

National Aeronautics and Space Administration



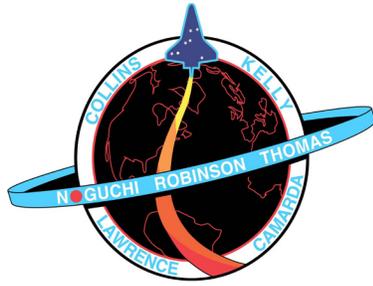
Volume 3

Space Shuttle Mission Chronology

2005 – 2006

STS-114

17th Space Station Flight



Discovery

Pad B:

114th shuttle mission
31st flight of OV-104
50th California landing

Crew:

Eileen Collins, commander (4th shuttle flight)
James Kelly, pilot (2nd)
Soichi Noguchi (JAXA), mission specialist (1st)
Stephen Robinson, mission specialist (3rd)
Andrew Thomas, mission specialist (4th)
Wendy Lawrence, mission specialist (4th)
Charles Camarda, mission specialist (1st)

Orbiter Preps:

OPF – Aug. 22, 2001; Oct. 24, 2001; Jan. 28, 2002;
March 8, 2002; April 24, 2002; June 20, 2002; Aug. 22,
2002; March 29, 2005 (rollover)

VAB – Sept. 17, 2001 (storage); Nov. 28, 2001 (stor-
age); April 17, 2002 (storage); June 14, 2002; June 26,
2002; July 2, 2002 (transfer aisle); May 26, 2005 (rollback)

Pad A – April 6, 2005; June 15, 2005

Launch:

July 26, 2005, at 10:39 a.m. EDT. A liquid hy-
drogen tank low-level fuel cut-off sensor failed a routine
prelaunch check during the launch countdown July 13,
causing mission managers to scrub Discovery's first
launch attempt. Members of an engineering team met to
review data and possible troubleshooting plans. Some of
the troubleshooting included conducting electromagnetic
interference and ground resistance testing on wiring in the
aft engine compartment. On July 26, the countdown was
flawless and liftoff occurred on time.

Landing:

Aug. 9, 2006, at 8:11:22 a.m. EDT. Landed on
Runway 22, Edwards Air Force Base, Calif. Main gear
touchdown: 8:11:36 a.m. Nose gear touchdown: 8:11:41
a.m. Wheel stop: 8:12:36 a.m. Rollout distance: 1.5 miles.
Mission duration: 13 days, 21 hours, 32 minutes and 48
seconds. Landed on orbit 219. Logged 5.8 million miles.
Waived off 2 landing opportunities Aug. 9 at KSC due to
weather. Landed on first opportunity at EAFB, marking
the 6th night landing at Edwards and the 50th Shuttle

landing in California. Kennedy Space Center was beset
with weather issues starting Aug. 7, the original landing
date. Several landing opportunities at KSC were waived
off Aug. 8 and again Aug. 9. Edwards was chosen as the
preferred landing site.

Mission Highlights:

Discovery's climb to orbit was extensively document-
ed 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 Dis-
covery's new Orbiter Boom Sensor System 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.

When Discovery neared the Station early Thursday
morning, Krikalev and Phillips used digital cameras and
high-powered 800-mm and 400-mm lenses to photo-
graph Discovery's thermal protective tiles and key areas
around its main and nose landing gear doors. All imagery
was downlinked to a team of 200 to analyze.

Before docking with the Space Station, Commander
Eileen Collins performed the first Rendezvous Pitch Ma-
neuver about 600 feet below the Station. The motion
flipped the Shuttle end over end at 3/4 degree per sec-
ond, allowing Expedition 11 crew members to photograph
the underside of Discovery and its heat-resistant tiles in
detail.

Imagery during launch showed a piece of foam be-
ing shed from the external tank, as well as smaller tile and
foam dings. Imagery of the tiles showed two areas where
gap fillers were protruding.

Mission managers spent several days to determine
if any action would be required of the crew. They finally
decided to allow Robinson attempt to pull out the protrud-
ing gap fillers with his hand or with forceps, or remove
the protrusions with a hacksaw. The astronauts reviewed
training for using the robotic arm and worked on assem-
bling a hacksaw should they need it.

A puffed out piece of thermal blanket near the cockpit
was identified in the imagery and became another area of
concern. Tunnel tests at NASA's Amers Research Cen-
ter in California and further engineering analysis showed
there was little reason to be concerned about debris
release during re-entry.

Prior to the first spacewalk, Mission Specialist Wendy
Lawrence and Pilot James Kelly guided the Station's ro-
botic arm, Canadarm2, to lift the Multi-Purpose Logistics
Module Raffaello from Discovery's Cargo Bay for attach-
ment to the Unity module. More inspection of Discovery
was conducted by Mission Specialist Charles Camarda
and Kelly.

During the mission, astronauts tested and examined
tiles in demonstration of repair techniques.

Other time was spent transferring equipment and supplies on the Station as well as removing and stowing the same on the MPLM Raffaello for return to Earth.

Three spacewalks were planned and conducted, including an add-on task for the gap filler removal:

EVA No. 1 — 6 hours, 50 minutes.

Mission Specialists Stephen Robinson and Soichi Noguchi worked with tiles and reinforced carbon-carbon intentionally damaged on the ground and brought into space in Discovery's cargo bay. They tested an Emittance Wash Applicator for tile repair and Non-Oxide Adhesive eXperimental for the reinforced carbon-carbon samples. They also installed a base and cabling for a stowage platform and rerouted power to Control Moment Gyroscope-2, one of four 600-pound gyroscopes that control the orientation of the Station in orbit.

EVA No. 2 — 7 hours, 14 minutes.

Noguchi and Robinson removed the failed CMG-1 and stowed it. They moved the new CMG from the payload bay and installed it. Four functioning CMGs now serve the Space Station.

EVA No. 3 — 6 hours, 1 minute.

Attached to the Canadarm2, Robinson was moved to the site on Discovery's underside where he gently pulled the two protruding gap fillers from between thermal protection tiles. Other events were installing an external stowage platform outside the Station to house spare parts and installing a fifth Materials International Space Station Experiment (MISSE). MISSE 5 exposes samples of various materials to the harsh space environment for several months.

Mission managers added one more day to the mission, to follow the third spacewalk. Both the Discovery crew and Expedition 11 crew paid tribute to the Columbia crew and other astronauts and cosmonauts who have lost their lives in the human exploration of space.

The MPLM was unberthed from the Unity node using the robotic arm and placed back in Discovery's cargo bay. Discovery and the MPLM carried 7,055 pounds of unneeded equipment and trash. Both the Canadarm2 and OBSS were restored to their locations in the cargo bay.

STS-121

18th Space Station Flight

Discovery

Pad B:

115th shuttle mission
32nd flight of OV-103
62nd KSC landing

Crew:

Steven Lindsey, commander (4th shuttle flight)
Mark Kelly, pilot (2nd)
Piers Sellers, mission specialist (2nd)
Michael Fossum, mission specialist (1st)
Lisa Nowak, mission specialist (1st)
Stephanie Wilson, mission specialist (1st)
Thomas Reiter, mission specialist (1st), representing the European Space Agency (ESA)

Orbiter Preps:

OPF – Aug. 22, 2005
VAB – May 12, 2006
Pad B – May 19, 2006

Launch:

July 4, 2006, at 2:38 p.m. EDT. Launch of Discovery was scrubbed twice, July 1 and 2, due to weather concerns. After a day's standdown, the launch attempt resumed on July 4 and liftoff occurred on time.

Landing:

July 17, 2006, at 9:15 a.m. EDT. Landed on Runway 15 at KSC. Main gear touchdown: 9:14:43 a.m. Nose gear touchdown: 9:14:53 a.m. Wheel stop: 9:15:49 a.m. Rollout distance: 4.2 miles. Mission duration: 12 days, 18 hours, 37 minutes and 54 seconds. Logged 5.3 million miles. Landed on first opportunity at KSC, marking the 62nd landing at Kennedy.

Mission Highlights:

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 station assembly. The mission also restored the station to a three-person crew for the first time since May 2003, leaving ESA astronaut 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 and climb to orbit. The images helped assess any damage sustained and potential risk for landing. In addition, the crew used the orbiter boom sensor system with a laser dynamic range imager, laser camera system and intensified television camera on the end, 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 multi-purpose logistics module Leonardo to the Unity module from which they moved 7,400 pounds of supplies and equipment during their stay. The cargo included a new heat exchange for the common cabin air assembly that collects 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 suit and emergency jet pack.

Astronauts performed three spacewalks:

EVA No. 1 — 7 hours, 31 minutes.

Mission Specialists Piers Sellers and Michael Fossum installed a blade blocker on the S0 truss in the zenith interface umbilical assembly to protect the undamaged power, data and video cable. They rerouted the cable through the IUA in order to move the mobile transporter rail car and replace the trailing umbilical system with the severed power and data cable. After that task, they tested the combination of the shuttle robotic arm and OBSS as a platform for spacewalking astronauts to repair a damaged orbiter if ever needed. The EVA was the fourth for Sellers and first for Fossum.

EVA. No. 2 — 6 hours, 47 minutes.

Sellers and Fossum restored the station's mobile transporter car to full operation, replacing the nadir-side trailing umbilical system, including a new interface umbilical assembly without a blade (the previous IUA had a blade, which inadvertently cut the cable that required the replacement). During the spacewalk, Fossum's emergency jet thruster backpack came loose on one side, requiring Sellers to secure it.



EVA No. 3 — 7 hours, 11 minutes.

The third and final spacewalk focused on testing repairs on thermal protection system reinforced carbon-carbon panels. Under evaluation was a pre-ceramic polymer sealant containing carbon-silicon carbide powder known as NOAX for use on damaged panels. Sellers and Fossum made three gouge repairs and two crack repairs. They also photographed the samples, as well as an area of Discovery's port wing.

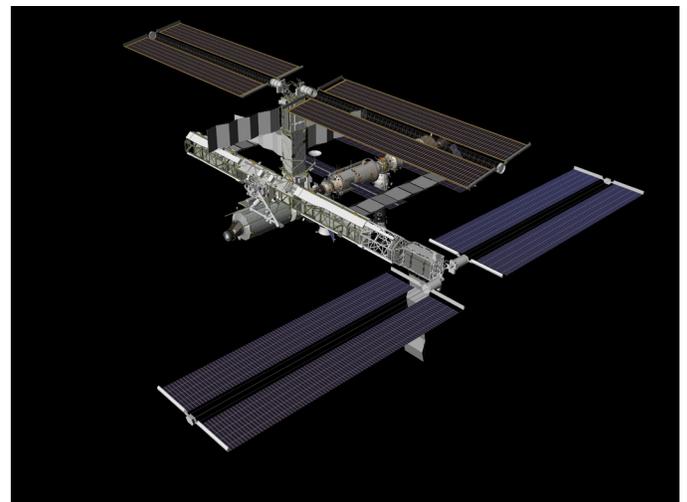
An added task during the EVA was removing the fixed grapple bar on the integrated cargo carrier in Discovery's payload bay and installing it on an ammonia tank inside the station's S1 truss to facilitate moving the tank on a later mission.

Refilled with 4,600 pounds of experiment samples, broken equipment and trash to be returned to Earth, Leonardo was moved back to Discovery's payload bay.

The return flight to Earth was delayed one day in order to add the third spacewalk. The mission management team determined there were enough consumables to extend the mission to test repair techniques and test a thermal imaging camera.

The trip home was one crew member short. Reiter remained behind to join Expedition 13, marking the first time since May 2003 that the station houses three crew members.

After unberthing from the station, the shuttle crew again used the robotic arm and boom sensors to inspect the starboard wing and nose cap heat shield. Still, no concerns were noted.



The International Space Station in August 2006.

STS-115

19th Space Station Flight



Atlantis

Pad B:

- 116th shuttle mission
- 27th flight of OV-104
- 63rd landing at KSC
- 15th night landing at KSC

Crew:

- Brent Jett, commander (4th shuttle flight)
- Christopher Ferguson, pilot (1st)
- Joseph Tanner, mission specialist (4th)
- Daniel Burbank, mission specialist (2nd)
- Steven MacLean, mission specialist (2nd)
- Canadian Space Agency
- Heidemarie Stefanyshyn-Piper, mission specialist (1st)

Orbiter Preps:

- OPF – Oct. 18, 2002
- VAB – July 24, 2006
- Pad B – Aug. 2, 2006

Launch:

Sept. 9 at 11:14:55 a.m. EDT. A lightning strike at the pad Aug. 25 caused the launch to slip to Aug. 27. As assessments of the strike's impact were conducted, Tropical Storm Ernesto threatened the Space Coast. Atlantis was rolled halfway back to the Vehicle Assembly Building on Aug. 29 for protection from the storm, but returned to the pad again on the same day after shuttle managers received a more favorable weather forecast.

Launch was rescheduled for Sept. 6 but a fuel cell problem occurred prior to tanking and the launch was scrubbed for 24 hours.

The crew boarded Atlantis again on Sept. 8 but the launch was again scrubbed 24 hours due to a faulty sensor reading.

Launch was successful Sept. 9.

Landing:

Sept. 21, 2006, at 6:21 a.m. EDT.

Atlantis landed on first opportunity, orbit 187, on Runway 33. Overall, the vehicle traveled 4,901,268 statute miles. Main gear touchdown was at 6:21:30 a.m. Nose gear touchdown was at 6:21:36 a.m. Wheel stop was

at 6:22:16 a.m. Rollout distance: 10,500 feet. Mission elapsed time was 11 days, 19 hours and six minutes.

The landing scheduled for Sept. 20 was postponed to allow for additional inspections of the spacecraft after video from cameras aboard the orbiter showed a piece of debris in proximity to the vehicle. The inspections included use of the orbiter boom sensor system and ensured all of Atlantis' critical equipment were in good shape.

Mission Highlights:

This mission resumed assembly of the International Space Station after a hiatus of four years.

Before the docking, the crew used the orbiter boom sensor system, the 50-foot-long extension for the shuttle's robotic arm, to inspect the reinforced carbon-carbon panels along the leading edge of Atlantis' starboard and port wings and the nose cap.

Approaching the space station, Commander Brent Jett flew Atlantis through an orbital back-flip while stationed 600 feet below the station to allow the Expedition 13 crew to photograph the orbiter's heat shield.

After the docking, Ferguson and 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 hatch opening, MacLean and Expedition 13 Flight Engineer Jeff 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 the spacewalkers avoid the condition known as the bends.

EVA No. 1 – 6 hours, 26 minutes, Sept. 12.

Tanner and Piper connected power cables on the 17.5-ton, 45-foot-long truss, released the launch restraints on the solar array blanket box and on the beta gimbal assembly and the solar array wings. They also configured the solar alpha rotary joint, which allows the arrays to track the sun, and removed two other circuit interrupt devices to prepare for the STS-116 mission.

To access the launch locks on the solar alpha rotary joint, the astronauts had to remove existing covers. This was a "get-ahead" task originally scheduled for the following day. Tanner and Piper's quick and efficient work enabled them to get ahead of the planned timeline. During this procedure on cover 21, a bolt and washer came off and floated into space.

EVA No. 2 — 7 hours, 11 minutes, Sept. 13.

First-time spacewalkers Dan Burbank and Steve MacLean released locks on the auto-sized solar alpha rotary joint, which allows the station's solar arrays to turn toward the sun. The locks had held the joint secure during its launch to orbit.

Minor problems occurred, including a malfunctioning helmet camera, a broken socket tool, a stubborn bolt requiring both astronauts to turn it, and a bolt that loosened from the mechanism designed to hold it.

EVA No. 3 — 6 hours, 42 minutes, Sept. 15.

Tanner and Piper powered up a cooling radiator for the newly unfolded solar arrays. They also replaced an S-band radio antenna that provides backup communications between the space station and the ground.

Other tasks, designed to reduce workload for future spacewalkers, included installing insulation for another communications antenna and (Tanner) taking photos of the shuttle's wings with an infrared camera to test its ability to detect damage.

After astronauts had prepared the solar alpha rotary joint for activation, Mission Control engaged the first of two drive-lock assemblies and rotated the joint 180 degrees. When they commanded the second drive-lock assembly to engage, they did not get an indication of engagement. A second command also failed. The glitch was resolved overnight.

The solar arrays on the newly delivered 17.5-ton truss segment were fully unfolded at 8:44 a.m. EDT on Sept. 14. During the unfurling, Atlantis' astronauts noted that some of the panels stuck. The phenomenon, called "stiction," also occurred during a shuttle mission in late 2000 when the station's first set of solar panels was deployed.

The power generated by the arrays will not be used by the station until mission STS-116, in December 2006, when astronauts will rewire the complex and activate a cooling system. The arrays currently are powering their own system, including batteries and other electronics equipment.

The solar panels have a wingspan of 240 feet attached on the port side of the station. They can generate 66 kilowatts of power.

The crew also maneuvered the Canadarm2 robotic arm in a "double walk off," moving it from the Mobile Base System to the Destiny Lab in an inchworm-like procedure.

STS-116

20th Space Station Flight

Discovery

Pad B:

117th shuttle mission
33rd flight OV-103
64th landing at KSC

Crew:

Mark Polansky, commander (2nd shuttle flight)
William Oefelein, pilot (1st)
Robert Curbeam, mission specialist (3rd)
Joan Higginbotham, mission specialist (1st)
Nicholas Patrick, mission specialist (1st)
Christer Fuglesang, mission specialist (ESA) (1st)
Sunita Williams, mission specialist (1st), to ISS
(Thomas Reiter returning)

Orbiter Preps:

OPF – July 17, 2006
VAB – Oct. 31, 2006
Pad B – Nov. 9, 2006

Launch:

Dec. 9, 2006, at 8:47 p.m. EST. NASA managers postponed the Dec. 7 space shuttle launch attempt until Dec. 9 because of low cloud cover. The interim day's weather was not expected to be favorable for a launch attempt.

The Space Shuttle Discovery and its seven-member crew lifted off Dec. 9 from NASA's Kennedy Space Center in Florida on one of the most complex missions ever to the International Space Station.

Landing:

Dec. 22 at 5:32 p.m. EST. On KSC Runway 15. Nose gear touchdown was at 5:32:12 p.m. and wheel stop was at 5:32:52 p.m. Mission elapsed time was 12 days, 20 hours, 44 minutes and 16 seconds. This was the 64th landing at KSC.

The original landing date of Dec. 21 was postponed due to the addition of a fourth spacewalk. Inclement weather at KSC caused some concern and the first landing opportunity at 3:56 p.m. EST was waved off. The first chance for landing at Edwards Air Force Base in California was passed due to gusty winds. Weather conditions at



KSC took a dramatic turn for the better and landing proceeded on the second opportunity. Returning with the crew was astronaut Thomas Reiter after his six-month tenure as part of the Expedition 14 crew on the space station. He was replaced by Flight Engineer Suni Williams.

Mission Highlights:

Discovery rocketed into a dark Florida sky on the first night launch in more than four years. After reaching orbit, the crew used the shuttle's robotic arm and orbiter boom sensor system to examine Discovery's thermal protection system.

Docking with the International Space Station occurred at 4:12 p.m. Dec. 11. An impromptu wing inspection was called for after a minor vibration reading on the port wing sensor. The imagery analysis team determined the shuttle's heat shield could support a safe return to Earth and further inspection was not needed.

Three spacewalks (EVAs) were planned to unberth the P5 truss from Discovery's payload bay, install it on the station's main truss and rewire the station's electrical system to its permanent power grid.

Using a start-stop-restart process, the crew spent six hours Dec. 13 attempting to fold and retract the port array on the P6 integrated truss structure without success. Guidewires apparently snagged. Repeated attempts the next day were also unsuccessful. A fourth and unscheduled spacewalk was added to the mission to try again to loosen and retract the port array.

With the fourth EVA, Mission Specialist Robert Curbeam set a record for the most spacewalks during a shuttle mission. He has a total of 45 hours, 34 minutes of spacewalking time.

The total time spent on spacewalks on this mission was 25 hours, 45 minutes.

Before undocking from the station, Mission Specialist Joan Higginbotham and her cargo team transferred more than two tons of food, water and equipment for the Expedition 14 crew. They also filled Discovery's pressurized cargo carrier with equipment and experiment samples for return to Earth.

EVA No. 1 - 6 hours, 36 minutes: Dec. 12.

Mission Specialists Curbeam and Christer Fuglesang attached the P5 truss and replaced a failed camera needed to support future assembly tasks. They completed additional tasks of plugging the new segment into the existing truss, removing the locks that held it steady during launch, and opening a latch to allow the P6 segment to be attached at the end when it is moved from its temporary location.

EVA No. 2 - 5 hours: Dec. 14

Curbeam and Fuglesang exited Discovery again to start rewiring the station's power. Using power generated by the solar arrays delivered in September, they rewired channels two and three. Before the cable connections could be swapped, some of the station's systems, such as lights, communication gear, ventilation fans and backup computers, had to be shut down. In less than three hours, one of two external thermal control system loops was shedding excess heat into space and the DC-to-DC converter units were regulating power voltages.

Despite problems retracting the P6 solar array, the P4 arrays were able to rotate and track the sun, generating power for the station.

Curbeam and Fuglesang also were able to relocate two small handcarts on the rails of the station's main truss, put a thermal cover on the station's robotic arm, and install bags of tools for future spacewalkers.

EVA No. 3 - 7 hours, 31 minutes: Dec. 16

Curbeam and Williams finished rewiring the station. They also installed a robotic arm grapple fixture and positioned three bundles of Russian debris shield panels outside the Zvezda service module, to be installed on a future spacewalk. Then the spacewalkers tackled grommets and guide wires on the P6 solar array and shook the array while the crew inside the station reeled it in one bay at a time. They achieved 65 percent retraction.

EVA No. 4 - 6 hours, 38 minutes: Dec. 18

Curbeam and Fuglesang finished the P6 retraction, guiding the array into its blanket box. They were aided by Williams and Higginbotham who used the station's robotic arm to position the spacewalkers near the array. Afterward, the spacewalkers also secured multi-layer insulation that had been installed on the robotic arm during an earlier spacewalk.

The retraction set the stage for the spring 2007 shuttle mission, when the station's starboard overhead array will also be stowed. The arrays will be moved to the far end of the port truss on STS-120 and redeployed.

The crew wrapped up eight days of docked operations, separating from the space station on Dec. 19. On Dec. 20, they inspected the heat shield for possible micrometeoroid debris damage using the sensor-equipped orbiter boom sensor system unfolded from the payload bay. They also deployed small technology demonstration

satellites, known as MEPSI or Micro-Electromechanical System-based PICOSAT Inspector, for the U.S. Department of Defense's Space Test Program, as well as student-experiment scientific satellites and the Atmospheric Neutral Density Experiment (ANDE) that will measure the density and composition of the low-Earth-orbit atmosphere while tracked from the ground.

On Dec. 21, Mission Control confirmed the shuttle's heat shield was in good shape and the crew and orbiter could plan for a safe landing.



The International Space Station after mission STS-116 in December 2006.

**Space Shuttle Mission Chronologies Volumes 1 and 2
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