A publication of the National Aeronautics and Space Administration

Mission Highlights STS-93

IS-1999-07-001.093JSC
July 1999

Mission Marks Milestones in Space Flight History

NASA marked milestones in both human space flight history and astronomy on this 95th space shuttle mission with the launch of the first woman as shuttle commander and the Chandra X-Ray Observatory.

Columbia's 26th flight was led by Air Force Col. Eileen Collins, who was the first woman to command a space shuttle mission following her two previous flights as Pilot.

Launched by the crew of STS-93, Chandra joined the Hubble Space Telescope and the Compton Gamma Ray Observatory in orbit as the next in NASA's series of "Great Observatories." Chandra will spend the next five years in a highly elliptical orbit taking it one-third of the way to the Moon to study invisible and often violent sources of astronomical activity in the distant universe.

Mission Events

The Shuttle *Columbia* rose from launch pad 39B at Kennedy Space Center at 12:31 a.m. EDT on July 23, on the second shuttle mission of 1999 with a soaring night launch.

Primary objective of the STS-93 mission was the deployment of the $1.5 billion Chandra X-Ray Observatory, the third in NASA's series of "Great Observatories."

NASA Photo S93-E-5122

The Chandra X-Ray Observatory, the world's most powerful X-Ray telescope is shown in *Columbia*'s payload bay before its deployment by the STS-93 crew.

Space Shuttle *Columbia*

July 23-27, 1999

Commander: Eileen M. Collins

Pilot: Jeffrey S. Ashby

Mission Specialists: Catherine "Cady" G. Coleman
Steven A. Hawley
Michel Tognini

NASA Photo S93-E-5057

Mission Commander Eileen Collins enters notes on a log at the commander's station on *Columbia*'s flight deck.

The crew deployed the observatory about seven hours after liftoff. Chandra was boosted from *Columbia* to its highly elliptical orbit by an Inertial Upper Stage (IUS) solid rocket motor.

The Chandra X-Ray Observatory consists of three major elements: a mirror assembly, a science instrument module and the spacecraft. It is a revolutionary telescope that combines the ability to make sharp images while it measures precisely the energies of X-Rays coming from cosmic sources.

Chandra's principle objective is to detect and image X-Ray sources that are billions of light years away. Images from Chandra will show fifty times more detail than any previous X-Ray telescope. Chandra's improved sensitivity will make possible more detailed studies of black holes, supernovae, and dark matter. Chandra will increase our understanding of the origin, evolution, and destiny of the universe.

Secondary objectives included the firing of *Columbia*'s orbital engines and jet thrusters at various times during the flight **(SIMPLEX, MSX**). Air Force satellites and ground facilities gathered data on the characteristics of the orbiter's jet plumes.

In addition, crew members operated the **Southwest Ultraviolet Imaging System (SWUIS)**, a small telescope mounted at the side hatch window in *Columbia*'s mid deck collecting data on ultraviolet light originating from the Earth's Moon, Mercury, Venus and Jupiter.

The crew also conducted an in-flight assessment of an exercise system planned for the International Space Station. The on-orbit treadmill, referred to as the Treadmill Vibration Isolation and Stabilization (TVIS) system, was expected to provide the crew with a reliable exercise device while also meeting International Space Station load transmission requirements to avoid disrupting on-orbit experiments.

Commander Collins flew *Columbia* to a textbook touchdown at 11:20 p.m. EDT on July 27th at Kennedy Space Center. The crew completed the mission spanning almost 1.8 million miles with 80 orbits in 4 days, 22 hours, and 50 minutes. STS-93 was the 12th night landing in the Shuttle Program's history.

Flight Day 1

Less than nine minutes after liftoff, the first woman shuttle commander and her crew were in orbit, ready to begin a full night of work to prepare **Chandra X-Ray Observatory** for its deployment as the third of NASA's Great Observatories. A little more than seven hours after *Columbia* and its five astronauts were launched, Chandra was spring-ejected from a cradle in the shuttle's cargo bay at 7:47 a.m. EDT as *Columbia* flew over the Indonesian Island chain.

Commander Collins maneuvered *Columbia* to a safe distance away from the telescope as an internal timer counted down to the first of a two-phase ignition of the solid-fuel Inertial Upper Stage. The telescope successfully reached its intended oval orbit one-third of the distance to the Moon.

Flight Day 2

Crew activities focused on activating the secondary payloads such as **Micro-Electromechanical Systems (MEMS)** and **Gelation of Sols: Applied Microgravity Research (GOSAMR, AEROGEL)** and other experiments on both the flight and mid decks of the shuttle. Mission Specialist Steven Hawley, the resident astronomer of the STS-93 crew, and Mission Specialist Michel Tognini worked on experiments involving everything from astronomy to biomedicine to plant growth as the shuttle continued to orbit the Earth every 90 minutes in excellent shape.

The crew set up the SWUIS and collected their first observations. The telescopic instrument was mounted on the side hatch window in the shuttle's mid deck. SWUIS was used to image planets and other solar system bodies in order to explore their atmospheres and surfaces in the ultraviolet (UV) region of the spectrum, which astronomers value for its diagnostic power. SWUIS, making its second flight, obtained ultraviolet imagery of Earth's Moon, Mercury, Venus and Jupiter.

Commander Collins and Pilot Jeffrey Ashby fired *Columbia*'s large orbital maneuvering system engines and primary reaction control system jets on several occasions to provide data for researchers in a pair of experiments designed to characterize jet thruster plumes in the space environment. They also conducted a successful test of a procedure called the "flycast" maneuver in a rehearsal for the STS-99 mission. The maneuver used multiple thruster firings and the shuttle's autopilot system to maintain stability.

Ashby and Mission Specialist Catherine "Cady" Coleman also conducted several tests of High Definition Television (HDTV) equipment carried on board *Columbia*. HDTV gear is being tested for future use on both the shuttle and the

Payloads

Biological Research in Canisters (BRIC) was designed to investigate the effects of space flight on small arthropod animals and plant specimens.

Cell Culture Module (CCM) validated models for muscle, bone, and endothelial cell biochemical and functional loss induced by microgravity stress.

Chandra X-Ray Observatory is designed to conduct comprehensive studies of the universe.

Commercial Generic Bioprocessing Apparatus (CGBA) samples included ladybugs, aphids and caterpillars.

Gelation of Sols: Applied Microgravity Research (GOSAMR, AEROGEL) investigated the influence of microgravity on the processing of gelled sols.

High Definition Television Camera (HDTV) The camera and gear were tested for future use on the shuttle and the International Space Station.

Light Weight Flexible Solar Array Hinge (LFSAH) consisted of several hinges fabricated from shape memory alloys which offered controlled shockless deployment of spacecraft appendages.

Micro-Electrical Mechanical System (MEMS) examined the performance, under launch, microgravity, and reentry conditions of a suite of MEMS devices including accelerometers, gyros, and environmental and chemical sensors.

Midcourse Space Experiment (MSX) required orbiter thruster firings used as a sensor calibration and evaluation target for the space-based ultraviolet, infrared, and visible sensors on the MSX satellite.

Plant Growth Investigations in Microgravity (PGIM) used plants to monitor the space flight environment for stressful conditions that affect plant growth.

Shuttle Amateur Radio Experiment (SAREX II) demonstrated the feasibility of amateur short-wave radio contacts between the shuttle and ground-based amateur radio operators.

Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX) determined the source of Very High Frequency (VHF) radar echoes caused by the orbiter and its OMS engine firings.

Southwest Ultraviolet Imaging System (SWUIS) was based around a Maksutov-design Ultraviolet (UV) telescope and an UV-sensitive, image-intensified Charge-Coupled Device (CCD) camera that frames at video frame rates.

Space Tissue Loss-B (STL-B) focused on direct video observation of cells in culture by using a video microscope imaging system.

Treadmill Vibration Information System (TVIS) measured vibrations and changes in microgravity levels during on-orbit workouts.

International Space Station to conform to evolving broadcasting industry standards for television products.

Flight Day 3

The five member STS-93 crew aboard *Columbia* was busy with a variety of secondary experiments. Hawley and Tognini continued their work with the SWUIS telescope collecting imagery of Mercury, Venus, Jupiter and the Moon.

Commander Collins and Ashby were responsible for maneuvering *Columbia* in support of various experiments including observations made with the SWUIS instrument and the **SIMPLEX**. Commander Collins also conducted a conversation with students at the Harbor View Elementary School in Corona Del Mar, California, using the **Shuttle Amateur Radio Experiment (SAREX)** system. She also checked experiments associated with the **Cell Culture Module (CCM)** and the **Biological Research In Canister (BRIC)** payloads.

Coleman worked with the **Plant Growth Investigations in Micro-Gravity (PGIM)** and the **Light Weight Flexible Solar Array Hinge (LFSAH)** experiments, and documented on-orbit operations with **High Definition Television (HDTV)** equipment.

Ashby tended to various orbiter systems and checked the **Space Tissue Loss (STL)** experiment. Mission Specialist Michel Tognini used the **SAREX** system to conduct a ham radio conversation with fellow French Astronaut Jean-Pierre Haignere who was aboard the Russian Mir Space Station. He also helped check the **BRIC** and **LFSAH** experiments, and worked with experiments in the **Commercial Generic Bio-Processing Apparatus (CGBA)**.

Flight Day 4

The first job for Ashby, Hawley and Tognini was to set up and evaluate an exercise treadmill called the **Treadmill Vibration Information System (TVIS)** which measured vibrations and changes in microgravity levels caused by on-orbit workouts. These workouts are needed to maintain astronauts' cardiovascular fitness and muscle tone, which can suffer in the absence of gravity.

Astronomer Hawley once again made observations of Jupiter, Venus and the Moon with the **SWUIS** as Commander Collins and Ashby put the shuttle in the proper orientation for his observations. Tognini and Cady Coleman checked on the bioprocessing experiments, and harvested mouse-ear cress plants as part of the **Plant Growth Investigations in Microgravity** experiment.

Commander Collins and Ashby fired the shuttle's engines so that the sophisticated sensors of the **Midcourse Space Experiment (MSX)** satellite could collect

NASA Photo STS093-320-037

Astronaut Cady Coleman captures video footage with a High Definition Television Camera.

NASA Photo STS093-322-017

The five STS-93 astronauts pose for the traditional in-flight crew portrait on *Columbia*'s mid deck. In front are astronauts Eileen Collins, mission commander, and Michel Tognini, mission specialist representing France's Centre National d'Etudes Spatiales (CNES). Behind them are (from the left) astronauts Steven Hawley, mission specialist; Jeffrey Ashby, pilot; and Cady Coleman, mission specialist.

ultraviolet, infrared and visible light data on the firing. The commander and pilot also practiced landings on a laptop computer, simulation software and joystick combination called the **Portable In-Flight Landing Operations Trainer (PILOT)**.

Flight Day 5

Columbia's crew began packing up experiments and preparing to return to Earth. Touchdown was planned on the Kennedy Space Center's shuttle runway in Florida at 11:20 p.m. EDT.

Commander Collins and Ashby checked out the shuttle's cockpit instruments, displays and flight control systems this evening as part of the preparations for landing. They also test-fired *Columbia*'s 38 small steering jets, finding everything in good shape and ready for the trip back to Earth.

The crew held a press conference, fielding questions from reporters in Houston, Texas, Florida and Massachusetts.

Flight Day 6

Columbia's astronauts glided to a smooth landing at the Kennedy Space Center, wrapping up their successful mission to deploy the Chandra X-Ray Observatory.

CREW BIOGRAPHIES

Commander: Eileen M. Collins (Colonel, USAF). Born in Elmira, New York, Eileen Collins received an A.A. degree in mathematics/science from Corning Community College, a B.S. degree in mathematics/economics from Syracuse University, a M.S. degree in operations research from Stanford University, and a M.A. degree in space systems management from Webster University. Collins graduated from pilot training at Vance Air Force Base (AFB), Oklahoma. She served as a C-141 pilot, aircraft commander, and instructor pilot at Travis AFB, California. In 1983, she flew in "Operation Urgent Fury" in Grenada. She was later assigned to the USAF Academy where she was an assistant professor in mathematics and a T-41 instructor pilot. In 1990, she graduated from the Air Force Test Pilot School at Edwards AFB, California, where she was the class leader.

Collins has logged over 5,000 hours in 30 different types of aircraft and was selected as an astronaut in 1990. Aboard STS-63 (1995), the first Shuttle-Mir rendezvous flight, she became the first woman pilot of a Space Shuttle mission. She also

NASA Photo STS093-347-027

Astronauts Steven Hawley (left) and Michel Tognini are pictured on *Columbia*'s mid deck with the Southwest Ultraviolet Imaging System.

served as pilot aboard STS-84 (1997), the sixth Shuttle-Mir docking mission.

She has flown a total of 17 days in space. With the flight of STS-93, Collins was the first woman in history to command a shuttle mission.

Pilot: Jeffrey S. Ashby (Captain, USN). Born in Dallas, Texas, and raised in the Colorado Mountains, Jeffrey Ashby received a B.S. degree in mechanical engineering from the University of Idaho and a M.S. degree in aviation systems from the University of Tennessee.

Also a graduate of the Naval Test Pilot School and the Naval Fighter Weapons (TOPGUN) School, he has logged over 6000 flight hours and 1000 Navy aircraft carrier arrested landings.

During his 16-year tenure as a fleet Navy pilot, he completed five carrier deployments and flew 33 combat missions in the FA-18 during "Operation Desert Storm." He also participated in the early flight test and development of the FA-18 aircraft, and was responsible for directing and flying tests of the aircraft's smart weapons systems and electronic warfare suite.

In his final operational Navy tour, he served as the Commanding Officer of Strike Fighter Squadron 94. Ashby was selected to be an astronaut in December 1994 and has served as assistant to the Director of Flight Crew Operations. STS-93 was Ashby's first Space Shuttle flight. He has now logged more than 118 hours in space.

Mission Specialist: Catherine "Cady" G. Coleman, Ph.D. (Lieutenant Colonel, USAF). Born in Charleston, South Carolina, Cady Coleman earned a B.S. degree in chemistry from the Massachusetts Institute of Technology and a Ph.D. in polymer science and engineering from the University of Massachusetts.

After entering active duty in 1988, Coleman conducted research in non-linear optical materials at the Polymer Branch of the Air Force Materials Laboratory. She also set endurance and tolerance records as a volunteer test subject for the centrifuge program at the Armstrong Aeromedical Laboratory.

An astronaut since 1992, Coleman was initially assigned to verify mission-critical Shuttle software for upcoming flights, followed by an assignment as the Special Assistant to the Johnson Space Center Director.

Subsequent Astronaut Office jobs included lead astronaut for long-term space flight habitability and human-factors issues such as acoustics and living accommodations aboard the International Space Station.

She was also responsible for the English labeling of all crew interfaces and control panels in the Russian modules of the ISS. As a mission specialist on STS-73 in 1995, she spent nearly 16 days in space. Coleman trained as a backup mission specialist for STS-83 in 1997. STS-93 was Coleman's second Space Shuttle Mission and has logged 21 days in space.

Mission Specialist: Steven A. Hawley (Ph.D.). Born in Ottawa, Kansas, and raised in Salina, Kansas, Steven Hawley received B.A. degrees in physics and astronomy, graduating summa cum laude, from the University of Kansas, and a Ph.D. in astrophysics from the University of California, Santa Cruz.

Following a one-year assignment as a research astronomer at Cerro Tololo Inter-American Observatory in La Serena, Chile, he was selected as an astronaut in 1978. Dr. Hawley has held a variety of technical and management positions in his 21 years

NASA Photo STS093-309-027

Bottom/right - Mission Commander Eileen Collins and Pilot Jeffrey Ashby peruse checklists on *Columbia*'s mid deck.

STS-93
Quick Look

Launch Date: July 23, 1999
Time: 12:31 a.m. EDT
Site: KSC Pad 39B

Orbiter: *Columbia*
OV-102 – 26th flight

Orbit/In.: 153 naut. miles
28.45 degrees

Mission Duration: 4 days, 22 hrs, 50 mns.

Landing Date: July 27, 1999
Time: 11:04 a.m. CST
Site: Kennedy Space Center

Crew:

Eileen M. Collins	(CDR)
Jeffrey S. Ashby	(PLT)
Catherine "Cady" G. Coleman	(MS1)
Steven A. Hawley	(MS2)
Michael Tognini	(MS3)

Mission Events: Flight marks the first time a woman was commander of a space shuttle mission. Primary objective of the STS-93 mission was the deployment of the $1.5 billion Chandra X-Ray Observatory. Secondary objectives included the firing of *Columbia*'s jet thrusters at various times during the flight to help an Air Force satellite gather data on the characteristics of jet plumes in orbit. In addition, crew members operated the Southwest Ultraviolet Imaging System, a small telescope mounted at the side hatch window in *Columbia*'s mid deck collecting data on ultraviolet light originating from a variety of planetary bodies.

Payloads:
Chandra X-Ray Observatory
Biological Research in Canisters (BRIC)
Cell Culture Model (CCM)
Commercial Generic Bioprocessing Apparatus (CGBA)
Gelation of Sols: Applied Microgravity Research (GOSAMR, AEROGEL)
High Definition Television Camera (HDTV)
Light Weight Flexible Solar Array Hinge (LFSAH)
Micro-Electromechanical Systems (MEMS)
Midcourse Space Experiment (MSX)
Plant Growth Investigations in Microgravity (PGIM)
Shuttle Amateur Radio Experiment (SAREX II)
Shuttle Ionospheric Modification with Pulsed Local Exhaust (SIMPLEX)
Southwest Ultraviolet Imaging System (SWUIS)
Space Tissue Loss - B (STL-B)
Treadmill Vibration Information System (TVIS)

with NASA including Deputy Chief of the Astronaut Office and Associate Director of Ames Research Center. He has been Deputy Director of Flight Crew Operations at the Johnson Space Center since 1992. STS-93 was Dr. Hawley's fifth space shuttle mission.

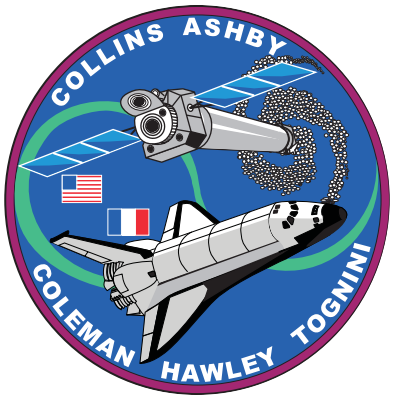
His previous missions have included the first flight of *Discovery* on mission STS-41D (1984), STS-61C (1986), the deployment of the Hubble Space Telescope on mission STS-31 (1990), and the second Hubble Servicing Mission in 1997, STS-82. He has accrued 27 days in space on his four previous flights.

Mission Specialist: Michel Tognini (Col., French Air Force). Born in Vincennes, France, Michel Tognini received an engineering degree from Ecole de l'Air (the French Air Force Academy), Salon de Provence, France. He subsequently attended the Empire Test Pilots School, Boscombe Down, United Kingdom, and the Institut des Hautes Etudes de Defense Nationale (IHEDN).

In 1986, Tognini was assigned as the backup for the Soyuz TM-7 mission. He reported to the Yuri Gagarin Cosmonaut Training Center, Star City, Russia, for alternate astronaut training, including training for extravehicular (or space walk) activity for the Soviet-French ARAGATZ mission.

During 1989-1990, Tognini supported the HERMES program in Toulouse, France. In 1991, he returned to Star City, Russia, to start prime crew training for the third Soviet-French ANTARES mission. Tognini made his first space flight on-board the Soyuz TM-15, TM-14 mission (July 27-August 10, 1992). During this mission, he spent 14 days conducting joint Soviet-French experiments. After this mission, he attended the French Institute for High Studies of National Defense (IHEDN).

Selected as an international astronaut in 1995, Tognini worked on technical issues associated with the International Space Station in the Operations Planning Branch of the Astronaut Office. He has 4,000 flight hours on 80 types of aircraft. He has logged a total of 19 days in space.



The STS-93 mission patch, as designed by the five crew members. The STS-93 mission carried the Chandra X-Ray Observatory into low Earth orbit initiating its planned five-year astronomy mission. Chandra is the third of NASA's great observatories, following the Hubble Space Telescope and the Compton Gamma Ray Observatory. Chandra provides scientists an order-of-magnitude improvement over current capabilities at X-Ray wavelengths. Observations of X-Ray emissions from energetic galaxies and clusters, as well as black holes, promise to greatly expand current understanding of the origin and evolution of our universe. The STS-93 patch depicts Chandra separating from the Space Shuttle *Columbia* after a successful deployment. A spiral galaxy is shown in the background as a possible target for Chandra observations. The two flags represent the international crew, consisting of astronauts from both the United States and France.