



CRS Report for Congress

Hubble Space Telescope: NASA's Plans for a Servicing Mission

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Summary

The National Aeronautics and Space Administration (NASA) estimates that without a servicing mission to replace key components, the Hubble Space Telescope will cease scientific operations in 2008. In January 2004, then-NASA Administrator Sean O'Keefe announced that the space shuttle would no longer be used to service Hubble. He indicated that this decision was based primarily on safety concerns in the wake of the space shuttle *Columbia* accident in 2003. Many critics, however, saw it as the result of the new Vision for Space Exploration, announced by President Bush in January 2004, which focuses NASA's priorities on human and robotic exploration of the solar system. Hubble supporters sought to reverse the decision and proceed with a shuttle servicing mission. Michael Griffin, who became NASA Administrator in April 2005, stated that he would reassess whether to use the shuttle to service Hubble after there were two successful post-*Columbia* shuttle flights. The second post-*Columbia* flight took place successfully in July 2006. In October 2006, NASA approved a shuttle mission to service Hubble. That mission is now scheduled for October 8, 2008.

Introduction

NASA launched the Hubble Space Telescope in 1990 aboard the space shuttle *Discovery*. Unlike other NASA space telescopes, Hubble was designed to be serviced regularly by astronauts. That design proved fortuitous when it was discovered that Hubble had a defective mirror that produced blurry images. Astronauts on the first servicing mission in 1993 were able to install corrective optics, allowing years of scientific accomplishments and generating widespread scientific and public support. Additional servicing missions were conducted in 1997, 1999, and 2002 to replace aging hardware and install advanced scientific instruments. Two more shuttle missions to Hubble were scheduled: a final servicing mission in 2004 (known as SM-4) and a retrieval mission to bring the telescope back to Earth in 2010. Following the space shuttle *Columbia* accident in February 2003, however, then-NASA Administrator Sean O'Keefe decided not to proceed with either flight. Current NASA Administrator Michael Griffin

revisited that decision once the shuttle returned to regular flight. A servicing mission is now scheduled for October 8, 2008. No retrieval mission is currently planned.

Roughly the size of a school bus, Hubble was designed to make astronomical observations of the universe in the visible, ultraviolet, and near-infrared wavelength bands. Although ground-based telescopes can also make visible and infrared observations, Hubble's location above Earth's atmosphere enhances image clarity, enabling astronomers to look at fainter, more distant objects and further back in time. Hubble is operated for NASA by the Space Telescope Science Institute (STScI) near Baltimore, MD. Websites maintained by STScI (<http://hubblesite.org/>) and NASA (<http://hubble.nasa.gov>) provide information about the telescope and its discoveries.

Hubble was designed to operate for 15 years, a milestone that was reached on April 25, 2005. NASA had planned to extend the operational period until 2010, at which time the space shuttle would bring Hubble back to Earth to prevent an uncontrolled reentry that could pose a debris risk to populated areas. Funding constraints, however, led some NASA officials to conclude that Hubble's operations should be brought to end earlier than 2010. The "funding wedge" created by ending the servicing missions would be used to build the new James Webb Space Telescope (JWST), which is being designed for infrared observations. The JWST mission was "replanned" in 2006 and is now scheduled for launch in 2013 rather than 2011. The debate over how long to continue to operate Hubble, including the linkage with funding for the JWST, was under way at the time of the *Columbia* accident.

Servicing Missions to Hubble

During servicing visits to Hubble, shuttle crews repair or replace aging equipment and install updated scientific instruments. Hubble has six gyroscopes for pointing the telescope, but two are now nonfunctional and one has degraded performance. Until August 2005, three were required to achieve the accuracy needed for scientific observations. New techniques now allow operation on just two gyroscopes, so that one is kept in reserve. Solar arrays generate electricity for the telescope; the energy is stored in batteries. Hubble has no propulsion system, relying instead on the space shuttle to boost its orbit so that it does not reenter Earth's atmosphere. The tasks for the SM-4 mission included replacing all the gyroscopes and batteries and a fine guidance sensor, emplacing new thermal protection blankets, boosting Hubble's orbit, and installing two new scientific instruments (the Cosmic Origins Spectrograph for ultraviolet observations of chemical composition, and the Wide Field Camera 3 for observations from ultraviolet through near-infrared). All these tasks are also included in the planned 2008 servicing mission.

One of Hubble's current instruments, the Advanced Camera for Surveys, malfunctioned in January 2007 and lost most of its capabilities. It was installed in March 2002 and was designed for five years of operation. Astronauts on the 2008 servicing mission will attempt to repair this instrument, even though NASA's plans did not originally call for that because of the difficulty and because the Wide Field Camera 3 will be more capable (although it will have a somewhat smaller field of view). The mission

will also attempt to repair another malfunctioning instrument, the Space Telescope Imaging Spectrograph.¹

The *Columbia* Accident and the Decision to Cancel SM-4

On February 1, 2003, the space shuttle *Columbia* disintegrated as it returned to Earth following a 16-day scientific mission. All seven astronauts aboard perished. The shuttle system was immediately grounded. NASA established the *Columbia* Accident Investigation Board (CAIB) to determine the causes of the accident and recommend corrective actions. (For more on the *Columbia* accident, see CRS Report RS21408, *NASA's Space Shuttle Program: The Columbia Tragedy, the Discovery Mission, and the Future of the Shuttle*.) It was quickly apparent that SM-4 would be delayed.

As the CAIB deliberated, NASA decided that the 2010 Hubble retrieval mission was too risky compared to the benefits. On January 16, 2004, Mr. O'Keefe informed workers at STScI and NASA's Goddard Space Flight Center (which built Hubble and oversees STScI) that he was canceling SM-4. According to the director of STScI, Dr. Steven Beckwith, Mr. O'Keefe cited several factors: the shuttle would not have the ISS as a safe haven; the changes required to meet the CAIB's recommendations regarding non-ISS related shuttle missions would not have application beyond the servicing mission, making their expense questionable; completing ISS construction by 2010 will require all the shuttle flights in that time period; Hubble's life would be extended for only a few years; and astronomers have other ground- and space-based telescopes they could use.²

Reaction to the Decision

Two days before Mr. O'Keefe announced his decision, President Bush directed NASA to embark on a new exploration initiative, requiring a shift in program and funding priorities. (See CRS Report RS21720, *Space Exploration: Issues Concerning the "Vision for Space Exploration"*.) Funding for the new initiative would come primarily from canceling, deferring, or delaying other NASA programs. Although Mr. O'Keefe stated that the Hubble decision was based primarily on shuttle safety concerns, the timing of his announcement led many commentators to conclude that it was linked to the priority shifts required by the President's initiative. While some media accounts praised the NASA Administrator for making a difficult decision, others called Hubble "the first victim" of the President's initiative and chided NASA for putting the new exploration goals ahead of the astronomical research performed with Hubble.³

¹ "NASA Announces Details of Hubble Servicing Mission," NASA press release 08-001, January 8, 2008.

² See [<http://www.stsci.edu/resources/sm4cancellation/sm4meeting.html>].

³ For example, see "Sacrificing Hubble," *Space News*, January 26, 2004, p. 12; and Brian Berger, "Canceled Hubble Repair the First Victim of New NASA Vision," *Space News*, January 26, 2004, p. 6.

Servicing Options

Initial opposition to the cancellation of SM-4 focused on attempts to reverse Mr. O’Keefe’s decision and proceed with a shuttle mission. The debate centered on comparing the risk of a mission to Hubble with the risk of a mission to the ISS. Shortly after the cancellation decision, NASA’s then-Chief Scientist, Dr. John Grunsfeld, an astronaut who was a member of the 1999 and 2002 Hubble servicing crews, commented that if a shuttle mission to Hubble were mounted, it would be necessary to have a second shuttle ready to launch in case the first one encountered difficulties.⁴ NASA has had a backup shuttle available for each of the shuttle launches since the *Columbia* accident, but may not for all future missions if safety modifications continue to work well.

Attention soon shifted to robotic servicing options, which dominated the public discussion of Hubble’s future throughout most of 2004. At a Senate Appropriations VA-HUD-IA Subcommittee hearing on March 11, 2004, Mr. O’Keefe agreed with a request from Senator Mikulski to ask the National Research Council (NRC) to study options for extending Hubble’s life, including both shuttle and robotic missions.

In November 2004, Congress passed the FY2005 Consolidated Appropriations Act (P.L. 108-447), which provided \$291 million for a Hubble servicing mission. The conference report (H.Rept. 108-792) stated that “a successful servicing mission to Hubble should be one of NASA’s highest priorities.” The report language did not specify whether the servicing mission should involve the space shuttle or a robotic mission.

The final NRC report on servicing options, released on December 8, 2004, found it “unlikely that NASA will be able to extend the science life of [Hubble] through robotic servicing” and that the risk of a shuttle mission to Hubble is similar to the risk of a single shuttle mission to the ISS. The report recommended a shuttle servicing mission, and a robotic mission only for deorbiting the telescope at the end of its useful lifetime.⁵ The robotic servicing option was off the table.

Shuttle Servicing Revisited

Dr. Michael Griffin was sworn in as NASA Administrator, replacing Mr. O’Keefe, on April 14, 2005. At his Senate confirmation hearing on April 12, 2005, Dr. Griffin stated that he would revisit the question of whether to use the shuttle to service Hubble after the second successful post-*Columbia* shuttle flight, at which time NASA would be able to assess the risk factors associated with “essentially a new vehicle”. The NASA Authorization Act of 2005 (P.L. 109-155), enacted in December 2005, called for a shuttle servicing mission after the shuttle returned to flight successfully “unless such a mission would compromise astronaut safety.” The second post-*Columbia* flight took place successfully in July 2006. In October 2006, NASA announced that a Hubble servicing

⁴ Quoted in Brian Berger, “Canceled Hubble Repair the First Victim of New NASA Vision,” *Space News*, January 26, 2004, p. 6.

⁵ National Research Council, *Assessment of Options for Extending the Life of the Hubble Space Telescope*, National Academies Press, 2005. Online at [<http://books.nap.edu/catalog/11169.html>].

mission will indeed take place. The launch is now scheduled for October 8, 2008, on space shuttle *Atlantis*.

In October 2006, Administrator Griffin stated that the “cradle to grave” cost of the servicing mission will be \$900 million: \$500 million to keep the Hubble team together from 2004 through 2008; \$200 million for the gyroscopes, batteries, and instruments that will be installed; \$100 million for external tanks and solid-rocket boosters for the additional shuttle flight; and \$100 million for shuttle launch processing.⁶

Hubble Operations After Servicing

NASA expects that if the 2008 servicing mission is successful, Hubble will continue to operate until 2013, rather than being deorbited in 2010 as previously planned. According to one NASA official, “Hubble’s most impressive accomplishments ... lie in its future.”⁷ The cost of the additional years of operation, however, may affect funding and scheduling for other astronomy missions. For example, to offset the funding that Congress provided for Hubble in FY2005, NASA’s May 2005 operating plan postponed two other astronomy missions and reduced funding for Mars exploration. Before the *Columbia* accident, the end of Hubble expenditures was expected to be a source of funding for the James Webb Space Telescope. According to NASA’s FY2009 congressional budget justification, Hubble costs are expected to be \$115 million in FY2011, \$95 million in FY2012, and \$94 million in FY2013, not including certain indirect costs.

Deorbiting Hubble

Plans for deorbiting Hubble remain uncertain. Before the *Columbia* accident, the space shuttle was to return Hubble to Earth at the end of its lifetime, but there is no longer any expectation of retrieval by the shuttle, whether or not the servicing mission in 2008 is successful. Hubble has no propulsion system of its own, however, so if it is not retrieved, a propulsion module would need to be attached to it to permit a controlled deorbit (that is, to ensure that any debris falls in an unpopulated area such as the Pacific Ocean). Analysis by NASA in 2005 indicated that Hubble is unlikely to make an uncontrolled reentry until at least 2020, rather than 2012 as previously believed, and the agency now considers the deorbiting issue to be “beyond the budget horizon.”⁸ Boosting Hubble’s orbit during the 2008 servicing mission will delay the date of reentry even further, but at some point, deorbiting will be necessary if an uncontrolled reentry is to be avoided.

⁶ Clinton Parks and Brian Berger, “NASA’s Mission to Service Hubble in 2008 Will Cost \$900 Million”, *Space News*, October 31, 2006.

⁷ Alan Stern, Associate Administrator for the Science Mission Directorate, quoted in “NASA Announces Details of Hubble Servicing Mission,” NASA press release 08-001, January 8, 2008.

⁸ NASA FY2007 congressional budget justification, p. SAE SMD 3-20.

Credit: NASA > Larger ImageOriginally planned for Earth return on the Shuttle, Hubble's scientific life will now extend beyond the planned retirement date of the Shuttle in 2010. As part of Servicing Mission 4, engineers have developed the Soft Capture and Rendezvous System, or SCRS, which will enable the future rendezvous, capture, and safe disposal of Hubble by either a crewed or robotic mission. The SCRS greatly increases the current Shuttle capture interfaces on Hubble, therefore significantly reducing the rendezvous and capture design complexities associated with the disposal mission. The official Facebook account for the NASA Hubble Space Telescope, managed and operated by NASA's Goddard... This galaxy was observed for a Hubble study on galactic bulges, the bright round central regions of spiral galaxies. Spiral galaxies like IC 2051 are shaped a bit like flying saucers when seen from the side; they comprise a thin, flat disk, with a bulky bulge of stars in the center that extends above and below the disk. The fifth and final Hubble servicing mission, Shuttle mission STS-125, was originally planned as an 11-day assignment to replace two instruments, hopefully fix two more and replace gyros, batteries and other components crucial for the NASA/ESA Hubble Space Telescope's continued success through to the year 2014. This mission, named Servicing Mission 4, or SM4 (since SM3 was split in two missions) almost failed to materialise. In the wake of the Columbia Space Shuttle tragedy in 2003, NASA officials decided that astronauts had to be able to reach a safe haven in case any damage caused to a shutt