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BEFORE THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
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THE NEXT GREAT OBSERVATORY: ASSESSING THE JAMES WEBB SPACE TELESCOPE

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Before the House Committee on Science, Space, and Technology
The Next Great Observatory: Assessing the Next Great Telescope

Chairman Hall, Ranking Member Johnson, and distinguished Members of the Committee, thank you for inviting me to appear before you today on behalf of the men and women of Northrop Grumman supporting the James Webb Space Telescope (JWST), National Aeronautics and Space Administration's (NASA) next great observatory. Identified as a top priority for astronomy and astrophysics by the National Research Council, JWST will reach beyond the Hubble Space Telescope, and serve as a key program for the world's ground-based and space-based astrophysics community. I commend the Committee for your continued support and oversight of the space program, especially with regards to your interest in JWST, and appreciate your commitment to further science, technology, engineering, and mathematics education.

I would be remiss if I did not recognize NASA's leadership – notably Goddard Space Flight Center, and the important contributions of the Johnson Space Center, Marshall Space Flight Center, and the Jet Propulsion Laboratory – that make the JWST program possible. Additionally, NASA's international partners, the European Space Agency and the Canadian Space Agency specifically, are providing key instruments and the launch vehicle. This program has also benefited from the invaluable contributions of the Space Telescope Science Institute, which serves as the Science and Operations Center for the mission. Finally, I must also acknowledge the ongoing contributions of our innovative science community. It is our combined efforts and domain expertise that bring us together as we build the world's next great observatory.

In 2002 Northrop Grumman (then TRW) was awarded a key contract for JWST, a larger-than-ever space telescope; required to operate at ultra-cold temperatures, designed to measure and explore the first stars and galaxies born in the universe, study planetary systems similar to our own, analyze the molecular composition of extrasolar planets' atmospheres, and directly image Jupiter-size planets orbiting nearby stars. Without question, JWST represents a challenge and capability beyond anything attempted by NASA, our nation, or anywhere in the international community.

As for Northrop Grumman's role in JWST, the estimated contract value for Northrop Grumman over the lifetime of the program is approximately $3.5 billion, with nearly half of those funds applied to advancing key technologies, completing designs, and fabrication accomplished to date. About half of Northrop Grumman's work is in-house, and half is apportioned to our subcontractors. Projects like JWST, as amazing as our discoveries will be, are about more than the science. This project has created a network of high-tech jobs across the country, capabilities that would not otherwise exist, and will lay the foundation for additional programs that need large deployed optics in space.

We currently employ approximately 265 engineers, scientists, technicians, and support staff at our Space Park facility in Redondo Beach, California, and in our efforts we partner with 193 suppliers across 31 states that harness the most advanced technical expertise in America. You can tour the country visiting the facilities and laboratories touched by the JWST program, from the JPW Welding Company in Syracuse, New York who created their most high-precision structure ever in order to be able to hold our telescope, or through the L-3 Integrated Optical Systems facility in Richmond, California where there is now a production line to make high precision mirrors. These abilities are cutting edge and uniquely American.

Mr. Chairman, at our most senior levels, Northrop Grumman takes great pride in our role as NASA's partner on the JWST program and remains fully committed to the success of its mission. We are deeply motivated, both personally and financially, to deliver a successful, on-budget and on-schedule mission.

In your letter inviting me to appear before the Committee, you asked that I respond to three specific questions: (1) What are the chief technical and programmatic challenges facing JWST?, (2) What steps is Northrop Grumman taking to ensure costs and schedule are met? How confident are you of the new cost and schedule estimates?, and (3) What is the role of integration and testing for the program completion? I offer responses, along with those of my fellow panelists, to inform the Committee's interest with regards to JWST.

Addressing Technical and Programmatic Challenges

JWST's chief technical and programmatic challenges are centered on building and testing the telescope and the thermal management system. To put our challenges in perspective, the JWST mirror is six times larger than the Hubble Space Telescope mirror and the satellite will weigh just over half as much. This telescope must be packaged for launch on an Ariane V rocket and then deployed a million miles from Earth where it will be operated at approximately 40 degrees Kelvin, which is negative 388 degrees Fahrenheit.

Northrop Grumman worked closely with NASA and our subcontractor partners to design and execute an innovative risk-reduction program to bring the JWST mirrors and thermal management system to maturity long before the Mission Critical Design Review (M-CDR) in 2010. Ahead of M-CDR, we focused on developing and maturing key technologies to reduce our risk position. NASA, Northrop Grumman, and our subcontractors identified the hardest engineering challenges early in the program, and developed effective solutions, which were verified by building and testing the components. As a result, some of the most technically challenging hardware – including the mirrors, components of the backplane, and template sunshield membranes – are complete.

It is hard to overstate the tremendous accomplishments we have made to date. In the early stages of JWST, there were those who doubted that it was possible to polish beryllium mirrors so smooth that the largest surface irregularity on their surfaces would be hundreds of times smaller than the diameter of a single bacterium, yet we have successfully completed all 18 hexagonal mirrors – all with a smoothness well within that requirement. The smaller secondary, tertiary, and fine-steering mirrors that complete the optical path have been cast, machined and polished, complete with their final reflective coating. The Northrop Grumman-led team has achieved what was deemed nearly impossible, and we are now conducting cryogenic testing on all of the JWST flight mirrors. Just as we have made tremendous progress in assembling the telescope, today, in Huntsville, Alabama, we are testing the template sunshield membranes, the flight-like material of the space umbrella-like shade that will allow JWST to operate at temperatures close to absolute zero.

At Northrop Grumman, our team is focused on all aspects of delivering a successful mission, from our technical progress; such as completing the composite backplane structure and completion of the sunshield, to the integration process; including the hardware assembly from the smallest elements to complex systems, and the testing at each level of our hardware functionality required to ensure mission success. Though much has been accomplished, challenges remain.

One of the most challenging aspects of the JWST mission continues to be thermal management. The observatory endures temperature differences of over 500 degrees from the warm Earth-facing side to the cold cryogenic mirror side. Never before has anyone created a telescope of this size, which can operate at these ultra-cold temperatures, while supporting a state-of-the-art suite of heat-generating cameras, spectrographs, and electronics.

It was challenging to manufacture 18 beryllium mirrors that can hold their shape to better than 20 nanometers at cryogenic temperatures. It was also challenging to design a deployable sunshield the size of a tennis court, but those challenges are behind us. The Independent Comprehensive Review Panel, led by John Casani, recognized these technological achievements and noted "a substantial amount of cutting-edge hardware has been delivered and is now being tested as part of the first steps toward the overall integration and test of the Observatory." The risk reduction investments have enabled the NASA/Northrop Grumman team to solve challenges on the complex and difficult journey to build the most powerful space telescope ever. As the Casani Panel concluded, "…the JWST project has invested wisely in advancing necessary technologies and reducing risk."

Cost and Schedule Steps

Though JWST has achieved incredible successes, the Casani Panel also found we need to do better going forward. Working closely with NASA, Northrop Grumman has implemented changes, which we have been effectively executing. In response to the Casani Panel findings, Northrop Grumman has made significant structural changes; including, improved communications and decision making processes between our team, NASA, and our partners. We have increased the frequency of senior management engagements to streamline program decisions, identifying issues to find resolution.

Additionally, Northrop Grumman manages a consistent and rigorous review system at all levels, from senior monthly program reviews down to weekly written progress reports with actively-managed metrics. We continuously evaluate actions to contain costs, while advancing the observatory beyond design and production already accomplished, moving forward through assembly, integration, and test for launch readiness. We have also implemented a set of improved financial controls in the form of metrics, reports, and alerts. These careful measures have been designed to ensure contractual discipline to avoid unintended cost growth.

JWST has a clear path forward, with evidence the current plan is proceeding on track. Northrop Grumman is, and has been, executing within cost, technical, and schedule milestones since the re-plan that has been in place since the beginning of the year. In addition, as a result of the management changes, Northrop Grumman – in partnership with our major subcontractor teammates – has made available three near-term 'critical path' development tracks for earlier delivery to NASA. We have been able to achieve these changes thanks to the careful cross-organizational examination that went into our re-plan.

Integration and Testing

For systems comprised of multiple complex components, it is essential to verify that all components precisely fit and operate together to achieve their intended function and performance within the integrated system. This is particularly important for JWST, a system that is not designed to be repaired on orbit. An additional complexity within the JWST program is that the testing that takes place on Earth does not exactly simulate our operational conditions on orbit, such as cryogenic temperatures at large scales and zero gravity. Therefore, the complexity and duration of the ground testing is disproportionately longer for this program compared to other satellite systems.

JWST's long integration, test, and verification span is designed to reduce program risk through a methodical, incremental build and test approach, which retires risk at each successive indenture level of the observatory. We have an extremely rigorous integration and technology flow to ensure that we identify issues at the lowest assembly level possible in order to prevent problems that require us to undo previous assembly. However, the complexity of ground testing is one that we must consistently address throughout the path to launch. We are using the largest cryogenic vacuum chamber in the world at NASA's Johnson Space Center, and even that chamber is not large enough to hold the full-up JWST observatory with the sunshield deployed.

Due to these size constraints, we test the JWST optics (large primary mirror, secondary, and optical components) and instruments at flight temperatures at the Johnson Space Center, but will use a combination of analytical and subsystem tests to prepare the sunshield for deployment in space. As was noted by the JWST Test Assessment Team, also led by John Casani, "the scale, complexity, and cryogenic nature of JWST prohibit and end-to-end system test and instead require an innovative approach to system verification, with more dependence on analysis and piece-wise testing."

At Northrop Grumman's Space Park facility, integration and testing of flight hardware begins with the Optical Telescope Element Structure. This structure supports the six and a half meter diameter large primary mirror, the secondary mirror, and the remaining mirror assembly that brings light to the instruments within the observatory. This complex structure is then delivered to NASA's Goddard Space Flight Center to be integrated with the flight primary hexagonal mirrors, as well as other flight mirrors, to create the fully assembled Optical Telescope Element. Also at Goddard Space Flight Center, the NASA team will be integrating and testing all four flight science instruments, including two from our international partners at the European Space Agency and Canadian Space Agency. The Goddard Space Flight Center will join the fully assembled mirror hardware to the instrument hardware and test this complex system at NASA's Johnson Space Center, where the JWST team is making modifications to create the world's largest cryogenic-chamber.

In parallel, at Northrop Grumman's Space Park our team will be conducting integration and test for the propulsion module, the spacecraft panel, and the sunshield. These systems will come together in the Spacecraft Element Integration and Test, where the sunshield will be deployed multiple times at room temperature to verify its performance. It is worth noting that a one-third scale sunshield replica has been tested at cryogenic temperatures to further validate our flight analytical models. With both the Spacecraft Element and Optical Telescope Integrated Science systems fully assembled and tested, these two primary aspects of the observatory will meet at Northrop Grumman's Space Park for complete observatory integration and test. From our facility, the final flight JWST will be delivered to our launch site for additional integration and test, and, finally, integration with the launch vehicle itself.

To ensure a comprehensive plan is in place, the program elements have been thoroughly reviewed by experts independent of the core program team, including: the Mission Critical Design Review Board (April 2010), the Test Assessment Team (June 2010), and several Standing Review Boards. Specific integration and verification factors were included in the JWST re-plan, and were derived from bottom-up estimates and confirmed to be at the high confidence level by an independent integrated cost and schedule assessment.

In conclusion, Mr. Chairman, I understand the concerns the Committee has raised, and feel confident Northrop Grumman is doing our part to address the technical and programmatic challenges before us. We are taking the proper steps to ensure cost and schedule guidelines are met, and we are enabling our team to successfully reach program completion by meeting integration and testing milestones for the JWST program. Like all astronomical telescopes that leap over the capability of their predecessors, fundamental breakthroughs will come from the scientific discoveries that JWST will reveal about the universe we live in.

I want to again thank you for asking me to appear before your Committee today, and welcome the Committee's questions.