Hubble Facts

National
Aeronautics and
Space
Administration

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Hubble Space Telescope Second Servicing Mission (SM-2)

Hubble's Next Challenge

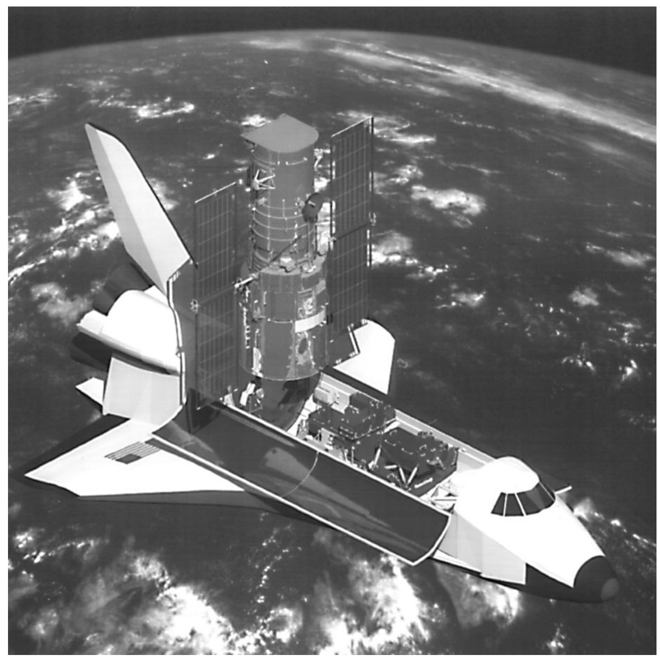
Discovery is set to lift off from the Kennedy Space Center, Cape Canaveral, Fla. in early 1997 on a ten-day mission to service the Hubble Space Telescope (HST). Mission STS-82 marks the second servicing mission of Hubble since the telescope was deployed in April 1990.

Hubble has revolutionized astronomers' vision of the universe more than any prior telescopes. Many new details about planets, stars, and galaxies have been revealed in the short span of six years: Hubble provided us with dramatic and detailed views of comet fragments smashing into Jupiter; we now have more clues about the existence of black holes in the core of galaxies; and thanks to Hubble, significant progress has been made in determining the age and size of the universe.

Now, with astronauts geared to embark on another mission to service the telescope, we can expect to see even deeper into our universe. Astronauts will install two new astronomy instruments and replace other hardware. This servicing will render the telescope more scientifically powerful than ever.

Mission Success Criteria

The objectives of the second Hubble servicing mission are to improve Hubble's productivity: to extend HST's wavelength range into the near infrared for imaging and spectroscopy, to greatly increase the efficiency of spectrographic science and to replace failed or degraded spacecraft components.



The payload complement for the mission includes three categories of items: 1. Science Instruments to enhance science productivity, 2. Primary spacecraft maintenace items and 3. Secondary spacecraft maintenance items.

New Science Instruments

The Space Telescope Imaging Spectrograph (STIS) provides unique and powerful spectroscopic capabilities for the HST. A spectrograph separates the light gathered by the telescope into its spectral components so that the composition, temperature, motion, and other chemical and physical properties can be analyzed.

STIS's two-dimensional detectors allow the instrument to gather 30 times more spectral data and 500 times more spatial data than existing spectrographs on Hubble which look at one place at a time. One of the greatest advantages to using STIS is in the study of supermassive black holes.

STIS will search for massive black holes by studying the star and gas dynamics around galactic centers. It will measure the distribution of matter in the universe by studying quasar absorption lines, use its high sensitivity and spatial resolution to study star formation in distant galaxies and perform spectroscopic mapping of solar system objects.

The Near Infrared Camera and Multi-Object Spectrometer (NICMOS) promises to gain valuable new information on the dusty centers of galaxies and the formation of stars and planets. NICMOS consists of three cameras. It will provide the capability for infrared imaging and spectroscopic observations of astronomical targets.

NICMOS will give astronomers their first clear view of the universe at near-infrared wavelengths between 0.8 and 2.5 micrometers—longer wavelengths than the human eye can see. The expansion of the universe shifts the light from very distant objects toward longer red and infrared wavelengths.

NICMOS's near infrared capabilities will provide views of objects too distant for research by current Hubble optical and ultraviolet instruments. NICMOS's detectors perform more efficiently than previous infrared detectors.

Primary Spacecraft Hardware

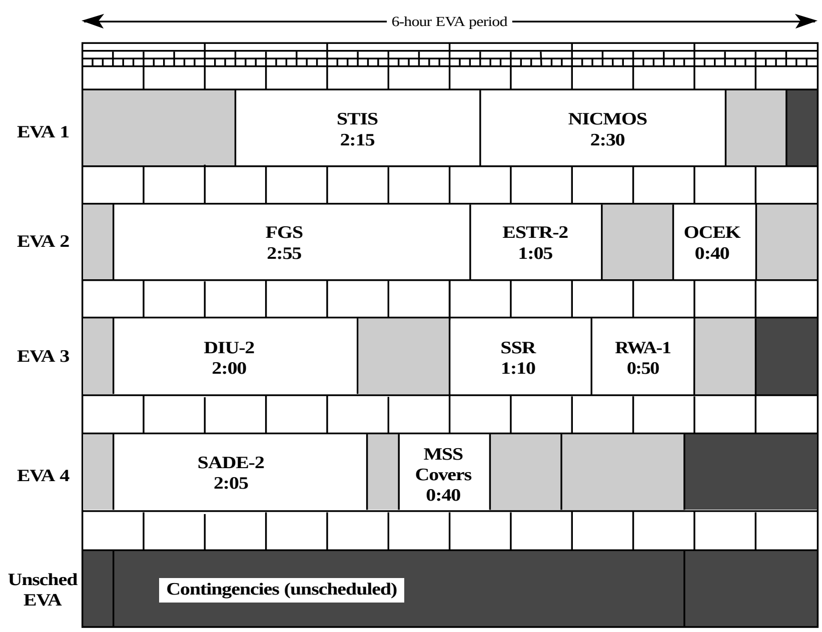
In addition to installing the new science instruments, astronauts will replace existing hardware with upgrades. Hubble will get a refurbished Fine Guidance Sensor (FGS), an optical sensor that is used on HST to provide pointing information for the spacecraft and as a scientific instrument for astrometric science. The modification to this FGS spare will add the capability for ground-controlled alignment corrections.

The addition of the Optical Contol Electronics Enhancement Kit (OCE-EK) will provide the electronic pathway for commanding the alignment mechanisms. The Solid State Recorder (SSR) will replace one of HST's three Engineering Science Tape Recorders (ESTR). The SSR provides much more flexibility than an ESTR, which is a reel-to-reel recorder and can store ten times more

HST SM-2 EVA Scenario

	Task Times (stand-alone)
1. 1st-SI {NICMOS (FOS)}	2:30
2. FGS (FGS-1)	2:55
3. 1st-DR {SSR (ESTR-1)}	1:10
4. 2nd-SI {STIS (GHRS)}	2:15
5. RWA (RWA-1)	0:50
6. DIU-2	2:00
7. 2nd-DR {ESTR-2}	1:05
8. OCE Kit	0:40
9. SADE-2	2:05
10. MSS Covers	0:40

Required Setup	Task Times
Setup	1:00 (1st day)
	0:15 (nth day)
Closeup	0:30 (nth day)
	1:00 (last day)



*Schedule is subject to change

data. One of the other ESTRs will also be replaced but with with a spare ESTR unit. Future missions may see all the reel-to-reel units replaced with solid state recorders.

One of Hubble's four Reaction Wheel Assemblies (RWA) will be replaced by a refurbished spare. The RWA is part of Hubble's Pointing Control System. Spin momentum in the wheels moves the telescope to a target and maintains it in a stable position.

Secondary Spacecraft Hardware

Four Data Interface Units (DIU) on HST provide command and data interfaces between the spacecraft's data management system and the other HST subsystems. DIU-2 will be replaced with a spare unit that has been modified and upgraded to correct for failures that occured in the original unit.

The Solar Array Drive Electronics (SADE) controls the positioning of the solar arrays. HST has two SADEs, one unit was replaced during the first servicing mission. The unit that was returned from orbit has been refurbished to correct for problems that resulted in transistor failures and will be used to replace the second unit, SADE-2. The SADEs are provided by the European Space Agency, NASA's partner in the Hubble program.

Work on the Magnetic Sensing System (MSS) on Hubble during the first servicing mission required the astronaut crew to construct protective covers for the hardware using materials that were available on the Shuttle. Some of this material is degrading in the space environment and will require the installation of more durable covers during the second servicing mission.

The crew will take more than 150 other crew aids and tools on this mission. They range from a simple bag for carrying some of the smaller tools to sophisticated, battery-operated power tools.

The HST was designed to allow new instruments to be easily installed as old ones become obsolete. Components will be changed out by astronauts conducting EVAs (extravehicular activity) or spacewalks.

Doing the Job

A seven-member crew has been selected for this mission. Four astronauts will conduct the planned spacewalks: Mark Lee, Gregory Harbaugh, Steven Smith and Joseph Tanner are part of the extravehicular activity crew. Kenneth Bowersox is the commander, Scott Horowitz is the pilot, and Steven Hawley is the Remote Manipulator System Operator.

The EVA crew will make at least four spacewalks. Training for this mission began nearly two years prior to launch. Astronauts train extensively at the Johnson Space Center in Houston, Texas in its 25-foot deep Weightless Environment Training Facility; at the Marshall Space Flight Center in Huntsville, Ala., in a 40-foot deep Neutral Buoyancy Simulator; and at Goddard Space Flight Center in Greenbelt, Md., in a 12,500 square-foot cleanroom.

A Glance at the Past

The HST is a joint project between NASA and the European Space Agency. There were great expectations for HST after is was launched in 1990. Because it did not have the distorting effects of Earth's atmosphere, it was expected to easily surpass the capabilities of ground-based telescopes. However, two months after the HST was released into orbit, engineers discovered that the telescope's 2.4-meter (94 inch) main mirror was flawed. The mirror was too flat near the edge by about 1/50th the width of a human hair. Instead of light being focused to a sharp point, light collected by the mirror spread into a fuzzy halo. Computer processing was used to sharpen the images.

To realize its full potential the telescope had to be repaired. The mirror itself couldn't be fixed or changed; so NASA had to develop corrective optics for HST's instruments, much like eyeglasses used to correct human sight. A new camera, called the Wide Field & Planetary Camera-2, had its corrective optics built right in. To correct the telescope's other instruments, engineers devised a special instrument, called the COSTAR

(Corrective Optics Space Telescope Axial Replacement) that would use mechanical arms to place pairs of small mirrors in front of the openings of the telescope's remaining three instruments. Each pair of mirrors was shaped to properly refocus light from the flawed main mirror.

That first servicing mission, on Dec. 2, 1993, was the most difficult and challenging spacecraft repair mission ever attempted. It was an eleven-day mission that included a record five EVAs.

Technological Advances

Besides rapidly advancing our understanding of the universe, the HST is making direct contributions to the health, safety, and quality of our lives through a variety of technological spinoffs.

A new, non-surgical breast biopsy technique using a device originally developed for HST's Imaging Spectrograph (STIS), is now saving women pain, scarring, radiation exposure, time and money. This technique, called stereotactic automated large-core needle biopsy, enables a doctor to precisely locate a suspicious lump and use a needle instead of a scalpel to remove tissue for study. This precise process is possible because of a key improvement in digital imaging technology known as a Charge Coupled Device or CCD.

Looking Toward the Future

The HST was designed to operate for 15 years. But like many of NASA's other observatories that have exceeded their projected operating years, HST will likely deliver new science for a long time. As long as the HST continues to rewrite astronomy text books, and as long as funds are available, NASA will likely continue to operate the telescope. So far, two more reservicing missions are planned for 1999 and 2002 to keep the telescope functioning efficiently and to improve its scientific capability.

HST Facts

Payload:	Hubble Space Telescope Servicing Mission-2 (HST SM-2)
Launch Date:	Feb. 13, 1997
Orbiter:	OV-103 Discovery (Flight 22)
Inclination:	28.45 degrees
Rendezvous Altitude:	Approximately 320 nautical miles
Flight Duration:	10 days
Number of EVAs:	4 scheduled (+ 1 unscheduled available)
Crew Size:	7

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