James Webb Space Telescope
Q&A, Key Messages
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Key Messages

- The engineering challenges of Webb are just as cutting-edge as the science. It is the most complex astronomy mission conceived and developed in history.
- Webb is an executable program with more technical hurdles satisfied than remain.
- The Casani Panel report acknowledged significant technological progress of the Webb telescope.
- The Webb telescope is a top priority for Northrop Grumman and we are fully committed to the success of the program. We are working, both internally and collaboratively with NASA, to enhance program efficiency and manage resources, improve planning and communications.
- We know that the program must be completed within the budget requested by NASA and approved by Congress. Along with NASA, we must be diligent in ensuring that every dollar is managed wisely.
- The 18 mirror segments are nearing completion, one excellent example of how the Webb team wisely invested $3B in the program. This investment has resulted in three quarters of the observatory mass in fabrication, with substantial risk retired.
- Mirror segment hardware development has been in progress since 2004, and all 18 hexagonal flight mirrors will be complete next year.
- The Webb telescope was the #1 recommendation in the 2000 National Academy of Sciences Astrophysics and Astronomy Decadal Survey and is thoroughly integral to the success of the 2010 decadal survey.

Science

Q. What are the main science goals of Webb?

A. Webb has four mission science goals:

- Search for the first galaxies or luminous objects that formed after the Big Bang.
- Determine how galaxies evolved from their formation until the present.
- Observe the formation of stars from the first stages to the formation of planetary systems.
- Measure the physical and chemical properties of planetary systems and investigate the potential for life in those systems.

Q. How far will Webb look?

A. One of the main goals of Webb is to detect some of the very first star formations in the Universe. This is thought to happen somewhere between redshift 15 and 30 (redshift explained below). At those redshifts, the Universe was only one or two percent of its current age. The Universe is now 13.7 billion years old, and these redshifts correspond to 100 to 250 million years after the Big Bang. The light from the first galaxies has traveled for about 13.5 billion years, over a distance of 13.5 billion light-years.

Q. Will Webb see planets around other stars?

A. The Webb will be able to detect the likely presence of planetary systems around nearby stars from their infrared radiation. It may even be able to see directly the reflected light of large planets - the size of Jupiter - orbiting around nearby stars. It will also be possible to see very young planets in formation, while they are still hot. Webb will have coronagraphic capability, which blocks out the light of the parent star of the planets. This is needed, as the parent star will be millions of times brighter than the planets orbiting it. Webb will not have the resolution to see any details on the planets; it will only be able to detect a faint light speckle next to the bright parent star. Webb can only see large planets orbiting at relatively large distances from the parent star. To see small Earth-like planets, which are billions of time fainter than their parent star, a space telescope capable of seeing at even higher angular resolution will be required. NASA is studying such a space mission, the Terrestrial Planet Finder.

Q. Why is Webb optimized for near- and mid-infrared light?

A. The primary goals of Webb are to study galaxy, star and planet formation in the Universe. To see the very first stars and galaxies formed in the early Universe, we have to look deep into space to look back in time (because it takes light time to travel from there to here, the farther out we look, the further we look back in time). The Universe is expanding, and therefore the farther we look, the faster objects are moving away from us, redshifting the light. Redshift means that light that is emitted as ultraviolet or visible light is shifted more and more to redder wavelengths, into the near- and mid-infrared part of the light spectrum for very high redshifts.

Therefore, to study the earliest star formation in the Universe, we have to observe infrared light and use a telescope and instruments optimized for this light. Star and planet formation in the local Universe takes place in the centers of dense, dusty clouds, obscured from our eyes at normal visible wavelengths. Near-infrared light, with its longer wavelength, is less hindered by the small dust particles, allowing near-infrared light to escape from the dust clouds. By observing the emitted near-infrared light we can penetrate the dust and see the processes leading to star and planet formation. Objects of about Earth's temperature emit most of their radiation at mid-infrared wavelengths. These temperatures are also found in dusty regions forming stars and planets, so with mid-infrared radiation we can see the glow of the star and planet formation taking place. An infrared-optimized telescope allows us to penetrate dust clouds to see the birthplaces of stars and planets.

Q. What about visible light?

A. The reflective surface on Webb's mirrors is gold. Although gold absorbs blue light, it reflects yellow and red visible light, and Webb's cameras will detect that visible light.

Q. At which wavelengths will Webb observe?
A. Webb will work from 0.6 to 28 micrometers, ranging from visible gold-colored light through the invisible mid-infrared. The short wavelength end is set by the gold coating on the primary mirror. The long wavelength cut-off is set by the sensitivity of the detectors in the Mid-Infrared Instrument.

Q. How faint can Webb see?
A. Webb is designed to discover and study the first stars and galaxies that formed in the early Universe. To see these faint objects, it must be able to detect things that are ten billion times as faint as the faintest stars visible without a telescope. This is 10 to 100 times fainter than Hubble can see.

Current Status

Q. What is the current status of the James Webb Space Telescope (JWST) program?
A. The first fully completed flight primary mirror segment has been delivered to Goddard Space Flight Center; ATK has delivered the pathfinder backplane to Northrop Grumman; the first flight primary mirror segment has passed its acoustics test, verifying that it can survive launch; and the full-size assembly stand upon which the flight telescope will be assembled has been completed by ITT and will be shipped to Goddard Space Flight Center in October.

The observatory passed the technical portion of a significant mission milestone, the Mission Critical Design Review, or MCDR in April 2010 at Northrop Grumman. This review confirmed the design, hardware and test plans for Webb will meet all science and engineering requirements for the mission.

Q. What did the MCDR mission milestone cover?
A. It encompassed all previous design reviews including:

- Integrated Science Instrument Module review completed March 2009
- Optical Telescope Element review completed October 2009
- Sunshield review completed January 2010
- The spacecraft design passed a 2009 preliminary review, final approval expected in 2011.

Q. How much of the telescope’s hardware is built?
A. Nearly 75% of the observatory mass is in fabrication. Mirror segment hardware development has been in progress since 2004. It includes:

- The first fully finished and tested primary mirror segment, an engineering development unit and flight spare, has been delivered to Goddard Space Flight Center. After the remaining flight segments receive the final coat, they will be sent to the X-ray and Cryogenic Facility at the Marshall Space Flight Center in Huntsville, Ala., for verification, completing the final step in the mirror manufacturing process in 2012. The first six flight mirrors have passed a vibroacoustic test simulating launch conditions.

- Manufacturing on the flight backplane, the structure that supports the mirror segments, is well underway at Alliant Techsystems (ATK). ATK has delivered the pathfinder backplane to Northrop Grumman. The pathfinder backplane is a full-scale engineering model of the flight backplane and will be used to demonstrate integration and test procedures prior to implementing them on the flight telescope.
- ITT Corp. has completed fabrication of a huge 139,000-pound, U-shaped assembly stand built to support the weight of the entire flight optical telescope, a load of more than 3.7 metric tons. It also demonstrated robotic mirror installation equipment designed to install mirror segments on the backplane.
- The telescope's sunshield moved into its fabrication and testing phase in 2010 and is continuing to make progress with a template sunshield in production. These full-size sunshield template layers are representative of the flight sunshield layers to follow.
- Engineering model builds and testing have been initiated for spacecraft subsystems. Engineering model testing was completed and flight production has begun for the spacecraft’s solid state recorder, the electronic memory that stores all science data for transmission to the ground station.

Q. How is the telescope’s performance going to be verified?
A. In a number of ways, with a core test, a simulator, and through modeling:

- In May 2009, a successful test was completed on a full-scale model of Webb’s "core" section to validate complex thermal modeling and design. The core test article was cooled passively to as low as -414 degrees Fahrenheit (slightly above absolute zero). The test article is a thermal facsimile of the Webb telescope's central region and consists of the top portion of the spacecraft bus, deployable tower, a truncated but fully tensioned five-layer sunshield, optical telescope element backplane support frame, and Integrated Science Instrument Module (ISIM) compartment.

- A full-scale simulator has been built as part of the Webb’s extensive test and verification program. The simulator, consisting of the telescope’s primary backplane assembly and the sunshield’s integrated validation article, will be used to develop the Webb telescope’s hardware design and to give technicians experience handling large elements in advance of working with the actual flight hardware. The simulator will rely on incremental verification, testing, and the use of crosschecks to ensure that the final end-to-end observatory test is a confirmation of the expected results.

- Because the fully integrated and deployed observatory will be too large for validation by actual testing, complex models of how it will behave during launch and in space environments are being integrated. The models are compared with prior test and review results from the observatory's components.

Q. What's next for the telescope?
A. Webb's three major elements – the Integrated Science Instrument Module, Optical Telescope Element and the spacecraft itself – will proceed through hardware production, assembly and testing before delivery for observatory integration and testing.

Q. How does JWST plan to finish on time and within budget?
A. NASA is re-planning the JWST program based upon findings and input from the Independent Comprehensive Review Panel (ICRP) and Testing Assessment Team (TAT), along with NASA's detailed internal assessments of progress to date and understanding of the work remaining. As part of this replan, the program will have a new launch date. The exact launch date will depend on how the technical review findings are incorporated into the program schedule and the yearly budget profile.

Q. What are the 10 new technologies developed for the Webb telescope?
A. The new technologies include:

- Cryogenic mirrors: lightweight for launch, distortion-free for excellent image quality
- Wave Front Sensing and Control: used for precision alignment of the mirror segments
- Near-IR detectors
- Mid-IR detectors: extremely sensitive to detect faint images with large-area detector arrays to efficiently survey the sky
- Cryogenic Data Acquisition Integrated Circuit: low-noise to digitize analog signals from the near IR detectors
- Large cryogenic composite mirror structure for stability and extreme precision
- Micro-shutter arrays that enable programmable object selection for the spectrograph (NIRSpec)
- Sunshield coatings of aluminum and silicon for extreme durability
- Heat switches to protect instruments from contamination during cool-down
- Pulse-tube cryocooler to keep the Mid Infrared Instrument at 7K

General Questions about Webb

Q. What advantages will Webb provide over Hubble, Spitzer and other existing telescopes?
A. The Webb telescope has a combination of large aperture, image quality and infrared sensitivity over a broad wavelength range that's not available from ground or space-based

telescopes. These features will enable Webb to see farther back in time than any other telescope and make discoveries that will re-write the world's science textbooks.

Q. **Why does Webb have a segmented, foldable primary mirror?**
A. Webb's primary mirror is too large to fit in its rocket. The mirror has to be large in order to see the faint light from the first stars and to see very small details at infrared wavelengths. Designing, building and operating a mirror that unfolds is one of the major technological developments of the Webb telescope. Unfolding mirrors will be necessary for future missions requiring even larger mirrors, and will find application in other scientific, civil and military space missions.

Q. How long will it take the Webb telescope to get to L2?
A. It will take Webb three months to reach its final orbit at the second Lagrange point, which is nearly one million miles (1.5 million km) away from Earth. Webb will start operating during its trip to L2 and complete deployment within 20 days after the launch phase is completed. The observatory will have real-time command and telemetry capability with the Deep Space Network. Critical deployment events include:

- Solar array deployment: Launch + 33 minutes
- High gain antenna deployment: Launch +1 day
- Ariane 5 burns
- Sunshield deployment
- Telescope deployment

Roles & Responsibilities

Q. What is Northrop Grumman's role in the Webb telescope?
A. In 2002, NASA selected Northrop Grumman as prime contractor to develop the James Webb Space Telescope. Northrop Grumman is designing and building the telescope and the deployable sunshield, providing the spacecraft and integrating the total system.

Q. What are the roles of the Webb subcontractors?
A. The observatory subsystems are developed by a Northrop Grumman-led team:

- Ball Aerospace, Boulder, Colo., provides the telescope's optical design and mirrors, and the wavefront sensing and control design and algorithms.
- ITT, Rochester, N.Y., integrates and tests the optical telescope.
- Alliant Techsystems (ATK), Magna, Utah, provides the telescope's composite structures.

Q. Who has overall responsibility for the telescope?
A. The National Aeronautics and Space Administration leads an international partnership that includes the European Space Agency and the Canadian Space Agency. NASA's

Goddard Space Flight Center is managing the Webb Telescope project, and the Space Telescope Science Institute is responsible for science and mission operations, as well as ground station development.

Q. What is Goddard Space Flight Center's role?
A. Goddard manages the Webb telescope project and provides components for the Integrated Science Instruments Module (ISIM): the ISIM infrastructure subsystems required for operation of these instruments. These include the ISIM Structure Subsystem; ISIM Thermal Control Subsystem; ISIM Control and Data Handling Subsystem; ISIM Flight Software, and ISIM Harness Assemblies.

Five other NASA centers are involved as well:

- Jet Propulsion Laboratory manages the Mid-Infrared Instrument.
- Ames Research Center was responsible for detector technology development.
- Johnson Space Center provides test facilities.
- Marshall Space Flight Center is responsible for mirror technology development and environmental research.
- Glenn Research Center was responsible for cryogenic component development.

Q. Who provides the Webb's four science instruments?
A. Instrument providers:

- The Mid-Infrared Instrument, or MIRI, is provided by the European Consortium under the direction of the European Space Agency (ESA), and by the NASA Jet Propulsion Laboratory (JPL).
- The Near-Infrared Camera or NIRCam, is provided by the University of Arizona under contract to NASA. The prime contractor for NIRCam is Lockheed Martin.
- The Near-Infrared Spectrograph, or NIRSpec, is provided by ESA, with components provided by NASA's Goddard Space Flight Center. The prime contractor for NIRSpec is EADS Astrium.
- The Fine Guidance Sensor, or FGS, and Tunable Filter Instrument are provided by the Canadian Space Agency. The prime contractor is COM DEV.

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