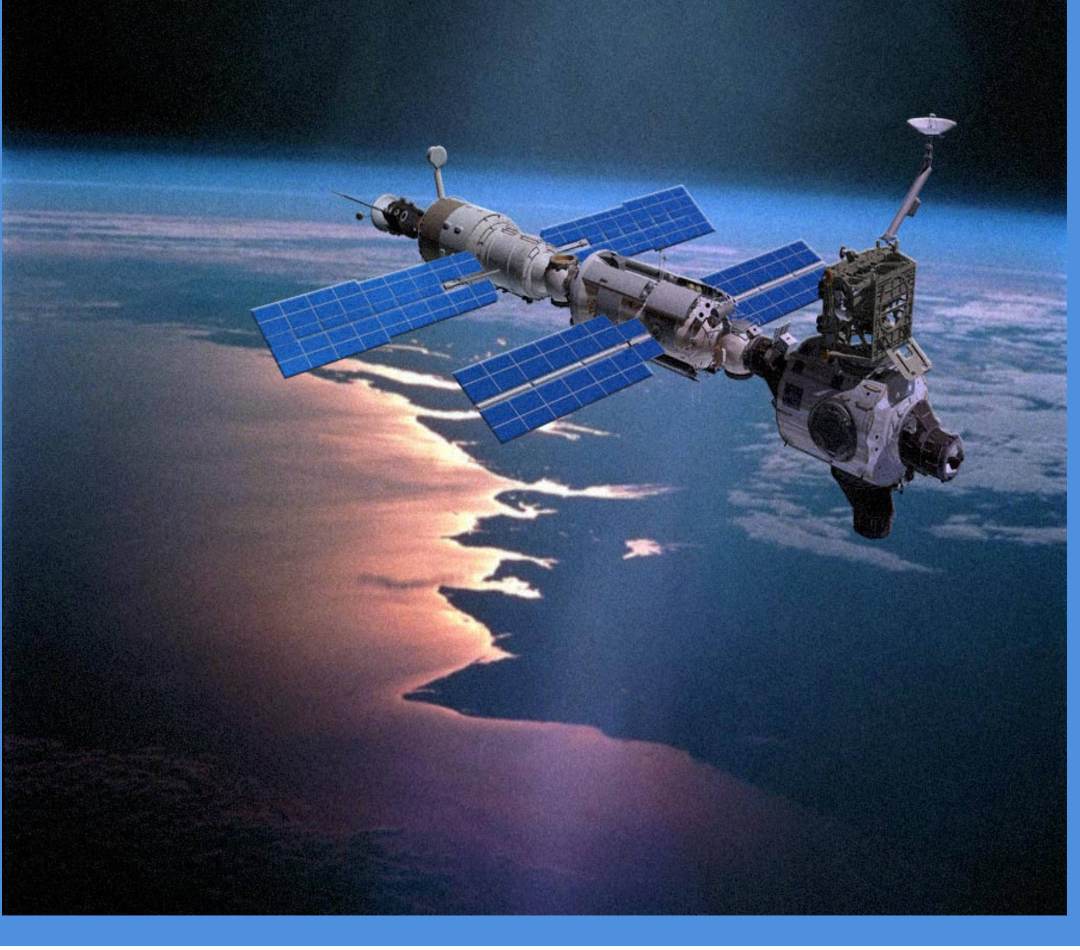
DISCOVERY: DELIVERING FRAMEWORK FOR FUTURE SPACE STATION GROWTH

STS-92



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Mission Overview

DISCOVERY DELIVERS FRAMEWORK FOR FUTURE SPACE STATION GROWTH

Space Shuttle Discovery is poised to deliver the next in a series of major hardware components to the International Space Station (ISS) during the STS-92 mission as the new international facility receives its first framework structure to house communications and motion control equipment.

Launch of Discovery is scheduled to occur no earlier than 9:38 p.m. EDT on Oct. 5 on the 28th flight of the orbiter and the 100th mission in Shuttle Program history.

A seven-person crew will be commanded by Brian Duffy, (Col., USAF), who will be making his fourth flight into space. Duffy will be joined on the forward flight deck by Pilot Pam Melroy (Lt. Col., USAF), who will be will making her first flight into space as the third female shuttle pilot in history, following in the footsteps of Eileen Collins and Susan Kilrain.

Over the course of four scheduled spacewalks, two teams of space walkers and an experienced robot arm operator will collaborate to install the so-called Z1 (Z for zenith port) truss structure on top of the U.S. Unity connecting node on the growing station and to deliver the third Pressurized Mating Adapter (PMA 3) to the ISS for the future berthing of new station components and to accommodate shuttle dockings.

The Z1 truss will be the first permanent lattice-work structure for the ISS, very much like a girder, setting the stage for the future addition of the station's major trusses or backbones. The Z1 fixture will also serve as the platform on which the huge U.S. solar arrays will be mounted on the next shuttle assembly flight, STS-97.

The Z1 contains four large gyroscopic devices, called Control Moment Gyros (CMGs), which will be used to maneuver the ISS into the proper orientation on orbit once they are activated following the installation of the U.S. laboratory.

STS-92

Discovery OV103

Launch: Thursday, October 05, 2000
9:38 PM (eastern time)

Mission Objectives

For Mission 3A, logistics transfer refers to the movement of items between the Space Shuttle and the ISS. These tasks are based on experience moving items between the Shuttle and the Russian Mir space station. The transfer tasks begin with the unbuckling of launch restraints (or opening lockers) and continue through the transfer and stowage. If required, transfer time also includes the installation and power-up of items.

The transfer of items between the Space Shuttle and the ISS is orchestrated by the loadmaster. The rest of the crew members do the actual moving. The loadmaster is the lead for all transfer tasks, organizes the orbiter unloading, supervises ISS stowage, is the single point of contact between the crew members and the ground for all transfer operations, and is responsible for keeping the transfer lists up to date. Since only a small number of items are to be transferred on Mission 3A, there is only one loadmaster.

Transfer Overview

STS-92 has two opportunities for transfer. As planned, ISS entry can occur on FD4 and FD9. Items can be transferred on both days, but some equipment can be transferred only on FD9 because of the mission design. The latter category includes WIS cables and EVA equipment that is to be stowed on board the ISS (e.g., EMU parts and EVA tools).

Stowage Accommodations

Crew transfer bags (CTBs) come in four sizes: half, single, double, and triple. These sizes relate to middeck locker equivalents (MLEs). Mission plans call for the transfer of single CTBs only, but the crew may need to maneuver all four sizes, depending on the stowage layout of the ISS.

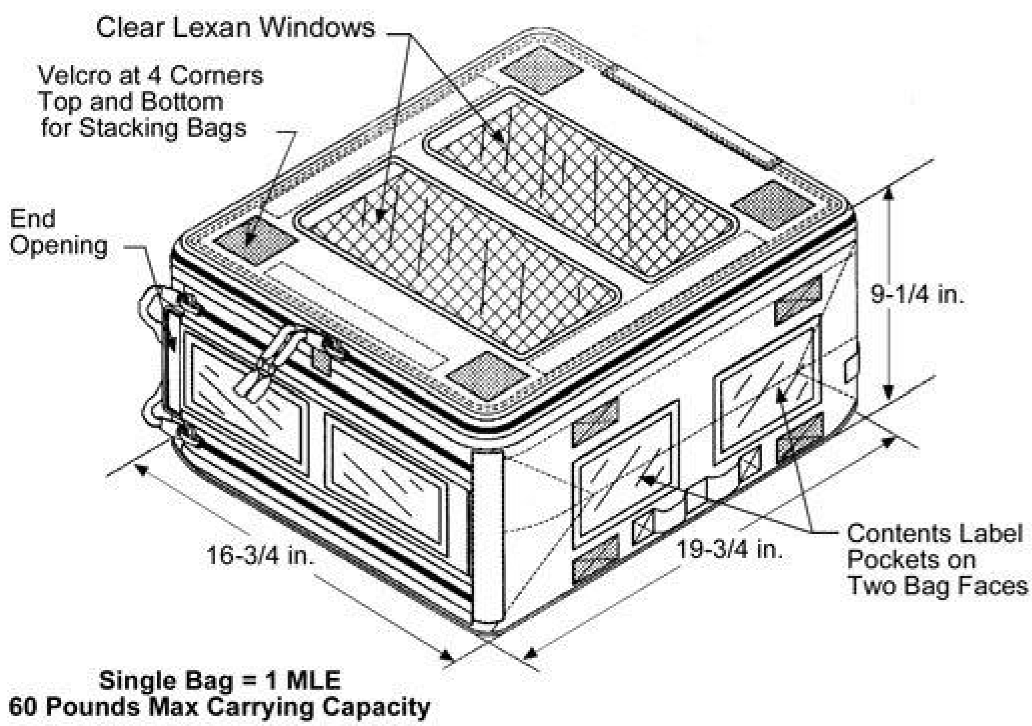
The carrying capacity and dimensions of the CTBs are as follows:

· Half bag: 30 pounds maximum carrying capacity, 16-3/4 by 9-3/4 by 9-1/4 inches

· Single bag: 60 pounds maximum carrying capacity, 16-3/4 by 19-3/4 by 9-1/4 inches

· Double bag: 120 pounds maximum carrying capacity, 18-3/4 by 19-3/4 by 18-3/4 inches

· Triple bag: 180 pounds maximum carrying capacity, 18-3/4 by 19-3/4 by 28 inches



CTB (1 MLE)

Content label information, in English, is as follows:

· Location code

· General description of what is in the bag (e.g., clothing, tools)

· Detailed equipment list and quantity

· Toxicity level of the most toxic item in the bag

Each item in the bags is labeled as follows:

· Bar code label

· Operations nomenclature

· Toxicity level

For a quick visual indication of stowage location, labels are color-coded as follows:

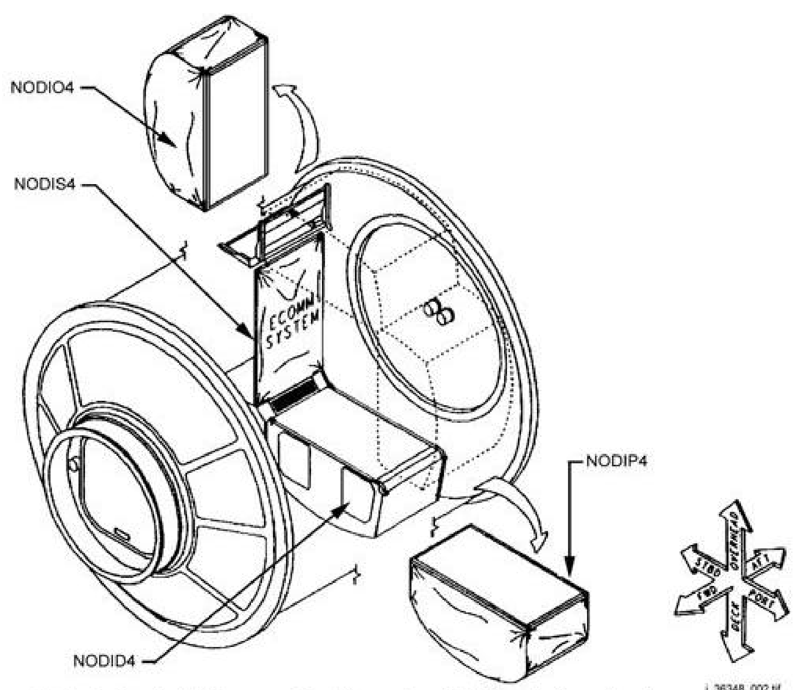
· Salmon--stowed in Node 1

· Buff/tan--stowed in Functional Cargo Block

· Green--"go home"

· White--bag label changes (For bags packed on orbit, the white cards are used to detail items inside the bag.)

Node 1 contains four bays for stowage. The deck bay (NOD1D4) contains the hard-shell stowage rack. The starboard bay (NOD1S4) contains the early communications system and can be used for stowing large items. The overhead bay (NOD1O4) contains a soft-stowage rack insert for bag stowage. The port bay (NOD1P4) also contains a soft-stowage rack insert.



Node 1 On-Orbit Stowage Configuration (Soft Racks Depolyed)

Some items are planned to be stowed in Zarya. Due to thermal, ventilation, and crew access concerns, there are areas of Zarya, the ceiling and starboard side, where stowage is not permitted.

The loadmaster uses transfer lists to track transfers. For Mission 3A, the transfer lists are located in the Assembly Ops book. Key information includes

· Items to be transferred

· Item location

· How the item is transferred (bag or stand-alone transfer)

· Items transferred and any special notes, handling, or reference to installation procedures

The loadmaster keeps the transfer lists current. Before or during a presleep period, the loadmaster transmits the number of items transferred during that day to Mission Control.

Resupply transfer lists for STS-92 include items that are transferred from the orbiter middeck to the ISS. These items include contingency water containers that are filled from the orbiter galley and new Station Operations Data File books for the Increment 1 crew.

Items for return include used harmful contaminant filters from the Zvezda and common berthing mechanism (CBM) controller assemblies from the Z1 vestibule.

General Transfer and Stowage Constraints

Transfer and stowage constraints for STS-92 include the following:

· Because Node 1 is not continuously thermally conditioned before STS-97, items stowed inside the node must be able to withstand the -35°F temperatures that could occur.

· Zarya's corridor must not be obstructed because it would hinder the ability of the crew to leave the ISS quickly.

· Panels that require crew interface (fire holes, caution and warning panels, etc.) must not be blocked by transfer items.

· Care must be taken to prevent items stored temporarily from blocking air circulation vents. The transfer lists prohibit the permanent stowage of items over these vents.

Items to be transferred are securely restrained with Velcro straps and Russian bungees. The flight rules (both generic and flight-specific rules) provide details on ISS transfer and stowage constraints.

Crew

Commander:	Brian Duffy
Pilot:	Pamela A. Melroy
Mission Specialist 1:	Leroy Chiao
Mission Specialist 2:	William "Bill" S. McArthur
Mission Specialist 3:	Peter "Jeff" J.K. Wisoff
Mission Specialist 4:	Michael E. Lopez-Alegria
Mission Specialist 5:	Koichi Wakata

Launch

Orbiter:	Discovery OV103
Launch Site:	Kennedy Space Center, Launch Pad 39A
Launch Window:	Between 2.5 and 5 Minutes
Altitude:	173 Nautical Miles
Inclination:	51.6 Degrees
Duration:	10 Days 19 Hrs. 4 Min.

Vehicle Data

Shuttle Liftoff Weight:	4,520,596 lbs.
Orbiter/Payload Liftoff Weight:	253,807 lbs.
Orbiter/Payload Landing Weight:	204,455 lbs.

Software Version: OI-27

Space Shuttle Main Engines

SSME 1: 2045 **SSME 2:** 2053 **SSME 3:** 2048

External Tank: ET-104A (Super Light Weight Tank)

SRB Set: BI-104PF

Shuttle Aborts

Abort Landing Sites

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

Landing

Landing Date:	10/16/00
Landing Time:	4:42 PM (eastern time)
Primary Landing Site:	Kennedy Space Center Shuttle Landing Facility

Payloads

Cargo Bay

Z1 Integrated Truss Segment

Pressurized Mating Adapter 3

Crew Profile Menu

Commander: Brian Duffy

Brian Duffy (Col., USAF), 47, is Discovery's Commander for the STS-92 mission. This is Duffy's fourth flight into space, having served as the Pilot on the STS-45 and STS-57 missions and Commander of the STS-72 mission. Duffy is responsible for the overall success and safety of the flight and will be in charge of Discovery's rendezvous and docking to the International Space Station. Before being assigned to this flight, Duffy served as the Acting Deputy Director of the Johnson Space Center.

STS-45 and STS-57: Pilot STS-72 mission: Commander

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

Pilot: Pamela A. Melroy

Pam Melroy (Lt. Col., USAF), 39, is Discovery's Pilot for the STS-92 mission. Flying on her first mission, Melroy becomes the third female Pilot in Shuttle program history.

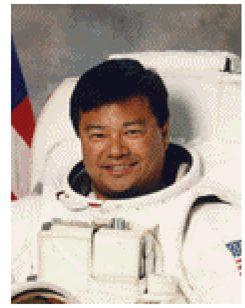
Melroy will assist Commander Brian Duffy in the rendezvous and docking to the International Space Station and will undock Discovery from the ISS at the end of docked operations before conducting a flyaround of the complex. Melroy will prepare the berthing port mechanisms for the mating of the Z1 truss to the U.S. Unity connecting node, then will join crewmate Jeff Wisoff in the newly Z1 truss structure to outfit the truss with grounding straps and other logistical hardware.

She will also operate a 3D IMAX movie camera during the mission to collect footage for a movie being produced about the assembly of the new Station.

STS-92 is Melroy's first flight.

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

Mission Specialist 1: Leroy Chiao



Dr. Leroy Chiao, 40, serves as Mission Specialist 1 (MS 1) on his third flight into space on STS-92.

Chiao is primarily responsible for Z1 truss systems and will serve as Extravehicular crew member 1 (EV 1) during the first and third space walks of the flight. He will wear the space suit bering the solid red stripes. Chiao and Bill McArthur will hook up umbilicals between the newly installed Z1 truss and other International Space Station components and will help to hook up electrical connections between the third Pressurized Mating Adapter and the Unity connecting node.

During the second and fourth space walks by Jeff Wisoff and Mike Lopez-Alegria, Chiao will serve as the intravehicular crew member (IV), responsible for the proper choreography of the space walk.

Chiao previously flew on the STS-65 and the STS-72 missions.

Ascent Seating: Mid Deck - Starboard
Entry Seating: Mid Deck - Starboard
EV1

Mission Specialist 2: William "Bill" S. McArthur

Bill McArthur (Col., USA), 49, is making his third flight into space on STS-92, having previously flown on STS-58 and STS-74, which was the second docking mission to the Russian Mir Space Station.

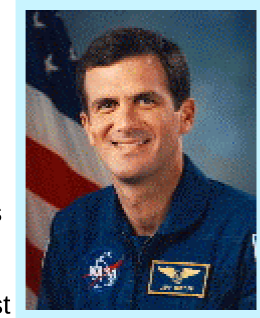
McArthur will serve as flight engineer during Discovery's launch and landing and is designated Mission Specialist 2 (MS 2). He will also be designated as Extravehicular crew member 2 (EV 2) during the flight, and will be teamed with Leroy Chiao during the first and third space walks of the flight to hook up umbilicals between the newly installed Z1 truss and other International Space Station components and electrical connections between the Station's third Pressurized Mating Adapter and Unity. McArthur will wear the white space suit bearing no stripes.

McArthur will also serve as the backup robot arm operator during the second and fourth spacewalks, joining Koichi Wakata on the flight deck to maneuver other spacewalkers around the International Space Station.

STS-58 and STS-74.

Ascent Seating: Flight Deck - Center Aft
Entry Seating: Flight Deck - Center Aft
EV2

Mission Specialist 3: Peter "Jeff" J.K. Wisoff



Dr. Jeff Wisoff, 42, is making his fourth flight into space on STS-92, having flown previously on STS-57, STS-68 and STS-81 to the Russian Mir Space Station.

Wisoff will serve as Mission Specialist 3 (MS 3) during the flight, and will be designated as Extravehicular crew member 3 (EV 3), conducting the second and fourth space walks of the mission along with Mike Lopez-Alegria. Wisoff will wear the space suit bearing the vertical red stripes. Wisoff and Lopez-Alegria will help to install and hookup the third Pressurized Mating Adapter (PMA 3) to the Unity connecting node and will conduct a test of jetpacks worn by spacewalkers as they assemble International Space Station hardware.

Wisoff will also serve as the intravehicular crew member (IV) during the first and third space walks of the flight, responsible for the proper choreography of those excursions by Leroy Chiao and Bill McArthur.

STS-57, STS-68 and STS-81.

Ascent Seating: Mid Deck - Port
Entry Seating: Mid Deck - Port
EV3

Mission Specialist 4: Michael E. Lopez-Alegria

Mike Lopez-Alegria (Cmdr., USN), 42, is making his second flight into space on STS-92, having first flown on STS-73.

Lopez-Alegria most recently served as the Director of Operations for NASA at the Gagarin Cosmonaut Training Center in Star City, Russia, supervising astronaut training for flights to the International Space Station. On STS-92, Lopez-Alegria will serve as Mission Specialist 4 (MS 4), and Extravehicular crew member 4 (EV 4). He will wear the space suit bearing the diagonal red stripes.

Lopez-Alegria will be paired with Jeff Wisoff for the second and fourth space walks of the flight, to install and hookup the third Pressurized Mating Adapter (PMA 3) to the Unity connecting node and to conduct a test of jetpacks worn by spacewalkers as they assemble International Space Station hardware.

Lopez-Alegria will also be the backup robot arm operator for the first and third space walks of the flight, joining Koichi Wakata on the flight deck to maneuver other spacewalkers around the International Space Station.

He will also serve as the "loadmaster" for this mission, responsible for the transfer of logistical supplies from Discovery to the ISS.

STS-73.

Ascent Seating: Mid Deck - Center
Entry Seating: Flight Deck - Starboard Aft
EV4

Mission Specialist 5: Koichi Wakata

Koichi Wakata, 37, represents the Japanese Space Agency (NASDA) on STS-92, his second flight into space. Wakata previously flew on STS-72, using the Shuttle's robot arm to retrieve a Japanese science satellite which had been launched on a Japanese H-II rocket.

Wakata is designated as Mission Specialist 5 (MS 5) during Discovery's flight, responsible for all robot arm operations. Wakata will grapple the Z1 truss structure and mate it to the U.S. Unity connecting node and will use the arm to install the third Pressurized Mating Adapter (PMA 3) to Unity as an additional docking port for International Space Station hardware.

Wakata will spend four days using the arm to transport four spacewalkers around the ISS as they connect umbilicals and electrical cables between the Z1 truss, the new mating adapter and the ISS modules.

STS-72.

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

Updated: 09/25/2000

STS-92

Flight Day Summary

DATE TIME (EST)	DAY	MET	EVENT
10/05/00 9:38:25 PM	1	000/00:00	Launch
10/06/00 1:22:25 AM	1	000/03:44	NC1 Burn
10/06/00 2:56:25 PM	2	000/17:18	NC2 Burn
10/06/00 6:26:25 PM	2	000/20:48	NPC Burn
10/06/00 11:37:25 PM	2	001/01:59	NC3 Burn
10/07/00 11:19:25 AM	3	001/13:41	NC4 Burn
10/07/00 12:45:25 PM	3	001/15:07	Ti Burn
10/07/00 4:31:25 PM	3	001/18:53	Docking
10/07/00 6:57:25 PM	4	001/21:19	ISS Ingress
10/08/00 11:55:25 AM	4	002/14:17	Z1 Grapple
10/09/00 12:43:25 PM	5	003/15:05	EVA 1 Start
10/10/00 12:54:25 PM	6	004/15:16	EVA 2 Start
10/11/00 12:52:25 PM	7	005/15:14	EVA 3 Start
10/12/00 1:13:25 PM	8	006/15:35	EVA 4 Start
10/14/00 12:33:25 PM	10	008/14:55	Undock
10/16/00 3:35:25 PM	12	010/17:57	Deorbit Burn
10/16/00 4:42:25 PM	12	010/19:04	KSC Landing

Updated: 09/30/2000

Rendezvous

Orbiter Operations

Overview

Rendezvous and Docking

The orbiter will rendezvous with the International Space Station (ISS) on Flight Day (FD) 3 at a time based on ISS-orbiter phasing.

The orbiter will perform a minus R-bar approach to the ISS to protect communications with Russian ground sites and will dock with Pressurized Mating Adapter (PMA) 2 on the forward common berthing mechanism (CBM) of Unity. If beta angles exceed 45 degrees, the ISS may need to perform a 90-degree roll to ensure adequate power production. If this occurs, the orbiter will have to perform a 90-degree yaw during the approach.

The primary prerendezvous activities include checking out the orbiter's robotic arm, the extravehicular maneuvering units (EMUs), the Ku-band antenna, the orbiter docking system (ODS), and the ground command system. It may be necessary to power down the station's systems to minimize battery discharge during solar array feathering. The power-down will be performed at approximately 2 hours before the terminal phase initiation, or Ti, burn.

Next the orbiter rendezvous radar will be activated, but it will not be used until after the normal course correction burn. The crew will then power the ODS and activate the docking lights at approximately 1 hour before the Ti burn.

The Ti burn will be performed when the ISS is ready for docking. If ISS power or thermal concerns arise, a Ti delay burn will be performed instead of the Ti burn.

Zvezda and Zarya solar arrays will be feathered (or positioned) and locked when the orbiter is 150 feet from the station. Feathering is initiated by a command to reposition and hold each beta (and alpha) joint at a predetermined angle, which will limit the induced loads.

The ISS will automatically switch to free drift at capture, and the orbiter will go to free drift to avoid imposing excessive loads on the orbiter docking system (ODS).

Light-emitting diodes (LEDs) on PMA-2 will blink when the ISS is in free drift. The crew will be able to see the red indicators through the overhead window on the orbiter's aft flight deck and verify that the ISS is in the free-drift mode.

The ODS will begin the automatic rigidization and retraction process, and its capture hooks will be closed. Then the ODS will be deactivated, Zvezda and Zarya solar arrays will resume sun tracking, and the orbiter-ISS stack will maneuver to the mated attitude.

Docked Operations

After the orbiter docks with the ISS, the crew will enter PMA-2, take an air sample from Unity, and activate the Unity cabin fan to scrub the atmosphere. After a 2-hour scrub, the crew will take another air sample. On FD4, the crew will unberth the Z1 segment of the station's integrated truss structure from the orbiter payload bay and mate it with Unity's zenith CBM port. After the CBM operations have been completed, the crew will enter Unity and Zarya. Over the next four days, crew members will conduct four spacewalks to connect umbilicals and configure hardware for future operations. The crew will re-enter the ISS on FD9 to transfer EMU hardware and complete any remaining entry or transfer tasks. The orbiter will undock from the ISS on FD10.

During mated operations, the orbiter will provide attitude control.

Departure

Before the orbiter departs on FD10, ground personnel will update the ISS vector and mass data. This data includes attitude departure maneuver data, attitude hold data, postdeparture mass properties, and postdeparture attitude maneuver data. A navigation platform alignment will be performed. Zvezda and Zarya solar arrays will be commanded to stop sun tracking and will be feathered to the edge-on position.

The orbiter crew will configure orbiter hardware for departure. This involves enabling rendezvous navigation and performing an orbiter-to-target state vector transfer. Next, the crew will configure the ODS. The orbiter docking lights will be activated, and orbiter power will be applied to the ODS. The orbiter digital autopilot will be configured for proximity operations and commanded to free drift. Orbiter interface unit (OIU) operations will be terminated, and OIU interfaces will be powered off.

The crew will undock the orbiter from PMA-2 and perform a series of separation burns with the primary RCS jets to move the orbiter away from the ISS.

Zvezda's flight control system will be activated by a separation signal from the androgynous peripheral attachment system (APAS). This signal initiates a 250-second delay before Zvezda's attitude control system is activated. Separation must occur within Russian ground coverage because the APAS indicator is mechanically zero-fault tolerant and electrically single-fault tolerant. Russian ground personnel will activate the attitude control system if the APAS indicator fails. Zvezda will maneuver to its postdeparture attitude and return to the XPOP flight mode. Zvezda and Zarya solar arrays will resume sun tracking. Finally, Russian segment equipment needed only during mated and departure operations (docking system, lights, etc.) will be deactivated.

EVAs

Z1 Assembly, Activation, and Checkout
Overview
Mission Operations Summary

STS-92 will carry a crew of seven on an 11-day mission that includes four spacewalks or EVAs on four consecutive days.

On Flight Day 1 (FD1), the DC-to-DC converter unit (DDCU) heaters and the wireless instrumentation system (WIS) radio frequency (RF) kit will be activated as initial spacewalk preparations begin.

On FD2, the crew will activate and check out orbiter and orbiter-based International Space Station (ISS) hardware, including the extravehicular mobility unit (EMU), the shuttle's robotic arm, or remote manipulator system (SRMS) and the orbiter interface unit (OIU), and assembly power conversion unit (APCU) hardware. After the SRMS checkout, the operator will perform a payload bay survey to inspect the integrity of the cargo.

The orbiter will rendezvous and dock with the ISS on FD3. After the docking, the crew will enter Pressurized Mating Adaptor (PMA) 2 to collect Unity air samples and initiate Unity air scrubbing before entering the ISS the next day.

On FD4, the Z1 element will be unberthed from the orbiter and mated with the zenith port of Unity. The first opportunity to enter the ISS will occur after Z1 has been installed. If the temperature in Unity is acceptable, the crew will enter Zarya,transfer any necessary hardware, install the Z1-to-Unity grounding straps, and remove the CPAs and latches in the Z1 vestibule.

The four spacewalks begin on FD5 and end on FD8 to link the Z1 Truss and PMA-3 to the ISS. The crew will return to the ISS on FD9 to perform tasks that were not completed during the first opportunity.

The orbiter is scheduled to undock from the ISS on FD10 and perform a flyaround, but that day has also been reserved as an unscheduled EVA day.

Two EVA teams, each composed of two crew members, ensure backup support on each EVA day. One team will perform spacewalks on FD5 and FD7, and the other team on FD6 and FD8. FD9 and FD10 are reserved in case an unscheduled EVA is required to properly configure any ISS elements or to perform a contingency undocking. The EVA teams are cross-trained for all assembly activities to accommodate unexpected situations that require shuffling of the EVA teams and crew members.

Z1 Installation

Before Z1 is mated with Unity, the zenith active common berthing mechanism (ACBM) is activated and checked out. This procedure is initiated by applying power to the controllers that control the ACBM. Once power has been applied, the 20 individual controller channels begin a power-on self-test (POST). The POST results are relayed after a master motor controller has been designated during the initialization.

The master controller controls all ACBM functions and reports statuses that it gathers from the slave controllers. The early portable computer system (EPCS) reports the status of the power-up and remote power controller module (RPCM) switches, and the crew reviews and compares the reported status to expected values.

The crew receives the current overall CBM command status, subsystem identification (latch/bolt controller), time, status of the motor current, motor speed, bolt load, and shaft position. This operation also sets all powered bolt and latch controller positions. Because the system has been initialized, these positions should have a reading of zero. If controller channel faults are present, fault detection, isolation, and recovery (FDIR) activities are initiated. If no faults are detected, the crew continues with the ACBM checkout.

The crew members test the bolts by turning them two turns out and three turns in before berthing to ensure that they are operable. The capture latch actuators fully deploy the four capture latches to ensure that they are operable before element berthing begins.

The capture latches are then moved from the deploy position to the capture position as part of the preberthing latch operation testing. The capture latches must then be redeployed before Z1 is positioned in Unity's zenith ACBM capture envelope. The crew uses the same procedure to perform a capture latch deploy test.

After the ACBM has been checked out successfully and the capture latches are extended, the robotic arm is maneuvered to the grapple position. Z1 is grappled, and the crew unlatches the payload retention latch assemblies (PRLAs) and the active keel assembly (AKA) holding Z1. The orbiter is taken to free drift, and the arm unberths and maneuvers Z1 to a low hover position. After some orbiter attitude cleanup, the orbiter is taken to free drift again, and Z1 is maneuvered to the premate position. After more attitude cleanup, the orbiter is taken back to free drift, and Z1 is maneuvered to the capture position. The orbiter must remain in free drift until initial bolt loading (ABOLT) occurs.

When the bolts are ready, they are taken to the final preload bolt (FBOLT) values by tightening the bolts, four at a time. An adequate pressure seal can be achieved if 15 of the 16 bolts or 14 of 16 (nonadjacent) bolts are at the FBOLT load. After FBOLT has been achieved, the capture latches are commanded from the capture position to the close position. Power is then removed from Unity's zenith ACBM.

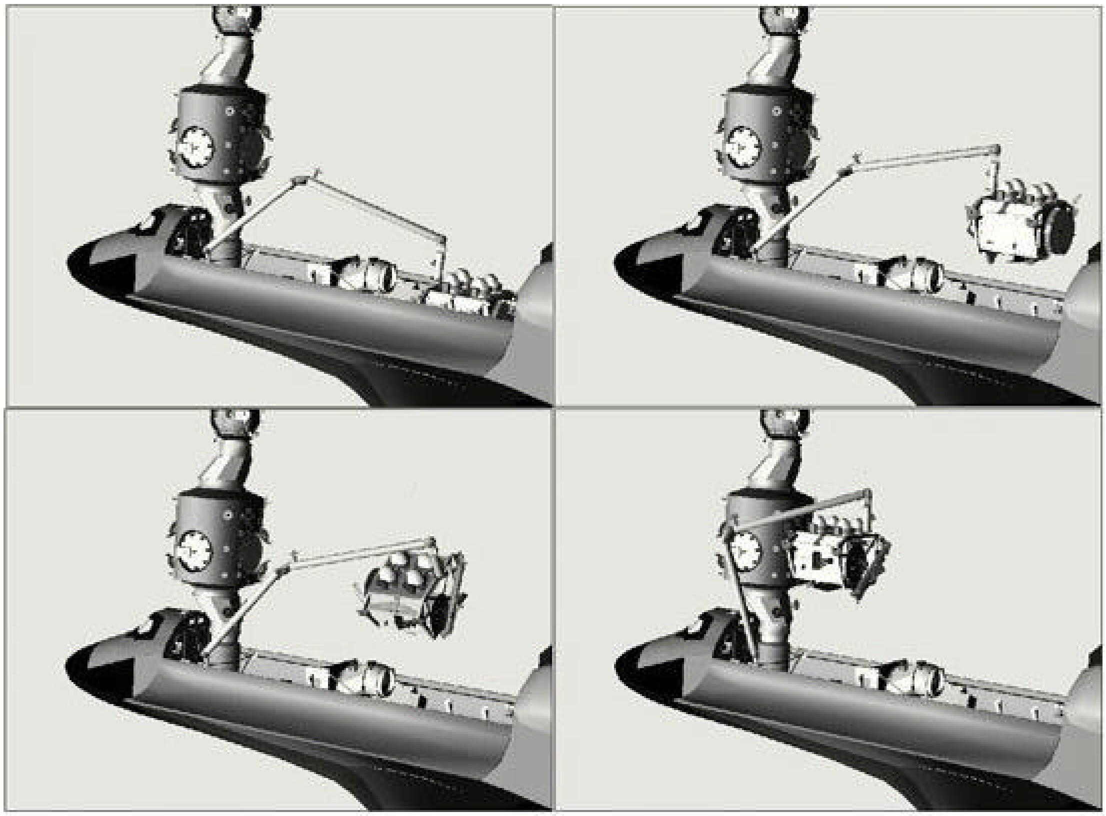


Figure 1. Z1 Installation

PMA-3 Installation

Before PMA-3 is mated with Unity, the nadir ACBM is activated and checked out. This is initiated by applying power to the controllers that control the Node 1 nadir ACBM. After power has been applied, the 20 individual controller channels begin a POST. The test results are relayed after a master motor controller has been designated during the initialization.

The master controller controls all ACBM functions and reports statuses that it gathers from the slave controllers. The EPCS reports the status of the power-up and RPCM switches, and the crew reviews and compares the status to expected values. The crew receives the current overall CBM command status, subsystem identification (latch/bolt controller), time, status of the motor current, motor speed, bolt load, and shaft position. This operation also sets all powered bolt and latch controller positions.

Before berthing begins, the crew members test the bolts to ensure that they are operable, and the capture latch actuators fully deploy the four capture latches to ensure that they are operable. The capture latches are moved from the deploy position to the capture position as part of the preberthing latch operation testing. The capture latches must then be redeployed before Z1 is positioned in Unity's zenith ACBM capture envelope. The crew uses the same procedure to perform a capture latch deploy test. After the activation and checkout of the ACBM, the crew must visually verify that there is no debris or contamination that would prevent mating with the PCBM or cause degradation of the CBM seals.

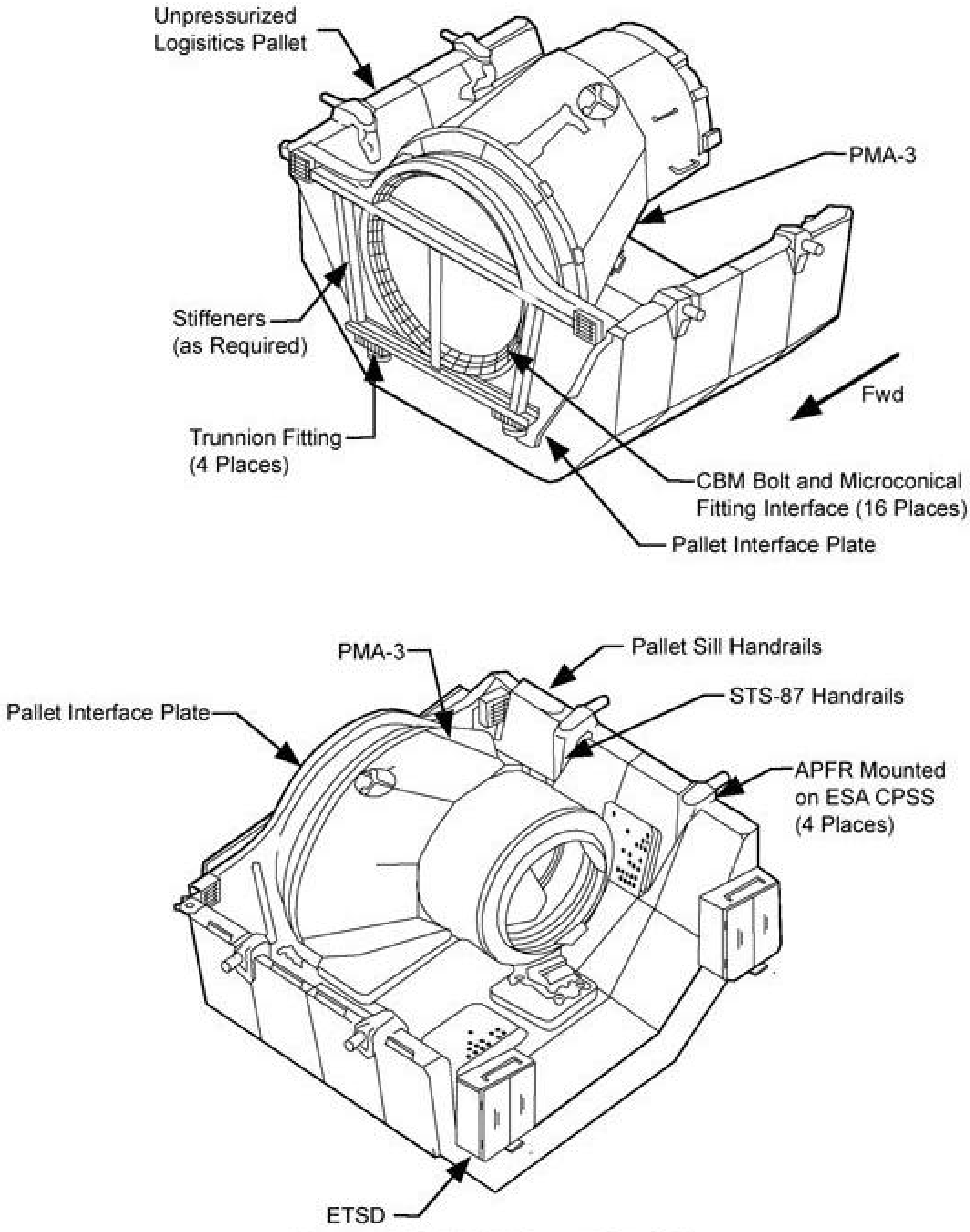


Figure 9. PMA-3 Mounted in SLP

After the ACBM has been checked out and the capture latches are extended, the EVA crew manually releases PMA-3 from the Spacelab pallet (SLP). The arm grapples PMA-3, and PMA-3 is released from the SLP. Due to the extremely tight clearances (6 inches) between the PMA-3 and the SLP, an EVA crew member monitors the unberthing.

When PMA-3 is clear of structure, it is maneuvered to the capture position. The orbiter must remain in free drift until ABOLT occurs.

At this point, the EVA crew connects two sets of umbilicals to PMA-3 and Node 1. An operational hold is required to prevent CBM seal scrubbing because of an excessive temperature delta between the ACBM and PCBM.

At the beginning of the next flight day, the powered bolts are taken to IBOLT values by tightening the bolts, four at a time. In order to achieve an acceptable seal between the PCBM and the ACBM, 15 of the 16 powered berthing bolts or 14 of 16 (nonadjacent) bolts must be engaged. Once the bolts have reached IBOLT status, they are taken to the FBOLT values by furhter tightening the bolts. After the final preload status has been achieved, the capture latches are commanded from the CAPTURE position to the CLOSE position.

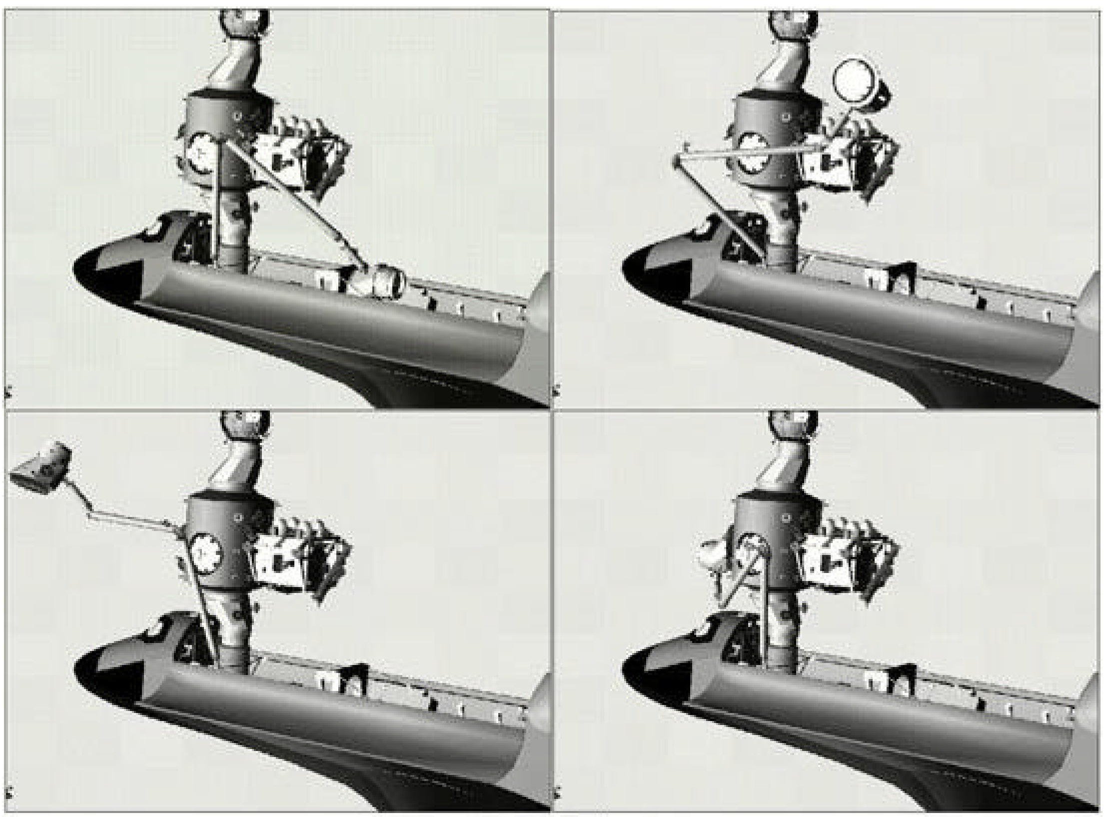


Figure 2. PMA-3 Installation

DDCU Heat Pipe (HP) Aliveness Test

During EVA3, Mission Control Center, Houston (MCC-H) will perform a DDCU-HP aliveness test to verify that the DDCU-HP blind-mate connections mated. There is no visible indication of proper connector mating, so this test mitigates the effect of a DDCU failure on follow-on flights. The orbiter crew can perform the procedure, but MCC-H will have the primary responsibility.

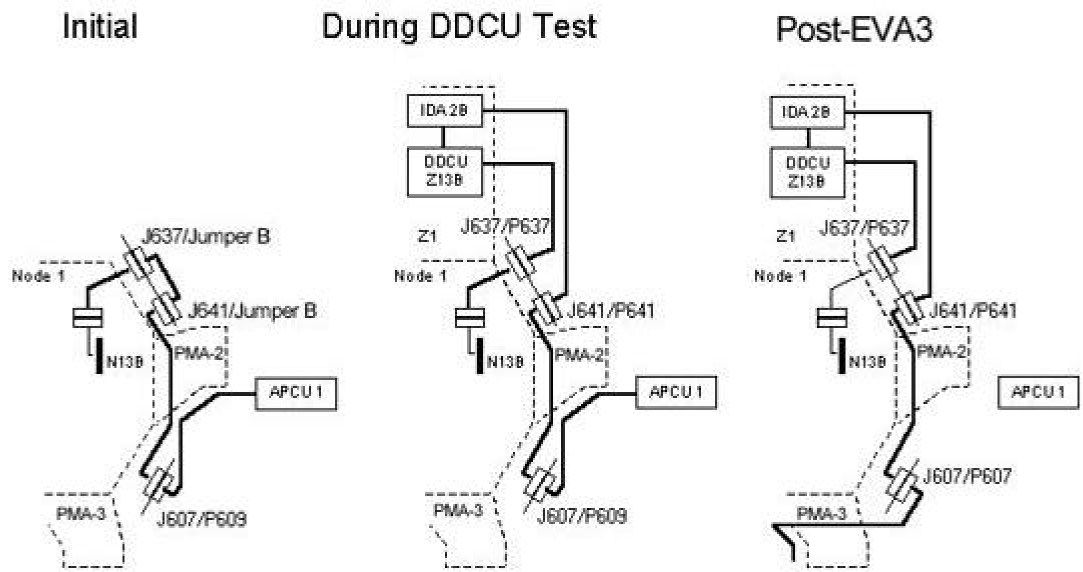


Figure 3. DDCU-HP Aliveness Test

EVA Operations

Relocation of S-Band Antenna Subassembly (SASA)

Leroy Chiao (EV1) and Bill McArthur (EV2) remove eight bolts on various parts of the SASA using the pistol grip tool (PGT). Using handrails on the SASA, McArthur pulls the unit away from Z1, ensuring it does not contact any structure. (The SASA can survive for only 1 hour if it is not attached to a structure.) The shuttle's robot arm guides McArthur through the unstow path as Chiao monitors progress and provides other assistance to McArthur. Chiao rotates SASA 180 degrees so that the high-gain antenna (HGA) is pointing in the nadir direction and then aligns the mast fasteners with a stowage bracket. Chiao then secures the mast to the stowage bracket. McArthur releases a bracket from the SASA and stows it in the Z1 stowage bin. Chiao connects cables W34-P4 and W07S-P3 to the SASA. The receptacle covers for J3 and J4 are then stowed on Z1 dummy receptacles. The ground applies heater power soon after the connectors have been mated.

This task must occur before the DDCU is installed because the SASA is launched in the DDCU installation locations.

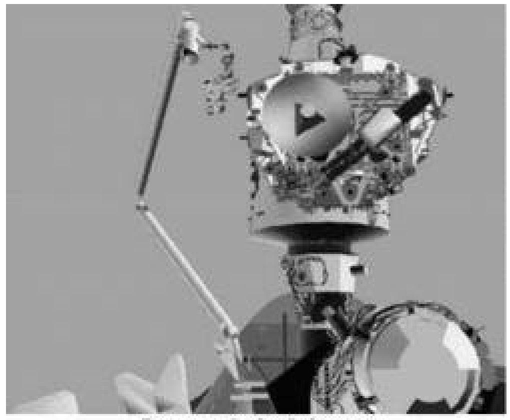


Figure 4. SASA Relocation

Connection of Z1-to-Unity Umbilicals

The immediate purpose of this task is to connect the umbilicals that provide keep-alive power to critical on-orbit replaceable units (ORUs) on Z1. Several Unity umbilicals provide APCU power to the CBMs, and these are not disconnected until CBM operations are completed later in the flight. With the exception of Russian-American conversion unit (RACU) commanding, all power-down and activation commands are sent via the portable computer system (PCS) on board the orbiter.

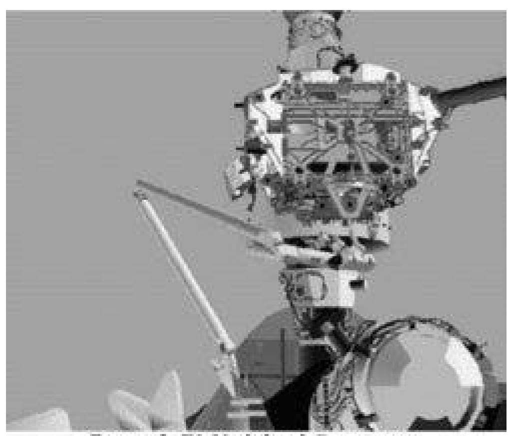


Figure 5. Z1 Umbilical Connection

Installation of Space-to-Ground Antenna (SGANT)

Before the SGANT dish can be removed from its launch location, remote power controller mode Z14B-B must be verified to be operational. Once the antenna is removed from the structure, the dish cools quickly, and the antenna cannot be reinstalled in the launch location. After the orbiter docks with the ISS, the SGANT will violate lower thermal limits within 20 hours, according to preflight thermal analysis.

To install the SGANT, Chiao positions himself in an APFR on the Z1 zenith bulkhead, and McArthur moves on the robot arm near the SGANT. McArthur unfastens two launch restraints on the antenna while Chiao holds it. Chiao slides the SGANT to the hard stop on Z1 and raises it using the upper deployment handles. The SRMS positions McArthur near the boom attachment interface while Chiao removes the APFR and installs and enters the APFR near the boom attachment interface.

Using the upper deployment handles and handles on the antenna group interface tube (AGIT), McArthur positions the AGIT near the boom. Chiao grasps the AGIT handles and aligns the AGIT coarse guide pins with the boom interface holes until the AGIT fine-guide pins are aligned and the SGANT dish is secured to the boom with four bolts. McArthur then connects the J1 and J2 connectors. The intravehicular (IV) crew member verifies that the RPCs feeding connector J1 are open and that closure is inhibited before mating.

Figure 6. SGANT Installation

Deployment of SGANT Boom

Before deploying the boom, the crew verifies that the SGANT and transmit/receive control (TRC) heaters are active. Preflight thermal analysis shows that the SGANT will violate lower thermal limits within 30 minutes after the boom is deployed.

The spacewalker on the arm removes a pip pin from the launch restraint bolt and then unfastens the bolt. The SGANT with boom is unstowed by both spacewalkers. McArthur attaches the antenna to Z1 by fastening two captive EVA bolts on the boom to the Z1 zenith bulkhead using the PGT.

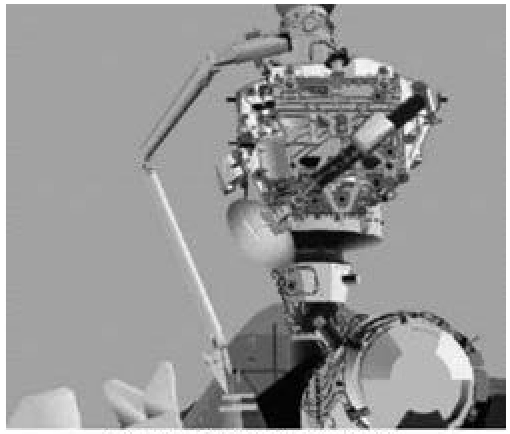


Figure 7. SGANT Boom Deploy

Installation of DDCU-HP

Two DDCU-HPs are being flown on STS-92. DDCU Z1-3B is on the starboard sidewall of the payload bay, and DDCU Z1-4B is on the port sidewall. The installation procedures for the two units are similar.

After the DDCU is released, the heat pipe radiator causes heat to leak from the DDCU. The DDCU will reach its survival thermal limit in one hour.

McArthur aligns the DDCU-HP on Z1, using the alignment marks on the unit with marks on the truss, and guides the box onto the aft tie-down nuts until the box is seated. When the DDCU-HP front screw is fastened to a hard stop, the front status indicator changes from UNLOCK to LOCK and the rear status indicator goes from LOCK to UNLOCK. After the rear screw is fastened to a hard stop, the rear status indicator goes from UNLOCK to LOCK. The ORU is installed.

The DDCU will continue to cool down until heater power is applied, which should occur within 1 hour of the installation on the Z1 structure.

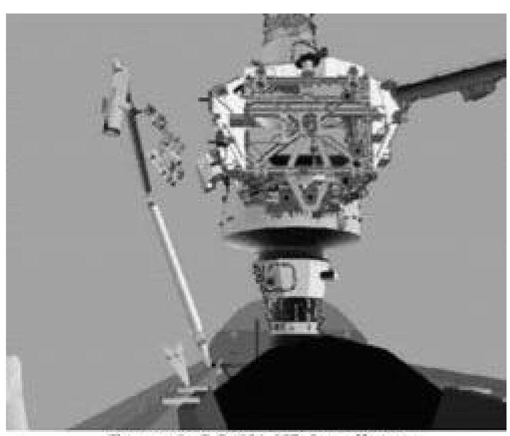


Figure 8. DDCU-HP Installation

Release of PMA-3 From SLP

Once the Unity nadir ACBM has been activated and checked out and the ACBM capture latches are all extended, EVA crew members Jeff Wisoff and Michael Lopez-Alegria can remove PMA-3 from the Spacelab pallet (SLP).

With the robotic arm attached to PMA-3, the two spacewalkers loosen the berthing bolts while deploying the capture latches. This series of maneuvers prevents asymmetrical loading on the PMA-3 from the MBM.

PMA-3 must be unberthed from the SLP in daylight because cameras must be used during the procedure. Because of the tight clearances, camera views are necessary to assist the SRMS crew member.

One spacewalker must open and close the capture latches to ensure that they are operational.

With the latches closed, the spacewalkers first loosen all bolts one-half turn to relieve pressure on the PCBM seal. This is done so that unloading occurs symmetrically; however, it does not have to be performed by the two crew members simultaneously. Because of the loading conditions, the crew members fully loosen and release all but the four bolts next to the MBM capture latches. The EVA astronauts fully unbolt the remaining berthing bolts simultaneously while working opposite from each other. PMA-3 is now free of all berthing bolts on the MBM ring.

The remaining restraints are the four capture latches. An EVA crew member takes up a position at the capture latch drive assembly and drives the latches at a low torque setting until they are one turn from being fully deployed. Then the latches are fully opened at a higher torque setting. After PMA-3 has been moved from the envelope of the MBM, an EVA astronaut drives the capture latches back to their closed position for entry, first within one turn of being fully deployed at a higher torque and then to the final position at a lower torque.

Monitoring PMA-3 Unberthing

Because of the 6-inch clearance between the PMA-3 docking light assembly and the SLP, an EVA crew member must monitor the unberthing. The orbiter-ISS stack must be in free drift; once the PMA-3 is clear of the SLP, the orbiter's vernier reaction control system (VRCS) is used for attitude control.

Connection of PMA-3 Umbilicals

Once PMA-3 has been successfully berthed and latched to Node 1, an EVA crew member can support the primary umbilical release. Lopez-Alegria releases launch restraints and clamps so that he can release the zero-gravity connectors and slide the thermal covers off the zero-g connectors. Lopez-Alegria then releases one PMA-3 primary umbilical launch fitting and disconnects the primary umbilicals from the dummy panel. The PMA-3 primary umbilical bunch is free of the PMA when the stanchion fitting is released. (A minimum of 20 pounds is required to release the stanchion after the EVA bolt is free.)

Lopez-Alegria moves to the node after releasing EVA clamp C4 and is ready to help guide the umbilical around the grapple fixture. The remaining clamps are released, and the primary umbilical is controlled to ensure that the lower part of the umbilical does not float into the path of the Wisoff or the SRMS. Wisoff carries the PMA-3 primary umbilical on the SRMS around the starboard side (orbiter port) of PMA-3 to the Node 1 end cone handrail, where it is temporarily secured. Wisoff holds the PMA-3 primary umbilical stanchion and controls the umbilical while moving to the Node 1 end cone on the SRMS. Lopez-Alegria must help guide the umbilical around the grapple fixture and ensure that it does not become entangled. The RPCs for the PMA shell heaters are opened to provide adequate safety inhibits before connectors are mated.

The primary PMA-3 umbilicals will be connected to Unity's forward nadir end cone connector panel. After a heater is used overnight to equalize the temperature of the two elements, the mating of PMA-3 with Node 1 will be completed at the start of FD7. After the two elements have been mated, the redundant cable bundle is connected at the beginning of EVA3 on FD7.

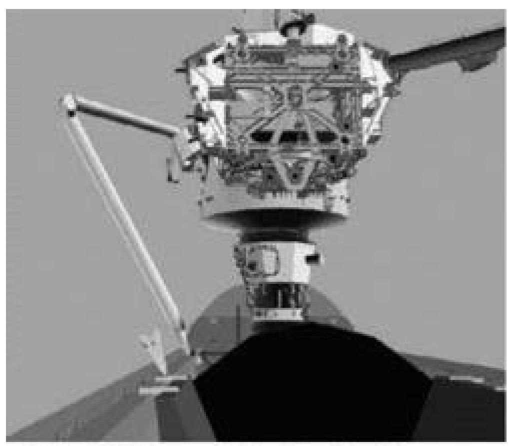


Figure 10. PMA-3- to Node 1 Umbilical Connection

History/Background

Installation of EVA Tool Stowage Devices (ETSDs)

The robot arm transports the EVA astronaut to the SLP, and he removes the launch restraints for ETSD 1. The arm then transports the astronaut and ETSD to the ISS port side (orbiter starboard side) of the Z1 aft face, where the ETSD corner pads are aligned with the Z1 brackets. Engagement is indicated when the Z1 corner guide soft-dock tabs latch over the ETSD corner brackets. Once the ETSD is soft docked, eight fasteners (four at each bracket) are engaged with a hard stop. The process is then repeated for the ETSD 2.

Figure 11 shows the ETSD installation.

Figure 11. ETSD Installation

Final Z1 and PMA-3 Umbilicals

Temporary EPS (APCU) jumpers A (W1002) and B (W1001), which were installed on Flight 2A, are removed from locations on the Unity forward zenith connector panel so the four Z1 umbilicals can be installed. Once APCU power is verified off, an EVA astronaut removes two APCU jumpers from the zenith side of Unity's forward end cone connector panel. Figure 12 shows this task, and Table 8 lists the function of each umbilical that is to be connected.

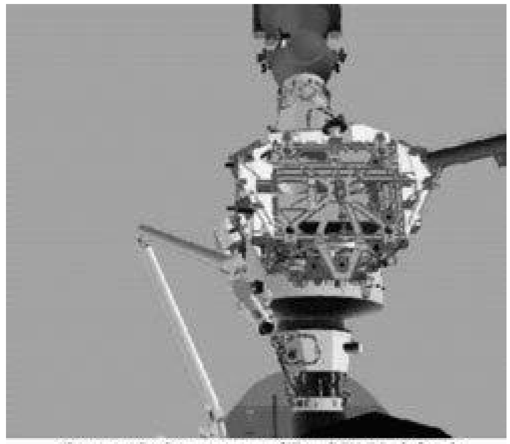


Figure 12. Connection of Final Z1 Umbilicals

After the four Z1 umbilicals are mated, the DDCU aliveness test can be performed on the ground. The PMA-3 and PMA-2 APCU node connectors can be swapped after the aliveness test is performed.

At this point, APCU power is no longer available to the ISS. This puts the ISS in a configuration to accept 140-volt APCU power on Mission 4A in support of P6 activation.

RTAS Launch Locks Removal

Lopez-Alegria uses the PGT to drive the primary bolt counterclockwise approximately 24 turns until it reaches a hard stop. Lopez-Alegria then pulls up on the pip pin to disengage the launch restraint from the bulkhead and disposes of it in a trash bag. This process is repeated for the three remaining bolts. This task must be completed after the Ku-band boom is deployed because of clearance problems.

Z1 Flight-Releasable Grapple Fixture (FRGF) Relocation

An EVA crew member disengages eight fasteners on the FRGF using the PGT and removes the FRGF from Z1. The SRMS transports the astronaut to the FRGF stowage location on Z1. The crew member inserts the FRGF through a hole in the zenith bulkhead and draws it up into the stowage bracket until it reaches a hard stop. Using the PGT, the astronaut engages two fasteners with a hard stop. Due to clearance problems, this task also must be completed after the Ku-band boom is deployed.

Deployment of Z1 Tray

This task supports the power-up of the U.S. Lab and PMA-2 relocation on Mission 5A. It must be performed after all Z1-to-Node 1 connectors are mated because access to the Node 1 zenith connector panel will be severely restricted once the tray is deployed. Wisoff, on the SRMS, holds the tray and applies 40 lbf against it in the stowed position while Lopez-Alegria, free floating, removes two pip pins and two restraint pins on the left and right of the tray. Lopez-Alegria then lifts the tray launch restraint bracket 3 inches.

Grasping the upper portion (zenith end) of the tray, Wisoff is transported through the unstow path by the robot arm. Wisoff adjusts the grasp position, as necessary, during the operation. Wisoff must apply up to 40 lbf from the initial unstow until the tray reaches the neutral position halfway through the deployment.

Final unstow also requires Wisoff to apply a force of up to 40 lbf until the tray reaches a hard stop. While Wisoff holds the tray in the deployed position, Lopez-Alegria engages pip pins at the starboard and port hinges to lock the tray. Wisoff folds the clevis down onto Z1 and stows the pip pins and restraint pins in the clevis. Lopez-Alegria free floats to the ISS starboard side of the clevis and attaches an adjustable tether to a loop on Z1. Lopez-Alegria feeds the free end of the tether through a loop on the clevis, hooks it on Z1, and tightens the tether. The tether stabilizes the position of the two space vision system (SVS) targets on the clevis, making the Z1 SVS target array ready for the P6-to-Z1 mating on Flight 4A.

Z1 Keel Pin Relocation

An EVA crew member unfastens two bolts using the Pistol grip tool with a 7/16-inch extension until the fastener plate tick marks are aligned with the end of the guide pins. A simultaneous push force of 5 pounds must be applied during torquing. The fasteners are stowed on the keel by attaching an adjustable tether to each fastener's lanyard and diagonally opposite handholds, snugging the tethers. The keel pin is detached, and the SRMS relocates the EVA astronaut and keel to the storage location on the starboard side of the zenith bulkhead. The crew member aligns the keel with the stowage lugs until a hard stop is reached. Using the Pistol grip tool, the astronaut inserts two bolts to attach the keel pin.

Cycle Z1 MBM Latch

This task must be performed after the Z1 tray is deployed because of structural clearance problems. The MBM capture latches are cycled, by fully deploying and then fully closing the latches, to verify their operability for future operations on Mission 5A/STS-98.

The crew retrieves the power tool that is used to actuate the capture latches on the Z1 MBM, removes an APFR from stowage, and moves to the worksite on the side of the Z1 MBM. The crew installs and enters the APFR and places the power tool over the microconical interface on the capture latch drive mechanism. The power tool drives the capture latches open to the deployed position. This position is the widest point at which the latches rotate away from the interface plane of the MBM.

While the power tool is turning the latch drive assembly, the EVA crew monitors the position indicator on the drive shaft. Two parallel columns of two holes each are 60 degrees apart on the shaft. These holes show the capture latches' position as the crew drives the mechanism. Markings fill the holes as the drive shaft moves the capture latches into position. When the markings fill the holes closest to the MBM, the latches are correctly deployed for capture, and the crew can stop the power tool. The crew removes the tool from the microconical interface and leaves the APFR. The operation is complete, and all supporting tools and equipment are returned to stowage.

Rocketdyne Truss Attachment System (RTAS) Capture Latch Cycle

The RTAS capture latch (the "claw") will be used to capture the P6 truss on Mission 4A. During Mission 3A, an EVA crew member cycles the latch to verify its functionality and leave it in a configuration to support P6 capture. This task is done in parallel with the keel pin relocation. The free-floating EVA astronaut moves to the worksite and opens the latch using the PGT. Once this is complete, the crew member cycles the latch closed and then open.

EVA Timeline for Z1 Assembly, Activation, and Checkout

Time	Event
3/15:20	EVA 1 Egress
3/15:00	EVA 1 Setup
3/16:06	EVA 1 Z1 String 1 Umb
3/17:40	EVA 1 SASA Relocate
3/19:11	EVA 1 Z1 String 2 Umb
3/18:10	EVA 1 SGANT Dish Install
3/19:09	EVA 1 SGANT Boom Deploy
3/19:30	EVA 1 Port ETSD Install
3/20:30	EVA 1 Cleanup
3/21:30	EVA 1 Ingress
4/15:10	EVA 2 Egress
4/15:15	EVA 2 Setup
4/15:55	EVA 2 PMA 3 Release from SLP
4/17:10	EVA 2 RTAS LL Release
4/17:10	EVA 2 CIDS Relocate
4/18:05	EVA 2 PMA 3 Install
4/18:40	EVA 2 RTAS LL Release
4/18:40	EVA 2 IAPFR Relocate
4/19:35	EVA 2 Connect PMA 3 Umb
4/20:25	EVA 2 Cleanup
4/21:40	EVA 2 Ingress
5/15:10	EVA 3 Egress
5/15:15	EVA 3 Setup
5/16:15	EVA 3 DDCU-HP 4B Install
5/17:05	EVA 3 DDCU-HP 3B Install

Time	Event
5/17:51	EVA 3 Final Z1 Umbs
5/18:20	EVA 3 Starboard ETSD Install
5/19:05	EVA 3 Final PMA 3 UMB
5/19:35	EVA 3 Z1 Keel Relocate
5/19:35	EVA 3 OHTS Bag Relocate
5/20:20	EVA 3 Cleanup
5/21:40	EVA 3 Ingress
6/15:30	EVA 4 Egress
6/15:35	EVA 4 Setup
6/16:35	EVA 4 RTAS Latch Cycle
6/17:05	EVA 4 Z1 Tray Deploy
6/17:35	EVA 4 MBM Cycle
6/18:07	EVA 4 4A APFR Relocated
6/18:35	EVA 4 Cleanup
6/19:35	EVA 4 SAFER Demo
6/21:05	EVA 4 Incap Crew Demo
6/21:45	EVA 4 Cleanup
6/22:00	EVA 4 Ingress

Updated: 09/30/2000

Payloads

Pressurized Mating Adapter 3
Payload Bay

Prime:
Backup:

Overview
Pressurized Mating Adaptor (PMA) 3 will provide a place for an orbiter to dock with the U.S. segment of the International Space Station (ISS). PMA-3 includes mechanical interfaces, spacewalk hardware and thermal control equipment, electrical power subsystem (EPS) and command and data handling (C&DH) passthroughs. PMA-3 will not be used for docking until Mission 4A/STS-97.

Command and Data Handling

PMA-3 provides a hard-line 1553 data bus connection between the orbiter and Unity via X-connectors on the PMA-3 androgynous peripheral attachment system (APAS), which interfaces with the orbiter docking system (ODS). Umbilical connections between Unity and PMA-3 complete this hard-line path. This path allows the orbiter interface units (OIUs) and orbiter portable computer system machines to talk on the ISS orbiter buses.

Extravehicular Activity (EVA) Support

The PMA-3 segment is equipped with the following spacewalk aids: A portable foot restraint (PFR) top-mounted worksite interface (WIF) fixture, two flight-releasable grapple fixtures (FRGFs), camera and laser targets, a number of Space Vision System (SVS) targets, handholds, and handrails.

The PFR WIF fixtures are used to attach the PFR workstation stanchions.

The FRGF provides the standard mechanical interface between the shuttle's robotic arm or remote manipulator system (SRMS) and payloads. It is compatible with all large ISS manipulator systems. The FRGF can be released during an EVA by rotating two release rods that allow the fixture's grapple shaft to be removed. A spare shaft can be installed on orbit, enabling the interface to be restored to a capture configuration for retrieving payloads.

Camera and laser targets consist of a camera target on the APAS hatch, a hemispherical laser target on PMA-3, and planar laser reflectors on the side of the APAS.

Handholds and handrails help EVA crew members move about. They have been placed in preplanned paths in and around worksites.

Motion Control System

PMA-3 has two sets of four red light-emitting diodes (LEDs) that tell the orbiter crew with the status of the ISS attitude control system. The crew can see the LEDs through the overhead window on the aft flight deck. Each set of four LEDs is controlled by a separate Node 1 MDM for one-fault tolerance during arrival or departure. Free drift is indicated when the two sets of LEDs alternately flash on and off at a 5-hertz rate. Every other state of the MCS is indicated by a steady on.

Structures and Mechanisms

The PMA-3 is a truncated conical shell with a 24-inch axial offset in the diameters between the end rings. It is a ring-stiffened shell structure machined from 2219 aluminum alloy roll ring forgings welded together. PMA-3 mechanical interfaces include a passive common berthing mechanism and a Russian APAS.

Thermal Control System

PMA-3 has ten 60-watt passive thermal control system heaters, temperature instrumentation, and multilayer insulation (MLI).

The PMA-3 shell's temperature is maintained above the minimum level by electrical resistance heater circuits, which are controlled by RPCM N1-RS2-B. Each heater has a resistive thermal device, which provides temperature data to the Node 1 MDMs. The ground or crew can control the shell heater states by altering the setpoints of the heaters.

Radiative heat loss and excessive radiative heating from the space environment are minimized by MLI blankets between a micrometeorite/orbital debris shield and the PMA's primary structure.

Updated: 09/30/2000

Payloads

Z1 Integrated Truss Segment

Payload Bay

Prime:
Backup:

Overview

The Z1 is the base structure for the U.S. solar array. It includes two plasma contactors, two DC-to-DC converter units (DDCUs), four control moment gyro (CMG) assemblies, part of one string of the S-band communications system, one Ku-band communications system, primary and secondary power distribution, thermal control system hardware, mechanical interfaces, and EVA/extravehicular robotics (EVR) hardware.

Command and Tracking Subsystem

S-Band Communications System. The S-band communications system consists of two redundant strings, each of which comprises three on-orbit replaceable units (ORUs) and two antennas, the baseband signal processor (BSP), the Tracking and Data Relay Satellite System (TDRSS) transponder, and the antenna RF group, which includes a low-gain antenna and a high-gain directional antenna.

The radio frequency group (RFG) has two main functions. It amplifies and filters the radio signal and receives and radiates the signal, providing the interface with free space. It also controls antenna switching and pointing.

The RFG unit has two antennas. The high-gain antenna (HGA) can support the high-rate data link, but it requires TDRSS pointing updates that are generated by the guidance, navigation, and control (GN&C) pointing function (which will not be available until the GN&C multiplexer/demultiplexer [MDM] is activated on Mission 5A). The low-gain antenna (LGA) is fixed in position and needs no pointing data.

The RFG is launched on the Z1 starboard bulkhead. Since this is the DDCU heat pipe (HP) installation location, the RFG must be relocated temporarily during EVA1 to the stowage bracket.

The BSP is the heart of the S-band system. It provides data and voice processing for downlink and uplink. A voice line connects directly to the BSP to provide voice communications.

The TDRSS transponder, which will arrive on Mission 4A, receives downlink information from the BSP and modulates the RF carrier for transmission to the ground. The transponder receives the uplink information from the RF group, demodulates the signal, and routes it to the BSP for information separation and distribution.

The downlink output of the BSP is a constant-rate data stream of either 192 kbps or 12 kbps, as specified by a configuration command.

To support the uplink, the BSP inputs a digital bit stream from the standard TDRSS transponder at either 72 or 6 kbps depending on whether the BSP is configured for the high or low data rate. The data is processed by decryption, CCSDS header validation, and demultiplexing functions. If uplink audio channel data is present, it is expanded to 192 kbps per channel for interface to the AUAIU and is routed to the appropriate output port. The uplink core data channel packets are passed to the 1553 interface for transfer to the command and control processor.

Ku-Band Communications System. The Ku-band system is the primary return link for International Space Station (ISS) video and payload data transmitted in digital format to the ground. The space-to-ground antenna (SGANT) will be relocated and attached to the single-beam boom of the current Ku-band antenna on EVA1.

The Ku-band provides a 50-Mbps fixed-rate downlink with up to four video signals or up to 43-Mbps high-rate data with 7 Mbps overhead. A communication outage recorder records payload data in the zone of exclusion and during structural blockage outages. There are 12 logical channels (4 video and 8 payload) in the Ku-band downlink.

Like the S-band system, the Ku-band system does not inspect the data passing through it.

The ISS transmits at a constant rate of 50 Mbps. Of this, 43 Mbps is available to the user.

The video channels can be configured to downlink full-motion video or stop-action video, which consists of skipping video frames. Normally, the service is configured on the ground and commanded through the S-band uplink to the on-board C&DH, which routes commands via the 1553 local bus to the Ku-band.

The on-board Ku-band equipment includes a single string of four avionics units-the video baseband signal processor (VBSP), high-rate frame multiplexer (HRFM), high-rate modem (HRM), and the transmit/receive controller (TRC)-plus an erectable, steerable antenna. Video signals must be processed by the VBSP before they are routed to the HRFM for interleaving with high-rate data (HRD). HRD comes from the payload patch directly to the HRFM for processing and interleaving with the video signal. The HRFM builds the downlink transfer frames and routes the data stream to the HRM for modulation on an S-band interface (I/F) frequency for routing to the TRC for translation to the Ku-band frequency. The data stream is power amplified and routed to the steerable antenna for transmission through the TDRSS to the ground. An uplink carrier is received and processed by the TRC to maintain antenna autotracking only.

Video channels are directed to the VBSP for processing. The VBSP has four audio and four video input channels and four video plus audio output channels. Connectors are also provided for power and 1553 bus and I/F data out. The four video plus audio output channels are directed to the HRFM. The VBSP performs audio and video analog-to-digital (A/D) format conversions, packet formatting, built-in test (BIT), and ORU control functions. The VBSP converts incoming analog signals to digital, formats them for the selected mode of operation, and forwards them to the HRFM for interleaving with high-rate payload data.

Electrical Power Subsystem

The Z1 truss assembly has several power distribution components. These include two initialization diode assemblies (IDAs), two secondary power distribution assemblies (SPDAs), two plasma contactor units (PCUs), two DDCUs, and two patch panels.

The IDAs provide diode-protected power from the shuttle assembly power conversion unit (APCU) to P6 for module initialization on Mission 4A. They also provide a connection path from P6 to the lab DDCUs from Mission 5A until Mission 12A, when the P4 module will be delivered.

The SPDAs consist of remote power controller modules (RPCMs), power and data connections (central utility rail), and a cold plate. They control, protect, and isolate secondary distribution lines. The SPDAs accept secondary power from the DDCUs and distribute this power to RPDAs or downstream loads. The SPDA cold plates transfer heat from the RPCMs via radiant fins.

The central utility rail provides power connections from the DDCU power feed to the RPCMs and data connections via redundant 1553B data buses. Because the DDCUs will not be active during Mission 3A, SPDAs Z1-3B and Z1-4B will receive power directly from Russian-American conversion units (RACUs) 5 and 6, respectively.

RPCMs are electronic switches that control, protect, and isolate secondary distribution lines. There are six types of RPCMs, which differ in their rated output current, number of switches per module, and trip functions.

The PCU emits electrons through a self-generated plasma and is self-regulating. The PCUs control the voltage between the space plasma and the ISS structure. PCUs mounted on the Z1 truss maintain the structure potential of the ISS within 40 volts of the plasma potential. A central element of each PCU is the hollow cathode assembly (HCA), which emits up to 10 amps of electron current to the ambient plasma. The PCU actively emits when the ISS is in sunlight. Without the PCUs, the ISS could reach structure potentials of approximately -150 volts.

Two DDCUs, which are launched attached to cargo handling interface adapters (CHIAs), will be delivered during STS-92. The DDCUs will be removed from the CHIAs and attached to the starboard side of Z1 during EVA1. The units convert power from primary (115 to 173 volts DC) to secondary (123 to 126 volts DC). They will not be activated until Mission 4A, when P6 power comes on line.

Two patch panels on the port side of Z1 allow the Z1 input power source to be changed. On the outside of the panels are a fixed output and three interchangeable input connectors. To change the panel configuration, an umbilical is simply demated and mated to a different connector on the patch panel. The launch configuration of the patch panels provides Russian segment (RS) power to Z1 components for keep-alive purposes. The panels will be reconfigured during Mission 4A to prepare for the transition to U.S. power via P6.

Extravehicular Activity Subsystems

The Z1 truss segment is equipped with several spacewalk aids: Two EVA tool stowage devices (ETSDs), 22 worksite interface (WIF) sockets, 1 flight-releasable grapple fixture (FRGF), 11 trusses, 2 tray launch restraints, numerous standard handholds and handrails, and several custom handles.

Motion Control Subsystem

The motion control subsystem (MCS) hardware launched as part of the Z1 element includes the CMGs and the CMG assemblies. This hardware will not be activated until Mission 5A, when the GN&C MDM will be activated with the U.S. Lab.

The CMG assembly consists of four CMGs and a micrometeorite/orbital debris shield. The four CMGs, which will control the attitude of the ISS, have a spherical momentum storage capability of 14,000 ft-lb/sec, the scalar sum of the individual CMG wheel moments. The momentum stored in the CMG system at any given time equals the vector sum of the individual CMG momentum vectors.

To maintain the ISS in the desired attitude, the CMG system must cancel, or absorb, the momentum generated by the disturbance torques acting on the station. If the average disturbance torque is nonzero, the resulting CMG output torque is also nonzero, and momentum builds up in the CMG system. When the CMG system saturates, it is unable to generate the torque required to cancel the disturbance torque, which results in the loss of attitude control.

The CMG system saturates when momentum vectors have become parallel and only momentum vectors change. When this happens, control torques perpendicular to this parallel line are possible, and controllability about the parallel line is lost.

Russian segment thrusters are used to desaturate the CMGs.

An ISS CMG consists of a large flat wheel that rotates at a constant speed (6,600 rpm) and develops an angular momentum of 3,500 ft-lb/sec about its spin axis. This rotating wheel is mounted in a two-degree-of-freedom gimbal system that can point the spin axis (momentum vector) of the wheel in any direction.

At least two CMGs are needed to provide attitude control. The CMG generates an output reaction torque that is applied to the ISS by inertially changing the direction of its wheel momentum. The CMG's output torque has two components, one proportional to the rate of change of the CMG gimbals and a second proportional to the inertial body rate of the ISS as sensed at the CMG base. Because the momentum along the direction of the spin axis is fixed, the output torque is constrained to lie in the plane of the wheel. That is why one CMG cannot provide the three-axis torque needed to control the attitude of the ISS.

Each CMG has a thermostatically controlled survival heater to keep it within thermal limits before the CMGs are activated on Mission 5A. The heaters are rated at 120 watts and have an operating temperature range of -42 to -35°F.

Structures and Mechanisms

Mechanical interfaces are provided between Z1 and the P6 long spacer on the Z1 zenith face, between Z1 and Node 1 on the Z1 nadir face, between Z1 and PMA-2 on the Z1 forward face, and across a cable tray from the Z1 forward face to the U.S. Lab.

A manual berthing mechanism (MBM) on the forward face of Z1 allows temporary stowage of PMA-2. The device is similar to the one used on the Spacelab pallet to stow PMA-3 on this flight (but without the perimeter bolts).

A hinged cable tray on the forward face of Z1 provides a direct interface for power, data, and coolant lines to the U.S. Lab. Mission 3A EVA crew members will deploy the tray to expose the MBM and will release 32 bolts on the 4 coolant lines.

The Z1 truss structure is designed to maximize component packaging and support load paths during launch and on orbit. A solid plate beneath the CMG face provides additional protection from micrometeorites and orbital debris for the CMGs and other Z1 components. The structural framework beam and shell elements are aluminum 2219-T851. The trunnion and keel pin beam elements are INCO 718, and the Ku-band antenna boom beam elements are steel.

Thermal Control Subsystem

The Z1 truss assembly includes the following elements of the early external active thermal control system (EEATCS): 4 accumulators, ammonia, and 12 quick disconnects and associated plumbing. The accumulators charge the EEATCS with ammonia on orbit, accommodate thermal expansion in the fluid, and maintain the system's operating pressure. The quick disconnects facilitate the connection of ammonia transfer lines between P6 and Z1 and between Z1 and the U.S. Lab.

Updated: 09/30/2000

STS-92

Incapacitated EVA Crewmember Translation
DTO 675

Overview
The object of this DTO is to verify techniques to allow a spacewalking crewmember to return a fellow EVA crewmember who is incapacitated to the shuttle airlock. The DTO will evaluate several techniques to determine how efficient each is.

This DTO will only be performed if all station assembly tasks are completed and consumables are available.

Safer Flight Demonstration

DTO 689

Overview

The purpose of the DTO is to demonstrate that the Simplified Aid for EVA Rescue (SAFER) performs as expected, and to build confidence in the design through an end-to-end, on-orbit functional checkout.

There are two test objectives that check out rotation/translation controllers and perform a point-to-point translation.

This DTO will be performed only if all station assembly tasks are complete and consumables are available.

Single-String Global Positioning System

DTO 700-14

Overview

DTO 700-14 will demonstrate the performance and operation of the Global Positioning System (GPS) during ascent, orbital and entry phases of the flight. It uses a modified military GPS receiver/processor and the existing orbiter GPS antennas and records data on a payload and general support computer (PGSC) hard drive.

STS-92

Solid-State Star Tracker (SSST) Size Limitations

DTO 847

Overview

The objective of this DTO is to characterize the performance of the Solid State Star Tracker (SSST) with a large and bright target. The assumption is that the SSST (-Y star tracker) will be able to track an object large enough and bright enough to eliminate the potential problems with the Image Dissecting Tracker (-Z star tracker) during day tracker passes for station flights.

STS-92

Structural Dynamics Model Verification

DTO 257

Overview

This DTO will fire a sequence of primary reaction control system (RCS) jets and observe the effects of the firings on the structural dynamics of the mated shuttle and International Space Station complex. The test is designed to confirm that primary reaction control system jet firings are acceptable for use if vernier reaction control system jets are not available.

Shuttle Reference and Data

Shuttle Abort Modes

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).

ABORT TO ORBIT (ATO)

The ATO mode is designed to allow the vehicle to achieve a temporary orbit that is lower than the nominal orbit. This mode requires less performance and allows time to evaluate problems and then choose either an early deorbit maneuver or an orbital maneuvering system thrusting maneuver to raise the orbit and continue the mission.

ABORT ONCE AROUND (AOA)

The AOA is designed to allow the vehicle to fly once around the Earth and make a normal entry and landing. This mode generally involves two orbital maneuvering system thrusting sequences, with the second sequence being a deorbit maneuver. The entry sequence would be similar to a normal entry.

TRANSOCEANIC ABORT LANDING (TAL)

The TAL mode is designed to permit an intact landing on the other side of the Atlantic Ocean. This mode results in a ballistic trajectory, which does not require an orbital maneuvering system maneuver.

RETURN TO LAUNCH SITE (RTLS)

The RTLS mode involves flying downrange to dissipate propellant and then turning around under power to return directly to a landing at or near the launch site.

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.

RETURN TO LAUNCH SITE OVERVIEW

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.

TRANSATLANTIC LANDING ABORT OVERVIEW

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 OVERVIEW

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 OVERVIEW

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 ABORT OVERVIEW

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.

Space Shuttle External Tank

The external tank contains the liquid hydrogen fuel and liquid oxygen oxidizer and supplies them under pressure to the three space shuttle main engines in the orbiter during lift-off and ascent. When the SSMEs are shut down, the ET is jettisoned, enters the Earth's atmosphere, breaks up, and impacts in a remote ocean area. It is not recovered.

The largest and heaviest (when loaded) element of the space shuttle, the ET has three major components: the forward liquid oxygen tank, an unpressurized intertank that contains most of the electrical components, and the aft liquid hydrogen tank. The ET is 153.8 feet long and has a diameter of 27.6 feet.

The ET is attached to the orbiter at one forward attachment point and two aft points. In the aft attachment area, there are also umbilicals that carry fluids, gases, electrical signals and electrical power between the tank and the orbiter. Electrical signals and controls between the orbiter and the two solid rocket boosters also are routed through those umbilicals.

Liquid Oxygen Tank

The liquid oxygen tank is an aluminum monocoque structure composed of a fusion-welded assembly of preformed, chem-milled gores, panels, machined fittings and ring chords. It operates in a pressure range of 20 to 22 psig. The tank contains anti-slosh and anti-vortex provisions to minimize liquid residuals and damp fluid motion. The tank feeds into a 17-inch-diameter feed line that conveys the liquid oxygen through the intertank, then outside the ET to the aft right-hand ET/orbiter disconnect umbilical. The 17-inch-diameter feed line permits liquid oxygen to flow at approximately 2,787 pounds per second with the SSMEs operating at 104 percent or permits a maximum flow of 17,592 gallons per minute. The liquid oxygen tank's double-wedge nose cone reduces drag and heating, contains the vehicle's ascent air data system (for nine tanks only) and serves as a lightning rod. The liquid oxygen tank's volume is 19,563 cubic feet. It is 331 inches in diameter, 592 inches long and weighs 12,000 pounds empty.

Intertank

The intertank is a steel/aluminum semimonocoque cylindrical structure with flanges on each end for joining the liquid oxygen and liquid hydrogen tanks. The intertank houses ET instrumentation components and provides an umbilical plate that interfaces with the ground facility arm for purge gas supply, hazardous gas detection and hydrogen gas boiloff during ground operations. It consists of mechanically joined skin, stringers and machined panels of aluminum alloy. The intertank is vented during flight. The intertank contains the forward SRB/ET attach thrust beam and fittings that distribute the SRB loads to the liquid oxygen and liquid hydrogen tanks. The intertank is 270 inches long, 331 inches in diameter and weighs 12,100 pounds.

Liquid Hydrogen Tank

The liquid hydrogen tank is an aluminum semimonocoque structure of fusion-welded barrel sections, five major ring frames, and forward and aft ellipsoidal domes. Its operating pressure range is 32 to 34 psia. The tank contains an anti-vortex baffle and siphon outlet to transmit the liquid hydrogen from the tank through a 17-inch line to the left aft umbilical. The liquid hydrogen feed line flow rate is 465 pounds per second with the SSMEs at 104 percent or a maximum flow of 47,365 gallons per minute. At the forward end of the liquid hydrogen tank is the ET/orbiter forward attachment pod strut, and at its aft end are the two ET/orbiter aft attachment ball fittings as well as the aft SRB/ET stabilizing strut attachments. The liquid hydrogen tank is 331 inches in diameter, 1,160 inches long, and has a volume of 53,518 cubic feet and a dry weight of 29,000 pounds.

ET Thermal Protection System

The ET thermal protection system consists of sprayed-on foam insulation and premolded ablator materials. The system also includes the use of phenolic thermal insulators to preclude air liquefaction. Thermal isolators are required for liquid hydrogen tank attachments to preclude the liquefaction of air-exposed metallic attachments and to reduce heat flow into the liquid hydrogen.

ET Hardware

Each propellant tank has a vent and relief valve at its forward end. This dual-function valve can be opened by ground support equipment for the vent function during prelaunch and can open during flight when the ullage (empty space) pressure of the liquid hydrogen tank reaches 38 psig or the ullage pressure of the liquid oxygen tank reaches 25 psig.

The liquid oxygen tank contains a separate, pyrotechnically operated, propulsive tumble vent valve at its forward end. At separation, the liquid oxygen tumble vent valve is opened, providing impulse to assist in the separation maneuver and more positive control of the entry aerodynamics of the ET.

There are eight propellant-depletion sensors, four each for fuel and oxidizer. The fuel-depletion sensors are located in the bottom of the fuel tank. The oxidizer sensors are mounted in the orbiter liquid oxygen feed line manifold downstream of the feed line disconnect. During SSME thrusting, the orbiter general-purpose computers constantly compute the instantaneous mass of the vehicle due to the usage of the propellants. Normally, main engine cutoff is based on a predetermined velocity; however, if any two of the fuel or oxidizer sensors sense a dry condition, the engines will be shut down.

The locations of the liquid oxygen sensors allow the maximum amount of oxidizer to be consumed in the engines, while allowing sufficient time to shut down the engines before the oxidizer pumps cavitate (run dry). In addition, 1,100 pounds of liquid hydrogen are loaded over and above that required by the 6:1 oxidizer/fuel engine mixture ratio. This assures that MECO from the depletion sensors is fuel-rich; oxidizer-rich engine shutdowns can cause burning and severe erosion of engine components.

Four pressure transducers located at the top of the liquid oxygen and liquid hydrogen tanks monitor the ullage pressures.

Each of the two aft external tank umbilical plates mate with a corresponding plate on the orbiter. The plates help maintain alignment among the umbilicals. Physical strength at the umbilical plates is provided by bolting corresponding umbilical plates together. When the orbiter GPCs command external tank separation, the bolts are severed by pyrotechnic devices.

The ET has five propellant umbilical valves that interface with orbiter umbilicals: two for the liquid oxygen tank and three for the liquid hydrogen tank. One of the liquid oxygen tank umbilical valves is for liquid oxygen, the other for gaseous oxygen. The liquid hydrogen tank umbilical has two valves for liquid and one for gas. The intermediate-diameter liquid hydrogen umbilical is a recirculation umbilical used only during the liquid hydrogen chill-down sequence during prelaunch.

The ET also has two electrical umbilicals that carry electrical power from the orbiter to the tank and the two SRBs and provide information from the SRBs and ET to the orbiter.

A swing-arm-mounted cap to the fixed service structure covers the oxygen tank vent on top of the ET during the countdown and is retracted about two minutes before lift-off. The cap siphons off oxygen vapor that threatens to form large ice on the ET, thus protecting the orbiter's thermal protection system during launch.

ET Range Safety System

A range safety system provides for dispersing tank propellants if necessary. It includes a battery power source, a receiver/decoder, antennas and ordnance.

Various parameters are monitored and displayed on the flight deck display and control panel and are transmitted to the ground.

The contractor for the external tank is Martin Marietta Aero space, New Orleans, La. The tank is manufactured at Michoud, La. Motorola, Inc., Scottsdale, Ariz., is the contractor for range safety receivers.

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

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 (41 statute miles). SRB impact occurs in the ocean approximately 122 nautical miles (141 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.

Space Shuttle Super Light Weight Tank (SLWT)

The super lightweight external tank (SLWT) made its first Shuttle flight June 2, 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/D	Analog to Digital
AC	Assembly Contingency
ACBM	Active Common Berthing Mechanism
ACBSP	Assembly Contingency Baseband Signal Processor
ACRFG	Assembly Contingency RF Group
ACS	Attitude Control System
AD	Active Device
AFD	Aft Flight Deck
AGIT	Antenna Group Interface Tube
AKA	Active Keel Assembly
AOH	Assembly Operations Handbook
APAS	Androgynous Peripheral Attachment System
APCU	Assembly Power Conversion Unit
APFR	Articulating Portable Foot Restraint
AR	Atmosphere Revitalization
ASCR	Assured Safe Crew Return
AUAIU	Audio Interface Unit
B/U	Backup
BIT	Built-In Test
BITE	Built-In Test Equipment
BIU	Bus Interface Unit
BMR	Body-Mounted Radiator
BSP	Baseband Signal Processor
C&C	Command and Control
C&DH	Command and Data Handling
C&T	Communications and Tracking
C&W	Caution and Warning
CBM	Common Berthing Mechanism
CC	Central Computer
CCSDS	Consultative Committee for Space Data System
CCTV	Closed Circuit Television
CCW	Counterclockwise
CDRA	Carbon Dioxide Removal Assembly
CHIA	Cargo Handling Interface Adapter
CL	Close
CMG	Control Moment Gyro
COTS	Commercial-off-the-Shelf
CP	Coldplate
CTP	Command/Telemetry Processor
DAP	Digital Auto Pilot
DCCU	DC to DC Connector Unit
DDCU	Direct Current-to-Direct Current/Converter Unit
DMS	Data Management Subsystem
DSCU	Docking System Control Unit

EATC	External Active Thermal Control
ECLSS	Environmental Control and Life Support System
ECOMM	Early Communications System
EDAC	Error Detection and Correction
EEATCS	Early External Active Thermal Control System
EEPROM	Electrically Erasable Programmable Read Only Memory
EMU	Extravehicular Maneuvering Unit
ENA	Enable
EPCS	Early Portable Computer System
EPS	Electrical Power Subsystem
ERSU	External Remote Sensing Unit
ESA	European Space Agency
ETSD	EVA Tool Stowage Device
EVA	Extravehicular Activity
EVAS	Extravehicular Activity Support
EVR	Extravehicular Robotics
FBOLT	Final Preload Bolt
FD	Flight Day
FDF	Flight Data File
FDIR	Fault Detection, Isolation, and Recovery
FDS	Fire Detection and Suppression
FGB	Functional Cargo Block
FRGF	Flight Releasable Grapple Fixture
FRM CTR	Frame Counter
GFE	Government-Furnished Equipment
GLONASS	Global Navigational Satellite System
GN&C	Guidance, Navigation, and Control
GPC	General Purpose Computer
HCA	Hollow Cathode Assembly
HEI	Hernandez Engineering, Inc.
HGA	High-Gain Antenna
HRD	High-Rate Data
HRFM	High-Rate Frame Multiplexer
HRM	High-Rate Modem
HX	Heat Exchanger
I/F	Interface
IATC	Internal Active Thermal Control
IBOLT	Initial Preload Bolt
ICD	Interface Control Document
IDA	Initialization Diode Assembly
IMV	Intermodule Ventilation
INH	Inhibit
INP	Input
ISS	International Space Station
ITS	Integrated Truss Segment
IVA	Intravehicular Activity
IWIS	Internal Wireless Instrumentation System

JOP	Joint Operations Panel
JSC	Lyndon B. Johnson Space Center
L/L	Liquid to Liquid
LAN	Land Area Network
LGA	Low-Gain Antenna
LSM	Life Support Module
LT	Low Temperature
LTA	Launch to Activation
LVLH	Local Vertical/Local Horizontal
M/OD	Micrometeorite/Orbital Debris
MBM	Manual Berthing Mechanism
	Modified Berthing Mechanism
MCC	Mission Control Center
MCC-H	Mission Control Center - Houston
MCC-M	Mission Control Center - Moscow
MCDS	Multi-CRT Display System
MCS	Motion Control System
MDM	Multiplexer/Demultiplexer
MIL-STD	Military Standard
MLI	Multilayer Insulation
MOD	Mission Operations Directorate
MPEV	Manual Pressure Equalization Valve
MPM	Manipulator Positioning Mechanism
MRK	Moisture Removal Kit
MRL	Manipulator Retention Latch
MT	Moderate Temperature
NASA	National Aeronautics and Space Administration
NCC	Nominal Course Correction
NCS	Node Control Software
NCU	Network Control Unit
NPRV	Negative Pressure Relief Valve
NIU	Network Interface Unit
OCA	Orbiter Communications Adapter
OCC	Onboard Computer System
ODF	Operations Data File
ODS	Orbiter Docking System
ODTS	
OIU	Orbiter Interface Unit
OMS	Onboard Measuring Subsystem
OP	Open
ORU	On-Orbit Replaceable Unit
OS	On-Orbit Segment
OUT	Output

PCBM	Passive Common Berthing Mechanism
PCM	Pulse Code Modulation
PCMMU	Pulse Code Modulation Master Unit
PCN	Page Change Notice
PCS	Portable Computer System
PCU	Plasma Contactor Unit
PD	Physical Device
PDU	Power Distribution Unit
PFR	Portable Foot Restraint
PFRWS	Portable Foot Restraint Workstation Stanchion
PGSC	Payload and General Support Computer
PGT	Pistol Grip Tool
PMA	Pressurized Mating Adapter
PRI	Primary
psid	Pounds Per Square Inch - Differential
PRLA	Payload Retention Latch Assembly
PTCS	Passive Thermal Control System
RACU	Russian American Conversion Unit
RCS	Remote
RF	Radio Frequency
RFG	Radio Frequency Group
RMS	Remote Manipulator System
ROS	Russian On-Orbit Segment
RPC	Remote Power Connector
RPCM	Remote Power Controller Mode
RPDA	Remote Power Distribution Assembly
RR	Rendezvous Radar
RS	Russian Segment
RSA	Russian Space Agency
RSU	Remote Sensing Unit
RTAS	Rocketdyne Truss Attachment System
RTD	Resistive Temperature Device
RTS	Radiotelemetry System
S&M	Structures and Mechanisms
SAG	S-Band Antenna Group
SASA	S-Band Antenna Subassembly
SEC	Secondary
SECAM	
SFOC	Space Flight Operations Contract
SGANT	Space-to-Ground Antenna
SGTRC	Space-to-Ground Transmit/Receive Controller
SHF	S-Band High Frequency
SLP	Spacelab-Pallet
SM	Service Module
SMCC	Shuttle Mission Control CenterR
SODF	Station Operations Data File
SPDA	Secondary Power Distribution Assembly
SRMS	Shuttle Remote Manipulator System
SSP	Space Shuttle Program

	Standard Switch Panel
SSRMS	Space Station Remote Manipulator System
STBD	Starboard
SWIS	Shuttle-Based Wireless Instrumentation System
TC	Terminal Computer
TCS	Thermal Control Subsystem
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TEA	Torque Equilibrium Attitude
THC	Temperature and Humidity Control
Ti	Terminal Phase Initiation
TRC	Transmit/Receive Control
TTCS	Telephone-Telegraph Communication Subsystem
UHF	Ultra High Frequency
US	
USA	United Space Alliance
USL	United States Laboratory
USOS	United States On-Orbit Segment
USW	Ultra Short Wave
VBSP	Video Baseband Signal Processor
VRCS	Vector/Vernier Reaction Control System
VTS	Video-Teleconferencing System
WIF	Worksite Interface
WIS	Wireless Instrumentation System
WM	Waste Management
WRM	Water Recovery and Management
WS	Worksite
WSGT	White Sands Ground Terminal
XCVR	Transmitter/Receiver

Mission Benefits

Research on the International Space Station

The International Space Station represents a quantum leap in our capability to conduct research on orbit. It will serve as a laboratory for exploring basic questions in a variety of disciplines, and as a testbed and springboard for exploration. Research on the ISS will include commercial, science, and engineering research in the following areas:

Advanced Human Support Technology: Researchers develop technologies, systems, and procedures to enable safe and efficient human exploration and development of space.

Long Term Benefits: Reduce the cost of space travel while enhancing safety; develop small, low power monitoring and sensing technologies with applications in environmental monitoring in space and on Earth; and develop advanced waste processing and agricultural technologies with applications in space and on Earth.

Biomedical Research and Countermeasures: Researchers seek to understand and control the effects of the space environment on space travelers (e.g. muscle atrophy, bone loss, fluid shifts, . . .).

Long Term Benefits: Enhance the safety of space travel; develop methods to keep humans healthy in low-gravity environments; and advance new fields of research in the treatment of diseases,

Fundamental Biology: Scientists study gravity's influence on the evolution, development, growth, and internal processes of plants and animals. Their results expand fundamental knowledge that will benefit medical, agricultural, and other industries.

Long Term Benefits: Advance understanding of cell, tissue, and animal behavior;use of plants as sources of food and oxygen for exploration; improved plants for agricultural and forestry,

Biotechnology: Microgravity allows researchers to grow three-dimensional tissues that have characteristics more similar to tissues in the body than has ever been previously available and to produce superior protein crystals for drug development.

Long Term Benefits: Culture realistic tissue for use in research (cancerous tumors, organ pieces); and provide information to design a new class of drugs to target specific proteins and cure specific diseases,

Fluid Physics: The behavior of fluids is profoundly influenced by gravity. Researchers use gravity as an experimental variable to explain and model fluid behavior in systems on Earth and in space.

Long Term Benefits: Improved spacecraft systems designs for safety and efficiency; better understanding of soil behavior in earthquake conditions; and improved mathematical models for designing fluid handling systems for powerplants, refineries and innumerable other industrial applications

Materials Science: Researchers use low gravity to advance our understanding of the relationships among the structure, processing and properties of materials. In low gravity, differences in weight of liquids used to form materials do not interfere with the ability to mix these materials opening the door to a whole new world of composite materials.

Long Term Benefits: Advance understanding of processes for manufacturing semiconductors, metals, ceramics, polymers, and other materials; and determine fundamental physical properties of molten metal, semiconductors, and other materials with precision impossible on Earth.

Combustion Science: The removal of gravity allows scientists to simplify the study of complex combustion (burning) processes. Since combustion is used to produce 85 percent of Earth's energy, even small improvements in efficiency and reduction of soot production (a major source of pollution on earth) will have large environmental and economic benefits.

Long Term Benefits: Enhance efficiency of combustion processes; enhance fire detection and safety on Earth and in Space; and improve control of combustion emissions and pollutants

Fundamental Physics: Scientists use the low gravity and low temperature environment to slow down reactions allowing them to test fundamental theories of physics with degrees of accuracy that far exceed the capacity of Earthbound science.

Long Term Benefits: Challenge and expand theories of how matter organizes as it changes state (important in understanding superconductivity); test fundamental theories in physics with precision beyond the capacity of Earth-bound science; and potential for improved magnetic materials

Earth Science and Space Science: Space Station will be a unique platform with multiple exterior attach points from which to observe the Earth and the Universe.

Long Term Benefits: Space Scientists will use the location above the atmosphere to collect and search for cosmic rays, cosmic dust, antimatter and "dark" matter. Earth Scientists can obtain global profiles of aerosols, ozone, water vapor, and oxides in order to determine their role in climatological processes and take advantage of the longevity of ISS to observe global changes over many years.

Mission Benefits

The Space Shuttle, Still Young at 100

Safer, More Capable and More Reliable Than Ever Before

1. The shuttle has amassed an amazing array of accomplishments in the past 20 years:

It has launched 3 million pounds of cargo and almost 600 (596 counting the STS-92 crew) passengers and pilots.

The shuttle fleet has cumulatively spent almost three years in flight (2 years, 336 days, 14 hours, 47 minutes, 59 seconds to be exact, not including the planned duration of STS-92).

The fleet has amassed more than 15 years of passenger-hours in space.

Over 850 payloads have flown, including hundreds of individual experiments.

The Shuttle has deployed more than 60 payloads and retrieved more than two dozen.

The shuttle has traveled more than 345 million miles (not including STS-92) and completed more than 13,500 orbits of Earth (exactly 13,573, not including STS-92).

2. The shuttle has enabled us to make unprecedented discoveries about ourselves, our planet and our universe.

The shuttle has supported two space stations, made three maintenance flights to the Hubble Space Telescope and launched planetary missions to study Jupiter, Venus and the Sun. All of NASA's

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.

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SHUTTLE FLIGHTS AS OF OCTOBER 2000

99 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM -- 74 SINCE RETURN TO FLIGHT

		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-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 (27 flights)**	**OV-104 Atlantis (22 flights)**	**OV-105 Endeavour (14 flights)**

Table prepared by Richard W. Orloff, 02/2001