NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SHUTTLE MISSION STS-82

PRESS KIT FEBRUARY 1997

Second Hubble Servicing Mission

STS-82 INSIGNIA

STS082-S-001 -- *STS-82 is the second mission to service the Hubble Space Telescope (HST). The central feature of the insignia is HST as the crewmembers will see it through Discovery's overhead windows when the orbiter approaches for rendezvous, retrieval and a subsequent series of spacewalks to perform servicing tasks. The telescope is pointing toward deep space, observing the cosmos. The spiral galaxy symbolizes one of MST's important scientific missions, to accurately determine the cosmic distance scale. To the right of the telescope is a cross-like structure known as a gravitational lens, one of the numerous fundamental discoveries made using HST Imagery. The names of the STS-82 crew members are arranged around the perimeter of the insignia with the extravehicular activity's (EVA) participating crew members placed in the upper semicircle and the orbiter crew in the lower one.*

The NASA insignia design for space shuttle flights is reserved for use by the astronauts and for other official use as the NASA Administrator may authorize. Public availability has been approved only in the form of illustrations by the various news media. When and if there is any change in this policy, which we do not anticipate, it will be publicly announced.

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STS-82 SET FOR SECOND HUBBLE TELESCOPE SERVICING MISSION

Astronauts on the Space Shuttle Discovery STS-82 mission will significantly upgrade the scientific capabilities of NASA's Hubble Space Telescope (HST) during the ten-day servicing mission by installing two state-of-the-art instruments. They also will perform maintenance to keep HST functioning smoothly until the next scheduled servicing mission in 1999. STS-82, scheduled to launch Feb. 11, 1997, is the second servicing mission to HST since its deployment in April 1990.

The seven-member crew will conduct at least four spacewalks (also called Extravehicular Activities or EVAs) to remove two older instruments and install two new astronomy instruments, as well as other servicing tasks. The two older instruments being replaced are the Goddard High Resolution Spectrometer and the Faint Object Spectrograph. Replacing these instruments are the Space Telescope Imaging Spectrograph (STIS) and the Near Infrared Camera and Multi-Object Spectrometer (NICMOS). HST's current complement of science instruments includes two cameras, two spectrographs, and fine guidance sensors.

In addition to installing the new instruments, astronauts will replace other existing hardware with upgrades and spares. Hubble will get a refurbished Fine Guidance Sensor, an optical device that is used on HST to provide pointing information for the spacecraft and is used as a scientific instrument for astrometric science. The Solid State Recorder (SSR) will replace one of HST's current reel-to-reel tape recorders. The SSR provides much more flexibility than a reel-to-reel recorder and can store ten times more data.

One of Hubble's four Reaction Wheel Assemblies (RWA) will be replaced with a refurbished spare. The RWA is part of Hubble's Pointing Control Subsystem. The RWAs use spin momentum to move the telescope into position. The wheels also maintain the spacecraft in a stable position. The wheel axes are oriented so that the telescope can provide science with only three wheels operating, if required.

The STS-82 crew will be commanded by Ken Bowersox, who will be making his fourth Shuttle flight. The pilot is Scott Horowitz, who will be making his second flight. There are five mission specialists assigned to this flight. Joe Tanner, Mission Specialist-1, is making his second flight. Mission Specialist-2, Steve Hawley, is making his fourth flight. Greg Harbaugh, Mission Specialist-3, is making his fourth flight. Mark Lee, Mission Specialist-4, is making his fourth flight. Mission Specialist-5, Steve Smith, is making his second flight. The crew members who will conduct the planned EVAs are Mark Lee, Greg Harbaugh, Steve Smith and Joe Tanner.

Training for this mission began nearly two years ago. Extensive training for the EVAs was conducted at the Johnson Space Center in Houston, TX, in the 25-foot deep Weightless Environment Training Facility; at the Marshall Space Flight Center in Huntsville, AL, in the 40-foot deep Neutral Buoyancy Simulator; and at the Goddard Space Flight Center in Greenbelt, MD, in a 12,500 square-foot cleanroom.

During the training, the astronauts practiced every detail of every task they will have to perform during the four spacewalks. They also rehearsed using more than 150 specialized tools and crew aids developed specifically for this mission, ranging from a simple bag for carrying some of the smaller tools to sophisticated, battery-operated power tools. The hand-operated devices allow astronauts to more efficiently perform intricate, labor-intensive tasks. Tools will allow access to equipment bays on both HST and the Shuttle and will help remove and install scientific instruments and other components.

Discovery is targeted for an early morning launch on Feb. 11 from NASA's Kennedy Space Center (KSC) Launch Complex 39-A at 3:56 a.m. EST. The launch window is 61 minutes. With an on-time launch on Feb. 11 and a nominal 10-day mission, Discovery will land back at KSC on Feb. 21 at about 2:43 a.m. EST.

STS-82 will be the 22nd Flight of Discovery and the 82nd mission flown since the start of the Space Shuttle program in April 1981.

New Astronomy Instruments

The HST was designed to allow new instruments to be easily installed as old ones become obsolete. This was demonstrated during the first servicing mission in December 1993, when, during an 11-day mission that included a record five EVAs, astronauts successfully installed a new camera which had its corrective optics built right in, and a special instrument, called the COSTAR (Corrective Optics Space Telescope Axial Replacement) that would properly refocus light from the flawed main mirror to the other instruments.

The new instruments installed during this mission will again dramatically expand Hubble's scientific capabilities. 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 of astronomical objects 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 also 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.

Technological Advances

Besides rapidly advancing scientific understanding of the universe, HST is making direct contributions to the health, safety, and quality of people's lives through a variety of technological spin-offs.

For instance, 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 surgery 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 Hubble Space Telescope was designed to operate in space for 15 years. Since its deployment in 1990, HST 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 dramatic and detailed views of comet fragments smashing into Jupiter; clues about the existence of black holes in the core of galaxies; and has made significant progress in determining the age and size of the universe. With astronauts geared to embark on the second mission to service the telescope, scientists are looking forward to even greater capabilities to look deeper into the universe.

Two more servicing missions are planned for 1999 and 2002 to keep the telescope functioning efficiently and to improve its scientific capability. Among the tasks for the 1999 mission are installation of the Advanced Camera, new solar arrays, and the telescope will be reboosted into a higher orbit. In 2002, plans call for installation of an as-yet undefined advanced scientific instrument as well as maintenance to keep HST functioning until at least 2005.

The HST is a joint project between NASA and the European Space Agency.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS.)

MEDIA SERVICES INFORMATION

NASA Television Transmission

NASA Television is available through the Spacenet-2 satellite system. Spacenet-2 is located on Transponder 5, channel 9, C-Band, at 69 degrees West longitude, frequency 3880.0 MHz, audio 6.8 MHz.

The schedule for television transmissions from the orbiter and for mission briefings will be available during the mission at Kennedy Space Center, FL; Marshall Space Flight Center, Huntsville, AL; Dryden Flight Research Center, Edwards, CA; Johnson Space Center, Houston, TX; and NASA Headquarters, Washington, DC. The television schedule will be updated to reflect changes dictated by mission operations.

Television schedules also may be obtained by calling COMSTOR at 713/483- 5817. COMSTOR is a computer data base service requiring the use of a telephone modem. A voice update of the television schedule is provided daily at noon Eastern time.

Status Reports

Status reports on countdown and mission progress, on-orbit activities and landing operations will be produced by the appropriate NASA newscenter.

Briefings

A mission press briefing schedule will be issued before launch. During the mission, status briefings by a flight director or mission operations representative and when appropriate, representatives from the payload team, will occur at least once each day. The updated NASA television schedule will indicate when mission briefings are planned.

Internet Information

Information on STS-82 is available through several sources on the Internet. The primary source for mission information is the NASA Shuttle Web, part of the World Wide Web. This site contains information on the crew and their mission and will be regularly updated with status reports, photos and video clips throughout the flight. The NASA Shuttle Web's address is:

http://shuttle.nasa.gov

If that address is busy or unavailable, Shuttle information is available through the Office of Space Flight Home Page:

http://www.osf.hq.nasa.gov/

General information on NASA and its programs is available through the NASA Home Page and the NASA Public Affairs Home Page:

http://www.nasa.gov

or http://www.gsfc.nasa.gov/hqpao/hqpao_home.html

Information on other current NASA activities is available through the Today@NASA page:

http://www.hq.nasa.gov/office/pao/NewsRoom/today.html

The NASA TV schedule is available from the NTV Home Page:

http://www.hq.nasa.gov/office/pao/ntv.html

Status reports, TV schedules and other information also are available from the NASA Headquarters FTP (File Transfer Protocol) server, ftp.hq.nasa.gov. Log in as anonymous and go to the directory /pub/pao. Users should log on with the user name "anonymous" (no quotes), then enter their E-mail address as the password. Within the /pub/pao directory there will be a "readme.txt" file explaining the directory structure:

* Pre-launch status reports (KSC): ftp.hq.nasa.gov/pub/pao/statrpt/ksc
* Mission status reports(JSC): ftp.hq.nasa.gov/pub/pao/statrpt/jsc
* Daily TV schedules: ftp.hq.nasa.gov/pub/pao/statrpt/jsc/tvsked.

NASA's Spacelink, a resource for educators, also provides mission information via the Internet. The system fully supports the following Internet services:

- World Wide Web: http://spacelink.msfc.nasa.gov
- Gopher: spacelink.msfc.nasa.gov
- Anonymous FTP: spacelink.msfc.nasa.gov
- Telnet : spacelink.msfc.nasa.gov

Spacelink's dial-up modem line is 205/895-0028.

Access by CompuServe

Users with CompuServe accounts can access NASA press releases by typing "GO NASA" (no quotes) and making a selection from the categories offered.

STS-82 QUICK LOOK

Launch Date/Site:	February 11, 1997/KSC Launch Pad 39-A
Launch Time:	3:56 AM EST
Launch Window:	61 minutes
Orbiter:	Discovery (OV-103), 22nd flight
Orbit Altitude/Inclination:	320 nautical miles, 28.45 degrees
Mission Duration:	9 days, 22 hours, 47 minutes
Landing Date:	February 21, 1997
Landing Time:	2:43 AM EST
Primary Landing Site:	Kennedy Space Center, FL
Abort Landing Sites:	Return to Launch Site - KSC Transoceanic Abort Sites - Ben Guerir, Morocco; Moron, Spain Abort-Once Around - Edwards AFB, CA
Crew:	Ken Bowersox, Commander (CDR), 4th flight Scott Horowitz, Pilot (PLT), 2nd flight Joe Tanner, Mission Specialist 1 (MS 1), 2nd flight Steve Hawley, Mission Specialist 2 (MS 2), 4th flight Greg Harbaugh, Mission Specialist 3 (MS 3), 4th flight Mark Lee, (Payload Commander) Mission Specialist 4 (MS 4), 4th flight Steve Smith, Mission Specialist 5, (MS 5), 2nd flight
EVA Crewmembers:	Mark Lee (EV 1), Steve Smith (EV 2), EVAs 1 and 3 Greg Harbaugh (EV 3), Joe Tanner (EV 4), EVAs 2 and 4 (Lee and Smith would conduct any contingency EVA)
Cargo Bay Payloads:	Second Axial Carrier (SAC) Orbital Replacement Unit Carrier (ORUC) Flight Support System (FSS)
HST Science Instruments and Hardware	Near Infrared Camera and Multi-Object Spectrometer (NICMOS) Space Telescope Imaging Spectrograph (STIS) Reaction Wheel Assembly-1 (RWA-1) Fine Guidance Sensor-1 (FGS-1) Solid State Recorder (SSR) Engineering/Science Tape Recorder (ESTR) Data Interface Unit-2 (DIU-2) Solar Array Drive Electronics-2 (SADE-2) Optical Control Electronics Enhancement Kit (OCE-EK) Magnetic Sensing System (MSS) Covers

CREW RESPONSIBILITIES

Payloads	Prime	Backup
Hubble Space Telescope	Lee	All Others
RMS	Hawley	Harbaugh, Lee
EVA	Lee, Tanner, Harbaugh, Smith	-----
Intravehicular Crewmember	Smith, Tanner, Lee, Harbaugh	-----
Rendezvous	Bowersox	Hawley, Harbaugh
Rendezvous Tools	Harbaugh	Tanner
Earth Observations	Horowitz	Hawley

DEVELOPMENTAL TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

DTO 255:	Wraparound DAP Flight Test Verification
DTO 312:	External Tank TPS Performance
DTO 684:	Radiation Measurements in Shuttle Crew Compartment
DTO 700-9A	Orbiter Evaluation of TDRS Acquisition in De-spreader
DTO 805:	Crosswind Landing Performance
DTO 840:	Hand-Held Lidar Procedures
DSO 331:	Integration of the Space Shuttle Launch and Entry Suit
DSO 487:	Immunological Assessment of Crewmembers
DSO 493:	Monitoring Latent Virus Reactivation and Shedding in Astronauts

PAYLOAD AND VEHICLE WEIGHTS

Vehicle/Payload	**Pounds**
Orbiter (Discovery) empty and 3 SSMEs	182,869
Shuttle System at SRB Ignition	4,513,207
Orbiter Weight at Landing with Cargo	213,312
Flight Support System	4,482
Orbital Replacement Unit Carrier	6,978
Second Axial Carrier	5,275
Hubble Space Telescope (while berthed to Discovery)	24,500

STS-82 ORBITAL EVENTS SUMMARY

(based on a Feb. 11, 1997 launch)

Event	MET	Time of Day (EST)
Launch	0/00:00	3:56 AM, Feb. 11
HST Grapple	1/22:55	1:51 AM, Feb. 13
EVA 1	2/19:25	11:21 PM, Feb. 13
EVA 2	3/19:25	11:21 PM, Feb. 14
EVA 3	4/19:25	11:21 PM, Feb. 15
EVA 4	5/19:25	11:21 PM, Feb. 16
HST Release	6/21:00	12:56 AM, Feb. 18
Crew News Conference	9/01:30	5:26 AM, Feb. 20
Deorbit Burn	9/21:32	1:28 AM, Feb. 21
KSC Landing	9/22:47	2:43 AM, Feb. 21

MISSION SUMMARY TIMELINE

Flight Day 1
Launch/Ascent
OMS-2 Burn
Payload Bay Door Opening
HST Rendezvous Burn

Flight Day 2
RMS Checkout
HST EVA Tool Preparations
FSS Preparation for HST Berthing
Rendezvous Tool Checkout
EMU Checkout
HST Rendezvous Burns

Flight Day 3
HST Rendezvous Burns
HST Grapple and Berthing
HST Survey

Flight Day 4
EVA 1 (STIS and NICMOS Installation)

Flight Day 5
EVA 2 (FGS and ESTR-2 Replacement)
VRCS Reboost

Flight Day 6
EVA 3 (DIU-2, SSR and RWA Replacement)
VRCS Reboost

Flight Day 7
EVA 4 (SADE-2 Installation and MSS Cover Replacement)
VRCS Reboost

Flight Day 8
Final HST Survey
HST Release
FSS Stowage
RMS Powerdown

Flight Day 9
Off-Duty Period

Flight Day 10
Flight Control System Checkout
Reaction Control System Hot-Fire
Cabin Stow
Crew News Conference

Flight Day 11
Deorbit Preparation
Payload Bay Door Closing
Deorbit Burn
KSC Landing

SHUTTLE ABORT MODES

Space Shuttle launch abort philosophy aims toward safe and intact recovery of the flight crew, Orbiter and its payload. Abort modes for STS-82 include:

- Abort-To-Orbit (ATO) -- Partial loss of main engine thrust late enough to permit reaching a minimal 105- nautical mile orbit with the orbital maneuvering system engines.

- Abort-Once-Around (AOA) -- Earlier main engine shutdown with the capability to allow one orbit of the Earth before landing at the Kennedy Space Center, FL.

- Transoceanic Abort Landing (TAL) -- Loss of one or more main engines midway through powered flight would force a landing at either Ben Guerir, Morocco; or Moron, Spain.

- Return-To-Launch-Site (RTLS) -- Early shutdown of one or more engines, and without enough energy to reach a TAL site, would result in a pitch around and thrust back toward Kennedy until within gliding distance.

SERVICING MISSION OVERVIEW

HUBBLE SCIENCE INSTRUMENTS AND REPLACEMENT HARDWARE

Science Instruments

The Space Telescope Imaging Spectrograph (STIS)

The Space Telescope Imaging Spectrograph replaces the Goddard High Resolution Spectrograph (GHRS). It includes all the major capabilities of both the current spectrographs, the GHRS and the Faint Object Spectrograph (FOS) and adds new technological capability. The STIS optical design features internal corrective optics to compensate for the HST primary mirror spherical aberration.

STIS is an instrument that spans ultraviolet, visible, and near infrared wavelengths. It separates the light gathered by the telescope into its component colors allowing scientists to analyze the composition of celestial objects -- their temperature, motion, and other chemical and physical properties.

STIS's main advance is its capability for two- dimensional rather than one-dimensional spectroscopy. 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. This means that many regions in a planet's atmosphere or many stars within a galaxy can be recorded in one exposure making the HST faster and more efficient. One of the greatest advantages to using STIS is in the study of supermassive black holes.

STIS contains a new generation electronic light sensor called a Multi-Anode Microchannel Array (MAMA), as well as a Charge Coupled Device (CCD). STIS's coronograph allows it to search the environment of bright stars for very faint companion objects (possible planets). STIS is also capable of taking ultraviolet images like a camera.

STIS's Science Capabilities

- STIS can search for massive black holes by studying the star and gas dynamics around galactic centers.

- STIS can measure the distribution of matter in the universe by studying quasar absorption lines.

- STIS can use its high sensitivity and ability to detect fine detail to study stars forming in distant galaxies.

- STIS can perform spectroscopic mapping - measuring chemical composition, temperature, gas density and motion across planets, nebulae and galaxies.

STIS Physical Characteristics

Dimensions: 7.1 x 2.9 x 2.9 feet (2.2 x 0.89 x 0.89 m)
Weight: 700 lbs. (318 kg)

The principal investigator for STIS is Dr. Bruce E. Woodgate, Goddard Space Flight Center, Greenbelt, MD. The prime contractor is Ball Aerospace Systems Group, Boulder, CO. Following installation and calibration, the operation of STIS will be managed by the Space Telescope Science Institute, Baltimore, MD.

The Near Infrared Camera and Multi-Object Spectrometer (NICMOS)

The Near Infrared Camera and Multi-Object Spectrometer will replace the Faint Object Spectrograph (FOS). Like STIS, NICMOS's design features corrective optics to compensate for HST's primary mirror spherical aberration. NICMOS provides the capability for infrared imaging and spectroscopic observations of astronomical targets. Its detectors perform much better than previous infrared detectors. 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 instruments which are sensitive only to optical and ultraviolet wavelength light.

NICMOS's Science Capabilities

- NICMOS will probe objects created near the beginning of the universe.

- NICMOS can look deeper into the clouds of dust to view how stars and planets are formed.

- NICMOS will be able to see further back in time and farther away in distance.

* NICMOS will be able to detect cold objects such as brown dwarfs which emit light most brightly at infrared wavelength.

NICMOS contains three cameras, each with a different spatial resolution. Camera 1 has the highest resolution for very finely detailed pictures at the shorter near infrared wavelengths. Camera 2 has the next highest resolution for detailed pictures at longer wavelengths, and Camera 3 has a much wider field of view to encompass extended objects at slightly lower resolution. Each camera has its own wheel of filters and optical components. Each individual camera can operate independently while the other cameras are also taking images.

NICMOS is much more than a camera. It is also a spectrometer, a coronograph and a polarimeter. Each of these operational modes is initiated by rotating the proper element in a wheel containing filters and optical components into the camera beam. A combination of grating and a prism called a grism provides spectroscopy for NICMOS. A set of polarizers in the wheel are rotated into place when observers want to determine the degree of polarization of radiation from a celestial object. One of the cameras has a special set of masks to block light from a bright object to observe an adjacent faint object, such as a faint planet near a bright star. This is called a coronograph.

The sensitive infrared detectors in NICMOS must operate at very cold temperatures, 58 degrees Kelvin (minus 355 degrees Fahrenheit), because any heat from surroundings will create extra infrared signals that would interfere with the actual signal from the object being studied. NICMOS keeps its detectors cold inside a cryogenic dewar (a thermally insulated container) containing frozen nitrogen. The dewar cools the detectors for up to five years. NICMOS is HST's first cryogenic instrument.

NICMOS Physical Characteristics

Dimensions: 2.2 m x 0.88m x 0.88 m (7.1 ft. x 2.8 ft x 2.8 ft.
Weight : 765 lbs. (347 kg.)

The principal investigator for NICMOS is Dr. Rodger I. Thompson of the University of Arizona (UA) under contract with NASA's Goddard Space Flight Center (GSFC), Greenbelt, MD. The major subcontractors are Ball Aerospace Systems Group, Boulder, CO, and Rockwell International Corp., Thousand Oaks, CA. Following its installation and calibration, NICMOS will be managed by the Space Telescope Science Institute, Baltimore, MD.

Replacement Hardware

Solid State Recorder. The Solid State Recorder (SSR) will replace one of HST's current reel-to-reel recorders. The data management system of the HST includes three tape recorders to store engineering or science data that cannot be transmitted to the ground immediately. The SSR has no reels, no tape and no moving parts to wear out.

The SSR is about the same size as the reel-to-reel recorder, but it can store ten times as much data in computer-like memory chips until HST's operators at GSFC command the SSR to play it back. The SSR stores 12 gigabits of data, while the tape recorder it replaces stores only 1.2 gigabits.

The SSR has two memory units. Each is a microelectronics device with 16 megabit chips stacked in a package and six packages in an array. There are three arrays in a group. In the event of a failure in a chip, a single row of the chips can be skipped over leaving the rest of the memory fully functional.

HST communicates with the ground through NASA's Tracking and Data Relay Satellite System (TDRSS). The engineering information from the spacecraft systems and the science data from the astronomical instruments can either be sent directly to the Space Telescope Operations Control Center at GSFC or recorded and played back at a later time.

The current operations procedure is to record all science data to ensure continuity and safeguard against any possible loss of unique information. Post-servicing mission plans are to use the SSR with its larger capacity and flexibility exclusively for science data storage. This will accommodate the higher data rates from the new instruments and promote greater efficiency in operations.

Fine Guidance Sensor. A refurbished Fine Guidance Sensor (FGS) replaces an existing FGS on this mission which is showing signs of mechanical wear. There are three fine guidance sensors on the HST located at 90- degree intervals around the circumference of the telescope. Two FGSs are used to point the telescope at an astronomical target and then hold that target in a scientific instrument's field of view. The third FGS can be used as a scientific instrument for celestial measurements (astrometry).

The replacement FGS has been fitted with a new mechanism to accomplish better optical alignment. Once this spare is exchanged for one of the original units, the telescope operators will be able to compensate for changes due to on-orbit conditions and optimize its performance by keeping the FGS more finely tuned.

The fine guidance sensors are one of five different types of sensors used by the HST's pointing control system to point the telescope at a target with an accuracy of 0.01 arcsecond (an arcsecond is 1/3600 of a degree). The guidance sensors lock on to a star and then measure any apparent motion to an accuracy of 0.0028 arcsec. This gives the HST the ability to remain pointed at that target with no more than 0.007 arcsec. of deviation over long periods of time. This level of stability is comparable to being able to hold a laser beam focused on a dime 200 miles away (about the distance from Washington, DC, to New York City).

Fine Guidance Sensors can also be used for astrometry, which is the science that deals with determination of precise positions and motions of stars and other celestial objects. The FGSs can provide star positions that are about 10 times more precise than those observed from a ground-based telescope.

When used for astrometric science, the fine guidance sensors will let the HST:

- Search for the wobble in the motion of nearby stars which could indicate the presence of a planetary companion.
- Determine if certain stars are really double stars.
- Measure the masses of stars.
- Measure the angular diameter of stars, galaxies, etc.
- Refine the positions and the absolute magnitude scale for stars.
- Help determine the true distance scale for the universe.

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

Data Interface Units. 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 occurred in the original unit.

Solar Array Drive Electronics. The Solar Array Drive Electronics (SADE) control 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.

Magnetic Sensing System. 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.

Engineering Science Tape Recorder. The Engineering Science Tape Recorder (ESTR) stores data onboard the telescope. There are three ESTRs onboard the HST. Engineering data are recorded during periods when no communications with the ground are scheduled. Science data are always recorded to prevent loss of data if an unplanned communications outage should occur. In normal operations, two ESTRs are used to record science and the third records engineering data when necessary. One of the ESTRs has failed and is scheduled to be replaced with an identical flight spare ESTR. Another ESTR will be replaced with the Solid State Recorder.

Optical Control Electronics Enhancement Kit. The Optical Control Electronics Enhancement Kit is a cable that is used on the Optical Control Electronics box to reroute signals to send commands to move the new adjustable mirror that is internal to the Fine Guidance Sensor.

Crew Aids and Tools

The crew will take more than 300 different crew aids and tools with them. These crew aids and tools, part of the Space Support Equipment (SSE) hardware, range from a simple bag for carrying some of the smaller tools to sophisticated, computer-controlled power tools.

Crew Aids: These are fixed-in-place or portable equipment items, other than hand tools, used to assist crew members in accomplishing servicing mission tasks. Crew aids permit the astronauts to maneuver safely or to anchor themselves in one location while working in the weightlessness of space. They also help in moving Orbital Replacement Units (ORUs) and Scientific Instruments (SIs), protect equipment and crew during the changeout activities, and provide temporary stowage of equipment during Extra Vehicular Activities (EVAs). Examples of crew aids are: handrails, handholds, transfer equipment, protective covers, tethering devices, grapple fixtures, foot restraints, and stowage and parking fixtures.

Tools: These hand-operated devices allow EVA astronauts to more efficiently perform intricate, labor-intensive tasks. Tools allow the crew to access equipment bays on both the spacecraft and the Shuttle, and to remove and install ORUs and SIs.

Among the tools to be carried aboard STS-82 for HST servicing are: the power ratchet tool, the multisetting torque limiter, adjustable extensions with 7/16-inch sockets, a newly developed, computer-controlled pistol grip tool, and a series of new connector tools. Spares of all the tools will be carried on the Shuttle to ensure the success of the mission and safety of the crew.

Power Ratchet Tool (PRT): The power ratchet tool is powered by a 28-volt battery. Made of titanium and aluminum, the 17-inch (43 cm) tool will be used for tasks requiring controlled torque, speed or turns, and can be used where right-angle access is required.

Multisetting Torque Limiter (MTL): This tool is provided to prevent damage to hardware due to the application of torque which may exceed design limits. Multisetting torque limiters are used in conjunction with the power tools or hand tools that interface with bolts and latches on the telescope.

Adjustable Extensions: Two extensions were designed to be adjustable, allowing astronauts to move more easily and efficiently.

Pistol Grip Tool (PGT): This unique tool was designed for use by the astronauts during EVA activities. The experiences of crew members on HST's first servicing mission led to recommendations for a smaller, more efficient tool for precision work in a space environment. The PGT is a self-contained, micro-processor controlled, battery-powered, hand-held tool. It also can be used as a non-powered ratchet wrench. The PGT's micro-processor can be programmed to control limits for torque, speed, and number of turns.

Stowage

The tools and crew aids will be stowed on or in the Solar Array Carrier (SAC), Orbital Replacement Unit Carrier (ORUC), Flight Support System (FSS), HST Tool Box, sidewall-mounted adapter plates, Provisions Stowage Assembly (PSA), an Adaptive Payload Carrier (APC), middeck lockers, aft flight-deck and airlock. Tools and crew aids are provided by Johnson Space Center and Goddard Space Flight Center.

Uses

Tools and crew aids with a wide variety of uses include the Power Ratchet Tool (PRT), Multi-setting Torque Limiter (MTL), adjustable extensions with 7/16th inch sockets, translation aids, and locking connector tools. More specific crew aid items are low-gain antenna (LGA) cover, a FGS pick-off mirror cover and a multi- layer insulation (MLI) repair kit.

To be used on the changeout of the FGS are the FGS handholds, guide studs, quick-release zip nuts, pick-off mirror cover, forward fixture, and the aft fixture.

MISSION OBJECTIVES AND SUCCESS

The objectives of the second Hubble servicing mission are to improve Hubble's productivity, to extend Hubble'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. These activities are consistent with Hubble's design philosophy: science instruments with improved or expanded capabilities are installed to take advantage of state-of-the-art advances, and spacecraft components are replaced as they age.

Two new scientific instruments will be installed to enhance science productivity of the spacecraft: the Near Infrared Camera and Multi-Object Spectrometer (NICMOS) and the Space Telescope Imaging Spectrograph (STIS). The primary maintenance items include the replacement of a degraded Fine Guidance Sensor (FGS) with an upgraded spare; replacement of a Reaction Wheel Assembly (RWA) with a refurbished RWA; and changeout of one of two data recorders, either the Solid State Recorder (SSR) or the Engineering Science Tape Recorder (ESTR).

SERVICING MISSION ORBITAL VERIFICATION (SMOV)

The purpose of SMOV is to "recommission" HST so that it can begin science operations as soon as possible following the second servicing mission. This involves a thorough engineering checkout of all serviced subsystems; optical alignment and focus; initial calibration of STIS, NICMOS, and the new Fine Guidance Sensor; and STIS and NICMOS observations for early release to the public. SMOV begins when the HST is released from the Shuttle and is expected to last approximately 18 weeks.

Key Activities During SMOV

- Activation and engineering checkout of the science instruments
- Optical alignment and focusing of NICMOS and STIS
- Redeployment of COSTAR corrective optics for Faint Object Camera
- Resume WF/PC II and Faint Object Camera science while completing STIS and NICMOS SMOV activities
- Engineering checkout and calibration of the new Fine Guidance Sensor
- Conduct contamination prevention operations during early SMOV
- Early release observations

Engineering Checkout Activities

- Decontaminate the WF/PC II detectors (charge-coupled devices or CCDs) of any foreign substances by heating the detectors to "drive-off" contaminates.
- Deploy the COSTAR for Faint Object Camera
- Activate and perform functional check-outs of STIS and NICMOS
- Perform WFPC-II cool down and initial sensitivity checks
- Perform Faint Object Camera initial sensitivity checks

Science Instruments Optical Alignment

- Adjust alignment and focus mechanisms to provide coarse and fine
- alignment and focus of STIS and NICMOS
- Reverify the COSTAR alignment and focus for Faint Object Camera

Science Instrument Calibration

- A series of tests and measurements to establish the actual performance of the new science instruments in the areas of sensitivity, resolution and detector response characteristics.

COMMANDS TO HUBBLE

Commands to HST are issued from the Space Telescope Operations Control Center (STOCC) at the Goddard Space Flight Center which manages the orbiting observatory. The STOCC has been the nerve center for Hubble operations since the telescope was launched. Commands to Hubble are issued from the STOCC and data gathered by the spacecraft arrive there first.

The STOCC is responsible for most commanding of the HST during STS-82, although the crew can send a limited number of commands from Discovery. The STOCC will send commands configuring the space telescope for retrieval by the orbiter; integrate commands with crew activities during extravehicular activities (EVA) to configure various spacecraft hardware and perform hardware checkouts and send commands to configure the space telescope deployment from Discovery.

EUROPEAN SPACE AGENCY (ESA) ROLE IN HST

The Hubble Space Telescope is a program of joint cooperation between NASA and ESA. ESA provided Hubble's deployable solar arrays, the major source of electrical power, which collects energy from the sun to recharge the spacecraft's six nickel-hydrogen batteries. ESA's second contribution was the Faint Object Camera, which was intended for imaging of the spatial resolution. ESA provided the refurbished Solar Array Drive electronics for this mission.

RENDEZVOUS AND RETRIEVAL

The rendezvous and retrieval operations associated with the Hubble Space Telescope will be similar to those carried out on other missions requiring capture of a free-flying satellite in orbit.

Discovery's initial rendezvous burn is actually the liftoff of the Space Shuttle itself. The launch is precisely timed to occur during about a one hour period as the telescope passes within the desired range from the Shuttle. After launch, the crew will oversee a number of orbit adjust burns to catch up with and retrieve the telescope on flight day three of the mission.

Once Discovery is safely in orbit and the payload bay doors are opened, signaling the start of orbital operations, activation of the Ku-band antenna on the orbiter takes place. The dish-shaped antenna is used to provide radar data to the crew and ground during the rendezvous process. The day after launch, the crew will checkout the Remote Manipulator System (RMS), or robot arm that will be used throughout the mission. Also, activation of the space support equipment is performed. This includes activating the flight support system and heaters on the various orbital replacement unit (ORU) containers housing scientific instruments and hardware that will be installed on and in the telescope.

The terminal initiation, or TI, burn occurs about two hours prior to capture as the Shuttle reaches a distance of about eight miles in front of the telescope. Several small midcourse correction burns follow before Commander Ken Bowersox, who was the pilot on the first servicing mission to Hubble, takes over manual control of Discovery at a distance of about 2,400 feet below the telescope. The approach from underneath minimizes any potential contamination to the telescope from the Shuttle's thruster firings.

Prior to capture, a ground-commanded maneuver of the telescope is performed to align its two grapple fixtures with Discovery's robot arm. The duration of the maneuver depends on the angle to the sun and should range from 70 to 180 degrees.

Once Discovery is within 35 feet of Hubble, astronaut Steve Hawley will use the robot arm to capture the telescope at one of the two grapple fixtures located midway up the HST structure. Hawley's last mission was STS-31 on which he also served as the primary operator of the robot arm, deploying Hubble for its astronomical mission.

Following its capture, the telescope will be lowered onto the flight support system, a turntable likened to a lazy susan for its ability to rotate and tilt to assist in the servicing tasks. An electrical cable is remotely attached to provide orbiter power to the telescope throughout the servicing portion of the mission.

EXTRAVEHICULAR ACTIVITY

A total of four spacewalks are planned during STS- 82. The Hubble Space Telescope was designed to be serviced while on orbit through extravehicular activity (EVA), or spacewalks. The telescope has two grapple fixtures for the Shuttle's mechanical arm, handholds and handrails for use by the spacewalking astronauts, and electrical connections and bolts designed for easier manipulation by the astronauts while wearing pressurized gloves.

As was the case on the first Hubble servicing mission in December 1993, the tasks scheduled for the four spacewalks on STS-82 have been prioritized to maximize the time that the astronauts are in the payload bay.

The four EVA astronauts will work in two different teams to perform the tasks, alternating to allow a rest day between spacewalks. Mark Lee and Steve Smith are scheduled to perform the servicing tasks on the first and third spacewalks and Greg Harbaugh and Joe Tanner will work on the telescope on EVAs two and four. While outside conducting the spacewalks, Lee can be distinguished by continuous red stripes around the arms and legs of his suit. Harbaugh's spacesuit will have a broken red stripe on the arms and legs. Smith and Tanner will be sharing the upper half of the third spacesuit and each will have his own lower portion. Smith will have no markings on his suit making it all-white, and Tanner will be distinguishable by diagonal red striping around the legs.

Although the various servicing tasks are prioritized, they have been designed to take into account the possibility that crew members may encounter unforeseen difficulties either in tasks or equipment that could change the preplanned schedule of installation of various equipment components. The four spacewalking astronauts have been cross-trained so that anyone is capable of performing any given task.

As currently planned, the first spacewalk will feature the installation of two new science instruments - - the Space Telescope Imaging Spectrograph (STIS) and the Near Infrared Camera and Multi-Object Spectrometer (NICMOS). The telephone-booth size instruments will be installed in an identical fashion to the corrective optics package that was installed during STS-61. STIS replaces the Goddard High Resolution Spectrograph and NICMOS replaces the Faint Object Spectrograph.

The second spacewalk will include the changeout of the pie-shaped Fine Guidance Sensor with an upgraded model and one of the Engineering/Science Tape Recorders along with installation of the Optics Control Electronics Enhancement Kit (OCEK). The FGS swap will be identical to the Wide Field and Planetary Camera changeout that took place on STS-61.

The third spacewalk includes the changeout of a Data Interface Unit and a Reaction Wheel Assembly. Also, another ESTR will be replaced by an improved Solid State Recorder.

The fourth and final scheduled spacewalk includes changeout of Solar Array Drive Electronics (SADE) unit number two, identical to the procedure performed on SADE number one on the first servicing mission, and installation of Magnetic Sensing Systems (MSS) covers over the makeshift ones installed during STS-61.

Throughout the EVAs the flight support system will be rotated so that the area being worked on faces forward to provide better visibility and access by the robot arm.

REBOOST AND DEPLOY

Near the end of spacewalks two, three and four, the Shuttle's small vernier thruster jets will be fired from 20 minutes to about one hour to provide a subtle increase of the Hubble Space Telescope's altitude by approximately five nautical miles. This procedure, tested on two previous Shuttle flights (STS-78 and STS-79), proved the feasibility of reboosting Hubble while in Discovery's payload bay.

The vernier jets will be used for the reboost because of the loads that potentially could be imparted to the HST solar arrays, which will not be stowed as the arrays were during STS-61. The reboost plan calls for the small thrusters located on the tail to fire continuously throughout the daily reboost while those located on the left and right of the nose fire sequentially at one minute intervals.

The reboost is desired to counteract aerodynamic drag effects which tend to lower Hubble's orbit.

The day following the spacewalks, the solar arrays on Hubble will be pointed toward the sun to provide electrical power and to charge the telescope's batteries. The robot arm will be used to grapple HST once again followed by transfer of power to the internal system from the orbiter power. The telescope will be lifted off of the rotating flight support system and released over the side of Discovery in similar fashion to the deploy following the first servicing mission.

HUBBLE SPACE TELESCOPE OVERVIEW

History and Program Information

The Hubble Space Telescope is a cooperative program of NASA and the European Space Agency (ESA) to operate a long-lived space-based observatory for the benefit of the international astronomical community. It is an observatory first envisioned in the 1940s, designed and built in the 1970s and 80s, and began operating in the 1990s. HST is a 2.4-meter reflecting telescope which was deployed in low-Earth orbit by the crew of the Space Shuttle Discovery (STS-31) on April 25, 1990.

Since its preliminary inception, HST was designed to be a different type of mission for NASA -- a permanent space-based observatory. To accomplish this goal, protect the spacecraft against instrument and equipment failures and to periodically upgrade the observatory with the latest start-of-the-art scientific instruments, NASA planned on regular servicing missions to the orbiting telescope. Hubble was built with special grapple fixtures and 76 handholds to help astronauts work on the spacecraft.

When originally planned in 1979, the Large Space Telescope program called for return to Earth, refurbishment, and relaunch every 5 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 eliminated the concept of ground return from the program. NASA decided that on-orbit servicing to maintain HST during its 15- year design life was best, and adopted a three year cycle of on-orbit servicing.

Following launch of HST in 1990, and the discovery of spherical aberration in the primary mirror, on-orbit servicing would prove itself a sound concept. Following the search for a practical solution and development of the corrective optics package, the first HST servicing mission was planned to restore the optical capabilities of HST to its original design specifications. Space Shuttle Endeavour's STS-61 mission in December 1993 was a success, completely correcting the optics as well as installing a new camera and other equipment. Future servicing missions are tentatively planned for February 1997, mid-1999, and mid-2002.

HST's current complement of science instruments includes two cameras, two spectrographs, and fine guidance sensors (primarily used for astrometric observations). Because of HST's location above the Earth's atmosphere, these science instruments can produce high resolution images of astronomical objects. Ground- based telescopes can seldom provide resolution better than 0.5 arc-seconds, except momentarily under the very best observing conditions. HST's resolution is about 10 times better, or 0.05 arc-seconds.

Responsibility for conducting and coordinating HST science operations rests with the Space Telescope Science Institute (STScI) on the Johns Hopkins University Homewood Campus in Baltimore, MD. STScI is operated for NASA by the Association of Universities for Research in Astronomy, Inc. (AURA).

HST'S CURRENT SCIENCE INSTRUMENTS

Wide Field/Planetary Camera 2 (WF/PC-2)

The original Wide Field/Planetary Camera (WF/PC-1) was changed out and replaced by WF/PC-2 on the STS-61 Shuttle mission in December 1993. WF/PC-2 was a spare instrument developed in 1985 by the Jet Propulsion Laboratory, Pasadena, CA.

WF/PC-2 is actually four cameras. The relay mirrors in WF/PC-2 are spherically aberrated to correct for the spherically aberrated primary mirror of the observatory. (HST's primary mirror is 2 microns too flat at the edge, so the corrective optics within WF/PC-2 are too high by that same amount.)

The "heart" of WF/PC-2 consists of an L-shaped trio of wide-field sensors and a smaller, high resolution ("planetary") camera tucked in the square's remaining corner.

Corrective Optics Space Telescope Axial Replacement (COSTAR)

COSTAR is not a science instrument; it is a corrective optics package that displaced the High Speed Photometer during the first servicing mission to HST. COSTAR is designed to optically correct the effects of the primary mirror's aberration on the three remaining scientific instruments: Faint Object Camera (FOC), Faint Object Spectrograph (FOS), and the Goddard High Resolution Spectrograph (GHRS).

Faint Object Camera (FOC)

The Faint Object Camera was built by the European Space Agency. It is the only instrument to utilize the full spatial resolving power of HST.

There are two complete detector systems of the FOC. Each uses an image intensifier tube to produce an image on a phosphor screen that is 100,000 times brighter than the light received. This phosphor image is then scanned by a sensitive electron-bombarded silicon (EBS) television camera. This system is so sensitive that objects brighter than 21st magnitude must be dimmed by the camera's filter systems to avoid saturating the detectors. Even with a broad-band filter, the brightest object which can be accurately measured is 20th magnitude.

The FOC offers three different focal ratios: f/48, f/96, and f/288 on a standard television picture format. The f/48 image measures 22 X 22 arc-seconds and yields resolution (pixel size) of 0.043 arc-seconds. The f/96 mode provides an image of 11 X 11 arc-seconds on each side and a resolution of 0.022 arc-seconds. The f/288 field of view is 3.6 X 3.6 arc-seconds square, with resolution down to 0.0072 arc-seconds.

Faint Object Spectrograph (FOS) (FOS will be replaced with the NICMOS during SM-2)

A spectrograph spreads out the light gathered by a telescope so that it can be analyzed to determine such properties of celestial objects as chemical composition and abundances, temperature, radial velocity, rotational velocity, and magnetic fields. The Faint Object Spectrograph examines fainter objects than the HR, and can study these objects across a much wider spectral range -- from the UV (1150 Angstroms) through the visible red and the near-infrared (8000 Angstroms).

Goddard High Resolution Spectrograph (GHRS)

(GHRS will be replaced with the STIS during SM-2)

The High Resolution Spectrograph also separates incoming light into its spectral components so that the composition, temperature, motion, and other chemical and physical properties of the objects can be analyzed. The HR contrasts with the FOS in that it concentrates entirely on UV spectroscopy and trades the extremely faint objects for the ability to analyze very fine spectral detail. Like the FOS, the HR. uses two 521- channel Digicon electronic light detectors, but the detectors of the HR. are deliberately blind to visible light. One tube is sensitive from 1050 to 1700 Angstroms; while the other is sensitive from 1150 to 3200 Angstroms.

Mission Operations and Observations

Although HST operates around the clock, not all of its time is spent observing. Each orbit lasts about 95 minutes, with time allocated for housekeeping functions and for observations. "Housekeeping" functions include turning the telescope to acquire a new target, or avoid the Sun or Moon, switching communications antennas and data transmission modes, receiving command loads and downlinking data, calibrating and similar activities.

When STScI completes its master observing plan, the schedule is forwarded to Goddard's Space Telescope Operations Control Center (STOCC), where the science and housekeeping plans are merged into a detailed operations schedule. Each event is translated into a series of commands to be sent to the onboard computers. Computer loads are uplinked several times a day to keep the telescope operating efficiently.

When possible, two scientific instruments are used simultaneously to observe adjacent target regions of the sky. For example, while a spectrograph is focused on a chosen star or nebula, the WF/PC-2 can image a sky region offset slightly from the main viewing target. During observations, the Fine Guidance Sensors (FGS) track their respective guide stars to keep the telescope pointed steadily at the right target.

If an astronomer desires to be present during the observation, there is a console at STScI and another at the STOCC, where monitors display images or other data as the observations occur. Some limited real-time commanding for target acquisition or filter changing is performed at these stations, if the observation program has been set up to allow for it, but spontaneous control is not possible.

Engineering and scientific data from HST, as well as uplinked operational commands, are transmitted through the Tracking and Data Relay Satellite (TDRS) system and its companion ground station at White Sands, NM. Up to 24 hours of commands can be stored in the onboard computers.

Data can be broadcast from HST to the ground stations immediately or stored on tape and downlinked later.

The observer on the ground can examine the "raw" images and other data within a few minutes for a quick- look analysis. Within 24 hours, GSFC formats the data for delivery to the STScI. STScI is responsible for data processing (calibration, editing, distribution, and maintenance of the data for the scientific community).

Competition is keen for HST observing time. Only one of every ten proposals is accepted. This unique space-based observatory is operated as an international research center and as a resource for astronomers world- wide.

HUBBLE'S TOP CONTRIBUTIONS TO ASTRONOMY

- Made the deepest-ever visible look into the universe revealing thousands of galaxies, allowing astronomers to trace the universe's evolution.
- Contributed important new evidence supporting the fact that the universe made most of its stars long ago (when the universe was 1/10 its present age), and that the vast majority of stars are only 1/5th the mass of our Sun.
- Provided the first definitive evidence quasars (extraordinarily energetic objects) are the bright active cores of galaxies, and that the host galaxies are remarkably varied, from normal-looking to colliding.
- Found massive black holes are common throughout the universe and dwell in the cores of most, if not all, galaxies.
- Showed that gas shells surrounding dying stars are remarkably complex.
- Traced the buildup of the heavier elements via star formation in the early universe. Such elements are a prerequisite for planets, and life in the cosmos.
- Showed stellar jets emanating from the centers of dust disks around young stars. Hubble's detection of dust disks in the Orion Nebula suggests that planetary system formation may be common in the Milky Way galaxy.
- Offered a detailed look at a once-in-a-millennium collision between Jupiter and a string of comet fragments (Comet Shoemaker-Levy 9).
- Provided enough visual detail to make the first surface map of the planet Pluto.
- Served as an interplanetary "weather satellite" for following the turbulent atmospheres of the major planets, and dust storms and other changes on Mars -- important information for future robotic and human explorers to the Red Planet.
- Found oxygen atmospheres on the moons Europa and Gannymede.

STS-82 CREWMEMBERS

STS082-S-002 -- These seven astronauts are prime crew members for NASA's STS-82 mission. They are, in the front row, from the left, Kenneth D. Bowersox, Steven A. Hawley and Scott J. Horowitz. In the back row are Joseph R. Tanner, Gregory J. Harbaugh, Mark C. Lee and Steve L. Smith. Bowersox and Horowitz are commander and pilot respectively, with Lee assigned as payload commander. Hawley, Harbaugh, Smith and Tanner are mission specialists. The seven are pictured with a small model of the Hubble Space Telescope (HST), to which they will be paying a visit for the second HST maintenance mission. Bowersox was pilot for the ST-61 mission, which performed the first maintenance on HST. Hawley was a mission specialist on STS-31, the mission whose astronauts deployed the telescope in 1990.

BIOGRAPHICAL DATA

Kenneth D. Bowersox (Commander, USN), will serve as Commander for STS-82. He was born November 14, 1956, in Portsmouth, VA, but considers Bedford, IN, to be his hometown. Bowersox graduated from Bedford High School in 1974, received a bachelor of science degree in aerospace engineering from the United States Naval Academy in 1978, and a master of science degree in mechanical engineering from Columbia University in 1979.

Bowersox was selected as an astronaut candidate by NASA in June 1987. A three flight veteran, he has logged over 40 days in space. Bowersox flew as pilot on STS-50 in 1992 and STS-61 in 1993, and was the spacecraft commander on STS-73 in 1995.

Scott J. "Doc" Horowitz, Ph.D. (Lieutenant Colonel, USAF) will serve as Pilot for STS-82. He was born March 24, 1957, in Philadelphia, PA, but considers Thousand Oaks, CA, to be his hometown. He graduated from Newbury Park High School, Newbury Park, CA, in 1974, received a bachelor of science degree in engineering from California State University at Northridge in 1978, a master of science degree in aerospace engineering from Georgia Institute of Technology in 1979, and a doctorate in aerospace engineering from Georgia Institute of Technology in 1982.

He was selected for the astronaut program in March 1992 Horowitz served as pilot on STS-75 in 1996 and has logged over 377 hours in space.

Joseph R. "Joe" Tanner will serve as Mission Specialist-1 on STS-82. He was born January 21, 1950, in Danville, IL. Tanner graduated from Danville High School in 1968, and received a bachelor of science degree in mechanical engineering from the University of Illinois in 1973.

Selected as an astronaut candidate by NASA in March 1992, Tanner reported to the Astronaut Office in August 1992. Tanner flew aboard the Space Shuttle Atlantis on STS-66, and has logged 262 hours in space.

Steven A. Hawley (Ph.D.) will serve as Mission Specialist-2 on STS-82. He was born December 12, 1951, in Ottawa, KS, but considers Salina, KS, to be his hometown. Hawley graduated from Salina (Central) High School in 1969, received a bachelor of arts degrees in physics and astronomy (graduating with highest distinction) from the University of Kansas in 1973, and a doctor of philosophy in astronomy and astrophysics from the University of California in 1977.

Hawley was selected as a NASA astronaut in January 1978 and served as a mission specialist on three flights -- STS-41D in 1984, STS-61C in 1986, and STS-31 in 1990 for a total of 412 hours in space. In June 1990, Dr. Hawley left the Astronaut Office to assume the post of Associate Director of NASA's Ames Research Center in California. In August 1992, Dr. Hawley returned to the Johnson Space Center as Deputy Director of Flight Crew Operations. In February 1996, Dr. Hawley was returned to astronaut flight status and named to the crew of the second Hubble Space Telescope servicing mission.

Gregory J. Harbaugh will serve as Mission Specialist-3 on STS-82. He was born April 15, 1956, in Cleveland, OH. Willoughby, OH, is his hometown. Harbaugh graduated from Willoughby South High School in 1974, received a bachelor of science degree in aeronautical and astronautical engineering from Purdue University in 1978, and a master of science degree in physical science from University of Houston-Clear Lake in 1986.

Harbaugh was selected as an astronaut by NASA in June 1987. He has flown on three Shuttle flights as a mission specialist - STS-39 in 1991, STS-54 in 1993, and STS-71 in 1995. Harbaugh has logged a total of 578 hours, 23 minutes in space.

BIOGRAPHICAL DATA

Mark C. Lee (Colonel, USAF) will serve as Mission Specialist-4 on STS-82. Lee was born August 14, 1952, in Viroqua, WI. He graduated from Viroqua High School in 1970, received a bachelor of science degree in civil engineering from the U.S. Air Force Academy in 1974, and a master of science degree in mechanical engineering from Massachusetts Institute of Technology in 1980.

Lee was selected as an astronaut candidate by NASA in May 1984. A veteran of three space flights, Lee has traveled over 9 million miles going around the world 368 times and spending over 550 hours in orbit. He flew on STS-30 in 1989, STS-47 in 1992, and STS-64 in 1994. During STS-64, he logged 6 hours and 51 minutes of EVA time.

Steven L. Smith will serve as Mission Specialist-5 on STS-82. He was born December 30, 1958, in Phoenix, AZ, but considers San Jose, CA, to be his hometown. Smith graduated from Leland High School in San Jose in 1977, received a bachelor of science degree in electrical engineering from Stanford University in 1981, a master of science degree in electrical engineering from Stanford University in 1982, and a master's degree in business administration from Stanford University in 1987.

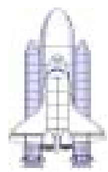
Smith was selected as an astronaut candidate by NASA in March 1992. He flew on mission STS-68 in 1994 and has logged 269 hours in space.

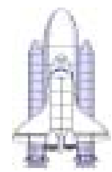
Additional biographical information on the STS-82 crew members and other NASA astronauts is available on the World Wide Web at:

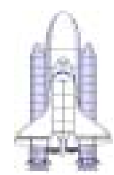
http://www.jsc.nasa.gov/Bios/astrobio.html

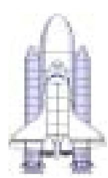
SHUTTLE FLIGHTS AS OF FEBRUARY 1997

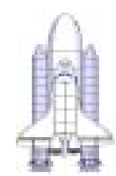
81 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM – 56 SINCE RETURN TO FLIGHT











OV-102 **Columbia** **(21 flights)**	**OV-099** **Challenger** **(10 flights)**	**OV-103** **Discovery** **(21 flights)**	**OV-104** **Atlantis** **(18 flights)**	**OV-105** **Endeavour** **(11 flights)**
STS-80 11/19/96 - 12/07/96		STS-70 07/13/95 - 07/22/95		
STS-78 06/20/96 - 07/07/96		STS-63 02/03/95 - 02/11/95		
STS-75 02/22/96 - 03/09/96		STS-64 09/09/94 - 09/20/94		
STS-73 10/20/95 - 11/05/95		STS-60 02/03/94 - 02/11/94	STS-81 01/12/97 - 01/22/97	
STS-65 07/08/94 - 07/23/94		STS-51 09/12/93 - 09/22/93	STS-79 09/16/96 - 09/26/96	
STS-62 03/04/94 - 03/18/94		STS-56 04/08/83 - 04/17/93	STS-76 03/22/96 - 03/31/96	
STS-58 10/18/93 - 11/01/93		STS-53 12/02/92 - 12/09/92	STS-74 11/12/95 - 11/20/95	
STS-55 04/26/93 - 05/06/93		STS-42 01/22/92 - 01/30/92	STS-71 06/27/95 - 07/07/95	
STS-52 10/22/92 - 11/01/92		STS-48 09/12/91 - 09/18/91	STS-66 11/03/94 - 11/14/94	
STS-50 06/25/92 - 07/09/92		STS-39 04/28/91 - 05/06/91	STS-46 07/31/92 - 08/08/92	
STS-40 06/05/91 - 06/14/91		STS-41 10/06/90 - 10/10/90	STS-45 03/24/92 - 04/02/92	STS-77 05/19/96 - 05/29/96
STS-35 12/02/90 - 12/10/90	STS-51L 01/28/86	STS-31 04/24/90 - 04/29/90	STS-44 11/24/91 - 12/01/91	STS-72 01/11/96 - 11/20/96
STS-32 01/09/90 - 01/20/90	STS-61A 10/30/85 - 11/06/85	STS-33 11/22/89 - 11/27/89	STS-43 08/02/91 - 08/11/91	STS-69 09/07/95 - 09/18/95
STS-28 08/08/89 - 08/13/89	STS-51F 07/29/85 - 08/06/85	STS-29 03/13/89 - 03/18/89	STS-37 04/05/91 - 04/11/91	STS-67 03/02/95 - 03/18/95
STS-61C 01/12/86 - 01/18/86	STS-51B 04/29/85 - 05/06/85	STS-26 09/29/88 - 10/03/88	STS-38 11/15/90 - 11/20/90	STS-68 09/30/94 - 10/11/94
STS-9 11/28/83 - 12/08/83	STS-41G 10/05/84 - 10/13/84	STS-51-I 08/27/85 - 09/03/85	STS-36 02/28/90 - 03/04/90	STS-59 04/09/94 – 04/20/94
STS-5 11/11/82 - 11/16/82	STS-41C 04/06/84 - 04/13/84	STS-51G 06/17/85 - 06/24/85	STS-34 10/18/89 - 10/23/89	STS-61 12/02/93 - 12/13/93
STS-4 06/27/82 - 07/04/82	STS-41B 02/03/84 - 02/11/84	STS-51D 04/12/85 - 04/19/85	STS-30 05/04/89 - 05/08/89	STS-57 06/21/93 - 07/01/93
STS-3 03/22/82 - 03/30/82	STS-8 08/30/83 - 09/05/83	STS-51C 01/24/85 - 01/27/85	STS-27 12/02/88 - 12/06/88	STS-54 01/13/93 - 01/19/93
STS-2 11/12/81 - 11/14/81	STS-7 06/18/83 - 06/24/83	STS-51A 11/08/84 - 11/16/84	STS-61B 11/26/85 - 12/03/85	STS-47 09/12/92 - 09/20/92
STS-1 04/12/81 - 04/14/81	STS-6 04/04/83 - 04/09/83	STS-41D 08/30/84 - 09/05/84	STS-51J 10/03/85 - 10/07/85	STS-49 05/07/92 - 05/16/92