CELEBRATING 30 YEARS
OF THE SPACE SHUTTLE PROGRAM

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Designed by Adam Chen
Edited by William Wallack and George Gonzalez

A Special Thanks to Robert D. Legler and Floyd V. Bennett, Mission Operations, Johnson Space Center

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Thank you to the astronauts, international partners, and thousands of civil servants and Government contractors who worked on the Space Shuttle program. Your efforts contributed to one of the most successful and longest-lasting programs in the history of the National Aeronautics and Space Administration. The people of the United States of America will be forever thankful for your contributions to push people and technology beyond their current limits and on to new horizons.

Information contained in this book was compiled from a variety of NASA resources and spans the Space Shuttle program's three decades of operation. Because of each mission's complexity, certain data, experiments, and information may not be included.

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Forward—A Message from Charles F. Bolden, Jr.

Thirty years ago today [April 12, 2011], Space Shuttle Columbia lifted off the launch pad at Kennedy Space Center for the very first time. In a flight that lasted 54 hours, NASA proved an amazing piece of technology. For 30 years, the best workforce in the world has launched 133 Shuttle flights, dedicated to making each better than the last.

I want to thank each and every person who has ever been part of the Shuttle workforce over the years for your significant contribution to this American accomplishment. You've helped make the world a better place and should take pride in that. Today belongs not just to the 360 men and women who have flown on the Shuttle, but to all of you who have helped their missions to succeed.

Your work means a great deal to me personally. Those of us who have flown the Shuttle put our lives in your hands each time we flew, and I never doubted that all of you on the ground, in launch and mission control, in orbiter processing, in every phase of the program, were absolutely dedicated, and among the most skilled and committed people I have ever known.

The Shuttle has provided this Nation with many firsts, with many proud moments, and it has helped the United States to lead the world in space exploration. Over three decades, this flagship program has become part of the fabric of our Nation's history. It's helped us improve communications on Earth and to understand our home planet better. It's set scientific satellites like Magellan and Ulysses speeding on their missions into the solar system and launched Hubble and Chandra to explore the universe.

The Shuttle program has given us tremendous knowledge about a reusable spacecraft and launch system from which future commercial systems will benefit. It's enabled construction of the International Space Station, our foothold for human exploration, which is leading to breakthroughs in human health and microgravity research. And it's provided "first ever" astronaut flight and command opportunities for women and minorities.

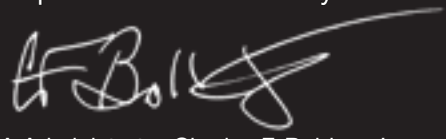
We'll never forget the crews of Challenger and Columbia. Many of us counted them as our personal friends, and their achievements will live on in the spirit of perseverance and grit and hope in which they lived and worked. They were all true heroes who made the ultimate sacrifice in service to this country.

The human space flight program will continue with astronauts living and working on the International Space Station until at least 2020. We wouldn't have been able to build that orbiting outpost without the Shuttle. We wouldn't have established that model of global cooperation that serves as a guidepost for how we can work together toward the greater things of which we are capable as human beings.

With the last flight of Atlantis in June, the Shuttles stop flying, but they don't stop inspiring, and they don't stop being part of the fabric of America. Three museums and one NASA Center will have a Shuttle orbiter to continue to tell the story of human space flight and American accomplishment.

There were many worthy institutions who requested an orbiter and far too few to go around. But millions of Americans and people from around the world will continue to learn from these amazing vehicles and the stories of their crews and their missions in their new homes.

The Shuttle's retirement is bittersweet for us, but I am also very excited about our future. A future that is bright and open to us because of the Shuttle program. We could not be reaching for new heights and developing the next generation of capabilities without the technological breakthroughs of the Shuttle and the many lessons learned that we will carry forward. Our commitment to human space flight is steadfast, and with this amazing workforce, we will continue to lead the world in human space exploration and discovery.



NASA Administrator Charles F. Bolden, Jr.

STS-1

A remote camera at the Kennedy Space Center's (KSC) Launch Pad 39A captured this scene of the maiden flight of the Space Shuttle Columbia. Commander John W. Young and pilot Robert L. Crippen were aboard Columbia as it began an orbital mission scheduled to last for 54 hours. Three main engines and two solid rocket boosters were necessary to lift the 150,000-pound vehicle into Earth orbit. The mission ended on April 14 with an unpowered landing at Edwards Air Force Base in California.

Mission
STS-1, First Shuttle mission;
Shuttle systems test flight

Space Shuttle
Columbia

Launched
April 12, 1981, at 7:00:04 a.m. EST from
Launch Pad 39A at Kennedy Space Center, FL

Landed
April 14, 1981, at 10:20:57 a.m. PST on
Runway 23 at Edwards Air Force Base, CA

Duration
2 days, 6 hours, 20 minutes, and 53 seconds

Distance Traveled
933,757 miles

Orbits
37

Crew
Commander John W. Young
Pilot Robert L. Crippen

The primary mission objectives of the maiden flight were to check out the overall Shuttle system, to accomplish a safe ascent into orbit, and to return to Earth for a safe landing. All of these objectives were met successfully, and the Shuttle's worthiness as a space vehicle was verified.

All major systems tested successfully on the first flight of the Space Transportation System (STS). However, the orbiter sustained tile damage on the launch from an overpressure wave created by the solid rocket boosters. Subsequent modifications to the water sound suppression system eliminated the problem. A total of 16 tiles were lost and 148 were damaged.

One of the payloads carried on the mission was a Development Flight Instrumentation (DFI) package, which contained sensors and measuring devices to record the orbiter's performance and the stresses that occurred during launch, ascent, orbital flight, descent, and landing.

STS-2

This view of the Space Shuttle Columbia provides a good study of the high-temperature protection material on the underside of the spacecraft, which was exposed to the friction of atmospheric entry during the orbiter's return to Earth.

Mission
STS-2, Office of Space and
Terrestrial Applications-1 (OSTA-1)

Space Shuttle
Columbia

Launched
November 12, 1981, at 10:10:00 a.m. EST from
Launch Pad 39A at Kennedy Space Center, FL

Landed
November 14, 1981, at 1:23:12 p.m. PST on
Runway 23 at Edwards Air Force Base, CA

Duration
2 days, 6 hours, 13 minutes, and 12 seconds

Distance Traveled
933,757 miles

Orbits
37

Crew
Commander Joe H. Engle
Pilot Richard H. Truly

The planned 5-day mission was cut short nearly 3 days due to a malfunctioning fuel cell that impacted the production of electricity and drinking water on the Shuttle. Yet despite the shortened time frame, 90 percent of the mission objectives were achieved, including the first Remote Manipulator System (RMS) tests. Mission scientists were satisfied with the data from the Office of Space and Terrestrial Applications-1 (OSTA-1) Earth-observation experiments that were mounted on the Spacelab pallet in the payload bay.

The flight marked the first time that a piloted space vehicle had been reflown with a second crew. It again carried the Development Flight Instrumentation (DFI) package, as well as the OSTA-1 payload, which consisted of a number of remote sensing instruments mounted on the Spacelab pallet. These instruments, including the Shuttle Imaging Radar (SIR-A), successfully carried out the remote sensing of Earth's resources, environmental quality, and ocean and weather conditions. Additionally, the Canadian-built RMS arm was operated in all its various operating modes for the first time.

STS-3

The Space Shuttle Columbia touches down on the Northrup Strip at White Sands Missile Range in New Mexico, marking the first time in its three-flight history that the Shuttle had touched New Mexico soil.

Mission
STS-3, Office of Space Science-1 (OSS-1)

Space Shuttle
Columbia

Launched
March 22, 1982, at 11:00:00 a.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
March 30, 1982, at 9:04:45 a.m. MST on Runway 17 at White Sands, NM

Duration
8 days, 0 hours, 4 minutes, and 46 seconds

Distance Traveled
3,900,000 miles

Orbits
130

Crew
Commander Jack R. Lousma
Pilot C. Gordon Fullerton

The third Shuttle mission continued to test systems for operational-flight worthiness and was the first launch where the external fuel tank appeared in its iconic orange color. Remote Manipulator System (RMS) tests and measurements of the orbiter's thermal responses in various attitudes to the Sun were conducted. A Get-Away Special (GAS) test canister and additional Spacelab experiments for NASA's Office of Space Science-1 (OSS-1) were deployed, obtaining data on the near-Earth space environment that included statistics on contamination (gases, dust, etc.) introduced into space by the orbiter.

Other onboard experiments included the Monodisperse Latex Reactor (MLR), the Electrophoresis Equipment Verification Test (EEVT), the Heflex Bioengineering Test (HBT), and the first Shuttle Student Involvement Program (SSIP) experiment.

STS-4

A view of the Space Shuttle Columbia sitting on Launch Pad 39A at the Kennedy Space Center (KSC) as preparations continue toward a late June launch. Columbia's fourth mission marked the final test flight in the STS program.

Mission
STS-4, Department of Defense;
Continuous Flow Electrophoresis System (CFES)

Space Shuttle
Columbia

Launched
June 27, 1982, at 11:00:00 a.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
July 4, 1982, at 9:09:40 a.m. PDT on
Runway 22 at Edwards Air Force Base, CA

Duration
7 days, 1 hour, 9 minutes, and 40 seconds

Distance Traveled
2,900,000 miles

Orbits
113

Crew
Commander Thomas K. Mattingly II
Pilot Henry W. Hartsfield, Jr.

STS-4 was the final Shuttle research and development flight. In addition to carrying a classified Department of Defense payload, mission cargo also included a Get-Away Special (GAS) that contained nine experiments from Utah State University students, the first commercial experiment involving the Continuous Flow Electrophoresis System (CFES), the Monodisperse Latex Reactor (MLR), the Induced Environment Contamination Monitor (IECM), and two Shuttle Student Involvement Program (SSIP) experiments.

For the SSIP experiments, the crew performed medical experiments on themselves. The astronauts also operated the Remote Manipulator System (RMS) arm to swing the IECM around the orbiter, and they took photos of lightning activity in Earth's atmosphere.

STS-5

The Space Shuttle Columbia makes its slow 3½-mile trip on a crawler transporter from the Vehicle Assembly Building (VAB) to Launch Pad 39A at the Kennedy Space Center (KSC) in Florida.

This first Shuttle operational mission deployed two commercial communications satellites, Anik C-3 for Telesat Canada and SBS-3 for Satellite Business Systems. Each satellite was equipped with a Payload Assist Module-D (PAM-D) solid rocket motor, which fired about 45 minutes after deployment, placing each satellite into a highly elliptical orbit. One Get-Away Special (GAS) and three Shuttle Student Involvement Program (SSIP) experiments were also conducted on this flight.

Mission
STS-5, Commercial communications satellites:
Telesat Canada (Anik C-3) and
Satellite Business Systems (SBS-3)

Space Shuttle
Columbia

Launched
November 11, 1982, at 7:19:00 a.m. EST from
Launch Pad 39A at Kennedy Space Center, FL

Landed
November 16, 1982, at 6:33:26 a.m. PST on
Runway 22 at Edwards Air Force Base, CA

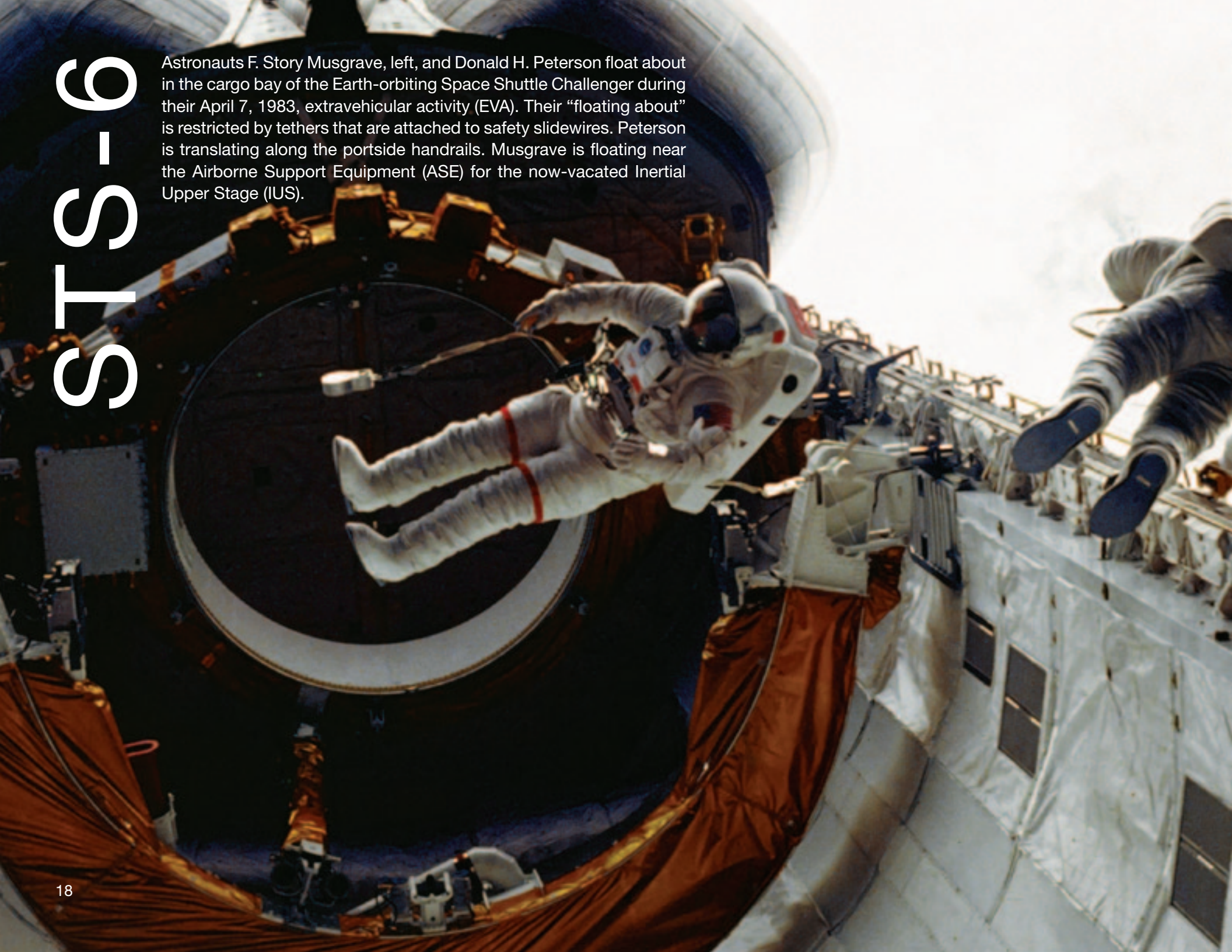
Duration
5 days, 2 hours, 14 minutes, and 26 seconds

Distance Traveled
1,850,000 miles

Orbits
82

Crew
Commander Vance D. Brand
Pilot Robert F. Overmyer
Mission Specialists Joseph P. Allen and
William B. Lenoir

STS-6



Astronauts F. Story Musgrave, left, and Donald H. Peterson float about in the cargo bay of the Earth-orbiting Space Shuttle Challenger during their April 7, 1983, extravehicular activity (EVA). Their “floating about” is restricted by tethers that are attached to safety slidewires. Peterson is translating along the portside handrails. Musgrave is floating near the Airborne Support Equipment (ASE) for the now-vacated Inertial Upper Stage (IUS).

Mission
STS-6, Tracking and Data Relay Satellite-A (TDRS-A); First Shuttle spacewalk

Space Shuttle
Challenger

Launched
April 4, 1983, at 1:30:00 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
April 9, 1983, at 10:53:42 a.m. PST on Runway 22 at Edwards Air Force Base, CA

Duration
5 days, 0 hours, 23 minutes, and 42 seconds

Distance Traveled
1,820,000 miles

Orbits
81

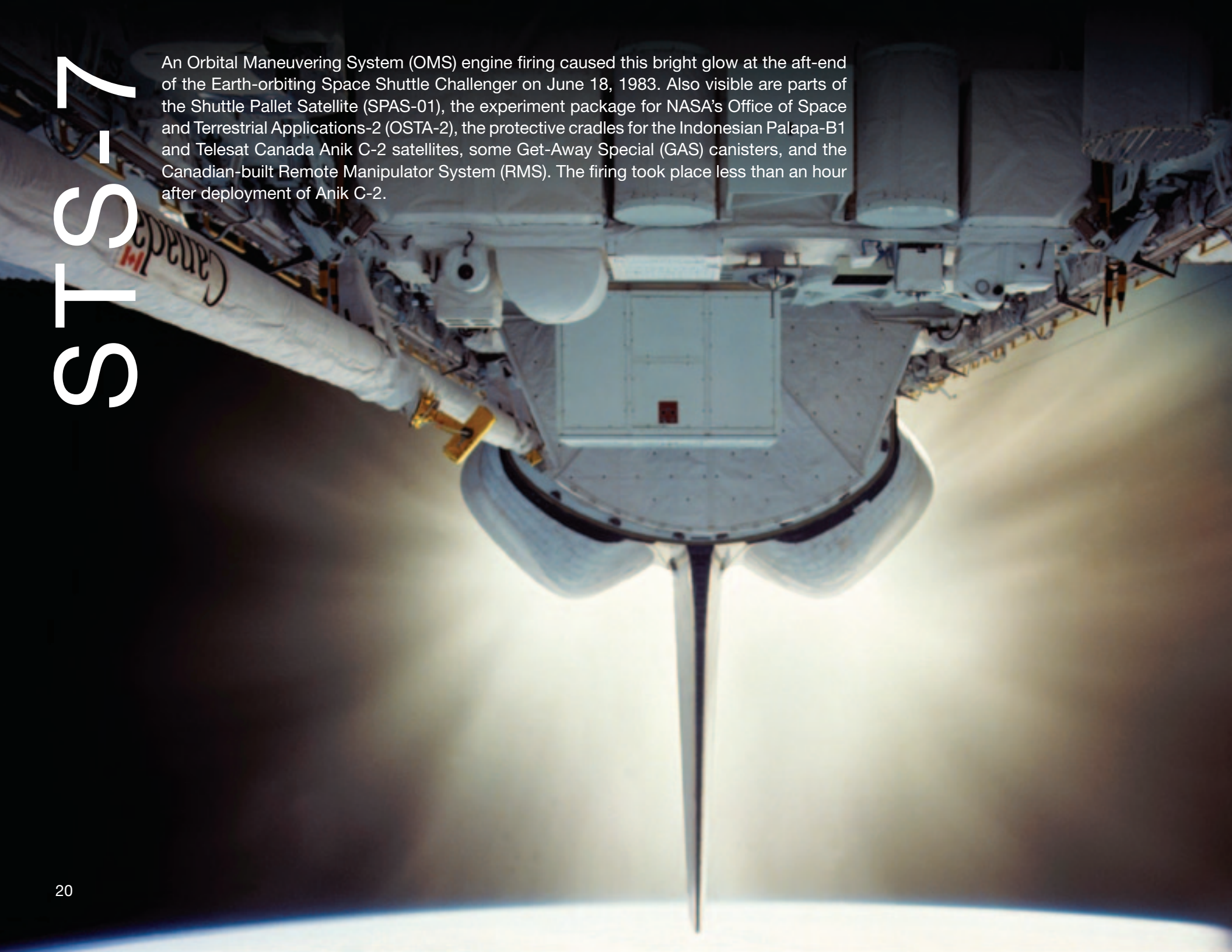
Crew
Commander Paul J. Weitz
Pilot Karol J. Bobko
Mission Specialists Donald H. Peterson and F. Story Musgrave

The primary payload of STS-6 was the first Tracking and Data Relay Satellite, TDRS-A. A malfunction of the Inertial Upper Stage (IUS) booster resulted in the placement of the spacecraft into an improper but stable orbit. Additional propellant aboard the satellite was used over the next several months to gradually place TDRS-A into its properly circularized orbit.

The first spacewalk of the Shuttle program was performed by astronauts Donald H. Peterson and F. Story Musgrave and lasted about 4 hours and 17 minutes.

Other payloads on this flight included the Continuous Flow Electrophoresis System (CFES), the Monodisperse Latex Reactor (MLR), the Radiation Monitoring Experiment (RME), the Night/Day Optical Survey of Lightning (NOSL), and three Get-Away Special (GAS) canisters. This mission used the first lightweight external tank and lightweight rocket booster casings.

STS-7



An Orbital Maneuvering System (OMS) engine firing caused this bright glow at the aft-end of the Earth-orbiting Space Shuttle Challenger on June 18, 1983. Also visible are parts of the Shuttle Pallet Satellite (SPAS-01), the experiment package for NASA's Office of Space and Terrestrial Applications-2 (OSTA-2), the protective cradles for the Indonesian Palapa-B1 and Telesat Canada Anik C-2 satellites, some Get-Away Special (GAS) canisters, and the Canadian-built Remote Manipulator System (RMS). The firing took place less than an hour after deployment of Anik C-2.

Mission
STS-7, Communications satellite launch;
First U.S. woman in space

Space Shuttle
Challenger

Launched
June 18, 1983, at 7:33:00 a.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
June 24, 1983, at 6:56:59 a.m. PDT on
Runway 15 at Edwards Air Force Base, CA

Duration
6 days, 2 hours, 23 minutes, and 59 seconds

Distance Traveled
2,220,000 miles

Orbits
98

Crew
Commander Robert L. Crippen
Pilot Frederick H. Hauck
Mission Specialists John M. Fabian,
Sally K. Ride, and Norman E. Thagard

Sally K. Ride became the first American woman to fly in space on STS-7. On the mission, two communications satellites were deployed, Anik C-2 for Telesat Canada and Palapa-B1 for Indonesia. Seven Get-Away Special (GAS) canisters in the cargo bay held a variety of experiments, including one studying the effects of space on the social behavior of an ant colony in zero gravity. Ten experiments were mounted on the Shuttle Pallet Satellite (SPAS-01) and performed research in forming metal alloys in microgravity and in using a remote sensing scanner. The orbiter's small control rockets were fired while SPAS-01 was held by the Remote Manipulator System (RMS) to test the movement on an extended arm.

Other payloads on this mission were the Office of Space and Terrestrial Applications-2 (OSTA-2), the Continuous Flow Electrophoresis System (CFES), the Monodisperse Latex Reactor (MLR), and one Shuttle Student Involvement Program (SSIP) experiment.

STS-8

NASA's eighth Space Shuttle launch lights up the Florida sky at 2:32 a.m., August 30, 1983. Challenger's third flight was the first night launch of the program.

Mission
STS-8, Multipurpose satellite;
First night launch and landing

Space Shuttle
Challenger

Launched
August 30, 1983, at 2:32:00 a.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
September 5, 1983, at 12:40:43 a.m. PDT on
Runway 22 at Edwards Air Force Base, CA

Duration
6 days, 1 hour, 8 minutes, and 43 seconds

Distance Traveled
2,220,000 miles

Orbits
98

Crew
Commander Richard H. Truly
Pilot Daniel C. Brandenstein
Mission Specialists Dale A. Gardner,
Guion S. Bluford, Jr., and William E. Thornton

Guion S. Bluford became the first African American to fly in space. During the mission, Insat-1B, a multipurpose satellite for India that was attached to the Payload Assist Module-D (PAM-D) motor, was deployed. For the Development Flight Instrumentation Pallet (DFI PLT), the crew filmed the performance of an experimental heat pipe mounted in the cargo bay. Additionally, the orbiter dropped to an altitude of 139 miles to perform tests on thin atomic oxygen to identify the cause of glow that surrounds parts of the orbiter at night.

Biofeedback experiments performed on this mission included six rats that were flown in an Animal Enclosure Module so that the astronauts could observe the rodents' reactions to space. Other payloads included the Continuous Flow Electrophoresis System (CFES), the Shuttle Student Involvement Program (SSIP) experiment, the Incubator-Cell Attachment Test (I CAT), the Investigation of STS Atmospheric Luminosities (ISAL), the Radiation Monitoring Equipment (RME), and five Get-Away Special (GAS) experiment packages, including eight cans of postal covers that were later sold to collectors by the U.S. Postal Service.

STS-9

Columbia lifts off from Launch Pad 39A at the Kennedy Space Center (KSC), kicking off a busy 9 days in space for the six crewmembers.

STS-9 carried the first Spacelab mission and the first European Space Agency (ESA) astronaut, Ulf D. Merbold of Germany. ESA and NASA jointly sponsored Spacelab-1 and conducted investigations that demonstrated advanced research was capable in space.

Spacelab was an orbital laboratory and contained an observation platform that consisted of cylindrical pressurized modules and U-shaped unpressurized pallets that remained in the orbiter's cargo bay during flight. Altogether, 73 separate investigations were carried out in astronomy and physics, atmospheric physics, Earth observations, life sciences, materials sciences, space plasma physics, and technology. This was the first time that six people were carried into space on a single vehicle.

Mission
STS-9, First Spacelab mission—orbital laboratory and observations platform; First six-crewmember flight

Space Shuttle
Columbia

Launched
November 28, 1983, at 11:00:00 a.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
December 8, 1983, at 3:47:24 a.m. PST on Runway 17 at Edwards Air Force Base, CA

Duration
10 days, 7 hours, 47 minutes, and 24 seconds

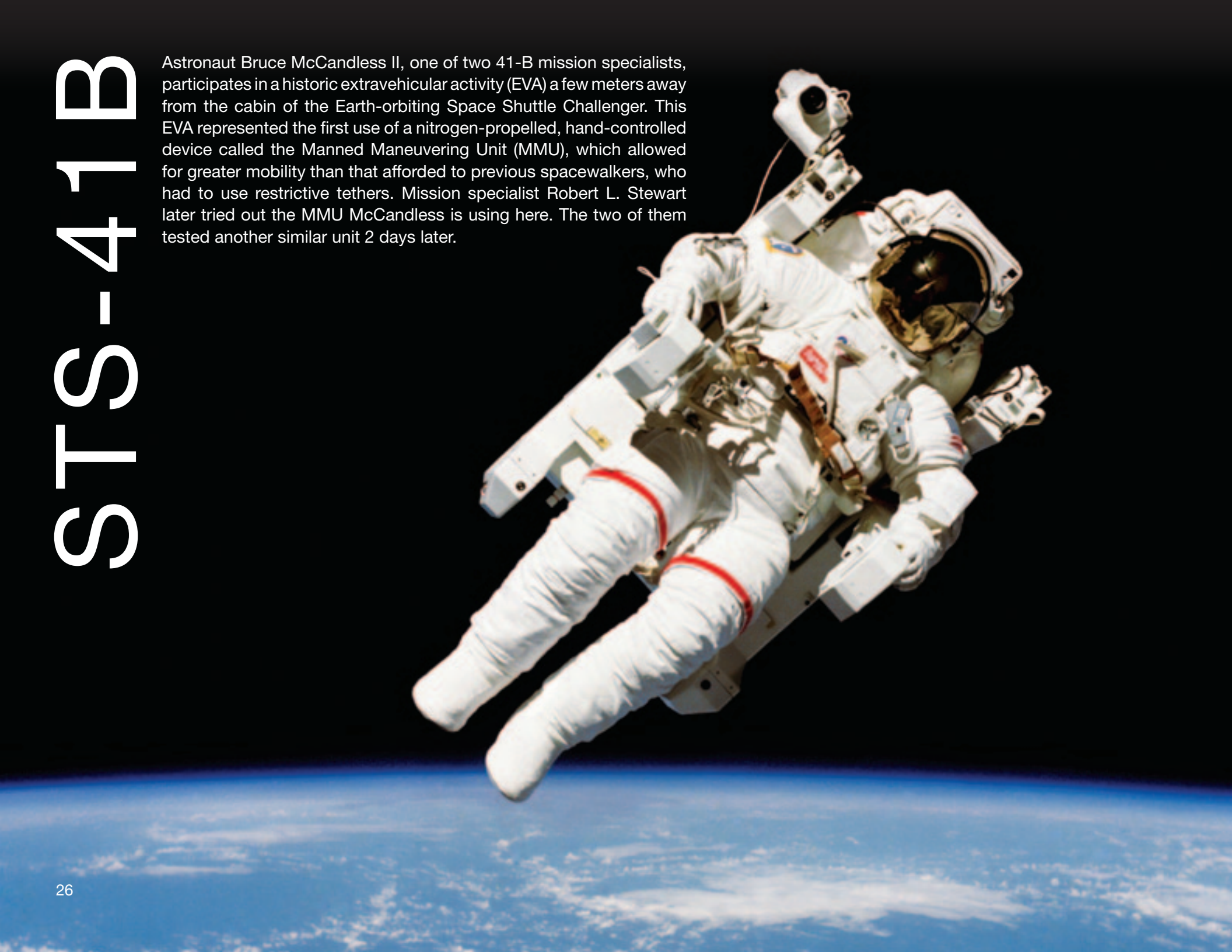
Distance Traveled
3,330,000 miles

Orbits
167

Crew
Commander John W. Young
Pilot Brewster H. Shaw, Jr.
Mission Specialists Owen K. Garriott and Robert A.R. Parker
Payload Specialists Byron K. Lichtenberg and Ulf D. Merbold

STS-41B

Astronaut Bruce McCandless II, one of two 41-B mission specialists, participates in a historic extravehicular activity (EVA) a few meters away from the cabin of the Earth-orbiting Space Shuttle Challenger. This EVA represented the first use of a nitrogen-propelled, hand-controlled device called the Manned Maneuvering Unit (MMU), which allowed for greater mobility than that afforded to previous spacewalkers, who had to use restrictive tethers. Mission specialist Robert L. Stewart later tried out the MMU McCandless is using here. The two of them tested another similar unit 2 days later.



Mission
STS-41B, Westar-VI, Palapa-B2;
Manned Maneuvering Unit (MMU);
First Kennedy Space Center (KSC) landing

Space Shuttle
Challenger

Launched
February 3, 1984, at 8:00:00 a.m. EST from
Launch Pad 39A at Kennedy Space Center, FL

Landed
February 11, 1984, at 7:15:55 a.m. EST on
Runway 15 at Kennedy Space Center, FL

Duration
7 days, 23 hours, 15 minutes, and 55 seconds

Distance Traveled
2,870,000 miles

Orbits
128

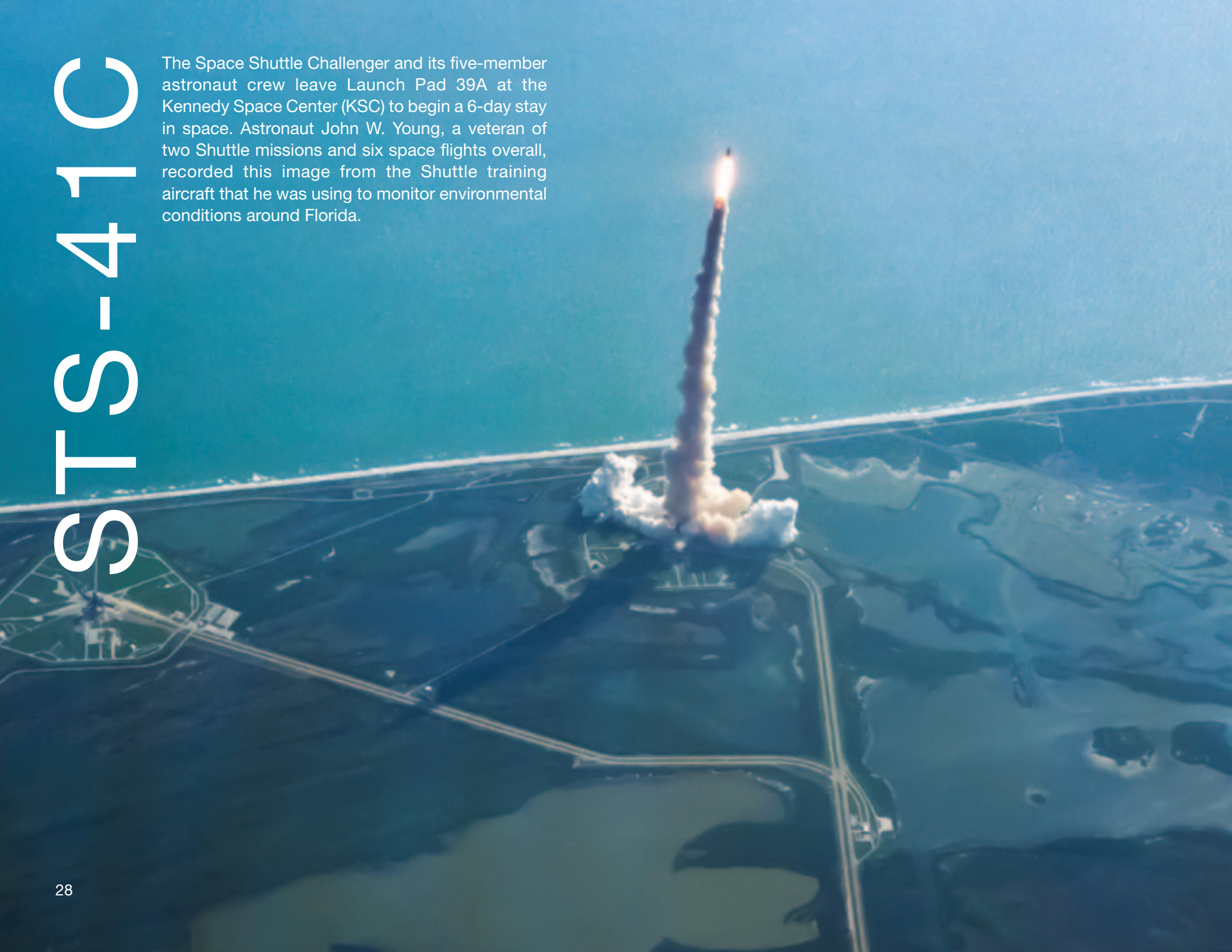
Crew
Commander Vance D. Brand
Pilot Robert L. Gibson
Mission Specialists Bruce McCandless II,
Ronald E. McNair, and Robert L. Stewart

On this mission, the first untethered spacewalks were carried out by Bruce McCandless II and Robert L. Stewart using the Manned Maneuvering Unit (MMU). The Westar-VI and Palapa-B2 satellites were deployed, but the failure of the Payload Assist Module-D (PAM-D) rocket motors left them in radical low-Earth orbits. The German-built Shuttle Pallet Satellite (SPAS-01), originally flown on STS-7, became the first satellite refurbished and carried back into space. SPAS-01 remained in the payload bay due to an electrical problem with the Remote Manipulator System (RMS). The RMS manipulator foot restraints were first used to practice procedures performed for the Solar Maximum satellite retrieval and repair that was planned for the next mission. The Integrated Rendezvous Target (IRT) failed due to an internal issue. Five Get-Away Special (GAS) canisters were flown in the cargo bay, and a Cinema 360 camera was used by the crew.

Other payload items included the Acoustic Containerless Experiment System (ACES), the Monodisperse Latex Reactor (MLR), the Radiation Monitoring Equipment (RME), and materials used for Isoelectric Focusing (IEF).

STS-41C

The Space Shuttle Challenger and its five-member astronaut crew leave Launch Pad 39A at the Kennedy Space Center (KSC) to begin a 6-day stay in space. Astronaut John W. Young, a veteran of two Shuttle missions and six space flights overall, recorded this image from the Shuttle training aircraft that he was using to monitor environmental conditions around Florida.



Mission
STS-41C, Long Duration Exposure Facility (LDEF); First on-orbit spacecraft repair

Space Shuttle
Challenger

Launched
April 6, 1984, at 8:58:00 a.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
April 13, 1984, at 5:38:07 a.m. PST on Runway 17 at Edwards Air Force Base, CA

Duration
6 days, 23 hours, 40 minutes, and 7 seconds

Distance Traveled
2,880,000 miles

Orbits
108

Crew
Commander Robert L. Crippen
Pilot Francis R. Scobee
Mission Specialists George D. Nelson, James D.A. van Hoften, and Terry J. Hart

STS-41C marked the first direct ascent trajectory for the Space Shuttle. The astronauts, using the Manned Maneuvering Unit (MMU), replaced the altitude control system and the coronagraph/polarimeter electronics box in the Solar Maximum Mission (Solar Max) satellite—executing the first spacecraft repair in orbit. The Long Duration Exposure Facility (LDEF) was also deployed, carrying 57 experiments that were left on orbit with the intention of retrieving them during a later mission.

Other payloads on this mission were an IMAX camera, the Radiation Monitoring Equipment (RME), a Cinema 360 camera, and a Shuttle Student Involvement Program (SSIP) experiment.

STS-41D

The Space Shuttle Discovery touches down on Runway 17 at Edwards Air Force Base in California to successfully complete its maiden flight.

Mission
STS-41D, SBS-D, Syncom IV-2, Telstar;
Solar wing extended

Space Shuttle
Discovery

Launched
August 30, 1984, at 8:41:50 a.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
September 5, 1984, at 6:37:54 a.m. PDT on
Runway 17 at Edwards Air Force Base, CA

Duration
6 days, 0 hours, 56 minutes, and 4 seconds

Distance Traveled
2,210,000 miles

Orbits
97

Crew
Commander Henry W. Hartsfield, Jr.
Pilot Michael L. Coats
Mission Specialists Judith A. Resnick,
Steven A. Hawley, and Richard M. Mullane
Payload Specialist Charles D. Walker

Three satellites were deployed during this mission: the Satellite Business Systems' SBS-D, the Syncom IV-2 (also known as Leasat-2), and the Telstar. The 102-foot-tall, 13-foot-wide Office of Application and Space Technology (OAST-1) solar wing extended from the payload bay. The wing carried different types of solar cells and extended to its full height several times. It demonstrated the feasibility of large lightweight solar arrays, which could be used to build large facilities in space, such as a space station.

Other payload included the Continuous Flow Electrophoresis System (CFES) III, the Radiation Monitoring Equipment (RME), a Shuttle Student Involvement Program (SSIP) experiment, an IMAX camera, and the United States Air Force experiment Cloud Logic to Optimize Use of Defense Systems (CLOUDS).

STS-41G

Hurricane Josephine was photographed with the Linhof camera aimed through the Challenger's aft flight deck windows. The hurricane's eye can be seen below the orbiter's vertical stabilizer. The large storm off the Florida coast did not prevent the spacecraft, with its record of seven crewmembers aboard, from landing at the Kennedy Space Center (KSC) landing facility.

This was the first Shuttle flight to include two women, Sally K. Ride and Kathryn D. Sullivan. Sullivan was the first American woman to walk in space. The Earth Radiation Budget Satellite (ERBS) was deployed less than 9 hours into the flight. The Office of Space and Terrestrial Applications-3 (OSTA-3) carried three experiments in the payload bay. Components of the Orbital Refueling System (ORS) were connected, demonstrating that it was possible to refuel satellites in orbit.

Other payload included the Large Format Camera (LFC), an IMAX camera, a package of Canadian Experiments (CANEX), the Auroral Photography Experiment (APE), the Radiation Monitoring Equipment (RME), the Thermoluminiscent Dosimeter (TLD), and eight Get-Away Specials (GAS).

Mission
STS-41G, Earth Radiation Budget Satellite (ERBS); Office of Space and Terrestrial Applications-3 (OSTA-3)

Space Shuttle
Challenger

Launched
October 5, 1984, at 7:03:00 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
October 13, 1984, at 12:26:38 p.m. EDT on Runway 33 at Kennedy Space Center, FL

Duration
8 days, 5 hours, 23 minutes, and 38 seconds

Distance Traveled
3,400,000 miles

Orbits
133

Crew
Commander Robert L. Crippen
Pilot Jon A. McBride
Mission Specialists Kathryn D. Sullivan, Sally K. Ride, and David C. Leestma
Payload Specialists Marc Garneau and Paul D. Scully-Power

STS-51A

Astronaut Dale A. Gardner, wearing the Manned Maneuvering Unit (MMU), approaches the spinning WESTAR VI satellite over Bahama Banks. The end effector of the Remote Manipulator System (RMS), controlled by Anna L. Fisher inside the Space Shuttle Discovery's cabin, awaits its duty at right.

Mission
STS-51A, Telesat-H, Syncom IV-1

Space Shuttle
Discovery

Launched
November 8, 1984, at 7:15:00 a.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
November 16, 1984, at 6:59:56 a.m. EST on Runway 15 at Kennedy Space Center, FL

Duration
7 days, 23 hours, 44 minutes, and 56 seconds

Distance Traveled
2,870,000 miles

Orbits
127

Crew
Commander Frederick H. Hauck
Pilot David M. Walker
Mission Specialists Anna L. Fisher, Dale A. Gardner, and Joseph P. Allen

The Canadian communications satellite Telesat-H (Anik), which was attached to a Payload Assist Module-D (PAM-D), was deployed into geosynchronous orbit on flight day 2. On day 3, the defense communications satellite Syncom IV-I (also known as Leasat-1) was deployed. Joseph P. Allen and Dale A. Gardner, wearing jet-propelled Manned Maneuvering Units (MMUs), retrieved two malfunctioning satellites: Palapa-B2 and Westar-VI; both of these satellites were deployed on mission 41-B. Fisher operated the Remote Manipulator System (RMS), grappling the satellites and depositing them in the payload bay.

Middeck payloads for this mission were the Diffusive Mixing of Organic Solutions (DMOS) experiment and the Radiation Monitoring Equipment (RME).

STS-51C

This was the first mission dedicated to the Department of Defense. The U.S. Air Force Inertial Upper Stage (IUS) booster was deployed and met the mission objectives.

Mission
STS-51C, Department of Defense mission

Space Shuttle
Discovery

Launched
January 24, 1985, at 2:50:00 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
January 27, 1985, at 4:23:23 p.m. EST on Runway 15 at Kennedy Space Center, FL

Duration
3 days, 1 hour, 33 minutes, and 23 seconds

Distance Traveled
1,242,566 miles

Orbits
49

Crew
Commander Thomas K. Mattingly II
Pilot Loren J. Shriver
Mission Specialists Ellison S. Onizuka and James F. Buchli
Payload Specialist Gary E. Payton

STS-51C was the first mission dedicated to the Department of Defense. Because of the mission's security classification, crew activities and accomplishments are not disclosed.

The scheduled launch for January 23, 1985, was scrubbed because of freezing weather conditions. Challenger was originally scheduled for mission 51-C, but thermal tile problems forced Discovery's substitution.

STS-51D

This photo of Discovery was taken shortly after lift-off from Launch Pad 39A at the Kennedy Space Center (KSC).

Mission
STS-51D, Telesat-I, Communications satellite Syncom IV-3; First sitting member of Congress in space

Space Shuttle
Discovery

Launched
April 12, 1985, at 8:59:05 a.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
April 19, 1985, at 8:54:28 a.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
6 days, 23 hours, 55 minutes, and 23 seconds

Distance Traveled
2,500,000 miles

Orbits
110

Crew
Commander Karol J. Bobko
Pilot Donald E. Williams
Mission Specialists M. Rhea Seddon, Jeffrey A. Hoffman, and S. David Griggs
Payload Specialists Charles D. Walker and Senator E. Jake Garn

On this mission, the Telesat-I (Anik C-1) communications satellite was deployed while attached to a Payload Assist Module (PAM-D) motor. Syncom IV-3 (also known as Leasat-3) was also deployed, but the spacecraft sequencer failed to initiate antenna deployment, spin-up operations, and ignition of the perigee kick motor. The mission was extended 2 days to ensure that the sequencer start lever was in the proper position. S. David Griggs and Jeffrey A. Hoffman performed a spacewalk to attach flyswatter-like devices to the Remote Manipulator System (RMS).

Other payload included the Continuous Flow Electrophoresis System (CFES) III, two Shuttle Student Involvement Program (SSIP) experiments, the American Flight Echocardiograph (AFE), two Get-Away Specials (GAS), the Phase Partitioning Experiments (PPE), an astronomy photography verification test, medical experiments, and toys in space—an informal study of the behavior of simple toys in a weightless environment, with the results made available to school students.

STS-51B

This photo of the open cargo bay doors shows a glimpse of Spacelab-3, one in a series of orbital laboratories developed through international partnerships.

Mission
STS-51B, Spacelab-3

Space Shuttle
Challenger

Launched
April 29, 1985, at 12:02:18 p.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
May 6, 1985, at 9:11:04 a.m. PDT on
Runway 17 at Edwards Air Force Base, CA

Duration
7 days, 0 hours, 8 minutes, and 46 seconds

Distance Traveled
2,900,000 miles

Orbits
111

Crew
Commander Robert F. Overmyer
Pilot Frederick D. Gregory
Mission Specialists Don L. Lind,
Norman E. Thagard, and William E. Thornton
Payload Specialists Lodewijk van den Berg and
Taylor G. Wang

The primary payload on STS-51B was Spacelab-3. This marked the first operational flight for the Spacelab orbital laboratory series developed by the European Space Agency (ESA). It consisted of five basic discipline areas: materials sciences, life sciences, fluid mechanics, atmospheric physics, and astronomy. The main mission objective with Spacelab-3 was to provide a high-quality microgravity environment for delicate materials processing and fluid experiments. Two monkeys and 24 rodents also were observed for effects of weightlessness. Of the 15 Spacelab primary experiments conducted, 14 were considered successful. Two Get-Away Specials (GAS) were also on board.

STS-51G

A low-angle view of the Space Shuttle Discovery, its external tank, and its two solid rocket boosters speeding away from Earth. The picture also captures the diamond shock effect associated with the launch phase of orbiter vehicles.

Mission
STS-51G, Morelos-A, Arabsat-A, and Telstar-3D communications satellites

Space Shuttle
Discovery

Launched
June 17, 1985, at 7:33:00 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
June 24, 1985, at 6:11:52 a.m. PDT on Runway 23 at Edwards Air Force Base, CA

Duration
7 days, 1 hour, 38 minutes, and 52 seconds

Distance Traveled
2,500,000 miles

Orbits
112

Crew
Commander Daniel C. Brandenstein
Pilot John O. Creighton
Mission Specialists Shannon W. Lucid, John M. Fabian, and Steven R. Nagel
Payload Specialists Patrick Baudry and Sultan Salman Al-Saud

On board Discovery for STS-51G were three communications satellites, all attached to Payload Assist Module-D (PAM-D) motors: Morelos-A, for Mexico; Arabsat-A, for the Arab Satellite Communications Organization; and Telstar-3D, for AT&T.

Also flown was the deployable/retrievable Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN-1), six Get-Away Specials (GAS), a Strategic Defense Initiative experiment called the High-Precision Tracking Experiment (HPTE), a materials processing furnace called the Automated Directional Solidification Furnace (ADSF), and two French biomedical experiments.

STS-51F

The Space Shuttle Challenger heads toward Earth orbit with the Spacelab-2 experiment pallet and a team of astronauts and scientists on board.

Mission
STS-51F, Spacelab-2

Space Shuttle
Challenger

Launched
July 29, 1985, at 5:00:00 p.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
August 6, 1985, at 12:45:26 p.m. PDT on
Runway 23 at Edwards Air Force Base, CA

Duration
7 days, 22 hours, 45 minutes, and 26 seconds

Distance Traveled
2,850,000 miles

Orbits
127

Crew
Commander C. Gordon Fullerton
Pilot Roy D. Bridges, Jr.
Mission Specialists F. Story Musgrave,
Anthony W. England, and Karl G. Henize
Payload Specialists Loren W. Acton and
John-David F. Bartoe

The primary payload on this mission was Spacelab-2. Despite an Abort-to-Orbit (ATO), which required mission replanning, the mission was declared a success. A special part of the modular Spacelab system, “the igloo,” located at the head of three-pallet train, provided onsite support to instruments mounted on pallets. The main mission objective was to verify the performance of Spacelab systems, determine interface capability of the orbiter, measure the environment induced by the spacecraft. Experiments covered life sciences, plasma physics, astronomy, high-energy astrophysics, solar physics, atmospheric physics, and technology research.

The flight marked the first time that the European Space Agency’s (ESA) Instrument Pointing System (IPS) was tested in orbit. This unique experiment-pointing instrument was designed with an accuracy of 1 arc second. Initially, some problems were experienced when it was commanded to track the Sun. A series of software fixes corrected the problems.

STS-51

This view of the predawn launch of the Space Shuttle Discovery shows a reflection of the ignition in the river across from the launch complex.

Mission
STS-51I, ASC-1, Aussat-1, Syncom IV-4

Space Shuttle
Discovery

Launched
August 27, 1985, at 6:58:01 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
September 3, 1985, at 6:15:43 a.m. PDT on Runway 23 at Edwards Air Force Base, CA

Duration
7 days, 2 hours, 17 minutes, and 42 seconds

Distance Traveled
2,500,000 miles

Orbits
112

Crew
Commander Joe H. Engle
Pilot Richard O. Covey
Mission Specialists James D.A. van Hoften, John M. Lounge, and William F. Fisher

Three communications satellites were deployed on this mission: ASC-1, for the American Satellite Company, Aussat-1, an Australian Communications Satellite, and Syncom IV-4, the Synchronous Communications Satellite. ASC-1 and Aussat-1 were both attached to Payload Assist Module-D (PAM-D) motors. Syncom IV-4 (also known as Leasat-4) failed to function after reaching the correct geosynchronous orbit. William F. Fisher and James D.A. van Hoften performed two extravehicular activities (EVAs) totaling 11 hours and 51 minutes. Part of their time was spent retrieving, repairing, and redeploying Leasat-3, which had been deployed on mission 51-D.

The middeck payload included the Physical Vapor Transport Organic Solid Experiment (PVTOS).

STS-51-J

The orbiter Atlantis sits poised for lift-off while preparing for its inaugural flight from Launch Pad 39A at the Kennedy Space Center (KSC) on the Florida coast.

STS-51J was the second mission dedicated to the Department of Defense. Because of the mission's security classification, crew activities and accomplishments are not disclosed.

Mission
STS-51J, Department of Defense mission

Space Shuttle
Atlantis

Launched
October 3, 1985, at 11:15:30 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
October 7, 1985, at 10:00:08 a.m. PDT on Runway 23 at Edwards Air Force Base, CA

Duration
4 days, 1 hour, 44 minutes, and 38 seconds

Distance Traveled
1,682,641 miles

Orbits
64

Crew
Commander Karol J. Bobko
Pilot Ronald J. Grabe
Mission Specialists David C. Hilmers, Robert L. Stewart, and William A. Pailes

STS-61A

On November 6, 1985, the record-setting eight crewmembers of STS 61-A file from their “home” for the past week after the completion of a successful Spacelab D-1 mission. Commander Henry W. Hartsfield, Jr., shakes hands with George W.S. Abbey, the Director of Flightcrew Operations at Johnson Space Center (JSC) in Houston, TX.

Mission
STS-61A, Spacelab D-1 mission (First German dedicated Spacelab); First eight-member crew

Space Shuttle
Challenger

Launched
October 30, 1985, 12:00:00 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
November 6, 1985, 9:44:51 a.m. PST on Runway 17 at Edwards Air Force Base, CA

Duration
7 days, 0 hours, 44 minutes, and 51 seconds

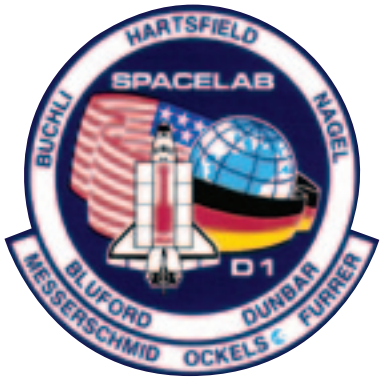
Distance Traveled
2,501,290 miles

Orbits
112

Crew
Commander Henry W. Hartsfield, Jr.
Pilot Steven R. Nagel
Mission Specialists James F. Buchli, Guion S. Bluford, and Bonnie J. Dunbar
Payload Specialists Reinhard Furrer, Ernst Messerschmid, and Wubbo J. Ockels

The first dedicated German Spacelab (D-1) mission was conducted in a long module configuration, which featured a Vestibular Sled that was designed to give scientists data on the functional organization of human vestibular and orientation systems. Spacelab D-1 encompassed 75 numbered experiments, most of which were performed more than once. The mission included basic and applied microgravity research in the fields of materials science, life sciences and technology, and communications and navigation. Although the orbiter was controlled from Johnson Space Center (JSC), scientific operations were controlled from the German Space Operations Center at Oberpfaffenhofen, near Munich.

Other objectives on this mission included the Global Low Orbiting Message Relay (GLOMR) satellite deployment from a Get-Away Special (GAS) canister.



STS-61 B

Astronauts Jerry L. Ross and Sherwood C. Spring, NASA flight 6l-B's mission specialists, approach a tower device they erected during the second of two extravehicular activities (EVAs). The tower was called the Assembly Concept for Construction of Erectable Space Structures. Ross and Spring are secured by a foot-restraint device connected to the Canadian-built Remote Manipulator System (RMS) arm aboard the Earth-orbiting Atlantis.

Mission
STS-61B, Morelos-B; Aussat-2; Satcom Ku-2

Space Shuttle
Atlantis

Launched
November 26, 1985, 7:29:00 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
December 3, 1985, 1:33:49 p.m. PST on Runway 22 at Edwards Air Force Base, CA

Duration
6 days, 21 hours, 4 minutes, and 49 seconds

Distance Traveled
2,466,956 miles

Orbits
109

Crew
Commander Brewster H. Shaw, Jr.
Pilot Bryan D. O'Connor
Mission Specialists Mary L. Cleave, Sherwood C. Spring, and Jerry L. Ross
Payload Specialists Rodolfo Neri Vela and Charles D. Walker

Three communications satellites were deployed on this mission including Morelos-B (Mexico), Aussat-2 (Australia), and Satcom Ku-2 (RCA Americom). Morelos-B and Aussat-2 were attached to Payload Assist Module-D (PAM-D) motors, while Satcom Ku-2 was attached to a PAM-D2 motor that was designed for heavier payloads. Two experiments were conducted to test assembling erectable structures in space: the Experimental Assembly of Structures in Extravehicular Activity (EASE) and the Assembly Concept for Construction of Erectable Space Structure (ACCESS). The experiments required two spacewalks by Sherwood C. Spring and Jerry L. Ross that lasted 5 hours, 32 minutes and 6 hours, 38 minutes, respectively.

Middeck payloads included the Continuous Flow Electrophoresis System (CFES), the Diffusive Mixing of Organic Solutions (DMOS) experiment, the Morelos Payload Specialist Experiments (MPSE), and the Orbiter Experiments (OEX). The payload bay also carried a Get-Away Special (GAS) and an IMAX Cargo Bay Camera (ICBC).

STS-61C

Although many miles away, the Space Shuttle Columbia can still be delineated in this distant scene following an early morning launch.

Mission
STS-61C, Satcom Ku-1

Space Shuttle
Columbia

Launched
January 12, 1986, 6:55:00 a.m. EST from
Launch Pad 39A at Kennedy Space Center, FL

Landed
January 18, 1986, 5:58:51 a.m. PST on
Runway 22 at Edwards Air Force Base, CA

Duration
6 days, 2 hours, 3 minutes, and 51 seconds

Distance Traveled
2,197,305 miles

Orbits
98

Crew
Commander Robert L. Gibson
Pilot Charles F. Bolden, Jr.
Mission Specialists Franklin R. Chang-Díaz,
Steven A. Hawley, and George D. Nelson
Payload Specialists Robert J. Cenker and
Congressman Bill Nelson

The Satcom Ku-I (RCA Americom) satellite, attached to a Payload Assist Module-D2 (PAM-D2) motor, was deployed on this mission. Unfortunately, the Comet Halley Active Monitoring Program (CHAMP) experiment, a 35-millimeter camera created to photograph Comet Halley, did not function properly due to battery problems.

Other payload included the Materials Science Laboratory-2 (MSL-2), the Hitchhiker G-1, the Infrared Imaging Experiment (IR-IE), the Initial Blood Storage Experiment (IBSE), the Handheld Protein Crystal Growth (HPCG) experiment, three Shuttle Student Involvement Program (SSIP) experiments, and 13 Get-Away Specials (GAS), with 12 of them mounted on a special GAS Bridge Assembly.

STS-51L

Challenger was the first Space Shuttle to lift-off from Kennedy Space Center's (KSC) Pad 39B in Florida. Challenger carried a crew of seven astronauts and a Tracking and Data Relay Satellite (TDRS) on board. An accident 73 seconds after lift-off claimed both the crew and the vehicle.

Mission
STS-51L, Tracking and Data Relay Satellite-B (TDRS-B), Spartan-203

Space Shuttle
Challenger

Launched
January 28, 1986, 11:38:00 a.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Loss of Crew
The crew and vehicle were lost 73 seconds after lift-off.

Crew
Commander Francis R. Scobee
Pilot Michael J. Smith
Mission Specialists Judith A. Resnik, Ellison S. Onizuka, and Ronald E. McNair
Payload Specialists Gregory B. Jarvis and Sharon Christa McAuliffe

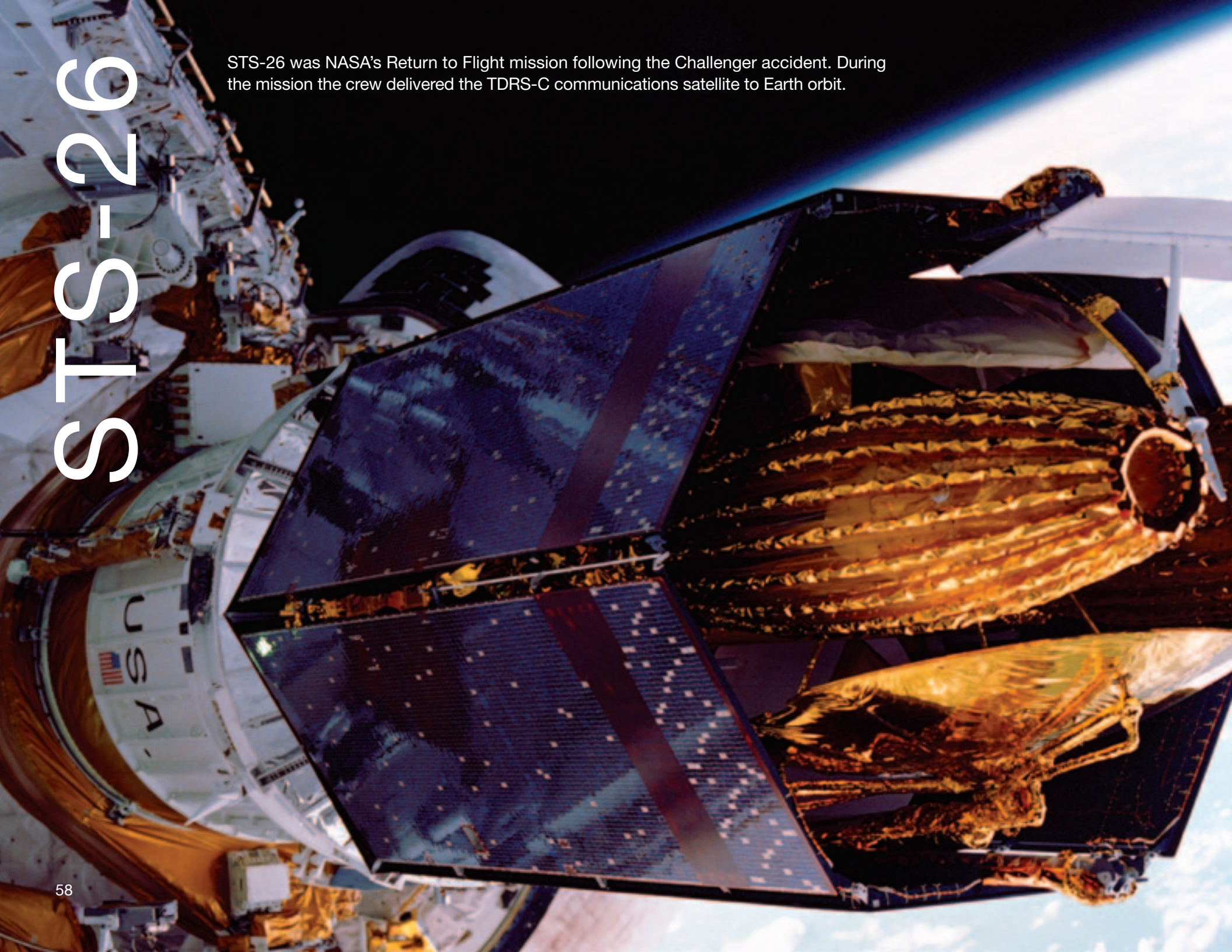
The planned objectives for STS-51L, the 25th Shuttle flight, were the deployments of the Tracking and Data Relay Satellite-B (TDRS-B) and the Shuttle-Pointed Autonomous Research Tool for Astronomy (Spartan-203)/Halley's Comet Experiment, a free-flying module designed to observe the tail and coma of Halley's Comet with two ultraviolet spectrometers and two cameras.

Other payload on the mission included the Fluid Dynamics Experiment (FDE), the Comet Halley Active Monitoring Program (CHAMP), the Phase Partitioning Experiment (PPE), three Shuttle Student Involvement Program (SSIP) experiments, and a set of lessons for the Teacher in Space Project (TISP).

An explosion 73 seconds after lift-off claimed the crew and the vehicle. The Presidential Commission on the Space Shuttle Challenger Accident determined that an O-ring failure in the right solid rocket booster caused the explosion. Cold weather was also determined to be a factor.

STS-26

STS-26 was NASA's Return to Flight mission following the Challenger accident. During the mission the crew delivered the TDRS-C communications satellite to Earth orbit.



Mission
STS-26, Tracking and Data Relay Satellite-C (TDRS-C)

Space Shuttle
Discovery

Launched
September 29, 1988, 11:37:00 a.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
October 3, 1988, 9:37:11 a.m. PDT on Runway 17 at Edwards Air Force Base, CA

Duration
4 days, 1 hour, 0 minutes, and 11 seconds

Distance Traveled
1,430,505 miles

Orbits
64

Crew
Commander Frederick H. Hauck
Pilot Richard O. Covey
Mission Specialists John M. Lounge, George D. Nelson, and David C. Hilmers

The primary payload of this mission, the NASA Tracking and Data Relay Satellite-C (TDRS-C) attached to an Inertial Upper Stage (IUS) booster, became the second TDRS deployed. After deployment, the IUS propelled the satellite to a geosynchronous orbit.

Secondary payload included the Physical Vapor Transport of Organic Solids (PVTOS) experiment, the Protein Crystal Growth (PCG) experiment, the Infrared Communications Flight Experiment (IRCFE), the Aggregation of Red Blood Cells (ARC) experiment, an Isoelectric Focusing (IEF) experiment, a Mesoscale Lightning Experiment (MLE), the Phase Partitioning Experiment (PPE), the Earth-Limb Radiance Experiment (ELRAD), the Automated Directional Solidification Furnace (ADSF), and two Shuttle Student Involvement Program (SSIP) experiments. The Orbiter Experiments Autonomous Supporting Instrumentation System-I (OASIS-I) recorded a variety of environmental measurements during several in-flight phases of the orbiter.

STS-27

The Space Shuttle Atlantis is rolled out to Launch Pad 39B in the early morning of October 9, 1986. Atlantis was scheduled to remain at Pad 39B for 7 weeks to support the checkout of new weather protection structures, a variety of special measurements, launch team proficiency exercises, and emergency egress simulations. The Shuttle and its five-person crew launched from Kennedy Space Center's (KSC) Pad 39B at 9:30 a.m. on December 2, 1988.

Mission
STS-27, Department of Defense mission

Space Shuttle
Atlantis

Launched
December 2, 1988, 9:30:34 a.m. EST from
Launch Pad 39B at Kennedy Space Center, FL

Landed
December 6, 1988, 3:36:11 p.m. PST on
Runway 17 at Edwards Air Force Base, CA

Duration
4 days, 9 hours, 5 minutes, and 37 seconds

Distance Traveled
1,812,075 miles

Orbits
68

Crew
Commander Robert L. Gibson
Pilot Guy S. Gardner
Mission Specialists Richard M. Mullane,
Jerry L. Ross, and William M. Shepherd

STS-27 was the third mission dedicated to the Department of Defense. Because of the mission's security classification, crew activities and accomplishments are not disclosed.

The launch, which was set for December 1, 1988, during a classified launch window between 6:32 a.m. and 9:32 a.m., was postponed due to unacceptable cloud cover and wind conditions and was reset for the same launch period on December 2.

STS-29

A rear view of Discovery just after the orbiter's main landing gear touches down on Runway 22 at Edwards Air Force Base, CA, following a successful 5-day mission in Earth orbit.

Mission
STS-29, Tracking and Data Relay Satellite-D (TDRS-D)

Space Shuttle
Discovery

Launched
March 13, 1989, 9:57:00 a.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
March 18, 1989, 6:35:50 a.m. PST on Runway 22 at Edwards Air Force Base, CA

Duration
4 days, 23 hours, 38 minutes, and 50 seconds

Distance Traveled
1,800,000 miles

Orbits
80

Crew
Commander Michael L. Coats
Pilot John E. Blaha
Mission Specialists James P. Bagian, James F. Buchli, and Robert C. Springer

The primary payload of STS-29 was the Tracking and Data Relay Satellite-D (TDRS-D), which was attached to an Inertial Upper Stage (IUS) booster and was the third TDRS to be deployed.

Secondary mission payload included the Orbiter Experiments Autonomous Supporting Instrumentation System-1 (OASIS-1), a Space Station Heat Pipe Advanced Radiator Experiment (SHARE), the Protein Crystal Growth (PCG) experiment, the Chromosomes and Plant Cell Division (CHROMEX) experiment, two Shuttle Student Involvement Program (SSIP) experiments, and an U.S. Air Force experiment using the orbiter as a calibration target for a ground-based experiment at the Air Force Maui Optical Site (AMOS) in Hawaii. The crew also photographed Earth with a handheld IMAX camera.

STS-30

Backdropped against partially cloudy Florida skies, the Space Shuttle Atlantis heads for a 4-day mission in Earth orbit with five astronaut crewmembers aboard.

Mission
STS-30, Magellan

Space Shuttle
Atlantis

Launched
May 4, 1989, 2:46:59 p.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
May 8, 1989, 12:43:26 p.m. PDT on
Runway 22 at Edwards Air Force Base, CA

Duration
4 days, 0 hours, 56 minutes, and 27 seconds

Distance Traveled
1,477,500 miles

Orbits
65

Crew
Commander David M. Walker
Pilot Ronald J. Grabe
Mission Specialists Norman E. Thagard,
Mary L. Cleave, and Mark C. Lee

The primary payload for STS-30—a Magellan/Venus radar mapper spacecraft and attached Inertial Upper Stage (IUS)—was deployed 6 hours and 14 minutes into the flight. The IUS's first and second stages fired as planned, boosting the Magellan spacecraft on a proper trajectory for a 15-month journey to Venus.

Secondary payload included the Mesoscale Lightning Experiment (MLE), the microgravity research with Fluids Experiment Apparatus (FEA), and an Air Force Maui Optical Site (AMOS) experiment.

One of the five General Purpose Computers (GPC) failed and had to be replaced with a sixth onboard hardware spare. This is the first time a GPC was switched out on orbit.

STS-28

The Space Shuttle Columbia is being lowered and attached to the solid rocket booster assembly in the Vehicle Assembly Building (VAB) at the Kennedy Space Center (KSC).

STS-28 was the fourth mission dedicated to the Department of Defense. Because of the mission's security classification, crew activities and accomplishments are not disclosed.

Mission
STS-28, Department of Defense mission

Space Shuttle
Columbia

Launched
August 8, 1989, 8:37:00 a.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
August 13, 1989, 6:37:09 a.m. PDT on
Runway 17 at Edwards Air Force Base, CA

Duration
5 days, 1 hour, 0 minutes, and 8 seconds

Distance Traveled
2,070,943 miles

Orbits
81

Crew
Commander Brewster H. Shaw, Jr.
Pilot Richard N. Richards
Mission Specialists James C. Adamson,
David C. Leestma, and Mark N. Brown

STS-34

The Space Shuttle Atlantis lifts off from Kennedy Space Center's (KSC) Launch Pad 39B at 12:53 p.m., marking the beginning of a 5-day mission in space. Atlantis carried a crew of five astronauts and the spacecraft Galileo. The Jupiter-bound probe deployed from Atlantis some 6 hours after launch.

Mission
STS-34, Galileo; Shuttle Solar Backscatter Ultraviolet (SSBUV) experiment

Space Shuttle
Atlantis

Launched
October 18, 1989, 12:53:40 p.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
October 23, 1989, 9:33:00 a.m. PDT on Runway 23 at Edwards Air Force Base, CA

Duration
4 days, 23 hours, 39 minutes, and 20 seconds

Distance Traveled
1,800,000 miles

Orbits
79

Crew
Commander Donald E. Williams
Pilot Michael J. McCulley
Mission Specialists Franklin R. Chang-Díaz, Shannon W. Lucid, and Ellen S. Baker

The primary payload for STS-34 was the Galileo spacecraft and the attached Inertial Upper Stage (IUS) booster. After deployment, the IUS stages fired, placing Galileo on a trajectory for a 6-year trip to Jupiter via gravitational boosts from Venus and Earth.

Secondary payload on this mission included the Shuttle Solar Backscatter Ultraviolet (SSBUV) experiment that was carried in the cargo bay. Stowed in the crew cabin was the Growth Hormone Crystal Distribution (GHCD) experiment, the Polymer Morphology (PM) experiment, the Sensor Technology Experiment (STEX), the Mesoscale Lightning Experiment (MLE), an IMAX camera, a Shuttle Student Involvement Program (SSIP) experiment that investigated ice crystal formation in zero gravity, and a ground-based Air Force Maui Optical Site (AMOS) experiment.

STS-33

The Space Shuttle Discovery approaches Edwards Air Force Base, CA, after the successful completion of the Department of Defense mission STS-33.

Mission
STS-33, Department of Defense mission

Space Shuttle
Discovery

Launched
November 22, 1989, 7:23:30 p.m. EST from
Launch Pad 39B at Kennedy Space Center, FL

Landed
November 27, 1989, 4:30:19 p.m. PST on
Runway 4 at Edwards Air Force Base, CA

Duration
5 days, 0 hours, 6 minutes, and 49 seconds

Distance Traveled
2,045,056 miles

Orbits
79

Crew
Commander Frederick D. Gregory
Pilot John E. Blaha
Mission Specialists F. Story Musgrave,
Manley L. Carter, Jr., and Kathryn C. Thornton

STS-33 was the fifth mission dedicated to the Department of Defense. Because of the mission's security classification, crew activities and accomplishments are not disclosed.

The original launch date set for November 20, 1989, was rescheduled to allow for the changeout of suspect integrated electronics assemblies on the twin solid rocket boosters.

STS-32

This photo was taken during a battery of documentary photographs of the recaptured Long Duration Exposure Facility (LDEF). The Atlantic Coast of Namibia serves as a backdrop for the colorful scene. After 5½ years of orbiting Earth, the LDEF was retrieved by STS-32 crewmembers and brought back home at the end of the 11-day mission for scientific observation. The bus-sized spacecraft was held in the grasp of Columbia's Remote Manipulator System's (RMS) end effector during the survey.

Mission
STS-32, Syncom IV-F5; LDEF retrieval

Space Shuttle
Columbia

Launched
January 9, 1990, 7:35:00 a.m. EST from
Launch Pad 39A at Kennedy Space Center, FL

Landed
January 20, 1990, 1:35:36 a.m. PST on
Runway 22 at Edwards Air Force Base, CA

Duration
10 days, 21 hours, 0 minutes, and 36 seconds

Distance Traveled
4,509,972 miles

Orbits
172

Crew
Commander Daniel C. Brandenstein
Pilot James D. Wetherbee
Mission Specialists Bonnie J. Dunbar,
G. David Low, and Marsha S. Ivins

The objectives for STS-32 were the deployment of the Syncom IV-F5 defense communications satellite and the retrieval of NASA's Long Duration Exposure Facility (LDEF). Syncom IV-F5 (also known as Leasat 5) was deployed first, and the third stage Minuteman solid perigee kick motor propelled the satellite to geosynchronous orbit. LDEF was retrieved on flight day 4 using the Remote Manipulator System (RMS).

The middeck payload included the Characterization of Neurospora Circadian Rhythms (CNCR) experiment, the Protein Crystal Growth (PCG) experiment, the Fluid Experiment Apparatus (FEA), the American Flight Echocardiograph (AFE), the Latitude/Longitude Locator (L3), the Mesoscale Lightning Experiment (MLE), an IMAX camera, and an Air Force Maui Optical Site (AMOS) experiment.

STS-36

The Space Shuttle Atlantis rests on the runway at Edwards Air Force Base, CA, after the successful completion of the sixth Department of Defense mission, STS-36.

Mission
STS-36, Department of Defense mission

Space Shuttle
Atlantis

Launched
February 28, 1990, 2:50:22 a.m. EST from
Launch Pad 39A at Kennedy Space Center, FL

Landed
March 4, 1990, 10:08:44 a.m. PST on
Runway 23 at Edwards Air Force Base, CA

Duration
4 days, 10 hours, 18 minutes, and 22 seconds

Distance Traveled
1,837,962 miles

Orbits
72

Crew
Commander John O. Creighton
Pilot John H. Casper
Mission Specialists Richard M. Mullane,
David C. Hilmers, and Pierre J. Thuot

STS-36 was the sixth mission dedicated to the Department of Defense. Because of the mission's security classification, crew activities and accomplishments are not disclosed.

The launch set for February 22, 1990, was postponed several days due to an illness of the crew commander and poor weather conditions. It was the first time since Apollo 13 in 1970 that a piloted space mission was affected by the illness of a crewmember.

STS-31

The Hubble Space Telescope (HST), still in the grasp of Discovery's Remote Manipulator System (RMS), orbits some 332 nautical miles above Earth. In this picture, Hubble has deployed one of its solar array panels but is yet to have extended the second.

Mission
STS-31, Hubble Space Telescope (HST)

Space Shuttle
Discovery

Launched
April 24, 1990, 8:33:51 a.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
April 29, 1990, 6:49:57 a.m. PDT on
Runway 22 at Edwards Air Force Base, CA

Duration
5 days, 1 hour, 16 minutes, and 6 seconds

Distance Traveled
2,068,213 miles

Orbits
80

Crew
Commander Loren J. Shriver
Pilot Charles F. Bolden, Jr.
Mission Specialists Steven A. Hawley,
Bruce McCandless II, and Kathryn D. Sullivan

The primary payload on STS-31 was the Hubble Space Telescope (HST), which was deployed in a 380-statute-mile orbit. Hubble became one of the most famous telescopes in history, producing some of the most iconic space images ever captured.

Secondary payload on this mission included an IMAX Cargo Bay Camera (ICBC) to document operations outside the crew cabin and a handheld IMAX camera for use inside the crew cabin. An Ascent Particle Monitor (APM) used to detect particulate matter was in the payload bay. Additional payload also included the Protein Crystal Growth (PCG) experiment to provide data on growing protein crystals in microgravity, the Radiation Monitoring Equipment III (RME III) to measure gamma ray levels in the crew cabin, the Investigations into Polymer Membrane Processing (IPMP) to determine porosity control in a microgravity environment, a Shuttle Student Involvement Program (SSIP) experiment to study the effects of near-weightlessness on electrical arcs, and an Air Force Maui Optical Site (AMOS) experiment.

STS-41

This rare view shows two Space Shuttles on adjacent pads at Launch Complex 39 with the Rotating Service Structures (RSS) retracted. The Space Shuttle Columbia (foreground) is on Pad A where it awaits further processing for a September 6, 1990, early morning launch on STS-35. The Space Shuttle Discovery is set to begin preparations for an October lift-off on STS-41, when the Ulysses spacecraft was scheduled to be taxied into space. Following the taking of this photograph, STS-35 was postponed and STS-41's Discovery was successfully launched on October 6.

Mission
STS-41, Ulysses; SSBUV; ISAC

Space Shuttle
Discovery

Launched
October 6, 1990, 7:47:15 a.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
October 10, 1990, 6:57:19 a.m. PDT on
Runway 22 at Edwards Air Force Base, CA

Duration
4 days, 2 hours, 10 minutes, and 4 seconds

Distance Traveled
1,707,445 miles

Orbits
66

Crew
Commander Richard N. Richards
Pilot Robert D. Cabana
Mission Specialists William M. Shepherd,
Bruce E. Melnick, and Thomas D. Akers

The primary payload on this mission was the European Space Agency's (ESA) Ulysses spacecraft, which was built to explore the polar regions of the Sun. Two upper stages, the Inertial Upper Stage (IUS), and a mission-specific Payload Assist Module-S (PAM-S) combined together for the first time to send Ulysses toward an out-of-ecliptic trajectory.

Other payloads and experiments flown on STS-41 were the Shuttle Solar Backscatter Ultraviolet (SSBUV) experiment, the Intelsat Solar Array Coupon (ISAC), the Chromosome and Plant Cell Division Experiment (CHROMEX), the Voice Command System (VCS), the Solid Surface Combustion Experiment (SSCE), the Investigations into Polymer Membrane Processing (IPMP) experiment, the Physiological Systems Experiment (PSE), the Radiation Monitoring Experiment III (RME III), a Shuttle Student Involvement Program (SSIP) experiment, and an Air Force Maui Optical Site (AMOS) experiment.

STS-38

The Space Shuttle Atlantis rests on Runway 33 at Edwards Air Force Base in California after completing the seventh Department of Defense mission.

Mission
STS-38, Department of Defense mission

Space Shuttle
Atlantis

Launched
November 15, 1990, 6:48:15 p.m. EST from
Launch Pad 39A at Kennedy Space Center, FL

Landed
November 20, 1990, 4:42:42 p.m. EST on
Runway 33 at Kennedy Space Center, FL

Duration
4 days, 21 hours, 54 minutes, and 27 seconds

Distance Traveled
2,045,056 miles

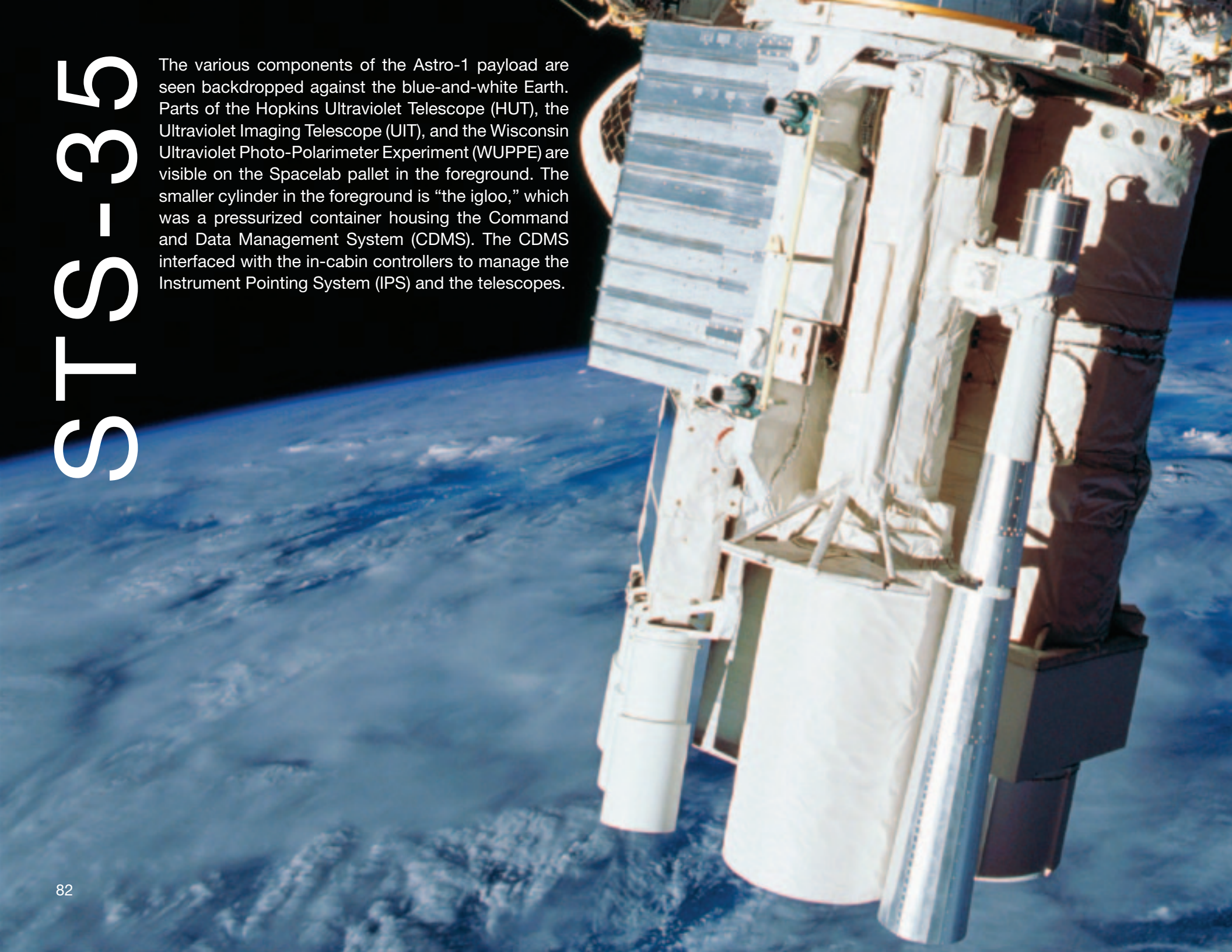
Orbits
79

Crew
Commander Richard O. Covey
Pilot Frank L. Culbertson, Jr.
Mission Specialists Robert C. Springer,
Carl J. Meade, and Charles D. Gemar

STS-38 was the seventh mission dedicated to the Department of Defense. Because of the mission's security classification, crew activities and accomplishments are not disclosed.

The launch was originally scheduled for July 1990; however, a liquid hydrogen leak found on Columbia during the STS-35 countdown prompted three precautionary tanking tests on Atlantis at the launch pad on June 29, July 13, and July 25. Tests confirmed a hydrogen fuel leak on the external tank side of the external tank/orbiter's 17-inch quick disconnect umbilical. This leak could not be repaired at the pad, and Atlantis was rolled back to the Vehicle Assembly Building (VAB) on August 9, was demated, and was transferred to the Orbiter Processing Facility (OPF). During rollback, the vehicle was parked outside the VAB for about a day while the Columbia STS-35 stack was transferred to the pad for launch. Outside, Atlantis suffered minor hail damage to its tiles during a thunderstorm. After repairs were made in the OPF, Atlantis was transferred to the VAB for mating on October 2. The vehicle was rolled out to Pad 39A on October 12.

STS-35



The various components of the Astro-1 payload are seen backdropped against the blue-and-white Earth. Parts of the Hopkins Ultraviolet Telescope (HUT), the Ultraviolet Imaging Telescope (UIT), and the Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE) are visible on the Spacelab pallet in the foreground. The smaller cylinder in the foreground is “the igloo,” which was a pressurized container housing the Command and Data Management System (CDMS). The CDMS interfaced with the in-cabin controllers to manage the Instrument Pointing System (IPS) and the telescopes.

Mission
STS-35, Astro-1

Space Shuttle
Columbia

Launched
December 2, 1990, 1:49:01 a.m. EST from
Launch Pad 39B at Kennedy Space Center, FL

Landed
December 10, 1990, 9:54:09 p.m. PST on
Runway 22 at Edwards Air Force Base, CA

Duration
8 days, 23 hours, 5 minutes, and 8 seconds

Distance Traveled
3,728,636 miles

Orbits
144

Crew
Commander Vance D. Brand
Pilot Guy S. Gardner
Mission Specialists Jeffrey A. Hoffman,
John M. Lounge, and Robert A. Parker
Payload Specialists Samuel T. Durrance
and Ronald A. Parise

The primary objectives on STS-35 were around-the-clock observations of the celestial sphere in ultraviolet as well as x-ray astronomy with the Astro-1 observatory, which consisted of the Hopkins Ultraviolet Telescope (HUT), the Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE), the Ultraviolet Imaging Telescope (UIT), and the Broad Band X-Ray Telescope (BBXRT). The loss of both of the data display units (used for pointing telescopes and operating experiments) during the mission impacted the crew's aiming procedures and forced the ground teams at the Marshall Space Flight Center (MSFC) in Huntsville, AL, to aim the ultraviolet telescopes, with supplemental fine-tuning conducted by the flightcrew.

Other experiments included the Shuttle Amateur Radio Experiment-2 (SAREX-2), a ground-based experiment to calibrate electro-optical sensors at the Air Force Maui Optical Site (AMOS) in Hawaii, and a crew-conducted Space Classroom Program Assignment: "The Stars," to spark students' interest in science, math, and technology.

STS-37

The Space Shuttle Atlantis lifts off from Launch Pad 39B at Kennedy Space Center (KSC) on the eastern coast of Florida.

Mission
STS-37, Gamma Ray Observatory

Space Shuttle
Atlantis

Launched
April 5, 1991, 9:22:45 a.m. EST from
Launch Pad 39B at Kennedy Space Center, FL

Landed
April 11, 1991, 5:55:29 a.m. PST on
Runway 33 at Edwards Air Force Base, CA

Duration
5 days, 23 hours, 32 minutes, and 44 seconds

Distance Traveled
2,487,075 miles

Orbits
93

Crew
Commander Steven R. Nagel
Pilot Kenneth D. Cameron
Mission Specialists Jerry L. Ross,
Jerome “Jay” Apt, and Linda M. Godwin

On STS-37, the primary payload was the Gamma Ray Observatory (GRO), which was deployed on flight day 3. The GRO high-gain antenna failed to deploy on command, but it was finally freed and manually deployed by Jerry L. Ross and Jerome “Jay” Apt during an unscheduled contingency spacewalk, the first since April 1985. The following day, the two astronauts performed the first scheduled spacewalk since November 1985 to test the means for astronauts to move themselves and equipment around the planned Space Station Freedom.

Secondary payload included the Crew and Equipment Translation Aids (CETA), which involved a scheduled 6-hour spacewalk by astronauts Ross and Apt; the Ascent Particle Monitor (APM); the Shuttle Amateur Radio Experiment-2 (SAREX-2); the Protein Crystal Growth (PCG) experiment; a Bioserve/Instrumentation Technology Associates Materials Dispersion Apparatus (BIMDA); the Radiation Monitoring Equipment III (RME III); and the Air Force Maui Optical Site (AMOS) experiment.

STS-39

The Strategic Defense Initiative Organization (SDIO) Shuttle Pallet Satellite-II (SPAS-II) is released by Discovery's Remote Manipulator System (RMS) to perform data collection.

Mission
STS-39, Department of Defense mission, AFP-675; IBSS; CRO; SPAS-II; STP-1

Space Shuttle
Discovery

Launched
April 28, 1991, 7:33:14 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
May 6, 1991, 2:55:35 p.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
8 days, 7 hours, 22 minutes, and 21 seconds

Distance Traveled
3,475,000 miles

Orbits
134

Crew
Commander Michael L. Coats
Pilot L. Blaine Hammond, Jr.
Mission Specialists Guion S. Bluford, Jr., Gregory J. Harbaugh, Richard J. Hieb, Donald R. McMonagle, and Charles L. Veach

STS-39 was the eighth dedicated Department of Defense mission. Discovery carried an unclassified payload including the Air Force Program-675 (AFP-675), an Infrared Background Signature Survey (IBSS) with Critical Ionization Velocity (CIV), a Chemical Release Observation (CRO) experiment, the Shuttle Pallet Satellite-II (SPAS-II) experiment, and the Space Test Payload-1 (STP-1).

The classified payload consisted of a Multipurpose Experiment Canister (MPEC). Also on board was the Radiation Monitoring Equipment III (RME III) and the Cloud Logic to Optimize Use of Defense Systems-IA (CLOUDS-IA).

STS-40

The Space Shuttle Columbia, with a seven-member crew aboard, soars toward a 9-day mission devoted to life sciences research.

Mission
STS-40, Spacelab Life Sciences-1

Space Shuttle
Columbia

Launched
June 5, 1991, 9:24:51 a.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
June 14, 1991, 8:39:11 a.m. PDT on
Runway 22 at Edwards Air Force Base, CA

Duration
9 days, 2 hours, 14 minutes, and 20 seconds

Distance Traveled
3,290,226 miles

Orbits
146

Crew
Commander Bryan D. O'Connor
Pilot Sidney M. Gutierrez
Mission Specialists James P. Bagian,
Tamara E. Jernigan, M. Rhea Seddon,
F. Drew Gaffney, and Millie Hughes-Fulford

STS-40 was the fifth dedicated Spacelab mission, Spacelab Life Sciences-1 (SLS-1), and the first mission dedicated solely to life sciences using the habitable module. The mission featured the most detailed and interrelated physiological measurements in space since the 1973–74 Skylab missions. The subjects were humans, 30 rodents, and thousands of tiny jellyfish. Primarily, the SLS-1 experiments studied six body systems; of 18 investigations, 10 involved humans, 7 involved rodents, and 1 involved jellyfish. The six body systems investigated were the cardiovascular/cardiopulmonary (heart, lungs, and blood vessels); the renal/endocrine (kidneys, hormone-secreting organs, and glands); the blood (plasma); the immune (white blood cells); the musculoskeletal (muscles and bones); and the neurovestibular (brain and nerves, eyes, and inner ears).

Additional payload included 12 Get-Away Special (GAS) canisters installed on the GAS Bridge Assembly for experiments in materials science, plant biology, and cosmic radiation; a Middeck 0-Gravity Dynamics Experiment (MODE); and seven Orbiter Experiments (OEX).

STS-43

The launch of Space Shuttle Atlantis was originally set for July 23, 1991, but was moved to July 24 to allow for the replacement of a faulty integrated electronics assembly that controlled the orbiter/external tank separation. The launch was finally rescheduled for August 2.

Mission
STS-43, Tracking and Data Relay Satellite (TDRS-E); SSBUV; SHARE II

Space Shuttle
Atlantis

Launched
August 2, 1991, 11:02:00 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
August 11, 1991, 8:23:25 a.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
8 days, 21 hours, 21 minutes, and 25 seconds

Distance Traveled
3,700,400 miles

Orbits
142

Crew
Commander John E. Blaha
Pilot Michael E. Baker
Mission Specialists Shannon W. Lucid, James C. Adamson, and G. David Low

The primary payload of STS-43 was the Tracking and Data Relay Satellite-E (TDRS-E), which was attached to an Inertial Upper Stage (IUS) and deployed about 6 hours into flight. The IUS propelled the satellite into geosynchronous orbit, making TDRS-E the fourth member of the orbiting TDRS cluster. Secondary payload on the mission included the Space Station Heat Pipe Advanced Radiator Element II (SHARE II); a Shuttle Solar Backscatter Ultra-Violet (SSBUV) instrument; the Tank Pressure Control Equipment (TPCE); and the Optical Communications Through Windows (OCTW) experiment.

Other experiments included the Auroral Photography Experiment (APE-B), Protein Crystal Growth III (PCG III), the Bioserve/ Instrumentation Technology Associates Materials Dispersion Apparatus (BIMDA), the Investigations into Polymer Membrane Processing (IPMP), the Space Acceleration Measurement System (SAMS), the Solid Surface Combustion Experiment (SSCE), the Ultraviolet Plume Imager (UVPI), and the Air Force Maui Optical Site (AMOS) experiment.

STS-48

The STS-48 mission launched aboard the Space Shuttle Discovery on the evening of September 12, 1991.

Mission
STS-48, UARS

Space Shuttle
Discovery

Launched
September 12, 1991, 7:11:04 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
September 18, 1991, 12:38:42 a.m. PDT on Runway 22 at Edwards Air Force Base, CA

Duration
5 days, 8 hours, 27 minutes, and 38 seconds

Distance Traveled
2,193,670 miles

Orbits
81

Crew
Commander John O. Creighton
Pilot Kenneth S. Reightler, Jr.
Mission Specialists Mark N. Brown, Charles D. Gemar, and James F. Buchli

STS-48's primary payload, the Upper Atmosphere Research Satellite (UARS), was deployed on flight day 3. During its planned 18-month mission, the 14,500-pound observatory made the most extensive study to date of Earth's troposphere—the upper level of the planet's envelope of life-sustaining gases that also includes the protective ozone layer. UARS had 10 sensing and measuring devices: the Cryogenic Limb Array Etalon Spectrometer (CLAES); the Improved Stratospheric and Mesospheric Sounder (ISAMS); the Microwave Limb Sounder (MLS); the Halogen Occultation Experiment (HALOE); the High Resolution Doppler Imager (HRDI); the Wind Imaging Interferometer (WINDII); the Solar Ultraviolet Spectral Irradiance Monitor (SUSIM); the Solar/Stellar Irradiance Comparison Experiment (SOLSTICE); the Particle Environment Monitor (PEM); and the Active Cavity Radiometer Irradiance Monitor (ACRIM II).

STS-44

The Defense Support Payload (DSP) prepares for deployment in the Shuttle's cargo bay, backdropped against a blue-and-white Earth.

Mission
STS-44, Department of Defense mission; DSP

Space Shuttle
Atlantis

Launched
November 24, 1991, 6:44:00 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
December 1, 1991, 2:34:43 p.m. PST on Runway 5 at Edwards Air Force Base, CA

Duration
6 days, 22 hours, 50 minutes, and 43 seconds

Distance Traveled
2,890,067 miles

Orbits
110

Crew
Commander Frederick D. Gregory
Pilot Terence T. Henricks
Mission Specialists Mario Runco, Jr., James S. Voss, F. Story Musgrave, and Thomas J. Hennen

This was the 44th Shuttle mission and the ninth Department of Defense mission. The unclassified payload included a Defense Support Program (DSP) satellite and an attached Inertial Upper Stage (IUS) booster that were deployed on flight day 1.

Cargo bay and middeck payload included the Interim Operational Contamination Monitor (IOCM), the Terra Scout M88-1 (Military Man in Space), the Air Force Maui Optical System (AMOS), the Cosmic Radiation Effects and Activation Monitor (CREAM), the Shuttle Activation Monitor (SAM), the Radiation Monitoring Equipment III (RME III), the Visual Function Tester-1 (VFT-1), the Ultraviolet Plume Instrument (UVPI), the Bioreactor Flow and Particle Trajectory experiment, and the Extended Duration Orbiter Medical Project, which was a series of investigations in support of the Extended Duration Orbiter.

STS-42

Astronauts Ronald J. Grabe (left) and Stephen S. Oswald occupy the commander and pilot stations, respectively, during the entry phase of the STS-42 mission. The pink glow through the front windows is a telltale sign of the friction and heat that occur as the orbiter reenters Earth's atmosphere.

Mission
STS-42, IML-1

Space Shuttle
Discovery

Launched
January 22, 1992, 9:52:33 a.m. EST from
Launch Pad 39A at Kennedy Space Center, FL

Landed
January 30, 1992, 8:07:17 a.m. PST on
Runway 22 at Edwards Air Force Base, CA

Duration
8 days, 1 hour, 14 minutes, and 44 seconds

Distance Traveled
3,349,830 miles

Orbits
129

Crew
Commander Ronald J. Grabe
Pilot Stephen S. Oswald
Mission Specialists Norman E. Thagard,
David C. Hilmers, and William F. Readdy
Payload Specialists Roberta L. Bondar and
Ulf D. Merbold

The primary payload on board Discovery for STS-42 was the International Microgravity Laboratory-1 (IML-1), which made its first flight using the pressurized Spacelab module. The international crew was divided into two teams for around-the-clock research on the human nervous system's adaptation to low gravity and on the effects of microgravity on other life-forms such as shrimp eggs, lentil seedlings, fruit fly eggs, and bacteria. Materials processing experiments were also conducted, including crystal growth from a variety of substances such as enzymes, mercury iodide, and a virus. On flight day 6, mission managers concluded that enough onboard consumables remained to extend the mission by 1 day to continue the science experiments.

Secondary payload included 12 Get-Away Special (GAS) canisters, which contained a variety of U.S. and international experiments. The middeck payload included the Gelation of Sols: Applied Microgravity Research-1 (GOSAMR-1); an IMAX camera; the Investigations into Polymer Membrane Processing (IPMP); the Radiation Monitoring Experiment III (RME III); and two Shuttle Student Involvement Program (SSIP) experiments.

STS-45

This view of the Shuttle flight control room at Johnson Space Center (JSC) in Houston, TX, shows the behind-the-scenes crew that helped ensure that every mission was successful.

Mission
STS-45, ATLAS-1

Space Shuttle
Atlantis

Launched
March 24, 1992, 8:13:40 a.m. EST from
Launch Pad 39A at Kennedy Space Center, FL

Landed
April 2, 1992, 6:23:06 a.m. EST on
Runway 33 at Kennedy Space Center, FL

Duration
8 days, 22 hours, 9 minutes, and 26 seconds

Distance Traveled
3,274,946 miles

Orbits
143

Crew
Commander Charles F. Bolden, Jr.
Pilot Brian Duffy
Mission Specialists Kathryn D. Sullivan,
David C. Leestma, and C. Michael Foale
Payload Specialists Byron K. Lichtenberg and
Dirk D. Frimout

The 46th Shuttle mission carried the first Atmospheric Laboratory for Applications and Science (ATLAS-1) on Spacelab pallets mounted in the orbiter's cargo bay. The nondeployable payload, equipped with 12 instruments from the U.S., France, Germany, Belgium, Switzerland, the Netherlands, and Japan, conducted studies in atmospheric chemistry, solar radiation, space plasma physics, and ultraviolet astronomy. The ATLAS-1 instruments included the Atmospheric Trace Molecule Spectroscopy (ATMOS); a Grille Spectrometer; the Millimeter Wave Atmospheric Sounder (MAS); the Imaging Spectrometric Observatory (ISO); the Atmospheric Lyman-Alpha Emissions (ALAE) experiment; the Atmospheric Emissions Photometric Imager (AEPI); the Space Experiments with Particle Accelerators (SEPAC); an Active Cavity Radiometer (ACR); a Measurement of Solar Constant (SOLCON) experiment; a Solar Spectrum (SOLSPEC) experiment; a Solar Ultraviolet Spectral Irradiance Monitor (SUSIM); and a Far Ultraviolet Space Telescope (FAUST).

STS-49

The successful capture of the Intelsat VI satellite is recorded in this image. Left to right, astronauts Richard J. Hieb, Thomas D. Akers, and Pierre J. Thuot have handholds on the satellite. The 9-day mission accomplished the capture of the Intelsat VI, the subsequent mating of the satellite to a booster, and its eventual deployment, as well as a Space Station preview extravehicular activity (EVA) called the Assembly of Station by EVA Methods (ASEM).

Mission
STS-49, Intelsat VI repair

Space Shuttle
Endeavour

Launched
May 7, 1992, 7:40:00 p.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
May 16, 1992, 1:57:39 p.m. PDT on
Runway 22 at Edwards Air Force Base, CA

Duration
8 days, 21 hours, 17 minutes, and 39 seconds

Distance Traveled
3,969,019 miles

Orbits
141

Crew
Commander Daniel C. Brandenstein
Pilot Kevin P. Chilton
Mission Specialists Pierre J. Thuot,
Kathryn C. Thornton, Richard J. Hieb,
Thomas D. Akers, and Bruce E. Melnick

STS-49 marked the first flight of the orbiter Endeavour. The Intelsat VI (F-3) satellite, stranded in an unusable orbit since its launch aboard a Titan vehicle in March 1990, was captured by crewmembers during an extravehicular activity (EVA) and equipped with a new perigee kick motor. The satellite was subsequently released into orbit, and the new motor was fired to put the spacecraft into a geosynchronous orbit for operational use.

STS-49 completed the first three-person EVA, and it was also the first Shuttle mission to require three rendezvous with an orbiting spacecraft. The mission also marked the first attachment of a live rocket motor to an orbiting satellite and the first to use a drag chute during a Space Shuttle landing.

STS-50

The Space Shuttle Columbia lands with the drag chute deployed, which was first used successfully on mission STS-49 aboard Endeavour.

Mission
STS-50, USML-1

Space Shuttle
Columbia

Launched
June 25, 1992, 12:12:23 p.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
July 9, 1992, 7:42:27 a.m. EDT on
Runway 33 at Kennedy Space Center, FL

Duration
13 days, 19 hours, 30 minutes, and 4 seconds

Distance Traveled
5,758,332 miles

Orbits
221

Crew
Commander Richard N. Richards
Pilot Kenneth D. Bowersox
Mission Specialists Bonnie J. Dunbar,
Ellen S. Baker, and Carl J. Meade
Payload Specialists Lawrence J. DeLucas and
Eugene H. Trinh

The primary payload of STS-50 was the United States Microgravity Laboratory-1 (USML-1), a piloted Spacelab module with a connecting tunnel to the orbiter crew compartment. USML-1 was a national effort to advance microgravity research in a broad number of disciplines. The 13-day mission, which was also known as the first Extended Duration Orbiter flight, also provided new information on the effects of long-term human stay in space. Experiments included the Crystal Growth Furnace (CGF), the Drop Physics Module (DPM), the Surface Tension Driven Convection Experiment (STDCE), the Glovebox Facility (GBX), the Space Acceleration Measurement System (SAMS), the Generic Bioprocessing Apparatus (GBA), Astroculture-1 (ASC), the Extended Duration Orbiter Medical Project (EDOMP), and the Solid Surface Combustion Experiment (SSCE), as well as experiments in Zeolite Crystal Growth (ZCG) and Protein Crystal Growth (PCG).

Secondary experiments included the Investigation in Polymer Membrane Processing (IPMP), the Shuttle Amateur Radio Experiment-2 (SAREX-2), and the Ultraviolet Plume Instrument (UVPI).

STS-46

A view of the Space Shuttle Atlantis deploying the European Space Agency's (ESA) European Retrievable Carrier (EURECA) into orbit.

Mission
STS-46, TSS-1; EURECA deployment

Space Shuttle
Atlantis

Launched
July 31, 1992, 9:56:48 a.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
August 8, 1992, 9:11:50 a.m. EDT on
Runway 33 at Kennedy Space Center, FL

Duration
7 days, 23 hours, 15 minutes, and 2 seconds

Distance Traveled
3,321,007 miles

Orbits
127

Crew
Commander Loren J. Shriver
Pilot Andrew M. Allen
Mission Specialists Jeffrey A. Hoffman,
Franklin R. Chang-Díaz, Claude Nicollier, and
Marsha S. Ivins
Payload Specialist Franco Malerba

STS-46's primary objective was deployment of the European Space Agency's (ESA) European Retrievable Carrier (EURECA) and operation of the joint NASA/Italian Space Agency Tethered Satellite System (TSS). The mission was extended 1 day to complete the science objectives. EURECA deployed 1 day later than scheduled because of a problem with its data handling system. After deployment, the spacecraft's thrusters were fired to boost EURECA to its planned operating altitude of about 310 statute miles. However, the thruster firing was cut to 6 minutes instead of the planned 24 minutes because of unexpected attitude data from EURECA. The problem resolved and EURECA was boosted to operational orbit on the sixth day of the mission. (The payload was later retrieved on STS-57 in 1993.) The TSS deployment was also delayed 1 day because of EURECA. During the TSS deployment, the satellite reached a maximum distance of only 840 feet from the orbiter instead of the planned 12.5 miles because of a jammed tether line. After numerous attempts over several days to free the tether, the TSS operations were curtailed and the satellite was stowed for return to Earth.

STS-47

A profile view of the Space Shuttle Endeavour as it launches from Kennedy Space Center (KSC) in Florida.

Mission
STS-47, Spacelab-J

Space Shuttle
Endeavour

Launched
September 12, 1992, 10:23:00 a.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
September 20, 1992, 8:53:22 a.m. EDT on Runway 33 at Kennedy Space Center, FL

Duration
7 days, 22 hours, 30 minutes, and 22 seconds

Distance Traveled
3,310,922 miles

Orbits
126

Crew
Commander Robert L. Gibson
Pilot Curtis L. Brown, Jr.
Mission Specialists Mark C. Lee, N. Jan Davis, Jerome “Jay” Apt, and Mae C. Jemison
Payload Specialist Mamoru M. Mohri

Spacelab-J—a joint NASA and National Space Development Agency of Japan (NASDA) mission utilizing a piloted Spacelab module—conducted microgravity investigations in materials and life sciences. The international crew, consisting of the first Japanese astronaut to fly aboard the Shuttle, the first African-American woman to fly in space, and the first married couple to fly on the same space mission, was divided into red and blue teams for around-the-clock operations. Spacelab-J included 24 materials science and 20 life sciences experiments, of which 35 were sponsored by NASDA, 7 were sponsored by NASA, and 2 were collaborative efforts.

Materials science investigations covered biotechnology, electronic materials, fluid dynamics, transport phenomena, glasses and ceramics, metals and alloys, and acceleration measurements. Life sciences included experiments on human health, cell separation and biology, developmental biology, animal and human physiology and behavior, space radiation, and biological rhythms. Test subjects included the crew, Japanese koi fish, cultured animal and plant cells, chicken embryos, fruit flies, fungi and plant seeds, and frogs and frog eggs.

STS-52

The photograph was taken through the aft flight-deck windows of the Earth-orbiting Space Shuttle Columbia. A crew of five NASA astronauts and a Canadian payload specialist spent 10 days aboard Columbia for the STS-52 mission.

Mission
STS-52, USMP-1; LAGEOS II

Space Shuttle
Columbia

Launched
October 22, 1992, 1:09:39 p.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
November 1, 1992, 9:05:53 a.m. EST on
Runway 33 at Kennedy Space Center, FL

Duration
9 days, 20 hours, 56 minutes, and 13 seconds

Distance Traveled
4,129,028 miles

Orbits
159

Crew
Commander James D. Wetherbee
Pilot Michael A. Baker
Mission Specialists Charles L. Veach,
William M. Shepherd, and Tamara E. Jernigan
Payload Specialist Steven A. MacLean

The primary mission objectives on STS-52 were the deployment of the Laser Geodynamic Satellite II (LAGEOS-II) and the operation of the U.S. Microgravity Payload-1 (USMP-1). LAGEOS-II, a joint effort between NASA and the Italian Space Agency (ASI), was deployed on flight day 2 and was boosted into an initial elliptical orbit by the ASI's Italian Research Interim Stage (IRIS). The spacecraft's apogee kick motor later circularized LAGEOS orbit at its operational altitude of 3,666 miles.

The USMP-1, which was activated on flight day 1, included three experiments mounted on two connected Mission Peculiar Equipment Support Structures (MPESS) installed in the orbiter's cargo bay. The USMP-1 experiments were the Lambda Point Experiment; the Materiel pour L'Etude des Phenomenes Interessant la Solidification sur Terre et en Orbite (MEPHISTO), sponsored by the French agency Centre National d'Études Spatiales (CNES); and the Space Acceleration Measurement System (SAMS).

STS-53

The drag chute on the Space Shuttle Discovery deploys while landing on Runway 22 at Edwards Air Force Base in California. The landing ended an 8-day space mission for the STS-53 crew.

Mission
STS-53, Department of Defense mission; ODERACS

Space Shuttle
Discovery

Launched
December 2, 1992, 8:24:00 a.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
December 9, 1992, 12:43:47 p.m. PST on Runway 22 at Edwards Air Force Base, CA

Duration
7 days, 7 hours, 19 minutes, and 47 seconds

Distance Traveled
3,034,680 miles

Orbits
116

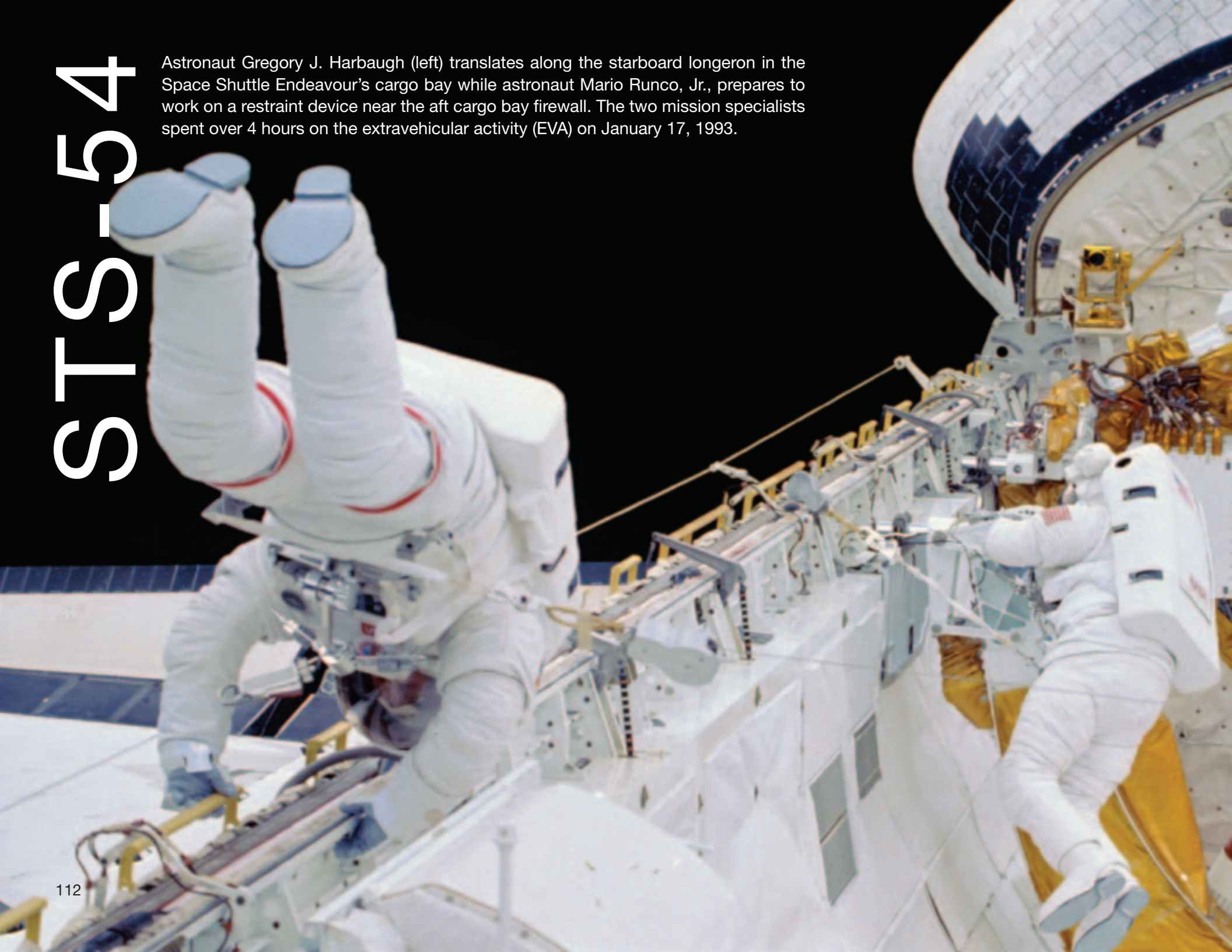
Crew
Commander David M. Walker
Pilot Robert D. Cabana
Mission Specialists Guion S. Bluford, Jr., James S. Voss, and Michael R. Clifford

STS-53 consisted of a classified Department of Defense primary payload, two unclassified secondary payloads, and nine unclassified middeck experiments.

Secondary payloads contained in or attached to Get-Away Special (GAS) hardware in the cargo bay included the Orbital Debris Radar Calibration Spheres (ODERACS) and the combined Shuttle Glow Experiment/Cryogenic Heat Pipe Experiment (GCP).

Middeck experiments included Microcapsules in Space (MIS-I); Space Tissue Loss (STL); the Visual Function Tester (VFT-2); the Cosmic Radiation Effects and Activation Monitor (CREAM); the Radiation Monitoring Equipment (RME-III); the Fluid Acquisition and Resupply Experiment (FARE); the Handheld, Earth-oriented, Real-time, Cooperative, User-friendly, Location-targeting, and Environmental System (HERCULES); the Battlefield Laser Acquisition Sensor Test (BLAST); and the Cloud Logic to Optimize Use of Defense Systems (CLOUDS).

STS-54



Astronaut Gregory J. Harbaugh (left) translates along the starboard longeron in the Space Shuttle Endeavour's cargo bay while astronaut Mario Runco, Jr., prepares to work on a restraint device near the aft cargo bay firewall. The two mission specialists spent over 4 hours on the extravehicular activity (EVA) on January 17, 1993.

Mission
STS-54, Tracking and Data Relay Satellite-F (TDRS-F); DXS

Space Shuttle
Endeavour

Launched
January 13, 1993, 8:59:30 a.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
January 19, 1993, 8:37:47 a.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
5 days, 23 hours, 38 minutes, and 17 seconds

Distance Traveled
2,501,277 miles

Orbits
96

Crew
Commander John H. Casper
Pilot Donald R. McMonagle
Mission Specialists Mario Runco, Jr., Gregory J. Harbaugh, and Susan J. Helms

The primary payload on Endeavour for STS-54 was the fifth operational Tracking and Data Relay Satellite, TDRS-F, which was deployed on the first day of flight. It was later successfully transferred to its proper orbit by the Inertial Upper Stage (IUS) booster.

Also carried into orbit in the payload bay was a Hitchhiker experiment called the Diffuse X-ray Spectrometer (DXS). This instrument collected data on x-ray radiation from diffuse sources in deep space.

On the fifth day, mission specialists Mario Runco, Jr., and Gregory J. Harbaugh spent nearly 5 hours in the open cargo bay performing a series of spacewalking tasks designed to increase NASA's knowledge of working in space. They tested their abilities to move about freely in the cargo bay, climbed into foot restraints without using their hands, and simulated carrying large objects in the microgravity environment.

STS-56

Most of the elements of the ATLAS-2 payload can be seen in the cargo bay of the Earth-orbiting Space Shuttle Discovery, but missing is the SPARTAN-201 satellite, which was in the midst of its separation from Discovery when the photo was taken.

Mission
STS-56, ATLAS-2; SPARTAN-201

Space Shuttle
Discovery

Launched
April 8, 1993, 1:29:00 a.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
April 17, 1993, 7:37:19 a.m. EDT on
Runway 33 at Kennedy Space Center, FL

Duration
9 days, 6 hours, 8 minutes, and 19 seconds

Distance Traveled
3,853,997 miles

Orbits
148

Crew
Commander Kenneth D. Cameron
Pilot Stephen S. Oswald
Mission Specialists C. Michael Foale,
Kenneth D. Cockrell, and Ellen L. Ochoa

The primary payload of STS-56 was the Atmospheric Laboratory for Applications and Science-2 (ATLAS-2), which was designed to collect data on the relationship between the Sun's energy output and Earth's middle atmosphere and how these factors affect the ozone layer. The payload included six instruments mounted on the Spacelab pallet in the cargo bay, with the seventh mounted on the cargo bay wall in two Get-Away Special (GAS) canisters. Additional instruments on the mission included the Atmospheric Trace Molecule Spectroscopy (ATMOS) experiment, the Millimeter Wave Atmospheric Sounder (MAS), the Shuttle Solar Backscatter Ultraviolet/A (SSBUV/A) spectrometer (on the cargo bay wall), the Solar Spectrum Measurement (SOLSPEC) instrument, the Solar Ultraviolet Spectral Irradiance Monitor (SUSIM), the Active Cavity Radiometer (ACR), and the Solar Constant (SOLCON) experiment.

ATLAS-2 is one element of NASA's Mission to Planet Earth (MTPE) program. All seven ATLAS-2 instruments first flew on ATLAS-I during STS-45.

STS-55

Four of the seven crewmembers who spent 10 days aboard the Space Shuttle Columbia are pictured during a brief shift overlap in the Spacelab D-2 Science Module. Left to right are Jerry L. Ross, Ulrich H. Walter, Bernard A. Harris, Jr., and Hans W. Schlegel. Ross, STS-55 mission specialist, is changing a sample in a materials processing furnace; Walter, a German payload specialist, is in the midst of a baroreflex test; and fellow payload specialist Schlegel assists mission specialist and physician Harris with a physiological test at the “Anthrorack.”

Mission
STS-55, D-2 Spacelab mission

Space Shuttle
Columbia

Launched
April 26, 1993, 10:50:00 a.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
May 6, 1993, 7:29:59 a.m. PDT on
Runway 22 at Edwards Air Force Base, CA

Duration
9 days, 23 hours, 39 minutes, and 59 seconds

Distance Traveled
4,164,183 miles

Orbits
160

Crew
Commander Steven R. Nagel
Pilot Terence T. Henricks
Mission Specialists Jerry L. Ross,
Charles J. Precourt, and Bernard A. Harris, Jr.
Payload Specialists Ulrich H. Walter and
Hans W. Schlegel

D-2 became the second Spacelab flight under German mission management with around-the-clock operations performed by the crew. Some 88 experiments were conducted, which included the following Material science investigations: the Material Science Experiment Double Rack for Experiment Modules and Apparatus (MEDEA); the Werkstofflabor (WL); the Holographic Optics Laboratory (HOLOP); and, on the Unique Support Structure (USS) located aft of D-2 in the cargo bay, the Material Science Autonomous Payload (MAUS) and the Atomic Oxygen Exposure Tray (AOET). Also located on the USS were Radiation Detectors (RD) experiments. One crystal growth experiment yielded the largest crystal of gallium arsenide produced in space. Life science research was performed with the Anthrorack (AR), the Biolabor (BB), and the Baroreflex (BA). Anthrorack, an advanced minidiagnostic laboratory, allowed for the most comprehensive medical screening to date of human adaptation to weightlessness. Bernard A. Harris, Jr., a medical doctor, set up the first intravenous line, injecting Hans W. Schlegel with saline as part of a study to replace body fluids lost during the adaptation to weightlessness.

STS-57

The external tank (ET) falls toward Earth after being jettisoned from the Space Shuttle Endeavour as the spacecraft headed toward its 10-day stay in Earth orbit.

Mission
STS-57, SPACEHAB-1; EURECA retrieval

Space Shuttle
Endeavour

Launched
June 21, 1993, 9:07:22 a.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
July 1, 1993, 8:52:16 a.m. EDT on
Runway 33 at Kennedy Space Center, FL

Duration
9 days, 23 hours, 44 minutes, and 54 seconds

Distance Traveled
4,118,037 miles

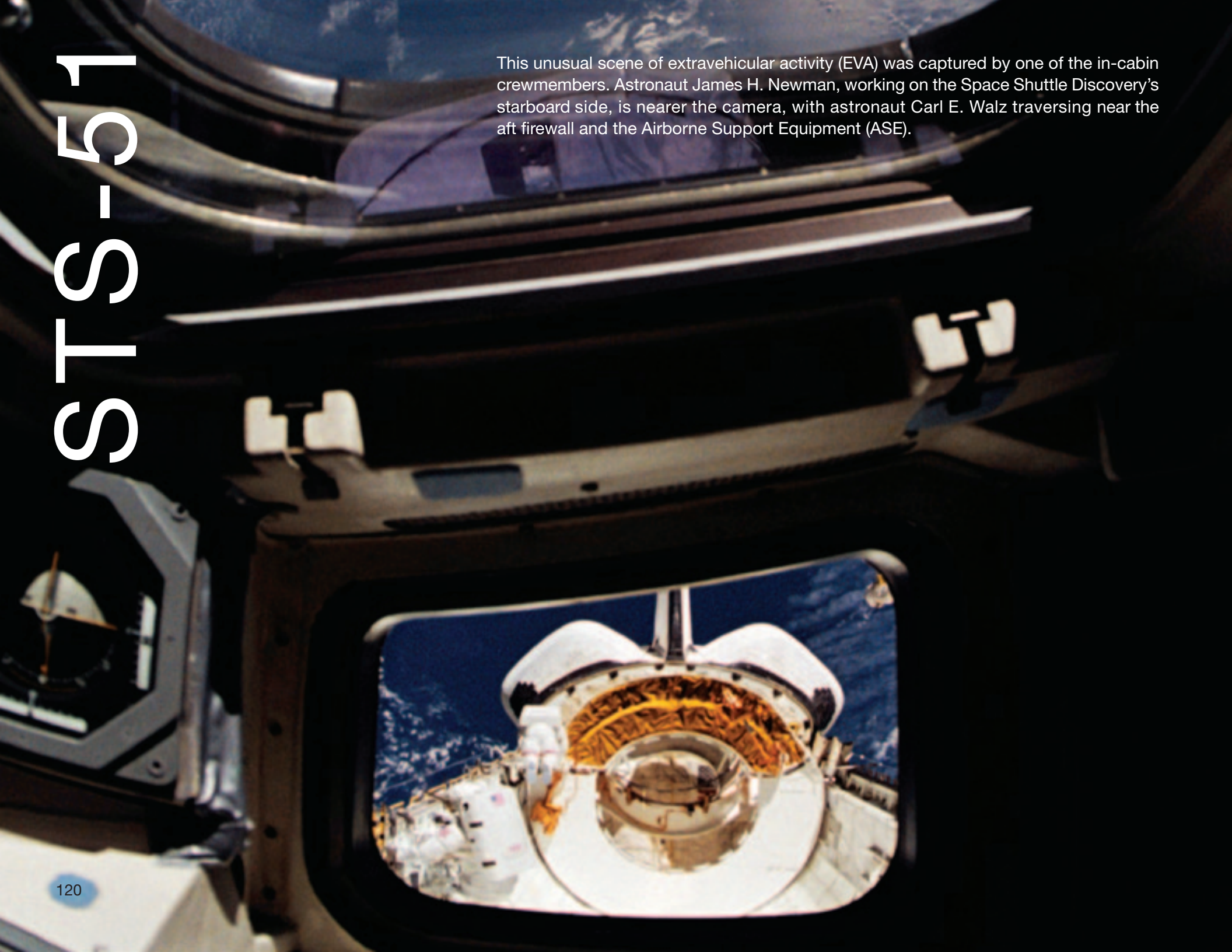
Orbits
155

Crew
Commander Ronald J. Grabe
Pilot Brian Duffy
Mission Specialists G. David Low,
Nancy J. Sherlock, Peter J. Wisoff,
and Janice E. Voss

STS-57 marked the first flight of the commercially developed SPACEHAB module, a pressurized laboratory designed to more than double the pressurized workspace for crew-tended experiments. Altogether, 22 experiments were flown, covering materials and life sciences as well as a wastewater recycling experiment for a space station.

On June 24, 1993, the crew captured and stowed the approximately 9,424-pound European Retrievable Carrier (EURECA) that was deployed on mission STS-46. However, EURECA ground controllers were unable to stow the spacecraft's two antennas, and, on June 25, astronauts G. David Low and Peter J. Wisoff spent the beginning of the scheduled extravehicular activity (EVA) manually folding the antennas. The remainder of the 5-hour, 50-minute EVA was spent on planned tasks.

STS-51



This unusual scene of extravehicular activity (EVA) was captured by one of the in-cabin crewmembers. Astronaut James H. Newman, working on the Space Shuttle Discovery's starboard side, is nearer the camera, with astronaut Carl E. Walz traversing near the aft firewall and the Airborne Support Equipment (ASE).

Mission
STS-51, ACTS/TOS; ORFEUS-SPAS

Space Shuttle
Discovery

Launched
September 12, 1993, 7:45:00 a.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
September 22, 1993, 3:56:06 a.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
9 days, 20 hours, 11 minutes, and 6 seconds

Distance Traveled
4,106,411 miles

Orbits
157

Crew
Commander Frank L. Culbertson, Jr.
Pilot William F. Readdy
Mission Specialists James H. Newman, Daniel W. Bursch, and Carl E. Walz

As one of the two primary payloads on STS-51, the Advanced Communications Technology Satellite (ACTS) was deployed on flight day 1. Approximately 45 minutes after the ACTS deployment, the attached Transfer Orbit Stage (TOS) booster was fired to propel the pioneering communications technology spacecraft to geosynchronous transfer orbit. On flight day 2, the crew deployed the second primary payload, the Orbiting and Retrievable Far and Extreme Ultraviolet Spectrograph-Shuttle Pallet Satellite (ORFEUS-SPAS), the first in a series of Astro-Shuttle Pallet Satellite (Astro-SPAS) astronomical missions. Extensive footage of the orbiter was recorded by an IMAX camera mounted on SPAS. A joint German-U.S. astrophysics payload was controlled via the SPAS Payload Operations Control Center (SPOC) at Kennedy Space Center (KSC), becoming the first Shuttle payload to be managed from Florida. After 6 days of data collection, ORFEUS-SPAS was retrieved with the Remote Manipulator System (RMS) arm and returned to the cargo bay.

On September 16, 1993, mission specialists James H. Newman and Carl E. Walz performed an extravehicular activity (EVA) lasting 7 hours, 5 minutes, and 28 seconds. The astronauts also evaluated tools, tethers, and foot restraint platforms intended for the upcoming Hubble Space Telescope (HST) Servicing Mission.

STS-58

This busy scene on the runway at Edwards Air Force Base, CA, was taken less than an hour following the landing of the Space Shuttle Columbia. The touchdown completed a 2-week mission in space devoted to medical research. The array of hardware and workers includes personnel and equipment designed to make the area safe. At far left is the Crew Transport Vehicle (CTV).

Mission
STS-58, SLS-2

Space Shuttle
Columbia

Launched
October 18, 1993, 10:53:10 a.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
November 1, 1993, 07:05:42 a.m. PST on Runway 22 at Edwards Air Force Base, CA

Duration
14 days, 0 hours, 12 minutes, and 32 seconds

Distance Traveled
5,840,450 miles

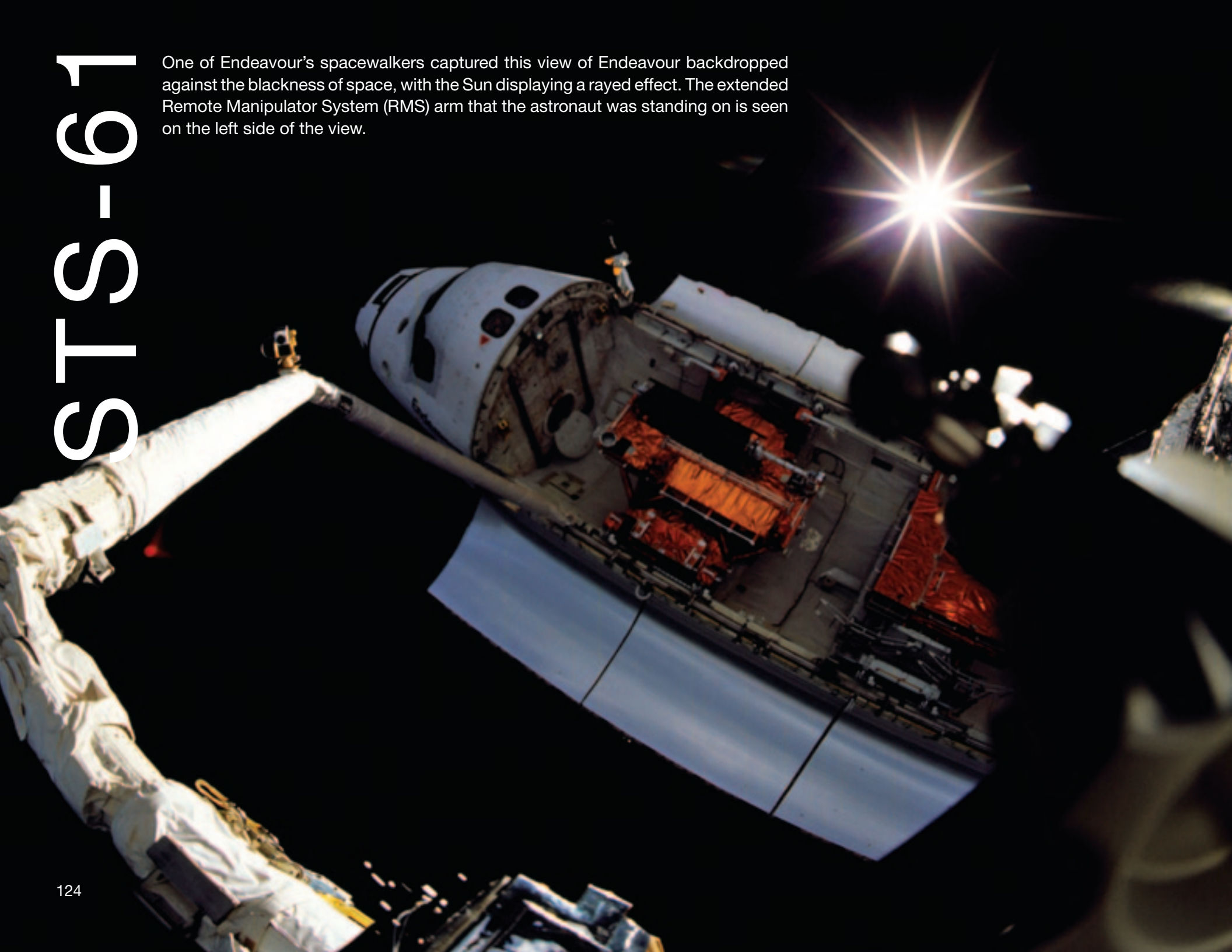
Orbits
225

Crew
Commander John E. Blaha
Pilot Richard A. Searfoss
Mission Specialists M. Rhea Seddon, William S. McArthur, Jr., David A. Wolf, and Shannon W. Lucid
Payload Specialist Martin J. Fettman

STS-58 was the second dedicated Spacelab Life Sciences mission (SLS-2). There were 14 experiments conducted in four areas: regulatory physiology, cardiovascular/cardiopulmonary, musculoskeletal, and neuroscience. Eight of the experiments focused on the crew, and six of the experiments centered on 48 rodents. The crew collected more than 650 different samples from themselves and the rodents, increasing the statistical base for life sciences research when combined with data from SLS-1 and SLS-2. Cardiovascular investigations: In-flight Study of Cardiovascular Deconditioning, Cardiovascular Adaptation to Zero Gravity, and Pulmonary Function During Weightlessness. Regulatory physiology investigations: Fluid Electrolyte Regulation During Space Flight, Regulation of Blood Volume During Space Flight, Regulation of Erythropoiesis in Rats During Space Flight, and Influence of Space Flight on Erythrokinetics in Man. Musculoskeletal investigations: Protein Metabolism During Space Flight; Effects of Zero Gravity on the Functional and Biochemical Properties of Antigravity Skeletal Muscle; Effects of Microgravity on the Electron Microscopy, Histochemistry and Protease Activities of Rat Hindlimb Muscles; Pathophysiology of Mineral Loss During Space Flight; and Bone, Calcium, and Space Flight. Neuroscience investigations: Study of the Effects of Space Travel on Mammalian Gravity Receptors and Vestibular Experiments in Spacelab.

STS-61

One of Endeavour's spacewalkers captured this view of Endeavour backdropped against the blackness of space, with the Sun displaying a rayed effect. The extended Remote Manipulator System (RMS) arm that the astronaut was standing on is seen on the left side of the view.



Mission
STS-61, First Hubble Space Telescope (HST) Servicing Mission

Space Shuttle
Endeavour

Launched
December 2, 1993, 4:27:00 a.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
December 13, 1993, 12:25:33 a.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
10 days, 19 hours, 58 minutes, and 33 seconds

Distance Traveled
4,433,772 miles

Orbits
163

Crew
Commander Richard O. Covey
Pilot Kenneth D. Bowersox
Mission Specialists F. Story Musgrave, Kathryn C. Thornton, Claude Nicollier, Jeffrey A. Hoffman, and Thomas D. Akers

The final Shuttle flight of 1993 was one of most challenging and complex missions ever attempted. During a record five back-to-back spacewalks that totaled 35 hours and 28 minutes, two teams of astronauts completed the first servicing of the Hubble Space Telescope (HST). Hubble rendezvous, grapple, and berthing occurred on flight day 3, with Claude Nicollier using the Remote Manipulator System (RMS) arm to position the 43-foot-long Hubble upright in the payload bay. Throughout the mission, test commands were sent to Hubble from the Space Telescope Operations Control Center (STOCC) at the Goddard Space Flight Center (GSFC) in Greenbelt, MD. After each servicing task was completed, STOCC controllers verified electrical interfaces between the replacement hardware and the telescope. Hubble was redeployed on flight day 9.

STS-60

A predawn sky above the Atlantic Ocean serves as the backdrop for the Space Shuttle Discovery as it heads toward an 8-day mission in Earth orbit. Aboard the Shuttle were five NASA astronauts and a Russian cosmonaut.

Mission
STS-60, WSF-1; SPACEHAB-2

Space Shuttle
Discovery

Launched
February 3, 1994, 7:10:00 a.m. EST from
Launch Pad 39B at Kennedy Space Center, FL

Landed
February 11, 1994, 2:19:22 p.m. EST on
Runway 15 at Kennedy Space Center, FL

Duration
8 days, 7 hours, 9 minutes, and 22 seconds

Distance Traveled
3,439,704 miles

Orbits
130

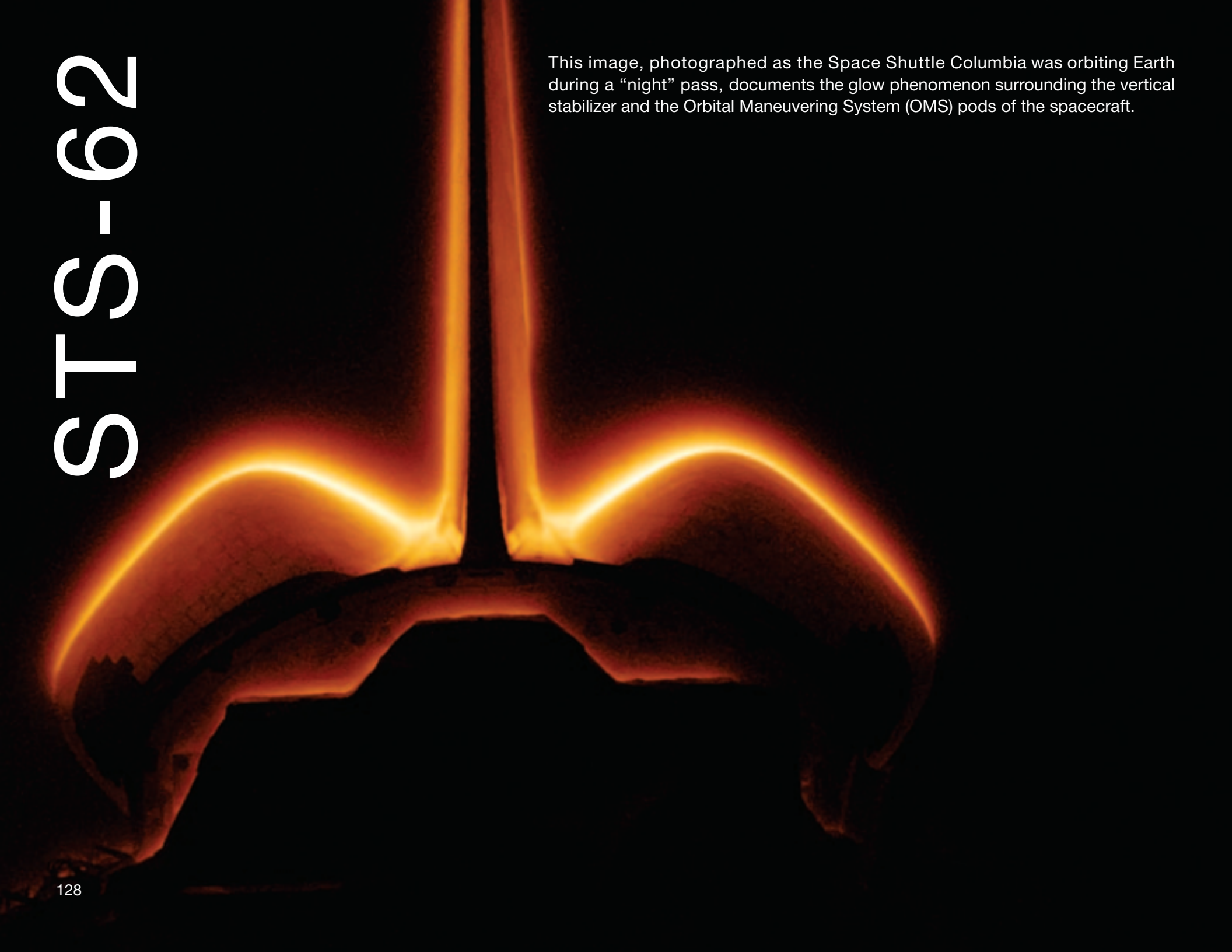
Crew
Commander Charles F. Bolden, Jr.
Pilot Kenneth F. Reightler, Jr.
Mission Specialists N. Jan Davis,
Ronald M. Sega, Franklin R. Chang-Díaz, and
Sergei K. Krikalev

STS-60 marked the first flight of a Russian cosmonaut on a U.S. Space Shuttle and was the initial step in implementing the Agreement on NASA/Russian Space Agency (RSA) Cooperation in Human Space Flight. The mission also marked the second flight of the SPACEHAB pressurized module and the 100th Get-Away Special (GAS) payload to fly in space. Also on board the Shuttle was the Wake Shield Facility-1 (WSF-1), making the first in a planned series of flights.

SPACEHAB-2 activated shortly after reaching orbit. Taking up about one quarter of the payload bay, the 1,100-cubic-foot module carried 12 experiments. Four of these experiments involved materials science topics, seven life sciences investigations, and a space dust collection experiment.

The crew also conducted the first joint NASA–Russian Space Agency in-flight medical and radiological investigations. Sergei K. Krikalev communicated with amateur radio operators in Moscow using the Shuttle Amateur Radio Experiment (SAREX) equipment.

STS-62



This image, photographed as the Space Shuttle Columbia was orbiting Earth during a “night” pass, documents the glow phenomenon surrounding the vertical stabilizer and the Orbital Maneuvering System (OMS) pods of the spacecraft.

Mission
STS-62, USMP-2; OAST-2

Space Shuttle
Columbia

Launched
March 4, 1994, 8:53:00 a.m. EST from
Launch Pad 39B at Kennedy Space Center, FL

Landed
March 18, 1994, at 8:09:41 a.m. EST on
Runway 33 at Kennedy Space Center, FL

Duration
13 days, 23 hours, 16 minutes, and 41 seconds

Distance Traveled
5,820,146 miles

Orbits
224

Crew
Commander John H. Casper
Pilot Andrew M. Allen
Mission Specialists Pierre J. Thuot,
Charles D. Gemar, and Marsha S. Ivins

The primary payloads on STS-62 were the United States Microgravity Payload-2 (USMP-2) and the Office of Aeronautics and Space Technology-2 (OAST-2). The USMP-2 included five experiments investigating materials processing and crystal growth in microgravity, while OAST-2 featured six experiments focusing on space technology and space flight. Both payloads were activated by the crew and operated by teams on the ground. USMP-2 experiments received emphasis at the beginning of the flight. The crew's experiments included the Dexterous End Effector (DEE), a new magnetic end effector and grapple fixture design that was tested for use on the Remote Manipulator System (RMS) arm; the Shuttle Solar Backscatter Ultraviolet/A (SSBUV/A) spectrometer; and the Limited Duration Space Environment Candidate Material Exposure (LDCE), which were all located in the payload bay.

Middeck experiments included the Advanced Protein Crystal Growth experiment; the Physiological Systems Experiment (PSE); the Commercial Protein Crystal Growth (CPCG) experiment; the Commercial Generic Bioprocessing Apparatus (CGBA); the Middeck 0-Gravity Dynamics Experiment (MODE); the Bioreactor Demonstration Systems (BDS); and the Auroral Photography Experiment (APE-B). The Air Force Maui Optical Site Calibration Test (AMOS) required no onboard hardware.

STS-59

A greenish-appearing aurora forms the backdrop for this scene of the Earth-orbiting Space Shuttle Endeavour's aft cargo bay. Featured in the bay are the antennae for the SIR-C/X-SAR imaging radar instruments, illuminated by moonlight. The crew sighted the southern lights (aurora australis) several times during each of the 11 days of the mission.

Mission
STS-59, Space Radar Laboratory (SRL-1)

Space Shuttle
Endeavour

Launched
April 9, 1994, at 7:05:00 a.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
April 20, 1994, 9:54:30 a.m. PDT on
Runway 22 at Edwards Air Force Base, CA

Duration
11 days, 5 hours, 49 minutes, and 30 seconds

Distance Traveled
4,704,835 miles

Orbits
183

Crew
Commander Sidney M. Gutierrez
Pilot Kevin P. Chilton
Mission Specialists Linda M. Godwin,
Jerome “Jay” Apt, Michael R. Clifford, and
Thomas D. Jones

The primary payload on board STS-59 was the Space Radar Laboratory (SRL-1), which was activated by the crew and operated by teams on the ground. The SRL-1 included the Spaceborne Imaging Radar-C and the X-band Synthetic Aperture Radar (SIR-C/X-SAR) and an atmospheric instrument called the Measurement of Air Pollution from Satellites (MAPS). The German Space Agency (DARA) and the Italian Space Agency (ASI) provided the X-SAR instrument. SIR-C/X-SAR covered approximately 38.5 million miles of Earth, the equivalent of 20 percent of the planet. More than 400 sites were imaged, including 19 primary observation sites (supersites) in Brazil, Michigan, North Carolina, and Central Europe.

Thirteen countries were represented in the project by 49 principal investigators and more than 100 scientists coordinated by the Jet Propulsion Laboratory (JPL) in Pasadena, CA. Some 133 hours of data were collected. The MAPS experiment measured the global distribution of carbon monoxide in the troposphere, or lower atmosphere.

STS-65

This view of the Space Shuttle Columbia, framed behind the Florida landscape, shows the launch of STS-65 from Pad 39A at the Kennedy Space Center (KSC) in Florida.

Mission
STS-65, International Microgravity Laboratory (IML-2)

Space Shuttle
Columbia

Launched
July 8, 1994, at 12:43:00 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
July 23, 1994, at 6:38:00 a.m. EDT on Runway 33 at Kennedy Space Center, FL

Duration
14 days, 17 hours, 55 minutes, and 0 seconds

Distance Traveled
6,143,846 miles

Orbits
235

Crew
Commander Robert D. Cabana
Pilot James D. Halsell, Jr.
Mission Specialists Richard J. Hieb, Carl E. Walz, Leroy Chiao, and Donald A. Thomas
Payload Specialist Chiaki Naito-Mukai

STS-65 marked the second flight of the International Microgravity Laboratory (IML-2), which carried more than twice the number of experiments and facilities as the IML-1. The crew split into two teams to perform around-the-clock research. More than 80 experiments, representing more than 200 scientists from six space agencies, were located in the Spacelab module in the payload bay (one piece of equipment was stowed in the middeck lockers). Fifty of the experiments delved into life sciences, including bioprocessing, space biology, human physiology, and radiation biology. Some of the equipment used for these investigations had flown on previous Spacelab flights, such as the European Space Agency's (ESA) Biorack, which marked its third flight. The IML-2 Biorack housed 19 experiments featuring chemicals and biological samples such as bacteria, mammalian and human cells, isolated tissues and eggs, sea urchin larvae, and fruit flies and plant seedlings. Over the course of a single mission, specimens evolved through several stages of life cycles, which allowed for the study of the effects of microgravity and cosmic radiation on living tissues.

Payload specialist Chiaki Naito-Mukai became the first Japanese woman to fly in space.

STS-64

Astronaut Mark C. Lee, an STS-64 mission specialist, tests the new Simplified Aid for EVA Rescue (SAFER) system 130 nautical miles above Earth with the forward cargo bay reflected in his helmet visor. Part of the hardware for the Lidar In-Space Technology Experiment (LITE) is also seen in the foreground.

Mission
STS-64, LITE; SAFER tested

Space Shuttle
Discovery

Launched
September 9, 1994, 6:22:05 p.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
September 20, 1994, 2:12:52 p.m. PDT on Runway 4 at Edwards Air Force Base, CA

Duration
10 days, 22 hours, 49 minutes, and 57 seconds

Distance Traveled
4,576,174 miles

Orbits
176

Crew
Commander Richard N. Richards
Pilot L. Blaine Hammond, Jr.
Mission Specialists Jerry M. Linenger, Susan J. Helms, Carl J. Meade, and Mark C. Lee

STS-64 marked the first flight of the Lidar In-space Technology Experiment (LITE) and the first untethered U.S. extravehicular activity (EVA) in 10 years. The LITE payload employs lidar, which stands for light detection and ranging, a type of optical radar using laser pulses instead of radio waves to study Earth's atmosphere. The first space flight of lidar was a highly successful technology test. The LITE instrument operated for 53 hours, yielding more than 43 hours of high-rate data. Unprecedented views were obtained of cloud structures, storm systems, dust clouds, pollutants, burning forest, and surface reflectance. The sites studied included the atmosphere above northern Europe, Indonesia, the South Pacific, Russia, and Africa. Sixty-five groups from 20 countries made validation measurements with ground-based and aircraft instruments to verify LITE data. The LITE science program was part of NASA's Mission to Planet Earth (MTPE).

Mission specialists Mark C. Lee and Carl J. Meade completed the 28th EVA of the Space Shuttle program on September 16. During the 6-hour, 15-minute EVA, they tested a new backpack called the Simplified Aid for EVA Rescue (SAFER), which was designed for use in the event a crewmember became untethered while conducting an EVA.

STS-68

The Space Shuttle Endeavour lifts off from Launch Pad 39A in a halo of light. Aboard the Shuttle were six NASA astronauts and the Space Radar Laboratory-2 (SRL-2). During the planned 10-day flight, around-the-clock operation of the SRL-2 yielded a wealth of data about Earth's global environment and the changes—both human-induced and natural—that are affecting it.

Mission
STS-68, Space Radar Laboratory (SRL-2)

Space Shuttle
Endeavour

Launched
September 30, 1994, 7:16:00 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
October 11, 1994, 10:02:08 a.m. PDT on Runway 22 at Edwards Air Force Base, CA

Duration
11 days, 5 hours, 46 minutes, and 8 seconds

Distance Traveled
4,703,000 miles

Orbits
182

Crew
Commander Michael A. Baker
Pilot Terrence W. Wilcutt
Mission Specialists Thomas D. Jones, Steven L. Smith, Daniel W. Bursch, and Peter J.K. Wisoff

STS-68 marked the second flight in 1994 of the Space Radar Laboratory (the first flight was STS-59 in April), which was part of NASA's Mission to Planet Earth (MTPE). Flying the SRL during different seasons allowed for comparisons between the first and second flights. The SRL-2 was activated on flight day 1, and around-the-clock observations were conducted by the astronauts, who split into two teams. In addition to repeated data takes over the same locations as SRL-1, unusual events were also imaged, including an erupting volcano in Russia and islands of Japan after an earthquake.

The mission also studied fires set in British Columbia, Canada, for forest management purposes. Special readings were taken with another SRL element, Measurement of Air Pollution from Satellites (MAPS), to gain a better understanding of carbon monoxide emissions from a burning forest. Flying for the fourth time on the Shuttle, MAPS was designed to measure the global distribution of carbon monoxide.

STS-66

Clouds over the Atlantic Ocean serve as the backdrop for this scene of the Atmospheric Laboratory for Applications and Science-3 (ATLAS-3) payload in the cargo bay of the Earth-orbiting Space Shuttle Atlantis.

Mission
STS-66, ATLAS-3; CRISTA-SPAS

Space Shuttle
Atlantis

Launched
November 3, 1994, 11:59:43 a.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
November 14, 1994, 7:33:45 a.m. PST on Runway 22 at Edwards Air Force Base, CA

Duration
10 days, 22 hours, 34 minutes, and 2 seconds

Distance Traveled
4,554,791 miles

Orbits
174

Crew
Commander Donald R. McMonagle
Pilot Curtis L. Brown, Jr.
Mission Specialists Ellen L. Ochoa,
Scott E. Parazynski, Joseph R. Tanner, and
Jean-François Clervoy

STS-66 further advanced a comprehensive effort to collect data about the Sun's energy output, the chemical makeup of Earth's middle atmosphere, and how these factors affect global ozone levels. Seven instruments on the Atmospheric Laboratory for Applications and Science-3 (ATLAS-3) also flew on the first two ATLAS flights.

Also considered a primary payload was the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere-Shuttle Pallet Satellite (CRISTA-SPAS), continuing a joint NASA–German Space Agency (DARA) series of scientific missions. ATLAS-3 and CRISTA-SPAS were considered a joint mission with a single set of science objectives. During the mission, the crew divided into two teams for around-the-clock research.

STS-63

This unique shot was taken from above the crew cabin and payload bay during a spacewalk. The astronaut is strapped to the foot restraint that is attached to the Remote Manipulator System (RMS) arm.

Mission
STS-63, SPACEHAB-3

Space Shuttle
Discovery

Launched
February 3, 1995, 12:22:04 a.m. EST from
Launch Pad 39B at Kennedy Space Center, FL

Landed
February 11, 1995, 6:50:19 a.m. EST on
Runway 15 at Kennedy Space Center, FL

Duration
8 days, 6 hours, 28 minutes, and 15 seconds

Distance Traveled
2,992,000 miles

Orbits
129

Crew
Commander James D. Wetherbee
Pilot Eileen M. Collins
Mission Specialists C. Michael Foale,
Janice E. Voss, Bernard A. Harris, Jr., and
Vladimar G. Titov

The first Space Shuttle flight of 1995 included several historic achievements, including the first flight of a female Shuttle pilot; the second flight of a Russian cosmonaut on the Shuttle, as part of Phase I of the International Space Station (ISS) program; and the Shuttle's first approach and flyaround of the Russian space station Mir.

After extensive negotiations and technical information exchanges between the U.S. and Russian space teams, the Russians concluded that the close approach could be safely achieved and the STS-63 crew was given a "go" to proceed. Ship-to-ship radio contact with Mir was achieved, and Valdimar G. Titov, who lived on Mir for more than a year, communicated excitedly with the three cosmonauts aboard the space station: Mir 17 Commander Alexander Viktorenko; flight engineer Elena V. Kondakova; and Valery Polyakov, a physician who broke Titov's record for extended time in space. After stationkeeping at a distance of 400 feet from Mir and with James D. Wetherbee manually controlling the orbiter, Discovery was flown to 37 feet from the Russian space station. "As we are bringing our spaceships closer together, we are bringing our nations closer together," Wetherbee said after Discovery was at the point of closest approach. "The next time we approach, we will shake your hand and together we will lead our world into the next millennium."

STS-67

This photo shows the wing of the Space Shuttle Endeavour orbiting high over clouds that are swirling in the form of a tropical storm on Earth.

Mission
STS-67, Astro-2

Space Shuttle
Endeavour

Launched
March 2, 1995, 1:38:13 a.m. EST from
Launch Pad 39A at Kennedy Space Center, FL

Landed
March 18, 1995, 1:47:14 p.m. PST on
Runway 22 at Edwards Air Force Base, CA

Duration
16 days, 15 hours, 8 minutes, and 48 seconds

Distance Traveled
6,892,836 miles

Orbits
262

Crew
Commander Stephen S. Oswald
Pilot William G. Gregory
Mission Specialists Tamara E. Jernigan,
John M. Grunsfeld and Wendy B. Lawrence
Payload Specialists Ronald A. Parise and
Samuel T. Durrance

Endeavour logged over 6.8 million miles during STS-67, allowing for a sustained examination of the “hidden universe” of ultraviolet light. The primary payload, the Astro-2 observatory, built upon the discoveries made by Astro-1.

Astro-2, which marked the second flight of three ultraviolet telescopes flown on Astro-1, was mounted on the Instrument Pointing System (IPS) on the Spacelab pallet in the cargo bay. The Hopkins Ultraviolet Telescope (HUT), developed at the Johns Hopkins University, performed spectroscopy in the far ultraviolet region of the spectrum to identify the physical processes and chemical composition of a celestial object. The improvements made to HUT after Astro-1 made it three times more sensitive. The Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE), built at the University of Wisconsin, measured the photometry and polarization of ultraviolet radiation from astronomical objects. The Ultraviolet Imaging Telescope (UIT), sponsored by NASA’s Goddard Space Flight Center (GSFC) in Greenbelt, MD, took wide-field photographs of objects in ultraviolet light.

STS-71

This view of the Space Shuttle Atlantis connected to Russia's Mir space station was photographed by the Mir 19 crew on July 4, 1995.

Mission
STS-71, First Shuttle-Mir docking

Space Shuttle
Atlantis

Launched
June 27, 1995, 3:32:19 p.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
July 7, 1995, 10:54:35 a.m. EDT on
Runway 15 at Kennedy Space Center, FL

Duration
9 days, 19 hours, 22 minutes, and 15 seconds

Distance Traveled
4,100,000 miles

Orbits
153

Crew
Commander Robert L. Gibson
Pilot Charles J. Precourt
Mission Specialists Ellen S. Baker,
Bonnie J. Dunbar, and Gregory J. Harbaugh
Mir 18 Crew: Norman E. Thagard,
Vladimir Dezhurov, and Gannady Strekalov
Mir 19 Crew: Anatoly Solovyev and
Nikolai Budarin

STS-71 marked a number of historic firsts in human space flight, including the 100th U.S. human space launch conducted from Cape Canaveral, FL, the first U.S. Space Shuttle–Russian space station Mir docking and joint on-orbit operations, the largest spacecraft ever in orbit, and the first on-orbit changeout of the Shuttle crew.

Docking occurred with Atlantis closing in on Mir from directly below. The manual phase of docking began with Atlantis about a half-mile below Mir, with Robert L. Gibson at the controls on the aft flight deck. Stationkeeping was performed when the orbiter was about 250 feet from Mir, pending approval from Russian and U.S. flight directors to proceed. Gibson then maneuvered the orbiter to a point at about 30 feet from Mir before beginning the final approach to the station. The closing rate was near the targeted 0.1 feet per second, and the closing velocity was about 0.107 feet per second at contact. Interface contact was nearly flawless: less than 1 inch lateral misalignment with an angular misalignment of less than 0.5 degrees per axis. Docking occurred about 216 nautical miles above the Lake Baykal region of the Russian Federation. The Orbiter Docking System (ODS) with Androgynous Peripheral Docking System served as the actual connection point to a similar interface on the docking port on Mir's Krystall module. ODS performed flawlessly during the docking sequence.

STS-70

This is a view of the Space Shuttle Discovery launch as seen through the brush surrounding the launch complex at the Kennedy Space Center (KSC) in Florida.

Mission
STS-70, Tracking and Data Relay Satellite-G (TDRS-G)

Space Shuttle
Discovery

Launched
July 13, 1995, at 9:41:55 a.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
July 22, 1995, at 8:02:00 a.m. EDT on Runway 33 at Kennedy Space Center, FL

Duration
8 days, 22 hours, 20 minutes, and 5 seconds

Distance Traveled
3,700,000 miles

Orbits
143

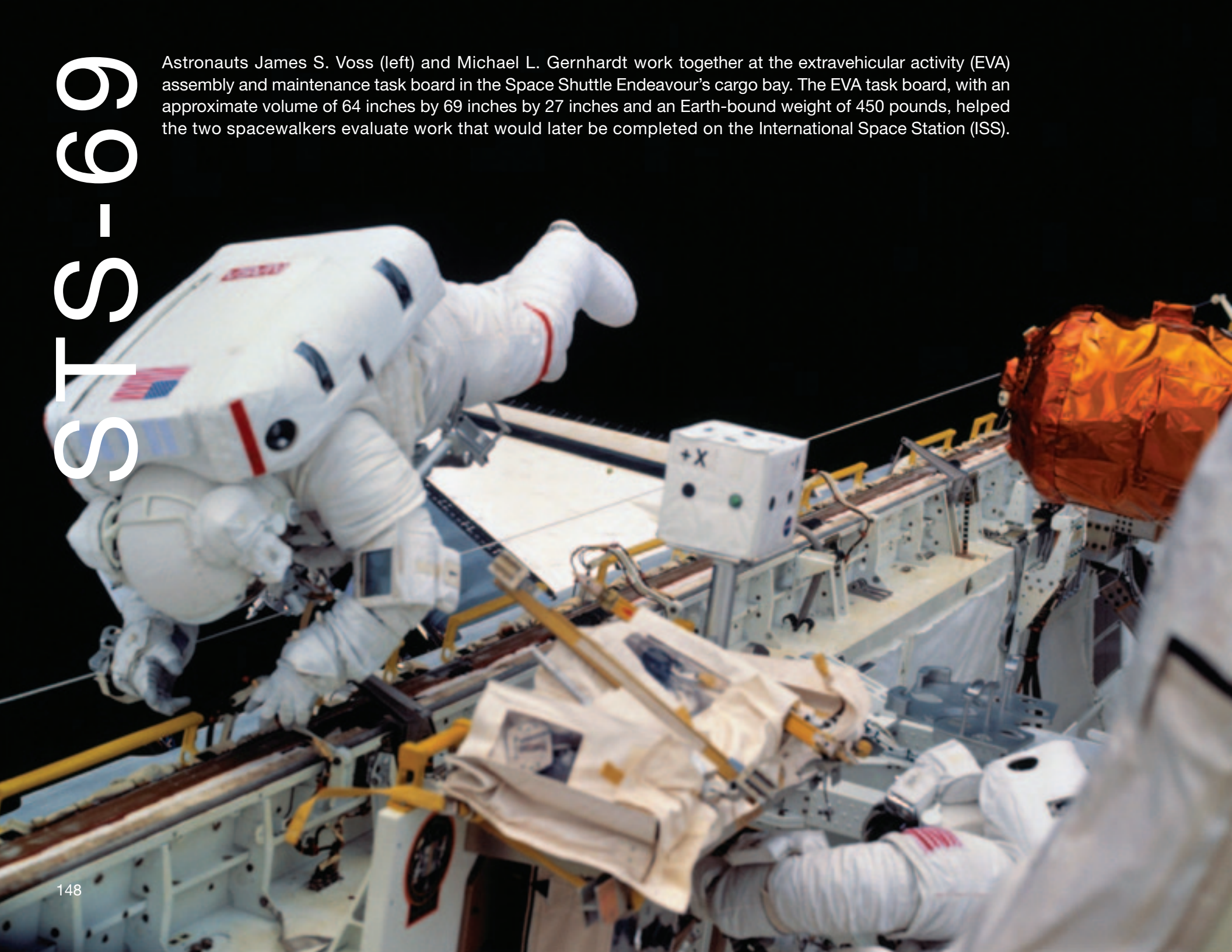
Crew
Commander Terence T. Henricks
Pilot Kevin R. Kregel
Mission Specialists Nancy J. Currie, Donald A. Thomas, and Mary Ellen Weber

The primary objective of the STS-70 mission was accomplished when the Tracking and Data Relay Satellite-G (TDRS-G) deployed from the orbiter payload bay about 6 hours after lift-off. Approximately 1 hour after deployment, the Inertial Upper Stage (IUS) booster attached to TDRS-G completed the first of two scheduled burns to place TDRS-G in geosynchronous orbit. Once it completed an on-orbit checkout, TDRS-G was scheduled to become an operational spare, completing an existing TDRS network of advanced tracking and communications satellites.

During the remainder of the mission, the five crewmembers completed a variety of experiments. The Biological Research in Canister (BRIC) experiments studied the effects of microgravity on a wide range of physiological processes in plants, insects, and small invertebrate animals. BRIC-4 examined how the hormone system and muscle formation of tobacco hornworms were affected by microgravity. BRIC-5 tested whether cell division changes in the daylily were due to microgravity or other causes. Also, the Bioreactor Development System (BDS), made of a device developed at the Johnson Space Center (JSC) in Houston, TX, used colon cancer cells to test bioreactor performance in microgravity; this experiment worked extremely well, yielding tissue cultures better than any seen previously.

STS-69

Astronauts James S. Voss (left) and Michael L. Gernhardt work together at the extravehicular activity (EVA) assembly and maintenance task board in the Space Shuttle Endeavour's cargo bay. The EVA task board, with an approximate volume of 64 inches by 69 inches by 27 inches and an Earth-bound weight of 450 pounds, helped the two spacewalkers evaluate work that would later be completed on the International Space Station (ISS).



Mission
STS-69, Spartan 201-03; UVCS/WLC

Space Shuttle
Endeavour

Launched
September 7, 1995, at 11:09:00 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
September 18, 1995, at 7:37:55 a.m. EDT on Runway 33 at Kennedy Space Center, FL

Duration
10 days, 20 hours, 28 minutes, and 55 seconds

Distance Traveled
4,500,000 miles

Orbits
171

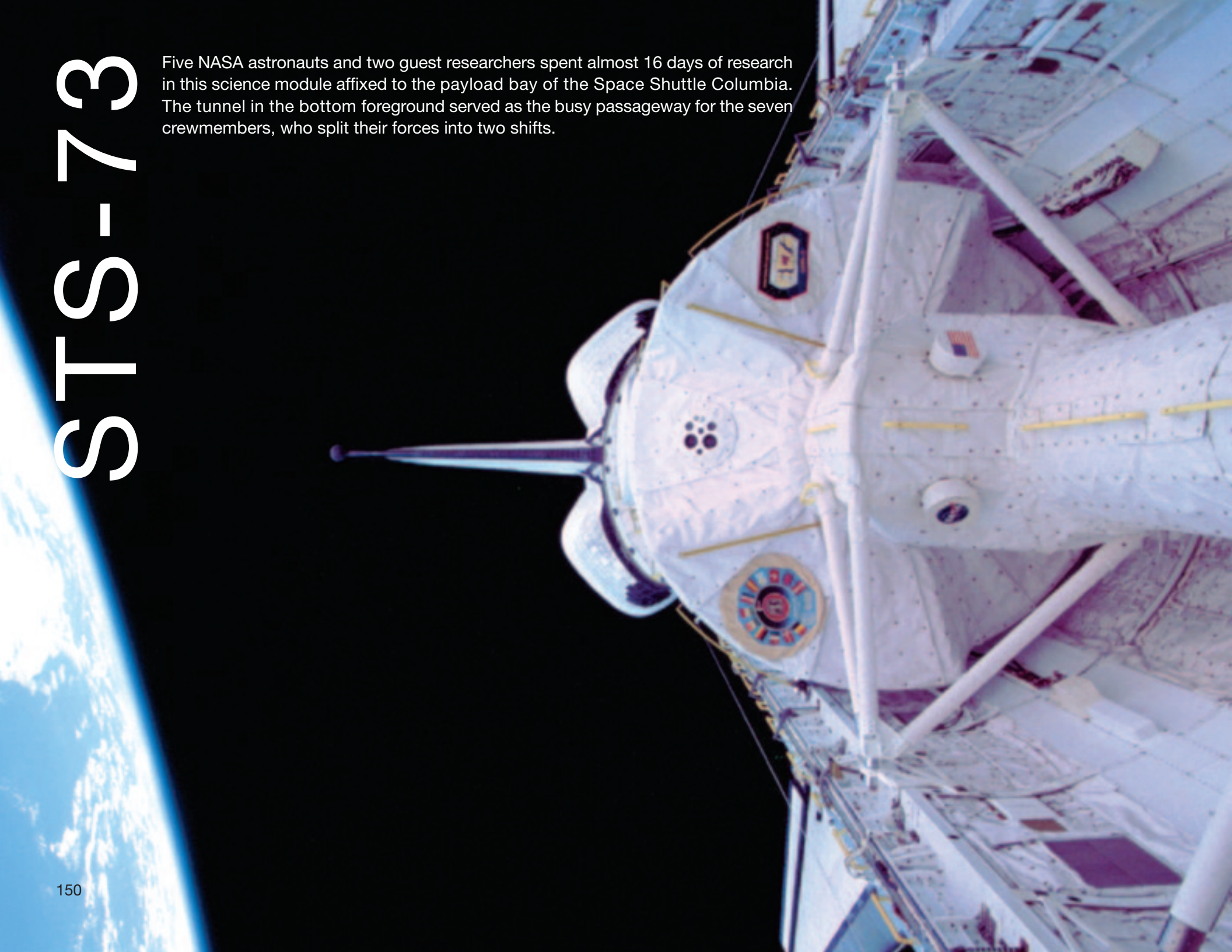
Crew
Commander David M. Walker
Pilot Kenneth D. Cockrell
Mission Specialists James S. Voss,
James H. Newman and Michael L. Gernhardt

STS-69 marked the first time two different payloads were retrieved and deployed during the same mission. The mission also featured an extravehicular activity (EVA) to practice for International Space Station (ISS) activities and to evaluate spacesuit design modifications.

The first of two primary payloads, Spartan 201-03, deployed on flight day 2. This was the third Spartan 201 mission in a planned series of four. The primary objective was to study the outer atmosphere of the Sun and its transition into the solar wind that constantly flows past Earth. The timing of the Spartan 201-03 flight was intended to coincide with the passage of the Ulysses spacecraft over the Sun's north polar region and to expand the range of data collected on the origins of solar wind. The Spartan 201-03 configuration featured two scientific instruments, the Ultraviolet Coronal Spectrometer (UVCS) and the White Light Coronagraph (WLC). The UVCS measured characteristics of light emitted by neutral hydrogen atoms in the solar corona, the outermost portion of the Sun's atmosphere from which the solar wind evolves. The WLC imaged the changing shape and form of the corona.

STS-73

Five NASA astronauts and two guest researchers spent almost 16 days of research in this science module affixed to the payload bay of the Space Shuttle Columbia. The tunnel in the bottom foreground served as the busy passageway for the seven crewmembers, who split their forces into two shifts.



Mission
STS-73, USML-2

Space Shuttle
Columbia

Launched
October 20, 1995, at 9:53:00 a.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
November 5, 1995, at 7:45:21 a.m. EDT on Runway 33 at Kennedy Space Center, FL

Duration
15 days, 21 hours, 52 minutes, and 21 seconds

Distance Traveled
6,600,000 miles

Orbits
255

Crew
Commander Kenneth D. Bowersox
Pilot Kent V. Rominger
Mission Specialists Kathryn C. Thornton, Catherine G. Coleman and Michael E. López-Alegría
Payload Specialists Fred W. Leslie and Albert Sacco, Jr.

STS-73 marked the second flight of the United States Microgravity Laboratory-2 (USML-2), building on the foundation of its predecessor, which flew on Columbia during mission STS-50 in 1992. Research during USML-2 concentrated within the same overall areas of USML-1, with many experiments flying for the second time. The crew divided into two teams to work around the clock in the 23-foot-long Spacelab module located in Columbia's payload bay. Research was conducted in five areas: fluid physics, materials science, biotechnology, combustion science, and commercial space processing. USML-2 activities were directed by NASA's Spacelab Mission Operations Control facility at Marshall Space Flight Center (MSFC) in Huntsville, AL.

There were unprecedented results from the Surface Tension Driven Convection Experiment (STDCE), which detailed basic fluid mechanics and heat transfer of thermocapillary flows, or the motions created within fluids. Oscillations observed on USML-2 samples had never been observed on Earth, and researchers controlling the experiment from the ground were able to pinpoint when fluid flows transitioned from stable to unstable. The research has direct applications on Earth, in that unwanted fluid flows during melting and resolidifying can create defects in high-tech crystals, metals, alloys, and ceramics.

STS-74

The Space Shuttle Atlantis completes its successful docking with Russia's Mir space station, and the STS-74 crewmembers inside Atlantis's cabin make preparations to meet with the Mir 20 crew. During the mission, astronauts used an IMAX camera to document the Space Shuttle Atlantis's rendezvous and docking with the Mir space station.

Mission
STS-74, Second Shuttle-Mir docking

Space Shuttle
Atlantis

Launched
November 12, 1995, at 7:30:43 a.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
November 20, 1995, at 12:01:29 p.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
8 days, 4 hours, 30 minutes, and 44 seconds

Distance Traveled
3,400,000 miles

Orbits
128

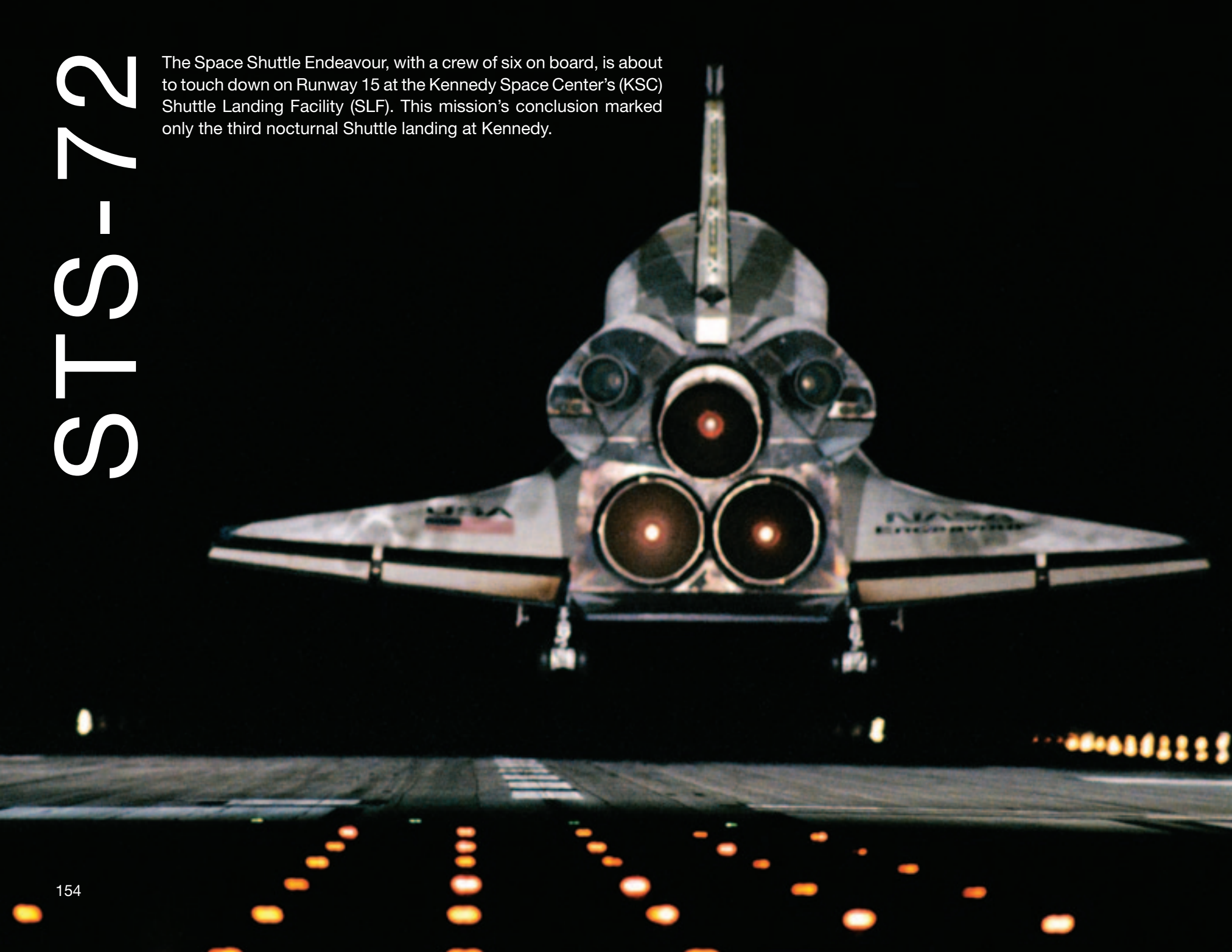
Crew
Commander Kenneth D. Cameron
Pilot James D. Halsell, Jr.
Mission Specialists Jerry L. Ross,
William S. McArthur, Jr., and Chris A. Hadfield

STS-74 marked the second docking of the U.S. Space Shuttle to the Russian space station Mir, continuing Phase I activities that lead to construction of the International Space Station (ISS) later that decade. The mission illustrated the international flavor of the Space Station effort with the fourth Canadian to fly on the Shuttle, Chris A. Hadfield, who was also the first Canadian mission specialist. Hardware in the payload bay included the Canadian-built Remote Manipulator System (RMS) arm, the U.S.-built Orbiter Docking System (ODS), the Russian-built Docking Module (DM) and solar array, and a U.S.-Russian–built solar array. Awaiting Atlantis aboard Mir were two Russian cosmonauts and a German cosmonaut, along with Russian and European Space Agency (ESA) research samples and equipment.

Unlike the first docking flight during which a crew exchange took place, the second docking focused on the delivery of equipment to Mir. The primary payload of the mission was the Russian-built DM, which was designed to become a permanent extension on Mir to afford better clearances for Shuttle-Mir linkups. Two solar arrays were stowed on DM for later transfer to Mir by spacewalking cosmonauts.

STS-72

The Space Shuttle Endeavour, with a crew of six on board, is about to touch down on Runway 15 at the Kennedy Space Center's (KSC) Shuttle Landing Facility (SLF). This mission's conclusion marked only the third nocturnal Shuttle landing at Kennedy.



Mission
STS-72, SFU; Office of Aeronautics and Space Technology-Flyer (OAST-Flyer)

Space Shuttle
Endeavour

Launched
January 11, 1996, at 4:41:00 a.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
January 20, 1996, at 2:41:40 a.m. EST on Runway 15 at Kennedy Space Center, FL

Duration
8 days, 22 hours, 0 minutes, and 40 seconds

Distance Traveled
3,700,000 miles

Orbits
142

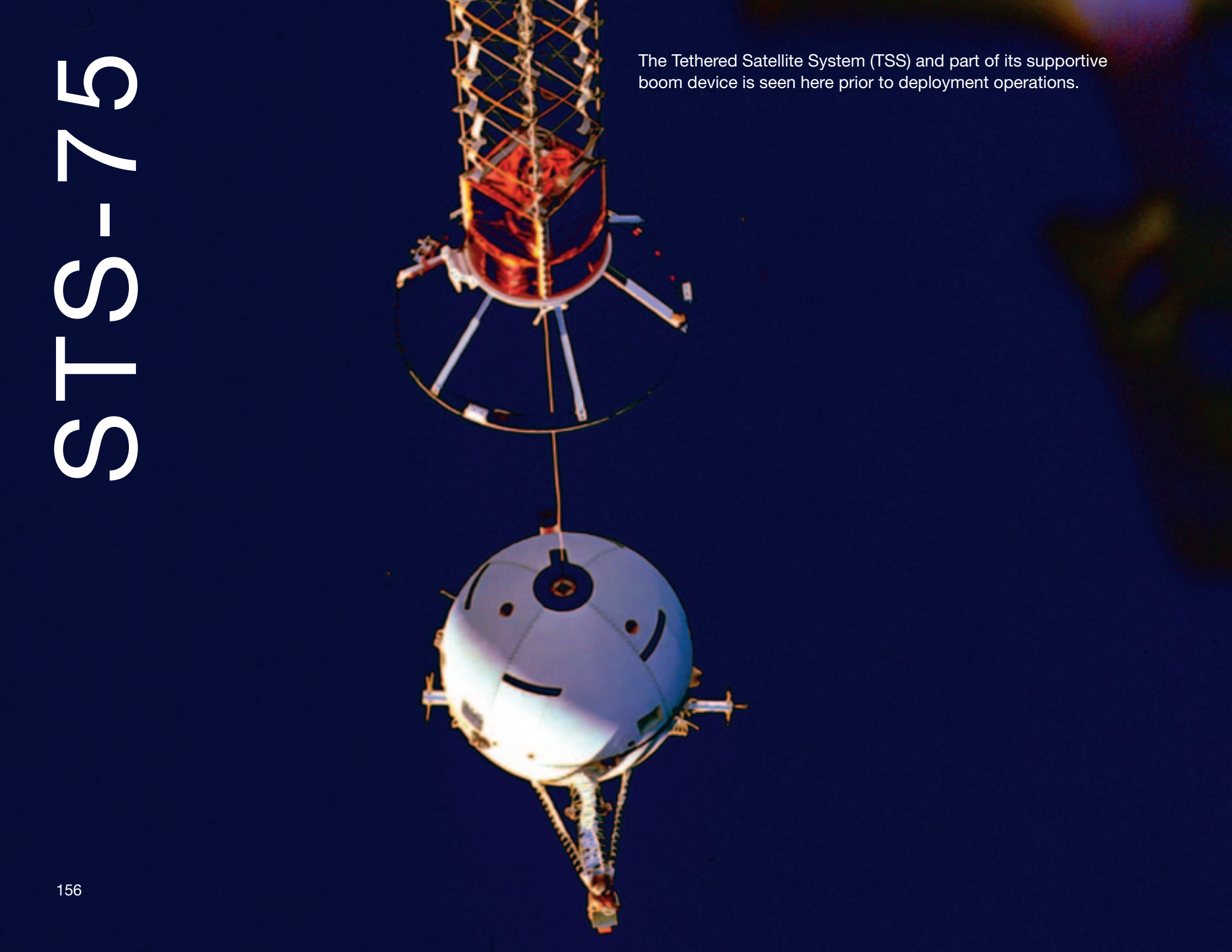
Crew
Commander Brian Duffy
Pilot Brent W. Jett
Mission Specialists Leroy Chiao, Daniel T. Barry, Winston E. Scott, and Koichi Wakata

The first Shuttle flight of 1996 was highlighted by the retrieval of a Japanese satellite, the deployment and retrieval of a NASA science payload, and two spacewalks.

Mission specialist Koichi Wakata operated the Remote Manipulator System (RMS) arm on flight day 3 to pluck the Japanese Space Flyer Unit (SFU) from orbit, completing a 10-month scientific mission involving almost a dozen experiments that ranged from materials science to biological studies. The SFU was launched aboard a Japanese H-2 rocket on March 18, 1995, from Tanegashima Space Center.

The Office of Aeronautics and Space Technology-Flyer (OAST-Flyer), which was released on flight day 4, housed the Spartan platform's four experiments: the Return Flux Experiment (REFLEX), to test the accuracy of computer models predicting spacecraft exposure to contamination; the Global Positioning System (GPS) Attitude Determination and Control Experiment (GADACS), to demonstrate GPS technology in space; the Solar Exposure to Laser Ordnance Device (SELODE), to test laser ordnance devices; and the Spartan Packet Radio Experiment (SPRE), an amateur radio communications experiment.

STS-75



The Tethered Satellite System (TSS) and part of its supportive boom device is seen here prior to deployment operations.

Mission
STS-75, TSS-1R; USMP-3

Space Shuttle
Columbia

Launched
February 22, 1996, at 3:18:00 p.m. EST from
Launch Pad 39B at Kennedy Space Center, FL

Landed
March 9, 1996, at 8:58:20 a.m. EST on
Runway 33 at Kennedy Space Center, FL

Duration
15 days, 17 hours, 40 minutes, and 21 seconds

Distance Traveled
6,500,000 miles

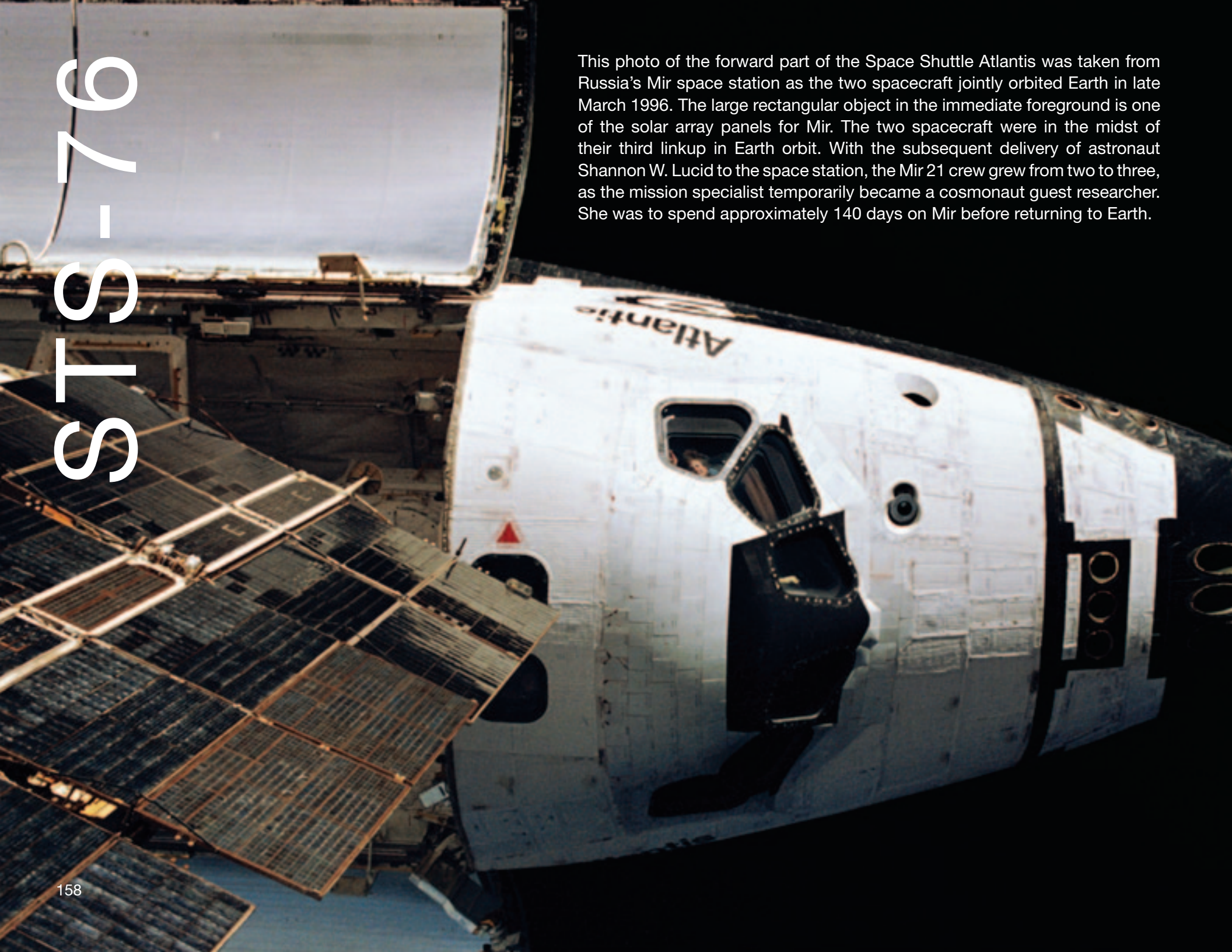
Orbits
251

Crew
Commander Andrew M. Allen
Pilot Scott J. "Doc" Horowitz
Mission Specialists Franklin R. Chang-Díaz,
Maurizio Cheli, Jeffrey A. Hoffman,
Claude Nicollier, and Umberto Guidoni

The reflight of the U.S.-Italian Tethered Satellite System (TSS-1R) was marred by the loss of the satellite on flight day 3, although valuable scientific data was still gathered. The other primary payload, the United States Microgravity Payload-3 (USMP-3), performed nominally. The TSS flew previously on mission STS-46 in June 1992, but experiment operations were curtailed due to a jammed tether.

The TSS concept was designed to study electrodynamics of a tether system in the electrically charged portion of Earth's atmosphere called the ionosphere. The satellite was provided by Italy, and the tether/deployer assembly was U.S.-built. Twelve investigations—six by NASA, five by the Italian Space Agency (ASI), and one by the U.S. Air Force—were planned. Deployment of the TSS-1R on STS-75 was delayed by 1 day to allow for the troubleshooting of onboard TSS computers by the flightcrew. Excellent scientific data was being gathered when the tether snapped on flight day 3, as the satellite was just short of full deployment of about 12.8 miles. The satellite immediately began speeding away from the orbiter as a result of orbital forces, and the crew was never in any danger. The crew retracted the remaining tether the following day.

STS-76



This photo of the forward part of the Space Shuttle Atlantis was taken from Russia's Mir space station as the two spacecraft jointly orbited Earth in late March 1996. The large rectangular object in the immediate foreground is one of the solar array panels for Mir. The two spacecraft were in the midst of their third linkup in Earth orbit. With the subsequent delivery of astronaut Shannon W. Lucid to the space station, the Mir 21 crew grew from two to three, as the mission specialist temporarily became a cosmonaut guest researcher. She was to spend approximately 140 days on Mir before returning to Earth.

Mission
STS-76, Third Shuttle-Mir docking; SPACEHAB

Space Shuttle
Atlantis

Launched
March 22, 1996, at 3:13:04 a.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
March 31, 1996, at 5:28:57 a.m. PST on Runway 22 at Edwards Air Force Base, CA

Duration
9 days, 5 hours, 15 minutes, and 53 seconds

Distance Traveled
3,800,000 miles

Orbits
145

Crew
Commander Kevin P. Chilton
Pilot Richard A. Searfoss
Mission Specialists Shannon W. Lucid, Linda M. Godwin, Michael R. Clifford, and Ronald M. Sega

The third linkup between a U.S. Space Shuttle and the Russian space station Mir was highlighted by the transfer of veteran astronaut Shannon W. Lucid to Mir. Lucid was the first American woman to live on the station. Her approximately 4½-month stay would also eclipse the long-duration U.S. space flight record set by the first American to live on Mir, Norman E. Thagard. Lucid was succeeded by astronaut John E. Blaha during STS-79 in August, giving her the distinction of having membership in four different flightcrews—two U.S. and two Russian. Her stay on Mir kicked off a continuous U.S. presence in space for the next 2 years.

The payload bay configuration included the Orbiter Docking System (ODS) in the forward area and the SPACEHAB single module toward the aft. STS-76 marked the first flight of the SPACEHAB pressurized module to support Shuttle-Mir dockings; the single module primarily served as a stowage area for a large supply of equipment slated for transfer to the space station, but it also carried the European Space Agency's (ESA) Biorack experiment rack for on-orbit research.

STS-77

The Space Shuttle Endeavour lifts off with six astronauts on the morning of May 19, 1996.

Mission
STS-77, SPACEHAB; SPARTAN (IAE)

Space Shuttle
Endeavour

Launched
May 19, 1996, at 6:30:00 a.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
May 29, 1996, at 7:09:20 a.m. EDT on
Runway 33 at Kennedy Space Center, FL

Duration
10 days, 0 hours, 39 minutes, and 20 seconds

Distance Traveled
4,100,000 miles

Orbits
161

Crew
Commander John H. Casper
Pilot Curtis L. Brown, Jr.
Mission Specialists Daniel W. Bursch,
Mario Runco, Jr., Marc Garneau, and
Andrew S.W. Thomas

The fourth Shuttle flight of 1996 was highlighted by four rendezvous activities with two different payloads. The primary payloads, all located in the cargo bay, were the SPACEHAB-4 pressurized research module; the Inflatable Antenna Experiment (IAE) mounted on a Spartan 207 free-flyer; and a suite of four technology demonstration experiments known as Technology Experiments for Advancing Missions in Space (TEAMS).

The SPACEHAB-4 single module carried nearly 3,000 pounds of support equipment and a variety of experiments covering such fields as biotechnology, electronic materials, polymers, and agriculture. The experiments included the Advanced Separation Process for Organic Materials (ADSEP), the Commercial Generic Bioprocessing Apparatus (CGBA), the Plant Generic Bioprocessing Apparatus (PGBA), the Fluids Generic Bioprocessing Apparatus-2 (FGBA-2), the Commercial Protein Crystal Growth (CPCG), the Gas Permeable Polymer Membrane (GPPM), the Handheld Diffusion Test Cell (HHDTC), the Commercial Float Zone Furnace (CFZF), and the Space Experiment Facility (SEF). Also considered part of the SPACEHAB payload but located in middeck lockers were IMMUNE-3 and NIH-C7.

STS-78

The Space Shuttle Columbia touches down on Runway 33 at the Kennedy Space Center (KSC) on the Florida coast.

Mission
STS-78, LMS

Space Shuttle
Columbia

Launched
June 20, 1996, at 10:49:00 a.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
July 7, 1996, at 8:39:36 a.m. EDT on Runway 33 at Kennedy Space Center, FL

Duration
16 days, 21 hours, 47 minutes, and 35 seconds

Distance Traveled
7,046,000 miles

Orbits
272

Crew
Commander Terence T. Henricks
Pilot Kevin R. Kregel
Flight Engineer Susan J. Helms
Mission Specialists Richard M. Linnehan and Charles E. Brady, Jr.
Payload Specialists Jean-Jacques Favier and Robert Brent Thirsk

Five space agencies (NASA, the European Space Agency, the French Space Agency, the Canadian Space Agency, and the Italian Space Agency) and research scientists from 10 countries worked together on the primary payload of STS-78, the Life and Microgravity Spacelab (LMS). More than 40 of the experiments flown were grouped into two areas: life sciences, which included human physiology and space biology, and microgravity science, which included basic fluid physics investigations, advanced semiconductor and metal alloy materials processing, and medical research in protein crystal growth.

The LMS investigations conducted were the most extensive telescience to date. Investigators were located at four remote European and four remote U.S. locations. The mission also made extensive use of video imaging to help crewmembers perform in-flight maintenance procedures on experiment hardware.

STS-79

The Space Shuttle Atlantis arrives at the top of the hardstand at Launch Pad 39A. STS-79 was the fourth United States Space Shuttle and Russian Mir space station docking flight.

Mission
STS-79, Fourth Shuttle-Mir docking

Space Shuttle
Atlantis

Launched
September 16, 1996, at 4:54:49 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
September 26, 1996, at 8:13:13 a.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
10 days, 3 hours, 18 minutes, and 24 seconds

Distance Traveled
3,900,000 miles

Orbits
160

Crew
Commander William F. Readdy
Pilot Terrence W. Wilcutt
Mission Specialists Thomas D. Akers, John E. Blaha, Jerome “Jay” Apt, Carl E. Walz, and Shannon W. Lucid

STS-79 was highlighted by the return to Earth of U.S. astronaut Shannon W. Lucid after 188 days in space, the first U.S. crew exchange aboard the Russian space station Mir, and the fourth Shuttle-Mir docking. Lucid’s long-duration space flight set new U.S. and world records for a woman in space. She embarked to Mir on March 22 with the STS-76 mission. Succeeding her on Mir for an approximately 4-month stay was John E. Blaha, who returned to Earth in January 1997 with the STS-81 crew.

STS-79 also marked the second flight of the SPACEHAB module in support of Shuttle-Mir activities and the first flight of SPACEHAB’s double module configuration. The Shuttle-Mir linkup occurred at 11:13 p.m., September 18, following an R-bar, or Earth radius vector, approach. The hatches opened at 1:40 a.m., September 19, and Blaha and Lucid exchanged places at 7 a.m. Awaiting Blaha on Mir were Valery G. Korzun, Mir 22 commander, and Alexander Y. Kaleri, flight engineer.

STS-80

Backdropped against part of Baja California, the Wake Shield Facility (WSF-3) is about to re-berth into the cargo bay of the Earth-orbiting Space Shuttle Columbia. Columbia's Remote Manipulator System (RMS) was used extensively during operations with the experiment.

Mission
STS-80, ORFEUS-SPAS II; WSF-3

Space Shuttle
Columbia

Launched
November 19, 1996, at 2:55:47 p.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
December 7, 1996, at 6:49:04 a.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
17 days, 15 hours, 53 minutes, and 17 seconds

Distance Traveled
7,043,950 miles

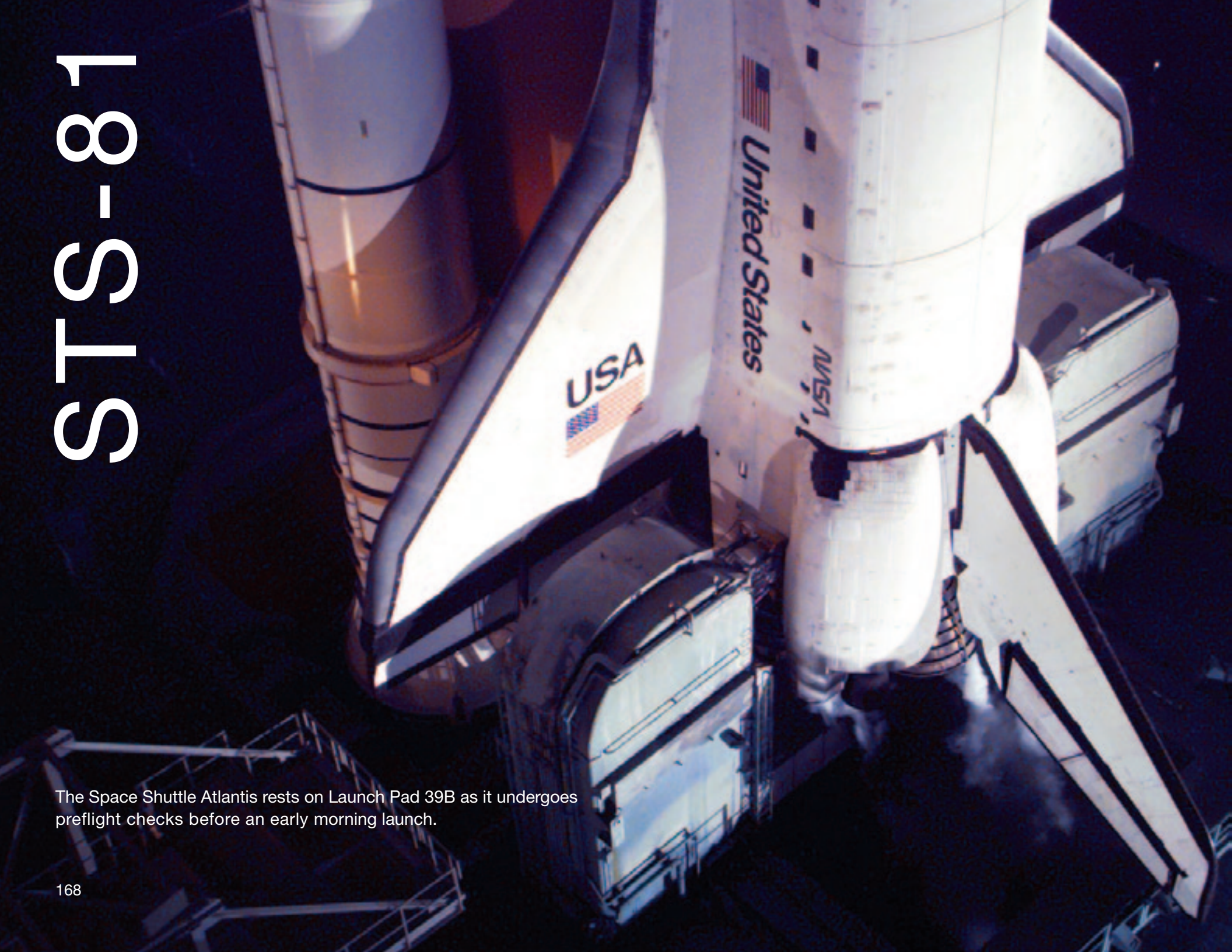
Orbits
279

Crew
Commander Kenneth D. Cockrell
Pilot Kent V. Rominger
Mission Specialists Tamara E. Jernigan, Thomas D. Jones, and F. Story Musgrave

The final Shuttle flight of 1996 was highlighted by the successful deployment, operation, and retrieval of two free-flying research spacecraft. The two planned extravehicular activities (EVAs) were canceled because the crew could not open the outer airlock hatch and, when troubleshooting did not reveal a cause, mission managers concluded it would not be prudent to attempt the two EVAs and risk unnecessary damage to the hatch or seals.

The Orbiting and Retrievable Far and Extreme Ultraviolet Spectrometer-Shuttle Pallet Satellite II (ORFEUS-SPAS II) deployed on flight day 1 to begin approximately 2 weeks of data-gathering. Making its second flight aboard the Shuttle, ORFEUS-SPAS II featured three primary scientific instruments: the ORFEUS-Telescope with the Far Ultraviolet (FUV) Spectrograph and the Extreme Ultraviolet (EUV) Spectrograph. A secondary but highly complementary payload was the Interstellar Medium Absorption Profile Spectrograph (IMAPS). Nonastronomy payloads on ORFEUS-SPAS included the Surface Effects Sample Monitor (SESAM), the ATV Rendezvous Pre-Development Project (ARP), and the Student Experiment on ASTRO-SPAS (SEAS).

STS-81



The Space Shuttle Atlantis rests on Launch Pad 39B as it undergoes preflight checks before an early morning launch.

Mission
STS-81, Fifth Shuttle-Mir docking

Space Shuttle
Atlantis

Launched
January 12, 1997, at 4:27:23 a.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
January 22, 1997, at 9:22:44 a.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
10 days, 4 hours, 55 minutes, and 21 seconds

Distance Traveled
3,900,000 miles

Orbits
160

Crew
Commander Michael A. Baker
Pilot Brent W. Jett, Jr.
Mission Specialists John M. Grunsfeld, Marsha S. Ivins, Peter J.K. Wisoff, Jerry M. Linenger, and John E. Blaha

The first Shuttle flight of 1997 was highlighted by both the return of U.S. astronaut John E. Blaha to Earth after a 118-day stay aboard the Russian space station Mir and the largest transfer to date of logistics between the two spacecraft. Atlantis also returned the first plants to complete a life cycle in space—a crop of wheat grown from seed to seed. This fifth of nine planned dockings continued Phase 1B of the NASA/Russian Space Agency (RSA) cooperative effort, with Jerry M. Linenger becoming the third U.S. astronaut in succession to live on Mir. The same payload configuration flown on the previous docking flight—featuring the SPACEHAB double module—flew again.

Blaha joined the Mir 22 crew of Commander Valeri G. Korzun and flight engineer Aleksandr V. Kaleri on September 19, 1996, when he arrived there with the crew of STS-79. Linenger was to work with the Mir 22 crew until the arrival in February of the Mir 23 crew of Commander Vasili Tsibliev, flight engineer Aleksandr Lazutkin, and German researcher Reinhold Ewald. Ewald was to return to Earth with the Mir 22 cosmonauts after a brief stay on the station. Astronaut C. Michael Foale replaced Linenger on Mir when the STS-84 mission arrived in May 1997.

STS-82

The Hubble Space Telescope (HST), one of the most famous telescopes in history, sits in the payload bay of Discovery for its second servicing.

Mission
STS-82, Second Hubble Space Telescope (HST) Servicing Mission

Space Shuttle
Discovery

Launched
February 11, 1997, at 3:55:17 a.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
February 21, 1997, at 3:32:24 a.m. EST on Runway 15 at Kennedy Space Center, FL

Duration
9 days, 23 hours, 37 minutes, and 7 seconds

Distance Traveled
3,800,000 miles

Orbits
150

Crew
Commander Kenneth D. Bowersox
Pilot Scott J. "Doc" Horowitz
Mission Specialists Mark C. Lee,
Steven A. Hawley, Gregory J. Harbaugh,
Steven L. Smith, and Joseph R. Tanner

STS-82 demonstrated the benefits of human space flight and the Space Shuttle's new capability of servicing orbiting spacecraft. A six-member crew completed the servicing and upgrading of the Hubble Space Telescope (HST) during four planned extravehicular activities (EVAs) and then performed a fifth unscheduled spacewalk to repair insulation on the telescope. The HST first deployed in April 1990 during STS-31. It was designed to undergo periodic servicing and upgrading over its lifespan, with its first servicing performed during STS-61 in December 1993. Steven A. Hawley, who originally deployed the telescope, operated the orbiter's Remote Manipulator System (RMS) arm on STS-82 to retrieve the HST for a second servicing at 3:34 a.m., February 13, 1997, and positioned it in the payload bay less than half an hour later.

Discovery's maneuvering jets fired several times during the mission to reboost the telescope's orbit by 8 nautical miles. Hubble redeployed on February 19 and began operating at its highest altitude ever flown, a 335-by-321-nautical-mile orbit. The Initial checkout of new instruments and equipment during the mission showed that all were performing nominally. The calibration of two new science instruments was to take place over a period of several weeks, with the first images and data anticipated to arrive about 8 to 10 weeks later.

STS-83

The Space Shuttle Columbia nears touchdown at the Kennedy Space Center (KSC) after completing almost 4 days of a scheduled 16-day mission in Earth orbit. A problem with one of the Shuttle's three fuel cells led to an early landing for the seven-member crew. The giant Vehicle Assembly Building (VAB) can be seen in the right background. Several hundred feet above the VAB, the Shuttle Training Aircraft (STA) can be seen in flight, having been assigned to monitor Columbia's landing.

Mission
STS-83, MSL-1

Space Shuttle
Columbia

Launched
April 4, 1997, at 2:20:32 p.m. EST from
Launch Pad 39A at Kennedy Space Center, FL

Landed
April 8, 1997, at 2:33:11 p.m. EDT on
Runway 33 at Kennedy Space Center, FL

Duration
3 days, 23 hours, 12 minutes, and 39 seconds

Distance Traveled
1,500,000 miles

Orbits
63

Crew
Commander James D. Halsell
Pilot Susan L. Still
Mission Specialists Janice E. Voss,
Donald A. Thomas, and Michael L. Gernhardt
Payload Specialists Roger K. Crouch and
Gregory T. Linteris

The first flight of the Microgravity Science Laboratory-1 (MSL-1) was cut short due to concerns about one of the Shuttle's three fuel cells, marking only the third time in Shuttle program history that a mission ended early. (STS-2, in 1981, and STS-44, in 1991, were the other missions to end prematurely). Fuel cell No. 2 had shown some erratic readings during prelaunch startup, but the Shuttle was cleared to fly after additional checkout and testing. Shortly after on-orbit operations began, the fuel cell No. 2 substack No. 3 differential voltage began trending upward. There are three fuel cells on each orbiter, each containing three substacks made up of two banks of 16 cells. In one substack of fuel cell No. 2, the difference in output voltage between the two banks of cells was increasing. The fuel cells used a reaction of liquid hydrogen and liquid oxygen to generate electricity and produce drinking water. Although one fuel cell produced enough electricity to conduct on-orbit and landing operations, Shuttle flight rules required that all three fuel cells function well enough to ensure the crew's safety and to provide sufficient backup capability during reentry and landing.

A decision to refly the mission in its entirety was made by the mission management team in the days following Columbia's return. The reflight was first designated STS-83R and then renamed STS-94.

STS-84

A panoramic view shows the Space Shuttle Atlantis illuminating the early morning sky at Kennedy Space Center (KSC) at 4:07 a.m. on May 15, 1997.

Mission
STS-84, Sixth Shuttle-Mir docking

Space Shuttle
Atlantis

Launched
May 15, 1997, at 4:07:48 a.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
May 24, 1997, at 9:27:43 a.m. EDT on
Runway 33 at Kennedy Space Center, FL

Duration
9 days, 5 hours, 19 minutes, and 55 seconds

Distance Traveled
3,600,000 miles

Orbits
144

Crew
Commander Charles J. Precourt
Pilot Eileen M. Collins
Mission Specialists C. Michael Foale,
Carlos I. Noriega, Edward T. Lu,
Jean-François Clervoy, Elena V. Kondakova,
and Jerry M. Linenger

The sixth Shuttle-Mir docking was highlighted by the transfer of the fourth successive U.S. crewmember to the Russian space station. U.S. astronaut C. Michael Foale exchanged places with Jerry M. Linenger, who arrived on Mir on January 15, 1997, as part of the STS-81 crew. Linenger spent 123 days on Mir and just over 132 days in space from launch to landing, placing him, at the time, second behind U.S. astronaut Shannon W. Lucid for most time spent on orbit by an American. Another milestone reached during his stay was the 1-year anniversary of having a continuous U.S. presence in space, which began with Lucid's arrival on Mir on March 22, 1996.

Another significant event that occurred during Linenger's stay included the first U.S.-Russian spacewalk. On April 29, Linenger participated in a 5-hour extravehicular activity (EVA) with Mir 23 Commander Vasily Tsibliev to attach a monitor to the outside of the station. The Optical Properties Monitor (OPM) was to remain on Mir for 9 months to study the effect of the space environment on optical properties, such as mirrors used in telescopes. On February 23, a fire broke out on the 11-year-old station. It caused minimal damage but required the station's inhabitants to wear protective masks for about 36 hours until the cabin air was cleaned.

STS-94

With its drag chute deployed, the Space Shuttle Columbia lands on Runway 33 at the Kennedy Space Center's (KSC) Shuttle Landing Facility (SLF) in Florida.

Mission
STS-94, MSL-1 reflight

Space Shuttle
Columbia

Launched
July 1, 1997, at 2:02:00 p.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
July 17, 1997, at 6:46:33 a.m. EDT on
Runway 33 at Kennedy Space Center, FL

Duration
15 days, 16 hours, 44 minutes, and 33 seconds

Distance Traveled
6,200,000 miles

Orbits
251

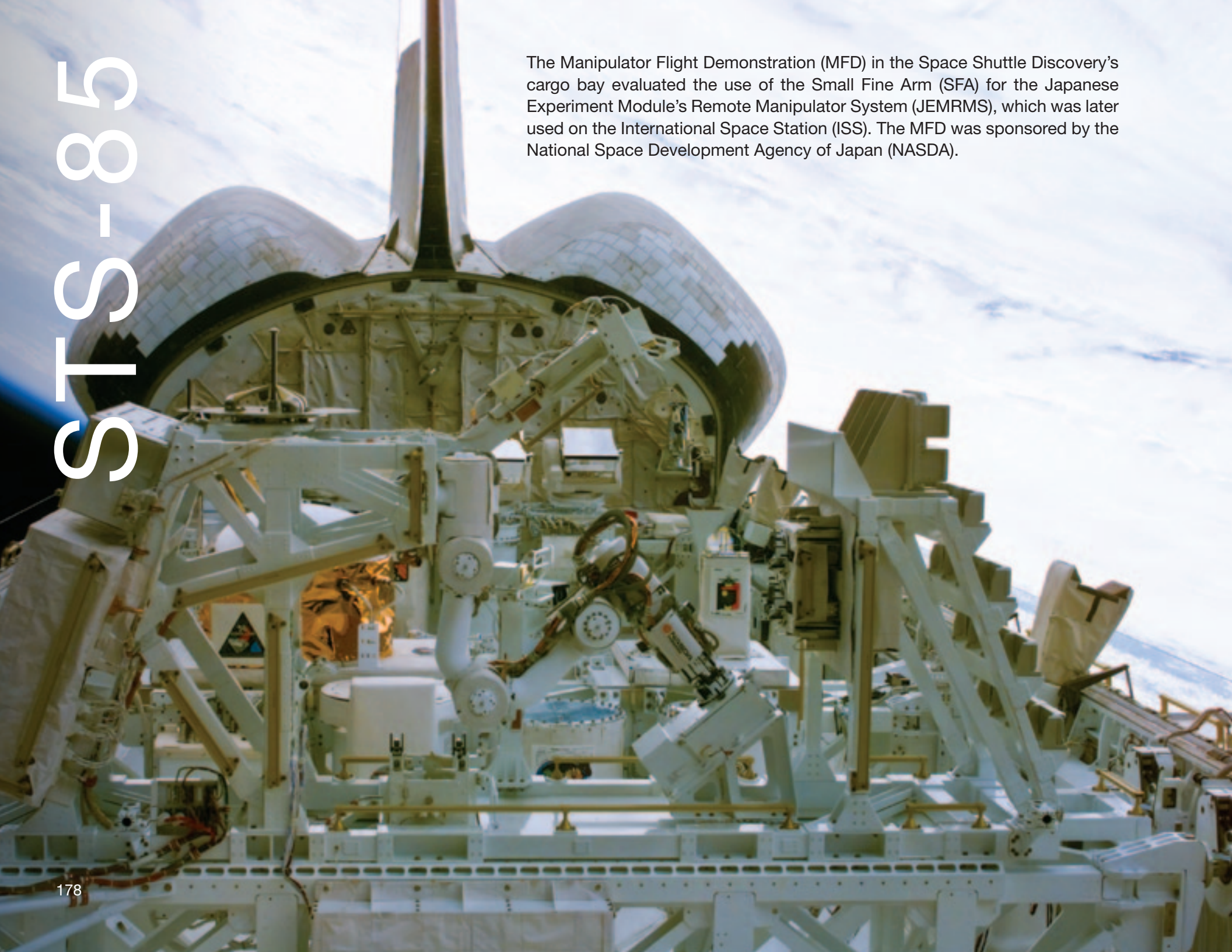
Crew
Commander James D. Halsell
Pilot Susan L. Still
Mission Specialists Janice E. Voss,
Donald A. Thomas, and Michael L. Gernhardt
Payload Specialists Roger K. Crouch and
Gregory T. Linteris

STS-94 marked the reflight of mission STS-83, which was shortened due a fuel cell malfunction. This was the first time that the same crew, vehicle, and payload configuration were reflown in space. The primary payload was the Microgravity Science Laboratory-1 (MSL-1). The quick turnaround in processing Columbia for reflight was accomplished in part by completing the first reservicing of MSL-1 in the orbiter. The crew maintained 24-hour/two-shift operations.

Using the Spacelab module as a test bed, MSL-1 tested some of the hardware, facilities, and procedures for future use on the International Space Station (ISS). The 33 investigations conducted also yielded new knowledge in the principal scientific fields of combustion, biotechnology, and materials processing.

The 25 primary experiments, four glovebox investigations, and four accelerometer studies on MSL-1 were contributed by scientists from NASA, the European Space Agency (ESA), the German Space Agency (DARA), and the National Space Development Agency of Japan (NASDA). A record number of commands—more than 35,000—were sent from the Spacelab Mission Operations Control Center at the Marshall Space Flight Center directly to the MSL-1 experiments.

STS-85



The Manipulator Flight Demonstration (MFD) in the Space Shuttle Discovery's cargo bay evaluated the use of the Small Fine Arm (SFA) for the Japanese Experiment Module's Remote Manipulator System (JEMRMS), which was later used on the International Space Station (ISS). The MFD was sponsored by the National Space Development Agency of Japan (NASDA).

Mission
STS-85, CRISTA-SPAS-02

Space Shuttle
Discovery

Launched
August 7, 1997, at 10:41:00 a.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
August 19, 1997, at 7:07:58 a.m. EDT on
Runway 33 at Kennedy Space Center, FL

Duration
11 days, 20 hours, 26 minutes, and 58 seconds

Distance Traveled
4,725,000 miles

Orbits
185

Crew
Commander Curtis L. Brown, Jr.
Pilot Kent V. Rominger
Mission Specialists N. Jan Davis,
Robert L. Curbeam, Jr., and
Stephen K. Robinson
Payload Specialist Bjarni V. Tryggvason

STS-85 carried payload that focused on the Mission to Planet Earth (MTPE) objectives as well as the International Space Station (ISS) assembly preparations. The payload included the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere-Shuttle Pallet Satellite-2 (CRISTA-SPAS-02), the Japanese Manipulator Flight Development (MFD), the Technology Applications and Science-01 (TAS-1), and the International Extreme Ultraviolet Hitchhiker-02 (IEH-02).

This was the second flight of the CRISTA-SPAS payload. CRISTA-SPAS-02 also represented the fourth mission in a cooperative venture between the German Space Agency (DARA) and NASA. The payload included three telescopes and four spectrometers, deployed on flight day 1, to gather data about Earth's middle atmosphere. After more than 200 hours of free flight, CRISTA-SPAS was retrieved on August 16, 1997. The three CRISTA telescopes collected 38 full atmospheric profiles of the middle atmosphere. A total of 22 sounding rockets and 40 balloons were launched to provide correlating data. Once science operations were complete, CRISTA-SPAS was used in a simulation exercise to prepare for the first ISS assembly flight, STS-88, with the payload being manipulated as if it were the Functional Cargo Block (FGB) that would be attached to the ISS Node 1.

STS-86

The helmet visor of astronaut Scott F. Parazynski reflects the Space Shuttle Atlantis's cargo bay, Russia's Mir space station, and Earth's horizon. Astronauts Parazynski and Vladimar G. Titov, both STS-86 mission specialists, spent several hours retrieving Mir Environmental Effects Packages (MEEP), which had been exposed to the space environment around Mir's permanent Docking Module (DM) since September of 1996. Titov represented the Russian Space Agency (RSA).

Mission
STS-86, Seventh Shuttle-Mir docking

Space Shuttle
Atlantis

Launched
September 25, 1997, at 10:34:19 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
October 6, 1997, at 5:55:10 p.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
10 days, 19 hours, 20 minutes, and 51 seconds

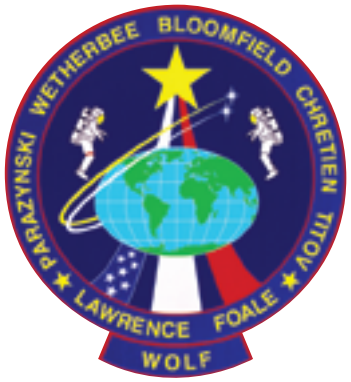
Distance Traveled
4,225,000 miles

Orbits
170

Crew
Commander James D. Wetherbee
Pilot Michael J. Bloomfield
Mission Specialists Vladimar G. Titov, Scott E. Parazynski, Jean-Loup J.M. Chrétien, Wendy B. Lawrence, David A. Wolf, and C. Michael Foale

The seventh Mir docking mission continued the presence of a U.S. astronaut on the Russian space station with the transfer of physician David A. Wolf to Mir. Wolf became the sixth U.S. astronaut in succession to live on Mir to continue Phase 1B of the NASA/Russian Space Agency (RSA) cooperative effort.

Astronaut C. Michael Foale returned to Earth after spending 145 days in space—134 of them aboard Mir. His estimated mileage logged was 58 million miles, making his excursion the second longest U.S. space flight, at the time, behind Shannon W. Lucid's record of 188 days. During his stay, a collision on June 25, 1997, between a Progress resupply vehicle and the station's Spektr module damaged a radiator and a solar array on Spektr. The mishap occurred while Mir 23 Commander Vasily Tsibliev was guiding the Progress capsule to a manual docking. It caused the Spektr module to depressurize. The crew sealed the hatch to the leaking Spektr module, leaving Foale's personal effects and several NASA science experiments inside, and repressurized the remaining modules.



STS-87

This view shows the Autonomous Extravehicular Activity Robotic Camera Sprint (AERCam Sprint) in the cargo bay of the Earth-orbiting Space Shuttle Columbia. The AERCam Sprint is a prototype free-flying television camera that could be used for remote inspections of the exterior of the International Space Station (ISS).

Mission
STS-87, USMP-4; Spartan 201-04

Space Shuttle
Columbia

Launched
November 19, 1997, at 2:46:00 p.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
December 5, 1997, at 7:20:04 a.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
15 days, 16 hours, 34 minutes, and 4 seconds

Distance Traveled
6,544,000 miles

Orbits
252

Crew
Commander Kevin R. Kregel
Pilot Steven W. Lindsey
Mission Specialists Winston E. Scott, Kalpana Chawla, Takao Doi, and Leonid K. Kadenyuk

The primary payload of STS-87, the United States Microgravity Payload-4 (USMP-4), performed well. Research using the other major payload, the SPARTAN 201-04 free-flyer, was not completed. SPARTAN deployment was delayed 1 day to November 21, 1997, to allow time for a companion spacecraft, the Solar and Heliospheric Observatory (SOHO), which was already on orbit, to come back online. Kalpana Chawla used the orbiter's mechanical arm to release SPARTAN at 4:04 p.m. The spacecraft failed to execute a pirouette maneuver several minutes later, suggesting that there was a problem with the attitude control system for fine pointing toward solar targets. Chawla then regrappled the SPARTAN but did not receive a firm capture indication. When she backed the arm away once more, a rotational spin of about 2 degrees per second was apparently imparted to the satellite.

After a plan was formulated to retrieve the free-flyer, Winston E. Scott and Takao Doi began a 7-hour, 43-minute spacewalk on November 24 and captured the SPARTAN by hand at 9:09 p.m. The two astronauts then completed a series of activities that continued preparations for on-orbit assembly of the International Space Station (ISS). Doi became the first Japanese citizen to walk in space.

STS-89

The Space Shuttle Endeavour heads toward its Earth-orbital destination to the Russian Mir space station. STS-89 represents the eighth docking mission with Mir (all previous such flights utilized the Atlantis). After docking with Mir, Andrew S.W. Thomas, mission specialist, transferred to the station, succeeding astronaut David A. Wolf as guest cosmonaut researcher. Wolf returned to Earth aboard Endeavour. Thomas would live and work on Mir until June 1998.

Mission
STS-89, Eighth Shuttle-Mir docking

Space Shuttle
Endeavour

Launched
January 22, 1998, at 9:48:15 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
January 31, 1998, at 5:35:09 p.m. EST on Runway 15 at Kennedy Space Center, FL

Duration
8 days, 19 hours, 46 minutes, and 54 seconds

Distance Traveled
3,610,000 miles

Orbits
139

Crew
Commander Terrence W. Wilcutt
Pilot Joe F. Edwards, Jr.
Mission Specialists Bonnie J. Dunbar, Michael P. Anderson, James F. Reilly, Salizhan Shakirovich Sharipov, Andrew S.W. Thomas, and David A. Wolf

Endeavour returned to space after completing its first Orbiter Maintenance Down Period (OMDP), becoming the first orbiter other than Atlantis to dock with Mir. On May 22, 1997, mission managers announced Endeavour would fly STS-89 instead of Discovery. The launch, which was originally targeted for January 15, 1998, changed first to no earlier than January 20 and then to January 22, per a request from the Russian space program to allow for completion of activities on Mir. This was the first launch overseen by one of two new rotational Launch Directors, Dave King, and following the retirement of veteran Launch Director James F. Harrington III.

The docking of Space Shuttle Endeavour to Mir occurred on January 24, at an altitude of 214 nautical miles. The transfer of Andrew S.W. Thomas to Mir and the return of David A. Wolf to the U.S. orbiter occurred at 6:35 p.m., January 25. Initially, Thomas thought that his Sokol pressure suit did not fit, and the crew exchange was allowed to proceed only after Wolf's suit was adjusted to fit Thomas. Once on Mir, Thomas was able to make adequate adjustments to his own suit (which would be worn should the crew need to return to Earth in the Soyuz capsule), and this suit remained on Mir with him. Wolf spent a total of 119 days aboard Mir, and upon landing his total on-orbit time was 128 days.

STS-90

The Space Shuttle Columbia is seen backdropped against Earth during the final internationally partnered Spacelab mission.

Mission
STS-90, Final Spacelab mission

Space Shuttle
Columbia

Launched
April 17, 1998, at 2:19:00 p.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
May 3, 1998, at 12:08:59 p.m. EDT on
Runway 33 at Kennedy Space Center, FL

Duration
15 days, 21 hours, 49 minutes, and 59 seconds

Distance Traveled
6,375,000 miles

Orbits
256

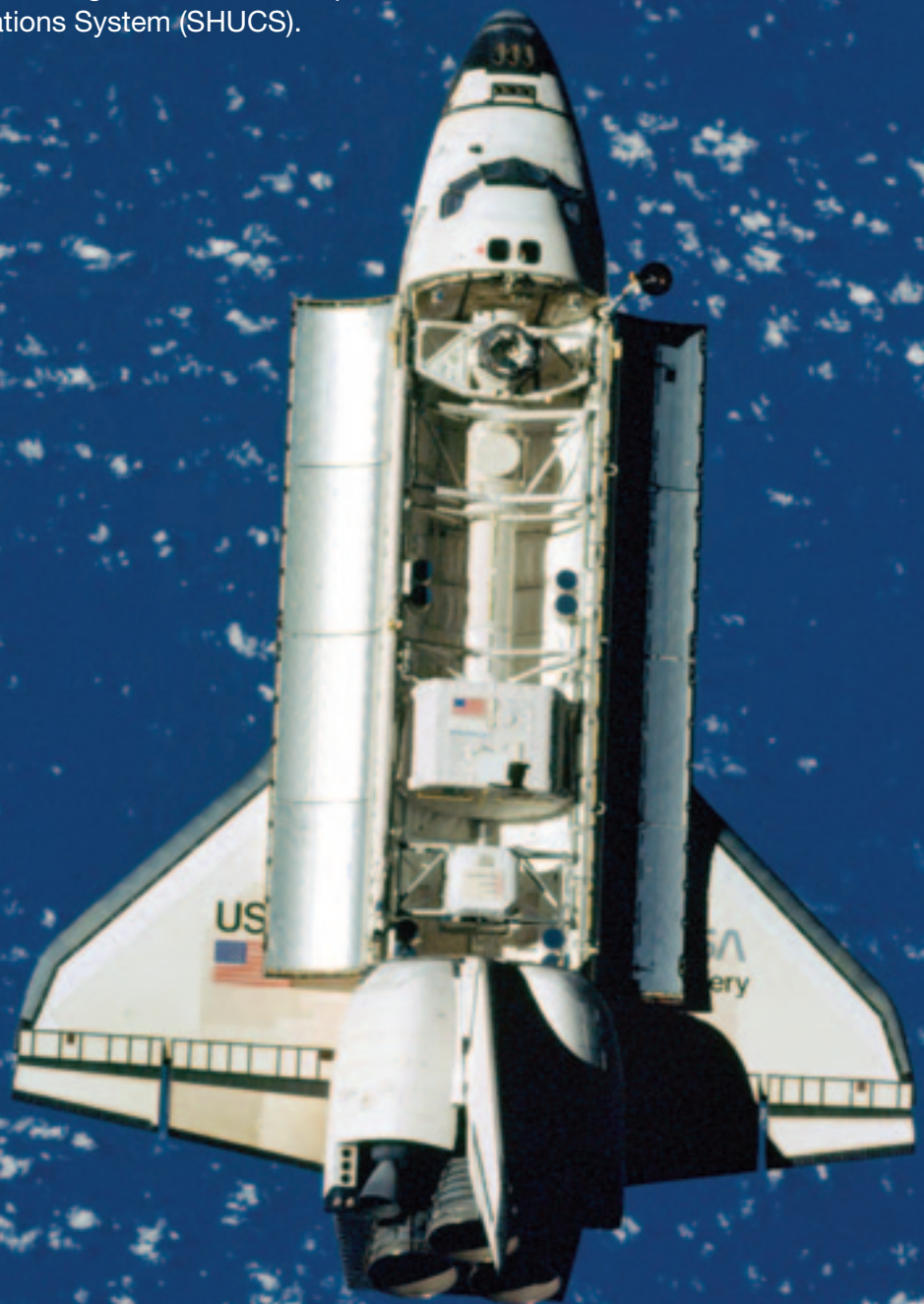
Crew
Commander Richard A. Searfoss
Pilot Scott D. Altman
Mission Specialists Richard M. Linnehan,
Dafydd Rhys Williams, and Kathryn P. Hire
Payload Specialists Dr. Jay C. Buckey, Jr., and
Dr. James A. Pawelczyk

Neurolab is a Spacelab module mission focusing on the effects of microgravity on the nervous system. Neurolab's 26 experiments targeted one of the most complex and least understood parts of the human body—the nervous system. The primary goals of these experiments were to conduct basic research in neurosciences and to expand our understanding of how the nervous system develops and functions in space. Test subjects were crewmembers, rats, mice, crickets, snails, and two kinds of fish. This was a cooperative effort of NASA, several domestic partners, and the space agencies of Canada (CSA), France (CNES) and Germany (DARA), as well as the European Space Agency (ESA) and the National Space Development Agency of Japan (NASDA). Most experiments were conducted in the pressurized Spacelab long module located in Columbia's payload bay. This was the 16th and last scheduled flight of the ESA-developed Spacelab module, although the Spacelab pallets were continued to be used on the International Space Station (ISS).

Other payloads on STS-90 included the Shuttle Vibration Forces (SVF) experiment, the Bioreactor Demonstration System-04, and three Get-Away Special (GAS) canister investigations.

STS-91

The Space Shuttle Discovery approaches Russia's Mir space station in this photograph taken from Mir. The nadir perspective affords a clear look at the layout of the cargo bay, revealing the open bay doors, the docking apparatus for connecting to Mir (near cabin), the tunnel, the SPACEHAB module (second element from aft), the Alpha Magnetic Spectrometer (near the aft firewall), and the Ku-band antenna for communications (near cabin). Affixed to the lower right corner of the top of SPACEHAB is the external antenna for the SPACEHAB Universal Communications System (SHUCS).



Mission
STS-91, Ninth and final Shuttle-Mir docking

Space Shuttle
Discovery

Launched
June 2, 1998, at 6:06:24 p.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
June 12 1998, at 2:00:17 p.m. EDT on
Runway 15 at Kennedy Space Center, FL

Duration
9 days, 19 hours, 53 minutes, and 53 seconds

Distance Traveled
3,800,000 miles

Orbits
155

Crew
Commander Charles J. Precourt
Pilot Dominic L. Pudwill Gorie
Mission Specialists Wendy B. Lawrence,
Franklin R. Chang-Díaz, Janet L. Kavandi,
Valery Victorovitch Ryumin, and
Andrew S.W. Thomas

The docking of Discovery to Mir, the first for that orbiter, occurred at 12:58 p.m., June 4, 1998, at an altitude of 208 miles. The hatches opened at 2:34 p.m. the same day. At hatch opening, Andrew S.W. Thomas officially became a member of Discovery's crew, completing 130 days of living and working on Mir. The transfer wrapped up a total of 907 days spent by seven U.S. astronauts aboard the Russian space station as long-duration crewmembers. During the next 4 days, the Mir 25 and STS-91 crews transferred more than 1,100 pounds of water and almost 4,700 pounds of cargo experiments and supplies between the two spacecraft. During this time, long-term U.S. experiments aboard Mir were moved into Discovery's middeck locker area and the SPACEHAB single module was moved into the orbiter's payload bay.

The crews also conducted Risk Mitigation Experiments (RMEs) and Human Life Sciences (HLS) investigations. When the hatches closed for undocking at 9:07 a.m., June 8, and the spacecraft separated at 12:01 p.m. that day, the final Shuttle-Mir docking mission was concluded and Phase 1 of the International Space Station (ISS) program came to an end.

STS-95

Backdropped against the blackness of space and Earth's horizon, Spartan 201-05 leaves the cargo bay of the Space Shuttle Discovery. The satellite would remain a free-flyer for several days while it recorded data on the solar wind and the Sun's corona. These data helped increase knowledge of the Sun's effect on our planet.

Mission
STS-95, John Glenn's flight; SPACEHAB

Space Shuttle
Discovery

Launched
October 29, 1998, at 2:19:34 p.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
November 7, 1998, at 12:03:30 p.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
8 days, 21 hours, 43 minutes, and 56 seconds

Distance Traveled
3,644,459 miles

Orbits
134

Crew
Commander Curtis L. Brown, Jr.
Pilot Steven W. Lindsey
Mission Specialists Scott E. Parazynski, Stephen K. Robinson, and Pedro F. Duque
Payload Specialists Chiaki Mukai and U.S. Senator John H. Glenn

The primary objectives of STS-95 included conducting a variety of science experiments in the pressurized SPACEHAB module, deploying and retrieving the Spartan free-flyer payload, and performing operations with the Hubble Space Telescope (HST) Orbiting Systems Test (HOST) and the International Extreme Ultraviolet Hitchhiker payloads. The scientific research mission also returned space pioneer and U.S. Senator John H. Glenn to orbit—36 years, 8 months, and 9 days after he became the first American to orbit Earth.

A slate of more than 80 experiments filled the mission's nearly 9 days in space. In addition to a variety of medical and material research, the crew released the Petite Amateur Naval Satellite, or PANSAT, to test innovative technologies that capture and transmit weak or interference-laden radio signals. The crew also released the Spartan free-flying satellite to study the Sun and the solar wind in an effort to help scientists better understand a phenomenon that sometimes can cause widespread disruptions of communications and power supplies on Earth.

STS-88

Astronaut Jerry L. Ross, STS-88 mission specialist, is pictured during one of three spacewalks that were conducted on the 11-day mission. Perched on the end of Endeavour's Remote Manipulator System (RMS) arm, James H. Newman, mission specialist, recorded this image. Newman can be seen reflected in Ross's helmet visor. The solar array panel for the Russian-built Zarya module can be seen along the right edge.

Mission
STS-88, First International Space Station (ISS) flight

Space Shuttle
Endeavour

Launched
December 4, 1998, at 3:35:34 a.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
December 15, 1998, at 10:53:30 p.m. EST on Runway 15 at Kennedy Space Center, FL

Duration
11 days, 19 hours, 17 minutes, and 56 seconds

Distance Traveled
4,650,000 miles

Orbits
186

Crew
Commander Robert D. Cabana
Pilot Frederick W. Sturckow
Mission Specialists Nancy J. Currie, Jerry L. Ross, James H. Newman, and Sergei K. Krikalev

All of the objectives were met during the 12-day mission to begin assembly of the International Space Station (ISS). On December 5, 1998, the 12.8-ton Unity connecting module was first connected to Endeavour's docking system. On December 6, using the 50-foot-long robot arm, the Zarya control module was captured from orbit and mated to Unity. Astronauts Jerry L. Ross and James H. Newman conducted three spacewalks to attach cables, connectors, and handrails. The two modules were powered up after the astronauts entered.

Other extravehicular activity (EVA) objectives were met as Ross and Newman tested a Simplified Aid for EVA Rescue (SAFER) unit, a self-rescue device should a spacewalker become separated from the spacecraft during an EVA. They also nudged two undeployed antennas on Zarya into position, removed launch restraint pins on Unity's four hatchways for mating future additions of Station modules and truss structures, installed a sunshade over Unity's two data relay boxes to protect them against harsh sunlight, stowed a tool bag on Unity and disconnected umbilicals used for the mating procedure with Zarya, installed a handrail on Zarya, and made a detailed photographic survey of the Station.

STS-96

This view shows the Space Shuttle Discovery as it lifts off from Launch Pad 39B at 6:49 a.m. on May 27, 1999.

Mission
STS-96, Second International Space Station (ISS) flight

Space Shuttle
Discovery

Launched
May 27, 1999, at 6:49:42 a.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
June 6, 1999, at 2:02:43 a.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
9 days, 19 hours, 13 minutes, and 1 second

Distance Traveled
4,051,000 miles

Orbits
154

Crew
Commander Kent V. Rominger
Pilot Rick D. Husband
Mission Specialists Ellen L. Ochoa, Tamara E. Jernigan, Daniel T. Barry, Julie Payette, and Valery Ivanovich Tokarev

All major objectives were accomplished during the STS-96 mission. On May 29, 1999, Discovery made the first docking to the International Space Station (ISS). Kent V. Rominger eased the Shuttle to a textbook linkup with Unity's Pressurized Mating Adapter-2 (PMA-2) as the orbiter and the ISS flew over the Russian-Kazakh border.

The 45th spacewalk in Space Shuttle history and the fourth of the ISS era lasted 7 hours and 55 minutes, making it the second-longest ever conducted at the time. Tamara E. Jernigan and Daniel T. Barry transferred a U.S.-built crane, called the Orbital Transfer Device, and parts of the Russian crane Strela from the Shuttle's payload bay and attached them to locations on the outside of the Station. The astronauts also installed two new portable foot restraints that would fit both American and Russian space boots, and they attached three bags filled with tools and handrails that would be used during future assembly operations. The cranes and tools fastened to the outside of the Station totaled 662 pounds. Once those primary tasks were accomplished, Jernigan and Barry installed an insulating cover on a trunnion pin on the Unity module, documented painted surfaces on both the Unity and Zarya modules, and inspected one of two Early Communications System (E-Com) antennas on Unity.

STS-93

This photo shows the Chandra X-ray Observatory, backdropped against a desert area in Namibia, just prior to its release from Columbia's payload bay. The primary duty of the STS-93 crew was to deploy the world's most powerful x-ray telescope. It was also one of the first actions taken by the astronauts, occurring just a few hours following the Shuttle's arrival in Earth orbit.

Mission
STS-93, Chandra X-ray Observatory

Space Shuttle
Columbia

Launched
July 23, 1999, at 12:31:00 a.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
July 27, 1999, at 11:20:35 p.m. EDT on
Runway 33 at Kennedy Space Center, FL

Duration
4 days, 22 hours, 49 minutes, and 35 seconds

Distance Traveled
1,796,000 miles

Orbits
80

Crew
Commander Eileen M. Collins
Pilot Jeffrey S. Ashby
Mission Specialists Steven A. Hawley,
Catherine G. Coleman, and Michel A.C. Tognini

STS-93 was the first mission in Space Shuttle history to be commanded by a woman, Eileen M. Collins. This was also the shortest scheduled mission since 1990.

On the first day of the 5-day mission, the Chandra X-ray Observatory was deployed from Columbia's payload bay. Chandra's two-stage Inertial Upper Stage (IUS) booster propelled the observatory into a transfer orbit of 205 miles by 44,759 miles in altitude. Following the second IUS burn, Chandra's solar arrays were deployed and the IUS separated from the observatory as planned.

During the rest of the mission, secondary payloads and experiments were activated including the Southwest Ultraviolet Imaging System (SWUIS), which was used aboard Columbia to capture ultraviolet imagery of Earth, the Moon, Mercury, Venus, and Jupiter.

STS-103

Astronauts C. Michael Foale, left, and Claude Nicollier install a Fine Guidance Sensor (FGS) into a protective enclosure in the Shuttle's payload bay. Foale and Nicollier performed the second of three spacewalks to service the Hubble Space Telescope (HST) during the STS-103 mission.

Mission
STS-103, Third Hubble Space Telescope (HST) Servicing Mission

Space Shuttle
Discovery

Launched
December 19, 1999, at 7:50:00 p.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
December 27, 1999, at 7:00:47 p.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
7 days, 23 hours, 10 minutes, 47 seconds

Distance Traveled
3,267,360 miles

Orbits
119

Crew
Commander Curtis L. Brown, Jr.
Pilot Scott J. Kelly
Mission Specialists Steven L. Smith, C. Michael Foale, John M. Grunsfeld, Claude Nicollier, and Jean-François Clervoy

STS-103 restored the Hubble Space Telescope (HST) to working order and upgraded some of its systems, readying the decade-old observatory for its second scheduled decade of astronomical observations.

The first few days of the 8-day mission, the crew prepared for the rendezvous and capture of the HST and the three maintenance spacewalks to follow. After a 30-orbit chase, Commander Curtis L. Brown, Jr. and pilot Scott J. Kelly maneuvered the orbiter to a point directly beneath Hubble, then moved upward toward it. Mission specialist Jean-François Clervoy grappled Hubble using the orbiter's robotic arm and placed it on the Flight Support System in the rear of Discovery's cargo bay.

Hubble was released from Discovery's cargo bay on Christmas Day. Mission STS-103 was the third time in the history of the U.S. space program that a crew had spent Christmas in space.

STS-99

The Space Shuttle Endeavour orbits Earth with part of the Shuttle Radar Topography Mission (SRTM) payload silhouetted in the cargo bay. The airglow effect of Earth's atmosphere makes for an interesting light and color display.

Mission
STS-99, Shuttle Radar Topography Mission (SRTM)

Space Shuttle
Endeavour

Launched
February 11, 2000, at 12:43:40 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
February 22, 2000, at 6:22:24 p.m. EDT on Runway 33 at Kennedy Space Center, FL

Duration
11 days, 5 hours, 38 minutes, and 44 seconds

Distance Traveled
4,708,821 miles

Orbits
181

Crew
Commander Kevin R. Kregel
Pilot Dominic L. Pudwill Gorie
Mission Specialists Janet L. Kavandi, Janice E. Voss, Mamoru M. Mohri, and Gerhard P.J. Thiele

The Shuttle Radar Topography Mission (SRTM) mast was deployed successfully to its full length and the antenna was turned to its operation position. After a successful checkout of the radar systems, mapping began at 12:31 a.m., less than 12 hours after launch. Crewmembers, split into two shifts so they could work around the clock, began mapping an area from 60 degrees north to 56 degrees south. Data was sent to NASA's Jet Propulsion Laboratory (JPL) for analysis, and early indications showed the data to be of excellent quality.

Mapping proceeded fairly smoothly, but during an attitude-hold period for payload mapping during the second day of flight, it was determined that orbiter propellant usage had doubled from 0.07 to 0.15 percent an hour. The increase was caused by a failure of the payload cold-gas thrust system, which was used to offset the gravity gradient torque of the mast. As a result of this failure, orbiter propellant was being used at a higher-than-planned rate to maintain the attitude of the vehicle. Measures to reduce the expenditure were evaluated, and based on the analysis, enough propellant could be saved to complete the planned science mission.

STS-101

Astronauts Jeffrey N. Williams (bottom) and James S. Voss work with the newly delivered main boom of the Russian crane (Strela). The two were later successful in attaching the boom to its operator post, which had been delivered by an earlier mission. The two mission specialists also secured a U.S.-built crane that was installed on the Station a year earlier, replaced a faulty antenna for one of the Station's communications systems, and installed several handrails and a camera cable on the Station's exterior.

Mission
STS-101, International Space Station (ISS) Assembly Flight 2A.2a

Space Shuttle
Atlantis

Launched
May 19, 2000, at 6:11:10 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
May 29, 2000, at 2:20:19 a.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
9 days, 20 hours, 9 minutes, and 9 seconds

Distance Traveled
5,076,281 miles

Orbits
155

Crew
Commander James D. Halsell, Jr.
Pilot Scott J. “Doc” Horowitz
Mission Specialists Mary Ellen Weber, Jeffrey N. Williams, James S. Voss, Susan J. Helms, and Yury Vladimirovich Usachev

On their 10-day mission, the astronauts completed one extravehicular activity (EVA), equipped the International Space Station (ISS) with new or replacement gear, and transferred more than a ton of supplies for use by future ISS residents.

The EVA marked the fifth spacewalk for construction of the ISS, the 49th conducted from a Space Shuttle, and the 85th overall conducted by U.S. astronauts. During the 6-hour, 44-minute EVA, mission specialists James S. Voss and Jeffrey N. Williams secured a U.S.-built crane that was installed on the Station last year; installed the final parts of a Russian-built crane, Strela, on the Pressurized Mating Adapter-1 (PMA-1) that connects the Unity node to the Zarya control module; replaced a faulty antenna for one of the Station’s communications systems; and installed various handrails and a camera cable on the ISS exterior. Mission specialist Mary Ellen Weber operated the Shuttle’s robotic arm, which she used to maneuver Voss during much of the spacewalk. Over the course of 3 days, the crew installed 4 batteries and associated electronics, 10 new smoke detectors in the Zarya module, 4 new cooling fans, additional cables for the Zarya computer, a new communications memory unit, and a new power distribution box for the U.S.-built communications system.

STS-106

This view of shock wave condensation collars backlit by the Sun occurred during the launch of the Space Shuttle Atlantis on September 8, 2000. Although the primary effect is created by the forward fuselage of Atlantis, secondary effects can be seen on the Solid Rocket Booster (SRB) forward skirt, the Shuttle vertical stabilizer, and the wing trailing edge behind the Space Shuttle's main engines.

Mission
STS-106, International Space Station (ISS)
Assembly Flight 2A.2b

Space Shuttle
Atlantis

Launched
September 8, 2000, at 8:45:47 a.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
September 20, 2000, at 3:56:44 a.m. EDT on
Runway 15 at Kennedy Space Center, FL

Duration
11 days, 19 hours, 10 minutes, and 57 seconds

Distance Traveled
4,919,243 miles

Orbits
185

Crew
Commander Terrence W. Wilcutt
Pilot Scott D. Altman
Mission Specialists Daniel C. Burbank,
Edward T. Lu, Richard A. Mastracchio,
Yuri I. Malenchenko, and Boris V. Morokov

The crew of STS-106, during its 11-day mission to the International Space Station (ISS), completed all assigned mission objectives to prepare the Station for its first occupants, who were to arrive later that year. The mission to the 143-foot-long ISS focused on unloading nearly three tons of cargo from the orbiter and a Progress supply craft already docked to the opposite end of the Station. The crew transferred more than 6,000 pounds of material to the interior of the Station—including six 100-pound bags of water, all of the food for the first resident crew, office supplies, onboard environmental supplies, a vacuum cleaner, and a computer and monitor.

The astronauts spent a total of 5 days, 9 hours, and 21 minutes inside the Station before closing the hatch on the orbiting outpost. Terrence W. Wilcutt and Scott D. Altman commanded a series of four altitude boosts to place the Station in an orbit of approximately 241 by 233 statute miles, raising the average altitude by 14 miles. After spending 7 days, 21 hours, and 54 minutes linked to the Station, Atlantis undocked at 11:46 p.m. as Wilcutt and Altman fired Atlantis's jets to move to a distance of about 450 feet for a double-loop flyaround.

STS-92

Following a successful landing at Edwards Air Force Base in California, the Space Shuttle Discovery is prepared to be transported back to Kennedy Space Center (KSC) in Florida after finishing the 100th Shuttle mission.

Mission
STS-92, International Space Station (ISS) Assembly Flight 3A

Space Shuttle
Discovery

Launched
October 11, 2000, at 6:17:00 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
October 24, 2000, at 12:59:42 p.m. PST on Runway 22 at Edwards Air Force Base, CA

Duration
12 days, 21 hours, 42 minutes, and 42 seconds

Distance Traveled
5,331,301 miles

Orbits
202

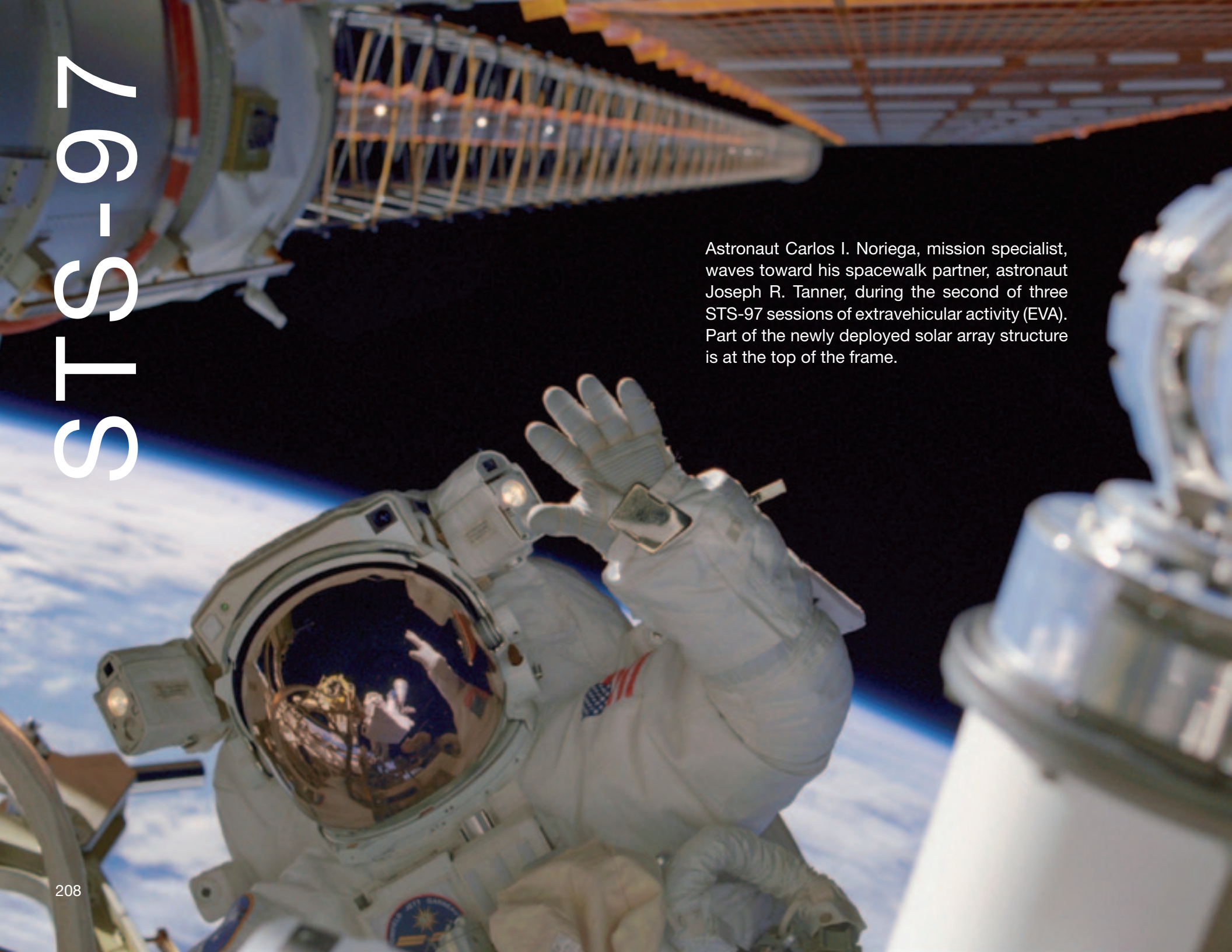
Crew
Commander Brian Duffy
Pilot Pamela A. Melroy
Mission Specialists Koichi Wakata, Leroy Chiao, Peter J.K. Wisoff, Michael E. López-Alegría, and William S. McArthur

STS-92, during its 12-day mission to the International Space Station (ISS), completed all assigned objectives to install the Zenith Z1 Truss and the third Pressurized Mating Adapter-3 (PMA-3) for use as a docking port for subsequent Shuttle missions.

In the afternoon of flight day 2, Discovery and its crew completed a successful rendezvous and docking with the ISS, setting the stage for 6 days of construction and outfitting. Discovery's five mission specialists, Leroy Chiao, William S. McArthur, Peter J.K. Wisoff, Michael E. López-Alegría, and Koichi Wakata, performed a total of four extravehicular activities (EVA) during the Space Shuttle program's 100th mission.

On flight day 9, the crew of Discovery shifted their attention to the interior of the ISS as they completed connections for the newly installed Z1 Truss external framework and began transferring equipment and supplies for the first resident crew of the ISS. They also successfully completed testing the four Control Moment Gyroscopes (CMG) that would be used to orient the ISS as it orbits Earth.

STS-97



Astronaut Carlos I. Noriega, mission specialist, waves toward his spacewalk partner, astronaut Joseph R. Tanner, during the second of three STS-97 sessions of extravehicular activity (EVA). Part of the newly deployed solar array structure is at the top of the frame.

Mission
STS-97, International Space Station (ISS) Assembly Flight 4A

Space Shuttle
Endeavour

Launched
November 30, 2000, at 10:06:01 p.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
December 11, 2000, at 6:03:23 p.m. EST on Runway 15 at Kennedy Space Center, FL

Duration
10 days, 19 hours, 57 minutes, and 22 seconds

Distance Traveled
4,476,164 miles

Orbits
171

Crew
Commander Brent W. Jett
Pilot Michael J. Bloomfield
Mission Specialists Joseph R. Tanner, Marc Garneau, and Carlos I. Noriega

On their 11-day mission, the astronauts of STS-97 completed three spacewalks, or EVAs, to deliver and connect the first set of U.S.-provided solar arrays to the International Space Station (ISS), to prepare a docking port for the arrival of the U.S. Destiny laboratory, to install Floating Potential Probes to measure electrical potential surrounding the Station, and to install a camera cable outside the Unity module.

At 9:36 a.m. on Friday, December 8, 2001, the STS-97 crew paid its first visit to the Expedition 1 crew residing in the International Space Station (ISS). Until then, the Shuttle and the Station had kept one hatch closed to maintain respective atmospheric pressures, allowing the Shuttle crew to conduct their spacewalks and mission goals. After a welcome ceremony and briefing, the eight spacefarers conducted structural tests of the Station and its solar arrays; transferred equipment, supplies, and refuse between the spacecraft; and checked out the television camera cable installed by Joseph R. Tanner and Carlos I. Noriega for an upcoming mission.

STS-98

In the grasp of the Shuttle's Remote Manipulator System (RMS) robot arm, the Destiny laboratory is moved from its stowage position in the cargo bay of the Space Shuttle Atlantis.

Mission
STS-98, International Space Station (ISS) Assembly Flight 5A

Space Shuttle
Atlantis

Launched
February 7, 2001, at 6:13:02 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
February 20, 2001, at 12:33:06 p.m. PST on Runway 22 at Edwards Air Force Base, CA

Duration
12 days, 20 hours, 20 minutes, and 4 seconds

Distance Traveled
5,369,576 miles

Orbits
203

Crew
Commander Kenneth D. Cockrell
Pilot Mark L. Polansky
Mission Specialists Robert L. Curbeam, Jr., Thomas D. Jones, and Marsha S. Ivins

After docking to the International Space Station (ISS) on flight day 2, the Station and the Shuttle crews opened hatches and unloaded supplies, including three 12-gallon bags of water, a spare computer, cables to power up Destiny, and various personal items for the Station crew.

On February 10, 2001, the U.S. Destiny laboratory was successfully installed on the ISS using the Remote Manipulator System (RMS) and concurrent extravehicular activities (EVAs). Mission specialist Marsha S. Ivins, using the RMS, grappled the Pressurized Mating Adapter-2 (PMA-2) on Node 1 and maneuvered it to the Z1 Truss for a temporary stay. Ivins latched the RMS onto the Destiny laboratory in the payload bay and lifted it out. She then flipped the 16-ton laboratory 180 degrees and moved it into position to attach it to Node 1. A set of automatic bolts tightened to hold the lab permanently in place.

STS-102

Beginning a 5.3-million-mile mission, the Space Shuttle Discovery leaves a trail of smoke as it rises through Earth's atmosphere.

A sunrise launch carried the second resident crew to the International Space Station (ISS) as well as the first Multipurpose Logistics Module (MPLM), Leonardo, which was full of supplies, equipment, and science racks, to the U.S. Destiny laboratory. The Shuttle and Station crews unloaded almost 5 tons of experiments and equipment from Leonardo and packed almost 1 ton of items for return to Earth. Discovery's spacewalkers—James S. Voss, Susan J. Helms, Andrew S.W. Thomas, and Paul W. Richards—set the stage for the continued expansion of the Station by installing a platform that would be used to mount a Canadian-built robotic arm, the Space Station Remote Manipulator System (SSRMS), to the Station on a future mission.

Discovery docked with the Station at 1:38 a.m. on March 10, 2001. Hatches between the two spacecraft were opened at 3:51 a.m. All 10 crewmembers greeted each other for several minutes in the Destiny module. The first Expedition 2 crewmember to trade places was Yury V. Usachev, who replaced Yuri P. Gidzenko on March 10, 2001. Voss swapped places with Sergei K. Krikalev on March 11, and Helms swapped with William M. Shepherd on March 14. A formal transfer of command was conducted on March 19 as Commander Shepherd passed Station responsibility to Usachev.

Mission
STS-102, International Space Station (ISS) Assembly Flight 5A.1

Space Shuttle
Discovery

Launched
March 08, 2001, at 6:42:09 a.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
March 21, 2001, at 2:31:41 a.m. EST on Runway 15 at Kennedy Space Center, FL

Duration
12 days, 19 hours, 49 minutes, and 32 seconds

Distance Traveled
5,357,432 miles

Orbits
102

Crew
Commander James D. Wetherbee
Pilot James M. Kelly
Mission Specialists Andrew S.W. Thomas and Paul W. Richards
Expedition 1 crew: Sergei K. Krikalev, William M. Shepherd, and Yuri P. Gidzenko
Expedition 2 crew: James S. Voss, Yury V. Usachev, and Susan J. Helms

STS-100

Raffaello, the second Multipurpose Logistics Module (MPLM) provided by the Italian Space Agency (ASI), can be seen in its berthed position in the Space Shuttle Endeavour's cargo bay as the Shuttle approached the orbital outpost for an April 21, 2001, docking. Topography in northern Africa serves as the backdrop for the scene.

Mission
STS-100, International Space Station (ISS)
Assembly Flight 6A

Space Shuttle
Endeavour

Launched
April 19, 2001, at 2:40:42 p.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
May 1, 2001, at 9:10:43 a.m. PDT on
Runway 22 at Edwards Air Force Base, CA

Duration
11 days, 21 hours, 30 minutes, and 1 second

Distance Traveled
4,910,188 miles

Orbits
186

Crew
Commander Kent V. Rominger
Pilot Jeffrey S. Ashby
Mission Specialists Chris A. Hadfield,
Scott E. Parazynski, John L. Phillips,
Umberto Guidoni, and Yuri V. Lonchakov

Docking with the International Space Station (ISS) occurred at 9:59 a.m. on April 21, 2001. The advanced robotic arm, called Canadarm2, was attached to a pallet on the outside of the Destiny laboratory. It later was directed to “walk off” the pallet and grab onto an electrical grapple fixture on the lab, which would provide data, power, and telemetry to the arm. Days later, the arm was used to hand off the cradle to the orbiter’s arm. The exchange of the cradle from the Station arm to the Shuttle arm marked the first ever robotic-to-robotic transfer in space. The 6,000 pounds of cargo inside the Multipurpose Logistics Module (MPLM) Raffaello was transferred to the Station, including two new scientific experiment racks for Destiny and the first three U.S. commercial payloads. In turn, 1,600 pounds of material was stored inside Raffaello for the return to Earth.

On April 23, 4 days after launch, the hatches between Endeavour and the Space Station were opened, allowing the Shuttle crew and the Station crew to greet one another for the first time. Other crew activities during the mission included attaching an ultrahigh-frequency antenna to the outside of the Station; calibrating the Space Vision System, an alignment aid for operating the robotic arm; helping repair the Space Station’s treadmill; and filming for IMAX.

STS-104

Backdropped by the blackness of space and by Earth's horizon, the Space Shuttle Atlantis was photographed while docked to the Destiny laboratory on the International Space Station (ISS) during the STS-104 mission.

Mission
STS-104, International Space Station (ISS) Assembly Flight 7A

Space Shuttle
Atlantis

Launched
July 12, 2001, at 5:03:59 a.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
July 24, 2001, at 11:38:55 p.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
12 days, 18 hours, 34 minutes, and 56 seconds

Distance Traveled
5,309,429 miles

Orbits
200

Crew
Commander Steven W. Lindsey
Pilot Charles O. Hobaugh
Mission Specialists Michael L. Gernhardt, James F. Reilly, and Janet L. Kavandi

After docking with the International Space Station (ISS) on July 13, 2001, both Atlantis and ISS crews reviewed their extravehicular activity (EVA) procedures. In a series of three spacewalks, the joint airlock module was attached to the Unity Node, and high-pressure gas tanks were attached to the airlock, which was christened “Quest.” The crews tested nitrogen and oxygen lines for use on future Shuttle missions and installed valves to connect Quest to the ISS environmental control system. The crews also installed a computer to run the airlock’s systems. Air bubbles in a coolant line caused a water spill—its cleanup caused a task to be postponed to another day. Astronauts replaced a leaky air circulation valve and moved the hatch for the airlock into position between the Equipment Lock and the Crew Lock.

Janet L. Kavandi, Michael L. Gernhardt, and James F. Reilly transferred items between the Shuttle and the Station, storing equipment and spacesuits in the airlock. Both Station and Shuttle crews checked out and activated the new Quest airlock, conducting a dry run before the inaugural event.

STS-105

Backdropped over the blue-and-white Earth, astronaut Daniel T. Barry, mission specialist, is pictured near the end of the Space Shuttle Discovery's Remote Manipulator System (RMS) arm during the early stages of the second extravehicular activity (EVA) of the STS-105 mission.

Mission
STS-105, International Space Station (ISS) Assembly Flight 7A.1

Space Shuttle
Discovery

Launched
August 10, 2001, at 5:10:14 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
August 22, 2001, at 2:22:59 p.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
11 days, 21 hours, 12 minutes, and 45 seconds

Distance Traveled
4,912,390 miles

Orbits
186

Crew
Commander Scott J. “Doc” Horowitz
Pilot Frederick W. Sturckow
Mission Specialists Daniel T. Barry and Patrick G. Forrester
Expedition 2 crew: James S. Voss, Yury V. Usachev, and Susan J. Helms
Expedition 3 crew: Frank L. Culbertson, Jr., Mikhail V. Tyurin, and Vladimir N. Dezhurov

After the linkup of the Space Shuttle Discovery to the International Space Station (ISS), the hatches were opened and the crews greeted one another. Part of the mission was to bring the next resident crew, Expedition 3, to the ISS and return Expedition 2 to Earth. The payload included the Early Ammonia Servicer (EAS) and the Multipurpose Logistics Module (MPLM) Leonardo.

On the fifth day of the mission, August 16, 2001, Discovery maintained control of the Space Station while Russian flight controllers completed loading and upgrading software commands to the Zvezda module. After completion of the upgrade, the Zvezda module again assumed control of the Station’s attitude, or position in space. While docked with the ISS, the crews unloaded 7,000 pounds of supplies, equipment, and science racks from the MPLM Leonardo, storing the new cargo on the Space Station. This was the second flight of Leonardo to the ISS.

On August 20, the Discovery crew undocked from the ISS and performed a flyaround. The crew later deployed a small science satellite, Simplesat, via a spring ejection from a canister at the rear of the cargo bay.

STS-108

Florida foliage frames the Space Shuttle Endeavour as it lifts off into an afternoon sky to begin the STS-108 mission to the International Space Station (ISS).

Shuttle Commander Dominic L. Gorie brought Endeavour to a gentle linkup with the International Space Shuttle (ISS) as the two craft sailed over England. Within minutes, pilot Mark E. Kelly and mission specialists Linda M. Godwin and Daniel M. Tani began postdocking checks of the mechanical interface between Endeavour and the Station's Destiny laboratory prior to the opening of the hatches on the two vehicles. Mission managers extended Endeavour's flight to a duration of 12 days to allow Endeavour's crew to assist with additional maintenance tasks on the Station, including work on a treadmill and replacing a failed compressor in one of the air conditioners in the Zvezda Service Module.

The astronauts and cosmonauts completed the transfer of more than 5,000 pounds of supplies and material from Endeavour and the Raffaello Multipurpose Logistics Module (MPLM) to the Station. The transferred items included more than 850 pounds of food, 1,000 pounds of clothing and other crew provisions, 300 pounds of experiments and associated equipment, 800 pounds of spacewalking gear, and 600 pounds of medical equipment. In turn, the crew packed up the Raffaello module with items bound for a return trip to Earth.

Mission
STS-108, International Space Station (ISS) Assembly Flight UF-1

Space Shuttle
Endeavour

Launched
December 5, 2001, at 5:19:28 p.m. EST from Launch Pad 39B at Kennedy Space Center, FL

Landed
December 17, 2001, at 11:55:12 a.m. EST on Runway 15 at Kennedy Space Center, FL

Duration
11 days, 19 hours, 35 minutes, and 44 seconds

Distance Traveled
4,817,649 miles

Orbits
186

Crew
Commander Dominic L. Gorie
Pilot Mark E. Kelly
Mission Specialists Linda M. Godwin and Daniel M. Tani
Expedition 3 crew: Frank L. Culbertson, Jr., Mikhail Tyurin, and Vladimir N. Dezhurov
Expedition 4 crew: Yury I. Onufrienko, Daniel W. Bursch, and Carl E. Walz

STS-109

The third Hubble Space Telescope (HST) Servicing Mission takes off from Kennedy Space Center (KSC) aboard the Space Shuttle Columbia.

Mission
STS-109, Hubble Space Telescope (HST) Servicing Mission

Space Shuttle
Columbia

Launched
March 1, 2002, at 6:22:02 a.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
March 12, 2002, at 4:31:53 a.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
10 days, 22 hours, 9 minutes, and 51 seconds

Distance Traveled
3,941,705 miles

Orbits
165

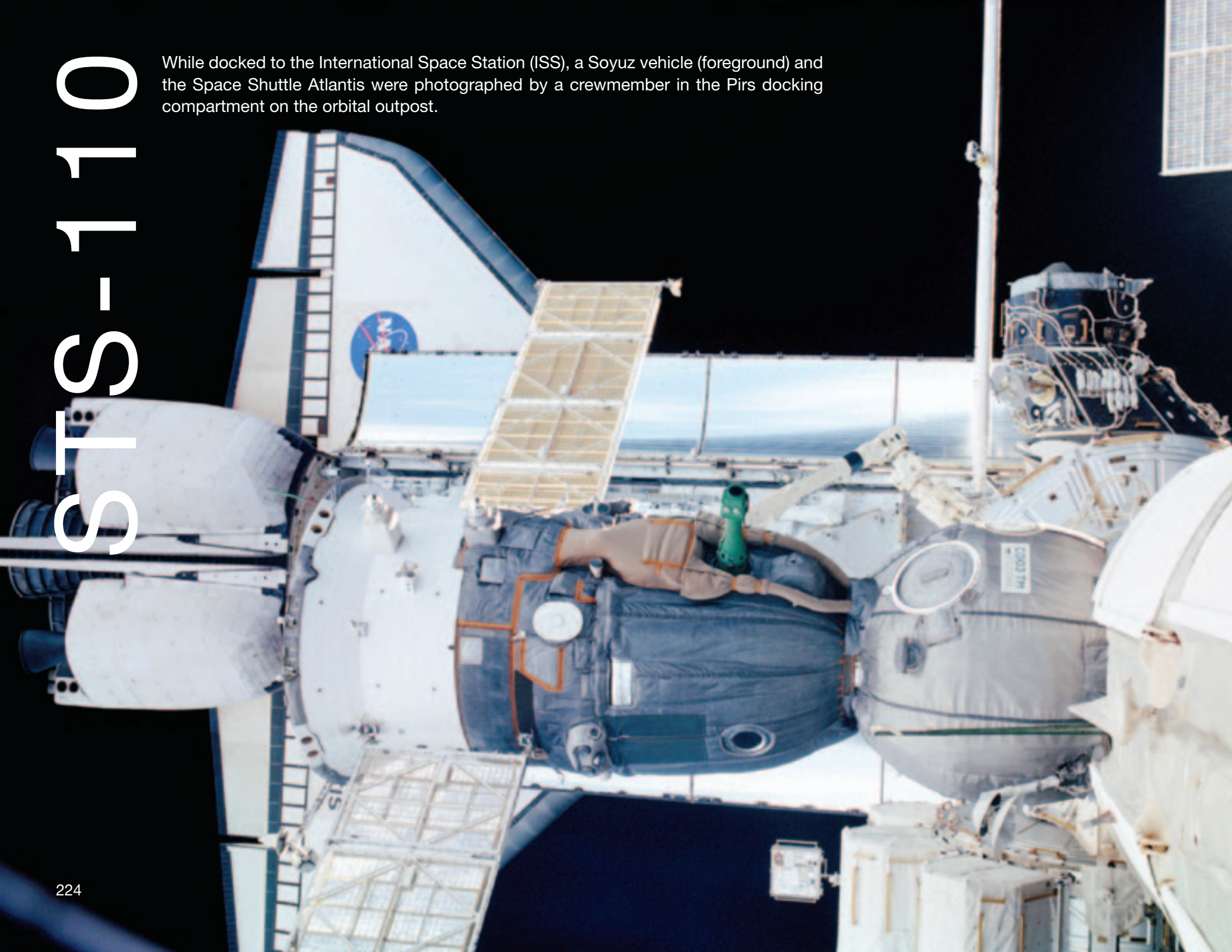
Crew
Commander Scott D. Altman
Pilot Duane G. Carey
Mission Specialists John M. Grunsfeld, Nancy J. Currie, James H. Newman, Richard M. Linnehan, and Michael J. Massimino

The 11-day mission rejuvenated the Hubble Space Telescope (HST) in a series of five spacewalks. After grasping the telescope and pulling it into the payload bay, the spacewalkers, assisted by mission specialist Nancy J. Currie operating the Shuttle's robotic arm, installed new-and-improved equipment that gave the telescope more power, a new module to dispense the power, and a camera able to see twice as much area with more speed and clarity. They also installed an experimental cooling system in the hope of restoring life to the Near-Infrared Camera and Multi-Object Spectrometer.

The HST was released from the grasp of Columbia's robotic arm at 5:04 a.m. on March 9, 2002. The spacewalks that were needed to install the new and upgraded equipment set a new EVA record for a single Shuttle mission with a total time of 35 hours and 55 minutes. The previous record was 35 hours and 28 minutes, set by STS-61 during the first Hubble Servicing Mission.

STS-110

While docked to the International Space Station (ISS), a Soyuz vehicle (foreground) and the Space Shuttle Atlantis were photographed by a crewmember in the Pirs docking compartment on the orbital outpost.



Mission
STS-110, International Space Station (ISS) Assembly Flight 8A

Space Shuttle
Atlantis

Launched
April 8, 2002, at 4:44:19 p.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
April 19, 2002, at 12:26:58 p.m. EDT on Runway 33 at Kennedy Space Center, FL

Duration
10 days, 19 hours, 42 minutes, and 39 seconds

Distance Traveled
4,525,299 miles

Orbits
171

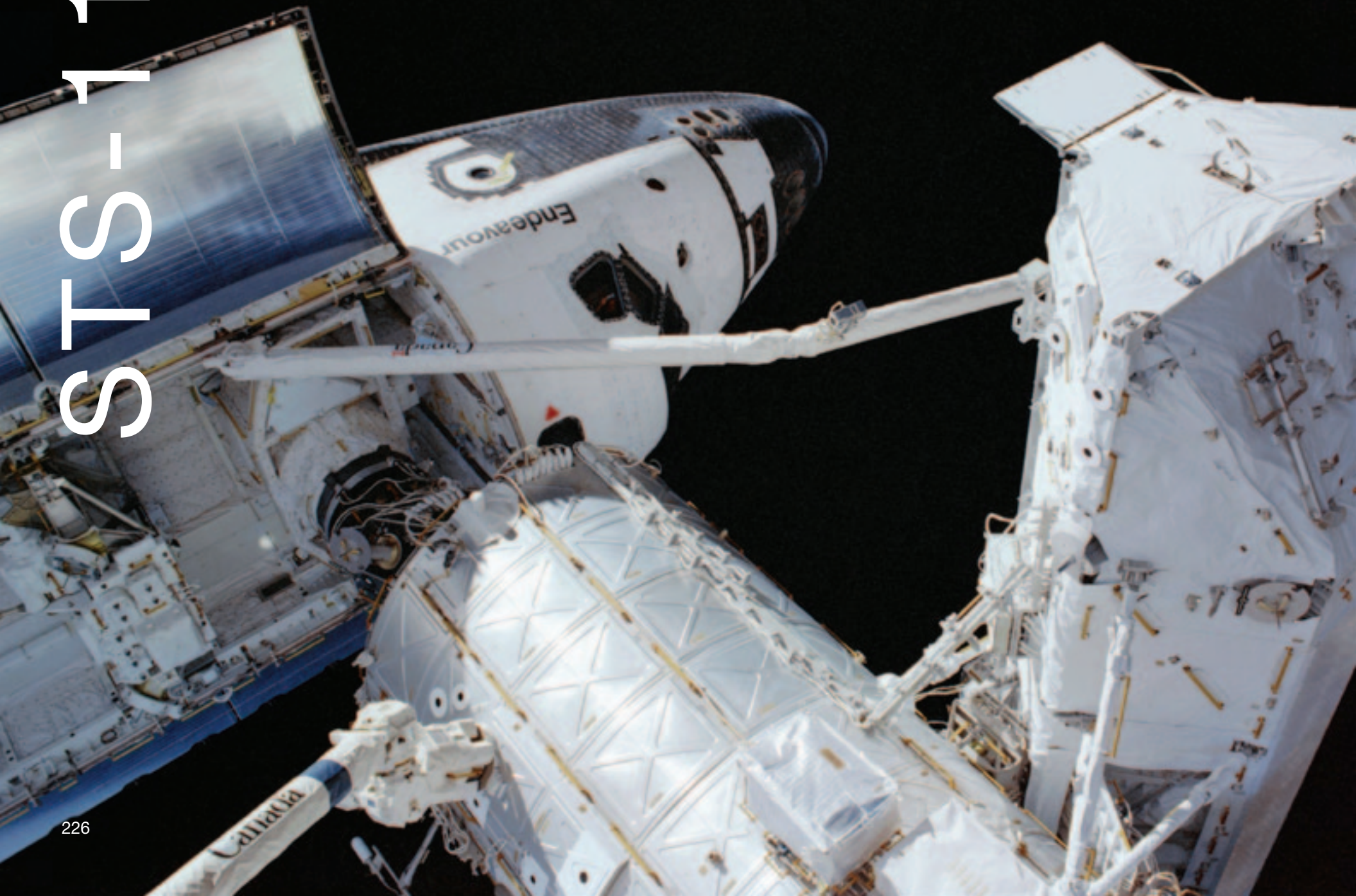
Crew
Commander Michael J. Bloomfield
Pilot Stephen N. Frick
Mission Specialists Jerry L. Ross, Steven L. Smith, Ellen L. Ochoa, Lee M.E. Morin, and Rex J. Walheim

The launch marked a milestone as mission specialist Jerry L. Ross became the first human to fly in space seven times, breaking his own and other astronauts' records of six space flights. His two spacewalks on STS-110 gave him a total of 58 hours and 18 minutes of cumulative extravehicular activity (EVA) in space.

The installation of the S0 (S-zero) Truss was the primary objective of STS-110 and began with the removal of the truss from Atlantis's payload bay. Mission specialist Ellen L. Ochoa lifted it out with the Station's robotic arm and maneuvered it onto a clamp at the top of the Destiny laboratory. The truss contained the navigational devices, computers, and cooling and power systems needed to attach additional laboratories to the complex. Four spacewalks were required for the task. The truss served as a platform on which other trusses were attached and additional solar arrays were mounted to form the 356-foot-long Space Station. Between and during spacewalks, Shuttle and ISS crewmembers transferred experiments and supplies between the spacecraft. They also transferred oxygen from the Shuttle to one of the four high-pressure gas tanks, which were used to repressurize the module after spacewalks.

STS-111

Backdropped by the blackness of space, the Space Shuttle Endeavour is pictured while docked to the Pressurized Mating Adapter (PMA-2) at the forward end of the Destiny laboratory on the International Space Station (ISS). A portion of the Canadarm2 is visible in the lower left corner, and Endeavour's robotic arm is in full view as it is stretched out with the S0 (S-zero) Truss at its end.



Mission
STS-111, International Space Station (ISS) Assembly Flight UF-2

Space Shuttle
Endeavour

Launched
June 5, 2002, at 5:22:49 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
June 19, 2002, at 10:57:42 a.m. PDT on Runway 22 at Edwards Air Force Base, CA

Duration
13 days, 20 hours, 34 minutes, 53 seconds

Distance Traveled
5,781,115 miles

Orbits
217

Crew
Commander Kenneth D. Cockrell
Pilot Paul S. Lockhart
Mission Specialists Franklin R. Chang-Díaz and Philippe Perrin

On June 7, 2002, mission specialist Franklin R. Chang-Díaz completed his seventh Shuttle flight, tying astronaut Jerry L. Ross for the most trips to space. After docking with the International Space Station (ISS) and linking to the Destiny laboratory's forward docking port, the Endeavour and ISS crews transferred equipment, supplies, and experiments. On June 8, using the Shuttle's robotic arm, Commander Kenneth D. Cockrell moved the Multipurpose Logistics Module (MPLM) Leonardo from Endeavour's payload bay to the Unity module. Leonardo carried a total of 8,062 pounds of supplies and equipment to the Space Station, including a new science rack to house microgravity experiments and a glovebox that would allow Station crews to conduct experiments requiring isolation. This mission also featured the 41st spacewalk in support of ISS assembly, bringing the total mission extravehicular activity (EVA) time to 19 hours and 31 minutes.

The Expedition 4 crew—Yuri I. Onufriyenko, Daniel W. Bursch and Carl E. Walz—unofficially ended their 182-day residence aboard the ISS, and the Expedition 5 crew—Commander Valery G. Korzun and flight engineers Peggy A. Whitson and Sergei Y. Treschev—began their tenure.

STS-112

The main landing gear of the Space Shuttle Atlantis is seconds away from touchdown at the Shuttle Landing Facility (SLF), completing a 4.5-million-mile journey that included a week of work with the International Space Station (ISS).

Mission
STS-112, International Space Station (ISS) Assembly Flight 9A

Space Shuttle
Atlantis

Launched
October 7, 2002, at 3:45:51 p.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
October 18, 2002, at 11:43:41 a.m. EDT on Runway 33 at Kennedy Space Center, FL

Duration
10 days, 19 hours, 57 minutes, and 50 seconds

Distance Traveled
4,513,015 miles

Orbits
171

Crew
Commander Jeffrey S. Ashby
Pilot Pamela A. Melroy
Mission Specialists David A. Wolf, Piers J. Sellers, Sandra H. Magnus, and Fyodor N. Yurchikhin

The primary payloads for STS-112 were the S1 integrated truss segment and the Crew and Equipment Translation Aid (CETA) Cart A. The CETA was the first of two human-powered carts that rode along the International Space Station (ISS) railway to provide mobile work platforms for future spacewalking astronauts.

Activities on this mission included three spacewalks to attach the S1 truss to the Space Station. Mission specialist Sandra H. Magnus and ISS science officer Peggy A. Whitson lifted the 14-ton, 45-foot S1 truss from Atlantis's payload bay using the Station's Canadarm2. They then attached it to the Station with four remotely operated bolts.

Other tasks completed on this mission included repairing the Station's exercise treadmill, adjusting protective circuits that measured current in the S1 truss radiator assembly to greater tolerance levels for space, and removing and replacing a humidity separator in the Quest airlock.

STS-113

The Earth's horizon and the blackness of space serve as the backdrop for two miniature satellites that were released from the Space Shuttle Endeavour as part of MEPSI, or the Micro Electro-Mechanical Systems-based PicoSat Inspector. Funded by the Defense Advanced Research Projects Agency (DARPA), the two small satellites, which were tethered together, were released from Endeavour's payload bay to fly free for 3 days as a technology demonstration of the launcher and the use of micro and nanotechnologies in space systems.

Mission
STS-113, International Space Station (ISS) Assembly Flight 11A

Space Shuttle
Endeavour

Launched
November 23, 2002, at 7:49:47 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
December 7, 2002, at 2:37:13 p.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
13 days, 18 hours, 47 minutes, and 26 seconds

Distance Traveled
5,735,600 miles

Orbits
216

Crew
Commander James D. Wetherbee
Pilot Paul S. Lockhart
Mission Specialists Michael E. López-Alegría and John B. Herrington

Over the course of the 14-day mission, the STS-113 crew and the Expedition 6 crew installed the new P1 truss on the International Space Station (ISS), performed three spacewalks to outfit and activate the truss, and transferred supplies and equipment between the two spacecraft. Endeavour brought more than 2,500 pounds of material to the Station. Included among the transfer were the Protein Crystal Growth-Single Locker Enclosure System (PCG-STES) and the Plant Generic Bioprocessing Apparatus (PGBA), both of which returned to Earth, and the PCG-STES Unit 10, which moved onto the Station. While Endeavour was docked to the Space Station, Expedition 5 NASA science officer Peggy A. Whitson and Expedition 6 Commander Kenneth D. Bowersox replaced two valves and cleared debris from vent lines of the Carbon Dioxide Removal Assembly (CDRA) in the Station's U.S. Destiny Laboratory.

Prior to the first spacewalk, Commander James D. Wetherbee removed the P1 truss from Endeavour's payload bay, using the Shuttle's robotic arm, and handed it off to the Station's Canadarm2. Whitson and Bowersox maneuvered the P1 to its installation position. STS-113 is also noteworthy because mission specialist John B. Herrington was the only Native American to fly in space.

STS-107

The Space Shuttle Columbia leaves Launch Pad 39A during lift-off. Upon reentering Earth's atmosphere at the mission's conclusion, the crew and Shuttle were lost when the orbiter disintegrated just 16 minutes before landing.

Mission
STS-107, Microgravity Research Mission/ SPACEHAB

Space Shuttle
Columbia

Launched
January 16, 2003, at 10:39:00 a.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Loss of Crew
The crew and vehicle were lost during reentry, 16 minutes before landing on February 1, 2003.

Duration
15 days, 22 hours, 20 minutes, and 32 seconds

Distance Traveled
6,649,757 miles

Orbits
256

Crew
Commander Rick D. Husband
Pilot William C. “Willie” McCool
Mission Specialists Michael P. Anderson, Kalpana Chawla, David M. Brown, and Laurel B.S. Clark
Payload Specialist Ilan Ramon

The landing at the Kennedy Space Center (KSC) was planned for February 1, 2003, after a 16-day mission, but the crew and Columbia were lost during reentry over East Texas at about 9 a.m., 16 minutes prior to the scheduled touchdown. A 7-month investigation followed, including a 4-month search across Texas to recover debris. Nearly 85,000 pieces of orbiter debris were shipped to KSC and housed in the Columbia Debris Hangar near the Shuttle Landing Facility (SLF). About 38 percent of the orbiter was eventually recovered. The Columbia Accident Investigation Board concluded that damage incurred during launch to the Shuttle’s left wing led to the loss of the crew and orbiter.

STS-107 carried seven crewmembers, including the first Israeli astronaut, on a marathon international scientific research flight. As a research mission, the crew was kept busy 24 hours a day performing various chores involved with science experiments. Experiments in the SPACEHAB Research Double Module (RDM) included nine commercial payloads involving 21 separate investigations. In the physical sciences, three studies inside a large, rugged chamber examined the physics of combustion, soot production, and fire-quenching processes in microgravity. These experiments provided new insights into combustion and fire suppression that could not be gained on Earth.

STS-114

The Space Shuttle Discovery was about 600 feet from the International Space Station (ISS) when cosmonaut Sergei K. Krikalev, Expedition 11 Commander, and astronaut John L. Phillips, NASA Space Station science officer and flight engineer, photographed the spacecraft as it approached the Station and performed a backflip to allow photography of its heat shield. Astronaut Eileen M. Collins, STS-114 Commander, guided the Shuttle through the flip. The photos were analyzed by engineers on the ground to evaluate the condition of Discovery's heat shield. The scene is over Switzerland.

Mission
STS-114, International Space Station (ISS) Assembly Flight LF1

Space Shuttle
Discovery

Launched
July 26, 2005, at 10:39:00 a.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
August 9, 2005, at 5:11:23 a.m. PDT on Runway 22 at Edwards Air Force Base, CA

Duration
13 days, 21 hours, 32 minutes, and 23 seconds

Distance Traveled
5,796,419 miles

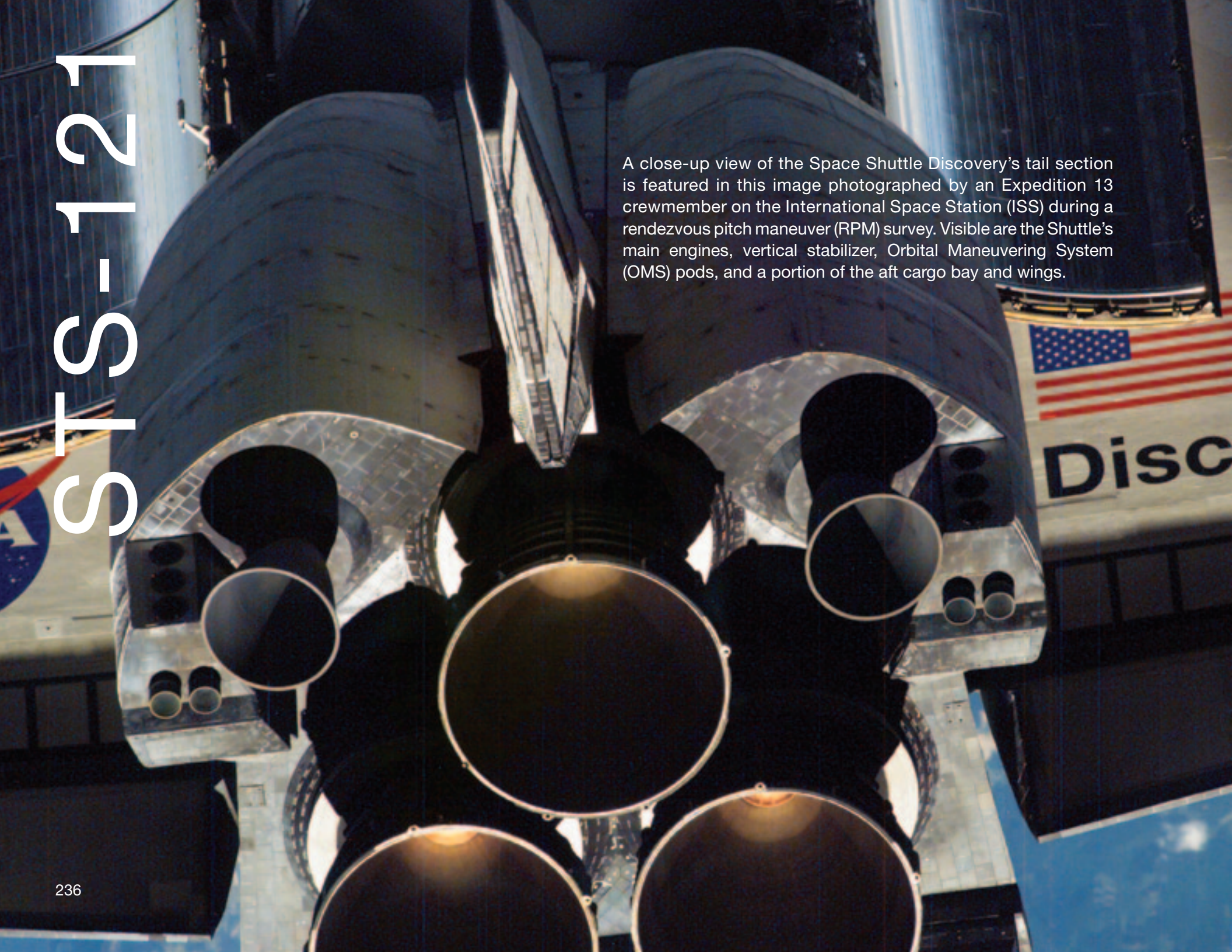
Orbits
219

Crew
Commander Eileen M. Collins
Pilot James M. Kelly
Mission Specialists Charles J. Camarda, Wendy B. Lawrence, Soichi Noguchi, Stephen K. Robinson, and Andrew S.W. Thomas

STS-114 was the first Return to Flight mission since the tragic loss of Columbia on February 1, 2003. Two-and-a-half years were spent researching and implementing safety improvements for the orbiters and their external tanks. The changes included greater in-depth examination of reinforced carbon-carbon panels that were used on the wing leading edges, plus replacing bolts and new foam applications on the tanks.

Discovery's climb to orbit was extensively documented through a system of new and upgraded ground-based cameras, radar systems, and airborne cameras aboard high-altitude aircraft. The imagery captured of Discovery's launch, and additional imagery from laser systems on Discovery's new Orbiter Boom Sensor System (OBSS) laser scanner as well as data from sensors embedded in the Shuttle's wings, helped mission managers determine the health of Discovery's thermal protection system. Before docking with the International Space Station (ISS), Commander Eileen M. Collins performed the first Rendezvous Pitch Maneuver (RPM) about 600 feet below the ISS. The motion flipped the Shuttle end-over-end at ¾ degree per second, allowing Expedition 11 crewmembers to photograph the underside of Discovery and its heat-resistant tiles in detail. All imagery was downlinked to a team of 200 to analyze.

STS-121



A close-up view of the Space Shuttle Discovery's tail section is featured in this image photographed by an Expedition 13 crewmember on the International Space Station (ISS) during a rendezvous pitch maneuver (RPM) survey. Visible are the Shuttle's main engines, vertical stabilizer, Orbital Maneuvering System (OMS) pods, and a portion of the aft cargo bay and wings.

Mission
STS-121, International Space Station (ISS) Assembly Flight ULF1.1

Space Shuttle
Discovery

Launched
July 4, 2006, at 2:37:55 p.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
July 17, 2006, at 9:14:42 a.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
12 days, 18 hours, 36 minutes, and 47 seconds

Distance Traveled
5,293,923 miles

Orbits
202

Crew
Commander Steven W. Lindsey
Pilot Mark E. Kelly
Mission Specialists Stephanie D. Wilson, Michael E. Fossum, Piers J. Sellers, Thomas A. Reiter, and Lisa M. Nowak

STS-121 was the second Return to Flight mission, demonstrating techniques for inspecting and protecting the Shuttle's thermal protection system and replacing critical hardware needed for future International Space Station (ISS) assembly. The mission also restored the Station to a three-person crew for the first time since May 2003, leaving European Space Agency (ESA) astronaut Thomas A. Reiter aboard to join Expedition 13. This was the most photographed Shuttle mission in history, with more than 100 high-definition, digital, video and film cameras documenting the launch. The images helped assess any damage sustained during launch. In addition, the crew used the Orbiter Boom Sensor System (OBSS) with a laser dynamic range imager, laser camera system, and intensified television camera to examine the Shuttle's nose cap, port wing, leading edge of the starboard wing, and outside of the crew cabin. No risk was found.

After docking to the Station, the crew transferred the Multipurpose Logistics Module (MPLM) Leonardo to the Unity module, moving 7,400 pounds of supplies and equipment during their stay. The cargo included a new heat exchange that collected condensation out of the air on the Station, a new window and window seals for the Microgravity Sciences Glovebox, and a spare U.S. extravehicular activity (EVA) suit and emergency jet pack.

STS-115

This overhead image of the Space Shuttle Atlantis, recorded by an Expedition 13 crewmember on board the International Space Station (ISS) as the Shuttle approached the Station, gives an excellent view of the hardware stowed in the cargo bay that would later be used to resume the construction of the orbital outpost during the STS-115 mission. A Russian Progress resupply vehicle is docked to the Station at left.

Mission
STS-115, International Space Station (ISS)
Assembly Flight 12A

Space Shuttle
Atlantis

Launched
September 9, 2006, at 11:14:55 a.m. EDT from
Launch Pad 39B at Kennedy Space Center, FL

Landed
September 21, 2006, at 6:21:23 a.m. EDT on
Runway 33 at Kennedy Space Center, FL

Duration
11 days, 19 hours, 6 minutes, and 28 seconds

Distance Traveled
4,910,268 miles

Orbits
186

Crew
Commander Brent W. Jett, Jr.
Pilot Christopher J. Ferguson
Mission Specialists Steven G. MacLean
Heidemarie M. Stefanyshyn-Piper,
Joseph R. “Joe” Tanner, and Daniel C. Burbank

This mission resumed assembly of the International Space Station (ISS) after a hiatus of 4 years. Before the docking, the crew used the Orbiter Boom Sensor System (OBSS), the 50-foot-long extension for the Shuttle’s robotic arm, to inspect the reinforced carbon-carbon panels along the leading edge of Atlantis’s starboard and port wings and the nose cap. After docking, Christopher J. Ferguson and Daniel C. Burbank attached the Shuttle’s robotic arm to the P3/P4 truss, lifted it from its berth in the payload bay, and maneuvered it for handover to the Station’s Canadarm2. After opening the hatch, Steven G.MacLean and Expedition 13 flight engineer Jeffrey N. Williams used the Canadarm2 to take the truss from the Shuttle’s robotic arm. MacLean was the first Canadian to operate the Canadarm2 in space.

Three spacewalks were later planned to install the P3/P4 integrated truss, deploy the solar arrays, and prepare them for operation. A new procedure called a “camp out” was implemented, in which astronauts slept in the Quest airlock prior to their spacewalks. The process shortens the “prebreathe” time during which nitrogen is purged from the astronauts’ systems and air pressure is lowered so that spacewalkers avoid the decompression sickness known as “the bends.”

STS-116

As seen through windows on the aft flight deck of the Space Shuttle Discovery, the Remote Manipulator System (RMS) was photographed while Discovery was docked with the International Space Station (ISS). The blackness of space, Earth's horizon, and airglow provide the backdrop for the scene.

Mission
STS-116, International Space Station (ISS) Assembly Flight 12A.1

Space Shuttle
Discovery

Launched
December 9, 2006, at 8:47:35 p.m. EDT from Launch Pad 39B at Kennedy Space Center, FL

Landed
December 22, 2006, at 5:31:58 p.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
12 days, 20 hours, 44 minutes, and 23 seconds

Distance Traveled
5,330,398 miles

Orbits
204

Crew
Commander Mark L. Polansky
Pilot William A. Oefelein
Expedition 14 Flight Engineer Sunita L. Williams
Mission Specialists Joan E.M. Higginbotham, Nicholas J.M. Patrick, Christer A. Fuglesang, Robert L. Curbeam, Jr., and Thomas A. Reiter (not shown)

Discovery rocketed into a dark Florida sky on the first night launch in more than 4 years. After reaching orbit, the crew used the Shuttle's robotic arm and Orbiter Boom Sensor System (OBSS) to examine Discovery's thermal protection system. Docking with the International Space Station (ISS) occurred at 4:12 p.m. on December 11, 2006, and four extravehicular activities (EVAs) allowed astronauts to continue construction of the ISS. The total time spent on spacewalks on this mission was 25 hours and 45 minutes. The crew wrapped up 8 days of docked operations, separating from the ISS on December 19.

On December 20, the crew inspected the heat shield for possible micrometeoroid debris damage using the sensor-equipped OBSS that unfolded from the payload bay. They also deployed small technology demonstration satellites, known as MEPSI, or the Microelectromechanical System-based PicoSat Inspector, for the Department of Defense Space Test Program, as well as student experiment scientific satellites and the Atmospheric Neutral Density Experiment (ANDE), which measured the density and composition of the low-Earth orbit atmosphere.

STS-117

The drifting smoke plumes from the launch of the Space Shuttle Atlantis (out of frame) swirl above the Vehicle Assembly Building (VAB) near sunset. Atlantis and its seven-member STS-117 crew headed toward Earth orbit and a scheduled linkup with the International Space Station (ISS).

Mission
STS-117, International Space Station (ISS) Assembly Flight 13A

Space Shuttle
Atlantis

Launched
June 8, 2007, at 7:38:04 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
June 22, 2007, at 12:49:37 p.m. PDT on Runway 22 at Edwards Air Force Base, CA

Duration
13 days, 20 hours, 11 minutes, and 33 seconds

Distance Traveled
5,809,363 miles

Orbits
219

Crew
Commander Frederick W. Sturckow
Pilot Lee J. Archambault
Mission Specialists Patrick G. Forrester, John “Danny” Olivas, Clayton C. Anderson, James F. Reilly II, and Steven R. Swanson

STS-117, flown by the Space Shuttle Atlantis, launched from Kennedy Space Center (KSC) on June 8, 2007. Damage from a hail storm on February 26 postponed the originally planned launch date of March 15. The launch of STS-117 marked the 250th orbital human space flight. Atlantis delivered the second starboard truss segment (the S3/S4 truss) and its associated energy systems, including a set of solar arrays, to the International Space Station (ISS). During the course of the mission, the crew installed the new truss segment, retracted one set of solar arrays, and unfolded the new set on the starboard side of the Station. STS-117 and Expedition 15 also swapped crewmembers, leaving Shuttle crewmember Clayton C. Anderson on the Station and returning ISS crewmember Sunita L. Williams back to Earth.

On June 11, NASA mission managers announced a 2-day extension of the mission, adding a fourth extravehicular activity (EVA). These 2 days were inserted into the mission timeline after flight day 8. Because of the launch day and rendezvous day uncertainty, the decision to extend the mission was deferred until after the launch. The repair of the gap in the Orbital Maneuvering System (OMS) thermal blanket (heat shielding) was conducted during EVA 3.

STS-118

The Space Shuttle Endeavour and its seven-member crew head toward low-Earth orbit and a link-up with the International Space Station (ISS). While in orbit, the crew delivered a third starboard truss segment and other payloads, including the SPACEHAB module and the External Stowage Platform-3 (ESP-3), to the ISS.

Mission
STS-118, International Space Station (ISS) Assembly Flight 13A.1

Space Shuttle
Endeavour

Launched
August 8, 2007, at 6:36:42 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
August 21, 2007, at 12:32:17 p.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
12 days, 17 hours, 55 minutes, and 35 seconds

Distance Traveled
5,274,977 miles

Orbits
201

Crew
Commander Scott J. Kelly
Pilot Charles O. Hobaugh
Mission Specialists David R. Williams, Barbara R. Morgan, Richard A. Mastracchio, Tracy E. Caldwell, and B. Alvin Drew

The Space Shuttle Endeavour's STS-118 mission was the 22nd Shuttle flight to the International Space Station (ISS). The STS-118 mission delivered and assembled the starboard S5 truss segment of the ISS, as well as the External Stowage Platform-3 (ESP-3) and a replacement Control Moment Gyroscope (CMG). The mission was also the final flight to include the SPACEHAB logistics single module.

The SPACEHAB logistics single module, a pressurized aluminum habitat that was carried inside the payload bay, had a capacity of 6,000 pounds and carried a variety of cargo and research projects, including supply materials for the ISS. SPACEHAB also returned cargo, including the Materials International Space Station Experiment–Passive Experiment Container (MISSE–PEC) 3 and 4, a Department of Defense payload that had been installed on the ISS. Launched in July 2006, the MISSE–PEC 3 and 4 contained over 850 materials specimens that were studied to determine the effects of long-term exposure to the environment of space.

STS-120

Backdropped by a blue-and-white Earth, the Space Shuttle Discovery approaches the International Space Station (ISS) during STS-120 rendezvous and docking operations. The Harmony node is visible in Discovery's cargo bay.

Mission
STS-120, International Space Station (ISS) Assembly Flight 10A

Space Shuttle
Discovery

Launched
October 23, 2007, at 11:38:19 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
November 7, 2007, at 1:01:17 p.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
15 days, 2 hours, 22 minutes, and 58 seconds

Distance Traveled
6,249,432 miles

Orbits
238

Crew
Commander Pamela A. Melroy
Pilot George D. Zamka
Mission Specialists Scott E. Parazynski, Douglas H. Wheelock, Stephanie D. Wilson, Daniel M. Tani, and Paolo A. Nespoli

STS-120 was the 23rd Shuttle mission to the International Space Station (ISS). Retired Air Force Colonel Pamela A. Melroy commanded the mission, which took the Harmony Node 2 connecting module to the ISS. Melroy, a veteran Shuttle pilot, was the second woman to command a Shuttle.

The mission delivered launch package 10A to the ISS, which consisted of the U.S. Harmony module (also known as Node 2), with four DC-to-DC Converter Unit (DDCU) racks and three Zero-g Storage Racks (ZSR) installed; a Power and Data Grapple Fixture (PDGF) for the Station's robotic arm; and a Shuttle Power Distribution Unit (SPDU). Harmony was built for NASA by Thales Alenia Space in Torino, Italy, as part of an agreement between NASA and the European Space Agency (ESA) and was the first pressurized habitable module delivered to the Station since the Pirs docking compartment was installed in August 2001.

The final positioning of Harmony allowed for the later installation of the European Columbus and Japanese Kibō research modules, which were attached to the side ports of Harmony.

STS-122

In the grasp of the Station's robotic Canadarm2, the Columbus laboratory is moved from its stowage position in the Space Shuttle Atlantis's payload bay to the starboard side of the Harmony module of the International Space Station (ISS).

Mission
STS-122, International Space Station (ISS) Assembly Flight 1E

Space Shuttle
Atlantis

Launched
February 7, 2008, at 2:45:30 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
February 21, 2008, at 9:07:09 p.m. EST on Runway 15 at Kennedy Space Center, FL

Duration
12 days, 18 hours, 21 minutes, and 39 seconds

Distance Traveled
5,296,842 miles

Orbits
202

Crew
Commander Stephen N. Frick
Pilot Alan G. Poindexter
Mission Specialists Rex J. Walheim, Stanley G. Love, Leland D. Melvin, Hans W. Schlegel, and Léopold Eyharts

Flown by the Space Shuttle Atlantis, STS-122 marked the 24th Shuttle mission to the International Space Station (ISS) and the 121st Space Shuttle flight. The mission was also referred to as ISS-1E by the ISS program. The primary objective of STS-122 was to deliver the European Columbus science laboratory, built by the European Space Agency (ESA), to the Station, as well as the Biolab, the Fluid Science Laboratory (FSL), the European Drawer Rack (EDR), and the European Physiology Modules (EPM) payloads. It also returned Expedition 16 flight engineer Daniel M. Tani to Earth. Tani was replaced on Expedition 16 by Léopold Eyharts, a French flight engineer representing ESA.

STS-122 also carried the Solar Monitoring Observatory (SOLAR), the European Technology Exposure Facility (EuTEF), and a new Nitrogen Tank Assembly, mounted in the cargo bay of an Integrated Cargo Carrier (ICC)-Lite payload rack, as well as a spare Drive Lock Assembly (DLA) that was sent to orbit in support of possible repairs to the starboard Solar Alpha Rotary Joint (SARJ), which was malfunctioning.

STS-123

Astronaut Garrett E. Reisman, Expedition 16 flight engineer, takes a photo of his helmet visor during the mission's first scheduled session of extravehicular activity (EVA) as construction and maintenance continue on the International Space Station (ISS). Also visible in the visor's reflection are various components of the Station, the docked Space Shuttle Endeavour, and Earth.

Mission
STS-123, International Space Station (ISS) Assembly Flight 1J/A

Space Shuttle
Endeavour

Launched
March 11, 2008, at 2:28:14 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
March 26, 2008, at 8:39:06 p.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
15 days, 18 hours, 10 minutes, and 52 seconds

Distance Traveled
6,577,857 miles

Orbits
250

Crew
Commander Dominic L. Gorie
Pilot Gregory H. Johnson
Mission Specialists Garrett E. Reisman, Robert L. Behnken, Michael J. Foreman, Takao Doi, Richard M. Linnehan, and Léopold Eyharts (not shown)

STS-123 was the 25th Shuttle mission to the International Space Station (ISS). It delivered the first component of the Japanese Experiment Module (Kibō) and the Canadian Special Purpose Dexterous Manipulator (SPDM) robotics system to the Station. This was the first mission to fully utilize the Station-to-Shuttle Power Transfer System (SSPTS), which allowed Space Station power to augment the Shuttle's power systems. The mission also set a record for a Shuttle's longest stay at the ISS.

The mission delivered NASA astronaut Garrett E. Reisman to the Station and returned European Space Agency (ESA) astronaut Léopold Eyharts to Earth.

STS-124

The Space Shuttle Discovery is moments away from touchdown on Runway 15 of the Shuttle Landing Facility (SLF) at NASA's Kennedy Space Center (KSC) in Florida, concluding the 14-day STS-124 mission to the International Space Station (ISS).

Mission
STS-124, International Space Station (ISS)
Assembly Flight 1J

Space Shuttle
Discovery

Launched
May 31, 2008, at 5:02:12 p.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
June 14, 2008, at 11:15:18 a.m. EDT on
Runway 15 at Kennedy Space Center, FL

Duration
13 days, 18 hours, 13 minutes, and 6 seconds

Distance Traveled
5,735,643 miles

Orbits
217

Crew
Commander Mark E. Kelly
Pilot Kenneth T. Ham
Mission Specialists Karen L. Nyberg,
Gregory E. Chamitoff, Akihiko Hoshide,
Ronald J. Garan, Michael E. Fossum,
and Garrett E. Reisman (not shown)

STS-124 was the 26th Shuttle mission to the International Space Station (ISS) and was the second of three flights that would launch components to complete the Kibō laboratory. The mission also included three spacewalks.

The mission successfully delivered the Pressurized Module (PM) of the Japanese Experiment Module (JEM), called Kibō, to the ISS. Kibō was berthed to the Harmony module and the pressurized section of the JEM Experiment Logistics Module, brought up by the STS-123 crew, and was moved from Harmony to the JEM-PM. The Japanese Remote Manipulator System (RMS), a robotic arm, was also delivered by STS-124 and attached to Kibō.

Astronaut Gregory E. Chamitoff flew to the Station as a mission specialist on STS-124. He took astronaut Garrett E. Reisman's place as an Expedition 17 flight engineer and would return to Earth on Shuttle mission STS-126.

On this mission, NASA and Disney joined forces for elementary school education. "Buzz Lightyear," a 12-inch-tall action figure based on the cartoon character from the Pixar "Toy Story" movies, was delivered to the ISS for a 6-month stay.

STS-126

The Space Shuttle Endeavour sits on Launch Pad 39A at the Kennedy Space Center (KSC) in Florida as it goes through preparations for the launch of STS-126.

Mission
STS-126, International Space Station (ISS) Assembly Flight ULF2

Space Shuttle
Endeavour

Launched
November 14, 2008, at 7:55:39 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
November 30, 2008, at 1:25:09 a.m. PST on Runway 4 at Edwards Air Force Base, CA

Duration
15 days, 20 hours, 39 minutes, and 30 seconds

Distance Traveled
6,615,109 miles

Orbits
250

Crew
Commander Christopher J. Ferguson
Pilot Eric A. Boe
Mission Specialists Sandra H. Magnus, Stephen G. Bowen, Donald R. Pettit, Robert S. “Shane” Kimbrough, and Heidemarie M. Stefanyshyn-Piper

STS-126 was the 27th Shuttle mission to the International Space Station (ISS). Endeavour carried a reusable logistics module that held supplies and equipment, including additional crew quarters, exercise equipment, regenerative life-support system resources, and spare hardware.

STS-126 was scheduled to be a 16-day mission with four spacewalks largely dedicated to the servicing and repair of the Solar Alpha Rotary Joints (SARJ). An additional docked day was added to the flight plan to give the crew more time to complete their tasks. The starboard SARJ had shown anomalous behavior since August 2007, and its use had been minimized pending diagnosis and repair. Both the starboard and port SARJs were serviced. In addition to lubricating both bearings, the remaining 11 trundle bearings in the starboard SARJ were replaced. Trundle bearing assembly five was removed during an Expedition 16 extravehicular activity (EVA) for further examination in December 2007.

The mission also included the Leonardo Multipurpose Logistics Module (MPLM) on its fifth space flight. Leonardo held more than 14,000 pounds of supplies and equipment.

STS-119

The Space Shuttle Discovery is shown in this photograph while docked to the International Space Station (ISS).

Mission
STS-119, International Space Station (ISS) Assembly Flight 15A

Space Shuttle
Discovery

Launched
March 15, 2009, at 7:43:44 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
March 28, 2009, at 3:13:26 a.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
12 days, 19 hours, 29 minutes, and 42 seconds

Distance Traveled
5,304,106 miles

Orbits
202

Crew
Commander Lee J. Archambault
Pilot Anthony D. Antonelli
Mission Specialists Joseph M. Acaba, Steven R. Swanson, Richard R. Arnold, John L. Phillips, Koichi Wakata, and Sandra H. Magnus (not shown)

STS-119 was the 28th Space Shuttle mission to the International Space Station (ISS) and was flown aboard the orbiter Discovery. The mission delivered the S6 solar arrays to the ISS, completing the construction of the Integrated Truss Structure. STS-119 also carried several experiments, including the Shuttle Ionospheric Modification with Pulsed Local EXhaust (SIMPLEX), the Shuttle Exhaust Ion Turbulence Experiments (SEITE), and the Maui Analysis of Upper Atmospheric Injections (MAUI). STS-119 was also used for the Boundary Layer Transition Detailed Test Objective experiment. One tile of the thermal protection system was raised 0.25 inches above the others so that, at about Mach 15 during reentry, a boundary layer transition would be initiated.

Koichi Wakata remained on the Station, replacing Expedition 18 flight engineer Sandra H. Magnus, who returned to Earth with the STS-119 crew. Wakata would serve as a flight engineer for Expeditions 18 and 19 and return to Earth on Shuttle mission STS-127.

STS-125

Backdropped by the blackness of space and the thin line of Earth's atmosphere, the Space Shuttle Atlantis's payload bay, the Remote Manipulator System (RMS) robotic arm, the vertical stabilizer, and the Orbital Maneuvering System (OMS) pods are featured in this image.

Mission
STS-125, Hubble Space Telescope (HST)
Servicing Mission 4

Space Shuttle
Atlantis

Launched
May 11, 2009, at 2:01:56 p.m. EDT from
Launch Pad 39A at Kennedy Space Center, FL

Landed
May 24, 2009, at 8:39:04 a.m. PDT on
Runway 22 at Edwards Air Force Base, CA

Duration
12 days, 21 hours, 37 minutes, and 18 seconds

Distance Traveled
5,276,106 miles

Orbits
197

Crew
Commander Scott D. Altman
Pilot Gregory C. Johnson
Mission Specialists Michael J. Massimino,
Michael T. Good, K. Megan McArthur,
John M. Grunsfeld, and Andrew J. Feustel

STS-125, or HST-SM4 (Hubble Space Telescope Servicing Mission 4), was the fifth and final Space Shuttle mission to the Hubble Space Telescope (HST).

Atlantis's astronauts repaired and upgraded the HST, conducting five spacewalks during their mission to extend the life of the orbiting observatory. They successfully installed two new instruments and repaired two others, replaced gyroscopes and batteries, and added new thermal insulation panels to protect the orbiting observatory.

With the newly installed Wide Field Camera, Hubble could observe in the ultraviolet, infrared, and visible light spectrums; peer deep onto the cosmic frontier in search of the earliest star systems; and study planets in the solar system. The telescope's new Cosmic Origins Spectrograph allowed it to study the grand-scale structure of the universe, including the star-driven chemical evolution that produces carbon and other elements necessary for life.

STS-127

Captured by a remote camera during lift-off, the Space Shuttle Endeavour and its seven-member crew head toward Earth orbit and a rendezvous with the International Space Station (ISS).

Mission
STS-127, International Space Station (ISS) Assembly Flight 2J/A

Space Shuttle
Endeavour

Launched
July 15, 2009, at 6:03:10 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
July 31, 2009, at 10:48:07 a.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
15 days, 16 hours, 44 minutes, and 58 seconds

Distance Traveled
6,547,853 miles

Orbits
248

Crew
Commander Mark L. Polansky
Pilot Douglas G. Hurley
Mission Specialists David A. Wolf, Christopher J. Cassidy, Julie Payette, Thomas H. Marshburn, Timothy L. Kopra, and Koichi Wakata (not shown)

STS-127 was the 29th Shuttle mission to the International Space Station (ISS). When Endeavour docked with the ISS on this mission in July 2009, it set a record for having the most humans in space at the same time in the same vehicle—it was the first time 13 people had been on the Station at once. The mission also tied the record for having the most people in space, 13, at any one time.

Endeavour set sail on its 23rd mission with the Kibō Japanese Experiment Module Exposed Facility and Experiment Logistics Module Exposed Section. The facility provides a type of “front porch” for experiments in the exposed space environment, as well as a robotic arm that is attached to the Kibō pressurized module and is used to position experiments outside the Station. The mission included five spacewalks.

The mission delivered Timothy L. Kopra to the Station as a flight engineer and science officer and returned Japanese astronaut Koichi Wakata to Earth. Astronauts Douglas G. Hurley, Christopher J. Cassidy, Thomas H. Marshburn, and Kopra made their first trips to space.

STS-128

This high-angle view shows the Space Shuttle Discovery and the launch complex at the Kennedy Space Center (KSC) in Florida.

Mission
STS-128, International Space Station (ISS) Assembly Flight 17A

Space Shuttle
Discovery

Launched
August 28, 2009, at 11:59:37 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
September 11, 2009, at 5:53:20 p.m. PDT on Runway 22 at Edwards Air Force Base, CA

Duration
13 days, 20 hours, 53 minutes, 43 seconds

Distance Traveled
5,702,716 miles

Orbits
219

Crew
Commander Frederick W. Sturckow
Pilot Kevin A. Ford
Mission Specialists José M. Hernández, John D. “Danny” Olivas, Nicole M.P. Stott, Christer A. Fuglesang, Patrick G. Forrester, and Timothy L. Kopra (not shown)

This was Discovery’s 37th mission to space and the 30th mission of a Space Shuttle dedicated to the assembly and maintenance of the International Space Station (ISS).

The Space Shuttle Discovery carried the Multipurpose Logistics Module (MPLM) Leonardo as its primary payload. The MPLM contained three racks for life support, a crew quarter to be installed in Kibō, a new treadmill (COLBERT) that would temporarily be placed in Node 2 and later moved to Node 3, and an Air Revitalization System (ARS) that would temporarily be placed in Kibō and later moved to Node 3. Three spacewalks were carried out during the mission to remove and replace a materials processing experiment outside the European Space Agency’s (ESA’s) Columbus module and to return an empty ammonia tank assembly.

Nicole M.P. Stott remained on the Station as an Expedition 20 flight engineer, replacing Timothy L. Kopra. Kopra returned home aboard Discovery as a mission specialist.

STS-129

The top exterior of the Space Shuttle Atlantis's crew cabin is featured in this image photographed by a STS-129 crewmember during the mission's first session of extravehicular activity (EVA).

Mission
STS-129, International Space Station (ISS) Assembly Flight ULF3

Space Shuttle
Atlantis

Launched
November 16, 2009, at 2:28:01 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
November 27, 2009, at 9:44:21 a.m. EST on Runway 33 at Kennedy Space Center, FL

Duration
10 days, 19 hours, 16 minutes, and 14 seconds

Distance Traveled
4,490,138 miles

Orbits
171

Crew
Commander Charles O. Hobaugh
Pilot Barry E. Wilmore
Mission Specialists Michael J. Foreman, Leland D. Melvin, Robert L. Satcher, Jr., Randolph J. Bresnik, and
Nicole M.P. Stott (not shown)

STS-129 was the 31st Shuttle mission to the International Space Station (ISS). The mission focused on staging spare components outside the Station. The 11-day flight included three spacewalks. The payload bay carried two large ExPRESS (Expedite the Processing of Experiments to the Space Station) Logistics Carriers (ELC) holding two spare gyroscopes, two nitrogen tank assemblies, two pump modules, an ammonia tank assembly, a spare latching end effector for the Station's robotic arm, a high-pressure gas tank, and a spare trailing umbilical system for the Mobile Transporter (MT)—a railway that runs along the outside of the ISS. STS-129 was the first flight of an ExPRESS Logistics Carrier. The completion of this mission left six Space Shuttle flights remaining until the end of the Space Shuttle program, after STS-135 was approved in February 2011.

Atlantis returned Station crewmember Nicole M.P. Stott to Earth, making STS-129 the final Space Shuttle crew rotation flight to or from the Space Station.

STS-130

This photo of the Space Shuttle Endeavour silhouetted against the atmosphere of Earth was taken from the International Space Station (ISS) during Expedition 22.

Mission
STS-130, International Space Station (ISS) Assembly Flight 20A

Space Shuttle
Endeavour

Launched
February 8, 2010, at 4:14:07 a.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
February 21, 2010, at 10:20:29 p.m. EST on Runway 15 at Kennedy Space Center, FL

Duration
13 days, 18 hours, 6 minutes, and 22 seconds

Distance Traveled
5,738,991 miles

Orbits
217

Crew
Commander George D. Zamka
Pilot Terry W. Virts, Jr.
Mission Specialists Nicholas J.M. Patrick, Stephen K. Robinson, Robert L. Behnken, and Kathryn P. Hire

STS-130 was the 32nd Shuttle mission to the Station. During the STS-130 mission, the Space Shuttle Endeavour delivered the Tranquility node and its cupola, a dome-shaped extension from Tranquility made up of seven windows. The node and cupola were the last major U.S. modules added to the Space Station, and together they helped clear out premium workspace in other areas of the Station—as well as offer a window on the world.

At 15-feet-wide and 23-feet-long, the Tranquility node provided a centralized home for the Station's environmental control equipment—one of the systems that remove carbon dioxide from the Station's air, one of the Station's bathrooms, and the equipment that converts urine into drinkable water—all of which took up space in the Destiny laboratory.

STS-131

The Space Shuttle Discovery is docked with the International Space Station (ISS) in this picture, with shadows from the ISS solar panels cast over the orbiter's wing.

Mission
STS-131, International Space Station (ISS) Assembly Flight 19A

Space Shuttle
Discovery

Launched
April 5, 2010, at 6:21:25 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
April 20, 2010, at 9:08:34 p.m. EDT on Runway 33 at Kennedy Space Center, FL

Duration
15 days, 2 hours, 47 minutes, and 9 seconds

Distance Traveled
6,232,235 miles

Orbits
238

Crew
Commander Alan G. Poindexter
Pilot James P. Dutton, Jr.
Mission Specialists Richard A. Mastracchio, Clayton C. Anderson, Dorothy M. Metcalf-Lindenburger, Stephanie D. Wilson, and Naoko Yamazaki

STS-131 was the 33rd Shuttle mission to the Station. The primary payload of STS-131 was the Multipurpose Logistics Module (MPLM) Leonardo. The MPLM was filled with food and science supplies for the International Space Station (ISS). The MPLM also carried the third and final Minus Eighty Degree Laboratory Freezer for ISS (MELFI), the Window Orbital Research Facility (WORF), one Crew Quarters Rack, the Muscle Atrophy Resistive Exercise (MARES) rack, the Resupply Stowage Racks (RSRs), and the Resupply Stowage Platforms (RSPs).

The mission featured three spacewalks performed by Richard A. Mastracchio and Clayton C. Anderson. The astronauts replaced an ammonia tank assembly, retrieved a Japanese experiment from the Station's exterior, and switched out a rate gyro assembly on the S0 (S-zero) element of the Station's truss.

STS-132

The launch of Space Shuttle Atlantis to the International Space Station (ISS) is seen through the windows of Firing Room 4 of the Launch Control Center at Kennedy Space Center (KSC) in Florida. STS-132 was the 132nd Shuttle flight, the 32nd for Atlantis, and the 34th Shuttle mission dedicated to ISS assembly and maintenance.

Mission
STS-132, International Space Station (ISS) Assembly Flight ULF4

Space Shuttle
Atlantis

Launched
May 14, 2010, at 2:20:09 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
May 26, 2010, at 8:48:08 a.m. EDT on Runway 33 at Kennedy Space Center, FL

Duration
11 days, 18 hours, 27 minutes, and 59 seconds

Distance Traveled
4,879,978 miles

Orbits
186

Crew
Commander Kenneth T. Ham
Pilot Anthony D. Antonelli
Mission Specialists Garrett E. Reisman, Michael T. Good, Piers J. Sellers, and Stephen G. Bowen

On mission STS-132, the Space Shuttle Atlantis delivered an Integrated Cargo Carrier and a Russian-built Mini Research Module to the International Space Station (ISS). STS-132 was the 32nd mission for Atlantis.

Three spacewalks were conducted while Atlantis was docked to the orbiting laboratory. During the first spacewalk, mission specialists Garrett E. Reisman and Stephen G. Bowen installed a spare antenna and a stowage platform. On the second spacewalk, Bowen and mission specialist Michael T. Good replaced batteries on the P6 integrated truss that store solar energy. Outside for the final spacewalk were Good and Reisman, who replaced the last of the P6 truss batteries and retrieved a power data grapple fixture for installation at a later date.

Rassvet, the Russian-built Mini Research Module, was removed from the Shuttle's payload bay and installed on the Zarya module. Reisman and mission specialist Piers J. Sellers operated the Station's robotic arm, Canadarm2, during this process. Reisman and Sellers also maneuvered the Integrated Cargo Carrier from Atlantis into position on the Station with Canadarm2.

STS-133

Robonaut R2A waves goodbye as Robonaut R2B launches into space aboard STS-133. R2 was the first humanoid robot in space.

Mission
STS-133, International Space Station (ISS) Assembly Flight ULF5

Space Shuttle
Discovery

Launched
February 24, 2011, at 4:53:24 p.m. EST from Launch Pad 39A at Kennedy Space Center, FL

Landed
March 9, 2011, at 11:57:15 a.m. EST on Runway 15 at Kennedy Space Center, FL

Duration
12 days, 19 hours, 3 minutes, and 53 seconds

Distance Traveled
5,304,140 miles

Orbits
202

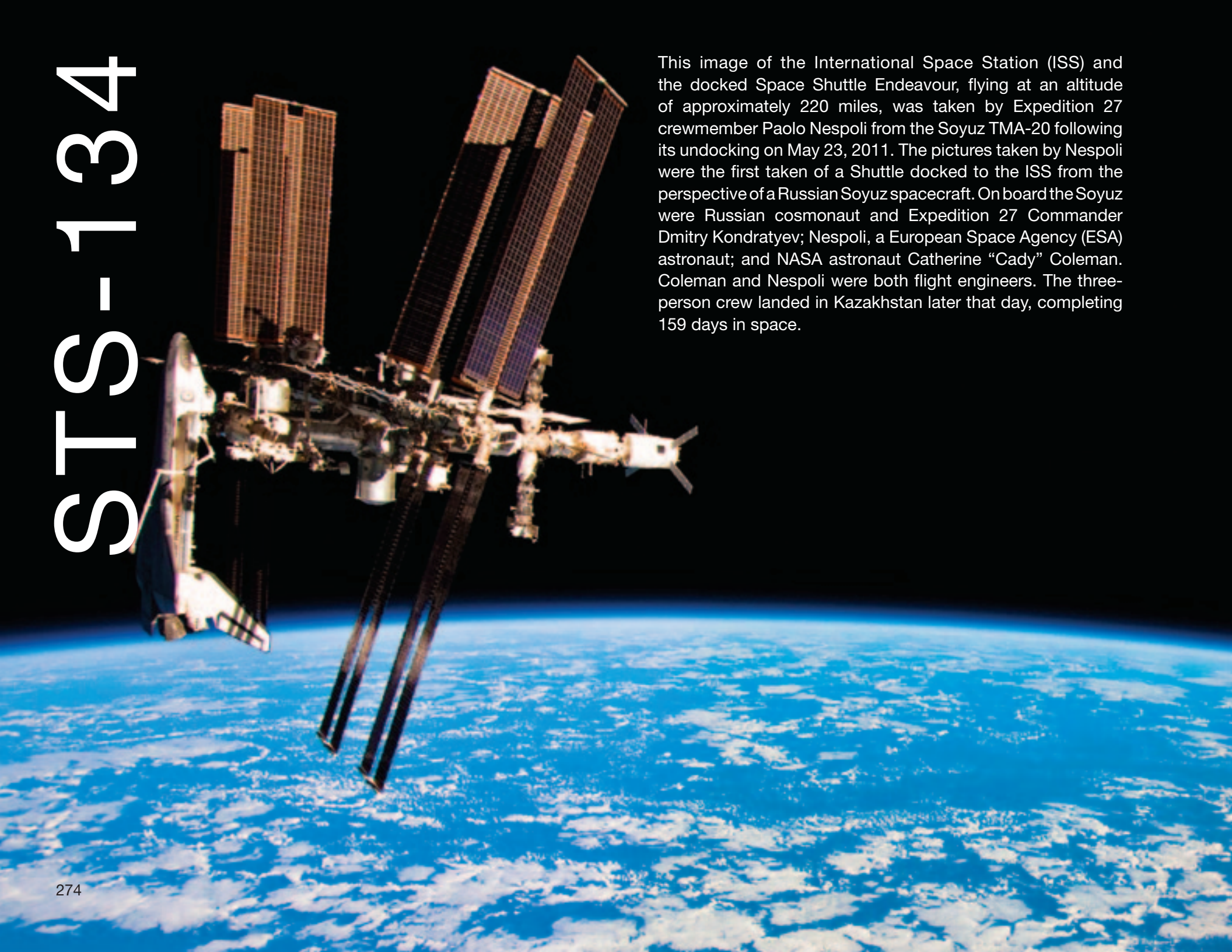
Crew
Commander Steven W. Lindsey
Pilot Eric A. Boe
Mission Specialists B. Alvin Drew, Nicole M.P. Stott, Stephen G. Bowen, and Michael R. Barratt

STS-133 Commander Steven W. Lindsey, pilot Eric A. Boe and mission specialists B. Alvin Drew, Stephen G. Bowen, Michael R. Barratt, and Nicole M.P. Stott delivered a new module and an external stowage platform to the International Space Station (ISS). During Space Shuttle Discovery's almost 9 days at the Station, Bowen and Drew performed two spacewalks for maintenance work and installation of new components.

Discovery's visit to the Station was extended by 2 days so its crew could help outfit the Permanent Multipurpose Module (PMM) Leonardo that it delivered. Leonardo had visited the Station seven times earlier as a cargo carrier before being refurbished to serve as a permanent 2,472-cubic-foot addition to the orbiting laboratory. Among the 6,000 pounds of Leonardo cargo was Robonaut 2, a human-upper-torso-like robot that could be a precursor of devices to help during spacewalks. About 2,000 pounds of additional cargo for the Station was carried on the Shuttle's middeck.

This was the 35th Shuttle mission to the Station and the final flight of Discovery.

STS-134



This image of the International Space Station (ISS) and the docked Space Shuttle Endeavour, flying at an altitude of approximately 220 miles, was taken by Expedition 27 crewmember Paolo Nespoli from the Soyuz TMA-20 following its undocking on May 23, 2011. The pictures taken by Nespoli were the first taken of a Shuttle docked to the ISS from the perspective of a Russian Soyuz spacecraft. On board the Soyuz were Russian cosmonaut and Expedition 27 Commander Dmitry Kondratyev; Nespoli, a European Space Agency (ESA) astronaut; and NASA astronaut Catherine “Cady” Coleman. Coleman and Nespoli were both flight engineers. The three-person crew landed in Kazakhstan later that day, completing 159 days in space.

Mission
STS-134, International Space Station (ISS) Assembly Flight ULF6

Space Shuttle
Endeavour

Launched
May 16, 2011, at 8:55:42 p.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
June 1, 2011, at 2:34:50 a.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
15 days, 17 hours, 38 minutes, and 22 seconds

Distance Traveled
6,510,221 miles

Orbits
248

Crew
Commander Mark E. Kelly
Pilot Gregory H. Johnson
Mission Specialists Michael E. Fincke, Gregory E. Chamitoff, Andrew J. Feustel, and Roberto Vittori

STS-134, International Space Station (ISS) Assembly Flight ULF6, was the penultimate mission of NASA's Space Shuttle program. The mission marked the 25th and final flight of the Space Shuttle Endeavour. This flight delivered the Alpha Magnetic Spectrometer and an ExPRESS Logistics Carrier to the ISS. The Alpha Magnetic Spectrometer 2 (AMS-02) was carried to the ISS in Endeavour's payload bay and was attached to the ISS's S3 truss segment. The AMS-02 unit was a particle physics detector that contained a large permanent magnet and was designed to search for antimatter and investigate the origin and structure of dark matter.

STS-134 was expected to be the final Space Shuttle mission had STS-135 not received funding from Congress; however, in February 2011, NASA stated that STS-135 would fly "regardless" of the funding situation. The Launch On Need (LON) mission, a contingency mission to rescue a stranded STS-134 crew, would have been the STS-135 flight (formerly STS-335) flown by Atlantis.

STS-135

STS-135 was the 33rd flight of Atlantis, the 37th Space Shuttle mission to the International Space Station (ISS), and the 135th and final mission of NASA's Space Shuttle program.

Mission
STS-135, International Space Station (ISS) Assembly Flight ULF7

Space Shuttle
Atlantis

Launched
July 8, 2011, at 11:29:04 a.m. EDT from Launch Pad 39A at Kennedy Space Center, FL

Landed
July 21, 2011, at 5:56:58 a.m. EDT on Runway 15 at Kennedy Space Center, FL

Duration
12 days, 18 hours, 27 minutes, and 56 seconds

Distance Traveled
5,284,862 miles

Orbits
200

Crew
Commander Christopher J. Ferguson
Pilot Douglas G. Hurley
Mission Specialists Rex J. Walheim and Sandra H. Magnus

STS-135 was the final mission of the American Space Shuttle program. It used the orbiter Atlantis and hardware originally processed for the STS-335 contingency mission, which was not flown. STS-135 launched on July 8, 2011, and was originally scheduled to land on July 20, but the mission was extended to July 21. The four-person crew was the smallest of any Shuttle mission since STS-6 in April 1983. The mission's primary cargo was the Multipurpose Logistics Module (MPLM) Raffaello and a Lightweight Multipurpose Carrier (LMC). The flight of Raffaello marked the only time that Atlantis carried a MPLM.

Although the mission was authorized, it initially had no congressional appropriation in the NASA budget, raising questions about whether the mission would fly. On January 20, 2011, program managers changed STS-335 to STS-135 on the flight manifest, a move that allowed for training and other mission-specific preparations. In February, NASA program managers told their workforce that STS-135 would fly via a continuing resolution. Until this point, there had been no official reference to STS-135 in NASA's official documentation for the general public.

Fresh from completing mission STS-126, the Space Shuttle Endeavour, mounted on its modified Boeing 747 carrier aircraft, flies over California's Mojave Desert en route to the Kennedy Space Center (KSC) in Florida on December 10, 2008.

The Space Shuttle Orbiter Facts

Orbiter
Enterprise

Designation
OV-101, Test Vehicle

Rollout
September 17, 1976

Weight
150,000 pounds

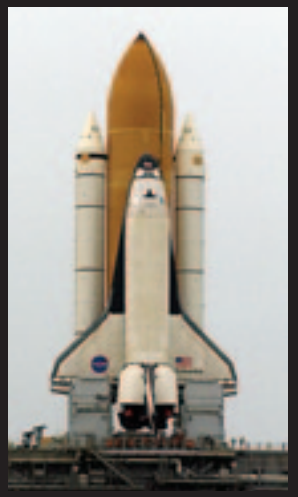
Flights Flown
0

Miles Traveled
0

Orbits
0

Crew Flown
0

Status
Decommissioned to the Intrepid Sea, Air & Space Museum, New York



Orbiter
Columbia

Designation
OV-102

Rollout
March 8, 1979

Weight
178,000 pounds

Flights Flown
28

Miles Traveled
121,696,993

Orbits
4,808

Crew Flown
160

Status
Lost

Orbiter
Challenger

Designation
OV-099

Rollout
June 30, 1982

Weight
175,111 pounds

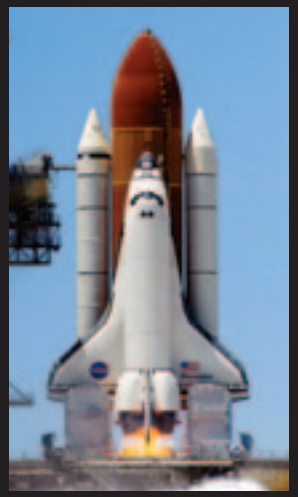
Flights Flown
10

Miles Traveled
23,661,290

Orbits
995

Crew Flown
60

Status
Lost



Orbiter
Discovery

Designation
OV-103

Rollout
October 16, 1983

Weight
171,000 pounds

Flights Flown
39

Miles Traveled
148,221,675

Orbits
5,830

Crew Flown
252

Status
Decommissioned to the National Air and Space Museum, Virginia

Orbiter
Atlantis

Designation
OV-104

Rollout
March 6, 1985

Weight
171,000 pounds

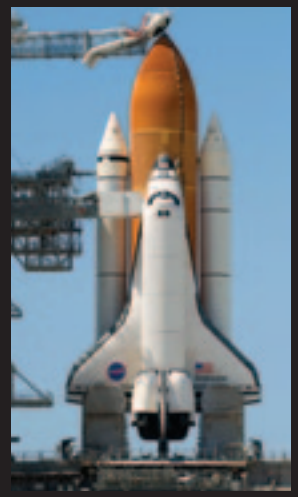
Flights Flown
33

Miles Traveled
125,935,769

Orbits
4,848

Crew Flown
207

Status
Decommissioned to the Kennedy Space Center Visitor's Complex, Florida



Orbiter
Endeavour

Designation
OV-105

Rollout
April 25, 1991

Weight
172,000 pounds

Flights Flown
25

Miles Traveled
122,883,151

Orbits
4,671

Crew Flown
173

Status
Decommissioned to the California Science Center, Los Angeles

Six NASA astronauts, three Russian cosmonauts, and one Japanese astronaut reunite in the International Space Station's U.S. Node 2, or Harmony, following a July 10, 2011, docking of the Space Shuttle Atlantis and the Station.

International Astronauts

Country
Russia

Space Flights
26

Astronauts
20

Country
Canada

Space Flights
14

Astronauts
8

Country
Japan

Space Flights
12

Astronauts
7

Country
France

Space Flights
9

Astronauts
7

Country
Germany

Space Flights
9

Astronauts
7

Country
Italy

Space Flights
6

Astronauts
5

Country
Switzerland

Space Flights
4

Astronauts
1

Country
Sweden

Space Flights
2

Astronauts
1

Country
Belgium

Space Flights
1

Astronauts
1

Country
Israel

Space Flights
1

Astronauts
1

Country
Mexico

Space Flights
1

Astronauts
1

Country
Netherlands

Space Flights
1

Astronauts
1

Country
Saudi Arabia

Space Flights
1

Astronauts
1

Country
Spain

Space Flights
1

Astronauts
1

Country
Ukraine

Space Flights
1

Astronauts
1

A Tribute to Challenger

A Tribute to Columbia


United States
Discovery

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