center, and the Agency are each held directly responsible for conducting in-depth analysis and projections of monthly JWST Project cost and schedule performance.

- NASA agrees and this recommendation is being implemented. NASA is establishing the program office and analysis capability using the Science Mission Directorate analysis team. Additionally, NASA HQ will use the IPCE and OCFO organizations for strengthened surveillance.

#### Communications (Recommendations 17-19)

17. Improve communications between the JWST Project and both GSFC management and NASA HQ SMD.

- NASA agrees and communications have improved (see paragraph below).

18. Assign at least one senior GSFC project person to be resident at NGAS throughout the Project. Consider having an NGAS manager resident at GSFC.

- NASA agrees and is working the details to implement this recommendation.

19. Conduct monthly or bi-monthly JWST Executive Project meetings, attended by the NASA Associate Administrator and the President of NGAS.

- NASA agrees and has implemented these regular senior level meetings (see paragraph below).

NASA agrees that the current venues for communications and current on-site activities such as the Ball Aerospace resident office and NGAS JWST East Coast Office could be improved and is moving aggressively to augment these arrangements. The ICRP recommended executive-level meetings among Headquarters, GSFC and the prime contractor. The first such meeting under the new governance approach for JWST was held on December 1-2, 2010, with the NASA Associate Administrator, the new JWST Program Director, and the GSFC Center Director traveling to California to meet with the senior management of the prime contractor to lay out the way forward for JWST management and organizational communication. Senior level management reviews are being planned on a quarterly basis between NASA HQ, GSFC, other NASA Centers, and contractors. In addition to these more formal reviews, communications between senior level management is now occurring when necessary as issues and concerns arise.

#### Potential Risk in Integration and Test Phase (Recommendation 20)

20. Implement the TAT Report recommendations to substantially reduce the scheduled test time by running complementary testing off the critical path and by more effective sequencing of certain critical cryogenic and optical test segments.

- NASA agrees and will factor into the development of the new baseline the recommendations from the TAT Report. NASA is already well underway in implementing the TAT Report recommendations, including changing JWST Project plans for thermal vacuum testing at the Johnson Space Center to prioritize tests, reduce risk, and minimize the amount of time it takes to complete the testing. NASA has also augmented the project integration and test management at GSFC by two senior positions: (1) a senior manager who will focus on the verification program across the entire project, and (2) an experienced integration and test manager who will focus exclusively on the integrated Optical Telescope and Science Instrument Module test program.

#### System Engineering (Recommendation 21)

21. Establish a plan that provides the required level of experience and that involves the appropriate NGAS personnel before changing the system engineering accountability.

- NASA agrees and has completed implementation of this recommendation to establish a plan that provides the required level of experience and involves appropriate prime contractor personnel before changing system engineering accountability. Key features of this plan were one subject of the December 1-2, 2010 Executive-level meeting with the prime contractor.

#### Project Scientist and Science Team (Recommendation 22)

22. Strengthen the role and the independent voice of the science team in the Project.

- NASA agrees, and has added a Deputy Senior Project Scientist/Technical position to the project science team. This individual will be responsible for day-to-day interactions with senior project management on all aspects of the mission; scientific,

technical, budgetary, and schedule. This individual will also regularly meet with other members of the project science team to insure rapid and substantive communication between the science and cost/schedule/risk worlds. This new position will assist the Senior Project Scientist in better integration of the science activities with the hardware development activities and enable closer coordination and understanding of technical drivers to science performance so fully informed decisions can be made.

## **NASA's Webb Telescope Technological Advances in 2010**

The James Webb Space Telescope will explore deep space phenomena from distant galaxies to nearby planets and stars as never before. It will give scientists clues about the formation of the Universe and the evolution of our own solar system, from the first light after the Big Bang to the formation of star systems capable of supporting life on planets like Earth. Components of JWST were under development last year, and those developments are continuing in FY 2011.

Several of the technological advances made on the JWST in FY 2009 paved the way for more progress in FY 2010. In FY 2009, several critical design reviews were completed on the backplane, integrated science instrument module (ISIM) and Optical Telescope Element (OTE). There were also primary mirror advancements and construction of a full-scale simulator.

This year, one of the most significant mission milestones occurred when the JWST passed the technical portion of the Mission Critical Design Review (MCDR). The programmatic portion of the MCDR was not completed (overtaken by ICRP and other reviews). This milestone signified the integrated observatory will meet all science and engineering requirements for its mission.

The technological successes achieved in FY 2010 included the completion of the first flight and engineering test mirrors, testing on the sunshield, infrared instruments and various components of the space telescope.

### **Mirrors**

This year, great progress was made on the development of the telescope's 18 primary mirrors. Of the 18, the first flight mirror segment and one engineering development unit were polished to their exact prescriptions and verified at operational cryogenic temperatures at the X-ray and Cryogenic Facility (XRCF) at NASA's Marshall Space Flight Center. These mirror segments, as well as the tertiary and fine steering mirrors, also progressed to the last step in the mirror manufacturing process, undergoing an ultra-thin coating of gold to increase reflective properties.

Four more flight primary mirror segments (of the 18) have completed coating and are awaiting verification. These milestones set the stage for the remaining flight segments to follow in the polishing and coating process.

### **Sunshield**

The Sunshield passed its critical design review, certifying that its design is complete and it meets mission requirements. The Sunshield also passed a Light Detection and Ranging (LIDAR) shape measurement test to ensure that it can withstand the cold temperatures of space.

Engineers tested a 1/3 scale model of the sunshield in a thermal vacuum chamber, verifying that the design can block and redirect the sun's energy before it reaches the telescope. This is significant because the infrared instruments need to operate in cold conditions. Three sunshield test articles underwent launch depressurization simulations to verify how the intricately folded sunshield membranes will perform under a rapid loss of pressure during launch. A LIDAR test was conducted on layer 5 of the sunshield (the coldest layer) near its cryogenic operating temperature, approximately 77K (-320.8°F) to confirm the computer model prediction of its shape at those temperatures in space.



## **Instrument Progress**

Throughout FY 2010, the test models of the JWST telescope cameras were delivered to NASA's Goddard Space Flight Center in Greenbelt, MD. for testing and integration into the Webb telescope's main frame known as the ISIM.

The Structural Thermal Model of the Mid InfraRed Instrument (MIRI), a pioneering camera and spectrometer, arrived from the Science and Technology Facilities Council's Rutherford Appleton Laboratory (STFC/RAL) in the United Kingdom. The Near-Infrared Spectrograph (NIRSpec) Engineering Test Unit instrument arrived from its manufacturer in Germany. The Near-Infrared Camera (NIRCam) Engineering Test Unit arrived from Lockheed Martin in Palo Alto, Calif. The microshutters were shipped from the European Space Agency (ESA) for installation into the NIRSpec instrument. The Canadian Space Agency delivered a test unit of the Fine Guidance Sensor. All of these components were brought to the largest clean room at NASA Goddard as engineers tested them and verified their operation.

Progress was also made on the deployment tower assembly which is a 9.6 foot telescoping tower that supports the primary mirror. The deployment tower test article, the outer cylinder of a composite structure, was successfully tooled and bonded. Finally, engineering model testing was completed for the spacecraft's Command and Data Handling system, the electronic brain that sends science data to the ground station.