STS-108

New Station Crew, Supplies and Spacewalk

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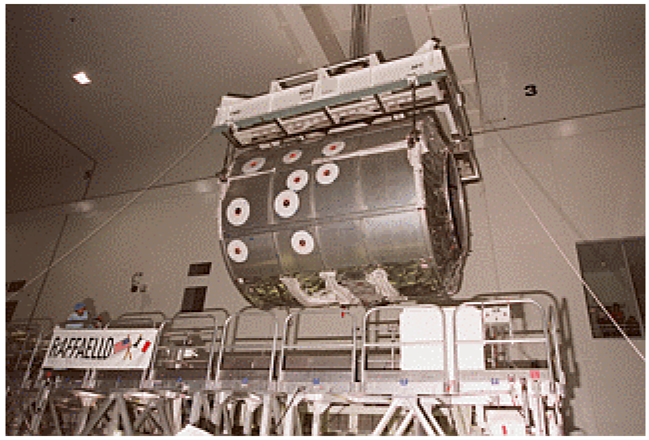
Mission Overview

New Station Crew, Logistics Ops., Spacewalk on Tap for STS-108

A new International Space Station crew, the fourth flight of an Italian-built Multipurpose Logistics Module and a spacewalk to install thermal blankets over two pieces of equipment at the bases of the space station's solar wings are major elements of the STS-108 flight of Endeavour.

The Expedition Four crew consists of Russian Commander Yury Onufrienko and Astronauts Carl Walz and Dan Bursch. They will replace the Expedition Three crew, Commander Frank Culbertson and Cosmonauts Mikhail Tyurin and Vladimir Dezhurov. Expedition Three crewmembers were launched to the station aboard Discovery on STS-105 on Aug. 10, 2001, and will return to Earth aboard Endeavour.

The Italian Multipurpose Logistics Module named Raffaello is making its second visit to the space station. It first flew aboard Endeavour on STS-100 in April 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 Leonardo has visited the station twice, on STS-102 in March 2001 and on STS-105 in August 2001.

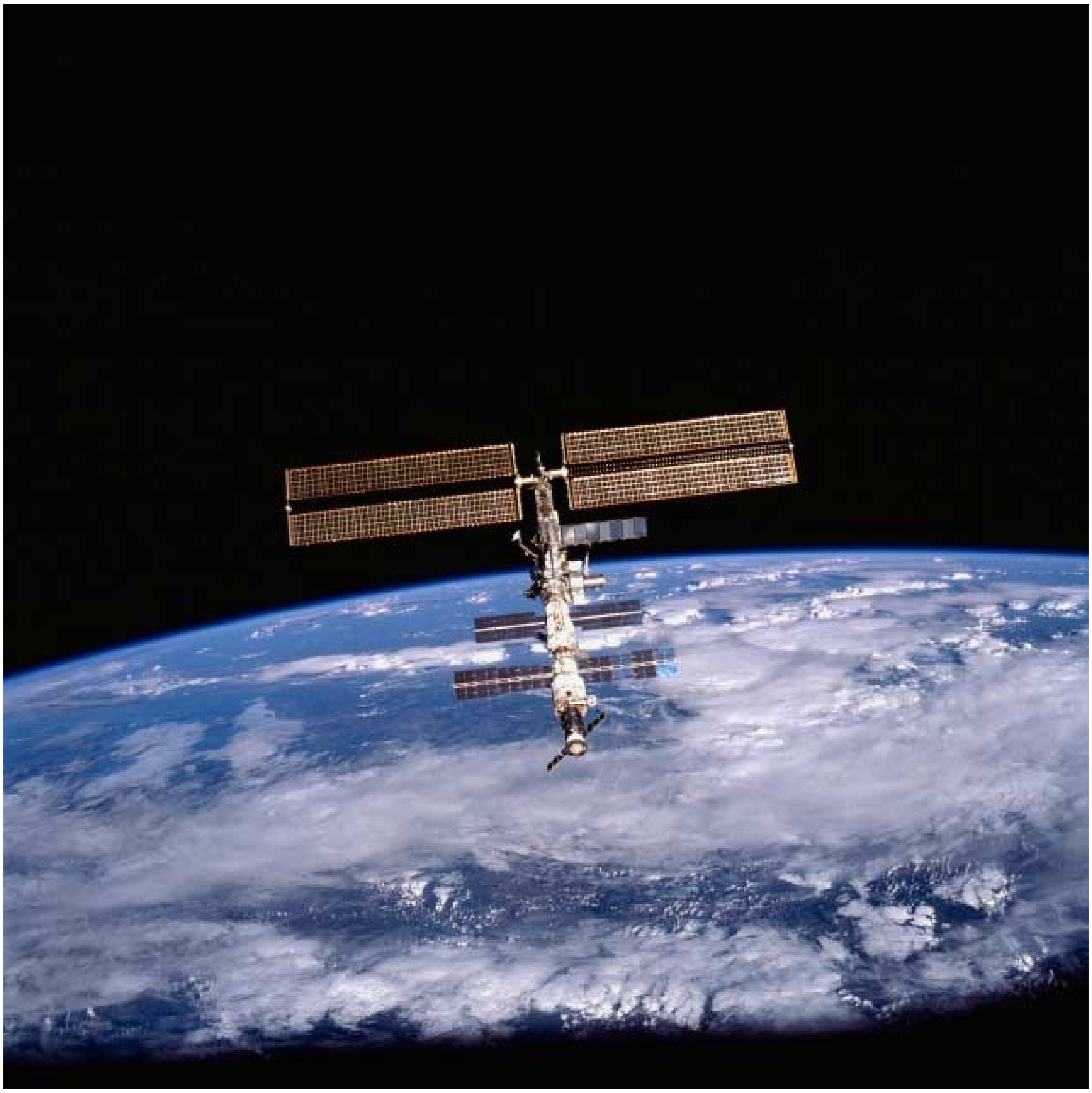


Raffaello will be lifted out of Endeavour's payload bay and attached directly to the station's Unity node for the unloading of its cargo, which consists of the contents of eight resupply stowage racks and four resupply stowage platforms. Much of the material will be transferred to the station's U.S. laboratory Destiny.

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 available 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.

Dominic Gorie, a Navy captain and former test pilot, is commanding his first shuttle flight on STS-108. He has flown twice before as pilot, on STS-91, the final shuttle flight to the Russian space station Mir in 1998, and on STS-99, the Shuttle Radar Topography mission in 2000. Pilot Mark E. Kelly, a Navy lieutenant commander, an honors graduate of the U.S. Merchant Marine Academy and a former test pilot, is making his first spaceflight. Mission Specialist Linda M. Godwin, who holds a Ph.D. in physics, is a veteran of three space flights – STS-37, the Gamma Ray Observatory mission in 1991; STS-59, the Space Radar Laboratory flight in 1994; and the STS-76, a flight to the Russian space station Mir in 1996. Mission Specialist Daniel M. Tani, who holds an M.S. in mechanical engineering from Massachusetts Institute of Technology and was selected as an astronaut in 1996, is making his first space flight.



About 46 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. Transfer operations begin about 2½ hours after docking. Spacesuit transfer from the station to Endeavour in preparation for the mission's four-hour spacewalk by Godwin and Tani is among the first activities on the logistics schedule.

The purpose of the spacewalk is to install thermal blankets over the Beta Gimbal Assemblies (BGAs) at the bases of the station's two large solar wings. Together the wings have a span of 240 feet. The BGAs, atop the station's P6 Truss, control the wings so that they are at an optimal angle to take power from the sun. The blanket installation is a sort of preventative maintenance. The BGAs to be covered continue to function; elements of them have shown some unexplained spikes in power consumption.

Godwin and Tani will take the blankets out of the airlock with them. The shuttle's robotic arm, controlled by Kelly, will take them as far up the P6 Truss as it can reach, perhaps 30 feet below the work site. They'll move the rest of the way to the top of the truss, taking the blankets with them.

The blanket installation is relatively straightforward. After it is completed, Godwin and Tani are likely to have some time to perform "get-ahead" tasks relating to future station assembly work.

After the spacewalk, attention again turns to logistics.

In addition to the new crew and the Multipurpose Logistics Module, the shuttle also brings to the ISS in its cargo bay the Lightweight Mission Peculiar Support Structure Carrier with four Get Away Special (GAS) experiments. Another cargo-bay payload is the Multiple Application Customized Hitchhiker-1 (MACH-1), situated between Endeavour's airlock and Raffaello. Among its payloads is the Starshine satellite.

Starshine is an 85-pound, 19-inch-diameter ball with a surface covered with 845 aluminum mirrors and 31 laser retro reflectors. More than 25,000 students from 26 countries polished the mirrors.

Starshine (the name is an acronym for Student Tracked Atmospheric Research Satellite for Heuristic International Networking Experiment) will be deployed by a spring mechanism from Endeavour's cargo bay the day before landing. It is among several small, optically reflective spherical Starshine student satellites, built by the U.S. Naval Research Laboratory, that are being deployed by NASA. The first was placed in orbit from Discovery on STS-96 in June 1999. A second was launched Sept. 29, 2001, from the Kodiak launch complex in Alaska. Students and other observers around the world precisely observe its position, calculate its orbital decay and use the information to study the density of the atmosphere.

Also aboard the Hitchhiker will be the Capillary Pumped Loop Experiment-3, the Prototype Synchrotron Radiation Detector, two Space Experiment Modules containing multiple small experiments and a GAS can containing seven experiments.

Just forward of the Hitchhiker, on the right payload bay wall, will be two GAS containers, one housing seven experiments from Utah State University and the other with an experiment looking at smoldering combustion in microgravity.

Behind Raffaello, at the rear of the cargo bay, is the Lightweight Multipurpose Experiment Support Structure Carrier (LMC), with four more GAS cans. One has three Penn State University experiments and another contains 10 student experiments. A third houses a Swedish Space Corp. experiment focusing on weak Marangoni flows and the fourth, from Ames Research Center, is a test of a prototype instrument cooler for planetary missions.

In Endeavour's middeck area will be the Avian Development Facility and the Commercial Biomedical Testing Module – Animal Enclosure Module. The Avian Development Facility is flown to validate subsystems and will contain two experiments on development in space of Japanese quail eggs. The Animal Enclosure Module is a commercial experiment using mice and seeking information that could lead to better treatment of osteoporosis in humans.

STS-108 is the 12th space shuttle mission in support of the space station, the 17th mission of Endeavour and the 107th flight in shuttle program history.

Endeavour

Endeavour, the newest addition to the four-orbiter fleet, is named after the first ship commanded by James Cook, the 18th-Century British explorer, navigator and astronomer.

On Endeavour's maiden voyage in August 1768, Cook sailed to the South Pacific (to observe and record the infrequent event of the planet Venus passing between the Earth and the sun). Determining the transit of Venus enabled early astronomers to find the distance of the sun from the Earth, which then could be used as a unit of measurement in calculating the parameters of the universe.

In 1769, Cook was the first person to fully chart New Zealand (which was previously visited in 1642 by the Dutchman Abel Tasman from the Dutch province of Zeeland). Cook also surveyed the eastern coast of Australia, navigated the Great Barrier Reef and traveled to Hawaii.

Cook's voyage on the Endeavour also established the usefulness of sending scientists on voyages of exploration. While sailing with Cook, naturalist Joseph Banks and Carl Solander collected many new families and species of plants, and encountered numerous new species of animals.

Endeavour and her crew reportedly made the first long-distance voyage on which no crewman died from scurvy, the dietary disease caused by lack of ascorbic acids. Cook is credited with being the first captain to use diet as a cure for scurvy, when he made his crew eat cress, sauerkraut and an orange extract.

The Endeavour was small at about 368 tons, 100 feet in length and 20 feet in width. In contrast, its modern day namesake is 78 tons, 122 feet in length and 78 feet wide. The Endeavour of Captain Cook's day had a round bluff bow and a flat bottom. The ship's career ended on a reef along Rhode Island.

For the first time, a national competition involving students in elementary and secondary schools produced the name of the new orbiter; it was announced by President George Bush in 1989. The space shuttle orbiter Endeavour was delivered to Kennedy Space Center in May 1991, and flew its first mission, highlighted by the dramatic rescue of a stranded communications satellite, a year later in May 1992.

Endeavour is called OV-105, for Orbiter Vehicle-105.

Day-by-day summary of the mission:

Day 1 – Launch

Endeavour's crew will launch in the afternoon of its day during a precisely timed, few-minutes-long launch window that begins the process of rendezvous with the International Space Station. Crewmembers begin a sleep period about seven hours after launch.

Day 2 – Equipment Checkouts, Rendezvous Preparations

Endeavour's crew will spend its first full day in space checking out equipment that will be used for upcoming major activities -- the shuttle's robotic arm and the controls and tools used for the final rendezvous and docking with the station. The crew also will power up and prepare the shuttle's docking system and perform several engine firings to optimize the rate at which Endeavour closes in on the station.

Day 3 – Rendezvous and Docking

Plans call for Endeavour to dock with the International Space Station on Flight Day 3. Expedition Four crewmembers' Individual Equipment Liner Kits are transferred to the station and stowed temporarily.

Day 4 – Berthing of the MPLM Raffaello

Raffaello will be attached to the station's Unity node, powered up and activated. The three Expedition Four crewmembers will install their Individual Equipment Liner Kits in the Soyuz capsule docked to the station, thus becoming members of the station crew.

Day 5 –Spacewalk Preparation

Astronauts will check out spacesuits and other spacewalking equipment. The station and shuttle arms will be prepared for the next day's activities.

Day 6 – The Spacewalk

Goodwin and Tani will install thermal blankets over the Beta Gimbal Assemblies, atop the P6 Truss at the bases of the station's two large solar wings. The spacewalk is expected to last about four hours. Transfer of equipment and supplies to the station continues, as do handover talks between the Expedition Three and Expedition Four crews.

Day 7 – Transfer and Handover

Transfer operations, including moving powered station payloads to the shuttle, continue. Biotechnology Refrigerator samples also will be transferred to Endeavour.

Day 8 – Equipment, Supplies Transfer

Again station and shuttle crewmembers will transfer equipment and supplies between Raffaello and the station. Raffaello will be loaded with unneeded equipment and supplies from the station for return to earth. Station crewmembers will continue handover activities.

Day 9 – Raffaello Returns to Endeavour

Raffaello will be unberthed from the space station and, loaded with its new cargo of unneeded equipment and supplies from the station, returned to Endeavour's cargo bay. Station and shuttle crewmembers will review undocking procedures.

Day 10 -- Shuttle-Station Hatch Closing, Undocking, Flyaround

The Endeavour and station crews will close hatches between the spacecraft. Gorie and Kelly will undock Endeavour from the station. With Kelly at the controls, Endeavour will do a flyaround of the complex before departing.

Day 11– Pre-Landing Checkouts, Cabin Stow

Activities include the standard day-before-landing flight control checks of Endeavour by Gorie and Kelly and the normal steering jet test firing. The crew will spend most of the day stowing gear on board the shuttle and preparing for the return home. The Starshine satellite will be deployed.

Day 12 – Entry and Landing

Kennedy Space Center, Fla., is the preferred landing site.

Mission Objectives

Endeavour (OV-105)

Top priorities for the STS-108 (UF-1) mission of Endeavour are rotation of the International Space Station Expedition Three and Expedition Four crews, bringing water, equipment and supplies to the station and completion of spacewalk and robotics tasks.

International Space Station Program priorities include the following tasks to be accomplished.

--Rotation of the Expedition Three and Expedition Four crews.

--Water transfer from the shuttle to the station. The quantity will be determined during the mission.

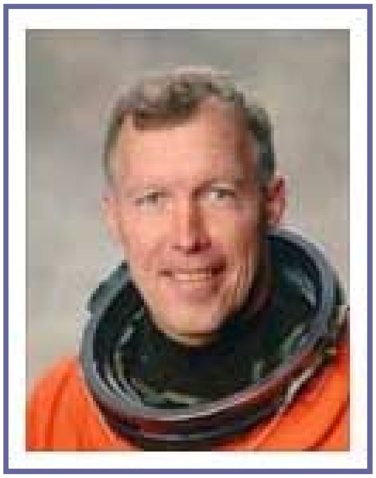
--Berth the Multipurpose Logistics Module to the station, check it out and transfer critical cargo to the space station, transfer and stow return cargo in the module and return the module to the cargo bay.

--Transfer and activate powered experiments hardware and other cargo on Endeavour's middeck, the space station's U.S. laboratory Destiny, and transfer and activate powered experiments from the station to Endeavour's middeck for return to Earth.

--Conduct spacewalk and robotics activities, including installation of blanket over Beta Gimbal Assemblies at the base of the solar wings.

Crew Members

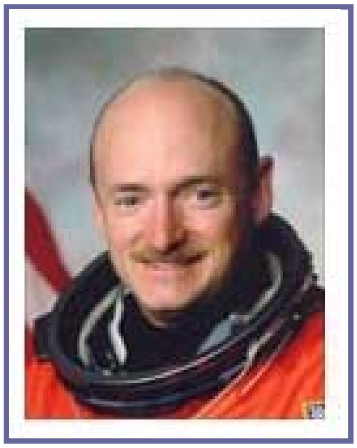
Commander: Dom Gorie



Dom Gorie, 44, a Navy captain, combat veteran of Desert Storm, former test pilot and veteran of two spaceflights, will command Endeavour's STS-108 flight to the International Space Station and be responsible for its safety and success. He will fly Endeavour through its rendezvous and docking with the International Space Station on the 107th flight of the Space Shuttle Program. He will be the intravehicular crewmember during the spacewalk, helping keep the astronauts on task and on time. Gorie will have primary responsibility for water transfer from the shuttle to the station, a mission priority. He will assist pilot Mark Kelly in Endeavour's flyaround of the station after undocking. Finally, he will land Endeavour at the end of the mission.

Gorie flew as pilot on STS-91, the last shuttle flight to Mir, in June 1998, and on STS-99, the Shuttle Radar Topography Mission to map much of the Earth, in February 2000.

Pilot: Mark Kelly



A Navy lieutenant commander and, like his commander, former test pilot and Desert Storm combat veteran, pilot Mark E. Kelly, 37, was selected as an astronaut in April 1996. Kelly will be responsible for monitoring critical shuttle systems and assisting Gorie during ascent and entry. He also will play a major role during rendezvous and docking operations, responsible for many of the shuttle's navigational tools. He will be responsible for operating still and video cameras. Kelly will be primary arm operator during the mission's single spacewalk. After participating in Endeavour's undocking from the station, he will perform the flyaround of the orbiting laboratory.

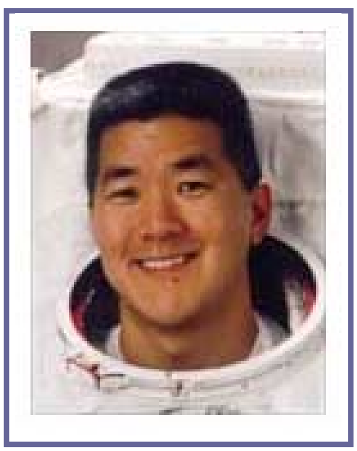
Kelly is making his first spaceflight.

Mission Specialist 1: Linda Godwin

Linda M. Godwin, 49, holds a Ph.D. in physics and is a veteran of three spaceflights. She will do the spacewalk planned for the STS-108 flight of Endeavour. She will have primary responsibility for opening and closing of the shuttle's payload bay doors after Endeavour reaches orbit and during deorbit preparations. Godwin will be shuttle loadmaster during logistics transfer operations. She will have primary responsibility for the Androgynous Peripheral Docking System on docking and undocking, and for shuttle pressure and leak checks on docking. She will be primary operator of the shuttle's robotic arm during berthing and unberthing of the Multipurpose Logistics Module, and be responsible for a number of scientific payloads.

Godwin was a mission specialist on STS-37, the Gamma Ray Observatory flight, in April 1991. She also flew on STS-59, the Space Radar Laboratory Mission in April 1994, and on STS-76, the third shuttle docking mission to the Russian space station Mir in March 1996.

Mission Specialist 2: Daniel Tani



Daniel M. Tani, 40, who holds bachelor's and master's degrees in mechanical engineering from Massachusetts Institute of Technology, was selected as an astronaut in April 1996 after working for about 10 years for space-related companies, primarily with Orbital Sciences Corp. There assignments included a period as launch operations manager of the Pegasus program. Tani will participate with Godwin in the flight's spacewalk. Tani will serve as Endeavour's flight engineer during ascent and entry. He will have primary responsibility in post-insertion activities, converting the shuttle from a launch vehicle to an orbiting spacecraft. He will provide information to the commander and pilot during rendezvous with the station and after undocking, and be responsible for shuttle laptop and payload support computers. He has primary responsibility for deploying the Starshine 2 satellite.

Tani is making his first spaceflight.

Expedition Four (Up only)

Commander: Yury Onufrienko

Col. Yury Ivanovich Onufrienko, 40, a test cosmonaut and former senior pilot in his country's air force, commanded the Mir 21 expedition in 1996. Fellow crewmembers included Astronaut Shannon Lucid and ISS Expedition Two Commander Yury Usachev. As ISS commander, he will have overall responsibility for expedition safety and success of the space station and the Expedition Four crew. He also will have duties aboard Endeavour. During rendezvous he will have backup responsibilities for communication with the station and with Mission Control-Moscow and for shuttle pressure and leak checks. He is backup shuttle robotic arm operator for the spacewalk. He has primary responsibility for transfer of the culture growth experiment and the contents of the biotechnology refrigerator from Endeavour to the station.

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. On Endeavour he will be one of two crew medics. He will have primary responsibility for contact with the station and with Mission Control-Moscow during rendezvous operations. Secondary responsibilities include ISS pressure and leak checks and initial operations.

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. On Endeavour, Walz will have primary responsibility for external tank photography, the handheld laser rangefinder on rendezvous, pressure and leak checks on docking and for moving two scientific experiments from Endeavour to the station. He will serve as backup for post-insertion activities and as backup for intravehicular spacewalk activities.

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.

Expedition Three (Down only)

Commander: Frank Culbertson

Frank Culbertson, 52, a retired Navy captain, former test pilot, and former manager of the ISS Phase One (Shuttle-Mir) Program, is commander of the Expedition Three mission to the space station. Culbertson also will have a number of responsibilities aboard Endeavour during STS-108. Among them will be primary responsibility for return of three experiments from the station to the shuttle, for crew equipment and stowage, for shuttle communications with the station and with Mission Control-Moscow and as a medic on the shuttle's trip home. He will have secondary responsibility for Endeavour's deorbit preparations.

Culbertson was pilot on STS-38, a five-day Defense Department mission in November 1990. He commanded STS-51, which launched the Advanced Communications Technology Satellite and the Shuttle Pallet Satellite in September 1993 and whose crew included Expedition Four's Walz and Bursch.

Flight Engineer: Vladimir Dezhurov

Vladimir Nikoaevich Dezhurov, 39, is a veteran of one previous long-duration spaceflight, having served as commander of a mission aboard the Russian space station Mir in 1995. That crew returned to Earth aboard the shuttle Endeavour's STS-71 mission on July 7, 1995, after 115 days in orbit. Dezhurov is a lieutenant colonel in his country's air force and served as a pilot and senior pilot, earning three Armed Forces Medals. He was first assigned to the Cosmonaut Training Center in 1987. Since 1989 he has trained with a group of test cosmonauts. He served as a backup member of the Expedition One crew to the International Space Station.

Dezhurov commanded the Mir-18 mission, a 115-day flight in 1995.

Flight Engineer: Mikhail Tyurin

Mikhail Tyurin, 41, worked as an engineer at RSC Energia after his graduation from the Moscow Aviation Institute in 1984. At Energia he worked in dynamics, ballistics and software development. He continues graduate studies, and his personal scientific research relating to psychological aspects of cosmonauts' training for manual control of spacecraft. Tyurin himself was selected to begin cosmonaut training in 1993. Since 1998 he has trained as an ISS flight engineer. He was a backup crewmember for Expedition One before being named an Expedition Three crewmember.

Tyurin is returning from his first spaceflight.

Flight Day Summary Timeline

EVENT	FD	MET LOCAL
Launch	01	00/00:00 11/29/01
OMS-2	01	00/00:38 11/29/01
NC1	01	00/03:34 11/29/01
NC2	02	00/18:24 11/30/01
NPC	02	00/21:49 11/30/01
NC3	02	01/02:36 11/30/01
NH	03	01/16:20 12/01/01
NC4	03	01/17:07 12/01/01
TI	03	01/18:40 12/01/01
ISS docking	03	01/21:00 12/01/01
Ingress 1	03	01/22:45 12/01/01
MPLM Berth to ISS	04	02/18:00 12/02/01
MPLM Hatch Open	04	03/02:50 12/02/01
Reboost 1	05	03/17:33 12/03/01
EVA (4 hrs)	06	04/19:30 12/04/01
Reboost 2	07	05/17:11 12/05/01
Reboost 3	08	06/17:49 12/06/01
MPLM Hatch Close	08	07/16:00 12/07/01
MPLM Berth to STS	09	07/22:25 12/07/01
Undock	10	08/17:48 12/08/01
Sep	10	08/19:17 12/08/01
Starshine DPLY	11	09/16:52 12/09/01

Rendezvous and Docking

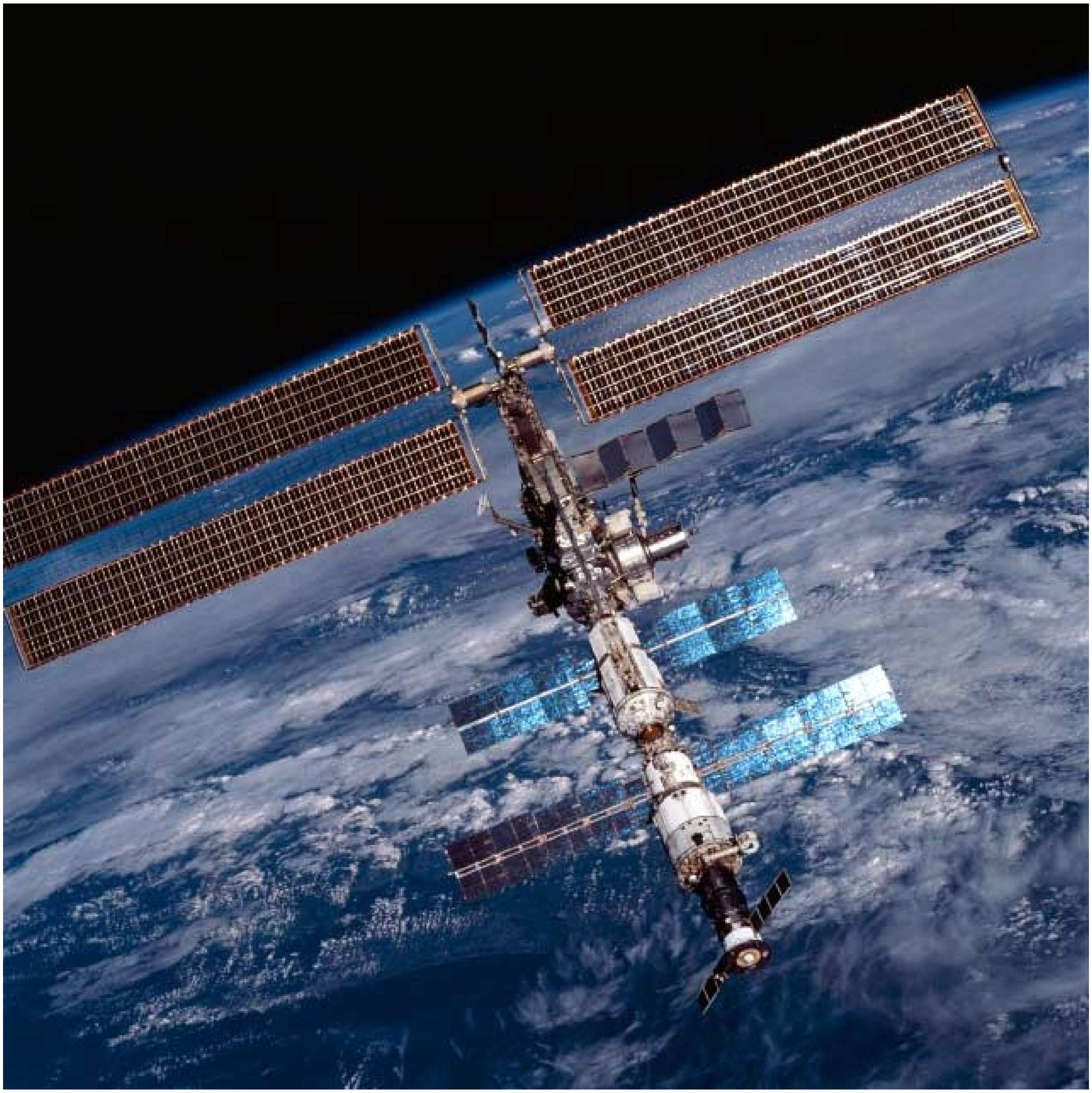
Endeavour's rendezvous and docking with the International Space Station begins with the precisely timed launch of the shuttle on a course for the station. During the first two days of the mission, periodic engine firings will gradually bring Endeavour to a point about 9½ statute miles behind the station,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

Endeavour will reach that point about 2½ hours before the scheduled docking time on Flight Day Three. There 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 the 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, the shuttle will have an opportunity to make four, small mid-course corrections at regular intervals.

Just after the fourth correction, Endeavour will be about half a mile below the station. There, about an hour before the scheduled docking, Commander Dom Gorie will take over manual control of the approach.

Gorie will slow Endeavour’s approach and fly to a point about 600 feet directly below the station. There 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.

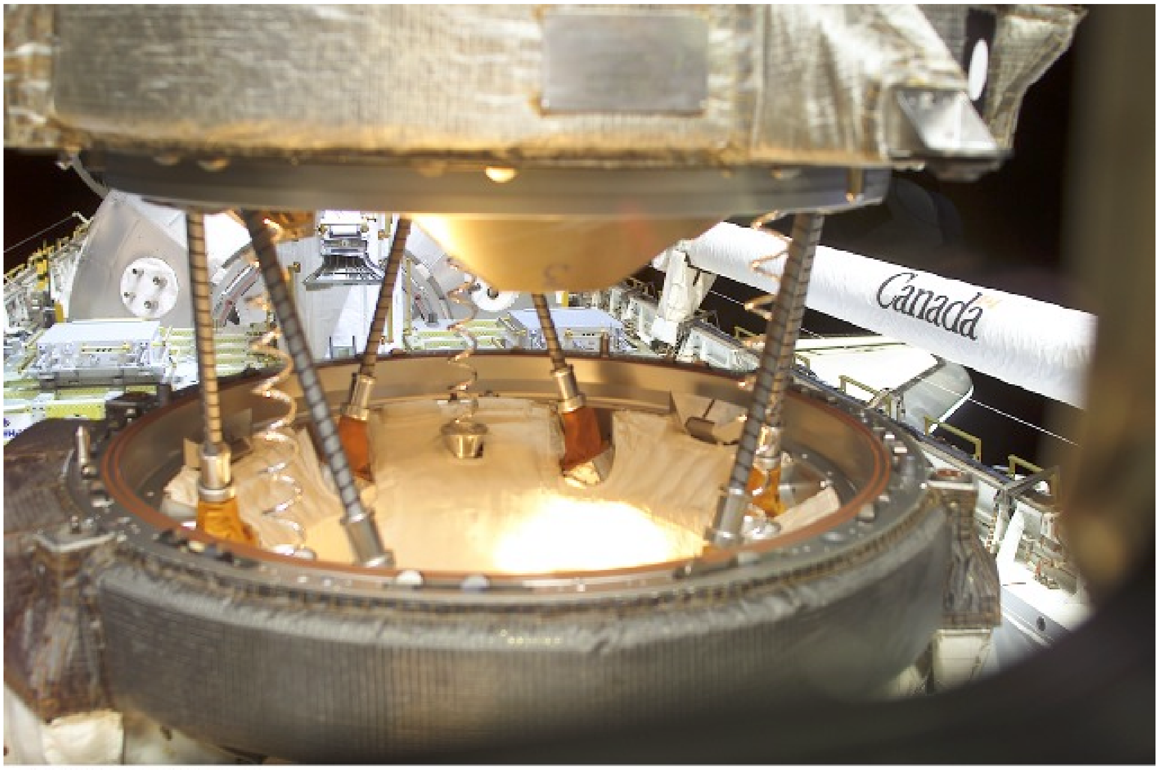


During the rendezvous, Gorie will be assisted by Pilot Mark Kelly in controlling Endeavour's approach. Mission Specialists Linda Godwin and Dan Tani also will play key roles in the rendezvous, with Godwin operating a handheld laser-ranging device and the shuttle's docking system that will latch the spacecraft together. Tani will be coordinating checklists and procedures on board the spacecraft.

Gorie will fly the quarter-circle of the station, while slowly closing in on the complex. He will stop Endeavour a little more than 300 feet directly in front of it. 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, Gorie will precisely center the docking ports of the two spacecraft. Gorie will fly to a point where the docking mechanisms are 30 feet apart, and pause for a few minutes to check the alignment.

For Endeavour's docking, Gorie 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 engage, attaching the spacecraft to one another.



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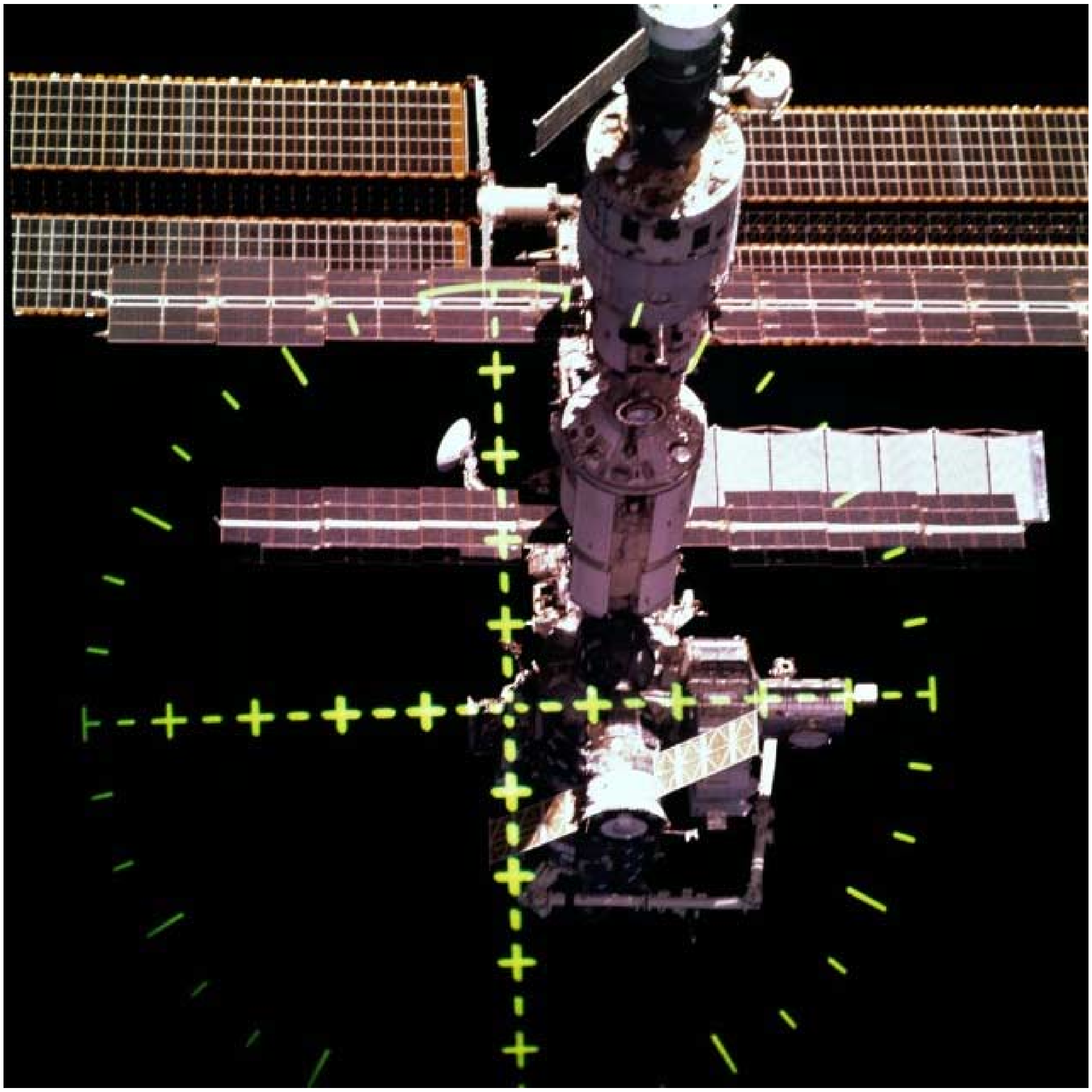
Immediately after Endeavour docks, the shuttle's steering jets will be deactivated to reduce the forces acting at the docking interface. Shock absorber-type springs in the docking mechanism will dampen any relative motion between the shuttle and the station.

Once relative motion between the spacecraft has been stopped, Godwin 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, Godwin 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, Kelly will turn the steering jets back on and fire them to begin very slowly moving away. From the aft flight deck, Kelly will manually control Endeavour within a tight corridor as he separates from the ISS, essentially the reverse of the task performed by Gorie when Endeavour docked.



Endeavour will continue away to a distance of about 450 feet, where Kelly will begin a close fly around of the station, circling the complex 1¼ times. Kelly will pass directly above the station, then behind, then underneath, then in front and then reach a point directly above it for a second time. At that point, passing above the station for a second time, Kelly will fire Endeavour's jets to separate the vicinity of the station. The fly around is expected to be completed about 90 minutes after undocking.

Extravehicular Activity

Astronauts Linda Godwin and Dan Tani will do a four-hour spacewalk on the sixth day of STS-108 to install insulating blankets around two cylindrical mechanisms that rotate the International Space Station's large United States solar array wings. Godwin and Tani also will perform some "get-ahead tasks" for station assembly work planned during STS-110 next year.

For the spacewalk, Godwin will be designated the Extravehicular 1 (EV1) crewmember, distinguishable by red stripes on her spacesuit, and Tani will be designated EV2, wearing an all white spacesuit. Commander Dom Gorie will serve as the Intravehicular (IV) crewmember, choreographing the spacewalk work from inside the shuttle cabin. Pilot Mark Kelly will operate the shuttle's robotic arm, maneuvering the spacewalkers during part of their work.

The spacewalk will originate from Endeavour's airlock. Two blankets will be installed, one on the mechanism that rotates the port side solar array wing, technically labeled the 4B array, and another on the mechanism that rotates the starboard side solar array wing, labeled the 2B array. The blankets are designed to moderate the extremes of heat and cold that the mechanisms experience in space, safeguarding their future operation. Godwin and Tani will carry the blankets out of the airlock with them, each carrying one up to the work site, located at the top of the station's P6 truss, about five stories above the station's modules.

After they have left the shuttle airlock, positioned each blanket for translation and gathered tools stowed in Endeavour's bay, Godwin and Tani will attach tethers to the end of the shuttle's robotic arm. As they hold on, Kelly will maneuver the arm to lift the spacewalkers to a point part way up the five-story truss structure, as high as the shuttle arm is able to reach. At that point, Godwin and Tani will leave the arm and climb the rest of the way up to the top of the truss to the starboard and port rotating mechanisms, called Beta Gimbal Assemblies.

The two spacewalkers will work together to install each custom-designed blanket, turning the first on portside mechanism. Tani will be carrying the port blanket and begin to unpack it, first attaching straps that will anchor it to handrails. Then, Tani will begin unrolling the blanket, wrapping around the barrel-shaped mechanism, passing it underneath the assembly and handing the blanket off to Godwin.

Godwin will continue to wrap the blanket around the mechanism and hand it back over the assembly to Tani, where it will be secured to its starting edge using Velcro straps to tighten it in place. A hood will unfurl as the blanket is unrolled that will be positioned to insulate connectors attached to the mechanism.

The spacewalkers will then reposition themselves and repeat the procedure to install the blanket carried by Godwin around the starboard mechanism. Then, crewmembers will turn their attention to several miscellaneous "get-ahead" tasks.

For the first such task, the crew will remain at the top of the station's truss and Godwin will use vice grips to help rotate a latch in place for one brace on the starboard, or 2B, solar array wing. The wing has four braces. The brace in question did not latch properly when the P6 truss and solar arrays were installed during shuttle mission STS-97 in 2000. The array is secure with three braces latched, but the spacewalkers will take advantage of their position atop the truss to latch the final brace as well. An analysis by engineers determined that the open latch can be engaged by using vice grips to slightly rotate the center shaft, an activity that should take only a few minutes.

Next Godwin and Tani will climb back down the five-story truss, stopping about midway to retrieve a protective cover that had been launched on an S-Band Antenna Assembly installed on the station last year. After being removed from the antenna, the cover was stowed in a storage bin on the truss exterior. Godwin and Tani will bring the cover inside Endeavour's cabin for return to Earth. It may be reused.

Several additional tasks will help with future spacewalks to be performed on shuttle mission STS-110 next year that will install a central truss segment on the station. As part of early preparations for that work, Godwin and Tani will retrieve several tools that will be needed on that flight from kits on the station's exterior and bring them aboard Endeavour.

The tools will be stowed aboard the station, saving time during that future spacewalk by allowing the needed tools to be taken outside with the spacewalkers rather than having to be retrieved from various outside toolboxes. Godwin and Tani also will take outside with them two Circuit Interrupt Devices, switches that will be temporarily secured to hand rails on the station's Z1 truss. The devices will be installed during mission STS-110.

Payloads

Raffaello – Second Round-trip

Overview

The Raffaello 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 racks and platforms filled with bags of experiments and supplies to and from the orbiting laboratory.

On this mission, Raffaello will be mounted in the space shuttle's payload bay for launch and remain there until after docking. Once the shuttle is docked to the station, the shuttle's robotic arm will remove Raffaello from the payload bay and attach it with common berthing mechanisms to the Unity Node on the station. During its berthed period to the station individual components will be transferred to the station.

After Raffaello is unloaded, used equipment and trash will be transferred to it from the station for return to Earth. The Raffaello logistics module will then be detached from the station and positioned back into the shuttle's cargo bay for the trip home. When in the cargo bay, Raffaello is independent of the shuttle cabin, and there is no passageway for shuttle crewmembers to travel from the shuttle cabin to the module.

Raffaello will be filled with equipment and supplies to outfit the U.S. laboratory Destiny, which was carried to the International Space Station on STS-98 in February 2001. Of the 16 racks the module can carry, this mission brings eight Resupply Stowage Racks (RSRs) and four Resupply Stowage Platforms (RSPs).

The RSRs and RSPs within the MPLM contain components to augment existing station systems, spare parts for systems already on the station, in addition to food and supplies to support the crew. RSRs and RSPs use Cargo Transfer Bags to carry components to the station but the racks, platforms, and bags themselves remain in the Raffaello module and are returned to Earth aboard the shuttle.

History/Background

Raffaello, built by the Italian Space Agency (ASI), is the second of three such pressurized modules that serve as the International Space Station’s "moving vans," carrying laboratory racks filled with equipment, experiments and supplies to and from the International Space Station aboard the space shuttle.

Construction of ASI's Raffaello module was the responsibility of Alenia Aerospazio in Turin, Italy. Raffaello was delivered to Kennedy Space Center from Italy in July 1999 by a special Beluga cargo aircraft. The cylindrical module is about 6.4 meters (21 feet) long and 4.6 meters (15 feet) in diameter. It weighs about 9,000 pounds (almost 4.1 metric tons). It can carry up to 20,000 pounds (9.1 metric tons) of cargo packed into 16 standard space station equipment racks.

Although built in Italy, Raffaello and two additional MPLMs are owned by the U.S. They were provided in exchange for Italian access to U.S. research time on the station.

The unpiloted, reusable logistics module functions as both a cargo carrier and a space station module when it is flown. To function as an attached station module as well as a cargo transport, Raffaello contains components that provide some life support, fire detection and suppression, electrical distribution and computer functions. Eventually, the modules also will carry refrigerator freezers for transporting experiment samples and food to and from the station.

Raffaello first flew to the station aboard Endeavour on STS-100/6A in April 2001.

Common Berthing Mechanism

The Common Berthing Mechanism (CBM) connects one pressurized module to another on the U.S. segment of the International Space Station. The active half weighs 583 pounds and is made up of an 80-inch-diameter structural ring, four capture latches, eight alignment guides, four powered bolts and actuators, four ready-to-latch indicators, four controller panel assemblies, and striker plates.

Only the active half of the CBM connects to power and data. The passive half weighs 360 pounds and has a structural ring, four capture latch fittings, eight alignment guides, 16 power bolt nuts and four ready-to-latch indicators.

During installation of a module that uses the CBM, the robotic arm of the shuttle or the space station moves the module with the passive half into the capture envelope of the active half. The latching process begins as the active CBM extends four capture latches to catch the passive CBM. The 16 power bolts then extend from the active CBM and are inserted into the bolt nuts of the passive CBM, completing the connection.

There are more than 25 CBMs on the space station.

Payloads

Avian Development Hardware Set for Flight

Overview

The second generation of avian development hardware, the Avian Development Facility, is designed for space experiments that use Japanese quail eggs. The main ADF objective on the STS-108 mission is to validate its subsystems and reduce the risk in developing the next generation of avian development hardware, the Egg Incubator.

The ADF provides optimal incubation conditions for embryo development during flight. It also minimizes crew time and improves the science return by using advanced telerobotics and teleoperations. NASA's Ames Research Center, Moffett Field, Calif., manages the ADF project.

Secondary objectives will be support of two experiments studying how the lack of gravity affects the development of avian embryos. Stephen Doty, Ph.D., of the Hospital for Special Surgery in New York City, will study the effects of spaceflight on embryonic skeletal development. The development and function of the avian vestibular system will be the focus of a study by David Dickman, Ph.D., of the Central Institute of the Deaf, Washington University, St. Louis, Mo.

The ADF is an automated avian egg incubator that requires no crew interaction with the eggs. It provides a snapshot of embryogenesis in space using the avian embryos as a biological model. Avian eggs are ideally suited for microgravity research because they are self-contained and self-sustaining.

The ADF will house 36 Japanese quail eggs in holders designed to isolate the eggs from vibration and to minimize any effects of launch and re-entry on the developing embryos. The egg holders are mounted on two rotating centrifuges that will provide either exposure to microgravity or to a gravity force equivalent to that found on Earth.

Interior environmental temperature, humidity, carbon dioxide and oxygen concentration can be pre-programmed to provide optimal incubation conditions. The ADF also has an automated fixative-injection system that can be programmed to fix or preserve the embryos at specific times during incubation. The egg holder is designed with a secondary containment system to prevent leaking of injected fixative into the incubator. The ADF rotates the eggs 180 degrees every hour, similar to turning in a natural environment. The facility fits into a space shuttle middeck locker.

The ADF is the first of several research habitats to fly on board the International Space Station that are being developed as part of the Space Station Biological Research Project (SSBRP) at NASA Ames. The SSBRP is responsible for managing the development of several habitats that provide life support, environmental control, and monitoring systems for various research subjects and specimens. The habitats are being developed to operate with three major host systems: the variable-gravity, 2.5-meter centrifuge; the microgravity-holding racks; and the Life Sciences Glovebox. In addition, SSBRP will manage the development of various laboratory equipment items needed for science operations.

Space Hardware Optimization Technology, Inc. (SHOT), of Greenville, Ind., developed the ADF for NASA Ames. The ADF is the second generation of avian development hardware from SHOT. The first-generation hardware flew on the space shuttle in 1986 and 1989. The third-generation Egg Incubator will be capable of supporting long-term egg incubation experiments on the International Space Station. Possible future studies will examine embryo orientation and mortality, embryogenesis, and development of bone and muscular tissue.

The two ADF experiments are supported by NASA's Office of Biological and Physical Research, which promotes basic and applied research to support human exploration of space and to take advantage of the space environment as a laboratory. More information is available at: http://spaceresearch.nasa.gov/.

The information collected from this mission is expected to help Earth-based biotechnology and health care research leap forward toward cures or treatments that may otherwise not have been realized.

More information about Ames' life sciences research and the Space Station Biological Research Project is available at http://lifesci.arc.nasa.gov/ and at http://brp.arc.nasa.gov/.

Details about SHOT are available at http://www.shot.com.

Payloads

Commercial Biomedical Testing Module Experiment

Principal Investigators: Dr. Paul Kostenuik, Amgen Thousand Oaks, Calif.

Overview

Osteoporosis is a debilitating disease that can lead to bone fractures and result in reduced quality of life for the elderly population it generally afflicts. With 80 percent of the incidence of osteoporosis in females, more than 30 million women in America are at risk of developing osteoporosis and subsequently have an increased risk of serious bone fractures.

A promising treatment for this brittle bone condition is being tested during STS-108 by Amgen Inc., a biotechnology firm in Thousand Oaks, Calif. This treatment is the protein osteoprotegerin (OPG), a potent regulator of bone metabolism. The experiment is made possible by Amgen's work with one of NASA's 17 Commercial Space Centers: BioServe Space Technologies at the University of Colorado, Boulder and Kansas State University, Manhattan.

Before launch, Amgen scientists will treat 12 lab mice with OPG; 12 similar lab mice will receive a placebo. During the flight, the rodents will reside in an Animal Enclosure Module. Similarly treated mice will remain on Earth to control for the effects of gravity. Periodically, crewmembers will monitor the status of the mice and their habitat. After the shuttle lands, the mice will be returned to Amgen and BioServe scientists who will examine the effects of spaceflight and the ability of OPG to mitigate the effects of spaceflight on osteoclast/ osteoblast signaling using various analysis methods.

This space experiment will contribute to Amgen's ground-based studies of OPG. Since spaceflight induces a complete, more systematic, accelerated bone loss, it is expected to provide a good model for osteoporosis and potential treatments. Potentially, it could provide scientists with further insight into the relationship between skeletal loss from microgravity and the role of OPG and OPG-ligand (or OPGL, a protein that OPG binds with) in the determination of bone composition, morphology and mechanical properties. This data may assist Amgen in its development of OPG as a treatment for osteoporosis.

NASA also is interested in treatments that prevent bone loss in astronauts. Microgravity-induced bone loss is a significant barrier for long-term human spaceflight. For various reasons, current medications for osteoporosis are not appropriate or ideal countermeasures for most astronauts. In addition to this study, NASA is studying bone loss in space station crewmembers.

This is the first time OPG will be studied in space. This payload is Amgen's first space experiment.

Payloads

Students to Track Starshine 2, Atmospheric Research Satellite

Overview

About 25,000 students from 26 countries are awaiting the deployment of Starshine 2 during the STS-108 mission. The students helped polish nearly 900 mirrors that cover the surface of the beach ball-sized hollow aluminum sphere that will orbit the earth for almost a year. During the satellite's mission, sunlight reflecting from the mirrors will be visible to the naked eye during morning and evening twilight hours. Teams of elementary, middle and high school students will visually track the satellite and note the times that it passes between selected pairs of targeted stars.

The students will enter their observations on the STARSHINE project's Internet site at http://www.azinet.com/starshine, and the U.S. Naval Research Laboratory and the U.S. Space Command will use the measurements to calculate the satellite's orbit. The orbital data will be used to post sighting predictions on a link from the web site so the students will know where and when to look for Starshine 2's next appearance over their observation sites. As the project progresses, high school students will be taught how to calculate the orbits on their personal computers.

Throughout the mission, students will measure the daily change in the time it takes Starshine 2 to circle the Earth. The students will use this information to calculate the density of the Earth's upper atmosphere. During its eight-month lifetime, Starshine 2 will gradually lose altitude because of the aerodynamic drag caused by the atmosphere's density and eventually will burn up like a flaming meteor approximately 50 miles (80 kilometers) above the Earth.

Students will also look at daily extreme ultraviolet radiation from the sun on the STARSHINE web site and count the sunspots on the solar surface. They will plot this radiation against the rate of change of Starshine 2's orbital period to learn how solar storms heat and expand the Earth's upper atmosphere, causing variations in its density and producing aerodynamic drag.

The spacecraft contains a special cold gas spin system that will rotate the satellite five degrees per second to enhance the rate at which sunlight will flash from its mirrors. In addition, the satellite carries twenty laser retro-reflectors, distributed evenly across its surface, to permit tracking by the International Satellite Laser Ranging Network.

The mirrors covering the entire spacecraft were machined by Utah high school technology students and were shipped to students around the world to be polished. They were then coated with a scratch-resistant, anti-oxidizing layer of Silicon Dioxide at the Hill Air Force Base and then installed by engineers at the NRL in Washington, D.C. Starshine 2 will fly into space in a Hitchhiker canister in the payload bay of Endeavour and will be deployed 240 miles (387 kilometers) above the Earth while inclined to the

Earth's equator by 51.6 degrees toward the end of the mission. The spacecraft weighs 86 pounds (39 kilograms) and is almost 20 inches (one half meter) in diameter.

Background

Starshine 2 is the third satellite of Project STARSHINE to be deployed. Project STARSHINE originally planned to launch one satellite per year over an 11-year solar cycle, but changes in launch schedules have resulted in two being launched in one year. Starshine 1 was launched aboard Space Shuttle Discovery in May 1999 and provided eight months of data for students around the world. Starshine 3 was launched from the Kodiak Launch Complex, Alaska, in September 2001 and is orbiting 470 kilometers above the Earth. By the end of this year, mirror-polishing kits will be sent to applying schools so they can begin work on the mirrors for Starshine 4 and 5.

Benefits

The principal objectives of Project STARSHINE are educational and motivational. If students help "build" the spacecraft (by polishing its mirrors), they should be more excited about tracking it and using it to measure upper atmospheric density and the response of that region of the atmosphere to solar storms.

Project STARSHINE is giving pre-college students a chance to work with real space hardware and learn how to do precision work on elements of that hardware. They also learn about satellite orbits and the earth's upper atmosphere and the interaction between the Earth's and sun's atmospheres and magnetospheres. The participants use the Internet to obtain knowledge, report their measurements, and communicate as team members with students in other countries. They are taught how to make precision optical measurements and use precision timing systems to make those measurements, and they learn something about observational astronomy and orbit dynamics. In short, they learn that science and engineering and technology can be fun and still produce useful results.

Through observations of STARSHINE satellites, students will learn the basic principles of solar-terrestrial physics. To further this end, the project posts daily satellite images of the sun on its web site.

Besides educating and motivating students, Project STARSHINE may have scientific benefits. If enough students do serious tracking of the spacecraft to get good orbits, especially during the terminal phase of flight, the project might be able to contribute to the pool of knowledge of the average density of the atmosphere in the 50- to 291-mile (80- to 470-kilometer) altitude regime. Since STARSHINE satellites are spherical, they have a much more uniform drag coefficient than spacecraft with solar arrays and helical antennas and other structures protruding from them, so the density measurements that will be made from tracking STARSHINE satellites will be more precise than those from tracking other re-entering spacecraft.

Payloads

Small Payloads Provide Worldwide Research Opportunities

Overview

Researchers worldwide will fly experiments on STS-108 through NASA's Shuttle Small Payloads Project (SSPP), managed at the Goddard Space Flight Center in Greenbelt, Md., and its Wallops Flight Facility, Wallops Island, Va. The SSPP designs, develops, tests, integrates and flies a group of carrier systems in the shuttle's cargo bay. These carriers – the Hitchhiker, Hitchhiker Jr., Get Away Specials and Space Experiment Module – support payloads supplied by NASA, other U.S. government agencies, domestic and foreign commercial customers, foreign governments, and schools from kindergarten through universities. The following small payloads will be flown aboard Endeavour during the STS-108 mission.

Hitchhikers

Hitchhiker payloads fly in mounted canisters attached to mounting plates of various sizes. For STS-108, the Hitchhikers, Hitchhiker Jr. and two SEMs will fly on a cross-bay platform. The Hitchhiker carrier provides electrical power, command signals, and "downlink" data interfaces. Hitchhiker customers may operate their payloads from the Hitchhiker Control Center at the Goddard Space Flight Center or from a remote site.

Hitchhiker web site: http://sspp.gsfc.nasa.gov/hh/index.html

Capillary Pumped Loop Experiment (CAPL-3)

NASA Goddard Space Flight Center/Naval Research Laboratory/Swales Corp.

Capillary Pumped Loops are two-phase heat transfer devices that use capillary forces for heat acquisition and fluid pumping with no moving parts. A single system can cool multiple components and reject heat to multiple radiators. The system can transfer high heat loads over long distances with reliable, vibration-free operation and passive control. The design provides versatility and lower weight compared to heat pipe systems. It uses heat load sharing. It can automatically use waste heat from operating components to warm non-operational components.

Earlier experiments flew on STS-60 and STS-69. The main objective of CAPL-3 is to demonstrate in space a multiple evaporator capillary pumped loop system, capable of reliable start-up, reliable continuous operation and at least 50 percent heat load sharing with hardware for a deployable radiator. It is a two-phase ammonia thermal control system consisting of a capillary pumped loop with multiple capillary evaporators and parallel direct condensation radiators.

Experiment Manager – Laura Ottenstein, GSFC

Hitchhiker Jr. (1)

The Hitchhiker Jr. carrier provides mechanical and electrical interfaces similar to a Get Away Special, but has avionics to monitor carrier and payload functions and power services.

Hitchhiker Jr. web site: http://sspp.gsfc.nasa.gov/hhjr/index.html

Collisions into Dust Experiment (COLLIDE-2)

NASA Glenn Research Center/University of Colorado

COLLIDE-2 is an investigation into planetary dust rings. A follow-on to COLLIDE-1, which flew on STS-90, COLLIDE-2 performs low-velocity impact experiments into simulated dusty regoliths in microgravity. These impacts simulate the conditions in planetary rings and early protoplanetary disks. The experiment will give scientists a look at the dynamics, origin and evolution of planetary ring systems. Rings are collisonally evolved systems. Collisions sculpt the ring, leading to spreading, transfer of anular momentum, release of dust particles and damping of waves and wakes. The rate of evolution depends on dissipation of energy in collisions. COLLIDE-2 results also can be applied to the lifecycles of planetary dust rings.

Principal Investigator: Joshua Colwell, University of Colorado

Project Manager: Monica Hoffmann, NASA Glenn Research Center

Web site: http://lasp.colorado.edu/collide

Get Away Special (GAS)

The Get Away Specials carrier provides limited mechanical and electrical interfaces for self-contained experiments. Simple crew control functions may be performed, but the user addresses internal system requirements. The GAS carriers flown will be about the size of a 55-gallon drum or half that size. The customer equipment can weigh up to 200 pounds (91.32 kilograms).

Get Away Special web site: http://www.wff.nasa.gov/gas

G-761

Argentine Experiments Package (Paquete Argentino de Experimentos – PADE)

The Argentine Association of Space Technology is flying seven experiments designed by personnel at Argentine universities and scientific institutions.

1. Transport Fluids in Non-Circular Tubing

   This experiment looks at the flow of fluids in microgravity through various geometric shaped tubes to determine the most efficient way to transport fluids in space.

2. Surface Vibration of Water Drops

   Scientists will measure the surface vibration generated by surface tension in water drops in microgravity. Similar tests on Earth are influenced by gravity. The results may have applications in the petrochemical industry as well as space applications.

3. Migration of Drops and Bubbles in Microgravity

   Scientists will study the convection of water drops and bubbles in microgravity to determine the feasibility for future development of a detector of drop and bubble movement based on thermal changes.

4. Exposure of Seeds to Space

   This experiment is designed to examine cell mutation and modifications in several types of seeds exposed to the space environment. The retrieved samples will be compared with samples maintained on Earth. The experiment will be used to interest Argentine high school students in biological experiments.

5. Crystal Formation and Growth in a Microgravity Environment

   The objective of this experiment is to determine the differences in crystal growth between Earth and space. The results may be applicable to the pharmaceutical and electronics industries.

6. Maximum Accelerations Register

   To aid in the development of an acceleration recorder that does not require electrical energy, the experiment will record maximum acceleration of the orbiter during flight. The experiment consists of two systems to record acceleration: a mechanical device which turns springs and a device activated by the change of shape of strings from one stable equilibrium position to another.

7. Geophysical Fluids Movement

   This experiment simulates a small "planet" in its container. Its goal is to use microgravity to simulate atmospheric and sea movement in spherical bodies to better understand the Earth's atmosphere and oceans.

Payload Manager: Pablo De León

PADE web site: http://www.aate.org/g761.htm

G-775

Microgravity Smoldering Combustion (MSC)
NASA Glenn Research Center

Smoldering combustion is a serious problem: 40 percent of all fire deaths in the U.S. can be attributed to the smoldering of household furniture, which releases toxic byproducts. Smolder is potentially an even greater problem in space. By increasing our fundamental understanding of smoldering combustion, the MSC experiment will improve our ability to predict and prevent smolder-originated fires on Earth and in space.

The experiment consists, essentially, of heat, fuel, and air. The hardware includes a cylindrical sample holder, whose major parts are a flow inlet for the introduction of air; an igniter to start the smoldering process; thermocouples to measure temperature and determine speed; and polyurethane foam which functions as the fuel. The sample holder is placed inside a sealed combustion chamber, which in turn is placed in the MSC flight assembly (which holds two combustion chambers). This assembly, which is placed inside the Get Away Special canister in the cargo bay of the space shuttle, includes an ultrasonic imaging system similar to those found in medical clinics and hospitals. This imaging system can "see" into the foam to measure the extent of smolder.

An earlier version of the MSC experiment flew on USML-1 in 1992. The present version was flown aboard STS-69 (1995), STS-77 (1996) and STS-105 (2001).

Principal Investigator: Prof. A. Carlos Fernandez-Pello, University of California-Berkeley

Project Scientist: Dr. David Urban, NASA Glenn Research Center, Cleveland, Ohio

Project Manager: Frank Vergilli, NASA Glenn Research Center

Web site: http://microgravity.grc.nasa.gov/combustion/index.htm#top.

G-221

Utah State University

Three high schools from Utah and Idaho designed and built experiments. Utah State University sponsored the GAS container and provided assistance to the students. G-221 also contains popcorn that will be used in science outreach programs by the university with local elementary school students.

Nucleic Boiling

We all know that when water boils, the bubbles go up. In space, because of the lack gravity, there is no up. So, where do the bubbles go? That is the question this experiment is trying to answer. The experiment boils water inside a chamber and videotapes the action of the bubbles. Small thermometers placed in different locations in the chamber record the temperature. The collected data will allow students at Box Elder High School, Brigham City, Utah, to see how the bubbles move in the chamber while it is being heated.

Chemical Unit Process

On a long journey in space, all you have is what you brought with you. That includes water. For the water to continue to be useful, a method of purifying the water needs to be developed for space applications. This experiment takes a solution of urea (a major component of urine) and purifies it through a process developed by students at Shoshone Bannock Jr./Sr. High School, Ft. Hall, Idaho, with the help of engineers at INEEL. Once the experiment returns, the students will analyze the water to identify any contamination.

Crystal Growth

Some crystals form differently in the microgravity of space than they do on Earth. This experiment is going to grow crystals from chemicals commonly found in the human body. During long-duration space flight it will be important to know how these crystals form differently in space. The results will be examined by students from Moscow High School, Moscow, Idaho.

Popcorn and Seeds

Elementary school students will be given a package of earthbound microwave popcorn and a package that flies on G-221. The students will determine which bag went to space. The students will characterize the two samples after popping. Each group will decide what properties of the popcorn to measure.

Principal Investigator: Jan Sojka

Web site: http://gas.physics.usu.edu

G-730

Weak Convection Influencing Radial Segregation

Swedish Space Corp.

The electrical properties of a semiconductor are strongly influenced by the addition of small amounts of a so-called dopant and its spatial distribution within the semiconductor crystal. In this experiment the influence of weak convection, caused by surface tension forces on radial dopant segregation, is studied under microgravity conditions in seven mirror furnaces. The method used is the floating zone technique, and antimony has been chosen as sample material.

Varying the geometry of the free surfaces among the seven flight samples offers the possibility to obtain different levels of the thermocapillary convection. The experiment sequence and furnace processing is controlled by a PC104 computer system with a CPU and a data acquisition board.

The payload is powered from two 44-volt batteries of sealed lead-acid cells with a nominal capacity of 1060 watts. During the experiment phase measured experiment data, house-keeping data and data from accelerometers are stored in a non-volatile memory.

Principal Investigator: Professor Dr. Torbjorn Carlberg, Mid Sweden University

Experiment system design and manufacturing: Swedish Space Corporation's Space Systems Division under contract from the European Space Agency (ESA) and the Swedish National Space Board (SNSB).

Project Manager: Per Holm, Swedish Space Corp. e-mail: per.holm@ssc.se , For more information on the Swedish Space Corporation see **http://www.ssc.se**.

For more information on ESA, see **http://www.esa.int**.

For more information on SNSB, see **http://www.snsb.se**.

For more information on Mid Sweden University, see **http://www.mh.se**

G-064

Penn State University

This GAS project provides an opportunity for about 50 Penn State University students to experience "hands-on" design and fabrication of hardware and to learn teamwork and project management. Three experiments have been prepared to investigate plant growth in space, the magnetic field environment in the shuttle, and the acoustic signature for collisions on the shuttle by space debris. Support for this project also is provided by Lockheed Martin Corp.

1. "PSU Germinator I" is a low-cost and reusable experimental plant growth chamber for seed germination and early seedling development. The experiment is designed to answer questions related to sustained plant life in space and provide an affordable space-rated test chamber for microgravity and life science researchers.
2. The "Magnetometer" will record a three-dimensional model of magnetic moment of the space shuttle and measure distortions of the uniform background signal from currents that produce a part of the Earth's magnetic field. The experiment will be activated at 50,000 feet during ascent of the shuttle and collect data for five hours.
3. The "Orbital Debris Experiment" will measure the acoustical signature from hits on the shuttle by micro-meteors or space junk to test a concept for a future space station monitoring sensor. The experiment will operate for seven days.

G-785

NASA Ames Research Center

This experiment is designed to determine zero-g performance of a miniature two-stage pulse tube cryocooler, a small refrigerator that uses oscillating gaseous helium to achieve a very cold temperature (-315° F, or -193° C) without using cold moving parts. A secondary objective is to measure the thermal conductance of the cryocooler stages (the cold head) over a wide temperature range in zero-g. A third objective is to demonstrate the launch survivability and performance of a cryocooler that uses mostly commercial components. On STS-90, the last two objectives were largely achieved and have been reported. However, the primary objective was not fully achieved due to low voltage on some of the batteries that supply power to the small compressor that produces the oscillating helium in the cold head. The re-flight payload incorporates a significantly improved battery system.

Miniature cryocoolers are required to cool infrared (IR) sensors in space-based instruments such as imagers and spectrometers. Remote IR sensing is used to measure the temperature and chemical composition of the earth's surface and atmosphere.

G-785 was developed as a collaboration among Lockheed Martin Corporation (LMC), Denver, Colo.; the National Institute of Standards and Technology (NIST), Boulder, Colo.; and NASA Ames Research Center (ARC), Moffett Field, Calif.

Primary and co-investigators: Dr. Peter Kittel (ARC)

Dr. Daniel Ladner (LMC)

Dr. Ray Radebaugh (NIST)

Space Experiment Module (SEM) (3)

The Space Experiment Module is a self-contained assembly of structure, power, command and data storage capabilities for microgravity experiments. SEM is open to students in grades K-12 and university level. Selected student experiments are flown in NASA-provided modules. The SEM carrier accommodates 10 modules in a standard Get Away Special canister.

For more information see: http://www.wff.nasa.gov/sem

SEM-11

This module has both active (power required) and passive (no power required) experiments from the United States, Argentina, Portugal and Morocco. It also includes winning entries from the 2000 and 2001 NASA Student Involvement Program.

RESUME (Restrain Release Using Melting-Wire Experiment) (Active)
Universidad Tecnológica Nacional, Argentina

The goal of RESUME is to perform design, analysis test and flight qualification of a multipurpose original restrain-release mechanism for fastening deployable systems in spacecraft. The mechanism is based on a melting wire triggered system. It is being flown through an agreement between NASA and the Argentine National Space Agency.

ARIA-3 (Passive)
Washington University, St. Louis, Mo.

The Aria-3 project is a joint Australian/U.S. K-12 education project that will carry 22 experiments focusing on the effects of space on Australian flora/fauna. Schools in Australia will select local flora/fauna that meet the long-duration storage requirement of the SEM program, prepare two samples, keep one on the ground, and fly the second one in space. Once the flight experiments are returned to earth, students will compare the flight and earth samples to detect differences. The Aria-3 involves schools in Australia teamed with schools in the United States. The Australian schools work via email with a “sister” school in Missouri.

Effect of Weightlessness on the Developmental Cycle in Gypsy Moth (Passive)
Mohamed V University, Morocco

This experiment will include several batches of gypsy moth eggs, in a state of diapause, to study the effects of weightlessness on development. Upon their return to Earth, development will be compared to that of control eggs maintained in the laboratory as measured by the degree of absorption of the extra-embryonic yolk, time to hatching, and survival rate. Histological organ data will also be compared.

PULS★R – Portugal – Unified Learning through Space & Research (Passive)
Ciência Viva - National Agency for Scientific and Technological Culture, Portugal

The experiments include testing for possible modifications in the seeds of plants, including some Portuguese endemic species and Mediterranean species.

Collaborative International SEM (Passive)
GADGET - Glenbrook North High School, Northbrook, Ill.

This experiment is part of a collaborative international SEM project. Students from the U.S., Portugal, Morocco and possibly other countries will be involved. The experiments will investigate the effects of the space environment on different types of seeds. Others will test plant products of Portugal and the U.S.

CRISTANAR (Active)
Argentina

This experiment studies microgravity’s effect on the growth and electro-optical properties of KDP crystals (potassium dihydrogen phosphate, KH_2PO_4) and compares them with crystals grown on Earth. Crystal growth uses the super saturation method with a slow temperature decrease. After the flight, the crystals remain in thermal equilibrium with the KDP aqueous solution that acts as a means of preservation.

Three-Dimensional Resonance Modes in Microgravity (Active)
GADGET - NSIP 2000 - Glenbrook North High School, Northbrook, Ill.

This experiment will study how Faraday resonance will affect a wax-like substance suspended in a sodium silicate solution in microgravity. It uses a tone-generated sound system with a speaker attached directly to the acrylic box containing the wax and sodium silicate, applying a sequence of tones. The results will be videotaped for further analysis in both constant and strobe lighting. Information gained from this experiment may some day help in understanding the resonance modes of structures made for microgravity.

Electro-Deposition of CUSO4 (Active)
NSIP 2000 - The Northwest School, Seattle, Wash.

The experiment uses electrodeposition to determine the effects of microgravity and cosmic radiation on the flow of electrons. The experiment will analyze the fractal patterns formed by the deposition of copper when an electric current is passed through a solution of cupric sulfate. Results will help determine how electrical currents flow in the space environment.

SISTEM (Passive)
Kingswood Regional Middle School, Wolfeboro, N.H.

This experiment examines whether the space environment will affect subsequent generations of various seeds flown in space. This experiment may include thousands of participants by the end of the fifth year.

Artemia Space Launch Experiment (Active)
NSIP 2001 - DuVal High School, Lanham, Md.

The purpose of the experiment is to see how microgravity affects the rate of hatching, growth, size and mobility of brine shrimp. Students from the two ISA classes have constructed a device to inject dehydrated brine shrimp eggs into a culture solution at a predetermined time during the mission. A micro video camera will film the eggs in the solution about every three hours.

SEM-12

SEM-12 will be mounted on the LMC. SEM-12 will carry only passive experiments.

Space FIZ-ics
Athol-Royalston Middle School, Athol, Mass., and Schaumburg High School, Schaumburg, Ill.

This experiment studies effects of microgravity, radiation, and temperature fluctuation on the production of carbon dioxide and the growth rate of yeast cells in a closed fermentation chamber. A secondary experiment is to test the ability of a launch-activated passive mechanical device to initiate the experiment.

Blast-Off
Anne Arundel County Schools, Anne Arundel County, Md.

This experiment is an extension of the fourth-grade curriculum Space and Space Technology. The value of the experiment is to see how the space environment will affect materials, and if they would be useful on the space station. The effect of space travel on dental gum will be investigated to determine the feasibility of using it to replace brushing teeth in space. The second experiment will determine the effect of the space environment on *tardigrades*, and how they will behave when reconstituted after spaceflight.

A Study on the Role of Adhesives in Entombed Hybrid Patches
Old Dominion University, Norfolk, Va.

An advanced repair concept with possible future applications for damaged space structures is the subject of this experiment. The repair patch uses weld bonding which is an advanced hybrid technology that has the advantages of laser welding and adhesive bonding combined. Also, third grade students at Hilton Elementary School in Newport News, Va., and Ghent Elementary School in Norfolk, Va., will send corn seeds into space to determine if the space journey affects their growth cycle.

The Effect of the Space Environment on Shape Memory Alloy
The Harker School, San Jose, Calif.

Nitinol is a material that exhibits shape memory properties. In one-g conditions, Nitinol devices that are deformed revert to their original shape when heated. This investigation looks at whether Nitinol devices deformed in microgravity can revert to their original shape when heated after return to Earth.

Medium Movement
Mechanicsburg School District, Mechanicsburg, Pa.

This experiment looks at movement of half-inch-diameter wooden spheres in closed containers of various media (balsa wood, cork, caulking material, play-dough, potting soil, pink fiberglass insulation, talcum powder, or Styrofoam insulation) during space flight. Results will be compared with a control experiment on the ground.

The Florida-Mars Connection
Palm Beach County Middle Schools, Boyton Beach, Fla.

The experiment looks for food plants that can grow in Martian soil. Students will plant seeds of a variety of plants, including soybeans, in simulated Martian soil in hydroponics grow pots. The same day they will prepare vials with simulated Martian soil and soybean seeds for flight, to see if they will grow when exposed to radiation, temperature extremes and microgravity.

Sprouting Seeds
Creekside Intermediate School, League City, Texas

The experiment team will investigate the effect of the space environment on sprouting seeds. A passive watering system, to be activated by the launch environment, will also be tested.

Neurospora Cresse on Bread in Space
Cranston High School, Cranston, R.I.

The experiment looks at how the space environment affects Neurospora cresse on different types of bread. This study could help determine how the space environment affects organisms harmful to food.

SEM Endeavour Program
Pennsylvania Middle Schools, Archbald, Pa.

Experiment participants are from Pennsylvania middle schools that have participated in the NASA Endeavour program for the past two years. Adhesives, plant seeds, tree seeds, spores, and bacterial samples will be tested to find the effects from spaceflight.

Space Soy, Generation GappED
New Oxford Elementary School, Brethren Home Retirement Community, Hanover, Pa.

Students will use the greenhouse at the retirement community and will work with the senior citizens on all aspects of the project. The investigation will determine how soy will grow after the seeds have been subjected to the space environment on a shuttle flight.

SEM-15

SEM-15 will be part of the MACH-1 Hitchhiker Bridge and contain only passive experiments.

Invertabraes in Microgravity
NORSTAR, Norfolk, Va.

The experiment will test the effects of microgravity on Edith's Checkerspot Butterflies. Butterfly eggs will be sent in a state of diapause, so there are no time limitations. After the shuttle flight the butterflies will be observed to see if they can still pollinate flowers, reproduce, and perform everyday functions. The Edith's Checkerspot Butterflies were chosen because they live in high mountain ranges, as well as coastal regions, and are known to be able to withstand both extreme cold and heat. As a secondary project, retesting a previous experiment, artemia eggs in diapause also will be flown.

MEDLAB
Guardian Lutheran School, Dearborn Heights, Mich.

The experiment studies the effects on animal tissue in space. By studying animal tissues, the students will hopefully gain insight as to the effects of space travel on mankind, as well as his traditional food sources.

Magnetic Stars
Henry E. Harris School, Bayonne, N.J.

This experiment investigates how magnets react during space travel. Students will construct structures using magnetic star/moon shapes. One structure will be packed for launch and the other five will have one variable added to each (suspended upside-down, submerged in water, placed into a freezer, placed sideways, etc.). When the structure returns from space, all six will be compared and measured to detect any movement in the structure.

Magnets and the Magnetosphere
Woodland Middle School, East Meadow, N.Y.

The purpose of the experiment is to study how the shuttle's passage through the Earth's magnetic field lines affects magnetic items. Magnets, security strips, nails, lodestone, and magnetic marbles are the primary objects under investigation. The experiment is a follow-up investigation on a previous SEM project.

Folger McKinsey Space Owls
Folger McKinsey Elementary, Severna Park, Md.

Students will study effects of the space environment on a variety of materials. Several student teams will share the available volume of the module. Flight materials will include balloons, electronic components, magnets, detergents, oils, sponges, rubber bands, and various fluids for pH testing. Students will determine how radiation, temperature, and microgravity of the space environment affect these materials.

Aria-4: Space, Man and Biology
Washington University, St. Louis, Mo.

The Aria-4 project is a St. Louis education project involving the effects of space on biology. The project involves students from the Central Institute for the Deaf and the Good Hope School in partnership with Washington University's School of Engineering and Applied Science. The project will have 22 experiments and controls. It compares effects of the space environment on biological samples such as vegetable seeds, flower seeds, yeast, brine shrimp, pond water samples, and human hair samples with the controls.

Soothing, Minty, and Fresh on ISS
Broadneck Elementary, Arnold, Md.

This experiment is an extension of the fourth-grade curriculum Space and Space Technology. It looks at how everyday materials are affected by the space environment, and if they would be useful on the International Space Station. Experiment materials will include dental gum, elastic, cough drops, and air freshener material.

The Effects of Environmental Conditions on Soil and Water
Northeastern Pennsylvania GLOBE Project

The experiment will test the effects of microgravity, radiation, and magnetism on samples of soil and water from throughout northeastern Pennsylvania. Characteristics tested will include pH, electric conductivity, nitrates, and NPK. These characteristics will then be compared to those materials that flew aboard the space shuttle. Consideration will be given as to how these effects would enhance the growth of seeds that were nurtured using this soil and water.

From Anthracite to Space Flight
Forest City Regional, Hazleton Area, Riverside, Scranton School Districts and Northeastern Educational Intermediate Unit 19, Northeastern Pennsylvania

The experiment lets students measure effects of microgravity, radiation, extreme temperature changes, and intense vibration on physical and chemical properties of various materials related to anthracite.

Countdown to Wildflowers
TODTWD 2001, Eastern Shore, Va.

The purpose of this experiment is to determine the effects of microgravity and space travel on wildflower seeds. Students also are keeping a control group on Earth. After the space shuttle returns, both sets of seeds will then be planted to compare their germination rates and their plants, flowers and seeds. Partner Fulton Elementary School of Howard County, Md., will share the module, flying vegetable seeds, flower seeds, brine shrimp, and a yeast sample.

Experiments

DSOs and DTOs

Detailed Supplementary Objectives (DSOs) are space and life sciences 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 and/or space station relative to crew health.

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

Such experiments aboard Endeavour are:

DSO 490

Bioavailability and Performance Effects of Promethazine During Space Flight

Promethazine (PMZ) is the anti-motion sickness medication of choice for treating space motion sickness (SMS) during shuttle missions. Usual side effects include dizziness, drowsiness, sedation and impaired psychomotor performance, which could impact crew performance of mission operations. Early reports from crewmembers indicate that these central nervous system side effects of PMZ are absent or greatly reduced in microgravity. DSO 490 will evaluate PMZ's performance, side effects, and efficacy in microgravity. Tests on Endeavour will test responses to various doses and effectiveness of administering it using intramuscular, oral and suppository methods of administration. Results will then be compared with preflight evaluations. This is the first flight of DSO 490.

DSO 498

Space Flight and Immune Function

Astronauts face an increasing risk of contracting infectious diseases as they work and live for longer periods in the crowded conditions and closed environments of spacecraft such as the International Space Station. The effect of spaceflight on the human immune system, which plays a pivotal role in warding off infections, is not fully understood. Understanding the changes in immune functions caused by microgravity will enable researchers to develop countermeasures to minimize infection risk. DSO 498 will look at effects of space flight on neutrophils, monocytes and cytotoxic cells, which play an important role in maintaining an effective defense against infectious agents. Scientists believe space changes the way these cells function. Researchers will analyze neutrophils and monocytes from astronaut blood samples taken before and after the flight. They will also assess the subjects' pre- and postflight production of cytotoxic cells and cytokine. This study will complement previous and continuing immunology studies of astronauts' adaptation to space.

DSO 500

Space Flight-Induced Reactivation of Latent Epstein-Barr Virus

The effects of microgravity, along with associated physical and psychological stress, decrease Epstein-Barr virus (EBV)-specific T-cell immunity and reactivate latent EBV in infected B-lymphocytes. DSO 500 will examine the mechanisms of spaceflight-induced alterations in human immune function and latent virus reactivation. Specifically, it will determine the magnitude of immunosuppression as a result of spaceflight by analyzing stress hormones, performing quantitative analysis of EBV replication using molecular and serological methods, and determining virus-specific T-cell immune function. This is the first flight of DSO 500.

DSO 503S

Test of Midodrine as a Countermeasure Against Postflight Orthostatic Hypotension

After spaceflight, astronauts returning to upright posture may experience the inability to maintain adequate arterial pressure and cerebral perfusion (orthostatic or postural hypotension). This may result in lightheadedness or loss of consciousness during re-entry or egress. DSO 503S will evaluate the efficacy of midodrine, a medicine commonly used to treat low blood pressure. It works by stimulating nerve endings in blood vessels, causing the blood vessels to tighten, which increases blood pressure. The experiment will assess midodrine's effectiveness in reducing the incidence and/or severity of orthostatic hypotension in returning astronauts. This is the first flight of DSO 503S.

DSO 632

Pharmacokinetics and Contributing Physiologic Changes During Space Flight

The physical, environmental and physiologic conditions of spaceflight alter gastrointestinal (GI) function and physiology. These changes affect the pharmacokinetics of oral medications. Previous tests indicated absorption and bioavailability of oral liquid dosages may be better and more reliable than that of an equivalent solid dosage form. DSO 632 will determine changes in the GI function and physiology in microgravity and continue to examine the pharmacokinetics of orally administered acetaminophen. This is the first flight of DSO 632.

DTO 262

On-Orbit Bicycle Ergometer Loads Measurement

This DTO studies the possibility of reducing engineering conservatism by measuring the joined shuttle/space station natural frequencies, using the bicycle ergometer as the natural frequency excitation source. Reduction of conservatism would allow more operational flexibility by reducing preflight load predictions and, thus, operational constraints. This is the second of seven planned flights of DTO 262.

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 is the 20^{th} flight of DTO 700-14.

DTO-700-22

Crew Return Vehicle (CRV) Space Integrated

Global Positioning System/Inertial Navigation System (SIGI)

The CRV SIGI is intended to be the primary navigation source for the space station CRV. DTO 700-22 will measure Global Positioning System (GPS) only and GPS/Inertial Navigation System (INS) blended position, velocity, time, and attitude performance during on orbit and re-entry, and will measure the time to first GPS fix (position, velocity, time) during on-orbit operations after warm or cold starts of the SIGI. This is the second flight of DTO 700-22.

DTO 805

Crosswind Landing Performance

DTO 805 is to demonstrate the capability to perform a manually controlled landing in a crosswind. The testing is done in two steps. 1) Prelaunch: Ensure planning will allow selection of a runway with Microwave Scanning Beam Landing System support, which is a set of dual transmitters located beside the runway providing precision navigation vertically, horizontally and longitudinally with respect to the runway. This precision navigation subsystem helps provide a higher probability of a more precise landing with a crosswind of 10 to 15 knots as late in the flight as possible. 2) Entry: This test requires that the crew perform a manually controlled landing in a 90-degree crosswind component of 10 to 15 knots steady state. During a crosswind landing, the drag chute will be deployed after nose gear touchdown when the vehicle is stable and tracking the runway centerline. This DTO has been on 67 flights.

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.

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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.

Updated: 05/22/2001

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

Updated: 05/22/2001

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.

Updated: 05/22/2001

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.

Updated: 05/22/2001

ACRONYMS AND ABBREVIATIONS

A/L	Airlock
AA	Antenna Assembly
ACBM	Active Common Berthing Mechanism
ACH	Assembly Console Handbook
ACS	Attitude Control System
ACSM	Attitude Control System Moding
ACU	Arm Computer Unit
AEA	Antenna Electronics Assembly
AFD	Aft Flight Deck
AOH	Assembly Operations Handbook
APAS	Androgynous Peripheral Attachment System
APCU	Assembly Power Converter Unit
APDS	Androgynous Peripheral Docking System
APFR	Articulating Portable Foot Restraint
APPCM	Arm Pitch Plane Change Mode
APS	Automated Payload Switch
ASCR	Assured Safe Crew Return
ATA	Ammonia Tank Assembly
ATCS	Active Thermal Control System
ATU	Audio Thermal Unit
AVU	Artificial Vision Unit
BC	Bus Controller
BCDU	Battery Charge/Discharge Unit
BCU	Bus Controller Unit
BDU	Backup Drive Unit
BGA	Beta Gimbal Assembly
BIT	Built-In Test
BITE	Built-In Test Equipment
BMRRM	Bearing Motor Roll Ring Module
C&C	Command and Control
C&DH	Command and Data Handling
C&M	Control and Monitor
C&W	Caution and Warning
C/A-code	Coarse/Acquisition-code
C/L	Crew Lock
CA	Control Attitude
CAM	Centrifuge Accommodations Module
CAS	Common Attach Assembly
CBC	Common Booster Core
CBM	Common Berthing Mechanism
CCAA	Common Cabin Air Assembly
CCD	Cursor Control Device

CCTV	Closed-Circuit Television
CDS	Command and Data Software
CETA	Crew and Equipment Translation Aid
CEU	Control Electronics Unit
CheCS	Crew Health Care System
CID	Circuit Interrupt Device
CIOB	Cargo Integration and Operations Branch
CIR	Cargo Integration Review
CMB	Common Berthing Mechanism
CMG	Control Moment Gyro
COTS	Commercial-Off-the-Shelf
CO_2	Carbon Dioxide (di-molecular)
CRV	Crew Return Vehicle
CSA	Computer Systems Architecture
CSC	Computer Software Component
CVT	Current Value Table
DC	Direct Current
	Docking Compartment
DCP	Display and Control Panel
DCSU	Direct Current Switching Unit
DDCU	DC-to-DC Converter Unit
DMCU	Docking Mechanism Control Unit
DMS-R	Data Management System-Russian
DOF	Degrees of Freedom
DPA	Digital Pre-Assembly
DPS	Data Processing System
DSM	Docking and Stowage Module
E/D	Electrodynamics
E/L	Equipment Lock
EACP	Extravehicular Audio Control Panel
EAIU	EMU Audio Interface Unit
EAS	Early Ammonia Servicer
EATCS	External Active Thermal Control System
ECLSS	Environmental Control and Life Support System
ECU	Electronics Control Unit
EDDA	EMU Don/Doff Assembly
EEATCS	Early External Active Thermal Control System
EETCS	Early External Thermal Control System
EF	Exposed Facility
EFGF	Electrical Flight Grapple Fixture
ELM	Experimental Logistics Module
EMU	External Maneuvering Unit
EPS	Electrical Power System
ERA	Electrical Replaceable Assembly
ES	Escape System

ESP	External Stowage Platform
ESSMDM	Enhanced Space Station Multiplexer/Demultiplexer
E-stop	Emergency Stop
ETCS	External Thermal Control System
ETI	Elapsed Time Indicator
ETSD	EVA Tool Storage Device
EV	Extravehicular
EVA	Extravehicular Activity
EVCPDS	Extravehicular Charged Particle Detection System
EVR	Extravehicular Robotics
EVSWS	Extravehicular Support Work Station
EXPRESS	Expediting the Process of Experiments to the Space Station
EXT	Experimental Terminal
FCC	Flat Collector Circuit
FCV	Flow Control Valve
FD	Flight Day
FDIR	Failure, Detection, Isolation, and Recovery
FGB	Functional Cargo Block
FPU	Fluid Pumping Unit
FRGF	Flight Releasable Grapple Fixture
FSEGF	Flight Support Equipment Grapple Fixture
GFE	Government Furnished Equipment
GLONASS	Russian Global Navigation Satellite System
GNC	Guidance, Navigation, and Control
GPC	General Purpose Computer
GPS	Global Positioning System
GUI	Graphical User Interface
HC	Hand Controller
HP	Heat Pipe
I/O	Input/Output
IAS	Internal Audio System
ICC	Integrated Cargo Carrier
ICS	Intersatellite Communication System
IDA	Integrated Diode Assembly
IEA	Integrated Equipment Apparatus
IFHX	Interface Heat Exchanger
IFM	In-Flight Maintenance
IMCA	Integrated Motor Controller Assembly
IMCS	Integrated Mission Control System
INCO	Instrumentation and Communications Officer
INS	Inertial Navigation System
IOCU	Input/Output Controller Unit
IP	International Partner
IRU	In-Flight Refill Unit

ISPR	International Standard Payload Rack
ISS	International Space Station
ISSSH	International Space Station Handbook
ITCS	Internal Thermal Control System
ITS	Integrated Truss Segment
IV	Intravehicular
IVA	Intravehicular Activity
IVCPDS	Intravehicular Charged Particle Detection System
JEM	Japanese Experiment Module
JEU	Joint Electronic Unit
KBAR	Knee-Brace Assembly Replacement
km	Kilometer
LA	Lab Assembly
Lab	US Laboratory Module
LAN	Local Area Network
LB	Local Bus
LCA	Lab Cradle Assembly
	Loop Crossover Assembly
LCD	Liquid Crystal Display
LDA	Launch Deployment Assembly
LDU	Linear Drive Unit
LED	Light Emitting Diode
LEE	Latching End Effector
LFDP	Load Fault Detect/Protect
LLA	Low-Level Analog
LTL	Low Temperature Loop
LVLH	Local Vertical/Local Horizontal
m	Meter
MA	Mechanical Assembly
MAM	Manual Augmented Mode
MBM	Manual Berthing Mechanism
MBS	Mobile Base System
	Mobile Remote Servicer Base System
MBSU	Main Bus Switching Unit
MCC	Mission Control Center
MCC-H	Mission Control Center-Houston
MCC-M	Mission Control Center-Moscow
MCDS	Multifunction Cathode Ray Tube Display System
MCS	Motion Control System
MDM	Multiplexer/Demultiplexer
MELF	Metal Electrical Face
METOX	Metal Oxide
MFCV	Manual Flow Control Valve

MILA	Moding Indicator Light Assembly
MLI	Multilayer Insulation
Mm	Millimeter
MM/OD	Micrometeoroid/Orbital Debris
MOD	Mission Operations Directorate
MPLM	Multipurpose Logistics Module
MPM/MRL	Manipulator Positioning Mechanism/Manipulator Retention Latch
ms	millisecond
MSD	Mass Storage Device
MSFC	Marshall Space Flight Center
MSS	Mobile Servicing System
MT	Mobile Transporter
MTL	Moderate Temperature Loop
MTS	Mobile Tracking Station
	Module-to-Truss Structure
MTSAS	Module-to-Truss Segment Attach System
N_2	Nitrogen (di-molecular)
NASA	National Aeronautics and Space Administration
NTA	Nitrogen Tank Assembly
O_2	Oxygen (di-molecular)
OCA	Orbital Communications Adapter
OCAD	Operational Control Agreement Document
OCJM	Operator Commanded Joint Position Mode
OCPM	Operator Commanded Point of Reference Mode
OCS	Operations and Control Software
ODS	Orbiter Docking System
OIU	Orbiter Interface Unit
OPP	Orbiter Space Vision System Patch Panel
OPS	Operations
ORU	Orbital Replacement Unit
OSE	Orbital Support Equipment
OSO	Operation Support Officer
OSVS	Orbiter Space Vision System
OSVU	Orbiter Space Vision Unit
OTD	Orbital Replacement Unit Transfer Device
P&S	Pointing and Support
P/L	Payload
PB	Power Bus
PC	Personal Computer
PCMCIA	Personal Computer Memory Card International Adapter
PCN	Page Change Notice
P-Code	Precision Code
PCR	Portable Computer Receptacle
PCS	Portable Computer System

PDGF	Power and Data Grapple Fixture
PDI	Payload Data Interface
PDIP	Payload Data Interface Panel
PDRS	Payload Deployment and Retrieval System
PEHG	Payload Ethernet Hub Gateway
PFCS	Pump and Flow Control Subassembly
PGSC	Payload General Support Computer
PGT	Pistol Grip Tool
PIHPC	Permanent International Human Presence Capability
PJAM	Prestored Joint Position Autosequence Mode
PL	Payload
PLB	Payload Bay
PMA	Pressurized Mating Adapter
PMCU	Power Management Controller Unit
POR	Point of Reference
	Point of Resolution
POST	Power On Self-Test
PPA	Pump Package Assembly
PPAM	Pre-Stored Point of Reference Autosequence Mode
PRLA	Payload Retention Latch Assembly
PS	Power Supply
PSP	Payload Signal Processor
PSRP	Payload Safety Review Panel
PTCS	Passive Thermal Control System
PTU	Pan/Tilt Unit
PV	Photovoltaic
PVCU	Photovoltaic Control Unit
PVM	Photovoltaic Module
PVRGF	Photovoltaic Radiator Grapple Fixture
PWP	Portable Work Platform
R&R	Remove and Replace
R/P	Receiver/Processor
RAM	Random Access Memory
RBI	Remote Bus Isolation
RF	Radio Frequency
RFCA	Rack Flow Control Assembly
RGA	Rate Gyro Assembly
RHC	Rotational Hand Controller
RHX	Regenerative Heat Exchanger
RJAM	Prestored Joint Position Autosequence Mode
RM	Research Module
RMS	Remote Manipulator System
ROS	Russian On-Orbit Segment
RPC	Remote Power Controller
RPCM	Remote Power Control Module
RPDA	Remote Power Distribution Assembly

RS	Russian Segment
RSP	Resupply Stowage Platform
RSR	Resupply Stowage Rack
RT	Remote Terminal
RU	Rigid Umbilical
RWS	Robotic Workstation
S0	Starboard Zero
SA	Solar Array
SAW	Solar Array Wing
SCA	Switchgear Controller Assembly
SCU	Service and Cooling Umbilical
	Signal Conditioning Unit
SDMS	Structural Dynamics Measurement System
SFA	Sunfinder Assembly
SFCA	System Flow Control Assembly
SHOSS	SpaceHab Oceaneering Space System
SIGI	Space Integrated Global Positioning System/Inertial Navigation System
SJRM	Single Joint Rate Mode
SLP	Spacelab Pallet
SM	Service Module
SMCC	Shuttle Mission Control Center
SMTC	Service Module Terminal Computer
SOC	State of Charge
SPCE	Servicing Performance and Checkout Equipment
SPD	Serial Parallel Digital
SPDA	Secondary Power Distribution Assembly
SPDC	Secondary Power Distribution Control
SPDM	Special Purpose Dexterous Manipulator
SPP	Science Power Platform
SRMS	Shuttle Remote Manipulator System
SSAS	Segment-to-Segment Attachment System
SSC	Station Support Computer
	Subsystem Computer
SSMDM	Space Station Multiplexer/Demultiplexer
SSOR	Space-to-Space Orbiter Radio
SSP	Space Shuttle Program
	Standard Switch Panel
SSRMS	Space Station Remote Manipulator System
SSSR	Space-to-Space Station Radio
SSU	Sequential Shunt Unit
SVS	Synthetic Vision System
TA	Thruster Assist
TC	Terminal Computer
TCS	Thermal Control System
TDRS	Tracking and Data Relay Satellite

TDRSS	Tracking and Data Relay Satellite System
TEPC	Tissue Equivalent Proportional Counter
THC	Translational Hand Controller
TORU	Teleoperator Control Mode
TRRJ	Thermal Radiator Rotary Joint
TSA	Tool Storage Assembly
TUS	Trailing Umbilical System
TV	Television
TVIS	Treadmill Vibration Isolation and Stabilization
UB	User Bus
UDG	User Data Generation
UDM	Universal Docking Module
UF	Utilization Flight
UHF	Ultra High Frequency
UIA	Umbilical Interface Assembly
UIP	Utility Interface Panel
ULC	Unpressurized Logistic Carrier
ULCAS	Unpressurized Logistic Carrier Attach System
UMA	Umbilical Mechanism Assembly
UOP	Utility Outlet Panel
URL	Uniform Resource Locator
USA	United Space Alliance
USOS	United States On-Orbit Segment
USS	United States Segment
VDS	Video Distribution System
VDU	Video Distribution Unit
VGS	Video Graphics Software
VRCS	Vernier Reaction Control System
VSW	Video Switches
VTR	Video Tape Recorder
WHS	Workstation Host Software
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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