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Table 4–50. Hubble Space Telescope Development

Date	Event
1940	Astronomer R.S. Richardson speculates on the possibility of a 300-inch telescope placed on the Moon's surface.
1960/1961	The requests for proposal (RFP) for the Orbiting Astronomical Observatory spacecraft and the astronomical instruments to be flown aboard them are issued.
1962	The National Academy of Sciences recommends the construction of a large space telescope.
1965	The National Academy of Sciences establishes a committee to define the scientific objectives for a proposed large space telescope.
1968	The first astronomical observatory, the Orbiting Astronomical Observatory-1, is launched.
1972	The National Academy of Sciences again recommends a large orbiting optical telescope as a realistic and desirable goal.
1973	NASA establishes a small scientific and engineering steering committee headed by Dr. C. Robert O'Dell of the University of Chicago to determine which scientific objectives would be feasible for a proposed space telescope.
1975	The European Space Agency becomes involved in the project.
1977	NASA selects a group of 60 scientists from 38 institutions to participate in the design and development of the proposed space telescope.
June 17, 1977	NASA issues the Project Approval Document for the space telescope. The primary project objective is to "develop and operate a large, high-quality optical telescope system in space which is unique in its usefulness to the international science community. The overall scientific objectives…are to gain a significant increase in our understanding of the university—past, present, and future—through observations of celestial objects and events...."
Oct. 19, 1977	NASA awards the contract for the primary mirror to Perkin-Elmer of Danbury, Connecticut.
1978	Congress appropriates funds for the development of the space telescope.
April 25, 1978	Marshall Space Flight Center is designated as the lead center for the design, development, and construction of the telescope. Goddard Space Flight Center is chosen to lead the development of the scientific instruments and ground control center.
Dec. 1978	Rough grinding operation begins at Perkin-Elmer in Wilton, Connecticut.
1979	
Jan. 20, 1979	Money requests for space science program increase 20 percent ($100 million), which includes money for the space telescope.
Feb. 1979	Debate over which institute NASA should choose to develop the space telescope takes place. (John Hopkins University is chosen.)

Table 4–50 continued

Date	Event
May 29, 1979	The decision is made to have Fairchild Space & Electronics Company modify the communications and data handling module it developed for NASA's Multimission Modular Spacecraft for use on the space telescope.
June 1979	Marshall Space Flight Center decides that the alternative sensor was receiving little management attention at the Jet Propulsion Laboratory and the space telescope was unlikely to be ready for a 1983 launch.
July 1979	Marshall Space Flight Center compiles its Program Operating Plan for fiscal year 1980; Lockheed and Perkin-Elmer overshot the cost for the space telescope by millions of dollars of the original budgeted adjusted program's reserves.
Nov. 18, 1979	Five states compete for the space telescope: Maryland, New Jersey, Illinois, Colorado, and California. Competing groups include University Research Association, Associated Universities, Inc. (AUI), and Association of Universities for Research and Astronomy (AURA). AUI wants the project at Princeton; AURA wants it at Johns Hopkins University.
Dec. 14, 1979	Goddard Space Flight Center releases the Space Telescope Science Institute RFP. Proposals are due March 3,1980.
1980	
Feb. 13, 1980	Dr. F.A. Speer, manager of the High Energy Astronomy Observatory program at Marshall Space Flight Center, is named manager of the space telescope project for Marshall.
Feb. 21, 1980	NASA Associate Administrator Dr. Thomas A. Mutch informs Congress that the space telescope can be completed within its "originally estimated costs." NASA estimates space telescope development costs at $530 million, with another $600 million allotted for operation of the system over a 17-year period. Mutch says progress toward launch in December 1983 "continues to be excellent."
May 29, 1980	NASA announces the selection of Ford Aerospace to negotiate a contract for overall system design engineering on preliminary operations requirements and the test support system for the space telescope.
Sept. 18, 1980	NASA officials admit to space telescope cost and schedule problems in hearing before the House Science and Technology subcommittee.
1981	
Jan. 6, 1981	A.M. Lovelace, NASA associate administrator/general manager, submits a revised space telescope cost and schedule estimate. The launch period is revised to the first half of 1985, and the estimated development cost at launch is $700 million to $750 million (in 1982 dollars).

Table 4–50 continued

Date	Event
Jan. 16, 1981	NASA selects AURA for final negotiation of a contract to establish, operate, and maintain the Space Telescope Science Institute. It will be located at Johns Hopkins University. The contractor's estimate of the cost of the 5-year contract is $24 million, plus additional funds to support a guest observer and archival research program.
April 29, 1981	Perkin-Elmer completes polishing of the 2.4-meter primary mirror (see events dated November 1990).
April 30, 1981	Goddard Space Flight Center awards the contract for the management of the Space Telescope Science Institute to AURA. The period of performance for the $40.4 million contract extends through 1986. The institute will be located at Johns Hopkins University.
Oct. 23, 1981	Space telescope's "main ring" is delivered to Perkin-Elmer Corp. from Exelco Corp., which fabricated the ring over a period of 18 months.
Dec. 10, 1981	Perkin-Elmer finishes putting an aluminum coating 3 millionths of an inch thick on the primary mirror.
1982	
Jan. 26, 1982	Congress increases space telescope funding by $2 million to $121.5 million.
March 1982	The Critical Design Review of the space telescope's support systems module is completed, and the design is declared ready for manufacturing.
March 28, 1982	A report from the House Appropriations Committee states that the space telescope would cost $200 million more and reach orbit a year later than expected because of difficulties in development. The report blames delays and cost overruns on NASA for understaffing the program by 50 percent in its early development and on Perkin-Elmer for failing to properly plan for a project of the technical and manufacturing difficulty of the space telescope. Also, unremovable dust on the primary mirror after 15 months in a Perkin-Elmer "clean room" had lowered its reflecting power by 20 to 30 percent.
1983	
Feb. 4, 1983	NASA Administrator Beggs tells the House Science and Technology Committee that technical problems in developing the electronics and guidance and pointing system of the optical telescope assembly of the space telescope will delay the launch of the telescope and increase costs.
March 24, 1983	NASA Administrator Beggs tells House subcommittee that the space telescope has problems in a number of areas—the latching mechanism, the fine guidance sensor system, and the primary mirror—that are likely to result in cost overruns of $200 million or more and at least a 12- to 18-month delay. Beggs says that the primary mirror is coated with dust after sitting in a clean room for a year and may not be able to be cleaned without harming its surface. Its capability could be limited to 70 or 80 percent.

Table 4–50 continued

Date	Event
March 25, 1983	The preliminary report by the Investigations and Survey Staff of the House Appropriations subcommittee states that the space telescope will overrun its costs by $200 million, boosting its overall cost to $1 billion.
April 13, 1983	NASA names James B. Odom as manager of Marshall Space Flight Center's space telescope project.
April 26, 1983	James Welch, NASA's director of space telescope development, states that NASA may accept the dirty primary mirror because a current study indicates that the mirror would be within the acceptable range and would meet the original specifications in the contract. Also, NASA has decided to coat the sticking latching mechanism with tungsten carbide rather than redesign it.
June 15, 1983	Dr. William Lucas, Marshall Space Flight Center director, tells the House Space subcommittee that NASA estimates that telescope project costs will increase $300 million to $400 million to approximately $1.1 billion to $1.2 billion, and it expects to be able to launch in June 1986. He states that technical problems "are now understood and resolution is in hand."
June 15, 1983	Administrator Beggs acknowledges that, in retrospect, NASA made some errors in planning and running the space telescope program, but that the instrument has not been compromised.
Oct. 5, 1983	The space telescope is officially renamed the Edwin P. Hubble Space Telescope.
Nov. 17, 1983	NASA submits a report to Congress on proposed action that would augment efforts planned for the space telescope development by $30.0 million above the authorized and appropriated amount, for a revised FY 1984 level of $195.6 million.
Dec. 22, 1983	Space telescope officials are cautiously optimistic that the serious problems that surfaced on the space telescope over the last year have been solved and that the instrument can be launched on schedule in 1986.
1984	
April 2, 1984	The estimated cost of the space telescope has risen to $1.175 million. NASA Administrator Beggs states that Lockheed will lose some of its award fees because of poor workmanship problems.
April 30, 1984	NASA reports that tests of the fine guidance sensors have demonstrated that the telescope will meet stringent pointing and tracking requirements.
May 14, 1984	The idea surfaces of refurbishing the space telescope in space.
May 31, 1984	The five science instruments to fly on the space telescope complete acceptance testing at Goddard Space Flight Center: high-resolution spectrograph, faint-object spectrograph, wide-field/planetary camera, faint-object camera, high-speed photometer.
July 12, 1984	Technicians at Perkin-Elmer clean the primary mirror. NASA states that cleaning of the primary mirror has confirmed that the observatory will have the very best optical system possible.

Table 4–50 continued

Date	Event
Dec. 6, 1984	Goddard Space Flight Center's Telescope Operations Control Center satisfactorily conducts command and telemetry tests with the Hubble Space Telescope at Lockheed Missile and Space Corporation. This is the first of seven assembly and verification tests.
1985	
Jan. 17–18, 1985	A workshop by the Space Telescope Science Institute is held to give scientists an opportunity to present their recommendations for key projects for the space telescope.
Feb. 1, 1985	The National Society of Professional Engineers presents an award to Perkin-Elmer Corp. for its development of the Hubble Space Telescope's optical telescope assembly.
July 8, 1985	Lockheed Missiles and Space Co. reports that it has completed assembly of the primary structure for the Hubble Space Telescope.
July 19, 1985	Goddard Space Flight Center releases the RFP for design and fabrication of an Imaging Spectrograph for the space telescope. Proposals are due September 17.
Dec. 5, 1985	NASA selects three scientific investigations for the space telescope to lead to the development of one or two advanced scientific instruments for Hubble.
1986	
Jan. 26, 1986	The destruction of *Challenger* delays the launch of Hubble and other missions.
Feb. 27, 1986	Hubble completes acoustic and dynamic and vibrational response tests. The tests indicate that it can endure the launch environment.
May 2– June 30, 1986	Thermal-vacuum testing is conducted.
May 21, 1986	The last elements of Hubble—the solar arrays—are delivered to Lockheed Missiles and Space Co. (Sunnyvale, California) for integration into the main telescope structure.
May 27, 1986	Hubble successfully completes the thermal-vacuum testing in the Lockheed thermal-vacuum chamber.
Aug. 7, 1986	NASA and the Space Telescope Science Institute in Baltimore announce that 19 U.S. amateur astronomers will be allowed to make observations with Hubble. This decision is to show gratitude to the amateur astronomers for their help with telescopes for the last 400 years.
Aug. 8, 1986	Hubble successfully completes 2 months of rigorous testing.
1987	
March 17, 1987	Hubble starts a 3-day ground system test involving the five instruments that will be carried on board: wide field and planetary camera, high-resolution spectrograph, faint object spectrograph, high-speed photometer, and faint object camera.
Aug. 31– Sept. 4, 1987	Goddard Space Flight Center's Space Telescope Operations Control Center, Marshall Space Flight Center, and the Space Flight Telescope Science Institute conduct a joint orbital verification test.

Table 4–50 continued

Date	Event
Sept. 9, 1987	Hubble completes the reevaluation of Failure Mode and Effects Analysis (FMEA). This reevaluation of the FMEA/Critical Items List/hazard analysis is directed by the Space Telescope Development Division as part of NASA's strategy to return the Space Shuttle to flight status.
1988	
Feb. 10, 1988	Fred S. Wojtalik is appointed manager of the Hubble project at Marshall Space Flight Center.
March 31, 1988	The draft Program Approval Document for Hubble is completed. The draft contains the objectives of Hubble, the technical plan, including the experiments and descriptions, and the systems performance requirements.
June 20, 1988	NASA begins the fourth ground system test (GST-4) of Hubble. This will be the longest ground test to date, lasting 5 1/2 days, and also the most sophisticated because all of the six instruments will be used in their various operational modes; the new instrument is the fine-guidance astrometer.
July 24, 1988	Hubble completes the GST-4 tests successfully, except for a timing incompatibility between the science instruments and the computer. The problem is to be corrected by adjusting the software.
August 31, 1988	NASA delays launch of Hubble from June 1989 to February 1990.
1989	
July 19, 1989	The Space Telescope Science Institute completes its selection of the first science observation proposals to be carried out using Hubble. Among the 162 accepted proposals (out of 556 submitted) are plans to search for black holes in neighboring galaxies, to survey the dense cores of globular star clusters, to better see the most distant galaxies in the universe, to probe the core of the Milky Way, and to search for neutron stars that may trigger bizarre gamma-ray bursts.
Oct. 1989	A modified Air Force C-5A Galaxy transports the Hubble Space Telescope from Lockheed in California to its launch site at the Kennedy Space Center in Florida.
1990	
Jan. 19, 1990	NASA delays the Hubble launch to replace O-rings.
Feb. 5–7, 1990	Confidence testing is held.
Feb. 10, 1990	End-to-end communications test run using Tracking and Data Relay Satellite-East is concluded to interconnect the payload interfaces of *Discovery* in its hangar, Hubble in the Vertical Processing Facility, and the Space Telescope Operations Control Center at Goddard Space Flight Center.
Feb. 13, 1990	The final confidence test is held.
Feb. 15, 1990	Closeout operations begin.
Feb. 17, 1990	Functional testing of Hubble's science instruments is completed.
March 29, 1990	Hubble is installed in the Space Shuttle orbiter *Discovery*'s payload bay.
April 24, 1990	Hubble is launched on STS-31.

Table 4–50 continued

Date	Event
June 21, 1990	Hubble's project manager announces the telescope's inability to focus properly.
July 2, 1990	The Hubble Space Telescope Optical Systems Board of Investigation is formed under the chairmanship of Dr. Lew Allen of the Jet Propulsion Laboratory.
Oct. 16, 1990	Responsibility for the Hubble project (except for the optical system failure questions) is transferred from Marshall to Goddard.
Nov. 1990	The Board of Investigation releases findings, which conclude that a spherical aberration was caused by a flawed measuring device that was used to test the primary mirror at the manufacturer's facility.
Dec. 2, 1993	The Hubble Repair Mission on STS-61 installs corrective lenses and replaces solar panels.