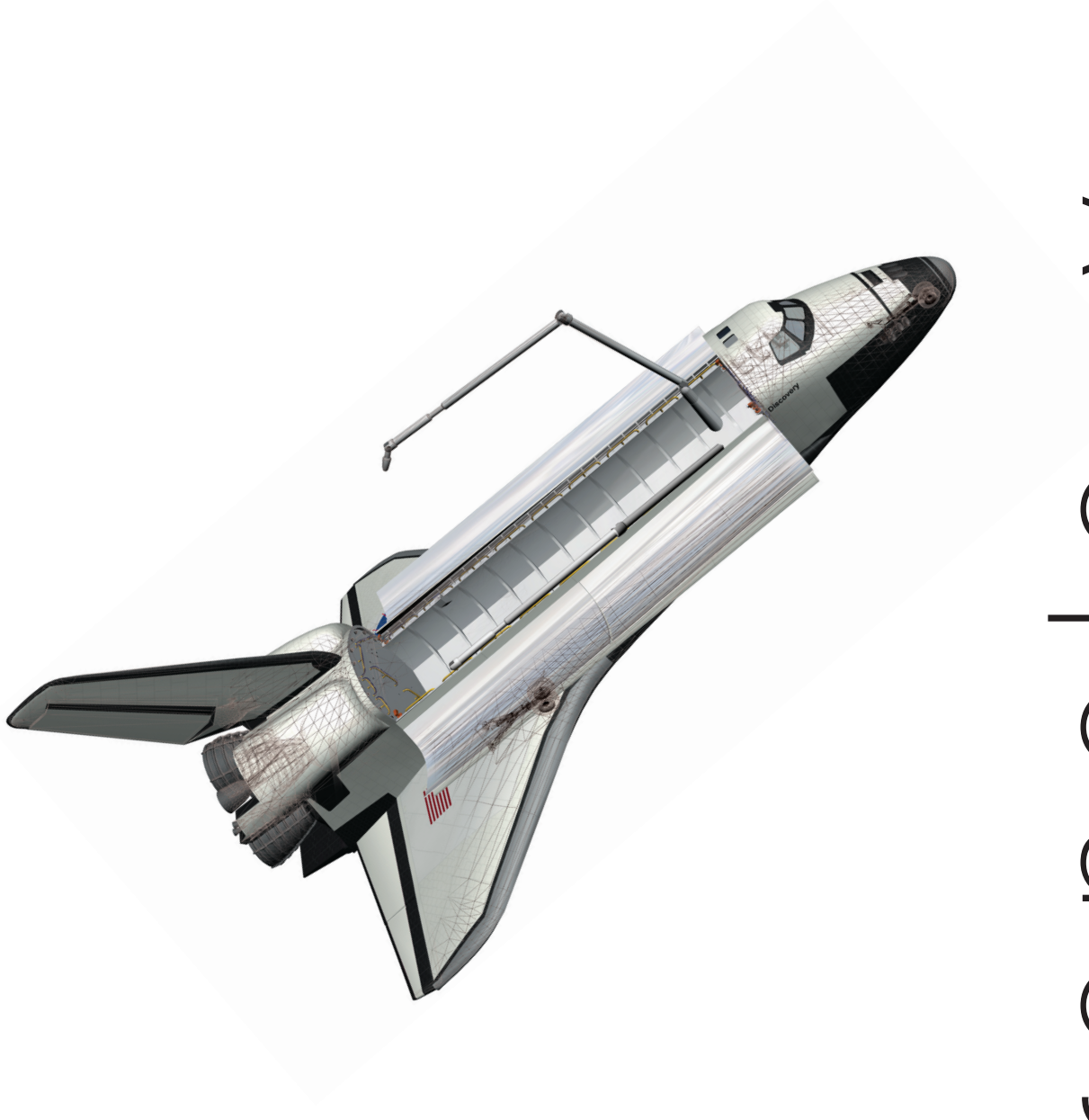
National Aeronautics and Space Administration



chronology

Volume 3
Space Shuttle Missions
2005 - 2009

2005

STS-114

17th Space Station Flight

Discovery

Pad 39B:

114th shuttle mission
31st flight of OV-103
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 (return); Oct. 24, 2001; Jan. 28, 2002; March 8, 2002; April 24, 2002; June 20, 2002; Aug. 22, 2002 (begins OMM); March 29, 2005 (rollover)

VAB – Sept. 17, 2001 (storage); Nov. 28, 2001 (storage); 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 (rollout)

Launch:

July 26, 2005, at 10:39 a.m. EDT. A liquid hydrogen 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 on 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 Kennedy 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 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, or 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.

When Discovery neared the station early Thursday morning, Krikalev and Phillips used digital cameras and high-powered 800-mm and 400-mm lenses to photograph 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 maneuver about 600 feet below the station. The motion flipped the shuttle end over end at 3/4 degree per second, 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 being 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 protruding 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 assembling 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 Center 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 robotic arm, Canadarm2, to lift the multipurpose logistics module, or MPLM, Raffaello from Discovery's cargo bay for attachment 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 — July 30: 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, or CMG, one of four 600-pound gyroscopes that control the orientation of the station in orbit.

EVA No. 2 — Aug. 1: 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 — Aug. 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.

2006

STS-121

18th Space Station Flight

Discovery

Pad 39B:

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 (return)
VAB – May 12, 2006 (rollover)
Pad B – May 19, 2006 (rollout)

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 — July 8: 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, or IUA, 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 — July 10: 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 — July 12: 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.

STS-115

19th Space Station Flight

Atlantis

Pad 39B:

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), representing the Canadian Space Agency
Heidemarie Stefanyshyn-Piper, mission specialist (1st)

Orbiter Preps:

OPF – Oct. 18, 2002 (return)
VAB – July 24, 2006 (rollover)
Pad B – Aug. 2, 2006 (rollout)

Launch:

Sept. 9, 2006, 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 — Sept. 12: 6 hours, 26 minutes.

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 proce-

dure on cover 21, a bolt and washer came off and floated into space.

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

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 — Sept. 15: 6 hours, 42 minutes.

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 39B:

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 (return)
VAB – Oct. 31, 2006 (rollover)
Pad B – Nov. 9, 2006 (rollout)

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, 2006, 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 Expediction 14 crew. They also filled Discovery's pressurized cargo carrier with equipment and experiment samples for return to Earth.

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

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 - Dec. 14: 5 hours.

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 - Dec. 16: 7 hours, 31 minutes.

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 – Dec. 18: 6 hours, 38 minutes.

Curbeam and Fuglesang finished the P6 retraction, guiding the array into its blanket box. They were aided by Willilams 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.

2007

STS-117

21st Space Station Flight

Atlantis

Pad 39A:

118th Shuttle mission
28th flight OV-104
51st landing at EAFB

Crew:

Rick Sturckow, commander (3rd shuttle flight)
Lee Archambault, pilot (1st)
Jim Reilly, mission specialist (3rd)
Patrick Forrester, mission specialist (2nd)
Steven Swanson, mission specialist (1st)
John "Danny" Olivas, mission specialist (1st)
Clay Anderson, Expedition 15/16 flight engineer, to ISS
Sunita Williams, Expedition 14/15 flight engineer, return from ISS after record 194 days, 18 hours, 58 minutes in space

Orbiter Preps:

OPF – Sept. 21, 2006 (return)
VAB – Feb. 7, 2007 (rollover)
Pad A – Feb. 15, 2007 (rollout)
VAB – March 4 (rollback)
Pad A – May 15, 2007, 2nd time (rollout)

Launch:

June 8, 2007, at 7:38:04 p.m. EDT. The space shuttle Atlantis rocketed into a Florida twilight sky on time, kicking off the first of four shuttle missions scheduled for 2007. Atlantis' climb to orbit was flawless, carrying a seven-member crew.

The mission was delayed in February after the shuttle suffered hail damage on the 26th to tiles and the external tank. The decision was made to roll back the shuttle and make repairs in the VAB.

Landing:

June 22, 2007, at 3:49:38 p.m. EDT. Atlantis landed on Runway 22 at Edwards Air Force Base in California, concluding a 13-day, 20-hour, 12-minute flight covering 5.8 million miles. The landing was diverted to California due to marginal weather at Kennedy. Main gear touchdown was at 3:49:38 p.m. EDT. Nose gear touchdown was at 3:49:49 p.m. and wheel stop was at 3:50:48 p.m. This was the 51st landing for the Space Shuttle Program at Edwards Air Force Base.

After preparations for a cross-country, piggyback flight on a shuttle carrier aircraft, Atlantis left EAFB on July 1. Several fuel stops and weather delays brought Atlantis to KSC on July 3, touching down at 8:27 a.m. EDT.

Mission Highlights:

On June 8, the crew used the robotic arm to take a closer look at an area of an insulation blanket on the port orbital maneuvering system pod that was seen to be pulled away from adjacent thermal tiles. On June 9, Pilot Lee Archambault and Mission Specialists Patrick Forrester and Steve Swanson used the shuttle's robotic arm and an extension boom-mounted sensor system to inspect the heat shield on Atlantis' wing leading edges and nose cap.

Clay Anderson was transferred to the International Space Station as an official station crewmember of Expedition 15 and Flight Engineer Suni Williams swapped places to join the Atlantis crew.

An issue surfaced during the mission with the Russian segment computers that provide backup attitude control and orbital altitude adjustments. Russian specialists worked with U.S. teams, troubleshooting and restoring computer capabilities. The shuttle's propulsion provided backup.

By June 15, Yurchikhin and Kotov got two of three lanes in both computers running after bypassing with external cabling what appeared to be a faulty power switch. They repeated the modification on the last two channels.

On June 18, the Russians were able to demonstrate the station's ability to maintain attitude control,

enabling the shuttle's departure.

Activation of the rotary joint provided use of four U.S. solar array wings tracking the sun during orbit of the station. Atlantis undocked from the station June 19, leaving behind 19 tons of food, water and equipment. A flyaround provided a good look at the reconfigured spacecraft. At a distance of 46 miles from the station, the shuttle robot arm and orbiter boom sensor system were used to inspect the thermal protection system on both wings and the orbiter's nose cap.

EVA No. 1 — June 11: 6 hours, 15 minutes.

Mission Specialists Jim Reilly and Danny Olivas focused on the final attachment of bolts, cables and connectors to begin the activation of the S3/S4 truss segment and ready it for deployment of its solar arrays.

The spacewalk was delayed for about an hour after the station temporarily lost attitude control when the station's control moment gyroscopes went offline due to the mass of the new truss segment in the final stage of its attachment. The loss was not unexpected because of the station's skewed asymmetry as the 17.8-ton, bus-sized S3/S4 truss was being moved toward the S1 truss.

EVA No. 2 — June 13: 7 hours, 16 minutes.

After station controllers unfurled the solar array attached to the newly installed S3/S4 truss segment on June 12 to soak up some sun, Forrester and Swanson removed all of the launch locks holding the 10-foot-wide solar alpha rotary joint in place.

The spacewalkers ran into a problem when Forrester tried to install a drive-lock assembly and found that commands being sent to it were actually being received by a drive-lock assembly installed during the mission's first spacewalk. Flight controllers confirmed that the drive-lock assembly installed earlier was in a safe configuration.

Spacewalkers also had to help retract an older solar array to clear the new array's path. All in all, 13 of the 31.5 solar array bays were folded.

EVA No. 3 — June 15: 7 hours, 58 minutes.

Olivas spent two hours stapling and pinning down a thermal blanket on Atlantis' orbital maneuvering system, or OMS, pod. A 4-inch by-6-inch corner had peeled up during the launch.

Reilly installed the hydrogen vent valve of a new oxygen generation system on the Destiny laboratory.

Both Olivas and Reilly aided in retracting the P6 truss. The retraction sequence required 28 commands for a total of 45 to complete the task.

EVA No. 4 — June 17: 6 hours, 29 minutes.

Forrester and Swanson retrieved a TV camera from a stowage platform attached to Quest and installed it on the S3 truss. They verified the drive- lock assembly 2 configuration and removed the last six solar alpha rotary joint launch restraints.

They cleared the path on the S3 truss for the mobile base system and began get-ahead tasks: installing a computer network cable on the Unity node, opening the hydrogen vent valve on the Destiny lab and tethering two orbital debris shield panels on the station's service module.

This was the 11th spacewalk completed in 2007.

STS-118

22nd Space Station Flight

Endeavour

Pad 39A:

119th shuttle mission
20th flight OV-105
65th landing at KSC

Crew:

Scott Kelly, commander (2nd shuttle flight)
Charlie Hobaugh, pilot (2nd)
Dave Williams, mission specialist (2nd)
Barbara R. Morgan, mission specialist (1st)
Rick Mastracchio, mission specialist (2nd)
Tracy Caldwell, mission specialist (1st)
Alvin Drew, mission specialist (1st)

Orbiter Preps:

OPF – Dec. 7, 2002 (return)
VAB – Jan. 9, 2004 (for OPF maintenance)
OPF-2 – Jan. 21, 2004 (return)
VAB HB-4 – Dec. 16, 2004 (rollover)
OPF-2 – Jan 12, 2005
SLF Hangar – Feb. 22, 2005 (for OPF modifications)
OPF – March 18, 2005 (return)
VAB – July 2, 2007 (rollover)
Pad A – July 11, 2007 (rollout)

Launch:

Aug. 8, 2007, at 6:36 p.m. EDT. Launch was on time and Endeavour lifted off into an early evening sky before sunset. Endeavour carried a crew of seven, including teacher-turned-astronaut Barbara R. Morgan. The payload comprised the S5 truss, SPACEHAB module and external stowage platform 3 with a replacement control moment gyroscope, or CMG. This mission was the final one for the SPACEHAB module. Astronauts replaced the CMG for a faulty one on the International Space Station.

The launch returned Endeavour to active service after a three-year hiatus for major modifications. The work, conducted at KSC, included addition of a "glass cockpit," a global positioning system for landing and the Station-to-Shuttle Power Transfer System, known as the SSPTS. The system enables the orbiter to draw power from the space station, enabling an extended stay for the mission.

Landing:

Aug. 21, 2007, at 12:32 p.m. EDT. Endeavour landed on Runway 15 on the first opportunity after deorbit. Main gear touched down at 12:32:16 p.m. EDT. Nose gear touchdown was at 12:32:29 p.m. and wheel stop was at 12:33:20 p.m. Endeavour landed on orbit 201. STS-118 was the second of four shuttle missions planned for 2007.

Mission Highlights:

On Aug. 9, before docking on the space station, the crew took a close look at the heat shielding on Endeavour's wing leading edges. They used the vehicle's robotic arm and orbiter boom sensor system. On Aug. 10, Commander Scott Kelly also performed a backflip with the orbiter so the International Space Station crew could take digital photos of the orbiter's underside, checking the tiles for damage.

The photography showed a 3-inch-round ding on the starboard underside and in-depth analysis showed damage occurred through the tile to the internal framework. After extensive engineering analyses and tests over several days, the mission management team decided not to direct a repair of the shuttle's damaged tile before landing. All members of the team believed that leaving the damaged tile "as is" did not pose a risk to the crew during re-entry.

The shuttle and space station docked at 2:02 p.m. EDT while traveling 214 miles above the southern Pacific Ocean, northeast of Sydney, Australia.

Mission managers first extended the flight to 14 days after successfully drawing power from the station via the SSPTS. The extension enabled a fourth spacewalk. Later, concern over Hurricane Dean's movement toward Texas caused mission managers to end the mission one day early.

Astronauts participated in a first for the space station. Mission Specialists Tracy Caldwell and Morgan installed a 7,000-pound storage platform using only the station's and shuttle's robotic arms. The stowage platform was attached to the P3 truss.

During the spacewalks, astronauts installed the S5 truss, a gyroscope and external stowage platform No. 3.

The mission also included three educational events featuring teacher-turned-astronaut Morgan. On several occasions, Morgan and other astronauts answered questions from children from the Discovery Center in Boise, Idaho, the Challenger Center for Space Science Education in Alexandria, Va., and in Saskatchewan, Canada.

On Aug. 11, the station's primary U.S. Command and Control computer shut down unexpectedly at 2:52 p.m. The redundant system reacted as designed and the primary backup computer took over, and the third computer moved into the backup slot. The shutdown did not affect the spacewalk. Station flight controllers brought up the third computer later after determining an errant software command was the cause of the shutdown.

EVA No. 1 — Aug. 11: 6 hours, 17 minutes.

First-time spacewalkers, Mission Specialists Rick Mastracchio and Dave Williams added the two-ton, 11-foot-long spacer, the Starboard 5 segment of the space station's truss. They also retracted the forward heat-rejecting radiator from the P6 truss, which will be relocated to the end of the port truss during the STS-120 mission.

EVA No. 2 — Aug. 13: 6 hours, 28 minutes.

Williams and Mastracchio installed the 600-pound control moment gyroscope onto the Z1 segment of the station's truss, storing the failed unit outside the station. It will be returned to Earth on a future mission. This was the 90th spacewalk devoted to station maintenance and construction.

EVA No. 3 — Aug. 14: 5 hours, 28 minutes.

Mastracchio and Expedition 16 Flight Engineer Clay Anderson relocated the S-band antenna sub-assembly from P6 to P1, installed a new transponder on P1 and retrieved the P6 transponder. Pilot Charlie Hobaugh and station Flight Engineer Oleg Kotov moved two CETA cards, enabling future relocation of a solar array segment on mission STS-120.

During the EVA, Mastracchio noted a hole on the thumb of his left glove. The hole was in the

second of five layers and did not cause any leak or danger to Mastracchio. However, as a precaution, he returned to the Quest airlock while Anderson completed his final task.

EVA No. 4 — Aug. 18: 5 hours.

Williams and Anderson installed the External Wireless Instrumentation System antenna, attached a stand for the shuttle's robotic arm extension boom and retrieved the two materials experiment containers to be brought home on the shuttle. Two other tasks originally planned for the spacewalk – cleaning up and securing debris shielding and moving a toolbox to a more central location – were deferred to a future spacewalk.

STS-120

23rd Space Station Flight

Discovery

Pad 39A:

120th shuttle mission
34th flight of OV-103
66th landing at Kennedy Space Center

Crew:

Pam Melroy, commander (3rd shuttle flight)
George Zamka, pilot (1st)
Scott Parazynski, mission specialist (5th)
Doug Wheelock, mission specialist (1st)
Stephanie Wilson, mission specialist (2nd)
Paolo Nespoli, ESA, mission specialist (1st)
Daniel Tani (2nd), up to ISS
Clay Anderson, down from ISS

Orbiter Preps:

OPF – Dec. 22, 2006 (return)
VAB – Sept. 23, 2007 (rollover)
Pad A – Sept. 30, 2007 (rollout)

Launch:

Oct. 23, 2007, at 11:38 a.m. EDT. Launch was on time and Discovery lifted off into a partly clouded sky, heading for the International Space Station on the 23rd assembly flight.

Landing:

Nov. 7, 2007, at 1:01 p.m. EST. Discovery landed on Runway 33 at Kennedy Space Center. Main gear touchdown was 1:01:16 p.m. EST. Wheel stop was at 1:02:07 p.m. Mission elapsed time was 15 days, 2 hours, 24 minutes and 2 seconds, covering 6.5 million miles.

Mission Highlights:

During the mission, the STS-120 crew continued the construction of the station with the installation of the Harmony Node 2 module and the relocation of the P6 truss.

Station managers added a 360-degree visual inspection of the station's starboard solar alpha rotary joint, or SARJ, during the second spacewalk. The SARJ had shown increased friction for more than 30 days.

An extra day was added to the mission between the fourth and fifth spacewalks to provide the crew off-duty time and equipment preparation for the fifth spacewalk.

However, the objective of the fourth spacewalk changed in order to repair the torn solar array and the fifth spacewalk was transferred to the station crew to perform after the shuttle left.

Teams on the ground worked around the clock to develop a plan for the repair. Astronauts constructed solar array hinge stabilizers using strips of aluminum, a hole punch, a bolt connector and 66 feet of wire. Working like a cuff link, the wire would feed through a hole on the solar array and be supported by the strip of aluminum.

They also positioned the station's mobile transporter and robotic arm at the end of the truss to serve as a base and "cherrypicker." Crew members insulated tools with Kapton tape to protect against electrical currents.

EVA No. 1 — Oct. 26: 6 hours, 14 minutes.

Mission Specialists Scott Parazynski and Doug Wheelock installed the Harmony module in its temporary location, readied the P6 truss for its relocation two days later, retrieved a failed radio communications antenna and snapped shut a window cover on Harmony that had opened during launch.

EVA No. 2 — Oct. 28: 6 hours, 33 minutes.

Parazynski and flight engineer Daniel Tani disconnected cables from the P6 truss to enable it to be removed from the Z1 truss. Tani inspected the SARJ and collected "shavings" he found under the joint's multi-layer insulation covers. Mission managers limited the use of the SARJ while

they assessed the anomaly.

The spacewalkers also outfitted the Harmony module, mated the power and data grapple fixture and reconfigured connectors on the S1 truss that will allow the radiator on S1 to be deployed from the ground at a later date.

EVA No. 3 — Oct. 30: 7 hours, 8 minutes.

Parazynski and Wheelock installed the P6 truss segment with its set of solar arrays to its permanent home. They installed a spare main bus switching unit on a stowage platform for future use if needed.

Parazynski looked at the port SARJ to compare with the starboard joint. The port SARJ was clean.

When the P6 solar arrays were deployed at the end of the spacewalk, a tear appeared in a blanket. Deployment was halted so engineers could analyze what steps to take next.

Despite the 80-percent deployment, the array was producing nearly normal power.

After reentering the station, Wheelock noticed a small hole in the outer layer of his right glove thumb. Options would be considered before his next spacewalk.

EVA No. 4 — Nov. 1: 7 hours, 19 minutes.

Prior to leaving the station, the orbiter boom sensor system was moved from the shuttle's robotic arm to the station arm. Parazynski and Wheelock then took 90 minutes to ride the arm to the torn array -- 165 feet down the truss and 90 feet up to the damage. Parazynski cut a snagged wire and installed homemade stabilizers to strengthen the array's structure and stability where the damage occurred. Ground controllers then were able to finish the deployment begun on Oct. 30 in increments of one half bay at a time. The procedure took 15 minutes.

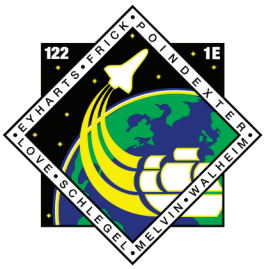
Before the undocking, the shuttle crew transferred items to the shuttle: 2,020 pounds of equipment and scientific samples, including the metal shavings from the SARJ for engineers to study and try to determine the cause of resistance in the starboard rotary joint.

Discovery backed away from the station at 5:32 a.m. EST on Nov. 5.

2008

STS-122

24th Space Station Flight



Atlantis

Pad 39A:

121st shuttle mission
29th flight of OV-104
67th landing at KSC

Crew:

Steve Frick, commander (2nd shuttle flight)
Alan Poindexter, pilot (1st)
Rex Walheim, mission specialist (2nd)
Stanley Love, mission specialist (1st)
Leland Melvin, mission specialist (1st)
Hans Schlegel, mission specialist (2nd), represents European Space Agency
Leopold Eyharts, mission specialist (1st), up to ISS
Daniel Tani, flight engineer, down from ISS

Orbiter Preps:

OPF – July 4, 2007, after ferry-flight from Dryden and arrival July 3 (return)
VAB – Nov. 3, 2007 (rollover)
Pad A – Nov. 10, 2007 (rollout)

Launch:

Feb. 7, 2008, **at 2:45 p.m. EST.** The STS-122 mission was twice delayed in December 2007 after false readings occurred in the engine cut-off sensor system while Atlantis' external fuel tank was being filled. Tests revealed that open circuits in the external tank's electrical feed-through connector were the most likely cause. A modified connector, designed with pins and sockets soldered together, was installed for the mission. The sensor system is one of several that protects the shuttle's main engines by triggering their shut down if fuel runs unexpectedly low.

The launch date was then reset to Feb. 7. The

sensor system was flawless during liftoff.

Landing:

Feb. 20, 2008, at 9:07 a.m. EST. Atlantis landed on Kennedy's Runway 15 after a journey of nearly 5.3 million miles. Main gear touchdown was 9:07:10 a.m. Nose gear touchdown was 9:07:20 a.m. Wheel stop was at 9:08:08 a.m. Mission elapsed time was 12 days, 18 hours, 21 minutes and 44 seconds.

Mission Highlights:

The mission delivered and installed the European Space Agency's Columbus laboratory, whose experiments will be coordinated by a data center to manage the research and collect its results. The Columbus Control Centre is in Oberpfaffenhofen, Germany.

During docking, one of the five computers on the International Space Station experienced problems with guidance and navigation software. The crew used other computers for the shuttle's rendezvous; only one computer is needed for the rendezvous, with one required for backup.

After docking with the space station, Mission Specialist Leopold Eyharts moved onto the orbiting outpost as the newest Expedition 16 crew member and flight engineer Dan Tani returned to the shuttle in his place.

The first spacewalk was postponed a day due to a medical issue with Mission Specialist Hans Schlegel. It was determined that Mission Specialist Stanley Love would take Schlegel's place on the spacewalk.

Close scrutiny of images of the thermal protection system on Atlantis revealed minor damage to a thermal blanket over the shuttle's right orbital maneuvering system pod. Mission managers eventually cleared the shuttle's thermal protection system for re-entry based on inspections.

Mission managers extended the mission an extra day to continue activation of the Columbus laboratory.

The shuttle and station crews spoke with German Chancellor Angela Merkel, ESA Director General Jean-Jacques Dordain and former astronaut Thomas Reiter, who is now a member of the German Space Agency, DLR.

EVA No. 1 — Feb. 11: 7 hours, 58 minutes.

Love and Mission Specialist Rex Walheim installed a grapple fixture on Columbus in the payload bay and prepared electrical and data connections on the module. Astronauts Leland Melvin, Tani and Eyharts used the space station's robotic arm to grab Columbus, lift it out of the orbiter and move it to the starboard side of the station. Walheim and Love also began work to replace a large nitrogen tank used for pressurizing the station's ammonia cooling system.

EVA No. 2 — Feb. 13: 6 hours, 45 minutes.

Walheim and Schlegel replaced the nitrogen tank and, using the station's robotic arm, placed the spent tank into Atlantis' payload bay. The astronauts then made minor repairs to the Destiny laboratory debris shield and worked on tasks to prepare for the final spacewalk.

EVA No. 3 — Feb. 15: 7 hours, 25 minutes.

Guided by Pilot Alan Poindexter, Walheim and Love transferred the first of two external experiment facilities, called SOLAR, to Columbus for installation. Melvin operated the station's robotic arm for the transfer. The astronauts also retrieved a stored failed gyroscope and moved it into Atlantis' payload bay for return to Earth. They then installed a second experiment onto Columbus, the European Technology Exposure Facility, or EuTEF. Finally, Walheim and Love examined a damaged handrail on the outside of the Quest airlock. They rubbed a tool covered with spacewalk overglove material over it to see if the handrail could be the source of glove abrasions occurring during recent activity outside the station.

All crew members worked to activate and initialize the Columbus laboratory, outfitting it with experiment racks.

Atlantis' propulsion system was used to reboost the station's altitude by about 1.4 miles -- the first reboost of the station using shuttle thrusters since 2002 -- to achieve proper alignment of the station in advance of the March arrival of space shuttle Endeavour on the STS-123 mission.

Hatches between the station and Atlantis were closed at 1:03 p.m. EST on Feb. 17. Atlantis undocked at 4:24 a.m. EST on Feb. 18.

STS-123

25th Space Station Flight

Endeavour

Pad 39A:

122nd shuttle mission
21st flight of OV-105
16th night landing at KSC

Crew:

Dominic Gorie, commander (4th shuttle flight)
Gregory Johnson, pilot (1st)
Richard Linnehan, mission specialist (4th)
Robert Behnken, mission specialist (1st)
Michael Foreman, mission specialist (1st)
Takao Doi, mission specialist (2nd), represents Japan Aerospace Exploration Agency
Garrett Reisman, mission specialist (1st), up to ISS
Leopold Eyharts, flight engineer, down from ISS

Orbiter Preps:

OPF – 08/21/07 (return)
VAB – 02/11/08 (rollover)
Pad A – 02/18/08 (rollout)

Launch:

March 11, 2008, at 2:28 a.m. EDT. After a smooth countdown with no weather concerns, the night launch was on time. A low cloud cover quickly swallowed the shuttle from ground view.

Landing:

March 26, 2008, at 8:39 p.m. EDT. The first landing attempt was waved off due to unstable weather of the Kennedy Space Center area. Endeavour landed on orbit 250 after a journey of 6.578 million miles. Main gear touchdown was at 8:39:08 p.m. EDT; nosegear touchdown at 8:39:17 p.m. and wheel stop at 8:40:41 p.m. Rollout distance was 13,506 feet. Mission elapsed time was 15 days, 18 hours, 10 minutes.

Mission Highlights:

Endeavour's cargo was the Japanese Experiment Logistics Module-Pressurized Section, or ELM-PS, to be temporarily attached to the Harmony Node 2 module, and the Canadian Space Agency's special purpose dextrous manipulator, called Dextre.

Before rendezvous with the International Space Station, or ISS, astronauts made a five-hour inspection of the Endeavour's heat shield. Commander Dominic Gorie also performed the rendezvous pitch maneuver -- an orbiter backflip -- while ISS crew members photographed the underside. Images showed a clean heat shield and the mission management team later cleared the shuttle's thermal protection system for re-entry.

Endeavour docked with the station March 12; the hatch was opened at 12:36 a.m. March 13. Shortly after, Mission Specialist Garrett Reisman swapped places with Expedition 16 Flight Engineer Leopold Eyharts, who spent 33 days on the station. Later, Pilot Gregory Johnson and Mission Specialist Robert Behnken, using the Canadarm2, unberthed the Spacelab Pallet containing the Dextre and mated ito the station's mobile base system.

Between spacewalks, Japan Aerospace Exploration Agency astronaut Takao Doi configured experiment and stowage racks with the newly installed ELM-PS. Also, Reisman and Behnken tested the joint brakes on Dextre before they later moved Dextre's arms for the first time, positioning them for final assembly.

Commander Dom Gorie examined minor condensation on a cooling line uner the shuttle's middeck floorboards. The condensation was deemed not to impact shuttle operations but was inspected periodically during the rest of the mission.

Eyharts and Johnson used the Canadarm2 to move Dextre to a position on the Destiny laboratory, attached to one of the lab's power and data grapple fixtures.

On March 19, Doi, Gorie and station Commander Peggy Whitson talked to Yasuo Fukuda, Japan's prime minister, who congratulated the astronauts for successfully installing the Kibo laboratory.

Hatches between Endeavour and the station were closed at 5:49 p.m. EST. The shuttle separated from the station at 10:08 p.m. EST, completing 11 days, 20 hours and 36 minutes of docked operations.

EVA No. 1 — March 13: 7 hours, 1 minute.

Linnehan and Reisman removed a thermal cover from the centerline berthing camera system on top of the Harmony module. The system provides live video to assist in docking spacecraft and modules together. The astronauts also removed contamination covers from the Japanese Logistics Module docking mechanism and disconnected other power and heater connections. They also installed the "hands" of Dextre's arms,

the orbital replacement unit/tool changeout mechanisms. Initial attempts to route power to Dextre were not successful. Canadian Space Agency engineers developed a bypass software patch to try at a later time.

EVA No. 2 — March 15: 7 hours, 8 minutes.

Linnehan and Foreman attached the two arms of Dextre that will allow installation and maintenance tasks to be conducted from inside the space station. The astronauts also removed thermal covers from Dextre, with help from Behnken choreographing their movements from inside the space station.

EVA No. 3 — March 18: 6 hours, 53 minutes.

Linnehan and Behnken installed Dextre's tool holder assembly and a camera light pan tilt assembly, which will serve as Dextre's eyes. Other tasks included preparing the Spacelab Logistics Pallet for its return to Earth in Endeavour, installing spare equipment for the space station on an external platform on the Quest airlock, including a yaw joint for the Canadarm2 and two spare direct-current switching units. The spacewalkers attempted to install the MISSE 6 experiment on the Columbus laboratory but were unable to engage the latching pins. The task was delayed for another EVA.

EVA No. 4 — March 20: 6 hours, 24 minutes.

Behnken and Foreman replaced an electrical circuit box called a remote power controller module on the station's truss.

The major focus was demonstrating use of a tile repair ablator dispenser to apply a substance called shuttle tile ablator-54 into intentionally damaged heat shield tiles. The test samples will undergo extensive testing on Earth to determine how STA-54 performs in both microgravity and vacuum environments.

The spacewalkers also removed a cover from Dextre and launch locks that were still attached to the Harmony module.

EVA No. 5 — March 22: 6 hours, 2 minutes.

Behnken and Foreman stored the orbiter boom sensor system on the station's truss to make room in the space shuttle Discovery's payload bay for the Japanese Kibo science laboratory. Later, Behnken installed the MISSE-6, with help from troubleshooting methods developed by engineers on the ground for difficult latching pins, on the outside of the Columbus laboratory. Foreman inspected the solar alpha rotary joint to look at an apparent pockmark previously photographed.

STS-124

26th Space Station Flight

Discovery

Pad 39A:

123rd shuttle mission
35th flight of OV-103
69th landing at Kennedy Space Center

Crew:

Mark Kelly, commander (3rd shuttle flight)
Ken Ham, pilot (1st)
Karen Nyberg, mission specialist (1st)
Ron Garan, mission specialist (1st)
Mike Fossum, mission specialist (2nd)
Akihiko Hoshide, mission specialist (1st) with the Japan Aerospace Exploration Agency
Gregory Chamitoff, up to ISS
Garrett Reisman, down from ISS

Orbiter Preps:

OPF – 11/08/07 (return)
VAB – 04/26/08 (rollover)
Pad A – 05/03/08 (rollout)

Launch:

May 31, 2008, at 5:02 p.m. EDT. A clean countdown produced a successful on-time launch. However, a walk-down of the pad after launch revealed severe launch damage on a 75' X 20' section of the east wall of the north flame trench. Investigation into the cause began immediately.

Landing:

June 14, 2008, at 11:15 a.m. EDT. On Runway 15 at Kennedy Space Center. Main gear touchdown was 11:15:19 a.m. Nose gear touchdown was 11:15:30 a.m. Wheelstop was at 11:16:19 a.m. Mission elapsed time was 13 days, 18 hours, 13 minutes and 7 seconds, covering 5.7 million miles.

Mission Highlights:

Before docking with the International Space Station, Ken Ham and Karen Nyberg inspected the shuttle's thermal protection system using the end effector

camera of the shuttle's robotic arm. The orbiter boom sensor system normally used was temporarily stored on the station by the STS-123 mission crew.

The shuttle docked with the station at 2:03 p.m. EDT June 2. Before docking, Commander Mark Kelly flew the shuttle through a slow backflip so that station crew members could take photos for ground experts to assess the health of Discovery's heat shield.

Using the station's robotic arm, Mission Specialists Akihiko Hoshide and Karen Nyberg removed the Japanese Pressurized Module from Discovery's payload bay and latched it to the Harmony module.

Cosmonaut Oleg Kononenko installed the spare gas liquid separator pump in the station's toilet to return it to useful service.

Astronauts Garrett Reisman and Gregory Chamitoff replaced a bed in the carbon dioxide removal assembly that cleanses air on board the station.

EVA No. 1 — June 3: 6 hours, 48 minutes.

After Mission Specialists Mike Fossum and Ron Garan disconnected cables and removed covers from Kibo's Pressurized Module while in Discovery's payload bay. Fossum and Garan also helped transfer the orbiter boom sensor system back to the shuttle, attaching it to the shuttle robotic arm. Then, the spacewalkers demonstrated a technique to clean debris from the station solar alpha rotary joint. Garan installed a new bearing on the joint. Fossum confirmed a spot noted previously is a divot.

EVA No. 2 — June 5: 7 hours, 11 minutes.

Fossum and Garan continued outfitting the exterior of Kibo. They installed front and rear television cameras on the outside of the Kibo Japanese Pressurized Module, or JPM, removed thermal covers from the Kibo robotic arm system, and prepared a JPM upper docking port where the Kibo Logistics Module will be attached. They also prepared an external storage platform for the removal and replacement of a nitrogen tank assembly to be completed on the third spacewalk.

EVA No. 3 — June 8: 6 hours, 33 minutes.

Fossum and Garan replaced a nitrogen tank on the station's starboard truss with a new one. Fossum then returned to the port SARJ and took samples of particulate matter from inside the joint, using a strip of tape, for engineers to analyze on Earth. He removed thermal insulation from the Kibo robotic arm's wrist and elbow cameras and launch locks from one of the Kibo windows. He deployed debris shields on Kibo and tightened a bolt holding a TV camera in place.

Garan retrieved a video camera removed during the second spacewalk and reinstalled it.

Extra tasks included installing a thermal cover on Harmony's outside connectors, relocating a foot-restraint aid, and removing a launch lock on the starboard SARJ.

Expedition 17 Flight Engineer Gregory Chamitoff and Nyberg later used the station's robotic arm to reposition the Japanese Logisitics Module from the Harmony module to its permanent site on top of the Kibo laboratory. After the Kibo laboratory's installation, all 10 crew members entered to sense the space.

Hoshide and Nyberg operated the robotic arm for its final deployment maneuver, then stowed the arm and checked out the brakes within its joints. They then opened the hatch between Kibo and its logistics module to use the module for storage.

The hatch between the station and Discovery was closed at 4:42 p.m. EDT June 10. The undocking was at 7:42 a.m. June 11. Pilot Ken Ham circled the station so the crew could take video and photos of the 330-ton complex.

Using the orbiter boom sensor system restored to Discovery's payload bay, the shuttle crew made a late inspection of the shuttle's heat shield. Imagery experts declared the heat shield safe for entry and landing.

The Mission Management Team revealed an object was seen floating away from the vehicle June 13 during the routine day-before-landing systems checkout to verify entry and landing system health. Engineers concluded the object was a heat-shield clip from the rudder/speed brake on the orbiter's tail that is used as a heat barrier during launch only and not a concern for entry.

STS-126

27th ISS flight

Endeavour

Pad 39A:

124th shuttle mission
22nd flight of OV-105
52nd landing at Edwards Air Force Base in California

Crew:

Chris Ferguson, commander (2nd shuttle flight)
Eric Boe, pilot (1st)
Steve Bowen, mission specialist (1st)
Shane Kimbrough, mission specialist (1st)
Heidemarie Stefanyshyn-Piper, mission specialist (2nd)
Donald Pettit, mission specialist (2nd)
Sandra Magnus, mission specialist (2nd) (up to ISS)
Gregory Chamitoff (down from ISS)

Orbiter Preparations:

OPF – 03/27/2008 (return)
VAB – 09/11/2008 (rollover)
Pad B – 09/19/2008 (rollout); Endeavour was on pad B to serve as an emergency vehicle during the STS-125 Hubble servicing mission to launch from pad A. That mission was postponed, enabling Endeavour to move to pad A.
Pad A – 10/23/2008 (rollaround)

Launch:

Nov. 14, 2008, at 7:55 p.m. EST. Endeavour lit up the night sky with a flawless liftoff.

Landing:

Nov. 30, 2008, at 4:25 p.m. EST. After two landing opportunities were waved off at the primary landing site in Florida due to weather concerns, Endeavour landed on a temporary runway adjacent to the concrete runway 22/04 at EAFB. The temporary runway is 12,000 feet long by 200 feet wide and is a concrete/asphalt runway with a 1,000-foot underrun and overrun capability for shuttle load bearing. Main gear touchdown was 4:25:06 p.m. EST. Nose gear touchdown was 4:25:21 p.m. Wheelstop was 4:26:03 p.m. Mission elapsed time was 15 days, 20 hours, 29 minutes and 37 seconds, covering 6.615 million miles.

Mission Highlights:

Prior to docking with the International Space Station, the crew conducted a five-hour inspection of Endeavour's heat shield using the shuttle's robotic arm and the Orbiter Boom Sensor System. Analysis of images taken during inspection revealed a small piece of thermal blanket was loose in the aft portion of the orbiter. Commander Chris Ferguson also flew the shuttle through a slow backflip so the station's Expedition 18 Commander Mike Fincke and Flight Engineer Greg Chamitoff could photograph the heat shield. Ground controllers reviewed the photos and determined there was no need for more inspection.

Inside the station, crews worked to prepare for an expanded six-person station crew and completed other tasks. Latches on the Exposed Facility Berthing Mechanism for the Japanese Kibo laboratory were tested. The mechanism will be used to install an exterior science platform from the Japan Aerospace Exploration Agency next year.

A new Water Recovery System was installed to treat wastewater and provide recycled water clean enough to drink. Part of that system, the Urine Processor Assembly, shut down during initial test operations. Station and shuttle crews, as well as ground controllers, explored possible causes and cures for several days. Engineers believed motion of the centrifuge caused physical interference with the UPA, resulting in increased power draw and temperatures. The UPA was hard-mounted onto the WRS rack after grommets were removed. The UPA ran normally after the change.

On the 10th day of the mission, NASA managers decided to extend Endeavour's stay by one day to provide extra time for troubleshooting the Water Recovery System, if needed.

On a series of four spacewalks, Mission Specialists Heidemarie Stefanyshyn-Piper, Steve Bowen and Shane Kimbrough fixed the starboard Solar Alpha Rotary Joint, or SARJ, replaced a depleted nitrogen tank, relocated hand-propelled cards that run along the rails of the station's main truss, and lubricated the grapple fixture on the end of the station's Canadarm2.

EVA No. 1 — Nov. 18: 6 hours, 52 minutes.

Piper and Bowen spent most of their time outside the station cleaning and lubricating part of the station's SARJ and removing two of the joint's 12 trundle-bearing assemblies, or TBAs. They also removed a depleted nitrogen tank from a stowage platform into Endeavour's cargo bay, moved a flex hose rotary coupler from the shuttle to the station's stowage platform, and removed insulation blankets from the common berthing mechanism on the Kibo laboratory.

About halfway into the spacewalk, one of the grease guns that Piper was preparing to use on the SARJ released some Braycote grease into her crew lock bag, which is the tool bag the spacewalkers use during their activities. As she was cleaning the inside of the bag, it drifted away from her toward the aft and starboard portion of the station. Inside the bag were two grease guns, scrapers, several wipes and tethers, and some tool caddies. Piper and Bowen spent the remainder of the spacewalk sharing a duplicate set of tools from the other crew lock bag they had with them.

EVA No. 2 — Nov. 20: 6 hours, 45 minutes.

Spacewalkers Piper and Kimbrough moved two Crew and Equipment Translation Aid carts, lubricated the space station robotic arm's latching end effector snare, cleaned and lubricated the starboard SARJ race ring, and replaced four TBAs.

EVA No. 3 — Nov. 22: 6 hours, 57 minutes.

Piper and Bowen replaced five TBAs and cleaned and lubricated race rings on the station's starboard SARJ.

EVA No. 4 — Nov. 24: 6 hours, 7 minutes.

Kimbrough and Bowen replaced the final TBA on the station's starboard SARJ, lubricated the race rings on the port SARJ, mounted a video camera on the Port 1 truss, installed two Global Position Satellite antennae on the Japanese Experiment Module (JEM) Logistics Module, retracted a latch on the JEM Exposed Facility Berthing Mechanism and reinstalled the mechanism's cover.

On Nov. 25, the crew was informed the starboard SARJ, during a three-hour, two-orbit test, was automatically tracking the sun for the first time in more than a year. Also, the UPA had completed its second full run without shutdowns.

The combined crews celebrated Thanksgiving aboard the station. They also sent a special greeting to American military away from home and families. They thanked the service members for their commitment and dedication and wished them well.

The end of the mission concluded with moving the Multi-Purpose Logistics Module Leonardo back into Endeavour's payload bay and packing equipment and supplies into Endeavour.

Endeavour separated from the station at 9:47 a.m. EST
Nov. 28. Boe, Pettit and Kimbrough completed the standard late inspection of Endeavour's thermal protection system using the shuttle's robotic arm and Orbiter Boom Sensor System extension. After examing the images, on Nov. 29 the Mission Management Team declared the heat shield safe for re-entry and landing.

As they prepared for landing, the crew deployed a small satellite, Picosat, designed to test space environment effects on new solar cell technologies. It will remain in orbit for several months.

2009

STS-119

28th Space Station Flight

Discovery

Pad A:

125th shuttle mission
36th flight OV-103
70th landing at KSC

Crew:

Lee Archambault, commander (2nd shuttle flight)
Tony Antonelli, pilot (1st)
Richard Arnold, mission specialist (1st)
Joseph Acaba, mission specialist (1st)
John Phillips, mission specialist (3rd)
Steve Swanson, mission specialist (2nd)
Up to ISS: Koichi Wakata, with JAXA (3rd)
Down from ISS: Sandra Magnus

Orbiter Preps:

OPF – 06/14/08 (return)
VAB – 01/07/09 (rollover)
Pad A – 01/14/09 (rollout)

Launch:

March 15, 2009, at 7:43 p.m. EDT. The original Feb. 12 launch date was postponed after an issue surfaced with the gaseous hydrogen flow control valves. Part of the main propulsion system, the valves channel gaseous hydrogen from the main engines to the external tank. The valves were replaced on space shuttle Discovery.

On the next scheduled launch date, March 11, the STS-119 launch was scrubbed at 2:37 p.m. for at least 24 hours because of a hydrogen leak in a liquid hydrogen vent line between the shuttle and the external tank. Managers and engineers looked at potential repair options and Discovery's launch attempt was planned no earlier than March 15, at 7:43 p.m. Discovery launched on time.

Landing:

March 28, 2009, at 3:14:45 p.m. EDT. Main gear touchdown was 3:13:17, nose gear touchdown at 3:13:40 and wheelstop at 3:14:45 on Runway 15 at Kennedy. Mission elapsed time was 12 days, 19 hours, 31 minutes and one second. The landing completed a 13-day journey of more than 5.3 million miles.

Mission managers waved off the first landing opportunity because of gusty winds and clouds at the Shuttle Landing Facility. Improved conditions afforded a successful landing on orbit 202.

Mission Highlights:

The STS-119 flight delivered the space station's fourth and final set of solar array wings and the S6 truss, completing the station's backbone. The additional electricity provided by the arrays will fully power science experiments and help support a six-person crew and station operations.

Crew members also replaced a failed unit on a system that converts urine to potable water. Samples from the station's Water Recovery System were collected for analysis to determine if the water is suitable for drinking.

On March 16, focus was on a close inspection of Discovery's wing leading edge panels using the shuttle's robotic arm and orbiter boom sensor system extension. In preparation for docking, the crew tested rendezvous equipment, installed an orbiter docking system "centerline" camera and extended the docking ring atop the docking system. Before docking on March 17, Commander Lee Archambault performed a "backflip" of Discovery, allowing the station's Expedition 18 Commander Michael Finke and Flight Engineer Sandra Magnus to take photos for analysis by imagery experts on the health of Discovery's heat shield. The analysts and Damage Assessment Team in Mission Control determined the heat shield was healthy for re-entry.

On March 24, the 10 shuttle and station crew members gathered in the station's Harmony module and spoke to President Barack Obama, members of Congress and school children from the Washington, D.C., area.

EVA No. 1 — March 19: 6 hours, 7 minutes.

Mission Specialists Steve Swanson and Richard Arnold bolted the S6 truss in place, connecting the power and data cables that allowed station flight controllers to remotely command the segment to life.

EVA No. 2 — March 21: 6 hours, 30 minutes.

Swanson and Mission Specialist Joseph Acaba prepared a work site for new batteries that will be delivered on the STS-127 mission on space shuttle Endeavour. They also installed a Global Positioning System antenna on the pressurized logistics module attached to the Kibo laboratory. It will allow Japan's H-II Transfer Vehicle to rendezvous with the station later in 2009 and set the stage for future assembly tasks by station and shuttle crews.

During installation of a cargo carrier attach system, a misaligned bracket proved too difficult to reposition and the crew moved to other tasks, including imagery documentation of station radiators.

EVA No. 3 — March 23: 6 hours, 27 minutes.

Acaba and Arnold relocated one of two crew equipment carts from one side of the mobile transporter to the other. They had trouble freeing a stuck mechanism to allow deployment of a spare equipment platform and deferred the deployment to a future spacewalk. Mission Control later decided to forego work on a similar payload attach system.

The astronauts also lubricated the end effector capture snares on the station's robotic arm, work proven on the STS-126 mission that will prevent the snare from snagging or not returning snuggly into its groove inside the latching mechanism.

On the 10th day of the mission, Discovery undocked from the ISS. As the shuttle moved away, Pilot Tony Antonelli circled the station while the crew photographed the completed truss structure with the final set of solar array wings fully deployed.

On March 26, Antonelli used the shuttle's robotic arm to hold the orbiter boom sensor system so the cameras and laser sensors could scan Discovery for signs of damage from orbital debris.

Astronaut Sandra Magnus returned to Earth aboard Discovery after 129 days aboard the space station. Japan Aerospace Exploration Agency astronaut Koichi Wakata, who launched aboard Discovery, remained on the station as a member of the Expedition 18 and 19 crews.

STS-125

5th Hubble Servicing Mission

Atlantis

Pad A:

126th shuttle mission
30th flight OV-104
53rd landing at Edwards Air Force Base

Crew:

Scott Altman, commander (4th shuttle flight)
Gregory C. Johnson, pilot (1st)
Michael Good, mission specialist (1st)
Megan McArthur, mission specialist (1st)
John Grunsfeld, mission specialist (5th)
Mike Massimino, mission specialist (2nd)
Andrew Feustel, mission specialist (1st)

Orbiter Preps:

OPF – 02/20/2008 (return)
VAB – 08/22/2008 (rollover)
Pad A– 09/04/2008 (rollout)
VAB – 10/20/2008 (rollback)
Pad A – 03/31/09 (rollout)

Launch:

May 11, 2009, at 2:01 p.m. EDT. A flawless liftoff began Atlantis' 13-day mission on the final Hubble Space Telescope Servicing mission. Atlantis was first scheduled to launch in October but was delayed when a system that transfers science data from the orbiting observatory to Earth malfunctioned.

Space shuttle Endeavour was designated to stand by at pad B in the unlikely event that a rescue mission was necessary during the mission. Both in October and in May, two shuttles were on the pads at the same time.

Landing:

May 24, 2009, at 11:39 a.m. EDT. Landing opportunities on May 22, May 23 and May 24 were waved off due to weather concerns at Kennedy. Atlantis landed on orbit 197 on Runway 22 at Edwards Air Force Base in California. Main gear touchdown was 11:39:05 a.m. EDT. Nose gear touchdown was at 11:39:15 a.m. Wheel stop was at 11:40:15 a.m. Mission elapsed time was 12 days, 21 hours, 37 minutes and 9 seconds, covering 5.3 million miles in 13 days.

On June 2, Atlantis arrived back at Kennedy piggyback on the Shuttle Carrier Aircraft, landing on the Shuttle Landing Facility at 6:53 p.m. EDT after a 2-day trip from Edwards AFB.

Mission Highlights:

During five spacewalks, crew members installed two new instruments on NASA's Hubble Space Telescope and repaired two others, bringing them back to life, replaced gyroscopes and batteries, and added new thermal insulation panels to protect the orbiting observatory. The result is six working, complementary science instruments with capabilities beyond what was available in 1990 and an extended operational lifespan until at least 2014.

Before the rendezvous with Hubble, the crew performed a thorough inspection of the shuttle's heat shield. Commander Scott Altman, Pilot Gregory C. Johnson and Mission Specialists Michael Good, Megan McArthur and Mike Massimino all used the shuttle's 50-foot orbiter boom sensor sytem attached to the 49-foot robotic arm to get a close look at the surface of the shuttle's belly and its wing-leading edges and nose cap. The data was sent to the ground for analysis. During the inspection, mission managers noted an area of damage on the forward part of Atlantis where the wing blends ito the fuselage. Although it appeared to be minor, standard expert analysis was conducted. Ultimately, mission managers declared Atlantis' thermal protection tiles safe for reentry.

Commander Scott Altman guided Atlantis within 50 feet of Hubble and Mission Specialist Megan McArthur grappled the observatory at 1:14 p.m. EDT while the shuttle orbited 340 miles above Western Australia. McArthur then maneuvered Hubble onto a Flight Support System maintenance platform in Atlantis' payload bay. The platform provided power for thermal control while the telescope was serviced. Five spacewalks followed that completed all of the mission objectives.

The spacewalking astronauts set two long-duration records of 7 hours, 56 minutes (eighth longest) and 8 hours, 2 minutes (sixth longest).

EVA No. 1 — May 14: 7 hours, 20 minutes.

Mission Specialists John Grunsfeld and Andrew Feustel installed Wide Field Camera 3 and replaced the Science Instrument Command and Data Handling Unit. Grunsfeld installed the soft capture mechanism for future service missions and Feustel installed two Latch Over Center Kits to ease opening and closing Hubble's large access doors on the remaining spacewalks.

EVA No. 2 — May 15: 7 hours, 56 minutes.

Mission Specialists Michael Good and Mike Massimino replaced three rate sensing units containing two gyroscopes each (one of the three originals would not fit so a spare was used), and replaced a battery module from Bay 2 of the telescope.

EVA No. 3 — May 16: 6 hours, 36 minutes.

Grunsfeld and Feustel removed the Corrective Optics Space Telescope Axial Replacement and installed the new Cosmic Origins Spectrograph to allow Hubble to peer farther into the universe than ever before in the near- and far-ultraviolet ranges. Then the two astronauts repaired the Advanced Camera for Surveys, removing 32 screws from an access panel to replace the camera's four circuit boards and install a new power supply.

EVA No. 4 — May 17: 8 hours, 2 minutes.

Massimino and Good repaired the Space Telescope Imaging Spectrograph by replacing a power supply board. A handrail obstructed the path of a fastener capture place and a stripped bolt prevented it from coming free. Under guidance from Goddard Space Flight Center, Massimino bent and broke the handrail free to install the capture plate. The astronauts were unable to install a New Outer Blanket Layer on the outside of Hubble's Bay 8. The task was delayed to the fifth and final spacewalk.

EVA No. 5 — May 18: 7 hours, 2 minutes.

Feustel and Grunsfeld swapped a battery module from Bay 3 with a fresh one and removed and replaced the Fine Guidance Sensor 2. They then installed the New Outer Blanket Layer on three bays outside the telescope.

To complete the mission, McArthur used the shuttle's robotic arm to grab Hubble, lift it out of Atlantis' payload bay and release.

Atlantis made a final separation maneuver from the telescope and the berthing mechanism to which Hubble had been attached during the mission was stored back in the payload bay.

Another inspection of Atlantis' heat shield searched for any possible damage from orbital debris.

The next day, the crew stowed gear, checked the reaction control system thrushters and flight control systems for reentry and descent through the atmosphere.

On May 21, the crew testified before the Senate Appropriations Committee, Subcommittee on Commerce, Justice, Science and Related Agencies, chaired by Sen. Barbara Mikulski of Maryland. She and former astronaut Sen. Bill Nelson of Florida talked with the crew. The STS-125 crew is the first to testify live from space in a Senate hearing.

STS-127

(29th Space Station Flight)

Endeavour

Pad A:

127th shuttle mission
23rd flight OV-105
71st landing at KSC

Crew:

Mark Polansky, commander (3rd shuttle flight)
Doug Hurley, pilot (1st)
Christopher Cassidy, mission specialist (1st)
Tom Marshburn, mission specialist (1st)
Dave Wolf, mission specialist (4th)
Julie Payette, mission specialist (2nd), with the Canadian Space Agency
Up to ISS: Tim Kopra, mission specialist (1st)
Down from ISS: Koichi Wakata, with JAXA

Orbiter Preps:

OPF – 12/13/08 (return)
VAB – 04/10/09 (rollover)
Pad B – 04/17/09 (rollout)
Pad A – 05/31/09 (rollaround)

Launch:

July 15 at 6:03 p.m. EDT. The first launch attempt was scheduled for June 13. A hydrogen leak at the Ground Umbilical Carrier Plate during tanking June 12 caused the mission to be scrubbed at 12:26

a.m. June 13. The seal on the 7-inch disconnect valve was replaced and launch rescheduled to June 17. The launch on June 17 was officially scrubbed at 1:55 a.m. EDT when the same type of hydrogen gas leak occurred at the Ground Umbilical Carrier Plate. Vent valve troubleshooting took place for about an hour before it became clear the problem could not be solved. Endeavour's next launch attempt for its STS-127 mission was scheduled for July 11 at 7:39 p.m. EDT. The July 11 launch was postponed one day to give technical teams more time to evaluate lightning strikes at the launch pad that occurred during thunderstorms July 10. Sensors indicted there were 11 lightning strikes within 0.35 miles, which is inside the launch pad's threshold. Liftoff was rescheduled for 7:13 p.m. July 12. The mission was scrubbed July 12 at 7:02 p.m. due to weather conditions near the Shuttle Landing Facility at Kennedy that violated rules for launching. A fifth attempt was scheduled for July 13 at 6:51 p.m. Lightning and thunderstorms within the 20-nautical-mile circle around the launch pad produced another delay which was called at 6:39 p.m. The sixth launch attempt was scheduled for July 15 at 6:03 p.m.

Landing:

July 31, 2009, at 10:48 a.m. EDT. Main gear touchdown was at 10:48:08 a.m. EDT. Nose gear touchdown was at 10:48:21 a.m., and wheel stop was at 10:49:13 a.m. Mission elapsed time was 15 days, 16 hours, 44 minutes and 58 seconds. Endeavour traveled 6,547,853 miles over 248 orbits.

The mission was the 29th flight to the station, the 23rd flight of Endeavour and the 127th in the Space Shuttle Program.

Mission Highlights:

Robotic arms performed many operations. After EVA No. 1, Commander Mark Polansky and Mission Specialist Julie Payette operated the shuttle robotic arm and Pilot Doug Hurley and Mission Specialist Koichi Wakata operated the station robotic arm to latch the JEF to the Kibo laboratory. Kibo's robotic arm also was used to view the installation.

More robotic activity by Payette and Kopra included installation of the Integrated Cargo Carrier-Vertical Light Deployable, a cargo pallet, on the port side of the space station's mobile base system.

Crew members and flight controllers spent time troubleshooting failure of the Waste and Hygiene Compartment, the toilet in the U.S. Destiny module.

On July 20, the space station and shuttle crews in a way honored the legacy of Apollo 11 by conducting a spacewalk on the same day that 40 years ago Neil Armstrong and Buzz Aldrin walked on the moon for the first time.

After the second spacewalk, Polansky and Payette used the robotic arm on the shuttle to pass the Japanese Logistics Module-Exposed Section frm Endeavour to Canadarm2 on the space station. Pilot Doug Hurley and Mission Specialist Koichi Wakata operated the Canadarm2 to attach it to the Kibo lab.

Hurley and Payette used the station's robotic arm to move the ICC securing the batteries to prepare for the P6 truss battery swap.

On July 23, Wakata, Kopra, Polansky, Hurley and Payette used the Japapnese robotic arm for the first time to move equipment from a Japanese payload carrier to the Japanese Exposed Facility outside Kibo. When the initial movement was faster than expected, the arm was transitioned to manual mode that was slower. Three experiments -- the Monitor of All-sky X-ray Image, Inter-orbit Communcaitons System and Space Environment Data Acquisition Equipment-Attached payload -- were installed on the facility.

Robotics work concluded with Polansky, Hurley, Payette and Kopra using the shuttle and station arms to grab the Japanese Exposed Section cargo carrier, hand it off and place it in Endeavour's payload bay.

The Carbon Dioxide Removal Assembly on the station tripped a circuit breaker July 25, and the ground team switched to manual operation of the backup heater.

Five spacewalks totaled 30 hours, 30 minutes for Mission Specialists Dave Wolf, Tim Kopra, Tom Marshburn and Christopher Cassidy.

EVA No. 1 — July 18: 5 hours, 32 minutes.

Wolf and Kopra completed all primary tasks: prepared berthing mechanisms on the Kibo laboratory and the Japan Exposed Facility; deployed an unpressurized cargo carrier attachment system on the Port 3 truss that had failed to unfurl on the STS-119 mission in March.

EVA No. 2 — July 20: 6 hours, 53 minutes.

Wolf removed a Ku-band space-to-ground antenna, a pump module and a linear drive unit from an Integrated Cargo Carrier. He and Marshburn attached them to a stowage platform on the P3 truss. Marshburn mounted a grapple bar onto an ammonia tank assembly that the STS-128 crew will be able to move with a robotic arm. He also attached two insulation sleeves for external power connectors to the Sation-to-Shuttle Power Transfer System. A video camera installation was deferred.

EVA No. 3 — July 22: 5 hours, 59 minutes.

Wolf and Cassidy removed insulation covers from the Kibo lab and prepared the Japanese Exposed Section payloads for transfer to the Exposed Facility July 23. They had also installed two batteries before ending the spacewalk when Cassidy's CO_2 levels increased more than expected.

EVA No. 4 — July 24: 7 hours, 12 minutes.

Cassidy and Marshburn installed the remaining four batteries on the P6 truss. They stored four more of the old batteries on the Integrated Cargo Carrier for return to Earth. Wakata and Payette used Canadarm2 to hand the carrier to the shuttle's arm, which Hurley and Polansky then used to stow it in Endeavour's payload bay.

EVA No. 5 — July 27: 4 hours, 54 minutes.

Marshburn and Cassidy installed video cameras on the front and back of the Japanese Exposed Facility to help with rendezvous and berthing of the H-II Transfer Vehicle scheduled to arrive in September. They also secured multi-layer insulation around the Special Purpose Dexterous Manipulator known as Dextre, split out power channels for two space station Control Moment Gyroscopes, tied down cables and installed hand rails and a portable foot restraint to aid future spacewalkers.

After leaving the station and preparing for the return to Earth, the crew deployed two pairs of small satellites from Endeavour's payload bay: the Dual RF Astrodynamic GPS Orbital Navigator Satellite (DRAGONSat) and the Atmospheric Neutral Density Experiment-2 (ANDE-2). The satellites were designed and built by students at the University of Texas in Austin, and Texas A&M University in College Station. The ANDE-2 microsatellites will measure the density and composition of the rarified atmosphere 200 miles above the Earth's surface.

STS-128

(30th Space Station Flight)

Discovery

Pad 39A:

128th shuttle mission
37th flight of OV-103
54th landing at EAFB

Crew:

Rick Sturckow, commander (4th shuttle flight)
Kevin Ford, pilot (1st)
Danny Olivas, mission specialist (2nd)
Patrick Forrester, mission specialist (3rd)
Jose Hernandez, mission specialist (1st)
Christer Fuglesang, mission specialist (2nd), with the European Space Agency
Nicole Stott, mission specialist, up to ISS
Tim Kopra, down from ISS

Orbiter Preps:

OPF – 03/28/09 (return)
VAB – 07/26/09 (rollover from OPF)
Pad 39A – 08/04/09 (rollout)

Launch:

Aug. 28, 2009, at 11:59 p.m. EDT. The first launch attempt on Aug. 25 was scrubbed due to weather conditions. The second attempt on Aug. 26 was postponed during fueling of the shuttle's external tank after an indication that a valve in the shuttle's main propulsion system failed to perform as expected. A third launch attempt was rescheduled for Aug. 28 at 12:20 a.m. EDT but postponed 24 hours to allow engineers more time to develop plans for resolving an issue with a valve in the shuttle's main propulsion system.

Landing:

Sept. 11, 2009, at 8:53 p.m. EDT. Discovery landed on Runway 22 at Edwards Air Force Base in California. Main gear touchdown was 8:53:25 p.m. Nose gear touchdown was at 8:53:34 p.m. Wheelstop was at 8:54:35 p.m.. Mission elapsed time was 13 days, 20 hours, 53 minutes and 45 seconds, covering 5.7 million miles in 219 orbits. Weather concerns prevented

the crew from returning to Kennedy on both Sept. 10 and 11.

Mission Highlights:

The mission marks the start of the transition from assembly of the ISS to continuous scientific research. Discovery carried the Leonardo Multi-Purpose Logistics Module with storage racks, materials and fluids science racks, a freezer for research samples, a new sleeping compartment, an air purification system and a treadmill named after comedian Stephen Colbert, the result of a contest to name station hardware.

Astronauts aboard Discovery conducted a day-long inspection of the shuttle's thermal protection system, checked out spacesuits and prepared to dock with the International Space Station. Pilot Kevin Ford and Mission Specialists Patrick Forrester and Jose Hernandez used the shuttle's robotic arm to inspect Discovery's right wing, nose cap and left wing. Later the crew tested equipment to be used for rendezvous operations.

Prior to docking, Commander Rick Sturckow flew Discovery through a backflip allowing Expediiton 20 Commander Gennady Padalka and Flight Engineer Michael Barratt to take photos that imagery experts reviewed to assess the health of Discovery's thermal protection system tiles.

After docking, the joint shuttle and station crews swapped crew members: Mission Specialist Nicole Stott for Flight Engineer Tim Kopra, who spent 58 days in space.

One of the first tasks while docked was removing Leonardo from the shuttle's cargo bay and installing it onto the station's Harmony module. Mission Specialists Danny Olivas and Christer Fuglesang then spent the rest of their day preparing the pressurized cargo module for the transfer work that was performed during the next six days. Olivas, Hernandez and Stott moved the tools to be used during the spacewalks into the station's airlock and got them ready for use.

On Sept. 2, shuttle and station crews transferred the Fluids Integrated Rack, Materials Science Research Rack-1 and Minus Eighty-Degree Laboratory Freezer-2 from Leonardo and installed them in the U.S. Destiny Laboratory.

Meanwhile, Barratt installed and outfitted the third of four planned NASA crew quarters.

The 14-day flight included three spacewalks to replace experiments outside the European Space Agency's Columbus laboratory and install a new ammonia storage tank. The mission's three spacewalks totaled 20 hours and 15 minutes:

EVA No. 1 — Sept. 1: 6 hours, 35 minutes.

Olivas and Stott removed a depleted ammonia tank assembly on the Port 1 segment of the truss. Ammonia in the tanks is used to cool the station and expel the heat generated by its residents and systems. They then retrieved two science experiments – the European Technology Exposure Facility and the sixth Materials International Space Station Experiment-6 from the Columbus laboratory. The EuTEF held nine different experiments, most of which collected various types of information on the environment of space. MISSE-6 was housed in two suitcase-sized containers and evaluated the effect of the space environment on various material and coating samples.

Spacewalker Olivas reported seeing what he described as MMOD (micrometeroid and orbital debris) "hits" on a station toolbox and the Quest airlock. He took pictures of the areas, which will be analyzed on the ground. The photos will help determine whether there are any concerns that need to be addressed in the future. MMOD hits are not completely unexpected.

During 30 minutes of the spacewalk, mission control didn't have communication with the station or shuttle. This was due to weather in Guam that affected a TDRSS (Tracking and Data Relay Satellite System) that is relied on for space-to-ground communication.

EVA No. 2 — Sept. 3: 6 hours, 39 minutes.

Olivas and Fuglesang installed a new ammonia tank assembly on the P1 truss segment. They also bolted the previously removed empty ammonia tank assembly inside the shuttle's cargo bay.

The astronauts installed protective lens covers on the cameras of the station's robotic arm, which will shield them from contamination when the arm is used to dock the Japanese H-II Transfer Vehicle to the station later this month. They installed a portable foot restraint on the station's truss system for use during upcoming missions.

Olivas and Fuglesang found that heater cables on the outside of pressurized mating adapter 3 appeared to be in an incorrect configuration to reach properly for relocation. That task was, therefore, deferred.

EVA No. 3 — Sept. 5: 7 hours, 1 minute.

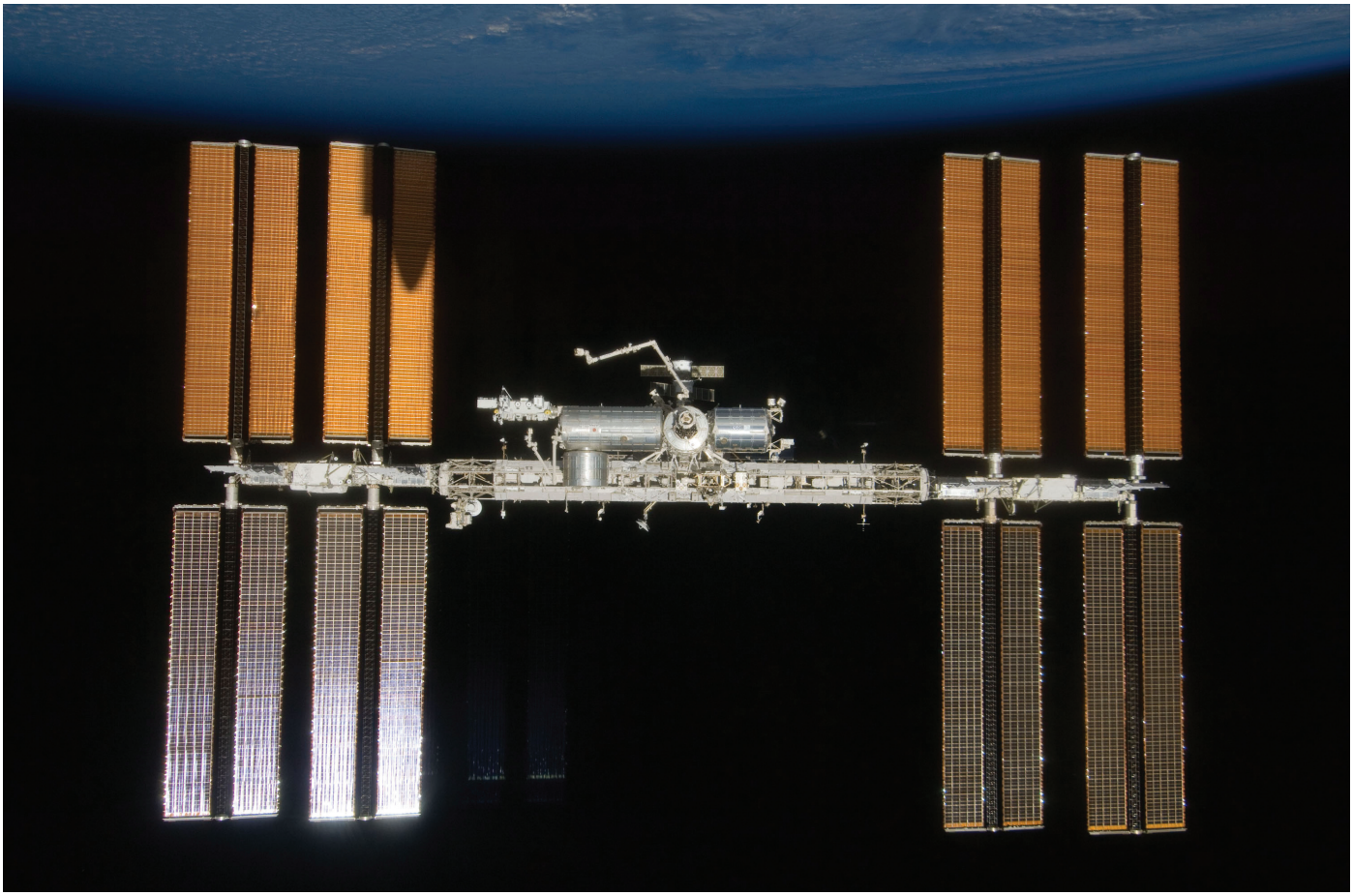
Spacewalkers Olivas and Fuglesang set up a payload attachment system on the station's truss to be called into service on the next mission. They also replaced a rate gyro assembly and a remote power control module, installed two GPS antennas and removed a slide wire on the Unity module. The spacewalkers were not able to connect two avionics cables that eventually will be connected to Tranquility, the final U.S. module to

be delivered to the station. Connectors on one of the cables would not mate, and so they were wrapped in insulation and left for a future spacewalk.

At the end of the spacewalk, Fuglesang's helmet-mounted video camera and headlight system became unlatched. Olivas helped Fuglesang connect a tether to the equipment and planned to inspect its latches after they got back inside.

Inside the station, crew members replaced one of 16 common berthing mechanism bolts used to secure the Leonardo cargo carrier to the station. The bolt had not operated as expected early in the mission. The crew also opened an oxygen generation assembly water filter that was replaced before the shuttle arrived, and saw that it was 70 to 80 percent blocked. The inspection increases confidence that the filter replacement has restored the system to full functionality.

During the mission, crew members transferred about 7.5 tons of equipment and supplies out of Leonardo and collected 2,400 pounds for return to Earth. Discovery's middeck transported about 860 pounds of return items. One of the items returned was Disney's toy astronaut Buzz Lightyear, part of NASA's Toys in Space project to encourage students to pursue studies in science, technology and mathematics.



The International Space Station is seen from space shuttle Endeavour as the two spacecraft begin their relative separation on the STS-127 mission in July 2009.

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