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Servicing History and Long-Term Plans

Why Service Rather Than Replace?

When NASA planners first began studies into the idea of placing an optical telescope in orbit free of obscuration from the Earth's atmosphere, they soon came up with the idea of on-orbit servicing. With servicing, they agreed, recurring development costs of placing a basic scientific platform in low Earth orbit would be reduced while still retaining the basic platform capabilities of high precision optics. In addition, a space telescope platform could be maintained and the science capabilities enhanced with new instruments and upgraded control subsystems over time. They further agreed that servicing served to maximize the scientific return on the dollar investment and allowed a consistent level of scientific activity over a longer period of time. Replacement of the spacecraft and its instruments, they indicated, would require basic redesign and fabrication, increasing costs considerably. Moreover, at the time, the development of the Hubble Space Telescope (HST) coincided with the development of NASA's space shuttle program, which promised a capable and efficient transportation system for servicing HST.

How Often Is Servicing Necessary?

When originally planned in 1979, HST program requirements called for ground return, refurbishment and relaunch every five years, with on-orbit servicing every 2.5 years. Hardware lifetime and reliability requirements were based on that 2.5-year interval between servicing missions. In 1985, contamination and structural loading concerns associated with return to Earth aboard the shuttle resulted in the concept of ground refurbishment being dropped from the HST program. At that time, officials recognized that on-orbit servicing would be adequate to maintain HST for its design life of 15 years. A three-year cycle of on-orbit servicing was adopted, and servicing missions are planned for December 1993, early 1997, mid-1999 and mid-2002. A possibility exists that contingency flights could be added to the schedule to perform specific tasks that cannot wait for the next regularly scheduled servicing mission, planned for 1997, or are required to complete tasks that were scheduled but not performed on a given servicing mission.

Plans For the First Servicing Mission Prior To Launch

HST program and project officials developed plans to install a second-generation Wide Field/Planetary Camera (WF/PC II) even before the launch of the observatory in April 1990. The WF/PC I showed great promise for astronomers--a promise which, incidentally, has proved to be quite justified, according to many astronomers--and the WF/PC II with enhanced visible and ultraviolet imaging capabilities already was under development at the Jet Propulsion Laboratory (JPL), Pasadena, Calif., where WF/PC I had been developed. Thus, even before Hubble was launched, the replacement of the Wide Field/Planetary Camera with a second generation instrument was planned as a primary activity for the first servicing mission. Secondary activities were to be defined based on performance of the instruments and subsystems after launch. An inventory of spare HST hardware already had been developed to support secondary servicing hardware activities. The HST servicing budget was sized to maintain the spare hardware, to sustain hardware expertise, to plan and develop servicing activities and to test and integrate the payload with the space shuttle. The yearly servicing budget was set at $120 million.

How Did Plans Change For The First Servicing Mission?

Immediately after launch, two primary problems surfaced: primary mirror spherical aberration, which severely affected optical images, and solar array-induced jitter, which also affected the quality of science data. With the spherical aberration, metrology of the reflective null corrector used to test the primary mirror, combined with data from star images obtained from the HST on orbit, allowed the radially-symmetric aberration to be well characterized and the prescription of the primary mirror to be determined accurately. Well-characterized radially-symmetric spherical aberration meant that the flaw could be corrected by polishing the opposite surface correction into an optical element, or mirror, and placing that optical element into the optical trains (optical paths) of the instruments at the location where the image from the primary mirror appears. With the solar array jitter, the thermal deformation and stick-slip mechanisms introduced in the solar array due to day/night and night/day transitions were characterized through on-orbit and ground testing, and modifications made to the design of the solar array bi-stem supports and mechanisms.

Because of the aberration in HST's primary mirror, WF/PC II was modified to include corrective optics in its relay optics assembly. A Corrective Optics Space Telescope Axial Replacement (COSTAR) instrument was designed and built (Ball Aerospace, Boulder, Colo.) to introduce corrective optics into the optical paths of the Goddard High Resolution Spectrograph (GHRS), the Faint Object Camera (FOC), and the Faint Object Spectrograph (FOS) through its integration into the spacecraft in place of the High Speed Photometer (HSP), which will be returned to Earth. Failures experienced in the DF-224 control computer memory, rate gyro assemblies, magnetic sensing system and GHRS since launch have caused additional activities to be added to the first servicing mission.

As a result, first servicing mission activities include:

- Solar Arrays Replacement
- WF/PC II Installation
- COSTAR Installation
- GYRO Replacement
- Computer Augmentation (Co-Processor)
- Magnetic Sensing System Replacement (Magnetometer)
- GHRS Repair Kit

All hardware modifications, new hardware development, and first servicing mission planning and development have been accomplished within the original servicing cost budget, according to NASA officials. The total cost for the first servicing mission will be approximately $250 million, excluding shuttle launch costs, they said.

The Hubble Space Telescope project is managed by the Goddard Space Flight Center, Greenbelt, Md for the Office of Space Science, NASA Headquarters, Washington, DC.