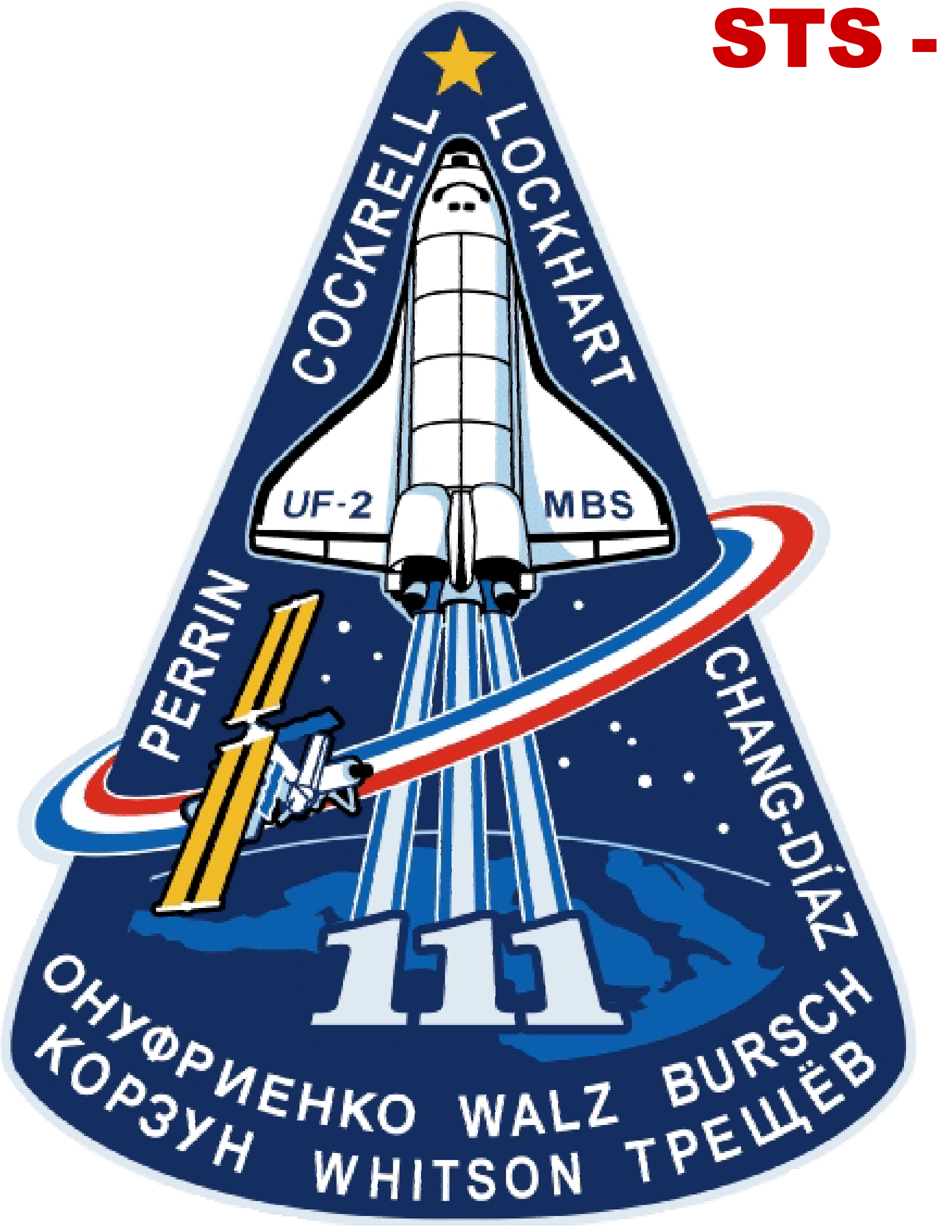
Continuing the Human Presence in Space

STS - 111



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New Station Crew, Three Spacewalks Set for STS-111

A new International Space Station crew, the fifth flight of an Italian-built Multi-Purpose Logistics Module (MPLM) and three spacewalks are major elements of the STS-111 flight of Endeavour.

The STS-111 crew, from left to right, Philippe Perrin, Paul Lockhart, Ken Cockrell and Franklin Chang-Diaz

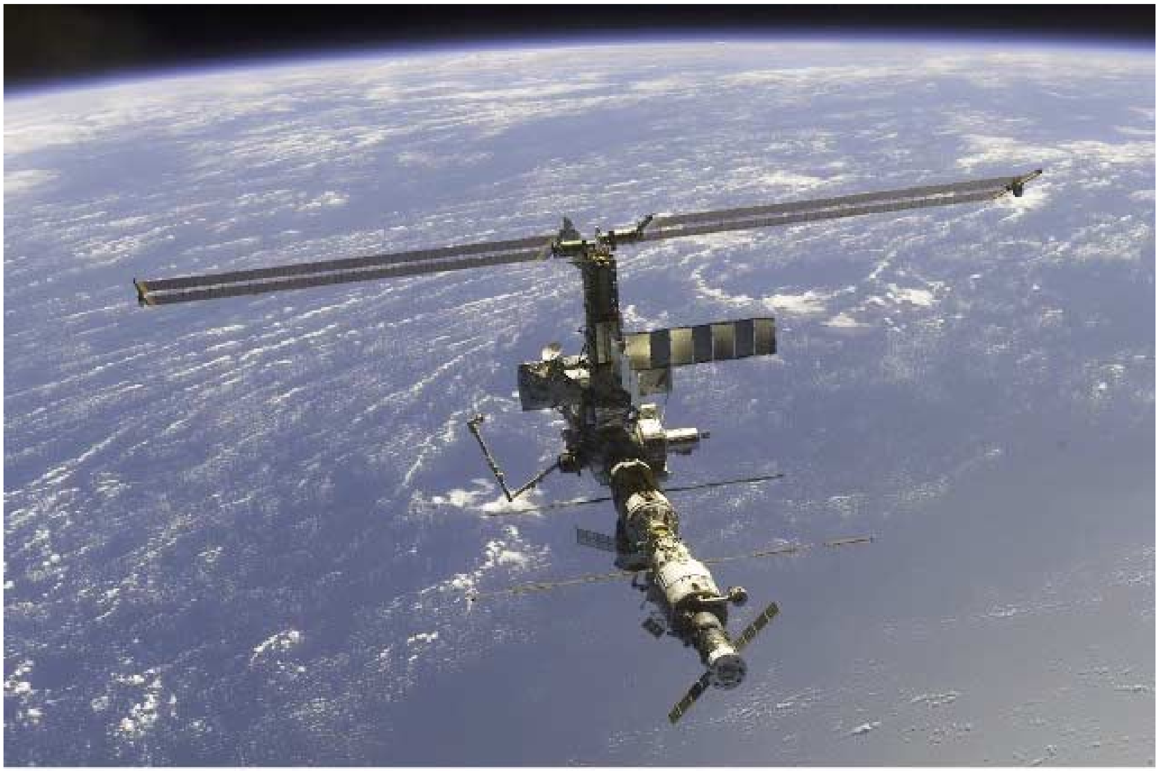
Ken Cockrell is making his third flight as commander and his fifth on a shuttle. He was commander on STS-80, the longest shuttle flight to date, on Columbia in November and December 1996. He also commanded STS-98 in February 2001, a mission that successfully delivered and installed the U.S. laboratory Destiny on the International Space Station. He served as pilot on STS-69 on Endeavour in September 1995 and as a mission specialist on STS-56, a scientific flight on Discovery in April 1993.

Paul Lockhart (Lt. Col., USAF), making his first flight into space, is Endeavour's pilot. Two mission specialists round out the orbiter crew. Franklin Chang-Diaz will be making a record-tying seventh flight into space. Chang-Diaz has six previous spaceflights to his credit:

STS-61C in January 1986, STS-34 in October 1989, STS-46 in August 1992, STS-60 in February 1994, STS-75 in February and March 1996, and STS-91 in June 1998. Philippe Perrin, a colonel in the French Air Force representing CNES, the French Space Agency, is making his first spaceflight.

The space station's Expedition 5 crew, pictured above from left to right, is Russian Commander Valery Korzun, Astronaut Peggy Whitson and Cosmonaut Sergei Treschev. Crewmembers will extend a continuous human presence aboard the space station that began when the Expedition 1 crew arrived on Nov. 2, 2000.

They will replace the Expedition 4 crew, Russian Commander Yury Onufrienko and Astronauts Carl Walz and Dan Bursch. That crew was brought to the station on Endeavour's STS-108 flight launched Dec. 5, 2001, and will return to Earth on Endeavour.



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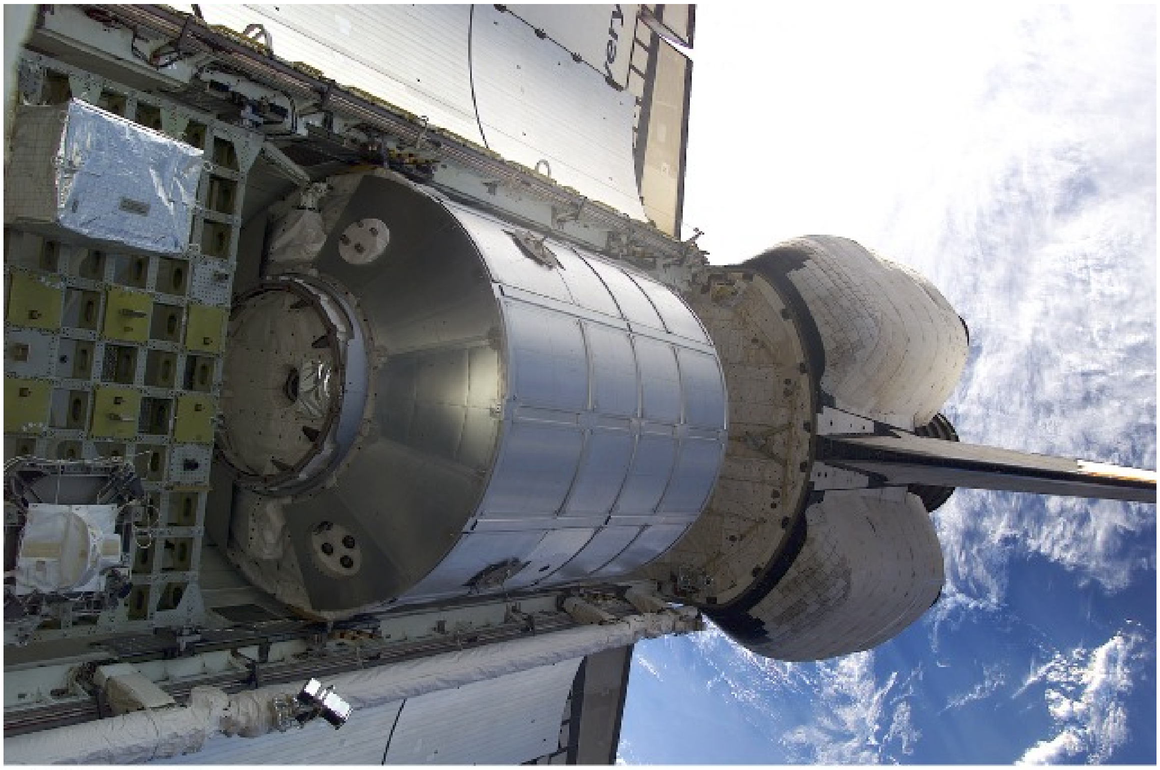
About 40 hours after its launch, Endeavour is scheduled to dock with the International Space Station. After hatches are opened, a welcoming ceremony and a safety briefing will be held for the new arrivals. Crew transfer operations begin shortly after docking, as do preparations for the first spacewalk.

A crewmember’s transfer officially occurs when a new arrival’s custom seat liner is installed in the Soyuz crew return vehicle attached to the space station. Treschev and Walz will swap out seat liners on docking day, while Whitson and Bursch and then Korzun and Onufrienko will change out liners the next day.



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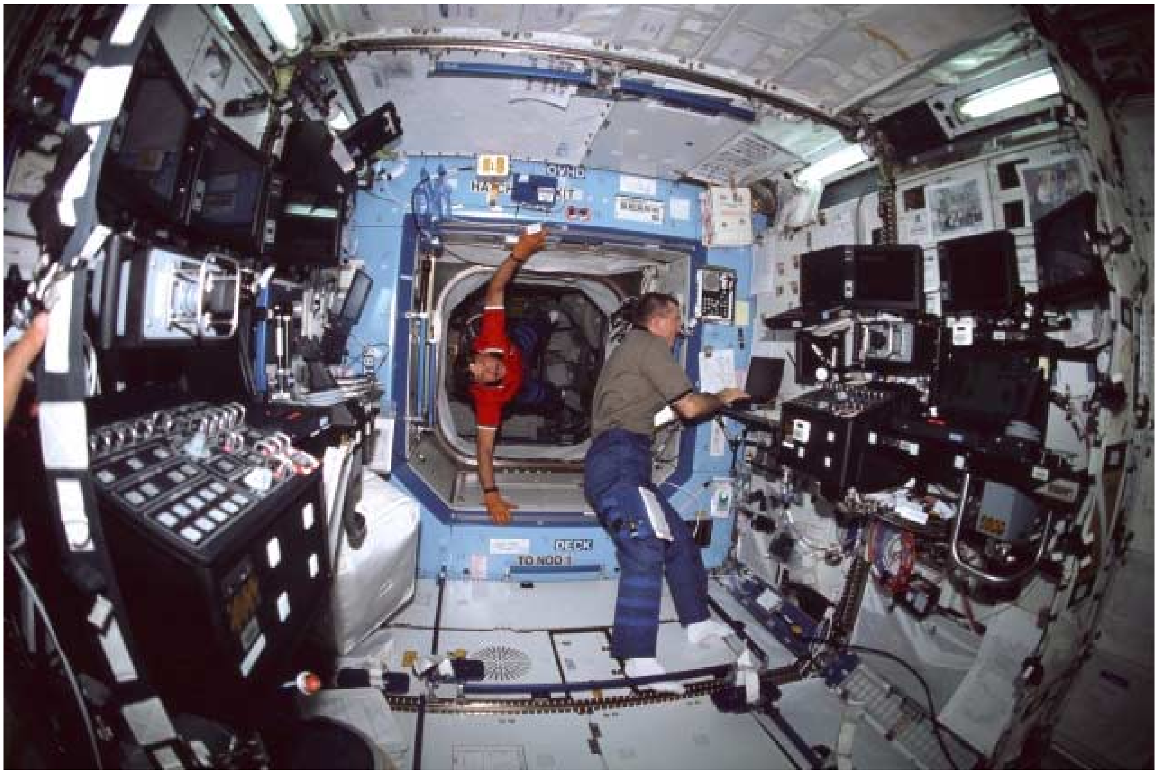
Leonardo, shown in the rear of Discovery's payload bay during shuttle mission STS-102 in March 2001

The Italian MPLM named Leonardo is making its third visit to the space station. It first flew on STS-102 in March 2001 and again on STS-105 in August 2001. It is one of three virtually identical modules that serve as pressurized moving vans, bringing equipment and supplies to the space station.

A sister module named Raffaello has visited the station twice, on STS-100 in April 2001 and on STS-108 in December 2001.

Leonardo will be lifted out of Endeavour's payload bay and attached directly to the station's Unity node for the unloading of its cargo. The MPLM brings to the station contents of eight resupply stowage racks, five resupply stowage platforms, two international standard payload racks and two scientific racks for the U.S. laboratory Destiny. One of the scientific racks is EXPRESS (for Expedite the Processing of Experiments to the Space Station) Rack No. 3. The other is the Microgravity Science Glovebox.



ISS crewmember Jim Voss works inside the Destiny lab, as shuttle astronaut Scott Horowitz enters the lab during STS-105

Destiny, installed on the STS-98 mission of Atlantis in February 2001, has slots for 24 of the interchangeable racks (six on the top, six on the bottom and six on each side). Eleven are systems racks, and one slot has Destiny 's 20-inch-diameter, optical-quality window. Remaining slots are for scientific racks.

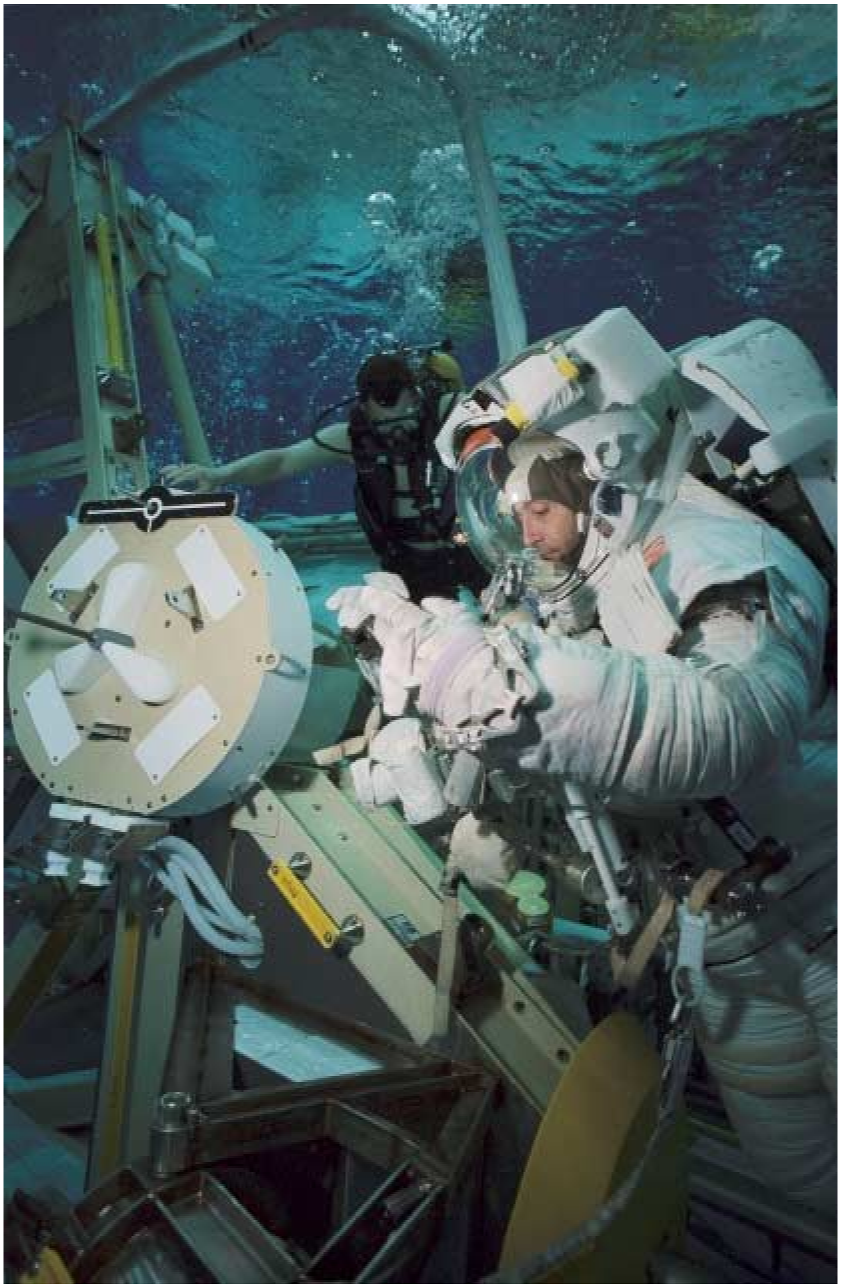
The MPLM will be put back into the cargo bay and returned to Earth for refurbishment and reuse on a subsequent mission. The MPLM is valued at $150 million.

STS-111 spacewalker Philippe Perrin practices in a ground-based mockup of the Quest Airlock

The mission's spacewalks will be conducted from the Joint Airlock Quest of the space station. Chang-Diaz and Perrin will perform all three.

During the first, on the crew's flight day five, Korzun, assisted by Walz, will operate the station robotic arm to move spacewalkers around while Cockrell will operate the shuttle's arm. The shuttle arm is used to provide camera views for the station arm operator. Lockhart will provide intravehicular support, providing guidance and advice to the spacewalkers to help them through their tasks and keep them on their timeline.

Chang-Diaz will remove a Power and Data Grapple Fixture (PDGF) from a carrier in the payload bay and both he and Perrin will install it on the P6 truss. This PDGF will be used during the 13A.1 stage to relocate the P6 truss structure to its final location on the station. The spacewalkers will then remove Service Module Debris Panel shields and install them on a temporary stowage location on Pressurized Mating Adapter 1 (PMA 1). These will be removed later by the station crew and installed at their final locations on the Zvezda module. Finally, they will remove thermal blankets from the Mobile Remote Servicer Base System (MBS) after it has been grappled and supplied with power by the station arm. The MBS will be unberthed from the payload bay by the Canadarm2 at the end of the first spacewalk, activated overnight by ground controllers, and latched to the Mobile Transporter the next morning.



Astronauts Philippe Perrin, foreground, and Franklin Chang-Diaz practice EVA tasks in the Neutral Buoyancy Lab in Houston

The second spacewalk, on flight day seven, will focus on connecting video/data cables and power umbilicals to the MBS and bolting it to its Mobile Transporter base. Spacewalkers also will deploy the POA (Payload ORU—On-Orbit Replaceable Unit—Accommodation), a fixed end effector identical to the one on the Canadarm2 to hold large payloads being transported along the truss structure, and will relocate a camera on the MBS. Neither the station arm nor the shuttle arm will be needed for the second spacewalk.

During the third spacewalk, on flight day nine, Chang-Diaz and Perrin will replace the wrist roll joint of the station's Canadarm2 with a backup unit brought into space aboard Endeavour. The shuttle arm will be used extensively on the third spacewalk to transport Perrin from worksite to worksite.

Handover briefings between Expedition 4 and Expedition 5 crewmembers continue throughout docked operations. A minimum of 12 hours of handover briefings is required for each Expedition 5 crewmember.

Logistics operations also continue throughout much of the docked period. Before the MPLM is returned to Endeavour's cargo bay, crewmembers will load Leonardo with unneeded equipment and trash from the station for return to Earth.

Leonardo is to be unberthed from the station and returned to Endeavour's cargo bay on flight day 10.

Pilot Paul Lockhart in the right-hand simulator seat at the Johnson Space Center, Houston

The shuttle will undock from the station the next day. Lockhart will do a one-revolution flyaround of the station before Endeavour leaves the area.

Endeavour is scheduled to land at Kennedy Space Center two days later.

STS-111 is the 14th space shuttle mission in support of the International Space Station, the 18th mission of Endeavour and the 110th flight in shuttle program history.

Day-by-day summary of the mission:

Day 1 – Launch

Activities consist primarily of post insertion, APCU activation and activating the MPLM shell heaters.

Day 2 – Equipment Checkout, Rendezvous Preparations

Crewmembers will check out the Docking Mechanism, the orbiter-based rendezvous tools and systems, the EMUs (spacesuits), make preparations for transfer, check out the shuttle’s robotic arm, and use its cameras to do a payload bay survey.

Day 3 – Rendezvous and Docking

ISS rendezvous, culminating in docking with the station, is the day’s major activity. The shuttle will dock to the PMA 2 on the forward end-cone of the U.S. laboratory Destiny. After docking and Orbiter Docking System (ODS) preparation, the crew will open the ODS hatch and the ISS and shuttle crews will meet for the first time in space. The ISS crew will give a safety briefing to the shuttle crew. Spacewalking equipment and one of the custom seat liners for the Soyuz crew return vehicle will be transferred later in the day.

Day 4 – Crew Transfer, MPLM Installation

The two remaining Expedition 5 crewmembers will transfer their seat liners to the Soyuz. The crew also will check the MPLM environment, and install, activate and outfit the vestibule, and prepare for entering the MPLM. Some equipment and supplies will be transferred from the middeck to the station and other cargo will be moved from the station to the shuttle for return to Earth.

Day 5 – Spacewalk 1, Transfer

Flight day five consists of MPLM transfer preparations and handover operations between ISS Expedition 4 and 5 commanders and the flight engineers. The first spacewalk is performed to install the P6 PDGF, install the meteoroid/debris shields on the PMA 1, remove the MBS thermal blankets and unberth the MBS from the payload bay. Flight controllers will activate the MBS from the ground overnight in preparation for the next day’s operations.

Day 6 – MBS Installation, Transfer

The day is reserved for MBS installation and middeck and MPLM transfer.

Day 7 – Spacewalk 2, Transfer

During this transfer and spacewalk day, EVA 2 will connect the MBS utilities, fully secure the MBS to the MT, deploy the MBS POA and relocate the camera. Middeck and MPLM transfer will continue.

Day 8 – MBS Checkout, Transfer

MBS checkout and transfer operations from both the MPLM and the shuttle’s middeck are the focus of this day.

Day 9 – Spacewalk 3

During the third spacewalk of the mission, Canadarm2’s wrist roll joint will be replaced. This spacewalk was added to the mission in late March.

Day 10 – MPLM Return to Endeavour

Preparations for Leonardo’s return to the shuttle’s cargo bay include crew egress and closeout, atmosphere conditioning, deactivation and utility disconnect. That done, Endeavour’s robotic arm will grapple and unberth the MPLM from the station and return it to Endeavour’s cargo bay. Once there, crewmembers will turn on its shell heaters. Middeck transfer will continue.

Day 11 – Farewell, Undocking

The departing crewmembers will bid Expedition 5 farewell. After hatches are closed and other preparations complete, Endeavour detaches itself from the International Space Station. Pilot Lockhart will fly Endeavour around the station before moving the orbiter away to begin its return to Earth.

Day 12 – Entry Preparations

The shuttle crew prepares for entry, checking out flight control surfaces and reaction control system jets, as well as stowing items for Endeavour’s return to Earth.

Day 13 – Landing

Endeavour is scheduled to land at Kennedy Space Center.

Crew

Commander:	Kenneth D. Cockrell
Pilot:	Paul S. Lockhart
Mission Specialist 1:	Philippe Perrin
Mission Specialist 2:	Franklin R. Chang-Diaz
(Up) Mission Specialist 3:	Peggy A. Whitson
(Up) Mission Specialist 4:	Valery G. Korzun
(Up) Mission Specialist 5:	Sergei Y. Treschev
(Dn) Mission Specialist 3:	Carl E. Walz
(Dn) Mission Specialist 4:	Daniel W. Bursch
(Dn) Mission Specialist 5:	Yury I. Onufrienko

Launch

Orbiter:	Endeavour (OV-105)
Launch Site:	Kennedy Space Center Launch Pad 39A
Launch Date:	May 30, 2002
Launch Window:	TBA
Altitude:	122 Nautical Miles
Inclination:	51.6 Degrees
Duration:	11 Days 18 Hrs. 22 Min.

Vehicle Data

Shuttle Liftoff Weight:	4,518,239 lbs.
Orbiter/Payload Liftoff Weight:	256,884 lbs.
Orbiter/Payload Landing Weight:	219,103 lbs.

Software Version: OI-29

Space Shuttle Main Engines:

SSME 1: 2050 **SSME 2:** 2044 **SSME 3:** 2054

External Tank: ET-113A (Super Light Weight Tank)

SRB Set: BI113PF

Shuttle Aborts

Abort Landing Sites

RTLS: Kennedy Space Center Shuttle Landing Facility
TAL: Primary – Zaragoza; Alternates Ben Guerir, Moron
AOA: Kennedy Space Center Shuttle Landing Facility

Landing

Landing Date:	06/11/02
Primary Landing Site:	Kennedy Space Center Shuttle Landing Facility

Mission Objectives

Priorities

Top priorities of the STS-111 (UF-2) mission of Endeavour are rotation of the International Space Station Expedition 4 and Expedition 5 crews, delivering water, equipment and supplies to the station and completion of robotics and spacewalk tasks.

International Space Station Program priorities include the following:

--Rotation of the Expedition 4 crew with Expedition 5 crew, transfer crew rotation equipment and perform crew handover.

--Transfer consumables – water and food -- from the shuttle to the station.

--Berth the Multi-Purpose Logistics Module to the station using the shuttle's robotic arm, and transfer experiment racks, equipment and supplies in it to the station.

--Remove the Mobile Remote Servicer Base System from Endeavour's cargo bay and install it on the Mobile Transporter.

--Replace the wrist-roll joint of Canadarm2.

--Install six Service Module Debris Panels on a temporary stowage location on Pressurized Mating Adapter 1.

--Install the Power, Data and Grapple Fixture on the P-6 truss.

--Transfer middeck powered payloads to the U.S. laboratory Destiny, install them and check them out.

STS-111 Crewmembers

Commander: Kenneth D. Cockrell

Ken Cockrell, 52, is the commander of Endeavour for the third shuttle flight of 2002 to deliver a new crew to the International Space Station and install the Mobile Remote Servicer Base System (MBS) on the station's railcar, the Mobile Transporter. He is making his third flight as commander and his fifth on a shuttle mission. As the STS-111 commander, Cockrell is primarily responsible for the success and safety of the flight, and will be at the controls for Endeavour's docking to the ISS on the third day of the mission. He will operate the shuttle's robotic arm during the spacewalks, moving the arm to optimize views from its television cameras for the first spacewalk and to position Mission Specialist Philippe Perrin during the third spacewalk. He will land Endeavour at the end of the mission.

A veteran of four spaceflights, Cockrell has logged more than 1,215 hours in space. He served as a mission specialist on STS-56 in 1993, was the pilot on STS-69, and was the mission commander on STS-80 in 1996 and STS-98 in 2001.

Pilot: Paul S. Lockhart

Paul Lockhart, 46, an Air Force lieutenant colonel making his first flight into space, is Endeavour's pilot. He holds a master's degree in aerospace engineering from the University of Texas. Lockhart will provide intravehicular support during the spacewalks. After the shuttle undocks on flight day 11, he will do a one-revolution flyaround of the station before Endeavour leaves the area. Selected by NASA in April 1996, Lockhart completed four years of training and evaluation.

Lockhart is making his first spaceflight.

Mission Specialist 1: Franklin R. Chang-Dìaz

Franklin Chang-Diaz, 52, will be making a record-tying seventh flight into space, equaling a record set by fellow astronaut Jerry Ross. Chang-Dìaz and fellow crewmember Philippe Perrin will perform three spacewalks during the mission on flight days five, seven and nine. Included in the activities for the first spacewalk will be the installation of a Power and Data Grapple Fixture for the station's robotic arm on the complex's P6 truss. Hooking up power, data and video lines to the newly attached MBS as well as bolting it permanently in place will be the focus of the second spacewalk. During the third spacewalk, Chang-Diaz and Perrin will replace the wrist roll joint of the station's Canadarm2 with a backup unit brought into space aboard Endeavour.

Selected by NASA in May 1980, Chang-Diaz holds a doctorate in applied plasma physics from the Massachusetts Institute of Technology earned in 1977. In December 1993, Chang-Dìaz was appointed director of the Advanced Space Propulsion Laboratory at the Johnson Space Center where he continues his research on plasma rockets. He is an adjunct professor of physics at Rice University and the University of Houston and has presented numerous papers at technical conferences and in scientific journals.

A veteran of six spaceflights (STS 61-C in 1986, STS-34 in 1989, STS-46 in 1992, STS-60 in 1994, STS-75 in 1996 and STS-91 in 1998), Chang-Diaz has logged more than 1,269 hours in space.

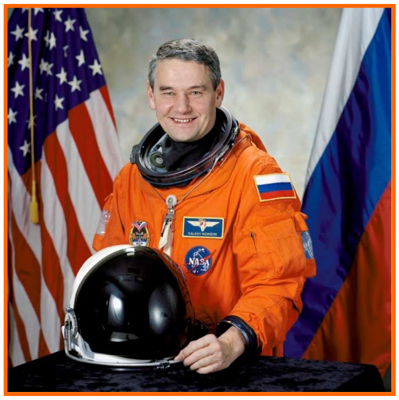
Mission Specialist 2: Philippe Perrin

Philippe Perrin, 39, is a colonel in the French Air Force and a French Space Agency (CNES) astronaut. Perrin and fellow crewmate Franklin Chang-Diaz will conduct all three of the mission's planned spacewalks to complete several tasks including hooking up power, data and video lines for the MBS and bolting it to the station's railcar, the Mobile Transporter, which was delivered, installed and successfully tested during STS-110. During the third spacewalk, they will replace the wrist roll joint of the station's robotic arm, Canadarm2. Perrin has flown 26 combat missions and has logged more than 2,500 flying hours in more than 30 types of aircraft (from jet fighters to Airbus).

Perrin is making his first spaceflight.

Expedition Five (Up only)

Commander: Valery Korzun



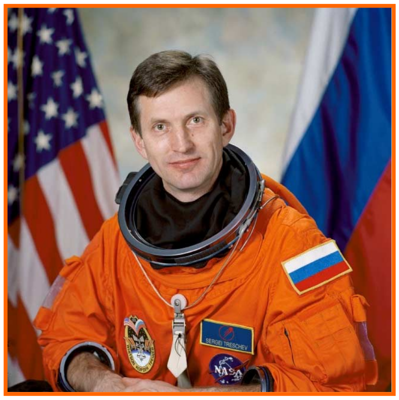
Valery Grigorievich Korzun, a cosmonaut and colonel in the Russian Air Force, is a veteran of 197 days on the Russian space station Mir. Korzun, 49, is a first-class military pilot. He has logged 1,473 hours in four types of aircraft. He also is an instructor of parachute training, with 337 parachute jumps to his credit. Korzun graduated from Kachin Military Aviation College in 1974. He served as a pilot, a senior pilot, flight section, and commanded an Air Force squadron. He was awarded six Air Force Medals.

In 1987 he was selected as a cosmonaut for training at the Gagarin Cosmonaut Training Center. Korzun was certified as a test cosmonaut in 1989. His flight aboard Mir began Aug. 17, 1996, and continued through March 2, 1997. During that period three NASA astronauts flew aboard Mir. A French astronaut and a German astronaut also visited the station during that time. While on Mir, Korzun performed two spacewalks totaling 12 hours and 33 minutes.

Flight Engineer: Peggy Whitson

U.S. astronaut Peggy A. Whitson holds a doctorate in biochemistry from Rice University and served in several research positions at Johnson Space Center before being selected as an astronaut in 1996. She completed two years of training and then performed technical duties in the Astronaut Office Operations Planning Branch. Whitson, 42, served as the lead for the Crew Test Support Team in Russia during 1998 and 1999. After receiving her doctorate in 1985, she remained at Rice as a postdoctoral fellow until late 1986. She began her studies at JSC as a National Research Council Resident Research Associate. She later served the center in a variety of scientific positions, including duty as the project scientist for Shuttle-Mir from 1992 to 1995. During Endeavour's approach to the station, she will operate a handheld laser range finder. This will be her first flight into space.

Flight Engineer: Sergei Treschev



Sergei Yevgenyevich Treschev, a cosmonaut of the RSC ENERGIA, is a graduate of the Moscow Energy Institute and served from 1982 to 1984 as a group leader in an Air Force regiment. He then joined RSC ENERGIA as a foreman and engineer. Responsibilities included analysis and planning of cosmonaut activities and their in-flight technical training. He also developed technical documentation and helped set up cosmonaut training with the Yuri Gagarin Cosmonaut Training Center. He supported training of crewmembers aboard Mir to help them maintain skills in performing descent and emergency escape operations. As a cosmonaut, Treschev, 43, trained from June 1999 to July 2000 as a flight engineer for the Soyuz-TM backup ISS contingency crew. This will be his first spaceflight.

Expedition Four (Down only)

Commander: Yury Onufrienko

Col. Yury Ivanov Onufrienko, 40, a test cosmonaut and former senior pilot in his country's air force, commanded the Expedition 4 crew. It was his second space station command – he led the Mir 21 expedition. Fellow crewmembers on Mir included astronaut Shannon Lucid and ISS Expedition 2 Commander Yury Usachev. As ISS commander, he has overall responsibility for expedition safety and success of the space station and the Expedition 4 crew. Onufrienko has made one previous spaceflight, as commander of the Mir 21 expedition from Feb. 21 to Sept. 2, 1996.

Flight Engineer: Daniel Bursch

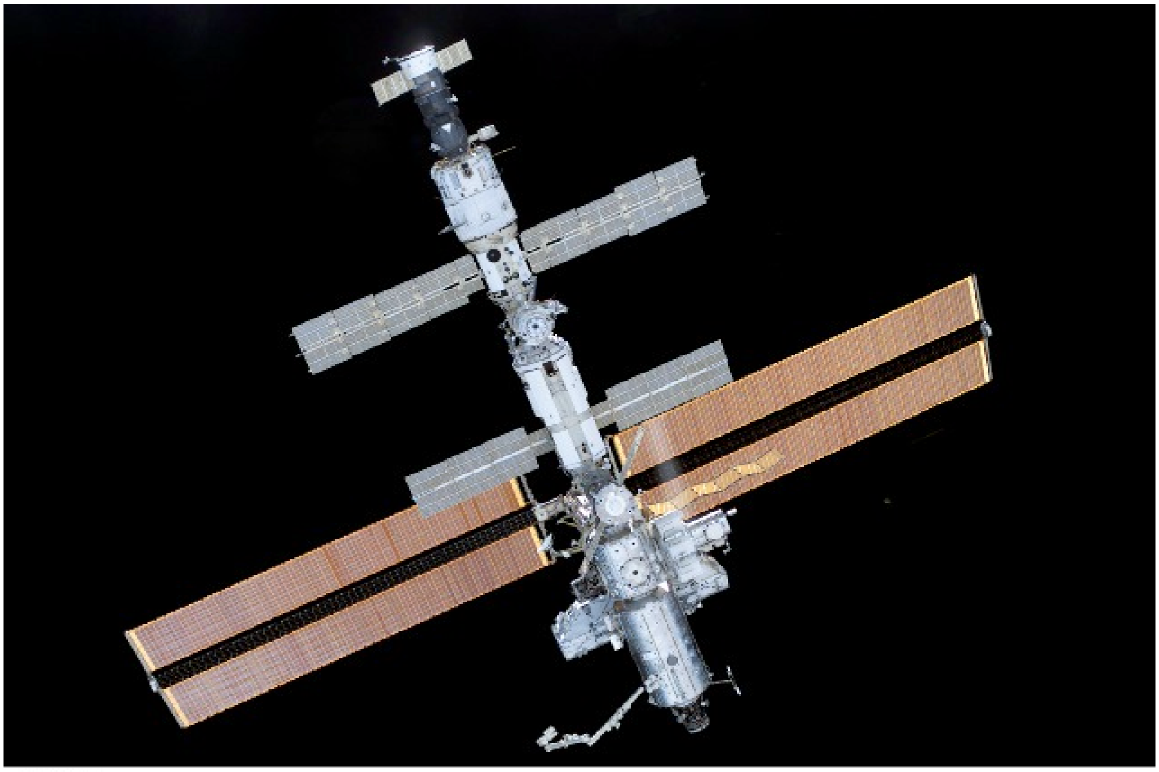
Daniel W. Bursch, 44, is a Navy captain, a former test pilot and test pilot school instructor, and a veteran of three spaceflights. He is a Naval Academy graduate and holds an M.S. in engineering science from the Naval Postgraduate School. He has more than 3,100 flight hours in 35 aircraft types. He became an astronaut in 1991. Bursch flew on STS-51, the Advanced Communications Technology Satellite and Shuttle Pallet Satellite flight, in September 1993. He also flew on STS-68, the Space Radar Lab-2 flight launched in September 1994 and on STS-77, with the fourth Spacehab module, in May 1996.

Flight Engineer: Carl Walz

Air Force Col. Carl E. Walz, 46, a former flight test engineer and flight test manager, was selected as an astronaut in 1990 and is a veteran of three spaceflights. He holds B.S. and M.S. degrees in physics and enjoys sports and music – he is lead singer for MAX-Q, the astronaut rock-n-roll band. Walz flew as a mission specialist with Bursch on STS-51, the Advanced Communications Technology Satellite and Shuttle Pallet Satellite flight, in September 1993. He also flew on STS-65, the second International Microgravity Laboratory Spacelab module, in July 1994 and on STS-79, a mission to the Russian space station Mir, in September 1997.

Rendezvous and Docking

Endeavour's rendezvous and docking with the International Space Station actually begins with the precisely timed launch of the shuttle on a course for the station. During the first two days of the mission, periodic engine firings will gradually bring Endeavour to a point about 9½ statute miles behind the station, the starting point for a final approach to the station.



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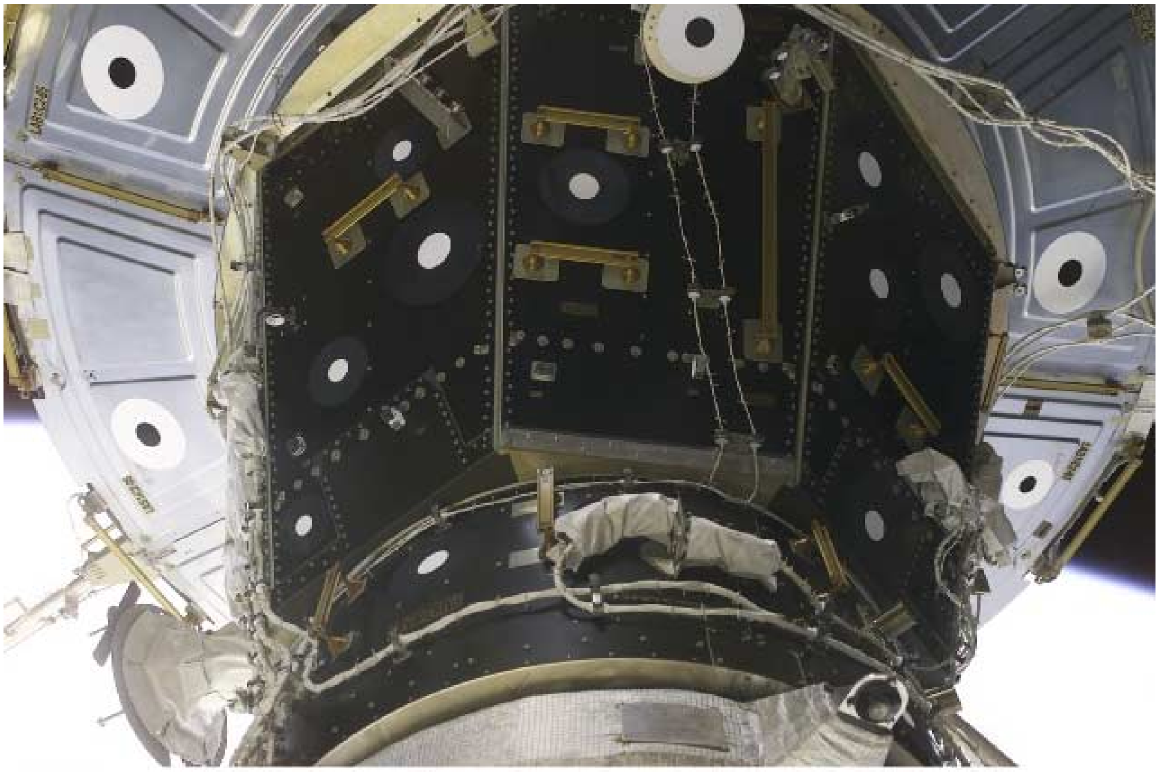
About 2½ hours before the scheduled docking time on flight day three, Endeavour will reach that point about 50,000 feet -- 9½ statute miles -- behind the ISS. At that time, Endeavour's jets will be fired in a Terminal Intercept (TI) burn to begin the final phase of the rendezvous. Endeavour will close the final miles to the station during the next orbit of Earth. As Endeavour closes in, the shuttle's rendezvous radar system will begin tracking the station and providing range and closing rate information to the crew. During the approach toward the station, the shuttle will have an opportunity to conduct four, small mid-course corrections at regular intervals. Just after the fourth correction is completed, Endeavour will reach a point about half a mile below the station. At that time, about an hour before the scheduled docking, Commander Ken Cockrell will take over manual control of the approach.

STS-111 Commander Ken Cockrell gives the "thumbs up" signal during simulator training at the Johnson Space Center, Houston

Cockrell will slow Endeavour's approach and fly to a point about 600 feet directly below the station, from which he will begin a quarter-circle of the station, slowly moving to a position in front of the complex, in line with its direction of travel. During the rendezvous, Pilot Paul Lockhart will assist Cockrell in controlling Endeavour's approach. Mission Specialists Philippe Perrin and Franklin Chang-Diaz also will play key roles in the rendezvous, with Perrin overseeing rendezvous navigation displays on a laptop computer aboard Endeavour and Chang-Diaz overseeing operations of the shuttle's docking system. Expedition 5 Flight Engineer Peggy Whitson also will assist, using a handheld laser ranging device to provide supplemental range and closing rate information to Cockrell.

Cockrell will fly the quarter-circle of the station, starting at a point 600 feet below, while slowly closing in on the complex, stopping at a point a little over 300 feet directly in front of the station. From that point, he will begin slowly moving directly toward the station's shuttle docking port – moving at a speed of about a tenth of a mile per hour. Using a view from a camera mounted in the center of Endeavour's docking mechanism as a key alignment aid, Cockrell will precisely center the docking ports of the two spacecraft. Cockrell will fly to a point where the docking mechanisms are 30 feet apart, and pause to check the alignment before proceeding to docking.

For Endeavour's docking, Cockrell will maintain the shuttle's speed relative to the station at about one-tenth of a foot per second, and keep the docking mechanisms aligned to within three inches of one another. When Endeavour makes contact with the station, preliminary latches will automatically attach the two spacecraft together. Immediately after Endeavour docks, the shuttle's steering jets will be deactivated to reduce the forces acting at the docking interface. Shock absorber-type springs in the docking mechanism will dampen any relative motion between the shuttle and the station.



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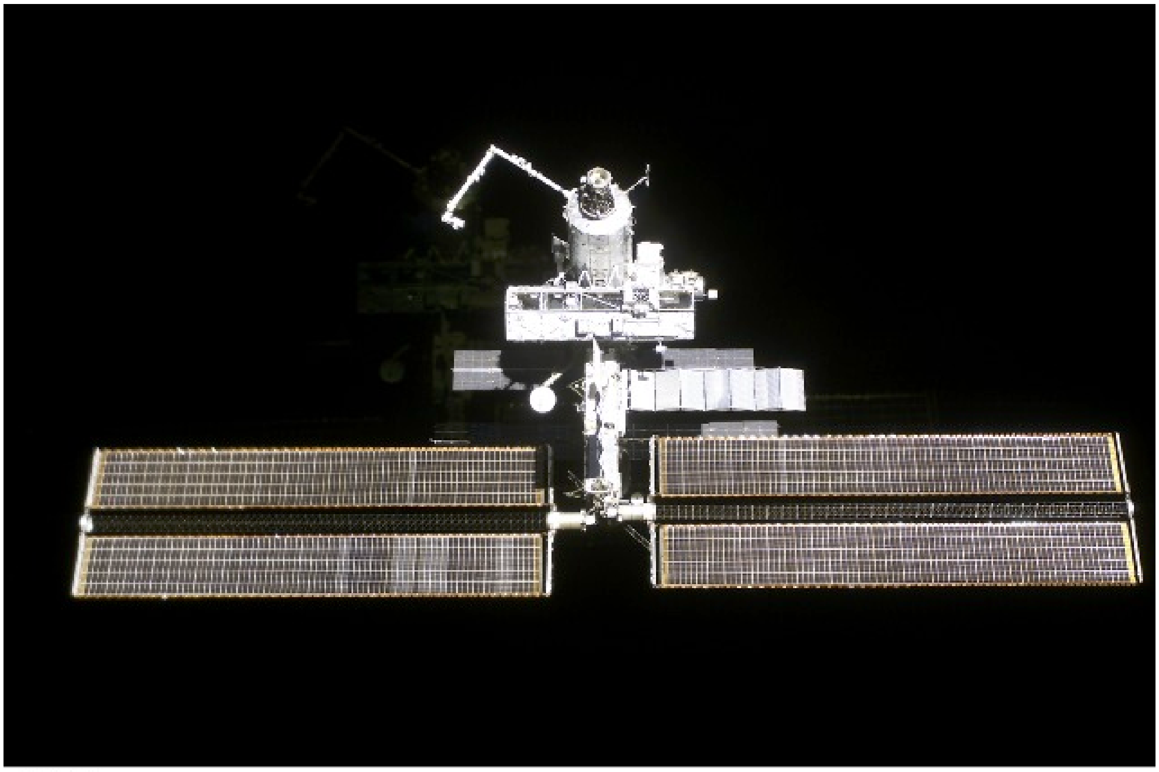
Once relative motion between the spacecraft has been stopped, Chang-Diaz will secure the docking mechanism, sending commands for Endeavour's mechanism to retract and close a final set of latches between the shuttle and station.

Undocking, Separation and Fly-Around

Once Endeavour is ready to undock, Chang-Diaz will send a command that will release the docking mechanism. The initial separation of the spacecraft will be performed by springs in the docking mechanism that will gently push the shuttle away from the station. Endeavour's steering jets will be shut off to avoid any inadvertent firings during this initial separation.

Once the docking mechanism's springs have pushed Endeavour away to a distance of about two feet, when the docking devices will be clear of one another, Lockhart will turn the steering jets back on and fire them to begin very slowly moving away. From the aft flight deck, Lockhart will manually control Endeavour within a tight corridor as he separates from the ISS, essentially the reverse of the task performed by Cockrell when Endeavour docked.



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Endeavour will continue away to a distance of about 450 feet, where Lockhart will begin a close flyaround of the station, circling the complex 1¼ times. Lockhart will pass a point directly above the station, then behind, then underneath, then in front and then reach a point directly above the station for a second time. At that point, passing above the station for a second time, Lockhart will fire Endeavour’s jets to depart the vicinity of the station. The flyaround is expected to be completed about an hour and half after undocking.

Spacewalks

STS-111 Extravehicular Activity

Astronauts Franklin Chang-Diaz and Philippe Perrin will perform three spacewalks during STS-111 to install the International Space Station's Mobile Remote Servicer Base System (MBS) and to replace a joint on the station's robotic arm. The spacewalks will be performed with one-day breaks in between to allow the crew to rest and prepare. The first spacewalk will take place on flight day five of the mission. The second will be on flight day seven, and the final venture outside is planned for flight day nine. The spacewalks will be the first extravehicular activity for both astronauts. During all of the spacewalks, Endeavour Pilot Paul Lockhart will serve as the Intravehicular (IV) crewmember, coordinating activities for the two spacewalkers from Endeavour's flight deck. STS-111 Commander Ken Cockrell will operate the shuttle’s robotic arm during the spacewalks, moving the arm to optimize views from its television cameras for the first spacewalk and to position Perrin during the third spacewalk. All of the spacewalks will originate from the station's Quest Airlock. During the work outside, the astronauts can be distinguished from one another by the markings on their spacesuits.

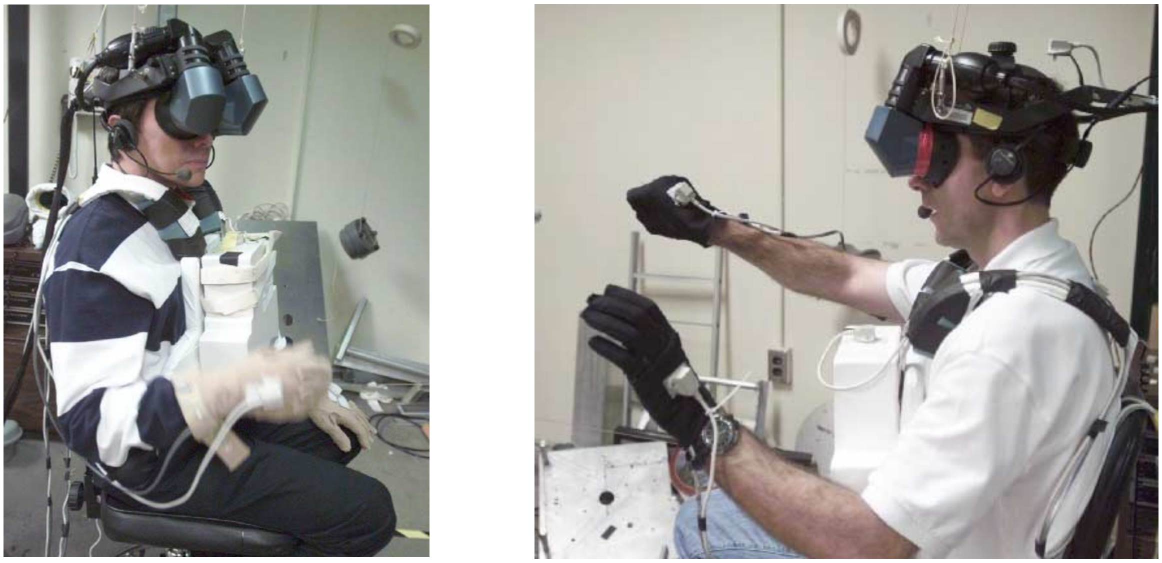
Recognizing the spacewalkers:

Chang-Diaz, Extravehicular Crewmember 1 (EV1) -- solid red stripes on legs of suit and top of backpack

Perrin, EV2 -- solid white suit legs (no stripes), French flag on arm of suit

Spacewalk No. 1, Flight Day Five: Install P6 Power and Data Grapple Fixture, Transfer and Stow Service Module Debris Panels, Remove Mobile Remote Servicer Base System Thermal Blankets

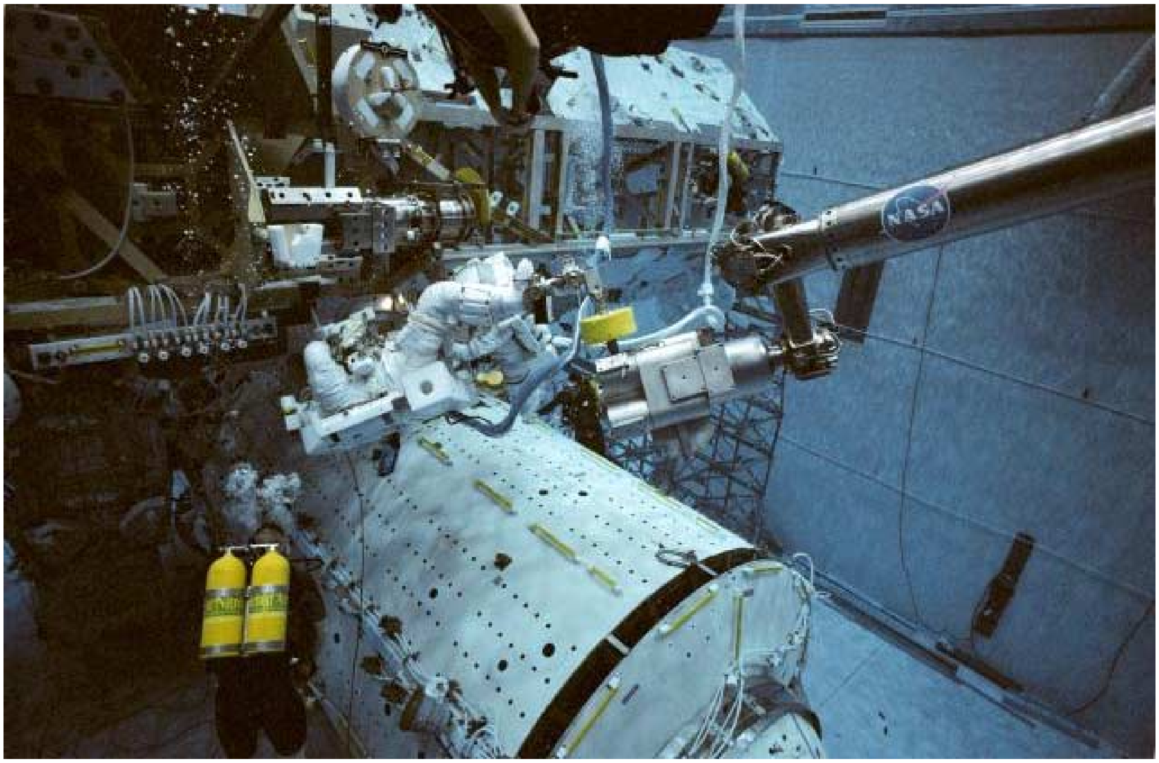
Chang-Diaz and Perrin will begin the spacewalks with the first excursion outside of Endeavour on flight day five. For the majority of the first spacewalk, planned to last about six hours, Chang-Diaz will work from a foot platform mounted at the end of the station's Canadarm2 robotic arm. The arm will be operated by station Expedition 5 Commander Valery Korzun and Expedition 4 Flight Engineer Carl Walz working at controls within the station’s Destiny lab. Perrin will work free-floating during much of the first EVA.



STS-111 astronauts Franklin Chang-Diaz, left, and Philippe Perrin practice their spacewalk tasks at the Johnson Space Center’s Virtual Reality Lab

The first spacewalk will begin with the installation of a Power and Data Grapple Fixture (PDGF) for the station's robotic arm on the complex's P6 truss. The PDGF will allow the robotic arm to grip the P6 truss for future station assembly operations. Chang-Diaz and Perrin will install the new fixture about halfway up the P6 truss, the vertical structure that currently supports the station's set of large U.S. solar arrays. The grapple fixture will be used during a later assembly flight when the robotic arm must reposition the P6 truss from its current location. Working from a foot platform at the end of the station arm, Chang-Diaz will remove the new grapple fixture from a shuttle cargo bay carrier where it was secured for launch. While Chang-Diaz is removing the grapple fixture from its payload bay carrier, Perrin will be installing a temporary attachment on the station's Pressurized Mating Adapter 1 (PMA 1). The attachment will be used later in the spacewalk to hold debris protection panels to be installed on the exterior of the station's Zvezda service module during a future spacewalk by station crewmembers. When Perrin has completed that task, he will climb up the P6 truss to await the arrival of Chang-Diaz, being maneuvered at the end of the station arm, carrying the grapple fixture. Midway up the P6 truss, the spacewalkers will work together to bolt the new fixture into place.

Once the grapple fixture has been installed, both spacewalkers will move to Endeavour's payload bay to unload the package of Service Module Debris Panels, shielding panels that will be installed on the Zvezda exterior by station crewmembers on a future spacewalk. Once unfastened from Endeavour, Chang-Diaz, still at the end of the station arm, will secure the panels as he is maneuvered to the station's PMA 1, a conical adapter between the Unity and Zarya modules of the station. Perrin will move to PMA 1 as well to assist with stowing the panels on the exterior of that adapter. Once the panels have been stowed on PMA 1, Chang-Diaz will get out of the arm foot platform and work free-floating for the remainder of the spacewalk along with Perrin.



Chang-Diaz and Perrin during one of many simulated spacewalks at Houston's Neutral Buoyancy Lab (NBL)

Before the spacewalkers begin the final task of EVA 1, Expedition 5 Flight Engineer Peggy Whitson will maneuver the station's robotic arm into position and latch it to a fixture on the MBS launched in Endeavour's payload bay. Once latched to the MBS, connections between the arm's tip and the MBS fixture will supply power to the base system's electronics heaters. Once those heaters are confirmed operating, Chang-Diaz and Perrin will begin removing insulating blankets from the MBS that had been in place for launch. Removing the blankets clears the way for the initial installation of the MBS atop the Mobile Transporter "railcar" that rides atop the station's truss. The MBS will serve as a movable base of operations for the station's robotic arm, enabling it to ride the railway on the station truss as it builds and maintains the eventual 356-foot-long structure. Removing the thermal blankets is the final task for the first spacewalk.

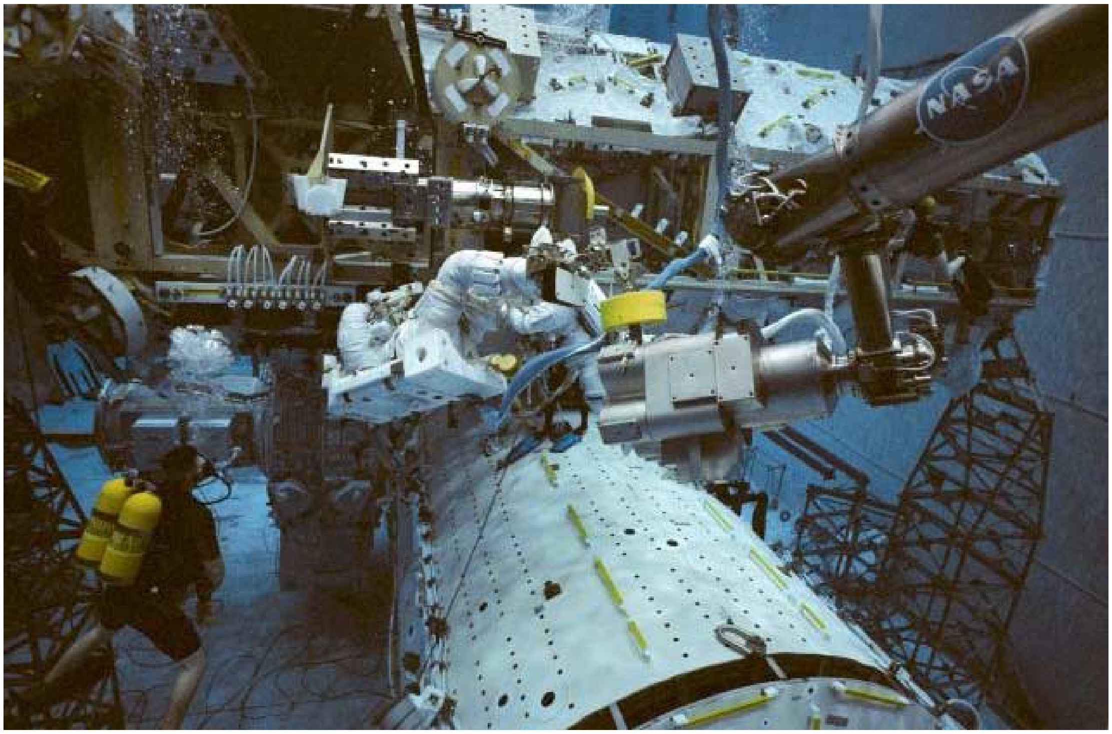
While Chang-Diaz and Perrin are gathering the tools and equipment they used during the work outside, Whitson, assisted by Walz, will use the station arm to lift the MBS from Endeavour's payload bay. They will maneuver the new station component into position just above the Mobile Transporter on the station truss where it will be installed. It will remain in that position overnight, to ensure temperatures on the MBS and the MT are similar before the MBS is lowered into place.

MBS Installation, Flight Day Six

While Chang-Diaz and Perrin rest and prepare for their second excursion planned on day seven, Whitson and Walz will lower the MBS into position to be initially latched to the MT. Once the MBS has been lowered into the proper location on the MT, a capture latch on the MBS will be commanded to close around a bar on the MT, providing the initial attachment of the new base system.

Spacewalk No. 2, Flight Day Seven: MBS connection

The second spacewalk, planned to last 6 ½ hours, will focus on hooking up power, data and video lines to the newly attached MBS as well as bolting it permanently in place. During the second spacewalk, both spacewalkers will be free-floating. At the start of the spacewalk, the station's Canadarm2 will have a grip on the MBS, which it had maneuvered into place and attached to the Mobile Transporter on day six. Through its grip, the Canadarm2 will be providing power to heaters and electronics on the base system. As the spacewalkers prepare to begin hooking up power and other lines from the MT to the MBS, the power provided to the base system by the arm will be shut off. Then Chang-Diaz and Perrin will work together to connect primary and redundant cables for video and data and primary cables for power between the MT and the MBS. Once the cable connections are completed, commands will be sent to the MT to remotely plug in its umbilical attachments to receptacles on the railway, a system called the Umbilical Mating Adapter (UMA), which will supply power and other services to the MBS via the MT. While the spacewalkers move on to other tasks, ground controllers will begin a check of MBS systems to ensure all connections are established.



Next, Chang-Diaz and Perrin will rotate a payload accommodations fixture, called the Payload Orbital Replacement Unit Accommodation (POA), on the MBS. The POA fixture will hold future cargoes on the base system as it is moved along the truss railway.

Then, with the ground-controlled MBS checks completed, Chang-Diaz will hook up redundant power cables between the MBS and the MT. Next, using a power wrench, the two spacewalkers will secure four bolts that complete the permanent structural connection between the MBS and the transporter railcar.

The final tasks for the second spacewalk will have the two EVA crewmembers work together to relocate a television camera on the MBS and to attach a bag to the MBS structure that contains a contingency MBS extension cable. The camera will be relocated from a position on the keel of the MBS, where it was used to provide visual cues needed to attach the MBS to the MT, to a position atop the MBS where it will be used to assist with the addition of the next station truss segment.

Spacewalk No. 3, Flight Day Nine: Replace Canadarm2 Wrist Roll Joint

The third spacewalk, added to STS-111 in March and planned to last 6 ½ hours, will replace the wrist roll joint on the International Space Station's Candarm2 with a new joint carried to the station by Endeavour. The wrist roll joint being replaced has experienced a problem that prevents brakes from being released when operating in a secondary mode. For the replacement, Chang-Diaz will work free-floating while Perrin works from a foot platform at the end of the shuttle's robotic arm. The station's arm will be positioned with its free end poised several feet away from the underside of the Destiny laboratory, the side of the lab that will be facing Endeavour's tail and will be directly above the shuttle payload bay.

All of the Canadarm2's joints are removable and were designed to be replaceable in orbit during a spacewalk. The new wrist roll joint is being carried aboard a special plate in Endeavour's cargo bay, a plate that will allow the faulty joint to be secured as well for the trip home aboard the shuttle. To access the wrist of the arm, the spacewalkers will first remove the Latching End Effector (LEE), the tip of the arm that is used to grip objects. Once the LEE is removed, the next portion of the arm is the wrist roll joint. Before removing the LEE, Perrin will install an insulating cover over the temperature-sensitive television camera and light assembly on the LEE. The insulation will moderate the temperatures experienced by that assembly while the LEE is unpowered. After the blanket is installed, the station crew will roll the end of the arm to provide access to the areas required for the joint changeout. Once in position, power will be shut off to the station arm.

Perrin maneuvers underwater during a simulated spacewalk at the NBL

When the station arm is powered off, Perrin will turn a bolt that will disconnect internal power, data and video connections between the LEE and the wrist roll joint. Next, Perrin and Chang-Diaz will loosen six special bolts, called Expandable Diameter Fasteners (EDFs), around the circumference of the LEE and roll joint. With those disconnected, Perrin, assisted by Chang-Diaz, will remove the almost 500-pound, washing machine-sized LEE from the arm and temporarily stow it in a fixture a few feet away on the exterior of the Destiny lab.

With the LEE removed, the wrist roll joint to be replaced will then be at the tip of the station's arm. The two spacewalkers, Perrin continuing to work from a foot platform at the end of Endeavour's robotic arm and Chang-Diaz working from a foot platform attached to Destiny, will turn their attention to removal of the faulty joint. In a fashion identical to the removal of the LEE, they will turn a bolt that detaches power, data and video connections within the roll joint and then loosen six EDF bolts. Once those are disconnected, the faulty joint will be detached from the rest of the arm.

Perrin, carrying the wrist roll joint, will then be maneuvered to Endeavour's payload bay to temporarily stow the faulty joint in a location adjacent to the new joint's launch position on a carrier designated the Flight Releasable Attachment Mechanism (FRAM). The joint can be "soft-docked" to the FRAM carrier. Installing three or four EDF bolts will complete the temporary stowage. Later, once the new joint has been removed and installed on the arm, the old joint will be permanently secured into the position where the new joint was for launch.

Together, the spacewalkers will then release the new joint from the FRAM payload bay carrier. Before removing the new joint from the FRAM, Lockhart will turn off power that ran heaters on the joint during its time in the shuttle bay. To release the new joint, the spacewalkers will first fold back insulation blankets that covered it during launch and then release six EDF bolts to free it from the shuttle carrier. Perrin will then carry the new joint as he is maneuvered at the end of the shuttle arm back up to the end of the station arm. Chang-Diaz will meet him there to begin the task of installing the new joint.

To install the new joint, Perrin and Chang-Diaz will align the wrist roll joint with the wrist yaw joint which will be at the end of the arm at that time and soft dock the new joint in place. Then, the two spacewalkers will work together to sequentially insert and tighten the six EDF bolts around the joint's circumference. They will tighten the bolts to a specified torque in stages. Once all of the EDFs are properly secured, Perrin will tighten a bolt that will connect power, video and data cables internal to the new joint with connections on the arm.

The next task will be to reinstall the LEE. The two will work together to remove the LEE from its position stowed on the exterior of Destiny and align it with the newly installed wrist joint. The LEE will be soft docked into position first, and then the six EDF bolts around its circumference tightened to secure it in place. Then a bolt will be turned to reconnect internal power, video and data connections. Once the LEE is reconnected and verified operating, the insulating cover will be removed from the camera assembly.

The final task for Chang-Diaz and Perrin will be to secure the failed joint in Endeavour's payload bay for return to Earth. The spacewalkers, with Perrin still working from a foot platform at the end of the shuttle's robotic arm, will first remove the joint from the payload bay bracket where they had temporarily secured it earlier. Then, they will move it to the adjacent bracket upon which the newly installed joint had been secured for launch. Using six EDF bolts, they will secure the joint in place for return to Earth. The bracket also will allow power to be supplied for heaters on the joint during its trip aboard Endeavour. The crew also will cover the old joint with a thermal cover that had protected the new joint during launch.

Payloads

Payload Overview

The launch package for mission STS-111 (International Space Station Assembly Flight UF-2) consists of a Multi-Purpose Logistics Module (MPLM), a Mobile Remote Servicer (MRS) Base System (MBS), a Space Station Remote Manipulator System (SSRMS) Wrist Roll Joint (WRJ) on a Get Away Special (GAS) Can beam, one Power and Data Grapple Fixture (PDGF) on an Increased Capacity Adaptive Payload Carrier (ICAPC) sidewall carrier, a set of six Service Module Debris Panel (SMDP) shields on a GAS Can beam, middeck payloads/stowage items, and crew rotation gear located in the shuttle middeck.

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The MPLM is manifested at the rear of the shuttle’s payload bay with the MPLM berthing mechanism facing forward. On orbit, a Remotely Operated Electrical Umbilical will provide electrical power to the MPLM shell heaters. After the payload bay door opening, avionics will be activated on the MPLM to monitor temperatures and pressures.

The MBS is manifested in the midsection of the payload bay, forward of the MPLM and aft of the Orbiter Docking System.

The SSRMS WRJ is manifested in Bay 6 port on a GAS beam using the Flight Releasable Attach Mechanism.

The ICAPC beam is manifested in Bay 13, port side, for carrying the PDGF. The PDGF will be attached to the P6 truss during the mission's first Extravehicular Activity (EVA).

The GAS Can beam is manifested in Bay 13, starboard side, for carrying the SMDP shields, with the Transportation Device Kit (TDK). The shields will be flown to the station aboard Endeavour on the STS-111 mission and will be temporarily stowed on the mating adaptor that connects the Unity module to the Zarya module by STS-111 spacewalkers Franklin Chang-Diaz and Philippe Perrin. The debris panels will be installed on the Service Module during the Expedition 5 stage via a spacewalk by Expedition 5 Commander Valery Korzun and Flight Engineer Peggy Whitson. The TDK will remain in the shuttle.

Two Assembly Power Converter Units with interconnect cabling and mounting brackets are manifested.

MPLM Transfer Items

Name	No.
Resupply Return Stowage Rack (RSR)	8
Resupply Stowage Platform (RSP)	5
International Standard Payload Rack (ISPR)	
Expedite the Processing of Experiments to the Space Station (EXPRESS) Rack No. 3	1
Microgravity Science Glovebox (MSG)	1
Shuttle Lithium Hydroxide (LiOH) Canisters (up to 8 transferred to ISS)	26
Various logistics and utilization items	

Middeck Powered Payload Transfer Items

Biomass Production System (BPS)
KSC Gaseous Nitrogen Freezer (KSC GN2 FREEZER)
Commercial Generic Bioprocessing Apparatus – 3 (CGBA-3)
Commercial Protein Crystal Growth – High Density – 1 (CPCG-H-1)
Protein Crystal Growth – Single Locker Thermal Enclosure System (PCG-STES 009)
STELSYS Commercial Refrigeration Incubator Module (CRIM) Contents

Payloads

Mobile Remote Servicer Base System

In April 2001, the first component of the Mobile Servicing System, Canadarm2, was launched and installed on the International Space Station during space shuttle mission STS-100. A larger and more sophisticated version of its predecessor shuttle robotic arm, Canadarm2 has seven joints and can flip hand-over-hand along the length of the space station. Canadarm2 was built to operate with two other components, a work platform called the Mobile Remote Servicer Base System (MBS) and a smaller dual-arm robot designed to accomplish more precise tasks, the Special Purpose Dexterous Manipulator. These three elements are essential to the assembly and maintenance of the station and represent the Mobile Servicing System, Canada's contribution to the ISS.

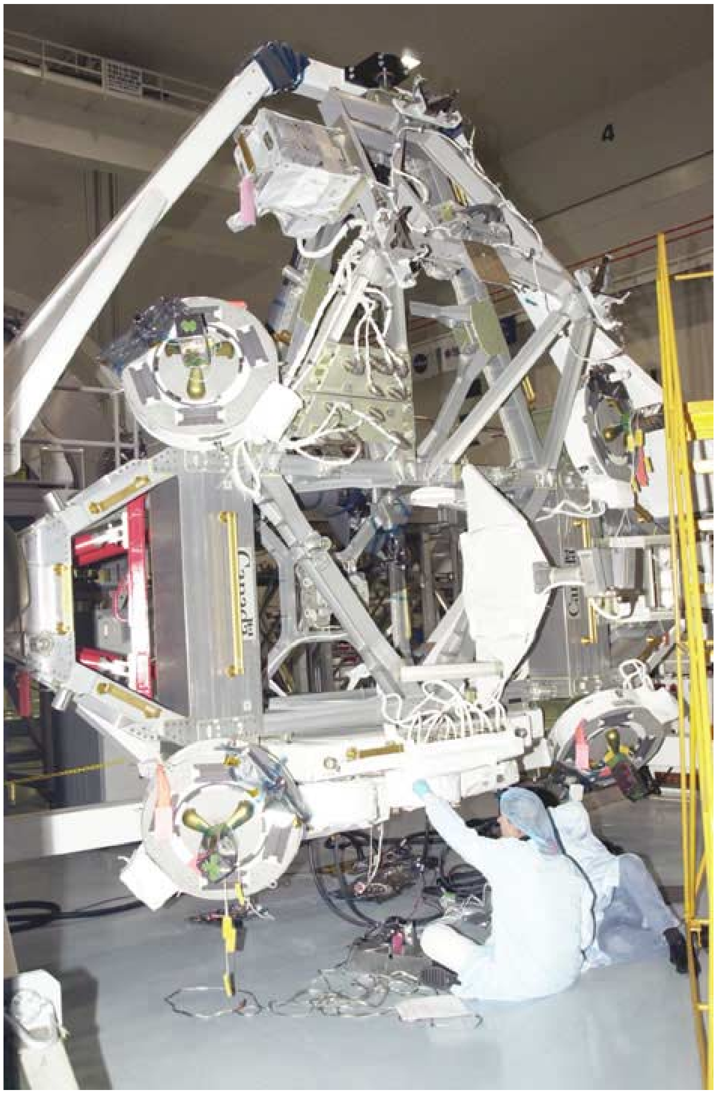
At Kennedy Space Center's Space Station Processing Facility, the Mobile Base System is hoisted to the weight and center of gravity stand

As the assembly of the ISS continues and the station grows larger, the MBS supports the need to provide greater mobility to Canadarm2 and access to the length of the station.

During shuttle mission STS-111, the MBS will be launched and installed on the space station. The MBS was designed and built by MD Robotics, the main contractor of Canadarm2, and a team of Canadian subcontractors.

The MBS will be mounted on the U.S.-provided Mobile Transporter that will slide on tracks along the length of the station. Attached to the MT, the MBS will provide greater mobility to Canadarm2 and allow the transport of payloads across the station using a fixture called the Payload Orbital Replacement Unit Accommodation or POA. The platform's POA will mainly be used to carry large structural elements and payloads, such as trusses, along the length of the station. Another attachment point called the MBS Common Attach System will be used to carry pallets containing lighter payloads like work tools and scientific experiments.

Astronauts will also use the MBS as a platform from which to perform spacewalks. The MBS can be used by the astronauts as a storage facility where they can keep various work tools and also as a means of transportation from one end of the station to another. Canadarm2 is designed so that repairs can be made in orbit throughout its lifetime and the MBS may serve as a maintenance platform that would hold both ends of Candarm2 if the replacement of any of its joints were warranted.



Four Payload Data Grapple Fixtures are clearly visible in this picture of the MBS at Kennedy Space Center's Space Station Processing Facility

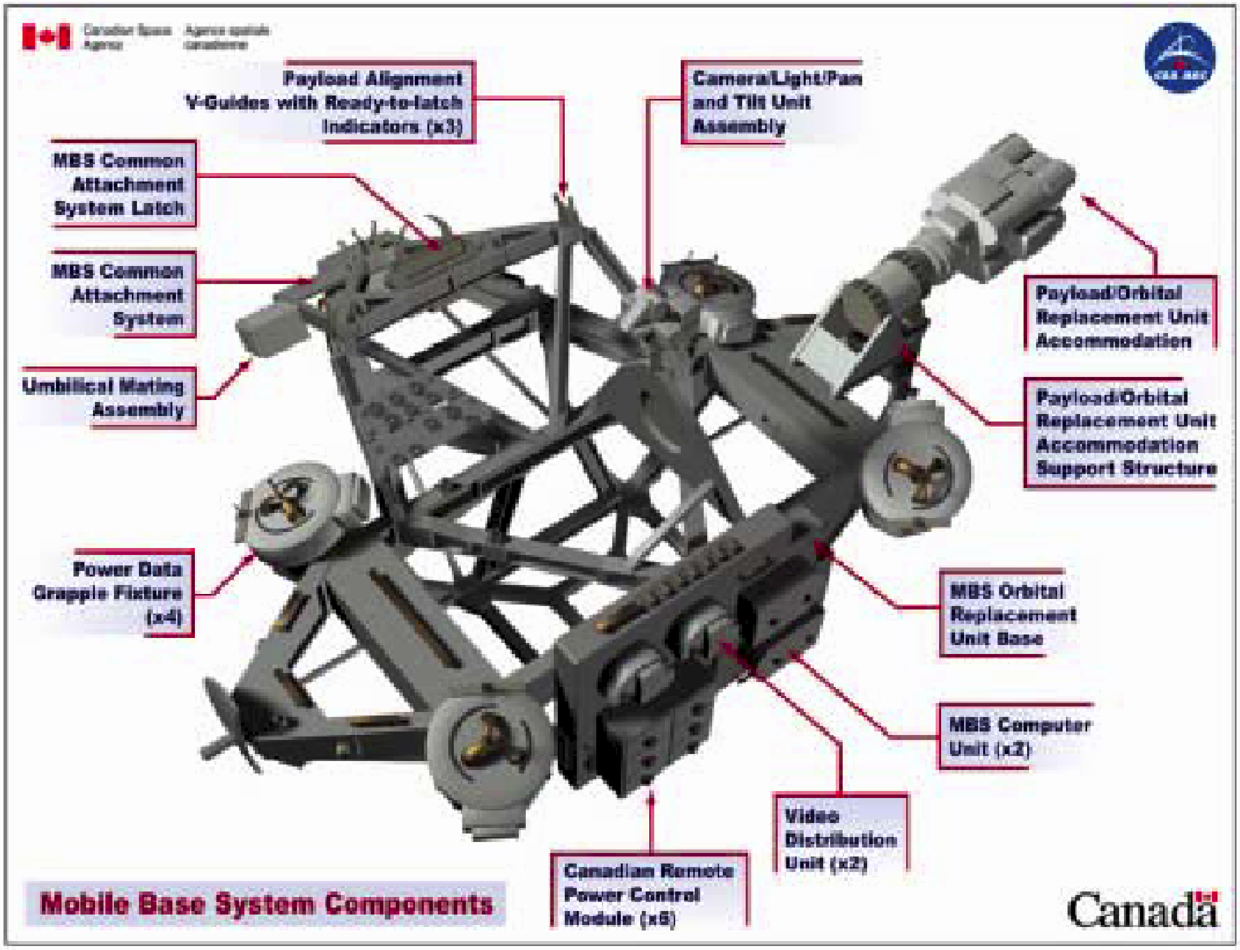
The MBS has four anchor points, referred to as Power Data Grapple Fixtures, which can serve as a base for operation of Canadarm2 and the SPDM robot. Through these anchor points, the MBS provides power and data to the robots as well as to the payloads that they may be supporting. These anchor points also transfer computer commands and video signals to and from the Robotic Work Station, a console located inside the station, from which the astronauts operate the entire MSS.

The MBS is also equipped with one removable Camera Light Pan & Tilt Assembly. The color camera is located on a mast behind the POA. This location provides not only a general view of the top surface of the MBS but also unobstructed views of all four of the anchor points. Initially, the camera will be installed on the underside of the MBS Common Attach System frame in order to provide suitable views of the mating of the MBS to the MT during STS-111. After the successful mating of the MBS to the MT, the camera will be relocated to its final position during a spacewalk.

The MBS is a strong and resistant aluminum structure with a life expectancy of at least 15 years. Like all elements of the ISS, the MBS is built with a series of separate and interchangeable modules called Orbital Replacement Units. In case of problems, the separate and interchangeable ORUs can be replaced during spacewalks or remotely once the SPDM has been installed on the space station. The MBS is also equipped with two main computer units.

The MBS measures about 18.7 by 14.7 by 9.5 feet (5.7 by 4.5 by 2.9 meters). Its mass is about 3,307 lbs (1,500 kg). Its mass handling transportation capacity is about 46,076 lbs (20,900 kg). The peak power (operational) of the MBS is 825 W. The average power (keep alive) is 365 W.

The MBS cost is $400 million (Canadian) or $254 million (usd).



Payloads

Leonardo - An Italian Space Veteran Carrying 5,600 lbs of Cargo to the ISS

The Leonardo Multi-Purpose Logistics Module (MPLM) acts as a moving van for the International Space Station Program, carrying laboratory racks with science equipment as well as storage racks and platforms filled with bags of experiments and supplies to and from the orbiting laboratory.

Leonardo, shown here in the payload bay of Discovery during shuttle mission STS-105/ISS 7A.1 in August 2001

Making its third trip into space, Leonardo is mounted in Endeavour's payload bay for launch and remains there until after the shuttle docks with the space station. Endeavour's astronauts will use the shuttle's robotic arm to remove Leonardo from the payload bay and attach it to the nadir port of the space station's Unity Node for unloading on flight day four.

Aboard Leonardo are eight Resupply Stowage Racks, five Resupply Stowage Platforms, and two International Standard Payload Racks; the Microgravity Science Glovebox Rack, and a new scientific experiment rack for the station's U.S. laboratory Destiny, the fifth rack to be carried to the station.

The new science rack (EXPRESS Rack 3) will add increased science capability to the station. EXPRESS stands for Expedite the Processing of Experiments to the Space Station. EXPRESS Rack 3 weighs 1,345 pounds. The empty weight of each EXPRESS rack is about 785 pounds.

EXPRESS Racks 4 and 5 were delivered to the station aboard the Leonardo cargo module during STS-105/7A.1 in August 2001. EXPRESS Racks 1 and 2A were delivered aboard the Raffaello cargo module during STS-100/6A in April 2001.

The Resupply Stowage Racks and Resupply Stowage Platforms are filled with Cargo Transfer Bags that contain equipment and supplies for the station. The eight Resupply Stowage Racks and the five Resupply Stowage Platforms contain about 5,600 pounds of cargo, not including the weight of the straps and fences that hold the bags in place.

The total weight of Leonardo with the cargo and racks is just over 23,275 pounds.

Leonardo's cargo includes equipment required for activation of the new science rack, a variety of parts for station systems and experiments including resupply items for the Human Research Facility and the Crew Health Care System, and food and other supplies to support the Expedition 5 crew. After the cargo is removed, the Resupply Stowage Racks and Resupply Stowage Platforms, which remain aboard Leonardo, will be filled with any unneeded station equipment and used crew provisions. Once filled, Leonardo will be detached from the station and put back into the shuttle's payload bay for the trip home.

History/Background

Construction of Leonardo began in April 1996 at the Alenia Aerospazio factory in Turin, Italy. Leonardo was flown from Italy to the Kennedy Space Center in Florida in August 1998 aboard a special Beluga cargo aircraft. Although built in Italy, Leonardo and two additional MPLMs, Raffaello and Donatello, are owned by the U.S. The MPLMs were provided in exchange for Italian access to U.S. research time on the space station.

The cylindrical Leonardo module is about 21 feet (6.4 meters) long and 15 feet (4.6 meters) in diameter. It weighs over 9,600 pounds (4.3 metric tons) empty and can carry up to 20,000 pounds (9.1 metric tons) of cargo packed into 16 standard space station equipment racks or platforms.

Expedition 1 Flight Engineer Yuri Gidzenko is dwarfed by transient hardware aboard Leonardo, the Italian Space Agency-built Multi-Purpose Logistics Module

Leonardo provides a controlled (human-rated) environment with components that provide some life support, fire detection and suppression, electrical distribution and computer functions. When in the payload bay, Leonardo is independent of the space shuttle and there is no passageway for shuttle crewmembers to travel to and from the module. In the future, the MPLMs will carry refrigerator freezers for transporting experiment samples and food to and from the station.

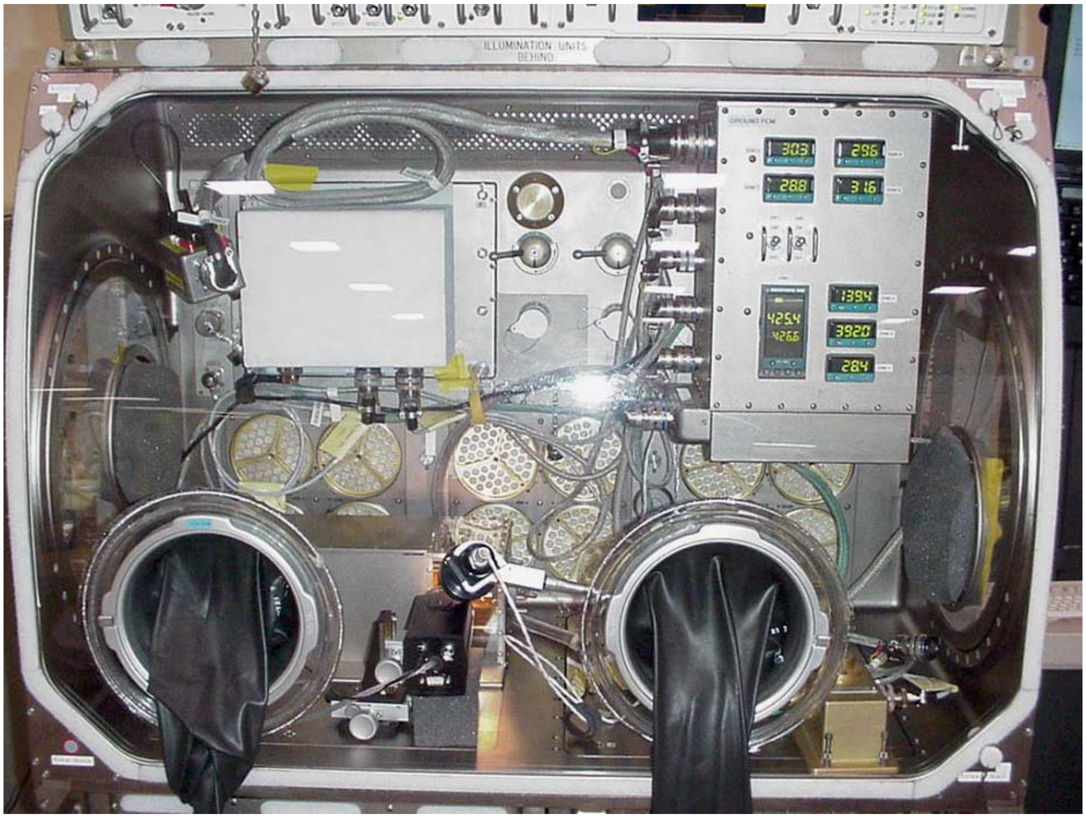
Leonardo first flew to the space station aboard Discovery on STS-102/5A.1 in March 2001. It flew again on STS-105 aboard Discovery in August 2001. The second MPLM, Raffaello, flew to the station aboard Endeavour on STS-100/6A in April 2001 and again aboard Endeavour on STS-108/UF-1 in December 2001. Donatello, the first powered module, is scheduled for flight in 2005.

Experiments

STS-111 Science Overview

When the space shuttle Endeavour returns to the International Space Station during the STS-111 mission, it will arrive with new equipment that enhances the orbiting outpost's construction and science capabilities and improves its safety.

The Multi-Purpose Logistics Module Leonardo will be making its third trip to space loaded with new science facilities and experiments to kick off Expedition 5. Leonardo is filled with new experiments and a major new science facility -- the Microgravity Science Glovebox.



The glovebox – a sealed container with built-in gloves on its sides and fronts – provides a facility that safely contains fluids, flames, particles and fumes, but still allows the crew to "get a grip" on science equipment via the gloves.

The glovebox, designed to stay in the Destiny laboratory for 10 years, will support the first two space station materials science experiments, also being delivered on STS-111. These experiments will study materials processes similar to those used to make semiconductors for electronic devices and components for jet engines. In exchange for building the glovebox, the European Space Agency will be able to perform experiments inside Destiny until that agency's space station laboratory – the Columbus Orbital Facility – is attached to the station in a couple of years.

The Microgravity Science Glovebox (MSG) is a sealed container with built-in gloves that provides an enclosed workspace for experiments with fluids, flames, particles or fumes. The MSG provides vacuum, venting and gaseous nitrogen, as well as power and data interfaces for experiments. The MSG occupies an entire rack inside the Destiny lab and is more than twice as large as gloveboxes flown previously on the space shuttle. This enables the MSG to hold experiments about the size of an airline carry-on bag. NASA's Marshall Space Flight Center worked with the European Space Agency to build the MSG - a facility that will support station experiments for the next 10 years. The MSG will be delivered during STS-111/UF2.

EXPRESS Rack 3, also ferried inside Leonardo, will be the fifth EXPRESS rack built at Marshall Space Flight Center, Huntsville, Ala., to be delivered to Destiny. These racks house experiments and provide them with power, fluids, cooling, data and other basic utilities.

The Expedition 5 research complement includes 24 new and continuing investigations, including the first two materials science experiments; two new plant experiments sponsored by industry; a commercial bioreactor that grows liver cells; facilities that grow biological crystals and zeolite crystals used in petroleum processing; and numerous experiments that study how the human body adapts to spaceflight.

All the station’s science experiments are operated from the ground by controllers on duty around the clock, seven days a week at the Payload Operations Center at Marshall. It is the command post for both planning and executing space station science activities. It links Earth-bound researchers with their experiments and the station crew.

Experiments

DTOs and DSOs

Detailed Test Objectives (DTOs) are aimed at testing, evaluating or documenting space shuttle systems or hardware, or proposed improvements to space shuttle hardware, systems and operations.

Detailed Supplementary Objectives (DSOs) are space and life science investigations. Their purpose is to determine the extent of physiological deconditioning resulting from spaceflight, to test countermeasures to those changes and to characterize the environment of the space shuttle relative to crew health.

The following such experiments are aboard Endeavour:

DTO 700-14

Single-String Global Positioning System

The purpose of the Single-String Global Positioning System (GPS) is to demonstrate the performance and operation of the GPS during orbiter ascent, on-orbit, entry and landing phases. It uses a modified military GPS receiver processor and the existing orbiter GPS antennas. GPS data may be downlinked during all mission phases. This has been previously manifested 23 times and was scheduled to fly on STS-110.

DTO 805

Crosswind Landing Performance

DTO 805 will demonstrate the capability to perform a manually controlled landing in the presence of a crosswind. This test requires that the crew perform a manually controlled landing in the presence of a 90-degree crosswind component of 10 to 15 knots steady state. This DTO has been manifested on 71 previous flights and was scheduled to fly on STS-110.

DTO 694

Biotechnology Water Treatment System

The purpose of the Biotechnology Treatment System is to produce ultra-pure water from the shuttle’s fuel cell water. This water, when processed, can replace manifested ultra-pure water supplies, and thus significantly decreases the mass and volume required to support biotechnology payloads. This will be the first flight for this DTO.

DSO 498

Spaceflight and Immune Function

The effects of spaceflight will be studied on selected immune elements that are important in maintaining an effective defense against infectious agents. The roles of neutrophils, monocytes, and cytotoxic cells -- all important elements of the immune response -- will be studied as part of this DSO.

DSO 499

Eye Movements and Motion Perception Induced by Off-Vertical Axis Rotation (OVAR) at Small Angles of Tilt after Spaceflight

The purpose of this study is to examine changes in spatial neural processing of gravitational tilt information following adaptation to microgravity. Postflight oculomotor and perceptual responses during off-vertical axis rotation will be compared with preflight baselines to track the time course of recovery. Comparison of data from short-duration and long-duration (ISS) crewmembers will allow us to assess the effect of flight duration.

DSO 500

Spaceflight-Induced Reactivation of Latent Epstein-Barr Virus

The combined effects of microgravity along with associated physical and psychological stress will decrease Epstein-Barr virus (EBV)-specific T-cell immunity and reactivate latent EBV in infected B-lymphocytes.

The mechanisms of spaceflight-induced alterations in human immune function and latent virus reactivation will be examined. Specifically, this study will determine the magnitude of immunosuppression as a result of spaceflight by:

1. Analysis of stress hormones

2. Quantitative analysis of EBV replication using molecular and serological methods; and

3. Determining virus-specific T-cell immune function.

DSO 503-S

Test of Midodrine as a Countermeasure Against Postflight Orthostatic Hypotension

Following exposure to spaceflight, upright posture can result in the inability to maintain adequate arterial pressure and cerebral perfusion (orthostatic or postural hypotension). This may result in presyncope (lightheadedness) or syncope (loss of consciousness) during re-entry or egress.

A new pharmacological countermeasure for protection from postflight orthostatic hypotension will be evaluated. This experiment will measure the efficacy of midodrine in reducing the incidence and/or severity of orthostatic hypotension in returning astronauts. Efficacy will be evaluated with an expanded tilt test.

DSO 634

Sleep–Wake Actigraphy and Light Exposure During Spaceflight

Disruption of sleep during spaceflight, both short- and long-duration, is associated with inappropriately timed (non-24 hour) or insufficiently intense light exposure. Sleep disruption and circadian misalignment will lead to subjective dissatisfaction with self-reported sleep quality and daytime alertness. Both of these conditions are associated with insomnia and associated impairment of alertness and cognitive performance that could impair mission success.

This experiment will use state-of-the-art ambulatory technology to monitor sleep-wake activity and light exposure patterns obtained in-flight. This data should help better understand the effects of spaceflight on sleep as well as aid in the development of effective countermeasures for both short- and long-duration spaceflight.

DSO 635

Spatial Reorientation Following Spaceflight

Before and after spaceflight, spatial orientation is altered by a shift of central vestibular processing from a gravitational frame-of-reference to an internal, head-centered frame-of-reference. This occurs during adaptation to microgravity and is reversed during the first few days after return to Earth. Discordant sensory stimuli during the postflight re-adaptive period will temporarily disorient and destabilize the subject by triggering a shift (state change) to the previously learned, internally-referenced, microgravity-adapted pattern of spatial orientation and sensorimotor control.

The purpose of this DSO is to examine both the adaptive changes in the spatial reference frame used for coding spatial orientation and sensorimotor control. Also being studied is the fragility of the adaptive process and the feasibility of driving state changes in central vestibular processing via discordant sensory stimuli using balance control tests and eye movement responses to pitch-axis rotation in a short-arm centrifuge. The findings are expected to demonstrate the degree to which challenging motion environments may affect postflight adaptation/re-adaptation and lead to a better understanding of safe postflight activity regimens. The findings are also expected to demonstrate the feasibility of triggering state changes between sensorimotor control sets using a centrifuge device.

Experiments

Ram Burn Observations (RAMBO)

Ram Burn Observations (RAMBO) is a Department of Defense experiment that observes shuttle Orbital Maneuvering System engine burns for the purpose of improving plume models. On STS-111 the shuttle will perform a 10-second, dual OMS burn to be observed by the appropriate sensors.

Shuttle Reference Data

Shuttle Abort History

RSLS Abort History:

(STS-41 D) June 26, 1984

The countdown for the second launch attempt for Discovery's maiden flight ended at T-4 seconds when the orbiter's computers detected a sluggish valve in main engine #3. The main engine was replaced and Discovery was finally launched on August 30, 1984.

(STS-51 F) July 12, 1985

The countdown for Challenger's launch was halted at T-3 seconds when on-board computers detected a problem with a coolant valve on main engine #2. The valve was replaced and Challenger was launched on July 29, 1985.

(STS-55) March 22, 1993

The countdown for Columbia's launch was halted by on-board computers at T-3 seconds following a problem with purge pressure readings in the oxidizer preburner on main engine #2 Columbia's three main engines were replaced on the launch pad, and the flight was rescheduled behind Discovery's launch on STS-56. Columbia finally launched on April 26, 1993.

(STS-51) August 12, 1993

The countdown for Discovery's third launch attempt ended at the T-3 second mark when on-board computers detected the failure of one of four sensors in main engine #2 which monitor the flow of hydrogen fuel to the engine. All of Discovery's main engines were ordered replaced on the launch pad, delaying the Shuttle's fourth launch attempt until September 12, 1993.

(STS-68) August 18, 1994

The countdown for Endeavour's first launch attempt ended 1.9 seconds before liftoff when on-board computers detected higher than acceptable readings in one channel of a sensor monitoring the discharge temperature of the high pressure oxidizer turbopump in main engine #3. A test firing of the engine at the Stennis Space Center in Mississippi on September 2nd confirmed that a slight drift in a fuel flow meter in the engine caused a slight increase in the turbopump's temperature. The test firing also confirmed a slightly slower start for main engine #3 during the pad abort, which could have contributed to the higher temperatures. After Endeavour was brought back to the Vehicle Assembly Building to be outfitted with three replacement engines, NASA managers set October 2nd as the date for Endeavour's second launch attempt.

Abort to Orbit History:

(STS-51 F) July 29, 1985

After an RSLS abort on July 12, 1985, Challenger was launched on July 29, 1985. Five minutes and 45 seconds after launch, a sensor problem resulted in the shutdown of center engine #1, resulting in a safe "abort to orbit" and successful completion of the mission.

Shuttle Reference Data

Shuttle Abort Modes

RSLS ABORTS

These occur when the onboard shuttle computers detect a problem and command a halt in the launch sequence after taking over from the Ground Launch Sequencer and before Solid Rocket Booster ignition.

ASCENT ABORTS

Selection of an ascent abort mode may become necessary if there is a failure that affects vehicle performance, such as the failure of a space shuttle main engine or an orbital maneuvering system. Other failures requiring early termination of a flight, such as a cabin leak, might also require the selection of an abort mode.

There are two basic types of ascent abort modes for space shuttle missions: intact aborts and contingency aborts. Intact aborts are designed to provide a safe return of the orbiter to a planned landing site. Contingency aborts are designed to permit flight crew survival following more severe failures when an intact abort is not possible. A contingency abort would generally result in a ditch operation.

INTACT ABORTS

There are four types of intact aborts: abort to orbit (ATO), abort once around (AOA), transoceanic abort landing (TAL) and return to launch site (RTLS).

Return to Launch Site

The RTLS abort mode is designed to allow the return of the orbiter, crew, and payload to the launch site, Kennedy Space Center, approximately 25 minutes after lift-off.

The RTLS profile is designed to accommodate the loss of thrust from one space shuttle main engine between lift-off and approximately four minutes 20 seconds, at which time not enough main propulsion system propellant remains to return to the launch site.

An RTLS can be considered to consist of three stages--a powered stage, during which the space shuttle main engines are still thrusting; an ET separation phase; and the glide phase, during which the orbiter glides to a landing at the Kennedy Space Center. The powered RTLS phase begins with the crew selection of the RTLS abort, which is done after solid rocket booster separation. The crew selects the abort mode by positioning the abort rotary switch to RTLS and depressing the abort push button. The time at which the RTLS is selected depends on the reason for the abort. For example, a three-engine RTLS is selected at the last moment, approximately three minutes 34 seconds into the mission; whereas an RTLS chosen due to an engine out at lift-off is selected at the earliest time, approximately two minutes 20 seconds into the mission (after solid rocket booster separation).

After RTLS is selected, the vehicle continues downrange to dissipate excess main propulsion system propellant. The goal is to leave only enough main propulsion system propellant to be able to turn the vehicle around, fly back towards the Kennedy Space Center and achieve the proper main engine cutoff conditions so the vehicle can glide to the Kennedy Space Center after external tank separation. During the downrange phase, a pitch-around maneuver is initiated (the time depends in part on the time of a space shuttle main engine failure) to orient the orbiter/external tank configuration to a heads up attitude, pointing toward the launch site. At this time, the vehicle is still moving away from the launch site, but the space shuttle main engines are now thrusting to null the downrange velocity. In addition, excess orbital maneuvering system and reaction control system propellants are dumped by continuous orbital maneuvering system and reaction control system engine thrustings to improve the orbiter weight and center of gravity for the glide phase and landing.

The vehicle will reach the desired main engine cutoff point with less than 2 percent excess propellant remaining in the external tank. At main engine cutoff minus 20 seconds, a pitch-down maneuver (called powered pitch-down) takes the mated vehicle to the required external tank separation attitude and pitch rate. After main engine cutoff has been commanded, the external tank separation sequence begins, including a reaction control system translation that ensures that the orbiter does not recontact the external tank and that the orbiter has achieved the necessary pitch attitude to begin the glide phase of the RTLS.

After the reaction control system translation maneuver has been completed, the glide phase of the RTLS begins. From then on, the RTLS is handled similarly to a normal entry.

Transoceanic Abort Landing

The TAL abort mode was developed to improve the options available when a space shuttle main engine fails after the last RTLS opportunity but before the first time that an AOA can be accomplished with only two space shuttle main engines or when a major orbiter system failure, for example, a large cabin pressure leak or cooling system failure, occurs after the last RTLS opportunity, making it imperative to land as quickly as possible.

In a TAL abort, the vehicle continues on a ballistic trajectory across the Atlantic Ocean to land at a predetermined runway. Landing occurs approximately 45 minutes after launch. The landing site is selected near the nominal ascent ground track of the orbiter in order to make the most efficient use of space shuttle main engine propellant. The landing site also must have the necessary runway length, weather conditions and U.S. State Department approval. Currently, the three landing sites that have been identified for a due east launch are Moron, Spain; Dakar, Senegal; and Ben Guerur, Morocco (on the west coast of Africa).

To select the TAL abort mode, the crew must place the abort rotary switch in the TAL/AOA position and depress the abort push button before main engine cutoff. (Depressing it after main engine cutoff selects the AOA abort mode.) The TAL abort mode begins sending commands to steer the vehicle toward the plane of the landing site. It also rolls the vehicle heads up before main engine cutoff and sends commands to begin an orbital maneuvering system propellant dump (by burning the propellants through the orbital maneuvering system engines and the reaction control system engines). This dump is necessary to increase vehicle performance (by decreasing weight), to place the center of gravity in the proper place for vehicle control, and to decrease the vehicle's landing weight.

TAL is handled like a nominal entry.

Abort to Orbit

An ATO is an abort mode used to boost the orbiter to a safe orbital altitude when performance has been lost and it is impossible to reach the planned orbital altitude. If a space shuttle main engine fails in a region that results in a main engine cutoff under speed, the Mission Control Center will determine that an abort mode is necessary and will inform the crew. The orbital maneuvering system engines would be used to place the orbiter in a circular orbit.

Abort Once Around

The AOA abort mode is used in cases in which vehicle performance has been lost to such an extent that either it is impossible to achieve a viable orbit or not enough orbital maneuvering system propellant is available to accomplish the orbital maneuvering system thrusting maneuver to place the orbiter on orbit and the deorbit thrusting maneuver. In addition, an AOA is used in cases in which a major systems problem (cabin leak, loss of cooling) makes it necessary to land quickly. In the AOA abort mode, one orbital maneuvering system thrusting sequence is made to adjust the post-main engine cutoff orbit so a second orbital maneuvering system thrusting sequence will result in the vehicle deorbiting and landing at the AOA landing site (White Sands, N.M.; Edwards Air Force Base; or the Kennedy Space Center). Thus, an AOA results in the orbiter circling the Earth once and landing approximately 90 minutes after lift-off.

After the deorbit thrusting sequence has been executed, the flight crew flies to a landing at the planned site much as it would for a nominal entry.

CONTINGENCY ABORTS

Contingency aborts are caused by loss of more than one main engine or failures in other systems. Loss of one main engine while another is stuck at a low thrust setting may also necessitate a contingency abort. Such an abort would maintain orbiter integrity for in-flight crew escape if a landing cannot be achieved at a suitable landing field.

Contingency aborts due to system failures other than those involving the main engines would normally result in an intact recovery of vehicle and crew. Loss of more than one main engine may, depending on engine failure times, result in a safe runway landing. However, in most three-engine-out cases during ascent, the orbiter would have to be ditched. The in-flight crew escape system would be used before ditching the orbiter.

ABORT DECISIONS

There is a definite order of preference for the various abort modes. The type of failure and the time of the failure determine which type of abort is selected. In cases where performance loss is the only factor, the preferred modes would be ATO, AOA, TAL and RTLS, in that order. The mode chosen is the highest one that can be completed with the remaining vehicle performance.

In the case of some support system failures, such as cabin leaks or vehicle cooling problems, the preferred mode might be the one that will end the mission most quickly. In these cases, TAL or RTLS might be preferable to AOA or ATO. A contingency abort is never chosen if another abort option exists.

The Mission Control Center-Houston is prime for calling these aborts because it has a more precise knowledge of the orbiter's position than the crew can obtain from onboard systems. Before main engine cutoff, Mission Control makes periodic calls to the crew to tell them which abort mode is (or is not) available. If ground communications are lost, the flight crew has onboard methods, such as cue cards, dedicated displays and display information, to determine the current abort region.

Which abort mode is selected depends on the cause and timing of the failure causing the abort and which mode is safest or improves mission success. If the problem is a space shuttle main engine failure, the flight crew and Mission Control Center select the best option available at the time a space shuttle main engine fails.

If the problem is a system failure that jeopardizes the vehicle, the fastest abort mode that results in the earliest vehicle landing is chosen. RTLS and TAL are the quickest options (35 minutes), whereas an AOA requires approximately 90 minutes. Which of these is selected depends on the time of the failure with three good space shuttle main engines.

The flight crew selects the abort mode by positioning an abort mode switch and depressing an abort push button.

Shuttle Reference Data

Space Shuttle Rendezvous Maneuvers

COMMON SHUTTLE RENDEZVOUS MANEUVERS

OMS-1 (Orbit insertion) - Rarely used ascent abort burn

OMS-2 (Orbit insertion) - Typically used to circularize the initial orbit following ascent, completing orbital insertion. For ground-up rendezvous flights, also considered a rendezvous phasing burn

NC (Rendezvous phasing) - Performed to hit a range relative to the target at a future time

NH (Rendezvous height adjust) - Performed to hit a delta-height relative to the target at a future time

NPC (Rendezvous plane change) - Performed to remove planar errors relative to the target at a future time

NCC (Rendezvous corrective combination) - First on-board targeted burn in the rendezvous sequence. Using star tracker data, it is performed to remove phasing and height errors relative to the target at Ti

Ti (Rendezvous terminal intercept) - Second on-board targeted burn in the rendezvous sequence. Using primarily rendezvous radar data, it places the Orbiter on a trajectory to intercept the target in one orbit

MC-1, MC-2, MC-3, MC-4 (Rendezvous midcourse burns) - These on-board targeted burns use star tracker and rendezvous radar data to correct the post-Ti trajectory in preparation for the final, manual proximity operations phase

Shuttle Reference Data

Space Shuttle Solid Rocket Boosters

The two SRBs provide the main thrust to lift the space shuttle off the pad and up to an altitude of about 150,000 feet, or 24 nautical miles (28 statute miles). In addition, the two SRBs carry the entire weight of the external tank and orbiter and transmit the weight load through their structure to the mobile launcher platform.

Each booster has a thrust (sea level) of approximately 3,300,000 pounds at launch. They are ignited after the three space shuttle main engines' thrust level is verified. The two SRBs provide 71.4 percent of the thrust at lift- off and during first-stage ascent. Seventy- five seconds after SRB separation, SRB apogee occurs at an altitude of approximately 220,000 feet, or 35 nautical miles (40 statute miles). SRB impact occurs in the ocean approximately 122 nautical miles (140 statute miles) downrange.

The SRBs are the largest solid-propellant motors ever flown and the first designed for reuse. Each is 149.16 feet long and 12.17 feet in diameter.

Each SRB weighs approximately 1,300,000 pounds at launch. The propellant for each solid rocket motor weighs approximately 1,100,000 pounds. The inert weight of each SRB is approximately 192,000 pounds.

Primary elements of each booster are the motor (including case, propellant, igniter and nozzle), structure, separation systems, operational flight instrumentation, recovery avionics, pyrotechnics, deceleration system, thrust vector control system and range safety destruct system.

Each booster is attached to the external tank at the SRB’s aft frame by two lateral sway braces and a diagonal attachment. The forward end of each SRB is attached to the external tank at the forward end of the SRB’s forward skirt. On the launch pad, each booster also is attached to the mobile launcher platform at the aft skirt by four bolts and nuts that are severed by small explosives at lift-off.

During the downtime following the Challenger accident, detailed structural analyses were performed on critical structural elements of the SRB. Analyses were primarily focused in areas where anomalies had been noted during postflight inspection of recovered hardware.

One of the areas was the attach ring where the SRBs are connected to the external tank. Areas of distress were noted in some of the fasteners where the ring attaches to the SRB motor case. This situation was attributed to the high loads encountered during water impact. To correct the situation and ensure higher strength margins during ascent, the attach ring was redesigned to encircle the motor case completely (360 degrees). Previously, the attach ring formed a C and encircled the motor case 270 degrees.

Additionally, special structural tests were performed on the aft skirt. During this test program, an anomaly occurred in a critical weld between the hold-down post and skin of the skirt. A redesign was implemented to add reinforcement brackets and fittings in the aft ring of the skirt.

These two modifications added approximately 450 pounds to the weight of each SRB.

The propellant mixture in each SRB motor consists of an ammonium perchlorate (oxidizer, 69.6 percent by weight), aluminum (fuel, 16 percent), iron oxide (a catalyst, 0.4 percent), a polymer (a binder that holds the mixture together, 12.04 percent), and an epoxy curing agent (1.96 percent). The propellant is an 11-point star-shaped perforation in the forward motor segment and a double-truncated-cone perforation in each of the aft segments and aft closure. This configuration provides high thrust at ignition and then reduces the thrust by approximately a third 50 seconds after lift-off to prevent overstressing the vehicle during maximum dynamic pressure.

The SRBs are used as matched pairs and each is made up of four solid rocket motor segments. The pairs are matched by loading each of the four motor segments in pairs from the same batches of propellant ingredients to minimize any thrust imbalance. The segmented-casing design assures maximum flexibility in fabrication and ease of transportation and handling. Each segment is shipped to the launch site on a heavy-duty rail car with a specially built cover.

The nozzle expansion ratio of each booster beginning with the STS-8 mission is 7-to-79. The nozzle is gimbaled for thrust vector (direction) control. Each SRB has its own redundant auxiliary power units and hydraulic pumps. The all-axis gimbaling capability is 8 degrees. Each nozzle has a carbon cloth liner that erodes and chars during firing. The nozzle is a convergent-divergent, movable design in which an aft pivot-point flexible bearing is the gimbal mechanism.

The cone- shaped aft skirt reacts the aft loads between the SRB and the mobile launcher platform. The four aft separation motors are mounted on the skirt. The aft section contains avionics, a thrust vector control system that consists of two auxiliary power units and hydraulic pumps, hydraulic systems and a nozzle extension jettison system.

The forward section of each booster contains avionics, a sequencer, forward separation motors, a nose cone separation system, drogue and main parachutes, a recovery beacon, a recovery light, a parachute camera on selected flights and a range safety system.

Each SRB has two integrated electronic assemblies, one forward and one aft. After burnout, the forward assembly initiates the release of the nose cap and frustum and turns on the recovery aids. The aft assembly, mounted in the external tank/SRB attach ring, connects with the forward assembly and the orbiter avionics systems for SRB ignition commands and nozzle thrust vector control. Each integrated electronic assembly has a multiplexer/ demultiplexer, which sends or receives more than one message, signal or unit of information on a single communication channel.

Eight booster separation motors (four in the nose frustum and four in the aft skirt) of each SRB thrust for 1.02 seconds at SRB separation from the external tank. Each solid rocket separation motor is 31.1 inches long and 12.8 inches in diameter.

Location aids are provided for each SRB, frustum/drogue chutes and main parachutes. These include a transmitter, antenna, strobe/converter, battery and salt water switch electronics. The location aids are designed for a minimum operating life of 72 hours and when refurbished are considered usable up to 20 times. The flashing light is an exception. It has an operating life of 280 hours. The battery is used only once.

The SRB nose caps and nozzle extensions are not recovered.

The recovery crew retrieves the SRBs, frustum/drogue chutes, and main parachutes. The nozzles are plugged, the solid rocket motors are dewatered, and the SRBs are towed back to the launch site. Each booster is removed from the water, and its components are disassembled and washed with fresh and deionized water to limit salt water corrosion. The motor segments, igniter and nozzle are shipped back to Thiokol for refurbishment.

Each SRB incorporates a range safety system that includes a battery power source, receiver/ decoder, antennas and ordnance.

HOLD-DOWN POSTS

Each solid rocket booster has four hold-down posts that fit into corresponding support posts on the mobile launcher platform. Hold-down bolts hold the SRB and launcher platform posts together. Each bolt has a nut at each end, but only the top nut is frangible. The top nut contains two NASA standard detonators, which are ignited at solid rocket motor ignition commands.

When the two NSDs are ignited at each hold-down, the hold-down bolt travels downward because of the release of tension in the bolt (pretensioned before launch), NSD gas pressure and gravity. The bolt is stopped by the stud deceleration stand, which contains sand. The SRB bolt is 28 inches long and is 3.5 inches in diameter. The frangible nut is captured in a blast container.

The solid rocket motor ignition commands are issued by the orbiter''s computers through the master events controllers to the hold-down pyrotechnic initiator controllers on the mobile launcher platform. They provide the ignition to the hold-down NSDs. The launch processing system monitors the SRB hold-down PICs for low voltage during the last 16 seconds before launch. PIC low voltage will initiate a launch hold.

SRB IGNITION

SRB ignition can occur only when a manual lock pin from each SRB safe and arm device has been removed. The ground crew removes the pin during prelaunch activities. At T minus five minutes, the SRB safe and arm device is rotated to the arm position. The solid rocket motor ignition commands are issued when the three SSMEs are at or above 90-percent rated thrust, no SSME fail and/or SRB ignition PIC low voltage is indicated and there are no holds from the LPS.

The solid rocket motor ignition commands are sent by the orbiter computers through the MECs to the safe and arm device NSDs in each SRB. A PIC single-channel capacitor discharge device controls the firing of each pyrotechnic device. Three signals must be present simultaneously for the PIC to generate the pyro firing output. These signals--arm, fire 1 and fire 2--originate in the orbiter general-purpose computers and are transmitted to the MECs. The MECs reformat them to 28-volt dc signals for the PICs. The arm signal charges the PIC capacitor to 40 volts dc (minimum of 20 volts dc).

The fire 2 commands cause the redundant NSDs to fire through a thin barrier seal down a flame tunnel. This ignites a pyro booster charge, which is retained in the safe and arm device behind a perforated plate. The booster charge ignites the propellant in the igniter initiator; and combustion products of this propellant ignite the solid rocket motor initiator, which fires down the length of the solid rocket motor igniting the solid rocket motor propellant.

The GPC launch sequence also controls certain critical main propulsion system valves and monitors the engine-ready indications from the SSMEs. The MPS start commands are issued by the onboard computers at T minus 6.6 seconds (staggered start--engine three, engine two, engine one--all approximately within 0.25 of a second), and the sequence monitors the thrust buildup of each engine. All three SSMEs must reach the required 90-percent thrust within three seconds; otherwise, an orderly shutdown is commanded and safing functions are initiated.

Normal thrust buildup to the required 90-percent thrust level will result in the SSMEs being commanded to the lift-off position at T minus three seconds as well as the fire 1 command being issued to arm the SRBs. At T minus three seconds, the vehicle base bending load modes are allowed to initialize (movement of approximately 25.5 inches measured at the tip of the external tank, with movement towards the external tank).

At T minus zero, the two SRBs are ignited, under command of the four onboard computers; separation of the four explosive bolts on each SRB is initiated (each bolt is 28 inches long and 3.5 inches in diameter); the two T-0 umbilicals (one on each side of the spacecraft) are retracted; the onboard master timing unit, event timer and mission event timers are started; the three SSMEs are at 100 percent; and the ground launch sequence is terminated.

The solid rocket motor thrust profile is tailored to reduce thrust during the maximum dynamic pressure region.

ELECTRICAL POWER DISTRIBUTION

Electrical power distribution in each SRB consists of orbiter-supplied main dc bus power to each SRB via SRB buses A, B and C. Orbiter main dc buses A, B and C supply main dc bus power to corresponding SRB buses A, B and C. In addition, orbiter main dc bus C supplies backup power to SRB buses A and B, and orbiter bus B supplies backup power to SRB bus C. This electrical power distribution arrangement allows all SRB buses to remain powered in the event one orbiter main bus fails.

The nominal dc voltage is 28 volts dc, with an upper limit of 32 volts dc and a lower limit of 24 volts dc.

HYDRAULIC POWER UNITS

There are two self-contained, independent HPUs on each SRB. Each HPU consists of an auxiliary power unit, fuel supply module, hydraulic pump, hydraulic reservoir and hydraulic fluid manifold assembly. The APUs are fueled by hydrazine and generate mechanical shaft power to a hydraulic pump that produces hydraulic pressure for the SRB hydraulic system. The two separate HPUs and two hydraulic systems are located on the aft end of each SRB between the SRB nozzle and aft skirt. The HPU components are mounted on the aft skirt between the rock and tilt actuators. The two systems operate from T minus 28 seconds until SRB separation from the orbiter and external tank. The two independent hydraulic systems are connected to the rock and tilt servoactuators.

The APU controller electronics are located in the SRB aft integrated electronic assemblies on the aft external tank attach rings.

The APUs and their fuel systems are isolated from each other. Each fuel supply module (tank) contains 22 pounds of hydrazine. The fuel tank is pressurized with gaseous nitrogen at 400 psi, which provides the force to expel (positive expulsion) the fuel from the tank to the fuel distribution line, maintaining a positive fuel supply to the APU throughout its operation.

The fuel isolation valve is opened at APU startup to allow fuel to flow to the APU fuel pump and control valves and then to the gas generator. The gas generator's catalytic action decomposes the fuel and creates a hot gas. It feeds the hot gas exhaust product to the APU two-stage gas turbine. Fuel flows primarily through the startup bypass line until the APU speed is such that the fuel pump outlet pressure is greater than the bypass line's. Then all the fuel is supplied to the fuel pump.

The APU turbine assembly provides mechanical power to the APU gearbox. The gearbox drives the APU fuel pump, hydraulic pump and lube oil pump. The APU lube oil pump lubricates the gearbox. The turbine exhaust of each APU flows over the exterior of the gas generator, cooling it, and is then directed overboard through an exhaust duct.

When the APU speed reaches 100 percent, the APU primary control valve closes, and the APU speed is controlled by the APU controller electronics. If the primary control valve logic fails to the open state, the secondary control valve assumes control of the APU at 112-percent speed.

Each HPU on an SRB is connected to both servoactuators on that SRB. One HPU serves as the primary hydraulic source for the servoactuator, and the other HPU serves as the secondary hydraulics for the servoactuator. Each sevoactuator has a switching valve that allows the secondary hydraulics to power the actuator if the primary hydraulic pressure drops below 2,050 psi. A switch contact on the switching valve will close when the valve is in the secondary position. When the valve is closed, a signal is sent to the APU controller that inhibits the 100-percent APU speed control logic and enables the 112-percent APU speed control logic. The 100-percent APU speed enables one APU/HPU to supply sufficient operating hydraulic pressure to both servoactuators of that SRB.

The APU 100-percent speed corresponds to 72,000 rpm, 110-percent to 79,200 rpm, and 112-percent to 80,640 rpm.

The hydraulic pump speed is 3,600 rpm and supplies hydraulic pressure of 3,050, plus or minus 50, psi. A high-pressure relief valve provides overpressure protection to the hydraulic system and relieves at 3,750 psi.

The APUs/HPUs and hydraulic systems are reusable for 20 missions.

THRUST VECTOR CONTROL

Each SRB has two hydraulic gimbal servoactuators: one for rock and one for tilt. The servoactuators provide the force and control to gimbal the nozzle for thrust vector control.

The space shuttle ascent thrust vector control portion of the flight control system directs the thrust of the three shuttle main engines and the two SRB nozzles to control shuttle attitude and trajectory during lift-off and ascent. Commands from the guidance system are transmitted to the ATVC drivers, which transmit signals proportional to the commands to each servoactuator of the main engines and SRBs. Four independent flight control system channels and four ATVC channels control six main engine and four SRB ATVC drivers, with each driver controlling one hydraulic port on each main and SRB servoactuator.

Each SRB servoactuator consists of four independent, two-stage servovalves that receive signals from the drivers. Each servovalve controls one power spool in each actuator, which positions an actuator ram and the nozzle to control the direction of thrust.

The four servovalves in each actuator provide a force-summed majority voting arrangement to position the power spool. With four identical commands to the four servovalves, the actuator force-sum action prevents a single erroneous command from affecting power ram motion. If the erroneous command persists for more than a predetermined time, differential pressure sensing activates a selector valve to isolate and remove the defective servovalve hydraulic pressure, permitting the remaining channels and servovalves to control the actuator ram spool.

Failure monitors are provided for each channel to indicate which channel has been bypassed. An isolation valve on each channel provides the capability of resetting a failed or bypassed channel.

Each actuator ram is equipped with transducers for position feedback to the thrust vector control system. Within each servoactuator ram is a splashdown load relief assembly to cushion the nozzle at water splashdown and prevent damage to the nozzle flexible bearing.

SRB RATE GYRO ASSEMBLIES

Each SRB contains two RGAs, with each RGA containing one pitch and one yaw gyro. These provide an output proportional to angular rates about the pitch and yaw axes to the orbiter computers and guidance, navigation and control system during first-stage ascent flight in conjunction with the orbiter roll rate gyros until SRB separation. At SRB separation, a switchover is made from the SRB RGAs to the orbiter RGAs.

The SRB RGA rates pass through the orbiter flight aft multiplexers/ demultiplexers to the orbiter GPCs. The RGA rates are then mid-value- selected in redundancy management to provide SRB pitch and yaw rates to the user software. The RGAs are designed for 20 missions.

SRB SEPARATION

SRB separation is initiated when the three solid rocket motor chamber pressure transducers are processed in the redundancy management middle value select and the head-end chamber pressure of both SRBs is less than or equal to 50 psi. A backup cue is the time elapsed from booster ignition.

The separation sequence is initiated, commanding the thrust vector control actuators to the null position and putting the main propulsion system into a second-stage configuration (0.8 second from sequence initialization), which ensures the thrust of each SRB is less than 100,000 pounds. Orbiter yaw attitude is held for four seconds, and SRB thrust drops to less than 60,000 pounds.

The SRBs separate from the external tank within 30 milliseconds of the ordnance firing command.

The forward attachment point consists of a ball (SRB) and socket (ET) held together by one bolt. The bolt contains one NSD pressure cartridge at each end. The forward attachment point also carries the range safety system cross-strap wiring connecting each SRB RSS and the ET RSS with each other.

The aft attachment points consist of three separate struts: upper, diagonal and lower. Each strut contains one bolt with an NSD pressure cartridge at each end. The upper strut also carries the umbilical interface between its SRB and the external tank and on to the orbiter.

There are four booster separation motors on each end of each SRB. The BSMs separate the SRBs from the external tank. The solid rocket motors in each cluster of four are ignited by firing redundant NSD pressure cartridges into redundant confined detonating fuse manifolds.

The separation commands issued from the orbiter by the SRB separation sequence initiate the redundant NSD pressure cartridge in each bolt and ignite the BSMs to effect a clean separation.

Shuttle Reference Data

Space Shuttle Super Light Weight Tank (SLWT)

The super lightweight external tank (SLWT) made its first shuttle flight June 2, 1998, on mission STS-91. The SLWT is 7,500 pounds lighter than the standard external tank. The lighter weight tank will allow the shuttle to deliver International Space Station elements (such as the service module) into the proper orbit.

The SLWT is the same size as the previous design. But the liquid hydrogen tank and the liquid oxygen tank are made of aluminum lithium, a lighter, stronger material than the metal alloy used for the shuttle's current tank. The tank's structural design has also been improved, making it 30% stronger and 5% less dense.

The SLWT, like the standard tank, is manufactured at Michoud Assembly, near New Orleans, Louisiana, by Lockheed Martin.

The 154-foot-long external tank is the largest single component of the space shuttle. It stands taller than a 15-story building and has a diameter of about 27 feet. The external tank holds over 530,000 gallons of liquid hydrogen and liquid oxygen in two separate tanks. The hydrogen (fuel) and liquid oxygen (oxidizer) are used as propellants for the shuttle's three main engines.

Acronyms and Abbreviations

A/B	Airborne
A/L	Airlock (ISS Joint Airlock)
AAA	Avionics Air Assembly
AAC	Aft Access Cone
ABC	Audio Bus Coupler
ABOLT	Acquire BOLT
ACBM	Active Common Berthing Mechanism
ACLS	Advanced Cardiac Life Support System
ACO	Assembly Checkout Officer
ACS	Assembly Contingency System Atmosphere Control and Supply Attitude Control System
ACU	Actuator Control Unit Arm Computer Unit
AD	Active Device
ADF	Air Diffusers
ADM	Antenna Distribution Module
ADP	Airlock Depressurization Pump
AFD	Aft Flight Deck
AIO	Analog Input/Output
AL	Airlock (ISS Joint Airlock)
ALSP	Advanced Life Support Pack
AMP	Ambulatory Medical Pack
AOH	Assembly Operations Handbook
APAS	Androgynous Peripheral Attachment System
APCF	Advanced Protein Crystallization
APCU	Assembly Power Converter Unit
APDS	Androgynous Peripheral Docking System
APFR	Articulating Portable Foot Restraint
APM	Attached Pressurized Module
APPCM	Arm Pitch Plane Change Mode
APS	Automated Payload Switch Auxiliary Power Supply
ARIS	Active Rack Isolation System
AR	Atmosphere Revitalization
ARC	Ames Research Center
ARS	Atmospheric Revitalization System
ASCR	Assured Safe Crew Return
ASK	Ames Stowage Kit
ASL	Atmosphere Sampling Line
ASV	Air Selector Valve
ATCS	Active Thermal Control System Advanced Television Systems Committee
ATU	Audio Terminal Unit

AUAI	Assembly UHF Audio Interface
AVU	Artificial Vision Unit
AVV	Air Vent Valve
BC	Bus Controller
BCDU	Battery Charge/Discharge Units
BCU	Backup Drive Control Unit
BDU	Backup Drive Unit
BGA	Beta Gimbal Assembly
BIT/BITE	Built-In Test/Equipment
BIV	Bulkhead Isolation Value
BMRRM	Bearing Motor Roll Ring Module
BOL	Beginning of Life
BP/ECG	Blood Pressure/Electrocardiogram
BPS	Biomass Production System
BSP	Baseband Signal Processor
BTLS	Basic Trauma Life Support System
BTR	Biotechnology Refrigerator
BUS	Bus Controller Unit
C&C	Command and Control
C&DH	Command and Data Handling
C&M	Control and Monitor
C&T	Communication and Tracking
C&W	Caution and Warning
C/D	Countdown
C/L	Crew Lock
CA	Control Attitude
CB	Control Bus
cb	Circuit Breaker
CBM	Common Berthing Mechanism
CCAA	Common Cabin Air Assembly
CCD	Cursor Control Device
CCDB	Configuration Controller Database
CCPK	Crew Contamination Protection Kit
CCTV	Closed Circuit Television
CDDT	Common Display Development Team
CDRA	Carbon Dioxide Removal Assembly
CDRS	Carbon Dioxide Removal System
CDS	Command and Data Software
CEU	Control Electronics Unit
CEVIS	Cycle Ergometer with Vibration Isolation System
CFA	Cabin Fan Assembly
CGA	Cable Guide Assembly
CGS	Cable Guide Shoe
CheCS	Crew Health Care System
CHX	Condensing Heat Exchanger
CLA	Camera Light Assembly

CLPA	Camera, Light, and Pan/Tilt Assembly
CMG	Control Moment Gyroscope
CMO	Crew Medical Officer
CMRS	Crew Medical Restraint System
Comm	Communications
COTS	Commercial-Off-The-Shelf
CPCG-H	Commercial Protein Crystal Growth-High
CPFSK	Continuous Phase Frequency Shift Key
CPS	Cabin Pressure Sensor
CPU	Central Processing Unit
CRPCM	Canadian Remote Power Control Module
CSA-CP	Compound Specific Analyzer-Combustion Products
CSA-H	CSA-Hydrazine
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
CTB	Cargo Transfer Bag
CVIU	Common Video Interface Unit
CVT	Current Valve Table
CVV	Carbon Dioxide Vent Valve
CWC	Contingency Water Collection
CWR	Collapsible Water Reservoir
DA	Depressurization Assembly
DAIU	Docked Audio Interface Unit
DC	Docking Compartment
DCP	Display and Control Panel
DCPCG-V	Dynamically Controlled Protein Crystal Growth-Vapor
DCSU	Direct Current Switching Unit
DDCU	DC to DC Converter Unit
DIO	Discrete Input/Output
DMCU	Docking Mechanism Control Unit
DOF	Degrees of Freedom
DPS	Data Processing System
E/L	Equipment Lock
EACP	EMU Audio Control Panel
EAIU	EMU Audio Interface Unit
EAS	Early Ammonia Servicer
ECB	Electronics Control Board
ECG	Electrocardiogram
ECLSS	Environmental Control and Life Support System
ECS	Early Communications Subsystem Environmental Control System
ECU	Electronic Control Unit
EDDA	EMU Don/Doff Assembly
EEATCS	Early External Active Thermal Control System
EELS	Emergency Egress Lighting System
EET	Experiment Elapsed Time

EETCS	Early External Thermal Control System
EFGF	Electrical flight grapple fixture
EIA	Electrical Interface Assembly
ELPS	Emergency Lighting Power Supply
ELS	Emergency Lighting Strip
EMU	Extravehicular Maneuvering Unit EXPRESS Memory Unit
EOL	End of Life
EPLS	Emergency Lighting Power Supply
EPS	Electrical Power System
ESA	External Sampling Adaptor
ESP	External Stowage Platform
ETI	Elapsed Time Indicator
EUE	Experiment Unique Equipment
EV	Extravehicular
EV-CPDS	Extravehicular – Charged Particle Directional Spectrometer
EVA	Extravehicular Activity
EVD	External Visual Display
EVR	Extravehicular Robotics
EXPRESS	Expedite the Processing of Experiments to the Space Station
FC	Firmware Controller
FCC	Flat Collector Circuit Federal Communications Commission
FCV	Flow Control Valve
FD	Flight Day
FDA	Fault Detection Annunciation
FDI	Failure Detection and Isolation
FDIR	Fault, Detection, Isolation and Recovery
FDS	Fire Detection and Suppression
FGB	Functional Cargo Block
FPU	Fluid Pumping Unit
FRGF	Flight Releasable Grapple Fixture
FSEGF	FSE Grapple Fixture
GAS	Get Away Special
GFE	Government Furnished Equipment
GLA	General Lighting Assembly
GLONASS	Global Navigational Satellite System
GNC	Guidance and Navigation Computer
GPC	General Purpose Computer
GPS	Global Positioning System
GSE	Ground Support Equipment
GSM	Gas Supply Module
GUI	Graphical User Interface
HCS	Humidity Control System
HCU	Headset Control Unit

HDR	High Data Rate
HEC	Headset Extension Cable
HEPA	High-Efficiency Particulate Arrestor (a filter for the CCAA)
HGA	High Gain Antenna
HP	High Pressure
HPGT	High Pressure Gas Tank (see ONTO)
HRF	Human Research Facility
HRFM	High Rate Frame Multiplexer
HRM	High Rate Modem Heart Rate Monitor
I/O	Input/Output
IAA	Internal Antenna Assembly
IAC	Internal Audio Controller
IAS	Internal Audio System
ICAPC	Increased Capacity Adaptive Payload Carrier
ICC	Integrated Cargo Carrier
IDA	Integrated Diode Assembly
IEA	Integrated Equipment Assembly
IELK	Individual Equipment Liner Kit
I/F	Interface
IFHX	Interface Heat Exchanger
IFM	In Flight Maintenance
IM-GAP	Internal Motor Gap
IMCA	Integrated Motor Controller Assembly
IMS	Inventory Management System
IMV	Intermodule Ventilation
IOCU	Input/Output Controller Unit
IP	International Partner
IRed	interim Resistive Exercise Device
IRED	Isolated Resistive Exercise Device
IRU	In-flight Refill Unit
ISA	International Sampling Adapter
ISIS	International Subrack Interface Standard
ISO	Inventory Stowage Officer
ISPR	International Standard Payload Rack
ISS	International Space Station
ISSIS	International Space Station Interface Standard
ISSP	International Space Station Program
ISSSH	International Space Station Systems Handbook
ITCS	Internal Thermal Control System
IV-CPDS	Intravehicular-Charged Particle Directional Spectrometer
IVA	Intravehicular Activity
IVSU	Internal Video Switch Unit
JEU	Joint Electronics Unit
JEUS	Joint Expedited Undocking and Separation

JSC	Johnson Space Center
KBAR	Knee-Brace Assembly Replacement
KFT	KSC Fixation Tube
KSC	Kennedy Space Center
LAB	Lower Avionics Bay
LAN	Local Area Network
LARR	Lab Atmosphere Revitalization Rack
LB	Local Bus
LCA	Lab Cradle Assembly
LCD	Liquid Crystal Display
LDA	Launch Deployment Assembly
LDR	Low Data Rate
LEE	Latching End Effector (both SRMS and SSRMS)
LED	Light Emitting Diode
LFDP	Load Fault Detect/Protect
LGA	Low Gain Antenna
LLA	Low Level Analog
LNS	Lab Nitrogen System
LP	Launch Package
LRU	Line Replaceable Unit
LTA	Launch to Activation
LTL	Low Temperature Loop
LVLH	Local Vertical/Local Horizontal
MA	Mechanical Assembly
MAM	Manual Augmented Mode
MAS	Microbial Air Sampler
Mb	Megabytes
MBE	Metal Bellows Expander
MBM	Manual Berthing Mechanism
MBS	Mobile Base System
MBSU	Main Bus Switching Unit
MCA	Major Constituent Analyzer
MCAS	MBS Common Attach System
MCAVV	MCA Vacuum Valve
MCC	Mission Control Center
MCC-H	MCC-Houston
MCC-M	MCC-Moscow
MCDS	Multifunction CRT Display System
MCS	Motion Control System
MCU	MBS Computer Unit
MDL	Middeck Locker
MDM	Multiplexer/Demultiplexer
MDPS	Meteoroid and Debris Protection System
MEC	Medical Equipment Computer
MELFI	Minus 80 Lab Freezer for ISS

MER	Mission Evaluation Room
MFCV	Manual Flow Control Valve
MILA	Merritt Island launch area
MLE	Middeck Locker Equivalent
MLI	Multilayer Insulation
MM/OD	Micrometeoroid/Orbital Debris
MO	Medical Operations
MOD	Mission Operations Directorate
MOV	Manual Only Valve
MPEV	Manual Pressure Equalization Valve
MPLM	Mini Pressurized Logistics Module Multipurpose Logistics Module
MPMs/MRLs	Manipulator Positioning Mechanisms/ Manipulator Retention Latches
MPR	Manual Pulmonary Resuscitator
MRS	Mobile Remote Servicer
MSD	Mass Storage Device
MSG	Microgravity Science Glovebox
MSS	Mobile Servicing System
MT	Mobile Transporter
MTCL	Mobile Transporter Capture Latch
MTL	Moderate Temperature Loop
MUP	Mission Unique Process
MWA	Maintenance Work Area
NASA	National Aeronautics and Space Administration
NCS	Node Control Software
NDS	Nutrient Delivery System
NET	No Earlier Than
NIV	Nitrogen Isolation Valve
Nm	Newton meter
NPRV	Negative Pressure Relief Valve
NST	Near Saturation Threshold
NTSC	National Television Systems Committee
OCA	Orbital Communication Adapter
OCAD	Operational Control Agreement Document
OCJM	Operator Commanded Joint Position Mode
OCPM	Operator Commanded POR Mode
ODA	Orbiter Disconnect Assembly
ODM	Orbiter Arm Drive Mechanism
ODS	Orbiter Docking System
OIU	Orbiter Interface Unit
OIV	Oxygen Isolation Valve
ONS	Off Nominal Situations
OPP	OSVS Patch Panel
OPS	Operations (Operational)

ORBITECH	Orbital Technologies Corporation
ORCA	Oxygen Recharge Compressor Assembly
ORU	Orbital Replacement Unit
OSO	Operations Support Officer
OSVS	Orbiter Space Vision System
OSVU	Orbiter Space Vision Unit
P&S	Pointing and Support Software
PAD	Portable Foot Restraint Attachment Device
PAV	Process Air Valve
PB	Power Bus
PBA	Portable Breathing Apparatus (mask)
PCA	Pressure Control Assembly
PCAM	Protein Crystallization Apparatus for Microgravity
PCBA	Portable Clinical Blood Analyzer
PCG-STES	Protein Crystal Growth, Single Locker Thermal Enclosure System
PCMCIA	Personal Computer Memory Card International Adapter
PCMMU	Pulse Code Master Modulation Unit
PCP	Pressure Control Panel
PCR	Portable Computer Receptacle
PCS	Portable Computer System
PD	Physical Device
PDA	Payload Disconnect Assemblies Passive Docking Assembly
PDB	Power Distribution Box
PDGF	Power and Data Grapple Fixture
PDI	Payload Data Interface
PDIP	Payload Data Interface Panel
PDRS	Payload Deployment and Retrieval System
PDS	Passive Dosimetry System
PDV	Perforated Damper Valve
PEHB	Payload Ethernet Hub Bridge
PEHG	Payload Ethernet Hub Gateway
PESTO	Photosynthesis Experiment and System and Operations
PEV	Pressure Equalization Valve
PFCS	Pump Flow Control Subassembly
PFE	Portable Fire Extinguisher
PG	Product Group
PGSC	Payload and General Support Computer
PJAM	Pre-stored Joint Position Auto-sequenced Mode
PL	Payload
PL PRI	Primary Payload
PLSS	Portable Life Support System
PMA	Pressurized Mounting Panel Pressurized Mating Adapter
PMCU	Power Management Control Unit
PMP	Payload Mounting Panel

PNOM	Procedural Nomenclature
POA	Payload ORU Accommodation
POR	Points of Reference
PPA	Pump Package Assembly
PPAM	Pre-stored POR Auto-sequence Mode
ppO_2	Partial Pressure of Oxygen
PPRA	Positive Pressure Relief Assembly
PPRV	Positive Pressure Relief Valve
PRLA	Payload Retention Latch Assembly
PSA	Power Supply Assembly
PSP	Payload Signal Processor
PSS	POA Support Structure
PTB	Payload Timing Buffer
PTCS	Passive Thermal Control System
PTT	Push To Talk
PTU	Pan/Tilt Units
PUNT	Peremptory Unilateral Network Tracking
PV	Photovoltaic
PVM	Photovoltaic Module
PWP	Power Work Platform
PV	Photovoltaic
PVCU	Photovoltaic Control Unit
PVM	Photovoltaic Module
PVTCS	Photovoltaic Thermal Control System
QD	Quick Disconnect
R&MA	Restraint and Mobility Aids
R&R	Remove and Replace
R-S	Reed-Solomon
R/F	Refrigerator/Freezer
RAB	Rack Attachment Block
RAIU	Russian Audio Interface Unit
RAM	Random Access Memory Radiation Area Monitor
RAMU	Rheostat Air Mix Valve
RCU	Remote Control Unit
RED	Resistive Exercise Device
RF	Radio Frequency
RFCA	Rack Flow Control Assembly
RFG	Radio Frequency Group
RGS	Russian Ground Site
RHC	Rotational Hand Controller
RHX	Regenerative Heat Exchanger
RIC	Rack Interface Controller
RIV	Rack Isolation Value
RMS	Remote Manipulator System

ROEU	Remote Operated Electrical Umbilical
ROFU	Remote Operated Fluid Umbilical
ROS	Russian Orbital Segment
RPC	Remote Power Controller
RPCM	Remote Power Controller Module
RPDA	Remote Power Distribution Assembly
RS	Russian Segment
RSA	Russian Space Agency
RSP	Respiratory Support Pack Resupply Support Platform
RSR	Resupply Stowage Rack
RT	Remote Terminal
RTD	Resistive Temperature Device
RTL	Ready to Latch Ready to Launch
RU	Remote Unit
RWS	Robotic Workstation
S0	Starboard Zero
SARJ	Solar Alpha Rotary Joint
SASA	S-Band Antenna Support Assembly
SAW	Solar Array Wing
SCA	Switchgear Controller Assembly
SCSI	Serial Command and Monitoring Interface
SCU	Servicing and Cooling Umbilical Sync and Control Unit
SD	Smoke Detector
SDO	Solenoid Driver Output
SDS	Sample Delivery System
SGANT	Space-to-Ground Antenna
SHOSS	Space Hab Oceaneering Space System
SJRM	Single Joint Rate Mode
SLDP	Spacelab Logistics Double Pallet
SM	Service Module
SMCC	Service Module Central Computer
SMDP	Six Service Module Debris Panel
SMMMOD	Service Module Micrometeoroid/Orbital Debris
SMTC	Service Module Terminal Computer
SOC	State of Charge
SOV	Shutoff Valve
SPCE	Servicing and Performance Checkout Equipment
SPD	Serial Parallel Digital
SPDA	Secondary Power Distribution Assembly
SPDM	Special Purpose Dexterous Manipulator
SPL	Sound Pressure Level
SPP	Science Power Platform
SRMS	Shuttle Remote Manipulator System

SSC	Station Support Computer Subsystem Computer
SSCS	Space-to-Space Communication System
SSE	Space Station Eyewash
SSER	Space-to-Space EMU Radio
SSK	Surface Sampler Kit
SSOR	Space-to-Space Orbiter Radio
SSOV	Sample line Shut-off Valve
SSP	Space Shuttle Program Standard Switch Panel
SSPC	Solid State Power Controller
SSPCM	Solid State Power Control Module
SSRMS	Space Station Remote Manipulator System
SSSR	Space-to-Space Station Radio
SSU	Sequential Shunt Unit
SSW	Scenario Set-up Workstation
STS	Space Transportation System
SVS	Space Vision System
SW	Software
TA	Thruster Assist
TCCS	Trace Contaminant Control Subassembly
TCCV	Temperature Control and Check Valve
TCS	Thermal Conditioning System Thermal Control System
TDK	Transportation Device Kit
TDMA	Time Division Multiple Access
TDRSS	Tracking and Data Relay Satellite System
TEA	Torque Equilibrium Attitude
TEPC	Tissue Equivalent Proportional Counter
TFL	Telemetry Format Load
THC	Temperature and Humidity Control Translational Hand Controller
TIG	Time of Ignition
TOCA	Total Organic Carbon Analyzer
TRC	Transmitter Receiver Controller
TVIS	Treadmill Vibration Isolation System
UAB	Upper Avionics Bay
UB	User Bus
UDG	User Data Generation
UF	Utilization Flight
UIA	Umbilical Interface Assembly
UIP	Utility Interface Panel
UHF	Ultrahigh Frequency
UMA	Umbilical Mechanism Assembly
UOP	Utility Outlet Panel

USOS	United States Orbital Segment
VAJ	Vacuum Access Jumper
VBSP	Video Baseband Signal Processor
VCR	Video Cassette Recorder
VDA-2	Vapor Diffusion Apparatus – Second Generation
VDS	Video Distribution System Video Distribution Subsystem
VDU	Video Distribution Unit
VES	Vacuum Exhaust System
VES/VRS	Vacuum Exhaust/Resource System
VGA	Video Graphics Array
VGS	Video Graphics Software
VHF	Very High Frequency
VIS	Vibration Isolation System
VMDS	Valve Motor Drive Switch
VRCV	Vent/Relief Control Valve
VRIV	Vent/Relief Isolation Valve
VRS	Vacuum Resource System
VRV	Vent/Relief Valve
VSC	Video Signal Converter
VSU	Video Switch Unit
VTR	Video Tape Recorder
WAA	Wireless Antenna Assembly
WHS	Workstation Host Software
WMK	Water Microbiology Kit
WMV	Water Modulating Valve
WOV	Water ON/OFF Valve
WPP	Water Pump Package
WRM	Water Recovery and Management
WS	Water Separator
WS&A	Water Sampler and Archiver Kit
WVA	Water Vent Assembly
WVNT	
WVS	Wireless Video System
ZSR	Zero-g Stowage Rack

Media Assistance

NASA Television Transmission

NASA Television is available through the GE2 satellite system which is located on Transponder 9C, at 85 degrees west longitude, frequency 3880.0 MHz, audio 6.8 MHz.

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

Status Reports

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

Briefings

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

Internet Information

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

http://spaceflight.nasa.gov

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

http://www.nasa.gov

or

http://www.nasa.gov/newsinfo/index.html

Shuttle Pre-Launch Status Reports

http://www-pao.ksc.nasa.gov/kscpao/status/stsstat/current.htm

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

http://www.nasa.gov/today/index.html

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

http://spaceflight.nasa.gov/realdata/nasatv/schedule.html

Resources for educators can be found at the following address:

http://education.nasa.gov

Access by CompuServe

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

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