

# CRS Report for Congress

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## Hubble Space Telescope: Should NASA Proceed with 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 instead of 2010. 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 NASA, announced by President Bush in January 2004, which focuses NASA's priorities on human and robotic exploration of the solar system. Hubble supporters hope to reverse the decision and proceed with a shuttle servicing mission. Developing a capability for robotic servicing has also been proposed, but now appears unlikely. Dr. Michael Griffin, who became NASA Administrator in April 2005, has stated that he will reassess whether to use the shuttle to service Hubble after there have been two successful post-*Columbia* shuttle flights. Problems during the first flight in July 2005 led to indefinite postponement of the second until some time in 2006. This report will be updated.

### 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: another 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 plans to revisit that decision once the shuttle returns to flight.

## **The Hubble Space Telescope**

Roughly the size of a school bus, the Hubble Space Telescope 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 the 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 ([\[http://hubblesite.org/\]](http://hubblesite.org/)) and NASA ([\[http://hubble.nasa.gov\]](http://hubble.nasa.gov)) provide information about the telescope and its discoveries.

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 recently, three were required to achieve the accuracy needed for scientific observations. New techniques implemented in August 2005 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).

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 debate over how long to continue to operate Hubble, and linkage with funding for the JWST, was under way at the time of the *Columbia* accident.

## **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. (CRS Report RS21408, *NASA's Space Shuttle Program: The Columbia Tragedy, the Discovery Mission, and the Future of the Shuttle*, by Marcia Smith, discusses the *Columbia* accident.)

It was quickly apparent that SM-4 would be delayed. As CAIB deliberated, NASA decided that the 2010 Hubble retrieval mission was too risky compared to the benefits. The agency began investigating alternatives for a controlled deorbit of the telescope so that any debris would fall in an unpopulated area such as the Pacific Ocean.

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.<sup>1</sup>

## 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’*, by Marcia Smith.) 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.<sup>2</sup>

In a letter to Mr. O’Keefe on January 21, 2004, Senator Mikulski asked the Administrator to reconsider his decision and appoint an independent panel to assess the issues involved. Mr. O’Keefe initially declined. Later the two agreed that Adm. Harold Gehman (Ret.), who chaired CAIB, would be invited to “offer his unique perspective.”<sup>3</sup> In a letter to Senator Mikulski on March 5, 2004, Adm. Gehman stated that “shuttle flights are dangerous and we should fly the minimum number necessary” but that “only a deep and rich study of the entire gain/risk equation can answer the question of whether an extension of the life of the wonderful Hubble Telescope is worth the risks involved.”<sup>4</sup>

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<sup>1</sup> See [<http://www.stsci.edu/resources/sm4cancellation/sm4meeting.html>].

<sup>2</sup> For example, see “Sacrificing Hubble,” *Space News*, Jan. 26, 2004, p. 12; and Brian Berger, “Canceled Hubble Repair the First Victim of New NASA Vision,” *Space News*, Jan. 26, 2004, p. 6.

<sup>3</sup> Letter from NASA Administrator O’Keefe to Sen. Mikulski, Jan. 28, 2004.

<sup>4</sup> See [<http://mikulski.senate.gov/Newsroom/GehmanReview.pdf>].

## 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.<sup>5</sup> NASA had a backup shuttle ready for the first shuttle launch after return to flight, and plans to have one for the second, but not for subsequent missions if safety modifications appear to be working 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.<sup>6</sup> Robotic servicing now appears to be 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 was very familiar with the robotic servicing option and did not think it was feasible within the required time frame. He added that he will revisit the question of whether to use the shuttle to service Hubble after the second successful post-RTF shuttle flight, at which time NASA will be able to assess the risk factors associated with “essentially a new vehicle”. The House and Senate NASA authorization bills (H.R. 3070 and S. 1281) would both call for a shuttle servicing mission after the shuttle returns to flight successfully “unless such a mission would compromise astronaut safety”; they would also both require a status report on servicing plans within 60 days of the landing

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<sup>5</sup> Quoted in Brian Berger, “Canceled Hubble Repair the First Victim of New NASA Vision,” *Space News*, Jan. 26, 2004, p. 6.

<sup>6</sup> 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>].

of the second successful post-RTF flight. Problems during the first post-RTF flight in July 2005 led to indefinite postponement of the second until some time in 2006.

Because Dr. Griffin's decision to reconsider a shuttle mission to Hubble came after the release of the FY2006 budget, its cost was not included in the budget request. The FY2006 budget amendment submitted on July 15, 2005, requested \$30 million for Hubble, but this was only to preserve the option of a shuttle servicing mission, and does not reflect the full cost of servicing Hubble if a decision is made to proceed. The House-passed FY2006 appropriations bill (H.R. 2862) applauded the decision to reassess SM-4 but did not specify a funding level. The Senate version provided \$250 million. The House authorization bill (H.R. 3070) authorized \$150 million for FY2006. The Senate authorization bill (S. 1281) did not specify a funding level. According to the Government Accountability Office (GAO), NASA estimated in late 2004 that a shuttle servicing mission would cost between \$1.7 billion and \$2.4 billion. GAO described this estimate as "not yet definitive".<sup>7</sup> It is considerably more than pre-*Columbia* estimates that were in the vicinity of \$100 million plus the marginal cost of a shuttle launch.

## Deorbiting Hubble

Plans for deorbiting Hubble also 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, even if there is a shuttle servicing mission. Hubble has no propulsion system of its own, however, so a propulsion module must be attached to the spacecraft to permit a controlled deorbit. Remotely attaching the required new hardware is technologically challenging. If there is a shuttle servicing mission, a deorbit module could be attached at that time. According to press reports in August 2005, new analysis by NASA indicates that Hubble is unlikely to make an uncontrolled reentry until 2020, rather than 2012 as previously believed, and the agency is considering foregoing a deorbit module in the near term.<sup>8</sup> Boosting Hubble's orbit during a shuttle servicing mission could delay the date of reentry even further, but at some point, deorbiting will be necessary if an uncontrolled reentry is to be avoided.

## Key Questions for Congress

If there is no successful servicing mission, Hubble's lifetime is likely to be limited by the failure of its gyroscopes and batteries.<sup>9</sup> Both systems wear out over time, and historical experience permits projections of their future performance. The NRC study estimated that science operations would likely cease in about September 2007 as the result of gyroscope failures. Now that Hubble is operating on two gyroscopes rather than three,

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<sup>7</sup> Government Accountability Office, *Space Shuttle: Costs of Hubble Servicing Mission and Implementation of Safety Recommendations Not Yet Definitive*, GAO-05-34, Nov. 2004.

<sup>8</sup> Brian Berger, "Griffin Likely to Delete Deorbit Module from Hubble," *Space News*, Aug. 29, 2005, p. 6.

<sup>9</sup> In some scenarios, the limiting factors might instead be the failure of Hubble's fine guidance sensors or its avionics system.

NASA believes that this date can be extended until mid-2008.<sup>10</sup> Servicing could still restart operations after science operations cease. However, the NRC also estimated that battery degradation would result in permanent structural damage in about May 2011, and perhaps as soon as December 2009 in the worst case. (A minimum level of battery power is required to keep Hubble warm and prevent warping of the optical system.) Servicing after this date would not be successful. NASA estimates that if left unattended, Hubble will make an uncontrolled reentry in about 2020.

As Congress continues to review this issue, the following questions may arise:

- How much would a shuttle servicing mission cost? What other programs would be cut to pay for it? (To offset the \$291 million that Congress provided for Hubble in FY2005, NASA's May 2005 operating plan postponed two other astronomy missions and reduced funding for Mars exploration.) What is the risk to the shuttle astronauts? Is the science to be gained worth the cost and risk?
- If Hubble is serviced, it is expected to operate for about five more years, rather than being deorbited in 2010 as previously planned. How much will operations after 2010 cost, and how might those costs affect other astronomy missions, such as JWST?
- Whether or not there is a servicing mission, NASA says it is committed to building a rocket that can be attached to Hubble to achieve a controlled deorbit at the end of Hubble's useful lifetime. How much will that cost, when will it be needed, and can it be ready in time? If there is a servicing mission, will it include attaching the deorbit module? If so, will that mean eliminating some of the previously planned servicing tasks? If not, when and how will the module be attached?
- If the Cosmic Origins Spectrograph and the Wide Field Camera 3 are not installed on Hubble, what will be their fate? On July 29, 2004, NASA selected a mission concept called the Hubble Origins Probe for further study. This probe would incorporate the two new instruments, independent of the Hubble telescope. How much would such a mission cost, and how would its capabilities compare with those of the Hubble telescope?
- To what extent could astronomers use ground-based telescopes instead of Hubble? To what extent could they use other space telescopes, such as JWST or the Spitzer Space Telescope? To what extent could they rely on analyzing the archive of data already collected by Hubble? (Approximately five years of Hubble data have yet to be analyzed.)

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<sup>10</sup> "Hubble Space Telescope Begins 'Two-Gyro' Science Operations", NASA press release, August 31, 2005.