DESTINY AND SCIENCE COME TO LIFE ON ISS

STS-98

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Scientific Cornerstone Set for Delivery to ISS

The U.S. Laboratory "Destiny" - centerpiece of scientific research aboard the International Space Station – is poised for launch aboard Space Shuttle Atlantis no earlier than 6:11 p.m. EST on Feb. 7, 2001. It is the first of six planned research modules of the station, and also will serve as the command and control center for the entire complex.

Partially outfitted with five systems racks containing equipment to provide electrical power and cooling for future racks, and computers for control of the entire ISS, Destiny's delivery and activation heralds the transfer of ISS operations from the Russian Mission Control Center outside Moscow to NASA's Mission Control in Houston. Destiny is the second U.S. module to be launched to the ISS and will be mated to the Unity module, which was launched in December 1998.

The 28-foot-long, 14-foot-diameter laboratory weighs 31,000 pounds and cost approximately $1.4 billion. It is the most sophisticated and versatile space laboratory ever built and eventually will house an additional 18 racks for crew support and scientific research that can be removed and replaced periodically as experiment operations warrant. This versatility will allow researchers from around the world to conduct experiments in the unique microgravity environment of space as never before. New racks will arrive with the next shuttle mission in March that also will deliver the second group of station residents – the Expedition Two crew – and bring home the current occupants, Expedition One Commander Bill Shepherd, Pilot Yuri Gidzenko and Flight Engineer Sergei Krikalev.

Veteran astronaut Ken Cockrell, making his fourth space flight, will command the STS-98 mission of Atlantis. Rookie Pilot Mark Polansky joins Cockrell on the forward flight deck. Seated behind them on the flight deck for launch and landing is Mission Specialist Marsha Ivins, who will serve as the flight engineer, and help activate Destiny after she uses the shuttle's robot arm to attach the lab to the station. She is the most experienced space traveler on the crew with four previous flights, including one to the Mir space station in 1997.

Atlantis will serve as the platform for three space walks to complete outside assembly and connection of electrical and plumbing lines between the laboratory, station and a relocated shuttle docking port. Mission Specialists Tom Jones and Bob Curbeam will conduct the space walks. While outside, Jones' suit will have red striping around the pant legs and Curbeam's will be all white. The third and final space walk will be the 60th in the shuttle program dating back to 1983 and the 100th in U.S. spaceflight history dating back to 1965.

Jones is making his fourth flight, while Curbeam is embarking on his second mission. For launch, Curbeam will sit behind Polansky on the flight deck swapping places with Jones on the middeck for entry and landing.

The day after launch, the shuttle crew will check out the robotic arm's operation in preparation for the work it will do to install the laboratory and serve as a high-tech cherry picker to move the two astronauts around the outside of the station and shuttle during the space walks. The primary arm operator will be Ivins with Cockrell serving as her backup. Polansky will be the intravehicular crewmember, or choreographer for the three space walks.

Atlantis will dock to the station about 43 hours after launch no earlier than the evening of Feb. 9th. Later that day, the cabin pressure will be lowered in preparation for the space walks, which will begin the next day. Within two hours of docking, hatches will swing open between Atlantis and the ISS enabling the shuttle and station crews to greet one another. It will be the second visit of a shuttle crew with the Expedition One crew, which has been aboard the station since Nov. 2. The hatches will be closed and reopened periodically throughout docked operations to accommodate the space walks and the outfitting of Destiny.

The two crews will spend a week working together transferring supplies to and from the station and activating the newest pressurized module of the ISS. Destiny will bring the station to a mass of about 112 tons with dimensions of 171 feet long, 90 feet high and 240 feet wide. That surpasses Mir in terms of habitable volume.

Destiny will provide many more functions of the station in addition to serving as the platform for experiment operations. It is launched with five system racks already installed. They include two avionics racks, two thermal control system racks and an atmosphere revitalization system rack. Each is capable of being tilted downward to provide access to the area behind.

The two avionics racks house equipment controlling the Communications and Tracking, Environmental Control and Life Support System, Thermal Control System, Command and Data Handling, and the Electrical Power System. These racks manage the audio equipment, video switching, and the computer switching boxes, called Multiplexer/Demultiplexers, which provide computer control of lab systems.

There are two thermal control system racks that circulate chilled water to cool other racks and the cabin air. One is a 'low temperature' system, with water chilled to about 4 degrees Celsius. The low temperature system provides cooling to selected racks. The 'moderate temperature' system, with water chilled to about 17 degrees Celsius, cools selected racks and the cabin air.

The atmosphere revitalization (AR) rack provides for carbon dioxide removal, trace contaminant control, and monitoring of the cabin air. On orbit, the AR rack will be moved from its launch location to its operational location during lab outfitting on Flight Day 5.

Additionally, the lab controls the function of the gyroscopes, called Control Moment Gyros (CMGs). These were preintegrated into the Z1 Truss launched on STS-92 in the fall of 2000 and will be activated during STS-98. The four CMGs are electrically powered and will provide attitude control of the station. At least two are required to provide attitude control without the need for supplementary control using the thrusters on Zvezda or Zarya.

Atlantis is scheduled to undock from the station no earlier than Feb. 16 and land no earlier than Feb. 18 back at the Kennedy Space Center, FL. The Expedition One crew will continue the outfitting of Destiny after Atlantis departs.

STS-98 marks the 23rd flight for Atlantis and the 102nd in shuttle program history. It also will be the seventh shuttle visit to the station and 12th dedicated to the assembly and operation of the complex. The other launches included two Russian Protons, two Progress supply vehicles and the Soyuz carrying the Expedition One crew.

A Quick Look at the STS-98 Mission

Flight Day One
Atlantis launches and conducts the first in a series of rendezvous burns to prepare for a docking with the International Space Station.

Flight Day Two
Flight Day Two is a day of preparation as the astronauts check out the shuttle's robotic arm, tools that will be used in support of the next day's rendezvous and docking with the Space Station, and a checkout of the spacesuits that will be used during three scheduled space walks.

Flight Day Three
Atlantis will dock with the International Space Station, and after a series of leak checks, the hatches between the two spacecraft will swing open allowing the STS-98 and Expedition One crews to meet. Cabin pressure on board Atlantis will be lowered in preparation for space walks.

Flight Day Four
Astronauts Tom Jones and Bob Curbeam will conduct the first of three space walks to remove and temporarily stow a shuttle docking port on the Z1 Truss; install Destiny to the station’s Unity module; make umbilical connections between Destiny and the Z1 Truss; and begin laboratory activation.

Flight Day Five
Control Moment Gyros, that will provide attitude control for the station will be spun up and initial testing begun; outfitting of Destiny will continue as will transfer operations and set up of environmental racks and systems.

Flight Day Six
On the second of three space walks, the astronauts will attach a shuttle docking port to the forward end of Destiny; install a Power Data Grapple Fixture and Video Signal Converter on Destiny, for subsequent use by the ISS robotic arm scheduled for delivery in April 2001; and install micrometeoroid debris shielding on Destiny.

Flight Day Seven
The crew will enjoy some scheduled off-duty time as testing of the CMGs continue and the shuttle boosts the station's altitude.

Flight Day Eight
On the third and final scheduled space walk, the astronauts will install a spare S-band antenna assembly; connect umbilicals between the shuttle docking port and Destiny; install window shutters on Destiny; and practice an "incapacitated crew rescue" technique.

Flight Day Nine
The two crews will complete final transfer operations; conduct a crew news conference and educational television event; perform an additional altitude reboost for the station if required; say final farewells and close the hatches between the two space craft.

Flight Day Ten
Atlantis will undock from the station and perform a flyaround before departing from the vicinity of the station. The crew is scheduled for additional off-duty time.

Flight Day Eleven
The astronauts' attention will turn to a return trip home as they check out all of the shuttle systems used for landing and stow away equipment on board.

Flight Day Twelve
The crew will begin formal deorbit preparations, conduct a deorbit burn and return for a landing at the Kennedy Space Center.

Crew Members

Commander: Kenneth D. Cockrell

Ken Cockrell, 50, is the Commander of Atlantis for the first flight of 2001 to install the U.S. Laboratory Destiny to the International Space Station.

As Commander, Cockrell is primarily responsible for overall mission success and safety of the flight, and will be at the controls for Atlantis' docking to the ISS on the third day of the mission.

Cockrell will be the lead for the initial activation of Destiny's systems from a control panel at the aft flight deck of Atlantis after the facility is installed and will back up Marsha Ivins in the operation of Atlantis' robot arm, which will be used to install Destiny, relocate a Station docking port to the aft berthing mechanism on Destiny and transport Atlantis' space walkers to various locations on the ISS during their three excursions outside the shuttle.

Previous Space Flights:
A former Navy test pilot, Cockrell is making his fourth flight into space, having previously served as a Mission Specialist on STS-56 in 1993, as Pilot on STS-69 in 1995 and as Commander on STS-80 in 1996.

Ascent Seating: Flight Deck - Port Forward
Entry Seating: Flight Deck - Port Forward

Pilot: Mark L. Polansky

Mark Polansky, 44, is Atlantis' Pilot for the STS-98 mission to install the U.S. Laboratory Destiny to the International Space Station.

Polansky will be responsible for Atlantis' key propulsion, hydraulic and guidance systems during launch and landing and will assist Commander Ken Cockrell during Atlantis' rendezvous with the ISS. Polansky also will be at Atlantis' controls during the post undocking flyaround of the station. Photographs taken during the flyaround are used to document the current conditions of the station following the addition of the Destiny module.

In addition, Polansky will be the intravehicular crew member, or choreographer, for the three space walks to be conducted by Tom Jones and Bob Curbeam to help install Destiny to the Unity module, hook up critical umbilical lines between the newly arrived laboratory and other Station components and perform other Station assembly tasks.

Previous Space Flights:
Making his first flight during STS-98, Polansky is a former Air Force test pilot who joined NASA in 1992 as an aerospace engineer and research test pilot prior to becoming an astronaut.

Ascent Seating: Flight Deck - Starboard Forward
Entry Seating: Flight Deck - Starboard Forward

Mission Specialist 1: Robert L. Curbeam

Bob Curbeam (Cdr., USN), 38, is making his second flight into space aboard Atlantis to deliver the U.S. Laboratory Destiny to the International Space Station, having first flew on the STS-85 mission in 1997.

Curbeam is Mission Specialist 1 (MS 1) for the STS-98 mission and will be one of two space walkers during the flight. He is designated Extravehicular crewmember 2 (EV 2) for the three space walks he will conduct with Tom Jones and will wear the pure white spacesuit. He and Jones will help to install the laboratory on the Unity module, hook up umbilical lines between Destiny and the Unity module and perform other Station assembly tasks. He will also be responsible for the operation of Atlantis' docking system which will be used to link up to a similar device on the ISS.

Curbeam will be seated on Atlantis' flight deck for launch and down on the middeck for landing.

Previous Space Flights:
STS-98 is Curbeam's second space flight.

Ascent Seating: Flight Deck - Starboard Aft
Entry Seating: Middeck - Port
EV2

Mission Specialist 2: Marsha S. Ivins

Marsha Ivins, 49, is making her fifth flight into space on Atlantis' mission to install the U.S. Laboratory Destiny to the International Space Station.

Ivins will serve as flight engineer during Atlantis' launch and landing, backing up Commander Ken Cockrell and Pilot Mark Polansky on the shuttle's flight deck as Mission Specialist 2 (MS 2).

Ivins will play a key role during the flight, with primary responsibility for the operation of Atlantis' robot arm which will be used to install Destiny to the Unity module, relocate a Station docking port to the aft berthing mechanism on Destiny and transport Atlantis' space walkers to various locations on the ISS during their three excursions outside the Shuttle. Ivins will also join Commander Ken Cockrell for the initial activation of laboratory systems and the rest of her crewmates for the outfitting of the laboratory itself. Ivins will also be the lead for the transfer of cargo from Atlantis to the ISS and the stowage of used items on Atlantis transferred from the Station.

Ivins will also be responsible for much of the photography and television tasks on the mission, in documenting the continuing assembly of the growing orbital outpost.

Previous Space Flights:
Ivins previously flew on the STS-32 mission in 1990, the STS-46 mission in 1992, the STS-62 mission in 1994 and the STS-81 mission to the Russian Mir Space Station in 1997.

Ascent Seating: Flight Deck - Center Aft
Entry Seating: Flight Deck - Center Aft
RMS

Mission Specialist 3: Thomas D. Jones

Tom Jones (Ph.D.), 45, will be making his fourth flight into space on Atlantis' mission to install the U.S. Laboratory Destiny to the International Space Station.

Jones will serve as Mission Specialist 3 (MS 3) and will be down on the middeck for launch and on the flight deck for landing. Jones is designated Extravehicular crewmember 1 (EV 1) for the three space walks he and Bob Curbeam will conduct during Atlantis' mission and wear the spacesuit bearing the red stripes on the elbows and the knees.

Jones and Curbeam will help to install the Destiny laboratory on the Unity module, hook up umbilical lines between Destiny and Unity and perform other Station assembly tasks. Jones will also join his crewmates for the outfitting of the laboratory once they enter Destiny on the fifth day of the mission. Jones is responsible for many of Atlantis' navigation systems during the Shuttle's rendezvous with the ISS and will perform Earth observation photography during the flight, using his expertise from his first two missions on which he served as the Payload Commander for a series of radar systems to study the Earth's topography and environment.

Previous Space Flights:
Jones previously flew on the STS-59 and 68 missions in 1994 and the STS-80 mission in 1996.

Ascent Seating: Middeck - Port
Entry Seating: Flight Deck - Starboard Aft
EV1

Mission Profile

Crew

Commander:	Kenneth D. Cockrell
Pilot:	Mark L. Polansky
Mission Specialist 1:	Robert L. Curbeam
Mission Specialist 2:	Marsha S. Ivins
Mission Specialist 3:	Thomas D. Jones

Launch

Orbiter:	Atlantis OV104
Launch Site:	Kennedy Space Center Launch Pad 39A
Launch Window:	2.5 to 5 Minutes
Altitude:	173 Nautical Miles
Inclination:	51.6 Degrees
Duration:	10 Days 19 Hrs. 28 Min.

Vehicle Data

Shuttle Liftoff Weight:	4,520,235 lbs.
Orbiter/Payload Liftoff Weight:	254,694 lbs.
Orbiter/Payload Landing Weight:	198,909 lbs.

Software Version: OI-28

Space Shuttle Main Engines: *(1 MB pdf)*

SSME 1: 2052 **SSME 2:** 2044 **SSME 3:** 2047

External Tank: ET-106A (Super Light Weight Tank)

SRB Set: BI-105PF

Shuttle Aborts

Abort Landing Sites

RTLS: Kennedy Space Center Shuttle Landing Facility
TAL: Zaragoza
AOA: Edwards Air Force Base, California

Shuttle Abort History

Landing

Landing Date:	02/18/01
Landing Time:	12:56 PM (eastern time)
Primary Landing Site:	Kennedy Space Center Shuttle Landing Facility

Mission Objectives

Atlantis OV104

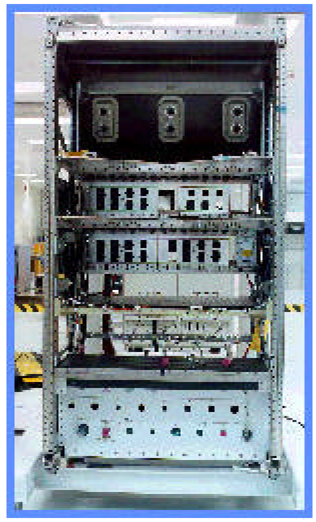
Launch: Wednesday, Feb. 7, 2001
6:11 PM (eastern time)

Overview

The primary objective of STS-98, International Space Station Assembly Mission 5A, is to deliver and install the U.S. Destiny Laboratory onto the ISS. The centerpiece of research on this world-class scientific orbiting outpost, this workshop in space will support experiments and studies in cancer, diabetes and materials, just to name a few.

The aluminum U.S. laboratory module is 28 feet long and 14 feet wide. It is comprised of three cylindrical sections and two endcones that contain the hatch openings through which astronauts will enter and exit the module. Destiny will be mated to the forward port of Unity.

In Destiny are five systems racks that will provide life-sustaining functions on board including electrical power, cooling water, air revitalization, and temperature and humidity control. Each rack weighs about 1,200 pounds. Six additional racks will be flown to Destiny on STS-102. Four standoffs provide raceways for module utilities—interfaces for ducting, piping, and wiring to be run to/from the individual racks and throughout the Lab. Twelve racks that will provide platforms for a variety of scientific experiments will follow on subsequent missions. In total, Destiny will hold 23 racks – six each on the port and starboard sides and overhead, and five on the deck.



Astronauts will work inside the pressurized facility to conduct research in numerous scientific fields. Scientists throughout the world will use the results to enhance their studies in medicine, engineering, biotechnology, physics, materials science, and Earth science.

The Boeing Co. began construction of the 16-ton, state-of-the art research laboratory in 1995 at the Marshall Space Flight Center in Huntsville, Ala. Destiny was shipped to the Kennedy Space Center in Florida in 1998 and was turned over to NASA for pre-launch preparations in August 2000.

Destiny's Laboratory Structure

Internal to the laboratory are racks, rack standoffs, and vestibule jumpers. The lab racks house the system hardware in removable modular units. The rack standoffs provide a volume for ducting, piping and wiring to be run to/from the individual racks and throughout the Lab. The racks interface to the piping and wiring in the standoff via outlets and ports located in the standoffs at the base end of each rack location.

Jumpers in the vestibule, the area between Unity and Destiny, connect the piping and wiring between the two. Grounding straps between Unity and Destiny will be installed. One side of the grounding strap will be connected to the Active Common Berthing Mechanism (ACBM) on Unity, while the other end will be connected to the Passive Common Berthing Mechanism (PCBM) on Destiny.

Some of the mechanisms on Destiny are the CBMs (passive and active), hatches, and the laboratory window shutter. The ACBM is in the forward port of the laboratory. It will be attached to the PCBM in Pressurized Mating Adapter 2 (PMA 2) when the PMA is berthed to the forward port of Destiny at the conclusion of the mission. Destiny's ACBM cannot be operated until the laboratory is activated. The PCBM on Destiny is located in the laboratory's aft port. The ACBM in Unity's forward port will be latched to the laboratory's PCBM to berth Destiny to Unity.

Each of the two berthing ports on Destiny contains a hatch. The aft hatch (hatch to Unity) will be opened and will remain open (unless a situation arises requiring a module to be isolated). The forward hatch will be used as the main access to the orbiter on future missions until Node 2 arrives.

Each hatch has a window. The hatches can be opened or closed from either side. The hatches have a pressure interlock feature, which prevents the hatch from being opened if there is a negative pressure across the hatch (higher pressure on the outside of the hatch).

Destiny has an optical quality window (principally for Earth science observations) and a window shutter to protect the window from potential micrometeoroid and orbital debris strikes during the life of the ISS. The crew manually opens the shutter to use the window. The shutter will be installed during the third scheduled space walk.

Installation and Activation

Mission Specialist Marsha Ivins will use the shuttle's robotic arm to attach Destiny to the forward port of Unity. Over the course of three scheduled space walks, Mission Specialists Tom Jones and Bob Curbeam will perform external outfitting and connect umbilical cables to provide power and data capability between Destiny and the space station. Following Destiny's installation to Unity, Ivins will once again use the robot arm to relocate Pressurized Mating Adapter 2 (PMA-2), which was moved to a temporary location to allow the installation of Destiny. She then will remove PMA-2 from its temporary location on the Z1 Truss and attach it to Destiny's forward Common Berthing Mechanism (CBM). At that point, Commander Ken Cockrell will issue a series of computer commands from the aft flight deck of Atlantis to command the final latching and berthing operations.

Lab installation activities will begin on Flight Day 4 with the first space walk. Key activities include connecting all of the critical power and fluid umbilicals between the Z1 Truss and the lab. The ISS crew will complete Unity-to-Destiny vestibule outfitting toward the end of the space walk. Together these connections will permit the lab activation upon completion of the space walk. The activation sequence of events is as follows:

Lab Activation Sequence of Events

Step	Rationale	Executed by
1	Activates the converters in the Lab DDCUs to provide secondary power to the Lab systems	Orb crew
2-3	Once the DDCUs are on, there is no need to have the Node 1 MDMs be the bus controllers on the CB GNC-1 and CB GNC-2. The Config 9 command is sent to each of the Node 1 MDMs so that once power is applied to the C&C MDM, it will not see any BCs on the GNC buses, and it will automatically transition to Primary.	Orb crew
4-5	The configuration command sent to the Primary Node 1 MDM will likely cause a loss of connection with the EPCS as well as the OIU. These interfaces are reestablished so the procedure can continue.	Orb crew
6	The RPCs are closed that provide power to the C&C1 MDM. It should initialize and transition to Primary in approximately 4 minutes.	Orb crew
7-8	The status of the C&C1 MDM is checked to verify that it is nominal. The ISS crew will have direct connectivity through a PCS machine once the C&C1 MDM transitions to Primary, providing extra insight to the orbiter crew.	Orb/ISS crew
9	The ISS crew can then perform the procedures to reestablish LDR S-band which was lost during the vestibule connections made on FD-5.	ISS crew
10	The N1-1 MDM is commanded to be an RT on the LB SYS-LAB 1 bus since it no longer needs to be BC, and the INT MDM will be expecting to find no BC on that bus when it is powered up.	Orb crew
11	The INT2 MDM is powered up by closing the appropriate RPCs that allow power to the MDM. The N1-2 MDM must become an RT on the LB SYS-LAB 2 bus within 2 minutes of powering on the INT2 MDM so that the INT2 MDM will transition to the Operational mode.	Orb crew
12-13	The configuration command sent to the Primary Node 1 MDM will likely cause a loss of connection with the EPCS as well as the OIU. These interfaces are reestablished so the procedure can continue.	Orb crew
14	The status of the INT2 MDM is checked after the approximate 4-minute initialization time.Once again, the ISS crewmember through the PCS machine has a little more insight into the status of the MDM than the orbiter crew.	Orb/ISS crew
15	The Node 1 MDMs should already be synced to the broadcast time coming from the C&C1 MDM.	Orb crew
16	The pass-thru interface is commanded that will allow the C&C1 MDM to be the recipient of all commands from the orbiter AFD PCS, and will also flow telemetry from the C&C1 MDM to the OIU and AFD PCS through the Node 1 MDMs.	Orb crew
17	The OIU format is reloaded to accept the data stream coming from the C&C1 MDM rather than the Node 1 MDM.	Orb crew
18	The orbiter crew must now set up a PCS machine in the AFD to communicate with the C&C1 MDM.	Orb crew
19-21	The LA MDMs are powered on. After the 2-minute initialization is complete, their status is verified.	Orb crew
22	Bus communication is enabled to the RPCMs to prepare for closing various RPCs.	Orb crew
23-26	RPCs are closed applying power to various pieces of MTL and LTL equipment in preparation for IATCS startup.	Orb crew

After Destiny is activated and active cooling has been established to avionics, the ground will take over activation of the laboratory systems. The Pressure Control Assembly (PCA) will be activated, followed by smoke detectors. Then the Common Cabin Air Assembly will be started to provide air circulation and scrubbing of the atmosphere inside the laboratory. The Guidance, Navigation and Control Multiplexer/Demultiplexers (MDMs) will then be activated and loaded with the appropriate software. Destiny's Power Management Controller Unit MDMs will be checked out as well. The ground will then command the Emergency Egress Lighting batteries to begin charging, followed by activation of the laboratory's interior lights. The condensation (shell) heaters will be activated, and the survival heaters will be deactivated. The ground will also activate and check out much of the audio equipment in the laboratory. The Control Moment Gyros (CMGs) will also be prepared for spinup, which will occur the following day.

Upon successful activation of Destiny's systems, both the STS-98 crew and the Expedition One crewmembers will enter Destiny on Flight Day 5 and begin outfitting the lab.

During the second space walk scheduled for Flight Day 6, PMA-2 will be moved to Destiny's forward port. The spacewalkers will then work together to remove the laboratory Power Data Grapple Fixture (PDGF) from the orbiter sidewall and install the PDGF on Destiny. The PDGF will be used by the Space Station Remote Manipulator System, the new station robotic arm that will arrive on Mission 6A.

The third space walk is scheduled for Flight Day 8. Key activities planned include moving the spare S-Band Antenna Support Assembly from the orbiter to the ISS stowage site, installing the window shutter on the lab and connecting PMA-2 umbilicals to the lab.

Deferred Activation and Checkout

The ISS crew and/or ground controllers will perform some activation and checkout tasks of the laboratory after the orbiter crew ingress is complete. The ground will command a checkout of the Internal Video Distribution Subsystem Orbital Replacement Units (ORUs). As there is no video capability on this mission, this will be a functional checkout of the equipment to verify that it survived launch in good shape. The ground also will perform a health and status check of the Ku-band radio frequency group. Once again, this will be a health check of the ORUs because there will not be any Ku-band capability until Mission 5A.1.

The ISS crew will inspect the wastewater tank in Destiny to verify there are no leaks. Other activation procedures that will be performed by the ISS crew after Atlantis leaves, include the activation and checkout of the water vent system, inhibiting the water vent system, and activation and checkout of the vacuum vent system. The ISS crew will also install a Pressure Control System extension duct to assist the flow of air through the PCA.

Systems

Destiny will provide the following for the International Space Station: Environmental Control and Life Support System, or ECLSS (temperature and humidity control; fire detection and suppression; atmosphere control and supply; wastewater, recovery and management; vacuum system); Thermal Control System (active thermal control system, passive thermal control system); Guidance, Control and Navigation; Extravehicular Activity; Extravehicular Robotics; Flight Crew Support; Communication and Tracking (audio system, video system, space-to-space communication system, Ku-band and S-band systems); Electrical Power System (EPS); Command and Data Handling; Structures and Mechanism; and Payload Capability.

The Command and Data Handling system gains 11 MDMs with the arrival of the lab. These MDMs are used to control the U.S. on-orbit segment systems including payloads. The Communication and Tracking system activates high-data rate S-band to replace the early com system. The audio system comes online and the hardware for Ku-band, UHF and the video distribution system are delivered but not activated until future missions.

The ECLSS maintains a pressurized habitable environment within the ISS by supplying correct amounts of oxygen and nitrogen, controlling the temperature and humidity, removing carbon dioxide and other atmospheric contaminants, and monitoring the atmosphere for the presence of combustion products. The system also collects, processes, and stores water removed from the ISS atmosphere.

The ECLSS receives equipment in the laboratory that will be used during most of the assembly stages. The atmosphere control and supply subsystem contains the pressure control assembly, vent relief assembly, and manual pressure equalization valves and gas lines. A complete rack of atmosphere revitalization equipment arrives, and the Sample Delivery System lines launched in the Destiny and Unity are connected to the major constituent analyzer in Destiny. The temperature and humidity control subsystem sees the arrival of two common cabin air assemblies and more intermodule ventilation equipment, as well as avionics air assemblies in several racks. The standard fire detection and suppression equipment is launched with Destiny, as are the water recovery and management condensate tank, water vent assembly and waste and fuel cell water lines.

The electrical power system, which manages, controls, and distributes electrical power to the U.S pressurized modules, receives all the new electrical loads in the laboratory. Power is brought to the Destiny from the P6 array through the Z1/laboratory umbilical tray. The power is brought to two DC-to-DC converter units in the laboratory and is distributed to the secondary power distribution assemblies and downstream loads.

The Motion Control System takes a major step with this mission. The U.S. segment begins contributing to the attitude control of the ISS with the CMGs. The U.S. segment Guidance, Navigation and Control System takes control of the ISS with state vector and attitude inputs from the Russian segment. The Russian segment propulsive capability is still needed for joint attitude control during CMG desaturation and for reboost.

Mission 5A delivers the systems that will assume station management and control from the Zvezda Service Module. The Motion Control System becomes integrated between Zvezda and Destiny's computers.

The Thermal Control System activates the early external and internal thermal control systems to accommodate the addition of Destiny's thermal loads.

The Russian segment continues to manage its own modules while interfacing with the U.S. segment Motion Control System for certain data and operations. The Node 1 MDM Node control software continues to provide closed-loop control of environmental, heater, thermal systems and power for Unity, the PMAs, and truss segments. Destiny's MDM architecture controls the rest of the U.S. on-orbit segment.

Mission 5A adds the additional capability of high-rate S-band and internal audio to the U.S. on-orbit segment. The S-band high-rate capability is the major communications and tracking addition to the ISS for Mission 5A. The S-band system provides two-way communications with the ISS and the Mission Control Center via the Tracking and Data Relay Satellite System for commands and system telemetry, voice and file transfer. The internal audio subsystem allows crewmembers to communicate with other crewmembers aboard the ISS.

Science

The centerpiece of research on the International Space Station, the U.S. Laboratory Destiny will support experiments and studies that may contribute to research toward cures for diseases like cancer and diabetes.

Destiny is the primary research laboratory for U.S. payloads. It will support experiments in microgravity research, human life science, fundamental biology and ecology, Earth observations, space science and commercial applications. By Flight 5A.1 (STS-102), the Destiny will support Earth photography and the Human Research Facility in which radiation measurements, psychological evaluations, and neural response experiments will be conducted.

In 2002, shuttle flights will deliver the Minus Eighty Laboratory Freezer for ISS, Microgravity Science Glovebox and Window Observational Research Facility. Eventually, Destiny will house up to 13 payload racks with experiments in human life science, materials research, Earth observations and commercial applications. The results of these experiments will allow scientists to better understand our world and ourselves and prepare us for future missions, perhaps to the Moon and Mars.

Destiny will be joined by laboratory modules sponsored by the National Space Development Agency of Japan, European Space Agency and Rosaviakosmos.

Flight Day Summary

DATE TIME (EST)	DAY	MET	EVENT
02/07/01 6:11:00 PM	1	000/00:00	Launch
02/07/01 6:55:00 PM	1	000/00:44	OMS2 Burn
02/07/01 9:53:00 PM	1	000/03:42	NC1 Burn
02/08/01 9:17:00 AM	2	000/15:06	NC2 Burn
02/08/01 1:41:00 PM	2	000/19:30	NPC Burn
02/08/01 6:21:00 PM	2	001/00:10	NC3 Burn
02/09/01 7:08:00 AM	3	001/12:57	NH Burn
02/09/01 7:53:00 AM	3	001/13:42	NC4 Burn
02/09/01 9:26:00 AM	3	001/15:15	TI Burn
02/09/01 10:41:00 AM	3	001/16:30	RBar
02/09/01 11:56:00 AM	3	001/17:45	Docking
02/09/01 1:41:00 PM	3	001/19:30	ISS Hatch Open
02/09/01 2:11:00 PM	3	001/20:00	Transfer Operations
02/10/01 10:31:00 AM	4	002/16:20	EVA 1 Start
02/10/01 4:46:00 PM	4	002/22:35	EVA 1 End
02/11/01 8:11:00 AM	5	003/14:00	Lab Ingress
02/12/01 10:56:00 AM	6	004/16:45	EVA 2 Start
02/12/01 5:11:00 PM	6	004/23:00	EVA 2 End
02/14/01 10:36:00 AM	8	006/16:25	EVA 3 Start
02/14/01 4:46:00 PM	8	006/22:35	EVA 3 End
02/16/01 7:16:00 AM	10	008/13:05	ISS Hatch Close
02/16/01 9:10:00 AM	10	008/14:59	ISS Undock
02/16/01 10:17:00 AM	10	008/16:06	Final Sep
02/18/01 11:53:00 AM	12	010/17:42	Deorbit Burn
02/18/01 12:56:00 PM	12	010/18:45	Landing

Updated: 01/31/2001

Rendezvous

Rendezvous and Docking Overview

Overview

Atlantis’ rendezvous with the International Space Station actually begins with its precisely timed launch from the Kennedy Space Center in Florida. The shuttle will rendezvous with the station either on Flight Day 3 or 4, based on the time and date of launch, and at a time based on ISS-orbiter phasing.

The primary pre-rendezvous activities include a check-out of the orbiter's remote manipulator system, or robot arm, (RMS), the extravehicular mobility units (EMUs) or spacesuits, the Ku-band antenna, the orbiter docking system (ODS), and the ground command system.

The final phase of rendezvous operations begins about three hours prior to Atlantis’ docking with the ISS. Atlantis will approach the ISS from below, in what is referred to as a plus-R bar approach, to minimize the effects of jet thruster firings on the station and its solar arrays. About 40 minutes before the terminal initiation burn (Ti burn) when Atlantis moves within 135,000 feet of the station, the shuttle’s rendezvous radar system is activated to provide supplemental navigation information. Prior to initiating the Ti burn, the crew will power on the ODS and activate Atlantis’s docking lights.

A series of course correction burns will bring Atlantis to a point almost directly below and behind the station, at which point Commander Ken Cockrell initiates the manual portion of his approach to the ISS.

Atlantis will intercept the R-bar about 700 feet below the station. Cockrell will slowly move Atlantis to a point about 600 feet below the station before performing a 180 degree yaw maneuver to position Atlantis in a “tail forward” attitude for the final approach and docking. As Cockrell gently moves Atlantis toward the station, the shuttle will stationkeep at distances of 170 feet and 30 feet before initiating the final approach and docking. Solar arrays on the Zarya and Zvezda modules and the recently-installed P6 solar arrays will be feathered and locked at a predetermined angle, to limit the induced loads from shuttle thruster firings.

Atlantis will dock with Pressurized Mating Adapter (PMA) 3 on the downward-facing port of the Unity module.

At initial contact and capture, the ISS and Atlantis will go to free drift to avoid imposing excessive loads on the orbiter docking system (ODS).

After capture, light-emitting diodes on PMA-3 will blink confirming the ISS is in free drift. The crew will be able to see the red indicators through the overhead window on Atlantis’s aft flight deck and verify that the ISS is in the free-drift mode before beginning the automatic rigidization and retraction process and closure of the capture latches between the two docking hatches.

Once a “hard dock” is confirmed, the ODS will be deactivated, solar arrays will resume sun tracking, and the Atlantis-ISS complex will maneuver to the mated attitude.

Docked Operations

Hatches between Atlantis and the ISS will open about two hours after docking to allow the Expedition One and STS-98 crews to greet one another. After the greeting and some initial cargo transfer, the hatches will be closed and Atlantis’ cabin pressure will be lowered in preparation for the space walks, which will begin the next day. Throughout a week of docked operations, the hatches will be opened and closed to support the transfer of supplies and three scheduled space walks to outfit the Destiny laboratory module.

On Flight Days 4, 6 and 8, Astronauts Tom Jones and Robert Curbeam will conduct space walks to relocate one docking port, attach the Destiny module and connect power cables; remove thermal coverings and hatch pins that were installed for launch; and relocate a spare S-band antenna assembly.

The astronauts also will transfer equipment and supplies to the space station and outfit the Destiny laboratory for future use.

Departure

Atlantis is scheduled to undock from the ISS on Flight Day 10. In preparation for the undocking the STS-98 crew will once again power-up the orbiter docking system, turn on the shuttle docking lights, terminate all OIU operations, and enable the shuttle’s navigational aids.

Following its undocking, Pilot Mark Polansky will slowly back Atlantis away from the ISS at the rate of about 1/10 of a foot-per-second before beginning a flyaround. Atlantis will move to a point about 450 feet below the station before beginning a tail-forward circuit of the station, arriving once again at a position approximately 450 feet below the station. At that point, Polansky will perform a final separation burn to move Atlantis away from the station.

Once Atlantis is about 30 feet away from the station, the Expedition One crew will activate the station’s attitude control systems. The Zvezda module will then maneuver station to its normal orientation for orbital operations, the solar arrays will be commanded to resume sun tracking, and the station docking system and lights will be deactivated.

EVAs

Three Space Walks Will Add Sophisticated Laboratory

Overview

Astronauts Tom Jones and Robert Curbeam will perfrom three spacewalks to continue assembly of the International Space Station while Atlantis is docked to the station during Shuttle mission STS-98. During the spacewalks, Jones will be identifiable by red stripes around the legs of his spacesuit while Curbeam's suit will be pure white. Astronaut Marsha Ivins will operate Atlantis' robotic arm from within the shuttle cabin during all of the spacewalks, and Pilot Mark Polansky will serve as the intravehicular crewmember, assisting with the choreography of the spacewalks from inside the cabin. As they are scheduled, the third spacewalk on STS-98 will be the 100th spacewalk conducted by United States astronauts.

Flight Day Four: First Space Walk

The first space walk, planned to last about six hours and fifteen minutes, will be conducted on the fourth day of the mission, the day after Atlantis docks to the station. The overall objective is to mechanically attach the Destiny laboratory to the station and then connect electrical, computer and cooling lines between the lab module and station. The space walk is planned to prepare the laboratory to be entered by both the shuttle and station crews for the first time on the following day to begin its activation.

Shortly before Jones and Curbeam begin the spacewalk, astronaut Marsha Ivins will latch Atlantis' robotic arm onto a capture fixture on one of the station's cone-shaped shuttle docking ports, called Pressurized Mating Adapter 2 (PMA-2), which occupies the berthing mechanism to which the Destiny lab must be attached. Before the spacewalkers leave the airlock, the shuttle crew will send commands to release the bolts holding PMA-2 to the station, and Ivins will move it from its berth, clearing the way for attaching Destiny to that berthing mechanism on the station's Unity connecting module.

Jones and Curbeam will begin the space walk working in separate locations. Curbeam's first task will be to disconnect umbilicals between Atlantis and Destiny that had powered heaters on the module while in the shuttle payload bay. Next, he will remove covers, in place to prevent contamination during launch, from the Destiny lab's berthing mechanism at the aft end of Atlantis' payload bay. Meanwhile, Jones will climb up the station to the first truss segment, called the Z-1 Truss, almost 40 feet above Atlantis' cargo bay. On the Z-1 Truss, Jones will guide Ivins' work with the robotic arm, providing verbal cues to assist in aligning PMA-2 with a temporary storage location on the truss. Once properly aligned, Jones then will manually latch PMA-2 in place to the truss, temporarily out of the way of ongoing activities to attach the Destiny lab.

Next, as Ivins latches the arm onto Destiny, lifts it from the shuttle cargo bay and rotates it into position to be attached to the station, the two spacewalkers will work farther up the station truss to prepare the station's starboard early cooling system radiator to be outstretched later in the mission. Then, they will release gimbal locks on a station communications antenna in preparation for the later activation of that system. When Ivins maneuvers Destiny to its berthing port on Unity and the crew sends commands for the berthing system to bolt together, Jones and Curbeam will stand by to assist if needed.

Once Destiny is securely attached to the station, Jones and Curbeam will begin connecting electrical, data and cooling lines between the new module and the rest of the station.

Flight Day Six: Second Space Walk

During the second space walk, also planned to last about six hours and fifteen minutes, the PMA-2 shuttle docking port will be relocated from the temporary position on the station truss where it was placed during the first spacewalk to a permanent location at the forward end of the Destiny lab. Jones and Curbeam also will attach various equipment and fixtures to the exterior of the new module.

After Ivins has latched Atlantis robotic arm onto PMA-2, Jones will manually loosen the latch that holds it to the temporary stowage location on the station. While Jones is working at the point on the station truss, Curbeam's first task will be to remove covers from the berthing mechanism at the forward end of the lab. Once Jones has released the temporary latch, Ivins will maneuver PMA-2 to the lab's forward berthing mechanism and attach it there, where it will serve as the primary shuttle docking location for most missions to come.

Next, Jones will install thermal covers on the Destiny's four trunnions, the pins which held the module in the shuttle cargo bay during launch, and attach the exterior portion of a vent that will be used by the station's life support systems. Curbeam will install a slidewire along the length of the lab's exterior that will be used to ease the tether work required by future spacewalkers as they move up and down the length of the lab. Curbeam also will install several foot platform mounts and handrails. Jones will install a non-propulsive vent to Destiny’s Pressure Control Assembly (PCA), part of its environmental control and life support system.

The next major task for both spacewalkers will be to install the future connection point for the station's robotic arm to Destiny’s exterior, preparing for the launch of that arm on shuttle mission STS-100 later in 2001.

Ivins will maneuver the robotic arm into position for Jones to install a foot platform at its end in preparation for his work with the arm connection point, called a Power and Data Grapple Fixture (PDGF). Then, working from the arm foot platform, Jones will release the PDGF from its launch location in Atlantis' cargo bay and carry it to the position where it will be attached to Destiny. Meanwhile, Curbeam will be working at the attachment location on Destiny, removing two portions of the modules debris shielding to prepare to make electrical and computer connections for the PDGF. Jones will then install the fixture and both spacewalkers will replace the lab debris shields.

Flight Day Eight: Third Space Walk

The third space walk, planned to last a little over five hours, will attach a spare S-band communications antenna and equipment, called the S-Band Antenna Support Assembly (SASA), to the station; install an exterior shutter on the Destiny lab window; and connect electrical and data lines between the PMA-2 shuttle docking port and Destiny. At the end of the space walk, Jones and Curbeam also plan to conduct a test of the ability of the Simplified Aid for Extravehicular Activity Rescue (SAFER) jet backpack to maneuver two crewmembers. The SAFER jet packs are attached to spacewalker's spacesuits at all times as a type of "space lifejacket," to allow an astronaut to fly back to the station under his own power in the event he were to become untethered.

The first task on the third space walk will be to remove the spare SASA from Atlantis' cargo bay and attach it to a stowage location on the exterior of the station's lower truss segment, the Z-1 Truss. For that task, Curbeam will be in a foot platform at the end of the shuttle's robotic arm and Jones will assist from the station and shuttle exterior.

Next, the two spacewalkers will work together to install an outside shutter on the Destiny lab window. The two spacewalkers will install the shutter and its associated gearbox and then remove a soft cover of insulation that protected the window during launch.

They then will attach electrical and data connections between the PMA-2 shuttle docking port and the Destiny module. The connections will allow shuttle power and commands to reach the station on future missions, when PMA-2 becomes the primary shuttle docking location.

The 30-minute SAFER test is planned as the last activity for the spacewalkers before they re-enter the shuttle cabin.

EVA Timeline for Three Space Walks Will Add Sophisticated Laboratory

Time	Event
2/16:20	EVA 1 Airlock Egress
2/16:25	EVA 1 Sortie Setup
2/16:40	EVA 1 Secure PMA2 to Z1 Truss
2/16:40	EVA 1 Disconnect Lab Heater Umbilicals
2/17:05	EVA 1 Remove PCBM Cover
2/17:15	EVA 1 Release Starboard Radiator Cinch
2/17:35	EVA 1 Unbearth Lab
2/17:50	EVA 1 Release Starboard Radiator Winch
2/17:55	EVA 1 Release Space to Ground Antenna Gimbal Locks
2/18:05	EVA 1 Lab Pre-Install
2/18:40	EVA 1 EZ Setup Tasks

Time	Event
2/19:45	EVA 1 Connect LTA P612 Umbilical
2/19:45	EVA 1 Connect Z1/Lab NH3 Umbilical
2/20:30	EVA 1 Starboard Connectors CIDS 1
2/20:30	EVA 1 Port Connectors CIDS 1
2/21:25	EVA 1 Starboard Connectors CIDS 2
2:21:25	EVA 1 Port Connectors CIDS 2
2/21:55	EVA 1 Sortie Cleanup
2/22:15	EVA 1 Airlock Ingress
4/16:45	EVA 2 Airlock Egress
4/16:45	EVA 2 Release PMA 2
4/16:45	EVA 2 Remove Lab Thermal Cover
4/17:15	EVA 2 Sortie Setup
4/17:35	EVA 2 Install Trunnion Covers
4/17:35	EVA 2 Install Slidewire
4/18:30	EVA 2 Install Pressure Control Assembly (PCA) Vent
4/19:45	EVA 2 Install Payload Data Grapple Fixture (PDGF)
4/21:45	EVA 2 Install MMOD
4/22:15	EVA 2 Sortie Cleanup
4/22:40	EVA 2 Airlock Ingress
6/16:20	EVA 3 Airlock Egress
6/16:25	EVA 3 Transfer S-Band Antenna Support Assembly (SASA)
6/16:25	EVA 3 Sortie Setup
6/17:40	EVA 3 Install Shutter and Gearbox
6/18:10	EVA 3 Attach PMA 2 toLab Umbilicals
6/19:50	EVA 3 Sortie Cleanup
6/20:40	EVA 3 Incapacited Crew Demonstration
6/21:10	EVA 3 Airlock Ingress

Experiments

Biological Protein Crystal Growth -- Enhanced Gaseous Nitrogen Dewar (EGN)

Prime: **Principal Investigator:** Dr. Alexander McPherson, University of California, Irvine;
Project Manager: Raymond A. French, NASA's Marshall Space Flight Center in Huntsville, Ala.

Overview

The second in a series of low-cost biological protein crystal growth experiments to be transferred to, and conducted aboard, the International Space Station, will again use the Enhanced Gaseous Nitrogen Dewar (EGN). Scientists anticipate that analysis of the human and other proteins that make up the payload may contribute to their understanding of gene function and help uncover the genetic roots of diseases. As part of a pilot education program, the payload also contains protein samples loaded by high school students and teachers from Alabama, California, Florida, Michigan, Tennessee and Texas.

The microgravity environment, or near-weightlessness of space sometimes helps grow higher-quality protein crystals. This allows researchers to better understand the molecular structure of proteins and how these proteins perform everything from carrying medicines in the body to making plants resist disease. The data obtained from the crystals grown in space are used to produce models of the structure of the protein molecules. Researchers also expect these experiments to contribute to their understanding of how, and why, biological crystals grow differently in space than they do on Earth.

History/Background

The Enhanced Gaseous Nitrogen Dewar is a vacuum-jacketed container, similar to a thermos bottle, with an absorbent inner liner saturated with liquid nitrogen. Before launch, the protein samples are frozen to -321 degrees Fahrenheit (-196 degrees Celsius) and placed in the Dewar. Once in orbit, the Dewar is transferred from the shuttle to the International Space Station. During this time, the liquid nitrogen warms and boils off (changes to gas), and the samples begin to thaw. After about 11 days, when the nitrogen is completely boiled off and thawing is completed, the crystallization process begins. The experiment is self-activating and does not require crew interaction. The Dewar and protein crystals remain aboard the space station until they are returned to Earth by STS-102, scheduled for March 2001.

Experiments

Shuttle Ionospheric Modification With Pulsed Local Exhaust (SIMPLEX)

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Overview

The SIMPLEX payload has no flight hardware. Shuttle orbital maneuvering system (OMS) thruster firings are used to create ionospheric disturbances for observation by the SIMPLEX radars. SIMPLEX has five different radar sites used for collecting data: Arecibo, Kwajalein, Millstone Hill, Alice Springs, and Jicamarca. One of the radar sites will also use a low-level laser to observe the effects on the ionosphere resulting from the thruster firing.

SIMPLEX is actually a "simple experiment" to study the complex interactions of exhaust vapors with the background atmosphere. This understanding will someday help us to detect, identify, and track the flight of unfriendly space vehicles with instruments that characterize and interpret the vehicle's exhaust plume.

The objective of the SIMPLEX activity is to determine the source of very high frequency radar echoes caused by the orbiter and its OMS engine firings. The principal investigator will use the collected data to examine the effects of orbital kinetic energy on ionospheric irregularities and to understand the processes that take place with the venting of exhaust materials. SIMPLEX sensors may collect data during any encounter opportunity when the orbiter support activities meet the criteria defined.

History/Background

The Earth is surrounded by a layer of electrons and ions called the ionosphere, which ranges in altitude from 30 to 250 miles. This layer becomes disturbed when gaseous materials released in engine exhaust, like those from the Space Shuttle OMS, burn in the ionosphere. The gases react chemically with the ions to produce ion beams, which move at orbital speeds, leaving a trail of turbulence in their wake. Eventually, the ions recombine with electrons to produce an ionospheric hole covering an area of 30 by 30 miles or greater.

The SIMPLEX engine burns are scheduled over each radar site. The radar will send up radio wave pulses that scatter off of the electrons in the ionosphere. Radar will monitor both the turbulence produced by the ion beams and the ultimate reduction in electron density that causes the ionospheric hole.

Experiments

Using Space to Observe the Earth

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Overview

Astronauts and Cosmonauts on the International Space Station are beginning their first scientific studies. They will be photographing the Earth's surface as part of an early payload -- Crew Earth Observations.

Since early space missions in the 1960s, astronauts have photographed the Earth below, observing the world's geography and documenting transient events like storms, floods, fires, and volcanic eruptions.

Target sites include major deltas in south and east Asia; coral reefs; smog-prone urban regions; areas experiencing major floods or droughts triggered by El Niño cycles, high altitude glaciers (reflecting longer-term climate changes), faults associated with major tectonic plate boundaries, and features on Earth, like impact craters, that are analogs to structures on other planets, like Mars. The Earth Sciences and Image Analysis Laboratory at the Johnson Space Center has provided a set of fact sheets as examples to better explain the science and applications behind some of these sites.

The Expedition One crew continues that tradition observing selected sites throughout the world to enhance the existing data base and assist scientists in understanding these changes. During their time on the ISS, the astronauts will document ecologically sensitive areas such as coral reefs and meteorological phenomena such as El Nino.

Experiments

Changes in the Yellow River Delta, 1989-2000

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Overview

Underlying Science

Coastal change caused by the effects of global warming and sea level rise, increasing population and development along all the world's coastlines, and human modifications of coasts (subsidence, seawalls, jetties) is a global issue. The Chinese coastline along the Gulf of Bohai has always experienced dramatic changes — the delta of the Yellow River is the fastest changing coast on the Earth's surface. Because the river carries an extremely heavy sediment load, the lower river channel silts up rapidly, resulting in frequent river course changes. The river has been engineered for millennia, but recent water demands and water diversions (amplified by several years of drought in the 1990s) have resulted in little or no water reaching the coast.

Dramatic changes in the tip of the Yellow River delta were documented by astronauts on the Space Shuttle between 1989 and 2000. Over this time, several hundred square kilometers have accreted and eroded from the coast. The delta grew nearly 400 km2 between 1989 and 1995, then began eroding back. In 1997 a new channel was cut near the tip of the delta, providing the water and sediment a shorter route to the sea. Between 1995 and 1997, the delta area eroded back about 255 square kilometers. From 1997 to February 2000, the delta tip again grew nearly 100 square kilometers.

Application

Remote sensing and image analysis of image data are efficient strategies for examining regional changes that occur over large areas, and are a way of providing context for smaller-scale changes. The photographs collected by astronauts can be assembled in a time series of images demonstrating both the scale and specific locations of coastal change. Quantitative measurements can be made when the images are referenced to standard maps. Such analyses can identify both natural and human-induced changes, lending some understanding of the processes involved in the coastline evolution. The Crew Earth Observations payload on the International Space Station will target rapidly changing wetlands in southeast Asia, such as the Yellow River.

Experiments

Coral Reefs

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Overview

Underlying Science

Healthy coral reefs sustain local and national economies through fisheries, coastal protection, and tourism. In spite of these benefits, it has been estimated that 58% of coral reefs globally are threatened by human activities. Scientists still lack basic data about the locations, spatial extent and health of reefs. Major efforts are underway in the U.S. and around the world to improve the mapping information on coral reefs. Astronaut photographs are a unique data source for these efforts because data on reefs has been collected for many years, and the images are available in the public domain. Of particular value is the fact that the astronauts actively looked for low-cloud opportunities, and used them to photograph reef areas. Astronaut photographs can be used as primary data for maps of the locations of reef crests and as supplemental data for use with other satellite images, especially when it is important to distinguish small clouds from reef areas.

Application

Astronaut photographs are being used as base layers in an international compilation of information on coral reefs and their resources, known as ReefBase. Images have also been included in a prototype reef data distribution system that uses data from the SeaWiFS satellite sensor as a backbone for distribution of reef remote sensing data from a number of different satellites. Investigations comparing the level of detail that can be mapped from an astronaut photograph compared to other satellite data are nearing completion. The Crew Earth Observations payload on the International Space Station will collect targeted images of the Tuamotu Archipelago, American Samoa and the Philippines, to provide additional data for these mapping investigations.

References

Robinson, J. A., G. C. Feldman, N. Kuring, B. Franz, E. Green, M. Noordeloos, and R. P. Stumpf. 2000. Data fusion in coral reef mapping: working at multiple scales with SeaWiFS and astronaut photography. Proceedings of the 6th International Conference on Remote Sensing for Marine and Coastal Environments, Vol. 2, pp. 473-483.

Experiments

El Niño – Southern Oscillation

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Overview

Underlying Science

El Niño- Southern oscillation (ENSO) cycles occur every few years. During these events, weather patterns around the world are disrupted, the human and economic tolls from extreme droughts and floods can be great. ENSO events affect rainfall patterns—leading to droughts in some places and extraordinary rainfall in others. Astronauts track indicators of drought such as increased incidence of wildfires and drops in the levels of lakes and reservoirs. Where rainfall increases, they observe floods and vegetation greening. The ISS crews will collect comparative photographs over parts of the world that were hardest hit by precipitation anomalies associated with the 1997-1998 El Niño. These new observations will build on the unprecedented data on El Niño-related floods and droughts that was collected by astronauts living on Mir.

Application

Imagery from space provides regional context for local events like floods or fires. The presence of smoke, the boundaries of smoke palls, and lake level fluctuations can be compiled for a regional and global assessment of El Niño impact. Rising and falling water levels in lakes, reservoirs and rivers, and vegetation characteristics can be monitored repeatedly to determine responses and rates of response to extreme weather events.

References

Evans, C.A.; Robinson, J.A.; Wilkinson, M.J.; Runco, S.; Dickerson, P.W.; Amsbury, D.L.; and Lulla, K.P.; 2000. The 1997-1998 El Niño: Images of floods and drought, in Dynamic Earth Environments: Remote Sensing Observations from Shuttle-Mir Missions. K. Lulla and L. Desinov (eds); John Wiley & sons, New York, pp. 61-76.

Experiments

Lower Nile River, Egypt

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Overview

Underlying Science

When it was completed in 1971, the Aswan Dam and Lake Nasser were considered one of the engineering marvels of the world. The lake functions as a water reservoir and allows Egypt to maintain high agricultural and industrial productivity in the Nile Valley despite flood and drought cycles. Lake levels fluctuated in the 1980s and 1990s in response to regional cycles of drought and monsoons. Today, the Egyptian government has broken ground on new irrigation projects that will further transform the Egyptian landscape. Since late 1998, four new lakes have been flooded in the Toshka depression (the New Valley Project) west of Lake Nasser . Soon, the Toshka depression will support agriculture and industry, and expand the amount of Egypt's arable land.

Application

The images of the New Valley Project and the rest of the lower Nile can be used as a time series to demonstrate changes over time. Astronauts have photographed the Nile and Lake Nasser since 1965, and the filling of the Toshka depression since late 1998. Since November 1998, the area of the lakes has grown from roughly 250 km2 (November 1998) to about 1300 km2 (February 2000). We anticipate seeing the extents of these lakes fluctuate with changes in annual rainfall annual wet-dry seasons, and future development in the New Valley. Monitoring watershed changes from space provides a useful and efficient way to demonstrate changes over a large area and communicate impacts to government and scientific user groups. Analyses from these images can be used as contributing or stand-alone data for regional impacts of climate shifts and continued development in the New Valley.

References

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DTO/DSO/RME

Shuttle Automatic Reboost Tuning

DTO 263

Overview

Shuttle reboost of the space station using the automatic reboost software requires jet-firing separation to avoid excitation of the joined Shuttle/ISS structural natural frequencies. Accurate specification of this jet-firing separation requires measurement of the on-orbit joined structure natural frequencies. A brief execution of the reboost software using benign parameters, such as burn length, will allow acquisition of structural dynamics data to validate the preflight estimate of the structural natural frequencies and damping and, thus, the jet-firing separation time.

The structural natural frequencies can be measured using the shuttle inertial measurement unit downlinked data, and the jet-firing separation time can be implemented by display inputs by the crew. This DTO is appropriate for shuttle flights to the ISS between availability of OI-28 reboost software and availability of the vernier jet reboost capability and which have a significant structural configuration difference from previous flights.

History/Background

This is the first flight of DTO 263.

DTO/DSO/RME

Individual Susceptibility to Post-Space Flight Orthostatic Intolerance

DSO 496

Overview

Susceptibility to postflight orthostatic intolerance – lightheadedness or fainting upon return to Earth – is highly individual. Some astronauts are little affected, while others have severe symptoms. Women are more often affected than men. The goal of this DSO is to discover the mechanisms responsible for these differences in order to customize countermeasure protocols.

History/Background

It has been well documented that spaceflight significantly alters cardiovascular function. One of the most important changes from a crew safety standpoint is postflight loss of orthostatic tolerance, which causes astronauts to have difficulty walking independently and induces lightheadedness or fainting. These may impair their ability to leave the orbiter after it lands.

This DSO will perform a flight-related study, designed to clarify preflight and postflight differences in susceptible and non-susceptible astronauts. There are no on-orbit activities associated with this DSO.

DTO/DSO/RME

Space Flight and Immune Function (pre-/postflight only)

DSO 498

Overview

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 effects 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 function caused by exposure to microgravity will allow researchers to develop countermeasures to minimize the risk of infection.

History/Background

The objective of this DSO is to characterize the effects of spaceflight on neutrophils, monocytes, and cytotoxic cells, which play an important role in maintaining an effective defense against infectious agents. The premise of this study is that the space environment alters the essential functions of these elements of human immune response.

Researchers will conduct a functional analysis of neutrophils and monocytes from blood samples taken from astronauts 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.

DTO/DSO/RME

Incapacitated EVA Crewmember Translation

DTO 675

Overview

The objective of this DTO is to verify techniques to allow an extravehicular activity (EVA) crewmember to return an incapacitated EVA crewmember to the shuttle airlock.

History/Background

The DTO will be manifested on several shuttle missions to allow the evaluation of a number of techniques to determine the most efficient. The evaluations will be conducted in the orbiter payload bay or on ISS so that the results of the DTO can be applicable to the ISS as well as the shuttle. Success will be defined as the ability to translate the equivalent length of the payload bay (at a minimum) and into the airlock safely, i.e., without posing additional risk to the crew, spacesuit, or vehicle.

DTO/DSO/RME

Single-String Global Positioning System

DTO 700-14

Overview

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 using a modified military GPS receiver processor and the existing orbiter GPS antennas. GPS data may be downlinked during all mission phases.

History/Background

This is the 13th flight of DTO 700-14.

DTO/DSO/RME

Crosswind Landing Performance

DTO 805

Overview

The purpose of this DTO is to demonstrate the capability to perform a manually controlled landing in the presence of a crosswind. The testing is done in two steps.

1. Pre-launch: 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 the presence of a 90-degree crosswind component of 10 to 15 knots steady state.

3. During a crosswind landing, the drag chute will be deployed after nose gear touchdown when the vehicle is stable and tracking the runway centerline.

History/Background

This DTO has been manifested on 61 previous flights.

DTO/DSO/RME

Educational Activities

DSO 802

Overview

The purpose of this activity is to use the attraction of spaceflight to capture the interest of students and motivate them toward careers in science, engineering, and mathematics. Educational products will include 20-minute video lessons with scenes recorded both on-orbit and on the ground. The on-orbit video will comprise about a third of the finished video product and will consist of educational activities performed by the astronauts as well as other educational activities deemed appropriate by the Educational Working Group and the flight crew.

Benefits

Scientific Research on the International Space Station

Crew Earth Observations

The centerpiece of research on the International Space Station, the U.S. Laboratory Destiny will support experiments and studies that may lead to cures for cancer and diabetes.

Destiny is the primary research laboratory for U.S. payloads. It will support experiments in microgravity research, human life science, fundamental biology and ecology, Earth observations, space science and commercial applications. By Flight 5A.1 (STS-102), the Destiny will support Earth photography and the Human Research Facility in which radiation measurements, psychological evaluations, and neural response experiments will be conducted. On Flight 6A, to expedite the processing of payloads to Space Station, racks containing microgravity and commercial payloads will be added to the Lab.

In 2002, shuttle flights will deliver the Minus Eighty Laboratory Freezer for ISS, Microgravity Science Glovebox and Window Observational Research Facility. Eventually, Destiny will house up to 13 payload racks with experiments in human life science, materials research, Earth observations and commercial applications. The results of these experiments will allow scientists to better understand our world and ourselves and prepare us for future missions, perhaps to the Moon and Mars.

Destiny will be joined by laboratory modules sponsored by the National Space Development Agency of Japan, European Space Agency and Rosaviakosmos.

Benefits

Documenting Changes on our Home Planet

Crew Earth Observations

With much of their time committed to construction of the International Space Station, astronauts and cosmonauts also are beginning their first scientific studies. They will be photographing the Earth's surface as part of an early payload, Crew Earth Observations. By keeping crew members active in observing the Earth, NASA is paving the way for a number of future Earth observing payloads that will place cameras and remote sensing instruments in an optical-quality window that is part of the U.S. Laboratory Module.

Since early space missions in the 1960s, astronauts have photographed the Earth below, observing the world's geography and documenting transient events like storms, floods, fires, and volcanic eruptions. Over the years, astronauts have also documented human impacts on the Earth — city growth, agricultural expansion, and reservoir construction. Today, images of the world from 10, 20 or 30 years ago provide valuable insight into Earth processes and the effects of human developments.

Photographic images taken by astronauts serve as both primary data on the state of the Earth and as secondary data to be combined with images from other satellites in orbit. Through their photography of the Earth, ISS astronauts will build on the time series of imagery started 35 years ago—insuring that this record of Earth remains unbroken. Crew Earth Observations will focus on some of the most dramatic examples of change on the Earth's surface.

Target sites include major deltas in south and east Asia; coral reefs; smog-prone urban regions; areas experiencing major floods or droughts triggered by El Niño cycles, high altitude glaciers (reflecting longer-term climate changes), faults associated with major tectonic plate boundaries, and features on Earth, like impact craters, that are analogs to structures on other planets, like Mars. The Earth Sciences and Image Analysis Laboratory at the Johnson Space Center has provided a set of fact sheets as examples to better explain the science and applications behind some of these sites.

Although today's Earth observations made by astronauts are similar to those from historic space missions — crew members still use hand-held film cameras — they also use an electronic still camera that allows for near-real time image downlink and quick analysis.

The first image of Earth downlinked from the ISS is posted at http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=4436 .

All of the imagery is cataloged and added to the database maintained at the Johnson Space Center by the Earth Sciences and Image Analysis Laboratory. Through today's digital technologies and global networking, the catalog of imagery is available to scientists, educators, and the public at http://eol.jsc.nasa.gov.

Shuttle Reference and Data

Shuttle Abort History

RSLS Abort History:

(STS-41 D) June 26, 1984
The countdown for the second launch attempt for Discovery's maiden flight ended at T-4 seconds when the orbiter's computers detected a sluggish valve in main engine #3. The main engine was replaced and Discovery was finally launched on August 30, 1984.

(STS-51 F) July 12, 1985
The countdown for Challenger's launch was halted at T-3 seconds when on-board computers detected a problem with a coolant valve on main engine #2. The valve was replaced and Challenger was launched on July 29, 1985.

(STS-55) March 22, 1993
The countdown for Columbia's launch was halted by on-board computers at T-3 seconds following a problem with purge pressure readings in the oxidizer preburner on main engine #2 Columbia's three main engines were replaced on the launch pad, and the flight was rescheduled behind Discovery's launch on STS-56. Columbia finally launched on April 26, 1993.

(STS-51) August 12, 1993
The countdown for Discovery's third launch attempt ended at the T-3 second mark when on-board computers detected the failure of one of four sensors in main engine #2 which monitor the flow of hydrogen fuel to the engine. All of Discovery's main engines were ordered replaced on the launch pad, delaying the Shuttle's fourth launch attempt until September 12, 1993.

(STS-68) August 18, 1994
The countdown for Endeavour's first launch attempt ended 1.9 seconds before liftoff when on-board computers detected higher than acceptable readings in one channel of a sensor monitoring the discharge temperature of the high pressure oxidizer turbopump in main engine #3. A test firing of the engine at the Stennis Space Center in Mississippi on September 2nd confirmed that a slight drift in a fuel flow meter in the engine caused a slight increase in the turbopump's temperature. The test firing also confirmed a slightly slower start for main engine #3 during the pad abort, which could have contributed to the higher temperatures. After Endeavour was brought back to the Vehicle Assembly Building to be outfitted with three replacement engines, NASA managers set October 2nd as the date for Endeavour's second launch attempt.

Abort to Orbit History:

(STS-51 F) July 29, 1985
After an RSLS abort on July 12, 1985, Challenger was launched on July 29, 1985. Five minutes and 45 seconds after launch, a sensor problem resulted in the shutdown of center engine #1, resulting in a safe "abort to orbit" and successful completion of the mission.

Shuttle Reference and Data

Shuttle Abort Modes

RSLS ABORTS

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

ASCENT ABORTS

Selection of an ascent abort mode may become necessary if there is a failure that affects vehicle performance, such as the failure of a space shuttle main engine or an orbital maneuvering system. Other failures requiring early termination of a flight, such as a cabin leak, might also require the selection of an abort mode.
There are two basic types of ascent abort modes for space shuttle missions: **intact aborts** and **contingency aborts**. Intact aborts are designed to provide a safe return of the orbiter to a planned landing site. Contingency aborts are designed to permit flight crew survival following more severe failures when an intact abort is not possible. A contingency abort would generally result in a ditch operation.

INTACT ABORTS

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

The RTLS abort mode is designed to allow the return of the orbiter, crew, and payload to the launch site, Kennedy Space Center, approximately 25 minutes after lift-off.
The RTLS profile is designed to accommodate the loss of thrust from one space shuttle main engine between lift-off and approximately four minutes 20 seconds, at which time not enough main propulsion system propellant remains to return to the launch site.

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

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

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

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

Transoceanic Abort Landing

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

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

To select the TAL abort mode, the crew must place the abort rotary switch in the TAL/AOA position and depress the abort push button before main engine cutoff.

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

Abort to Orbit

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

Abort Once Around

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

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

CONTINGENCY ABORTS

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

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

ABORT DECISIONS

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

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

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

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

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

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

Shuttle Reference and Data

Space Shuttle Rendezvous Maneuvers

COMMON SHUTTLE RENDEZVOUS MANEUVERS

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

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

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

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

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

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

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

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

Shuttle Reference and 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 corre sponding SRB buses A, B and C. In addition, orbiter main dc bus C supplies backup power to SRB buses A and B, and orbiter bus B supplies backup power to SRB bus C. This electrical power distribution arrangement allows all SRB buses to remain powered in the event one orbiter main bus fails.

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

HYDRAULIC POWER UNITS

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

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

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

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

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

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

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

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

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

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

THRUST VECTOR CONTROL

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

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

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

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

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

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

SRB RATE GYRO ASSEMBLIES

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

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

SRB SEPARATION

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

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

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

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

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

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

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

Shuttle Reference and Data

Space Shuttle Super Light Weight Tank (SLWT)

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

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

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

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

ACRONYMS AND ABBREVIATIONS

A/L	airlock
AAA	Avionics Air Assembly
ABC	Audio Bus Coupler
ACBM	Active Common Berthing Mechanism
ACS	Atmosphere Control System
	Atmosphere Control and Supply
	Attitude Control Subsystem
AD	Active Device
AFD	Aft Flight Deck
AOH	Assembly Operations Handbook
APAS	Androgynous Peripheral Assembly Systems
APCU	Assembly Power Converter Unit
APDS	Androgynous Peripheral Docking System
APFR	Articulating Portable Foot Restraint
APM	Attached Pressurized Module
AR	Atmosphere Revitalization
ARCU	American-to-Russian Power Control Unit
ARS	Air Revitalization System
ASCR	Assured Safe Crew Return
ASV	Air Selector Valve
ATCS	Active Thermal Control System
ATU	Audio Terminal Unit
ATV	Automated Transfer Vehicle
AUAI	ACS/UCS Audio Interface
AV	Avionics
AVV	Air Vent Valve
BBA	Baseplate Ballast Assembly
BC	Bus Controller
BDT	Binary Data Transfer
BIA	Bus Interface Adapter
BIT	Built-In Test
BMR	Body-Mounted Radiator
BPDU	Bitstream Protocol Data Unit
BPSMU	Battery Powered Speaker/Mike Unit
BSP	Baseband Signal Processor
C&C	Command and Control
C&DH	Command and Data Handling
C&M	Control and Monitor
C&T	Communication and Tracking
C&W	Caution and Warning
CADU	Channel Access Data Unit
CB	Command Bus
CBM	Common Berthing Mechanism

CCAA	Common Cabin Air Assembly
CCDB	Configuration Control Data Bases
CCH	Crew Communication Headset
CCHA	Crew Communication Headset Assembly
CCSDS	Consultative Committee for Space Data Systems
CCTV	Closed-Circuit Television
CDR	Contract Data Requirement
CDRA	Carbon Dioxide Removal Assembly
CETA	Crew and Equipment Translation Aid
CHeCS	Crew Health Care System
CHX	Condensing Heat Exchanger
CID	Circuit Interrupt Device
CIL	Critical Items List
CMG	Control Moment Gyro
CNPMS	Current Navigational Parameters Measurement System
CPS	Cabin Pressure Sensor
CRT	Cathode-Ray Tube
CRV	Crew Return Vehicle
CSCI	Computer Software Configuration Item
CSV	Carbon Dioxide Selector Valve
CTP	Command and Telemetry Processor
CTV	Crew Transfer Vehicle
CVIU	Common Video Interface Unit
CVT	Current Value Table
CVV	Carbon Dioxide Vent Valve
CWC	Contingency Water Collection
CWP	Caution and Warning Panel
DAIU	Docked Audio Interface Unit
DAP	Digital Auto Pilot
DCSU	Direct Current Switching Unit
DDCU	DC to DC Converter Unit
DDP	Design Decision Package
DDT&E	Design, Development, Test and Engineering/Evaluation
DMCU	Docking Mechanism Control Unit
DRAM	Dynamic Random Access Memory
DSCU	Docking System Control Unit
DSM	Docking Storage Module
DSP	Digital Signal Processor
EA	Electronics Assembly
Early Comm	Early Communications
EATC	External Active Thermal Control
EATCS	External Active Thermal Control System
ECLSS	Environmental Control and Life Support System
EDP	Electronic Document Project

EEATCS	Early External Active Thermal Control System
EEL	Emergency Egress Lighting
EEPROM	Electronically Erasable Programmable Read-Only Memory
EETCS	Early External Thermal Control System
EF	Exposed Facility
EFGF	Electrical Flight Grapple Fixture
EIA	Electrical Interface Assembly
EIB	Electrical Interface Box
ELPS	Emergency Lighting Power Source
ELS	Emergency Lighting Strip
EMF	Electromagnetic Force
EMI	Electromagnetic Interference
EMU	Extravehicular Mobility Unit
EPCE	Electrical Power Consuming Equipment
EPCS	Early Portable Computer System
EPS	Electrical Power System
ERA	European Robotic Arm
ETI	Elapsed Time Indicator
ETRO	Estimated Time of Return to Operation
EV	Extravehicular
EVA	Extravehicular Activity
EVAS	EVA System
EXPRESS	Expediting the Process of Experiments to the Space Station
FCV	Flow Control Valve
FCT	Flight Control Team
FD	Flight Day
FDF	Flight Data File
FDIR	Fault Detection, Isolation, and Recovery
FDS	Fire Detection and Suppression
FGB	Functional Cargo Block
	Functional Energy Block (Russian)
FQDC	Fluid Quick Disconnect Coupling
FRGF	Flight Releasable Grapple Fixture
FRR	Flight Readiness Review
FSE	Flight Support Equipment (Environment)
FSS	Fluid Servicing System
GFE	Government-Furnished Equipment
GFI	Ground Fault Interrupter
GLA	General Luminaire Assembly
GN&C	Guidance, Navigation, and Control
GLONASS	Global Navigational Satellite System
GPC	General Purpose Computer
GPS	Global Positioning System
GSFC	Goddard Space Flight Center

H/W	Hardware
HCU	Headset Control Unit
HDR	High Data Rate
HEC	Headset Extension Cable
HEPA	High Efficiency Particulate Air
HGA	High Gain Antenna
HIC	Headset Interface Cable
HT	High Temperature
HX	Heat Exchanger
I/F	Interface
I/O	Input/Output
IAC	Internal Audio Controller
IAS	Internal Audio System
IATC	Internal Active Thermal Control
ICD	Interface Control Document
IDR	Incremental Design Review
IFHX	Interface Heat Exchanger
IG	Inner Gimbal
IMV	Intermodule Ventilation
INT	Internal
IOCU	Input/Output Controller Unit
IOS	Integrated Operation Scenario
IP	International Partner
IRD	Interface Requirement Document
ISPR	International Standard Payload Rack
ISA	Inertial Sensor Assembly
ISS	International Space Station
ITCS	Internal Thermal Control System
ITS	Integrated Truss Segment
IV	Intravehicular
IVA	Intravehicular Activity
IVDS	Internal Video Distribution Subsystem
IVS	Internal Video System
JEM	Japanese Experiment Module
JOP	Joint Operation Panel
JSC	Lyndon B. Johnson Space Center
Kbps	Kilobytes per second
kg	kilogram
km	kilometer
KSC	Kennedy Space Center
Lab	Laboratory
LCA	Loop Crossover Assembly
LCC	Launch Commit Criteria

LDI	Local Data Interface
LDR	Low Data Rate
LDT	Loads and Dynamics Team
LED	Light-Emitting Diode
LGA	Low Gain Antenna
LHA	Lamp Housing Assembly
LLA	Low Level Analog
LP	Launch Package
LSAR	Logistics Support Analysis Report
LSS	Life Support System
LT	Low Temperature
LTA	Launch to Activation
LTL	Low Temperature Loop
M/OD	Meteoroid/Orbital Debris
MA	Mechanical Assembly
Mbps	megabytes per second
MBSU	Main Bus Switching Unit
MCA	Major Constituent Analyzer
MCS	Motion Control System
MCC-H	Mission Control Center-Houston
MCC-M	Mission Control Center-Moscow
MCDS	Multifunction CRT Display System
MDF	Minimum Duration Flight
MDM	Multiplexer/Demultiplexer
MET	Mission Elapsed Time
MFCV	Manual Flow Control Valve
MILA	Merritt Island Launch Area
MIP	Mission Integration Plan
MLI	Multi-Layer Insulation
mm	millimeter
MM/OD	Micro Meteoroid/Orbital Debris
MMU	Mass Memory Unit
MOD	Mission Operations Directorate
MPDU	Multiplexer Protocol Data Unit
MPEV	Manual Pressure Equalization Valve
MPLM	Mini Pressurized Logistics Module
	Multi-Purpose Logistics Module
MPM	Manipulator Positioning Mechanism
MRL	Manipulator Retention Latch
MRS BS	Mobile Remote Servicer Base Structure
ms	milliseconds
MSD	Mass Storage Device
MSS	Mobile Servicing System
MT	Mobile Transporter
	Moderate Temperature

MTL	Moderate Temperature Loop
MUE	MDM Utilities Extension
µs	microseconds
n. mi.	nautical mile
NASA	National Aeronautics and Space Administration
NCS	Node Control Software
NPRV	Negative Pressure Relief Valve
NPV	Nonpropulsive Vent
NSP	Network Signal Processor
OCAD	Operational Control Agreement Document
OCC	Onboard Complex Control
OCCS	Onboard Complex Control System
ODF	Onboard Data File
ODS	Orbiter Docking System
OG	Outer Gimbal
OIU	Orbiter Interface Unit
OSD	Operations Support Department
OSTP	Onboard Short Term Plan
OSVS	Orbiter Space Vision System
P&S	Pointing and Support
P/L	Payload
P6	Port 6
PAD	PFR Attachment Device
PAV	Process Air Valve
PBA	Portable Breathing Apparatus
PCA	Pressure Control Assembly
PCBM	Passive Common Berthing Mechanism
PCIA	Portable Computer Interface Adapter
PCMMU	Pulse Code Modulation Master Unit
PCN	Page Change Notice
PCP	Pressure Control Panel
PCR	Portable Computer Receptacle
PCS	Portable Computer System
PD	Physical Device
PDGF	Lab Power Data Grapple Fixture
PDI	Payload Data Interleaver
	Payload Data Interface Panel
PDIP	Payload Data Interface Panel
PDRS	Payload Deployment and Retrieval System
PFCS	Pump and Flow Control Subassembly
PFE	Portable Fire Extinguisher
PFMC	Pump Fan/Motor Controller
PFR	Portable Foot Restraint
PG	Product Group

PGSC	Payload General Support Computer
PIDS	Prime Item Development Specifications
PLB	Payload Bay
PM	Pressurized Module
PMA	Pressurized Mating Adapter
PMCA	Power Management Control Application
PMCU	Power Management Controller Unit
POST	Power-On Self-Test
PPA	Pump Package Assembly
PPL	Pre-Positioned Load
PPRV	Positive Pressure Relief Valve
PRCS	Primary Reaction Control System
PRLA	Payload Retention Latch Assembly
psid	pounds per square inch differential
psig	pounds per square inch gauge
PSP	Payload Signal Processor
PSS	Power Supply System
PTB	Payload Timing Buffer
PTCS	Passive Thermal Control System
PVCA	Photovoltaic Controller Application
PVCU	Photovoltaic Control Unit
RACU	Remote Acquisition and Command Unit
	Russian-to-American Converter Unit
RAIU	Russian Audio Interface Unit
RAMV	Rheostat Air Mix Valve
RCS	Reaction Control System
RF	Radio Frequency
RFPDB	RF/Power Distribution Box
RHC	Rotational Hand Controller
RMS	Remote Manipulator System
ROEU	Remotely Operated Electrical Umbilical
ROS	Russian On-Orbit Segment
RPC	Remote Power Controller
RPCM	Remote Power Controller Mode
RPDA	Remote Power Distribution Assembly
RS	Remote Station
	Russian Segment
RSA	Russian Space Agency
RSCC	RS Central Computer
RSOS	Russian On-Orbit Segment
RT	Remote Terminal
RTL	Ready to Latch
S/W	Software
S0	Starboard-zero

S1	Starboard-one
SARJ	Solar Array Rotary Joint
SASA	S-Band Antenna Support Assembly
SCI	Signal Conditioning Interface
SCU	Synchronization and Control Unit
SDA	Sample Distribution Assembly
SDO	Solenoid Driver
SDS	Sample Delivery System
SEPS	Secondary Electrical Power System
SFCA	System Flow Control Assembly
SIR	Stage Integration Review
SLP	Spacelab-Pallet
SM	Service Module
SMA	Sensor Module Assembly
SMC	Station Management and Control
SPDA	Secondary Power Distribution Assembly
SPDM	Special Purpose Dexterous Manipulator
SPDU	Station Power Distribution Unit
SPP	Science Power Platforms
SRAM	Static Random Access Memory
SRCA	System Remote Control Assembly
SRMS	Shuttle Remote Manipulator System
SRP	Safety Review Panel
SSAF	S-Band Single Access Forward
SSAS	Segment-to-Segment Attachment System
SSOR	Space-to-Space Orbiter Radio
SSP	Standard Switch Panel
SSRMS	Space Station Remote Manipulator System
SSSH	Space Shuttle Systems Handbook
SSSR	Space to Space Station Radio
STS	Shuttle Program
TB	Talk-Back
TBD	To be Determined
TC	Terminal Computer
TCCS	Trace Contaminant Control Subassembly
TCCV	Temperature Control and Check Valve
TCS	Thermal Control System
	Trajectory Control Sensor
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TEA	Torque Equilibrium Attitude
THC	Temperature and Humidity Control
	Translational Hand Controller
TMA	Torquer Motor Assembly
TMSS	Thermal Mode Control System

TP	Tone Processor
TRA	Transmitter/Receiver Assembly
TRC	Transmitter/Receiver/Controller
U.S.	United States
UDM	Universal Docking Module
UHF	Ultrahigh Frequency
UOP	Utilization Outlet Panel
UPLU	Universal Program Logic Unit
USA	United Space Alliance
USL	U.S. Lab
USOS	U.S. On-Orbit Segment
VAJ	Vacuum Access Jumper
VAP	Vacuum Access Port
VCDU	Virtual Channel Data Unit
VDS	Video Distribution System
VES/VRS	Vacuum Exhaust/Resource System
VRA	Vent Relief Assembly
VRCV	Vent and Relief Control Valve
VRIV	Vent and Relief Isolation Valve
VSC	Video Signal Converter
VSU	Video Switching Unit
VTS	Video Teleconferencing System
WIF	Worksite Interface
WRM	Water Recovery and Management
WVA	Water Vent Assembly
WS	Water Separator
WSC	White Sands Complex
WSS	Workstation Stanchion
XPNDR	Transponder
Z1	Zenith 1

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, FL; Marshall Space Flight Center, Huntsville, AL; Dryden Flight Research Center, Edwards, CA; Johnson Space Center, Houston, TX; 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 newscenter

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.

Media Contacts

NASA PAO CONTACTS

Dwayne Brown Space Shuttle/Space Station Policy Washington, DC dwayne.brown@hq.nasa.gov	NASA Headquarters	202 358-1726
Debbie Rahn NASA Headquarters Washington, DC debbie.rahn@hq.nasa.gov	International Partners	202 358-1638
Eileen Hawley NASA Johnson Space Center Houston, TX eileen.hawley1@jsc.nasa.gov	Astronauts/Mission Operations	281 483-5111
Kyle Herring NASA Johnson Space Center Houston, TX kyle.j.herring1@jsc.nasa.gov	International Space Station Operations	281 483-5111
Carlos Fontanot NASA Johnson Space Center Houston, TX carlos.fontanot1@jsc.nasa.gov	NASA Moscow PAO	256 961-6225 Moscow
Bruce Buckingham NASA Kennedy Space Center Kennedy space Center, FL bruce.buckingham-1@kmail.ksc.nasa.gov	Launch Operations	321 867-2468
Dave Drachlis NASA Marshall Space Flight Center Huntsville, AL Dave.Drachlis@msfc.nasa.gov	Space Station Science	256 544-0034

Jack King United Space Alliance Kennedy Space Center, FL KingJW@usafoo.unitedspacealliance.com	Shuttle Processing	321 861-4358
Kari Kelley Allen The Boeing Company Houston, TX kari.k.allen@boeing.com	International Space Station	281 336-4844
Beth Hill The Boeing Company Huntington Beach, CA sara.b.hill@boeing.com	Space Shuttle	714 372-4736
Dan Beck Boeing Rocketdyne Canoga Park, CA daniel.c.beck@boeing.com	Space Shuttle Main Engines	818 586-4572

SHUTTLE FLIGHTS AS OF FEBRUARY 2001

101 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM -- 76 SINCE RETURN TO FLIGHT

		STS-92 10/11/00 - 10/24/00		
		STS-103 12/19/99 - 12/27/99		
STS-93 07/23/99 - 07/27/99		STS-96 05/27/99 - 06/06/99		
STS-90 04/17/98 - 05/03/98		STS-95 10/29/98 - 11/07/98		
STS-87 11/19/97 - 12/05/97		STS-91 06/02/09 - 06/12/98		
STS-94 07/01/97 - 07/17/97		STS-85 08/07/97 - 08/19/97		
STS-83 04/04/97 - 04/08/97		STS-82 02/11//97 - 02/21/97	STS-106 09/08/00 - 09/20/00	
STS-80 11/19/96 - 12/07/96		STS-70 07/13/95 - 07/22/95	STS-101 05/19/00 - 05/29/00	
STS-78 06/20/96 - 07/07/96		STS-63 02/03/95 - 02/11/95	STS-86 09/25/97 - 10/06/97	
STS-75 02/22/96 - 03/09/96		STS-64 09/09/94 - 09/20/94	STS-84 05/15/97 - 05/24/97	
STS-73 10/20/95 - 11/05/95		STS-60 02/03/94 - 02/11/94	STS-81 01/12/97 - 01/22/97	
STS-65 07/08/94 - 07/23/94		STS-51 09/12/93 - 09/22/93	STS-79 09/16/96 - 09/26/96	
STS-62 03/04/94 - 03/18/94		STS-56 04/08/83 - 04/17/93	STS-76 03/22/96 - 03/31/96	
STS-58 10/18/93 - 11/01/93		STS-53 12/02/92 - 12/09/92	STS-74 11/12/95 - 11/20/95	STS-97 11/30/00 - 12/11/00
STS-55 04/26/93 - 05/06/93		STS-42 01/22/92 - 01/30/92	STS-71 06/27/95 - 07/07/95	STS-99 02/11/00 - 02/22/00
STS-52 10/22/92 - 11/01/92		STS-48 09/12/91 - 09/18/91	STS-66 11/03/94 - 11/14/94	STS-88 12/04/98 - 12/15/98
STS-50 06/25/92 - 07/09/92		STS-39 04/28/91 - 05/06/91	STS-46 07/31/92 - 08/08/92	STS-89 01/22/98 - 01/31/98
STS-40 06/05/91 - 06/14/91		STS-41 10/06/90 - 10/10/90	STS-45 03/24/92 - 04/02/92	STS-77 05/19/96 - 05/29/96
STS-35 12/02/90 - 12/10/90	STS-51L 01/28/86	STS-31 04/24/90 - 04/29/90	STS-44 11/24/91 - 12/01/91	STS-72 01/11/96 - 11/20/96
STS-32 01/09/90 - 01/20/90	STS-61A 10/30/85 - 11/06/85	STS-33 11/22/89 - 11/27/89	STS-43 08/02/91 - 08/11/91	STS-69 09/07/95 - 09/18/95
STS-28 08/08/89 - 08/13/89	STS-51F 07/29/85 - 08/06/85	STS-29 03/13/89 - 03/18/89	STS-37 04/05/91 - 04/11/91	STS-67 03/02/95 - 03/18/95
STS-61C 01/12/86 - 01/18/86	STS-51B 04/29/85 - 05/06/85	STS-26 09/29/88 - 10/03/88	STS-38 11/15/90 - 11/20/90	STS-68 09/30/94 - 10/11/94
STS-9 11/28/83 - 12/08/83	STS-41G 10/05/84 - 10/13/84	STS-51-I 08/27/85 - 09/03/85	STS-36 02/28/90 - 03/04/90	STS-59 04/09/94 – 04/20/94
STS-5 11/11/82 - 11/16/82	STS-41C 04/06/84 - 04/13/84	STS-51G 06/17/85 - 06/24/85	STS-34 10/18/89 - 10/23/89	STS-61 12/02/93 - 12/13/93
STS-4 06/27/82 - 07/04/82	STS-41B 02/03/84 - 02/11/84	STS-51D 04/12/85 - 04/19/85	STS-30 05/04/89 - 05/08/89	STS-57 06/21/93 - 07/01/93
STS-3 03/22/82 - 03/30/82	STS-8 08/30/83 - 09/05/83	STS-51C 01/24/85 - 01/27/85	STS-27 12/02/88 - 12/06/88	STS-54 01/13/93 - 01/19/93
STS-2 11/12/81 - 11/14/81	STS-7 06/18/83 - 06/24/83	STS-51A 11/08/84 - 11/16/84	STS-61B 11/26/85 - 12/03/85	STS-47 09/12/92 - 09/20/92
STS-1 04/12/81 - 04/14/81	STS-6 04/04/83 - 04/09/83	STS-41D 08/30/84 - 09/05/84	STS-51J 10/03/85 - 10/07/85	STS-49 05/07/92 - 05/16/92
OV-102 Columbia (26 flights)	**OV-099 Challenger (10 flights)**	**OV-103 Discovery (28 flights)**	**OV-104 Atlantis (22 flights)**	**OV-105 Endeavour (15 flights)**

Table prepared by Richard W. Orloff, 02/2001