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Hubble Space Telescope – Servicing Missions

Of the thousands of working spacecraft orbiting Earth, two were launched with the intention of being serviced while in orbit: NASA's Hubble Space Telescope and the International Space Station. Hubble was specifically designed for servicing so that as technologies advanced on the ground and components wore out in the hostile environment of space, upgrades and repairs could extend the telescope's scientific life. Hubble was launched into space in April 1990 with an anticipated lifespan of about 15 years.

Astronauts visited Hubble five times to replace or repair computers, electronics, batteries, gyroscopes, and insulation, and to change out science instruments with newer, more powerful technologies. These visits left Hubble in renewed condition and with expanded reach into the cosmos. In the year 2020, Hubble marked its 30th year of exploration, a direct result of servicing missions. It continues to conduct ground-breaking science today.

The Telescope Workplace

While Hubble was designed to be serviced, space is a dangerous environment, and astronauts are challenged by bulky spacesuits that limit movement and line of sight. Careful preparation and planning went into each extravehicular activity (EVA), or "spacewalk." Hubble servicing missions required specialized tools and carefully choreographed procedures to ensure that the astronauts could safely and swiftly accomplish many tasks over the course of a spacewalk. Astronauts made their way around Hubble using yellow handrails, whose color indicated they were safe for grasping, while being careful to avoid keep-out zones and no-touch surfaces. Working in pairs, spacewalking astronauts helped each other prevent inadvertent contact with delicate structures. For every hour a spacewalking astronaut spent working on Hubble, they trained and prepared for approximately 10-16 hours on the ground.

Servicing Mission 1 (SM1): Dec. 2-13, 1993

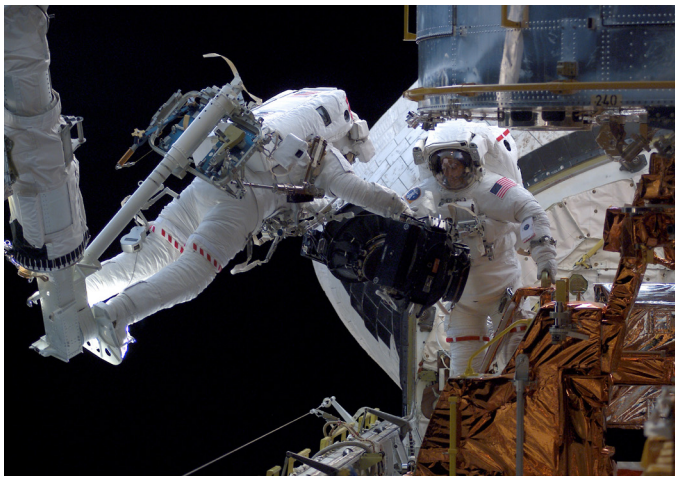
After Hubble's launch in 1990, NASA learned that the telescope's primary mirror had a slight flaw that blurred its vision. Space shuttle flight STS-61 was the first opportunity to correct the distortion and service the telescope. Astronauts installed two new instruments: the Corrective Optics Space Telescope Axial Replacement (COSTAR), which acted as a contact lens for Hubble's flawed mirror, and the Wide Field and Planetary Camera 2 (WFPC2), which had corrective optics built in and replaced the original Wide Field and Planetary Camera instrument. In addition, SM1 included the installation and replacement of other components, including solar arrays and two Rate Sensor Units with gyroscopes. Since the first servicing mission, every instrument added to Hubble was designed to compensate for the mirror flaw, allowing COSTAR to eventually be removed during Servicing Mission 4.

Crew: Richard O. Covey (Commander), Kenneth D. Bowersox (Pilot), Tom Akers, Jeffrey A. Hoffman, F. Story Musgrave, Claude Nicollier (ESA), Kathryn C. Thornton

Servicing Mission 2 (SM2): Feb. 11-21, 1997

STS-82 made significant improvements to Hubble's productivity. The installation of two new instruments—the Space Telescope Imaging Spectrograph (STIS) and the Near Infrared Camera and Multi-Object Spectrometer (NICMOS)—extended Hubble's wavelength range into the near-infrared for imaging and spectroscopy, allowing scientists to probe the most distant reaches of the universe. The replacement of several components, including a Fine Guidance Sensor (FGS), Reaction Wheel Assembly, and solid-state data recorder, increased efficiency and performance.

Crew: Kenneth D. Bowersox (Commander), Scott J. Horowitz (Pilot), Gregory J. Harbaugh, Steven A. Hawley, Mark C. Lee, Steven L. Smith, Joseph R. Tanner



Astronaut Michael J. Massimino, secured to the space shuttle Columbia's robotic arm, works on a reaction wheel with astronaut James H. Newman during SM3B. Credit: NASA

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Servicing Mission 3A (SM3A): Dec. 19-27, 1999

What was originally conceived as a mission of preventive maintenance turned more urgent on November 13, 1999, when the fourth of Hubble's six gyroscopes failed. At that time, Hubble needed at least three of its stabilizing gyroscopes to conduct science. Hubble went into a dormant "safe mode" while the telescope waited for repairs. NASA split the third servicing mission into two parts, beginning with STS-103, to more quickly bring Hubble back into operation. The new, improved, and upgraded equipment included six fresh gyroscopes; six battery voltage/temperature improvement kits; a faster, more powerful, main computer; a solid-state data recorder; a new transmitter; an enhanced Fine Guidance Sensor; and new thermal insulation.

Crew: Curtis L. Brown, Jr. (Commander), Scott J. Kelly (Pilot), Jean-François Clervoy (ESA), C. Michael Foale, John M. Grunsfeld, Claude Nicollier (ESA), Steven L. Smith

Servicing Mission 3B (SM3B): March 1-12, 2002

During the fourth mission to service Hubble, STS-109 astronauts replaced Hubble's solar panels with rigid and more powerful solar arrays and installed the Advanced Camera for Surveys (ACS) in place of the Faint Object Camera (FOC), the telescope's last original instrument. They also replaced the spacecraft's original Power Control Unit (PCU), which had been on the job for 11 years, requiring Hubble to be completely powered down for the first time since its launch in 1990.

Crew: Scott D. Altman (Commander), Duane G. Carey (Pilot), Nancy J. Currie, John M. Grunsfeld, Richard M. Linnehan, Michael J. Massimino, James H. Newman

Servicing Mission 4 (SM4): May 11-24, 2009

The Hubble Space Telescope was reborn after Servicing Mission 4 (SM4). During STS-125, astronauts installed two new scientific instruments: the Cosmic Origins Spectrograph (COS) and Wide Field Camera 3 (WFC3). Two instruments that had experienced electronic failures, STIS and ACS, were revived by creative and complex in-orbit repairs that had not been anticipated when the telescope was designed. With these efforts, Hubble reached the apex of its scientific capabilities. To prolong Hubble's life, astronauts also installed new batteries, new gyroscopes, a new science computer, a refurbished Fine Guidance Sensor, and new insulation on three electronics bays. Additionally, astronauts attached a soft-capture mechanism to the base of the telescope to assist NASA in safely deorbiting Hubble at the end of its life.

Crew: Scott Altman (Commander), Gregory C. Johnson (Pilot), Andrew J. Feustel, Michael T. Good, John M. Grunsfeld, Michael J. Massimino, K. Megan McArthur

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