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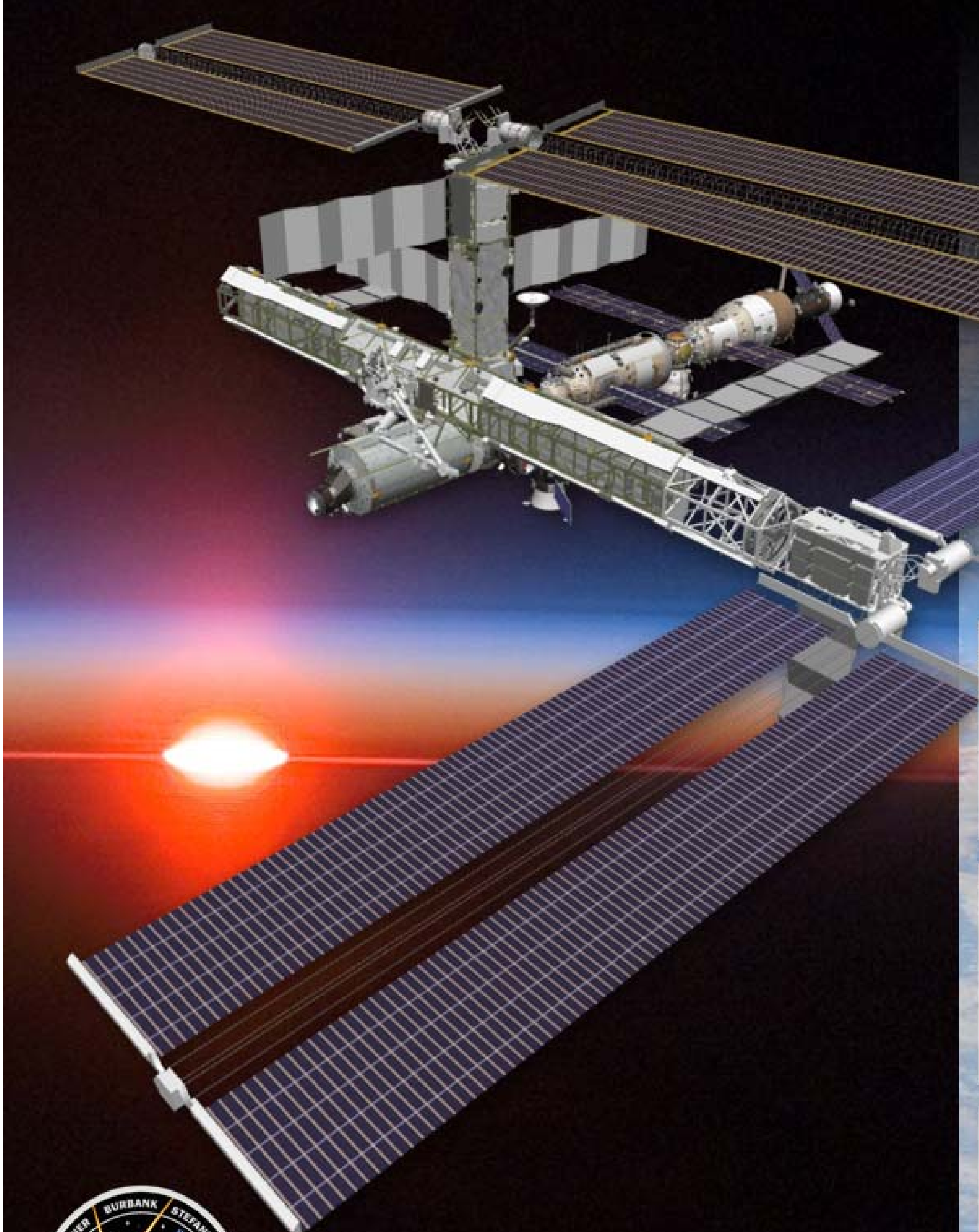

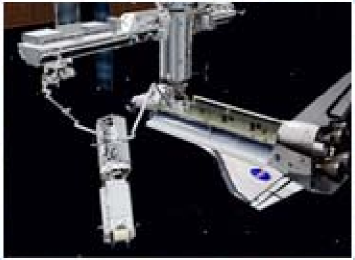

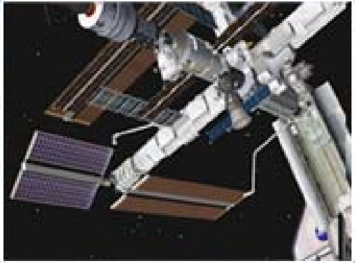

RETURN TO ASSEMBLY
STS-115

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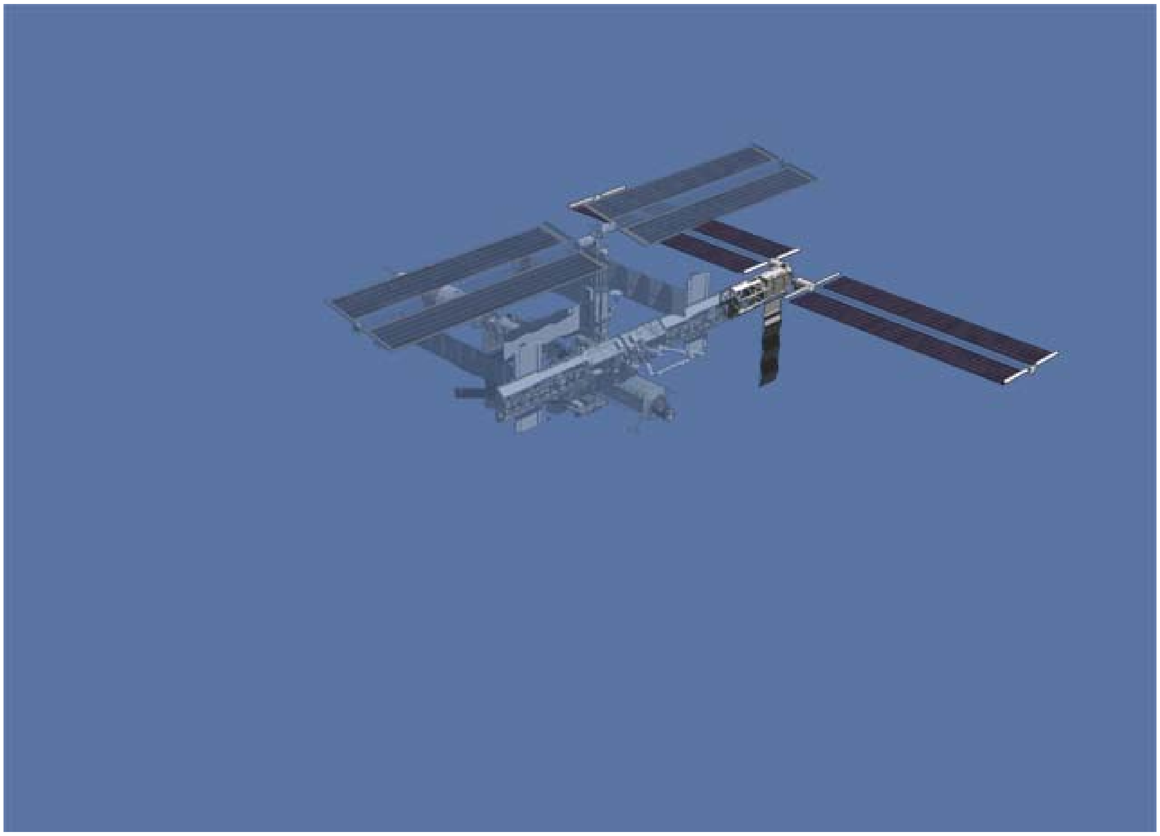
STS-115 MISSION OVERVIEW: SPACE STATION ASSEMBLY RESUMES



Configuration of the International Space Station at the completion of STS-115

For the first time since late 2002, assembly of the International Space Station (ISS) will resume on the STS-115 mission.

Six astronauts will be launched on the Space Shuttle Atlantis on the 116th shuttle mission and the 27th flight of Atlantis to deliver and install the 17-and-a-half ton P3 / P4 truss segment to the port side of the integrated truss system of the orbital outpost. The truss, part of the station's girder-like backbone, includes a new set of photovoltaic solar arrays. When unfurled to their full length of 240 feet, the arrays will provide additional power for the station in preparation for the delivery of international science modules over the next two years. Each of the 82 active array blankets that are grouped into 31-and-a-half "bays" contain 16,400 individual silicon photovoltaic cells to convert sunlight into electricity.

The truss also contains a device called the Solar Alpha Rotary Joint (SARJ), which will rotate 360 degrees either clockwise or counterclockwise to position the P4 and P6 solar arrays to track the sun for electrical power generation.

Space Shuttle Atlantis rolled over from the Orbiter Processing Facility to the Vehicle Assembly Building in late July in preparation for STS-115

Atlantis is scheduled to liftoff from Launch Pad 39-B at NASA's Kennedy Space Center, Florida, no earlier than late August. As was the case for the just completed STS-121 mission, Atlantis' launch is governed by daylight lighting requirements at the Florida spaceport and the proper lighting in orbit for photography of the external fuel tank once it is jettisoned eight and a half minutes after launch.

Each day's launch opportunity will be about five minutes long, timed to when the rotation of the Earth places the Kennedy Space Center in the plane of the station's orbit.

STS-115 is expected to last 11 days with the three scheduled spacewalks planned for flight days 4, 5 and 7. If a focused inspection of Atlantis' heat shield is requested once the shuttle is at the station, the flight could be extended by one or two days, changing the flight days on which the three spacewalks will be conducted.

The mission is commanded by Navy Capt. Brent Jett, 47, a veteran of three previous spaceflights, including the STS-97 mission in 2000 to the ISS that delivered the first U.S. solar arrays on the P6 truss structure.

Jett is joined by Navy Capt. Chris Ferguson, 45, a first-time flyer who will serve as the mission's pilot. Joe Tanner, 56, will lead two teams of

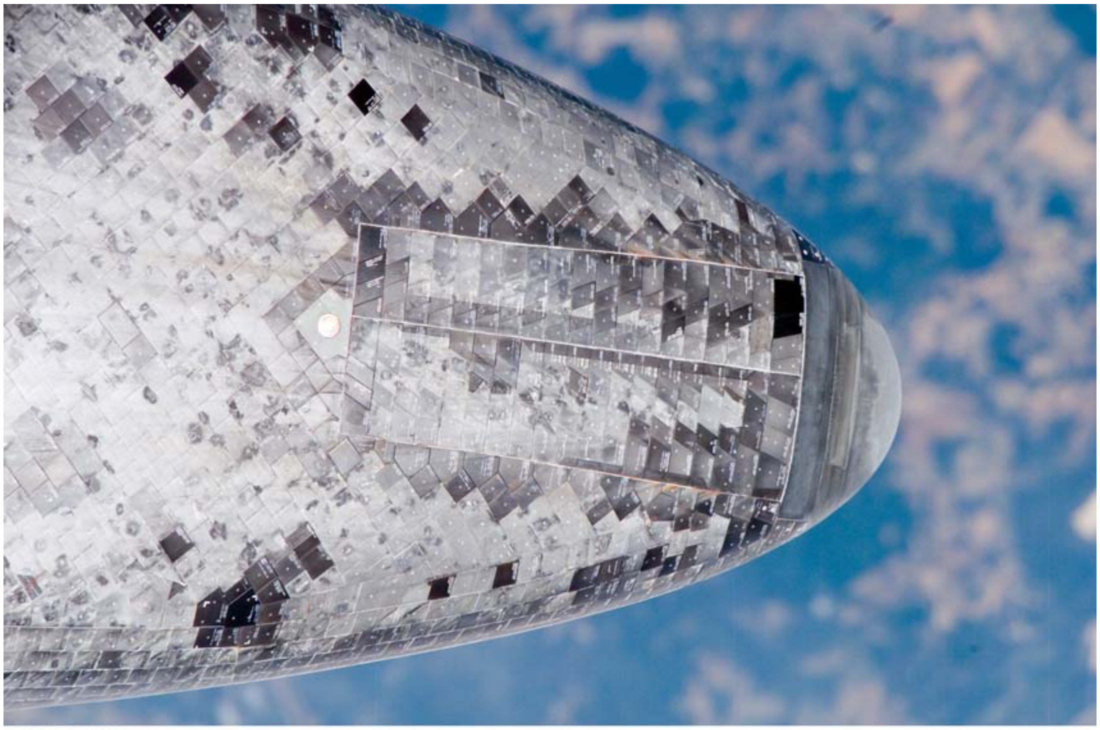
STS-115 Commander Brent Jett

spacewalkers in his fourth flight into space. Tanner was a crewmate of Jett's on the STS-97 mission. Coast Guard Cmdr. Dan Burbank, 45, makes his second flight to the ISS on the STS-115 mission and will serve as flight engineer during launch and landing. Navy Cmdr. Heide Stefanyshyn-Piper (Hye'-dee Steph-uh-nih'-shun Pye'-pur), 43, makes her first spaceflight on Atlantis' mission, joining Tanner for two of the three planned spacewalks. Canadian Space Agency astronaut Steve MacLean (Muh-klaine'), 51, rounds out the crew and will join Burbank for the second spacewalk of the flight in his second mission into space. He flew a scientific research mission aboard Columbia 14 years ago and will become the second Canadian astronaut to walk in space, following in the footsteps of his colleague, Chris Hadfield.

Tanner has conducted five spacewalks in his career both in service of the Hubble Space Telescope and at the station. Burbank, Piper and MacLean will be conducting their first spacewalks.

The primary purpose of the mission is to install the huge P3/P4 truss to the existing P1 truss on the port side of the station. Complex work with both the shuttle and the station’s robotic arms will be required to not only install the new truss segment, but also inspect Atlantis’ wings and thermal protection system, duplicating inspections performed on STS-114 and STS-121 missions. This heat shield inspection conducted over several days will ensure the shuttle is safe to return to Earth.

MacLean, who helped develop the Canadian-built robotic arms for both shuttle and station, will become the first Canadian to operate both systems during the STS-115 mission.



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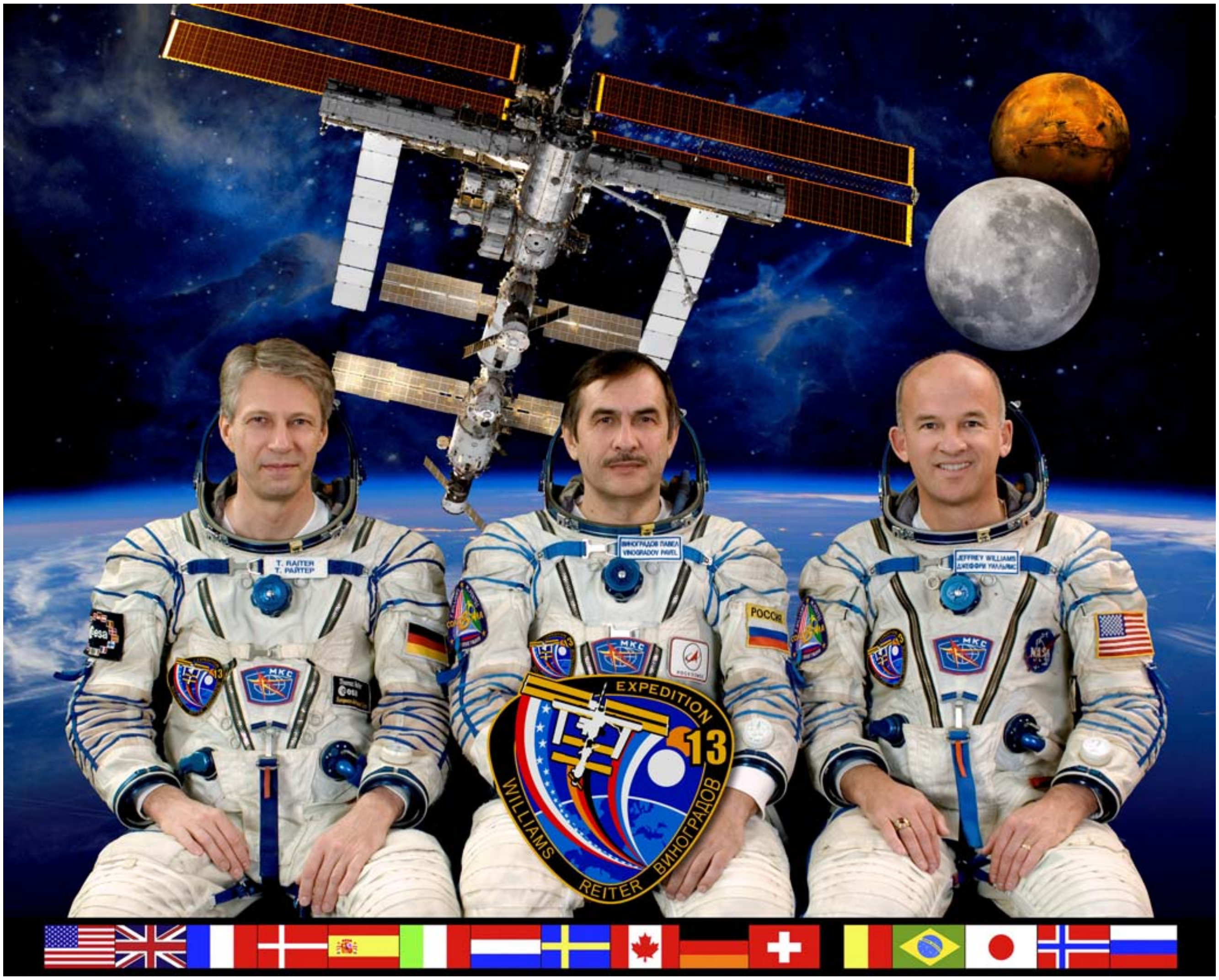
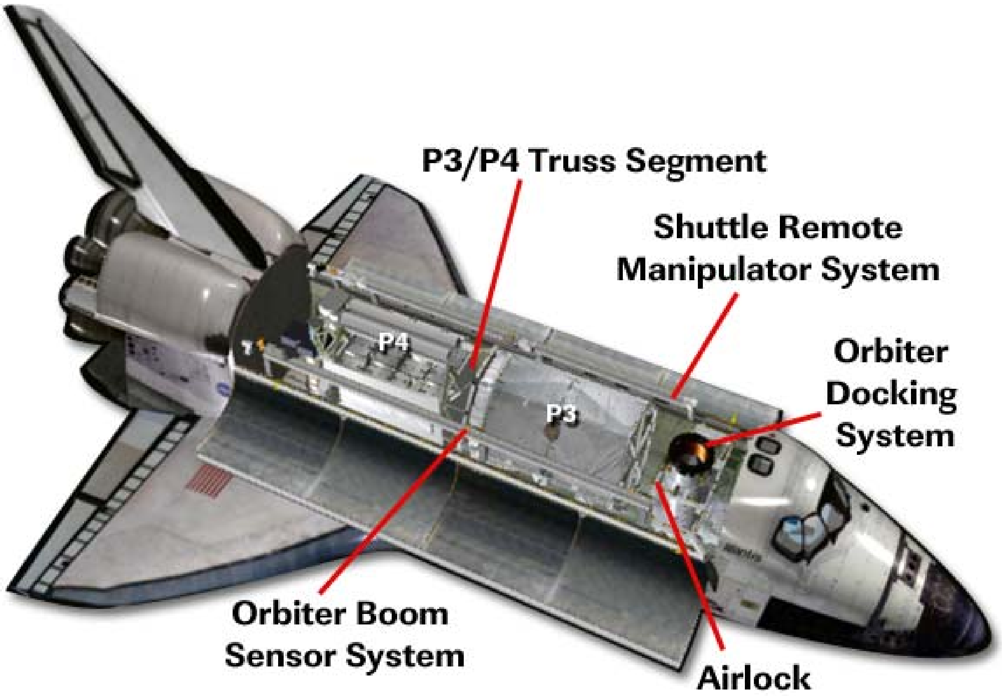
A view of Orbiter Discovery's underside during the STS-121 Rendezvous Pitch Maneuver



Expedition 13 crew - Commander Pavel Vinogradov (center), flight engineer and NASA science officer Jeff Williams (right) and European Space Agency (ESA) astronaut Thomas Reiter (left)

When Atlantis arrives at the station two days after its launch, the six-person shuttle crew will be greeted by the three-man Expedition 13 crew. Russian Commander Pavel Vinogradov, 53, and Flight Engineer and NASA Science Officer Jeff Williams, 48, have been aboard the complex since April 1 following their launch on the Soyuz TMA-8 spacecraft from the Baikonur Cosmodrome in Kazakhstan. They are scheduled to return to Earth in late September following the arrival of the next station crew, Expedition 14, which will launch in another Soyuz spacecraft right after the STS-115 mission. The third member of the Expedition 13 crew is European Space Agency astronaut Thomas Reiter, 48, who arrived at the outpost on the STS-121 mission. He will remain on board with the Expedition 14 crew through the end of the year.

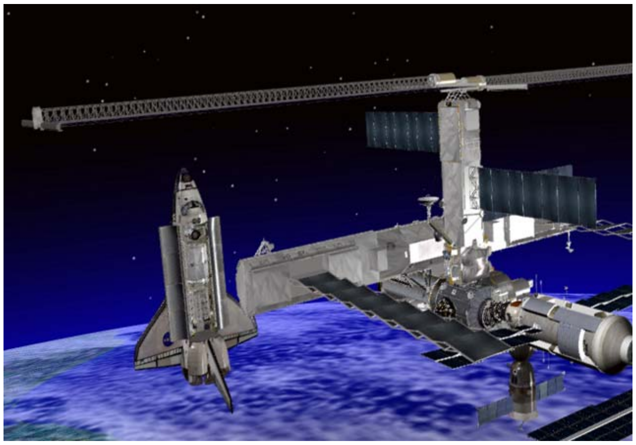
The STS-115 flight marks the second time as many as four out of the five partner agencies will have been represented on the station together.



After launching, the crew will spend its first hours in space setting up equipment and downlinking initial imagery of Atlantis' external fuel tank following its jettison.

The next day, Ferguson and Burbank will join MacLean at the aft flight deck of Atlantis to grapple and unberth the 50-foot-long Orbiter Boom Sensor System (OBSS), a crane extension for the shuttle's robotic arm. The extension uses two lasers and a high-resolution television camera to examine the leading edges of Atlantis' wings and its nose cap for any sign of damage that may have occurred during launch. Additional inspections of the wings and other orbiter surfaces will take place the day prior to undocking from the station and in the hours following undocking. Imagery analysts at the Johnson Space Center in Houston will pore over the data and report their findings to members of the Mission Management Team.

While the boom inspection is under way, Tanner and Piper will prepare the spacesuits and tools that they, Burbank and MacLean will use during their spacewalks. Jett and Ferguson will conduct periodic firings of Atlantis' jets in the standard plan to place Atlantis on a precise course to rendezvous with the station the following day. Once the initial boom inspection is complete, the boom will be put back onto the starboard sill, or edge, of the shuttle cargo bay for use later in the mission.

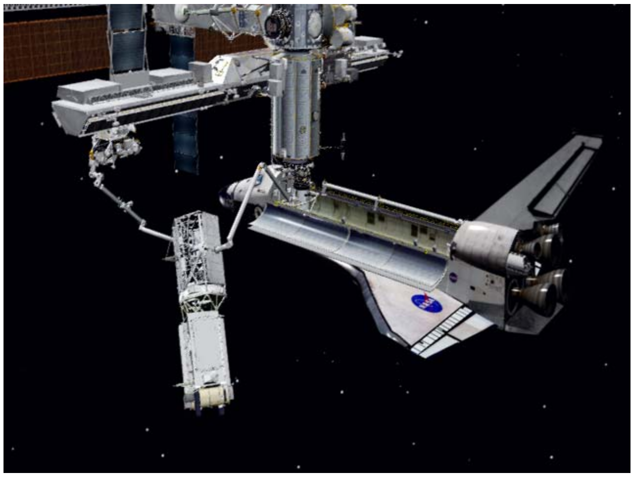


On the third day of the mission, Jett will take over manual control of Atlantis at a point about 1,000 feet directly below the station. He then will fly the shuttle to just 600 feet under the complex and begin a slow back-flip rotation of the orbiter. This will enable Vinogradov and Williams to capture high-resolution digital imagery of Atlantis for engineers on the ground to analyze the condition of the shuttle's heat shield.

With the backflip completed, Jett will slowly maneuver Atlantis to a docking with the station at the forward end of the Destiny Laboratory, setting the stage for a week of joint operations between the two crews.

Even before the hatches are opened to allow the nine crew members to greet one another, Ferguson and Burbank will use the shuttle's robotic arm to grapple the massive P3/P4 truss. Once hatches are opened, MacLean will join Williams in Destiny at the robotic work station to maneuver the station's Canadarm2 robotic arm for a handoff of the truss from Ferguson and Burbank. The truss will remain grappled to Canadarm2 overnight.

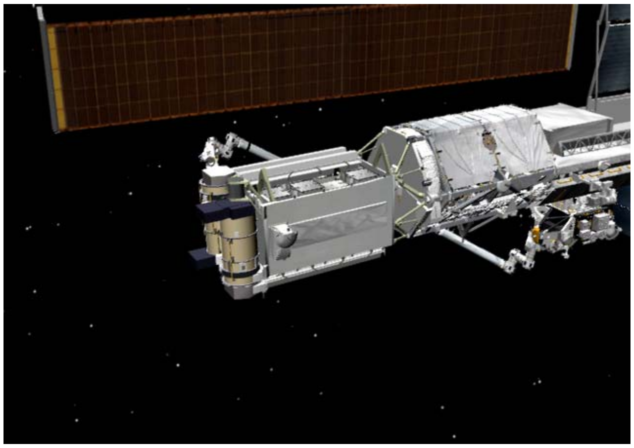
Tanner and Piper will then begin spacewalk preparations as they use a new technique called an extravehicular activity (EVA) "campout" protocol which requires them to prebreathe pure oxygen in masks to begin to cleanse nitrogen from their bloodstreams. That will prevent a condition known as decompression sickness, commonly called the "bends."



Tanner and Piper will sleep in Quest overnight as its pressure is lowered to 10.2 pounds per square inch to further rid their bloodstreams of nitrogen and shorten their final spacewalk preparations. Burbank and MacLean will follow the same regime prior to the second spacewalk of the mission, and Tanner and Piper will repeat the procedure prior to the third spacewalk.

As Tanner and Piper prepare to leave the Quest airlock for their first spacewalk, MacLean and Williams will slowly and carefully position the P3/P4 truss at the edge of the P1 truss. They will align it properly through the use of television cameras and install it to P1 so that the two segments are captured and hard mated to one another through a series of four structural bolts. Once the bolts are secure and the truss segments are mated, the Canadarm2 will release its grasp of the truss' grapple fixture.

After emerging from Quest, Tanner and Piper will move to the newly installed truss segment where they will first connect power cables in one of two trays housing the truss' electronics. The next operation calls for Piper to release launch restraints for the Solar Array Blanket Boxes (SABB) that house the folded arrays. Tanner and Piper will then release similar restraints for the Beta Gimbal Assemblies (BGA) that serve as the structural link between the truss' integrated electronics and the massive Solar Array Wings (SAWs). The BGAs will rotate to the correct position for the actual deployment of the arrays on flight day 6.



Before the spacewalkers can complete the unstowing of the array blanket boxes, they must move a keel pin out of the way. The pin held the P4 truss segment in place at the bottom of the payload bay for launch.

Next, Tanner and Piper will begin preparations for operation of the Solar Alpha Rotary Joint and completing the connection of electrical cables between the new P3 truss and the P1 truss.

As the spacewalk concludes, Mission Control in Houston will command the activation of the P4 truss for a thorough checkout of its systems and the arrays as they remain folded in their canisters.

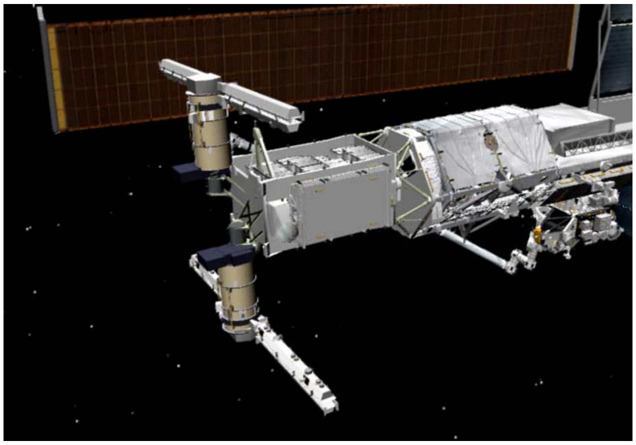
The second spacewalk by Burbank and MacLean on flight day 5 will be devoted to final preparations for the activation of the Solar Alpha Rotary Joint. Six launch restraints, four thermal covers and sixteen launch locks will be removed and released to set the stage for its activation.

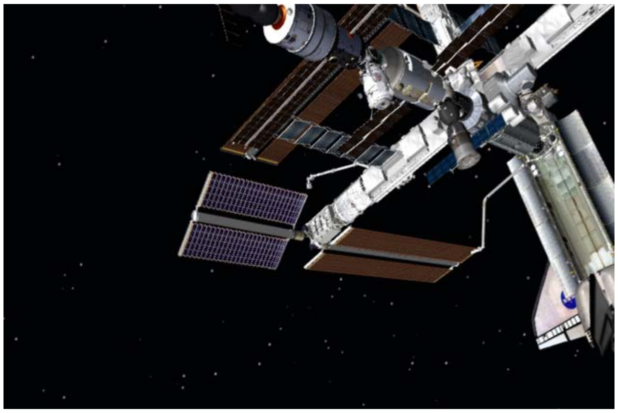
Before the crew is awakened to begin the sixth day of the mission, flight controllers will initiate the deployment of the new arrays on the P4 truss. Only one half of the 31.5 "bays" encapsulating the arrays will be immediately unfurled so that flight controllers can confirm a new deploy procedure developed after the P6 array deployment on the STS-97 mission in 2000.

At that time, the solar array panels experienced a phenomenon called "stiction" that caused a tension bar designed to keep the arrays taut to oscillate back and forth. The effect was similar to a sail flapping while held on the top and bottom. It was determined after the flight that a silicon coating designed to protect the copper wiring in the solar cells against the degrading effects of atomic oxygen particles had fused over time as the arrays were in their blanket boxes. In addition, the "stiction" could be lessened by deploying the arrays after they have been warmed in the sun first and by using a high- tension deployment mode. A second solar array wing was deployed on STS-97 using the high-tension mode without incident. Cameras and visual clues have also been added to make it easier for the crew to better monitor deployment.

For this flight, the arrays will be deployed at a high tension to avoid large motion by the tension bar itself. The temperature of the arrays also will be controlled to avoid a repeat of the “stiction” issue.

Once the crew is awake, they will take over the array deployment process, commanding the





wings to unfold to an interim position of 49 per cent of full deployment, then to their full length of 240 feet. The incremental deployment sequence is performed when the sun is at the correct angle relative to the station for the proper thermal conditioning of the array blankets.

After the arrays are fully deployed, the Canadarm2 will "walk-off" from the Mobile Transporter back to the Destiny Lab to enable the rail car to move to a work site at the P3 truss for a checkout of its functionality the next day. Work site No. 8 on the truss is where the station's robotic arm will be positioned during the next flight, STS-116, for the installation of the P5 truss component.

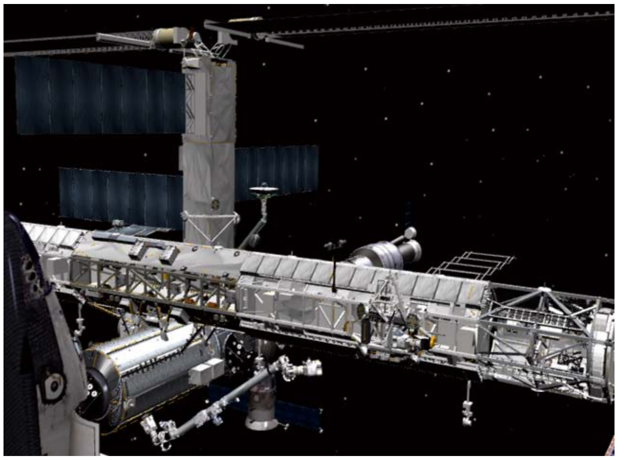
The following day, flight day 7, will find Tanner and Piper conducting the third and final spacewalk of the mission to release restraints for the deployment of the heat-dissipating radiator on the P4 truss. They also will deploy braces to hold the Solar Alpha Rotary Joint in place, remove a large keel pin that restrained the P3 truss during launch in Atlantis' cargo bay, and install bolt clips to properly position the Beta Gimbal Assemblies for the newly deployed P4 arrays.

In addition, Tanner and Piper expect to remove a materials science experiment from the hull of the Quest airlock to return to Earth, remove and replace components of the S1 (starboard) truss' S-band communications system and install a new external wireless communications antenna on forward end of Destiny to enable improved television transmissions from cameras mounted on the helmets of future spacewalkers. They will also install a thermal shroud on the station's KU-band antenna to protect it from the extreme heat and cold of low-Earth orbit.

Once the health check of the rail's work site No. 8 is completed, the rail car will return to its normal parking place on work site No. 4 at the S0 truss in the middle of the truss system. The station's arm will move from its grapple fixture on Destiny to the Mobile Transporter at work site No. 4 the next day to support additional inspections of Atlantis' thermal insulation.

The crew enjoy a half day of off-duty time on flight day 8 and conduct the final transfer of items to the station.

On flight day 9, the crew will complete its transfer work, say farewell to the Expedition 13 crew and close hatches between the two vehicles. Undocking from the station is now expected late in the shuttle crew's work day with a possible flyaround of the complex dependent on crew time and propellant capability.



Expedition 13 crew - Commander Pavel Vinogradov (left), flight engineer and NASA science officer Jeff Williams (right), and European Space Agency (ESA) astronaut Thomas Reiter (center)

Atlantis will separate from the station in a trajectory that will enable the crew to document the outpost with its newly installed truss that will make it asymmetrical as it orbits the Earth. The starboard truss will be built out in a similar fashion when the S3 / S4 truss segments are delivered to the ISS on the STS-117 mission next year.

Jett and Ferguson will monitor Atlantis' departure from the station as the shuttle moves to a distance of 40 nautical miles. At that point, an engine firing will place Atlantis in a station keeping orbit in the unlikely event it would have to return to the complex due to damage to its heat shield.

On flight day 10, the shuttle crew will use the ship's robotic arm to grapple the boom sensor system once again to conduct a complete "late" inspection of Atlantis' wings and nose cap in a procedure almost identical to the activity on flight day 2.

Ferguson, Burbank and MacLean will take turns monitoring the maneuvers of the boom sensor crane to view the reinforced carbon-carbon paneling on the leading edges of the shuttle's wings and nose cap. That will provide the imagery needed to permit mission managers to give Atlantis and its crew the final clearance to return home.

On shuttle mission STS-121, part of this inspection was performed while the shuttle was docked to the station. Using a lesson learned from STS-121, the inspection plan has been changed to provide a more efficient way for Atlantis' astronauts to conduct the final examination of the shuttle's heat shield. During Discovery's flight on STS-121, lighting and clearance issues caused time to be added to the inspection of the port wing. The revised timeline for STS-115 will eliminate such issues.

On flight day 11, the astronauts will stow their gear, test Atlantis' flight control surfaces and steering jets and review their entry and landing procedures.

Atlantis is scheduled to land on the morning of flight day 12, setting the stage for subsequent shuttle missions to continue the expansion of the International Space Station.

STS-115 TIMELINE OVERVIEW

FLIGHT DAY 1:

- Launch
- Payload Bay Door Opening
- Ku-Band Antenna Deployment
- Shuttle Robot Arm Power Up
- External Tank Handheld Video, Umbilical Well Imagery and Wing Leading Edge Sensor Data Downlink

FLIGHT DAY 2:

- Shuttle Robot Arm Checkout
- Shuttle Robot Arm Grapple of Orbiter Boom Sensor System (OBSS)
- Inspection of Shuttle Thermal Protection System and Wing Leading Edge reinforced carbon-carbon (RCC)
- Spacesuit Checkout
- Orbiter Docking System Outer Ring Extension
- Airlock Preparations
- Rendezvous Tool Checkout

FLIGHT DAY 3:

- Rendezvous Operations
- Terminal Initiation Engine Firing
- Rendezvous Pitch Maneuver and ISS Digital Photography of Atlantis
- Docking to the International Space Station
- Hatch Opening and Welcoming by Expedition 13 Crew
- Shuttle robot arm grapple of P3/P4 Truss and handoff to Station robot arm
- Tanner/Piper sleep in Quest Airlock for spacewalk pre-breathe campout protocol

FLIGHT DAY 4:

- Station robot arm installs P3/P4 Truss installation on P1 Truss attachment
- Tanner/Piper EVA No. 1 to connect power cables, release Solar Array Blanket Box and Beta Gimbal Assembly Restraints and to prepare the Solar Alpha Rotary Joint for operations
- Activation of the P4 array assembly
- Burbank/MacLean sleep in Quest Airlock for spacewalk pre-breathe campout protocol

FLIGHT DAY 5:

- Burbank/MacLean EVA No. 2 to complete preparations for the activation of the Solar Alpha Rotary Joint for operations
- Solar Alpha Rotary Joint activation and checkout during crew sleep
- Station robot arm is maneuvered to P4 array deploy viewing position

FLIGHT DAY 6:

- First bay of P4 Solar Array 4A and 2A masts are deployed before crew wake up
- Remaining bays of the P4 Solar Array 4A and 2A masts are deployed (31.5 bays per array)
- Station robot arm conducts “double walk off” from the Mobile Base System to the Destiny Lab to prepare for EVA No. 3 and Truss work site No. 8 checkout in preparation for use during the STS-116 mission
- Tanner/Piper sleep in Quest Airlock for spacewalk pre-breathe campout protocol

FLIGHT DAY 7:

- Tanner/Piper EVA No. 3 to release the photovoltaic radiator restraints for its deployment, deploy the Solar Alpha Rotary Joint braces, remove the P3 keel pin to clear the truss path for the Mobile Transporter, retrieve the MISSE 5 experiment, install an external wireless TV transmission antenna and conduct other get-ahead work for future spacewalks
- The Mobile Transporter is moved from work site 7 on the truss to work site 8 to checkout that location in advance of STS-116, then moves back to its normal “parking space” on work site 4

FLIGHT DAY 8:

- Crew off-duty period for a half a day
- Joint Crew News Conference
- Transfer activities and water supply transfers from shuttle to station

FLIGHT DAY 9:

- Final transfers
- Rendezvous tool checkout in preparation for undocking
- Final farewells and hatch closure
- Undocking

FLIGHT DAY 10:

- Shuttle robotic arm grapple of OBSS
- OBSS late inspection of Atlantis’ starboard wing and nose cap
- OBSS final berthing by shuttle robot arm
- Final shuttle robot arm powerdown

FLIGHT DAY 11:

- Flight Control System Checkout
- Reaction Control System Hot-Fire Test
- Cabin Stowage
- Deorbit Timeline Review
- Ku-Band Antenna Stowage

FLIGHT DAY 12:

- Deorbit Preparations
- Payload Bay Door Closing
- Deorbit Burn
- KSC Landing

MISSION PRIORITIES

Priorities for the STS-115 space shuttle mission include (in order):

- Perform flight day 2 inspections
- Perform rendezvous pitch maneuver during rendezvous and docking for orbiter thermal protection system inspection using International Space Station imagery
- Install integrated truss structure (ITS) P3/P4 to ITS P1
- Activate ITS P3/P4 systems to receive survival power from P6
- Transfer mandatory quantities of water
- Transfer critical items per transfer priority list
- Configure P4 for power generation and distribution and deploy P4 solar array wings
- Deploy Solar Alpha Rotary Joint (SARJ) drive lock assemblies
- Install four of four Alpha Joint Interface Structure (AJIS) struts
- Remove launch locks and restraints, activate and check out SARJ
- Install all SARJ brace beams
- Deploy P4 photovoltaic radiator
- Complete spacewalk tasks necessary to enable the mobile transporter (MT) to be moved to work site No. 8
- Remove circuit interrupt devices 6 and 8
- Remove and replace S-band string 1 S-band Antenna Support Assembly (SASA)
- Conduct orbiter late inspection for micrometeoroid orbital debris
- Relocate MT to worksite No. 8 and check out Mobile Servicing System
- Transfer remaining items per transfer priority list
- Remove and replace starboard S-band base band processor and transponder
- Install extravehicular activity (EVA) temporary rail stop, stow P3 MT stop and EVA shuttle tether stop
- Install P6 shoulder bolt retainer
- Retrieve Materials on the International Space Station Experiment (MISSE) 5
- Transfer minimum of 25 pounds of oxygen to station's high-pressure gas tanks
- Perform daily middeck activities to support payload operations:
  - MICROBE
  - Bioavailability and Performance Effects of Promethazine During Spaceflight
  - Sleep Wake Actigraphy and Light Exposure During Spaceflight
  - Latent Virus: Monitoring Reactivation and Shedding in Astronauts

- Perform U.S./Russian daily space station payload status checks as required
- Perform internal thermal control system sampling
- Perform defibrillator checkout
- Install antenna group interface tube heat shield
- Set the soft capture latches for the P5 install
- Conduct modified Rocketdyne truss attachment system visual inspection and foreign object debris check
- Engage P6 beta gimbal assembly hinge lock
- Reboost space station with orbiter, using available propellant, to maintain altitude and rendezvous requirements
- Perform imagery survey of the space station's exterior during orbiter flyaround (if propellant available)
- Perform ram burn observation and Maui analysis of upper-atmospheric injections payloads of opportunity
- Perform Station Detailed Test Objective (SDTO) 15003-U: Microgravity Environment Definition for the SARJ checkout
- Perform SDTO 12004-U: Shuttle Booster Fan Bypass
- Perform SDTO 13005-U: ISS Structural Life Validation and Extension
- Perform program-approved EVA get-ahead tasks:
    - Release P4 integrated equipment assembly micrometeoroid orbital debris shield bolt torques
    - Position auxiliary portable foot restraints for STS-116’s EVA 1
    - Install external wireless instrumentation system antennas and cable on U.S. lab
    - Install S1 crew and equipment translation aid light
    - Install non-propulsive vent on lab
    - Mate P1/P3 fluid umbilical

LAUNCH AND LANDING

LAUNCH

As with all previous space shuttle launches, Atlantis on STS-115 will have several modes available that could be used to abort the ascent if needed due to engine failures or other systems problems. Shuttle launch abort philosophy aims toward safe recovery of the flight crew and intact recovery of the orbiter and its payload. Abort modes include:

ABORT-TO-ORBIT (ATO)

Partial loss of main engine thrust late enough to permit reaching a minimal 105 by 85 nautical mile orbit with orbital maneuvering system engines.

TRANSATLANTIC ABORT LANDING (TAL)

Loss of one or more main engines midway through powered flight would force a landing at either Zaragoza, Spain; Moron, Spain; or Istres, France. For launch to proceed, weather conditions must be acceptable at one of these TAL sites.

RETURN-TO-LAUNCH-SITE (RTLS)

Early shutdown of one or more engines, and without enough energy to reach Zaragoza, would result in a pitch around and thrust back toward KSC until within gliding distance of the Shuttle Landing Facility. For launch to proceed, weather conditions must be forecast to be acceptable for a possible RTLS landing at KSC about 20 minutes after liftoff.

ABORT ONCE AROUND (AOA)

An AOA is selected if the vehicle cannot achieve a viable orbit or will not have enough propellant to perform a deorbit burn, but has enough energy to circle the Earth once and land about 90 minutes after liftoff.

LANDING

The primary landing site for Atlantis on STS-115 is the Kennedy Space Center's Shuttle Landing Facility. Alternate landing sites that could be used if needed due to weather conditions or systems failures are at Edwards Air Force Base, California, and White Sands Space Harbor, New Mexico.

MISSION PROFILE

CREW

Commander:	Brent Jett
Pilot:	Chris Ferguson
Mission Specialist 1:	Joe Tanner
Mission Specialist 2:	Dan Burbank
Mission Specialist 3:	Heidemarie Stefanyshyn-Piper
Mission Specialist 4:	Steve MacLean

LAUNCH

Orbiter:	Atlantis (OV-104)
Launch Site:	Kennedy Space Center Launch Pad 39B
Launch Date:	No Earlier Than August 27, 2006
Launch Time:	4:30 p.m. EDT (Preferred In-Plane launch time for 8/27)
Launch Window:	5 Minutes
Altitude:	122 Nautical Miles (140 Miles) Orbital Insertion; 190 NM (218 Miles) Rendezvous
Inclination:	51.6 Degrees
Duration:	10 Days 20 Hours 16 Minutes

VEHICLE DATA

Shuttle Liftoff Weight:	4,525,808 pounds
Orbiter/Payload Liftoff Weight:	269,840 pounds
Orbiter/Payload Landing Weight:	199,679 pounds
Software Version:	OI-30

Space Shuttle Main Engines:

SSME 1:	2044
SSME 2:	2048
SSME 3:	2047
External Tank:	ET-118
SRB Set:	BI-127
RSRM Set:	94

SHUTTLE ABORTS

Abort Landing Sites

RTLS:	Kennedy Space Center Shuttle Landing Facility
TAL:	Primary – Zaragoza, Spain. Alternates Moron and Istres, France
AOA:	Primary – Kennedy Space Center Shuttle Landing Facility; Alternate White Sands Space Harbor

Landing

Landing Date:	No Earlier Than Sept. 7, 2006
Landing Time:	12:02 p.m. EDT
Primary landing Site:	Kennedy Space Center Shuttle Landing Facility

PAYLOADS

P3/P4 Truss

STS-115 ATLANTIS CREW

The STS-115 mission will resume the assembly of the International Space Station with the delivery and installation of station's second port truss segment (P3/P4) onto the P1 truss and the second set of solar arrays and batteries. Following the installation of the segments utilizing both the shuttle and the station robotic arms, a series of three spacewalks will complete the final connections and prepare for the deployment of the station's second set of solar arrays.

To reflect the primary mission of the flight, the patch depicts a solar panel as the main element. As Atlantis launches toward the space station, its trail depicts the symbol of the Astronaut Office. The starburst, representing the power of the sun, rises over the Earth and shines on the solar panel. The shuttle flight number 115 is shown at the bottom of the patch, along with the space station assembly designation 12A (the 12th American assembly mission). The blue Earth in the background reminds us of the importance of space exploration and research to all of Earth's inhabitants.

Short biographical sketches of the crew follow with detailed background available at: http://www.jsc.nasa.gov/Bios/.

A veteran of three space missions, Brent Jett will command the crew of STS-115, the shuttle's 19th mission to the International Space Station. He served as the pilot of STS-72 in January 1996 and then again on STS-81 in 1997. He flew as the commander on STS-97 in 2000. A captain in the U.S. Navy, he has traveled more than 12 million miles over the three missions and logged 699 hours, 15 minutes and 57 seconds in space. He has overall responsibility for the on-orbit execution of the mission, orbiter systems operations and flight operations including landing the orbiter. In addition, Jett will fly the shuttle in a procedure called the rendezvous pitch maneuver while Atlantis is 600 feet below the station before docking to enable the station crew to photograph the orbiter's heat shield. He will then dock Atlantis to the station. Jett will also be heavily involved in spacewalk preparations and transferring cargo to the station during the docked phase of the mission.

Brent Jett

Chris Ferguson

A captain in the U.S. Navy, Chris Ferguson will make his first journey into space as the pilot of the STS-115 shuttle mission. He will be responsible for orbiter systems operations and assisting Jett in the rendezvous and docking to the International Space Station. Along with Dan Burbank, he will use the shuttle's robotic arm and the Orbiter Boom Sensor System to inspect Atlantis' heat shield. He will also assist Burbank with shuttle arm operations during the unberthing of the P3/P4 truss from the shuttle cargo bay and handing it off to the station robotic arm as well as transfer cargo to and from the shuttle. Ferguson will undock Atlantis from the station at the end of the mission.

Joe Tanner

With five spacewalks to his credit, STS-115 Mission Specialist 1 (MS1) Joe Tanner will make his fourth venture into space. Tanner will perform two of the three extravehicular activities (EVAs), or spacewalks, as EV1. He will conduct the first and the third planned spacewalks with Heide Stefanyshyn-Piper on flight days 4 and 7. He will share intravehicular duties with Stefanyshyn-Piper during the second spacewalk on flight day 5. He will be seated on the middeck for launch and landing.

Dan Burbank

Mission Specialist 2 (MS2) Dan Burbank, a commander in the U.S. Coast Guard, will be making his second spaceflight. He previously flew on Atlantis' STS-106 mission in 2000. Burbank, as EV3, will conduct the second spacewalk of the mission with his colleague Steven MacLean. He will serve as the intravehicular activity crew member helping to suit up and choreograph spacewalkers Tanner and Heidemarie Stefanyshyn-Piper for the first and third spacewalks. He will be the prime operator of the shuttle robotic arm, working with Ferguson to unberth the P3/P4 truss segment from the shuttle's cargo bay and hand it off to the station robotic arm, as well as conduct robotic inspections of the shuttle's thermal protection system. During the rendezvous, docking and undocking, he will manage the rendezvous navigation tools used to guide the shuttle's trajectory relative to the station. He will be seated on the flight deck for launch and landing, serving in the role of flight engineer.

Heidemarie Stefanyshyn-Piper

Mission Specialist 3 (MS3) Heide Stefanyshyn-Piper will be making her first flight into space. A captain in the U.S. Navy, she will serve as EV2 and conduct the first and third spacewalks of the mission with Tanner. She will be the prime operator of the space station robotic arm during the second spacewalk, during the deployment of the solar arrays and during the transfer of the station arm from the Mobile Base System to the Destiny laboratory. She will also assist Steve MacLean during the unberthing, handoff and berthing of the Orbiter Boom Sensor System. She will serve as the overall lead for transferring supplies from the shuttle's cargo module to the station. During the rendezvous, docking and undocking, she will manage the handheld laser and the Orbiter Docking System. She will oversee payload bay door closing operations. She will be seated on the middeck for launch and the flight deck for landing.

Mission Specialist 4 (MS4) Steve MacLean of the Canadian Space Agency will make his second spaceflight on STS-115. He first flew on STS-52 in 1992. MacLean will execute the second spacewalk of the mission with Burbank. He will be the prime operator of the space station robotic arm for the mission, overseeing its operation during the P3/P4 truss segment installation, during the Orbiter Boom Sensor System handoffs to the shuttle arm and during EVA 1 and EVA3. In addition, MacLean will assist Burbank and Ferguson during the robotic inspections of the shuttle's thermal protection system. MacLean will share intravehicular activity duties with Burbank helping to choreograph EVA1 and EVA 3 He will also oversee shuttle payload bay door opening once Atlantis reaches orbit. MacLean will be seated on the flight deck for launch and the middeck for landing.

Steve MacLean

MISSION PERSONNEL

CONSOLE POSITIONS FOR STS-115

	Flt. Director	CAPCOM	PAO
Ascent	Steve Stich	Tony Antonelli Ken Ham (Wx)	Kyle Herring
Orbit 1 (Lead)	Paul Dye	Megan McArthur	Kyle Herring (Lead)
Orbit 2	Cathy Koerner	Terry Virts	Kylie Clem
Planning	Bryan Lunney	Hans Schlegel	Nicole Cloutier
Entry	Steve Stich	Tony Antonelli Ken Ham (Wx)	Kelly Humphries
Shuttle Team 4	Mike Sarafin	N/A	N/A
ISS Orbit 1	Kelly Beck	Kevin Ford	N/A
ISS Orbit 2 (Lead)	John McCullough	Pam Melroy	N/A
ISS Orbit 3	Kwatsi Alibaruho	Zach Jones	N/A
Station Team 4	Annette Hasbrook	N/A	N/A
Mission Control, Korolev, Russia	Mark Ferring	N/A	N/A

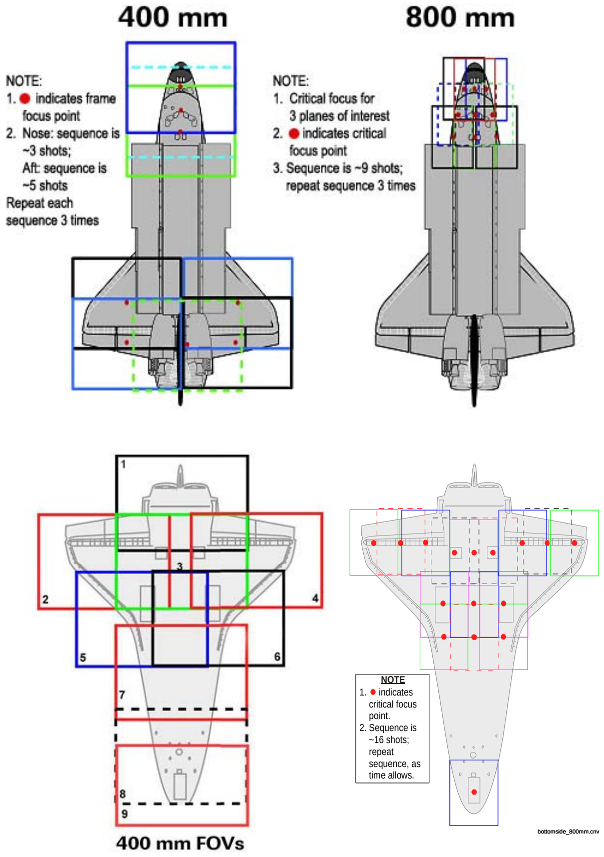
JSC PAO Representative at KSC for Launch – Kelly Humphries
KSC Launch Commentator – George Diller
KSC Launch Director – Mike Leinbach
NASA Launch Test Director – Jeff Spaulding

RENDEZVOUS AND DOCKING

Atlantis' approach to the International Space Station during the STS-115 rendezvous and docking process will include a tricky maneuver first demonstrated on STS-114 and repeated during the STS-121 mission. The orbiter will be commanded to conduct a back flip pirouette, enabling station crew members to take digital images of the shuttle's heat shield.

With Atlantis' Commander Brent Jett at the controls, the shuttle will perform the 360-degree pitch-around maneuver with the orbiter about 600 feet below the station. The flip will take about nine minutes to complete, offering Expedition 13 Commander Pavel Vinogradov and Flight Engineer Jeff Williams time to capture required tile surface imagery of Atlantis.

The photos will then be downlinked through the station's Ku-band communications system for analysis by systems engineers and mission managers.



The photography will be performed out of windows 6 and 8 in the Zvezda Service Module with Kodak DCS 760 digital cameras and 400mm and 800mm lenses. The imagery during the so-called Rendezvous Pitch Maneuver (RPM) is among several inspection procedures instituted after the Columbia accident. The procedures are designed to detect and determine the extent of any damage the orbiter's protective tiles and reinforced carbon-carbon surfaces might have sustained.

The sequence of events that brings Atlantis to its docking with the station begins with the precisely timed launch of the shuttle, placing the orbiter on the correct trajectory and course for its two-day chase to arrive at the station. During the first two days of the mission, periodic engine firings will gradually bring Atlantis to a point about nine-and-a-half statute miles behind the station, the starting point for a final approach.

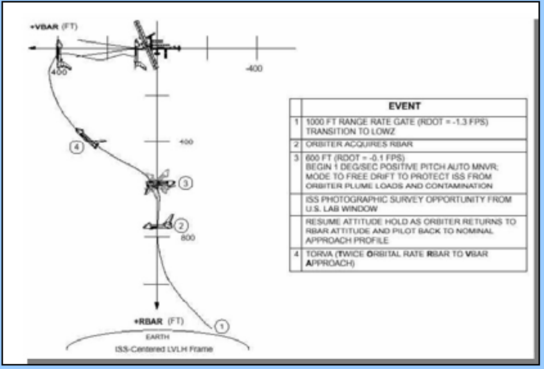
About two-and-a-half hours before the scheduled docking time on flight day 3, Atlantis will reach that point, about 50,000 feet behind the ISS. There, Atlantis' jets will be fired in what is called the Terminal Initiation (TI) burn to begin the final phase of the rendezvous. Atlantis will close the final miles to the station during the next orbit.

As Atlantis moves closer to the station, the shuttle’s rendezvous radar system and trajectory control sensor (TCS) will begin tracking the complex and providing range and closing rate information to the crew. During the final approach, Atlantis will execute several small mid-course corrections at regular intervals with its steering jets. That will place Atlantis at a point about 1000 feet directly below the station. Jett then will take over the manual flying of the shuttle up the radial vector, or R-bar. The R-bar is the the imaginary line drawn between the station and the Earth.

He will slow Atlantis’ approach and fly to a point about 600 feet directly below the station, and if required, wait for the proper lighting conditions. The rendezvous is designed to optimize lighting for inspection imagery as well as crew visibility for critical rendezvous events.

On verbal cue from Pilot Chris Ferguson to alert the station crew, Jett will command Atlantis to begin a nose-forward, three-quarter of a degree per second rotational back flip. At RPM start, the ISS crew will begin of series of photographs for inspection. The sequence of photography mapping provides optimization of the lighting conditions.

Rendezvous Approach Profile



	EVENT
1	1000 FT RANGE RATE GATE (RDOT = -1.3 FPS) TRANSITION TO LOWZ
2	ORBITER ACQUIRES RBAR
3	600 FT (RDOT = -0.1 FPS) BEGIN 1 DEG/SEC POSITIVE PITCH AUTO MNVR; MODE TO FREE DRIFT TO PROTECT ISS FROM ORBITER PLUME LOADS AND CONTAMINATION
	ISS PHOTOGRAPHIC SURVEY OPPORTUNITY FROM U.S. LAB WINDOW
	RESUME ATTITUDE HOLD AS ORBITER RETURNS TO RBAR ATTITUDE AND PILOT BACK TO NOMINAL APPROACH PROFILE
4	TORVA (**T**WICE **O**RBITAL RATE **R**BAR TO **V**BAR **A**PPROACH)

Space Shuttle Rendezvous Maneuvers

OMS-1 (Orbit insertion)- Rarely used ascent 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.

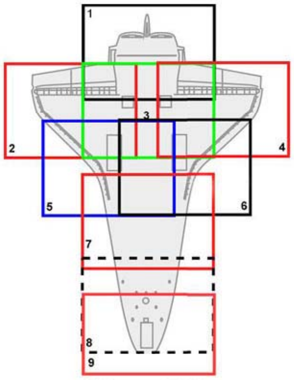
NH (Rendezvous height adjust)- Performed to hit a delta-height relative to the target at a future time.

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.



400 mm FOVs

Both the 400 and 800 mm digital camera lenses will be used to capture imagery of the required surfaces of the orbiter. The 400 mm lens provides up to three inch resolution and the 800 mm lens can provide up to one inch resolution as well as detect gap filler protrusions of greater than .25 inch. The imagery includes the upper surfaces of the shuttle as well as Atlantis' belly, capturing pictures of the nose landing gear door seals, the main landing gear door seals and the elevon cove with one inch analytical resolution. Since the STS-114 mission, additional zones were added for the 800 mm lens to focus on the gap fillers on Atlantis' belly when the orbiter is at 145 and 230 degree angles during the flip. There should be enough time for two sets of pictures.

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When Atlantis completes its rotation, it will return to an orientation with its payload bay facing the station.

Jett then will move Atlantis to a position about 400 feet in front of the station along the V-Bar, or the velocity vector, the direction of travel for both spacecraft. Ferguson will provide Jett with navigation information as he slowly inches the shuttle toward the docking port at the forward end of the station's Destiny Laboratory.

Ferguson will join mission specialists Joe Tanner, Dan Burbank and Heidemarie-Stefanyshyn-Piper in playing key roles in the rendezvous. They will operate laptop computers processing the navigational data, the laser range systems and Atlantis' docking mechanism.

Using a view from a camera mounted in the center of Atlantis' docking mechanism as a key alignment aid, Jett will precisely match up the docking ports of the two spacecraft. He will fly to a point where the docking mechanisms are 30 feet apart and pause to check the alignment.

For Atlantis' docking, Jett will maintain the shuttle's speed relative to the station at about one-tenth of a foot per second (while both Atlantis and the station are traveling at about 17,500 mph), and keep the docking mechanisms aligned to within a tolerance of three inches. When Atlantis makes contact with the station, preliminary latches will automatically attach the two spacecraft. Immediately after Atlantis docks, the shuttle's steering jets will be deactivated to reduce the forces acting at the docking interface. Shock absorber-like springs in the docking mechanism will dampen any relative motion between the shuttle and the station.

Once that motion between the spacecraft has been stopped, Tanner will secure the docking mechanism, sending commands for Atlantis' docking ring to retract and to close a final set of latches between the two vehicles.

UNDOCKING, SEPARATION AND DEPARTURE

With additional inspections of Atlantis' heat shield scheduled on flight day 9, the day before undocking, and flight day 10 immediately post undocking, the orbiter will undock with the shuttle robotic arm and Orbiter Boom Sensor System (OBBS) deployed in their mated configuration. The OBSS will be stowed after the inspections are completed.

Once Atlantis is ready to undock, Tanner will send a command to release the docking mechanism. At initial separation of the spacecraft, springs in the docking mechanism will push the shuttle away from the station. Atlantis' steering jets will be shut off to avoid any inadvertent firings during the initial separation.

Once Atlantis is about two feet from the station, with the docking devices clear of one another, Ferguson will turn the steering jets back on and fire them to very slowly move away. From the aft flight deck, Ferguson will manually control Atlantis within a tight corridor as the orbiter separates from the station, essentially the reverse of the task performed by Jett just before Atlantis docked.

Atlantis will continue moving away to a distance of about 450 feet, where Ferguson will initiate a maneuver to fly the shuttle directly above the station. Once Atlantis reaches that point, Ferguson will fire Atlantis' jets to depart the vicinity of the station for the final time. Atlantis will separate to a distance of about 40 nautical miles from the station. The shuttle will remain there to protect for a return to the complex in the unlikely event the late inspection reveals any damage to the heat shield.

SPACEWALKS

The primary focus for STS-115's spacewalks are to install the Port 3/Port 4 (P3/P4) truss segment to the port side of the integrated truss system and prepare it for on-orbit activities. Three spacewalks are planned and will be performed on flight days four, five and seven. EVAs 1 and 2 will be back-to-back spacewalks.

If a focused inspection of the space shuttle is required, EVA 1 and 2 will be performed on flight days four and six and EVA 3 will be on flight day 8.

Mission specialists Joe Tanner and Heide Stefanyshyn-Piper will perform EVAs 1 and 3. Mission specialists Dan Burbank and Steve MacLean, a Canadian Space Agency astronaut, will perform EVA 2. Tanner has conducted five previous spacewalks. These will be the first spacewalks for Stefanyshyn-Piper, Burbank and MacLean.

Mission Specialist Joe Tanner

Mission Specialist Heide Stefanyshyn-Piper

On EVAs 1 and 3, Tanner will wear the spacesuit marked with solid red stripes, while Stefanyshyn-Piper will wear an all-white spacesuit. On EVA 2 Burbank will wear the spacesuit marked with broken horizontal red stripes, while MacLean will wear a spacesuit marked with broken diagonal red stripes. Each spacewalk is estimated to last six and a half hours.

Mission Specialist Dan Burbank

Mission Specialist Steve MacLean

All the spacewalks will be conducted from the station's joint airlock, the U.S. Quest airlock. Before each EVA, the astronauts will prepare using a new prebreathe protocol first tested during the handover of Expedition 12 in April. The astronauts will spend the night as the procedure is called, in the airlock. "Camping out," helps reduce the amount of time typically required for the prebreathe exercise and, in some cases, the complexity of the next morning's EVA preparations. Consequently, it aids the crew to get outside earlier to perform the day's EVA tasks.

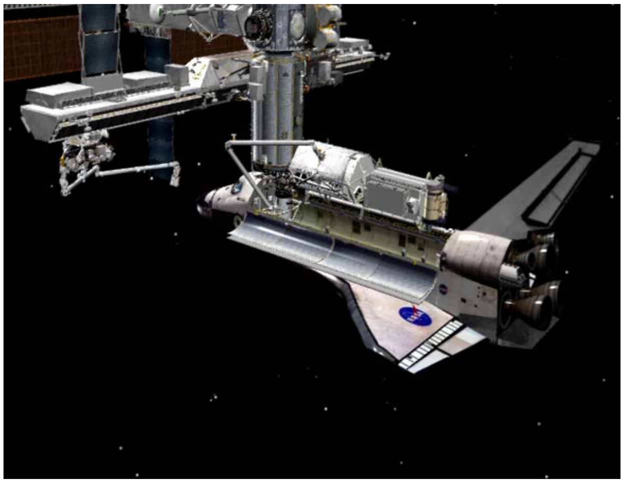
The protocol calls for the crew members to isolate themselves in the airlock and lower the air pressure to 10.2 pounds per square inch, or psi—the station is kept at 14.7 psi, or near sea-level pressure—and then camp out for the night. Astronauts aboard the shuttle perform a similar procedure for shuttle-based EVAs, lowering the spacecraft's air pressure a day or so before a spacewalk.

The morning of EVA 1, the Integrated Truss Segment (ITS) P3/P4 will be attached to the Port 1 (P1) segment. The P3 segment consists of the P3 truss and the Solar Alpha Rotary Joint (SARJ), a device which will rotate 360 degrees clockwise and counterclockwise to position the P4 and P6 solar arrays to track the sun for electrical power. The P4 segment provides the station with a second set of photovoltaic Solar Array Wings (SAWs) that will provide additional power for the station once unfurled to their full length of 240 feet.

MacLean will become the first Canadian to operate the Space Station Remote Manipulator System (SSRMS), or Canadarm2, when the crew mates the P3/P4 truss to the station. He will be the second Canadian to walk in space.

The station eventually will have 11 integrated truss segments that stretch 356 feet from end to end. They will support four virtually identical solar array assemblies that provide electrical power. They also will support radiators that will cool the station.

ISS assembly sequence, the trusses will provide a path for the Special Purpose Dexterous Manipulator (SPDM) that will slide along rails on the station's main truss structure. Major P3 subsystems include the Segment-to-Segment



Attach System (SSAS), Solar Alpha Rotary Joint (SARJ), and Unpressurized Cargo Carrier Attach System (UCCAS). Major P4 subsystems include the Photovoltaic Module (PVM), Photovoltaic Radiator (PVR), and Modified Rocketdyne Truss Attachment System (MRTAS).

The STS-115 spacewalks also include removal of Circuit Interrupt Devices (CIDs) 6 and 8 to support power reconfiguration tasks on Mission 12A.1, and an upgrade of the Integrated Truss Segment S1 truss S-band system Baseband Signal Processor (BSP) and Transponder.

EVA 1

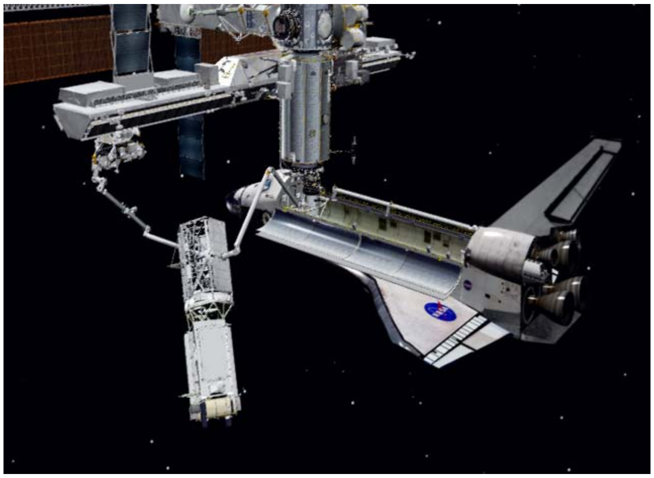
The P3/P4 activation operations are complex and challenging for both the crew and the ground teams. The activation involves detailed sequential task choreography, time and cooperation between the intra-vehicular, extra-vehicular crew members and multiple Mission Control systems disciplines.

During the first EVA, the crew will prepare the truss for activation and prepare the solar arrays for deployment.

As Tanner and Piper prepare for the spacewalk, Steve MacLean and Jeff Williams will use the station's robotic arm to slowly move the 17-and-a-half ton P3/P4 truss to the port side of the integrated truss system. They will align it using a television camera and then mate it to P1.

Once Tanner and Piper have left the airlock, they will move to the newly installed truss. Upon a "go" from Mission Control that the proper electrical inhibits are in place, Tanner will connect the power cables in the P1-to-P3 lower utility tray, where the electrical connections are housed. He will also close the number 7 Circuit Interrupt Devices. Upon completion, Tanner will give the ground control team a "go" to begin the activation of the P3/P4 truss.

Piper will also be working on the P3/P4 truss. Her first task will be to release the aft and forward Solar Array Blanket Box (SABB) launch restraints, unbolting the SABBs from the Integrated Equipment Assembly. The SABBs hold the folded solar arrays. Piper will release the aft SABB first.



Piper and Tanner will then release similar restraints for the Beta Gimbal Assemblies (BGA). The BGAs are the structural link between the truss' integrated electronics and the Solar Array Wings. Piper will release the forward wing BGA; Tanner will release the aft wing BGA.

Prior to the forward wing BGA release, Tanner will rotate a keel pin that held the P4 truss segment in place for launch. Tanner and Piper will then complete unstowing the SABBs. Next, the spacewalk crew will begin preparing the Solar Alpha Rotary Joint (SARJ) for rotation by installing the drive lock assemblies (DLA) to their on-orbit position. Piper will also deploy and rigidize the four Alpha Joint Interface Structure (AJIS) struts. The AJIS struts must be rigidized, for purposes of structural loading, prior to removing any of the launch locks on the subsequent EVA.

When Mission Control has completed the P3/P4 activation to a point where the next set of electrical inhibits are in place, Tanner will connect the electrical cables in the P1-to-P3 upper utility tray. He will also remove the number 6 and 8 Circuit Interrupt Devices in preparation for work on the next shuttle flight, STS-116.

With the conclusion of the spacewalk, Mission Control Houston will command the activation of the P4 truss to check out its systems and the still folded solar arrays.

The BGAs will rotate to the correct position for the deployment of the solar arrays on flight day 6.

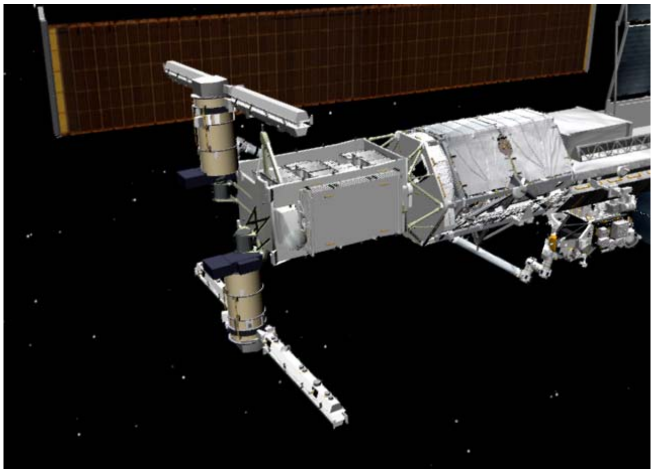
EVA 2

On flight day 5, Burbank and MacLean will continue preparing the SARJ for rotation by releasing and removing 16 launch locks, six of 10 outer launch restraints. The launch locks and launch restraints constrain the SARJ and handle loads during ascent. All of the launch locks must be removed before any of the launch restraints can be removed. In addition, the drive lock assemblies must be deployed to provide a method of controlling uncontrolled SARJ rotation.

Both Burbank and MacLean will work simultaneously to remove the launch locks. Each launch lock is located under a separate insulation cover which is in turn connected to the SARJ inboard bulkhead by four to six bolts, and connected to the outboard bulkhead by one to three spring-loaded clamp bolts. The cover must be removed to access the launch lock. After removing the cover, the launch lock is removed by releasing four bolts. Once the launch lock is removed, the cover is replaced and reattached to the SARJ inboard bulkhead. The outboard spring clamp bolts are left open to allow for SARJ rotation.

After the launch locks are removed, Burbank and MacLean will begin removing the SARJ launch restraints. These restraints hold together the inner and outer SARJ bulkheads. There are two additional launch restraints holding the forward face nadir and zenith SARJ stub rails to the inboard SARJ bulkhead as well as two additional launch restraints on aft truss beams.

The final task of EVA 2 will be the deployment of the SARJ brace beams. These beams are located on the P3 inboard side of the SARJ. These beams also help rigidize the SARJ interface.



Once these tasks are completed, the SARJ can be rotated and Mission Control will command a checkout that involves as series of tests, including rotating the SARJ a full 360 degrees, plus another 180 degrees to position the P4 photovoltaic radiator (PVR) pointing toward Earth. This position corresponds to the 0 degree SARJ position.

The solar array and SARJ preparation work must be completed by the end of EVA 2 so the SARJ can be checked out allowing the solar arrays' deployment on flight day 6.

EVA 3

On flight day 7, Tanner and Piper will again don their spacesuits for the third and final spacewalk. During the six-and-one-half-hour EVA, the crew will install bolt retainers on the P6 beta gimbal assembly (BGA), prepare the P4 PVR, a photovoltaic or heat-dissipating radiator, for deployment, clear the path on P3's forward face for the MT's move to work site 8, remove and replace the S1 S-band antenna support assembly (SASA), remove and replace the string 1 baseband signal processor (BSP) and transponder on the S1 truss, install the antenna group interface tube (AGIT) heat shield, and retrieve the Materials for ISS Experiment (MISSE) 5 from P6.

Before moving to P4, Tanner will move to the P6 zenith bulkhead to install eight bolt retainers on the P6 beta gimbal assemblies and engage a remaining P6 4-bar hinge lock. The bolt retainers will prevent the potential backing out of those bolts. One of the eight hinge locks did not engage during the STS-97 mission. Although previous attempts to engage the lock were unsuccessful, the team believes they have the correct tool for the non-standard task. Piper will spend some time preparing the work sites for the SASA task.

The crew then will move to P4 where they will prepare the P4 radiator for deployment by removing the cinches and winches on the radiator. These must be released before the crew inside the station can deploy the radiator.

The cinches are wire braided cables with nut assemblies on the end that serve as launch restraints for the PVR. One end of the cable is permanently attached to the PVR base plate, the opposite end contains an adjustable nut assembly that slides into a receptacle on the outermost PVR panel.

The nut assemblies secure the PVR for launch. The EVA crew will use a pistol grip tool (PGT) on the nuts to release the tension in the cable, remove the cable nut assembly from its receptacle on the PVR, and attach the cinch to a clip on the PVR base plate.

The next task will be to release the winch bar, which secured the PVR during launch, from the PVR. A PIP pin secures the winch bar to the outermost PVR panel. Tanner will release one of the winch PIP pins while Piper releases the other. After the winch bar is released from the PVR, the pip pin will be reinstalled into the winch bar. The radiator will then be ready for deployment.

Tanner and Piper will also "clear" the P3 forward face so the mobile transporter (MT) can move onto the P3 truss. The keel pin and drag link are located on P3 face 1. Tanner and Piper will remove the drag link and keel pin and stow them within the P3 structure. Tanner and Piper will remove the P3 space vision system (SVS) target, as well as rotate P1, P3 MT stops and tether shuttle stops. In addition, the crew will install the EVA temporary rail stop (ETRS). The ETRS will now perform the functions of the other MT and tether shuttle stop mechanisms while still allowing a Crew and Equipment Translation Aid (CETA) cart to be outboard of the MT/MBS while the MT/MBS is at the P3 work site. The crew will also relocate the articulating portable foot restraints (APFR) used during their tasks to the P4 truss where they will not interfere with the MT movement.

After completing their P3 and P4 tasks, Tanner and Piper will move back to the Z1 truss via the airlock. The EVA crew will start working on the removal and replacement of the SASA on S1 with a spare unit that is located on the Z1 truss. The task will require several handoffs between the crew to move the spare SASA up to the S1 truss. The crew will also need to temporarily stow the failed SASA while the spare SASA is installed. The crew will reverse their path and use the same technique to move the failed SASA back to the Z1 truss. The failed SASA will be returned to Earth on a later mission.

Piper will retrieve upgraded S-band BSP and transponders from the airlock. The new Orbital Replacement Units (ORUs) will be carried to the work site in a large ORU transfer bag. Piper will temporarily stow the bag on the S1 truss while she changes out the S-band transponder and base-band signal processor (BSP). She will return to the airlock with the older version BSP and transponder.

While Piper is busy on the S1 truss, Tanner will install a heat shield on the Ku-band antenna group interface tube (AGIT). This will help prevent over heating in this area during certain ISS attitudes. Tanner will then return to the P6 truss to remove MISSE 5 from the P6 truss for return to Earth.

PAYLOAD OVERVIEW

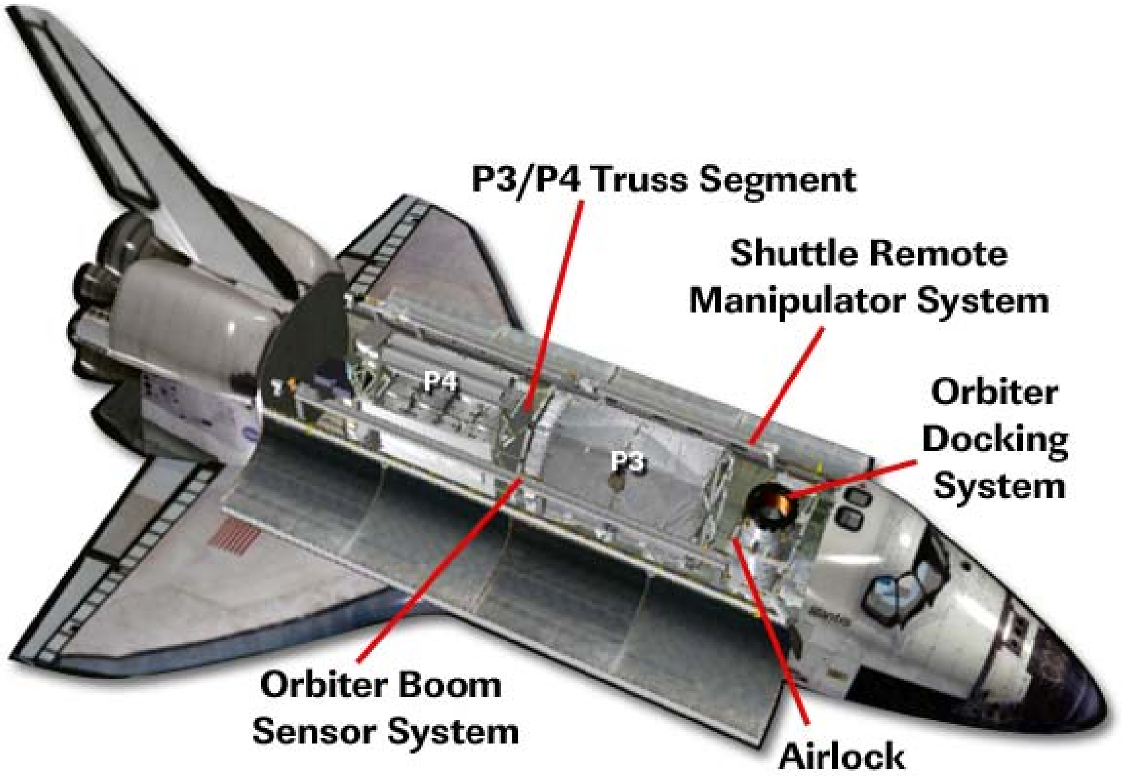
Space Shuttle Atlantis will carry equipment and supplies in its cargo bay to the International Space Station. Additional items will be carried on the shuttle middeck, including supplies, food, water and clothing for the station crew.

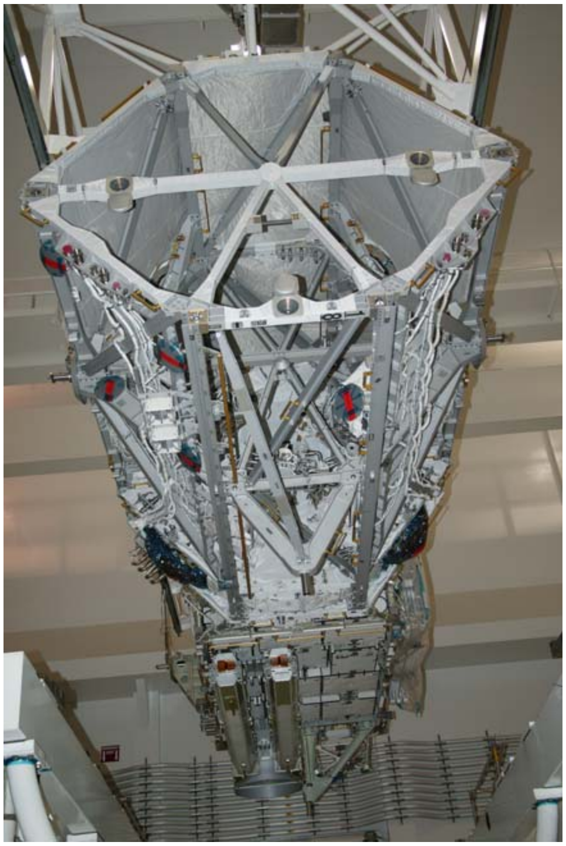
STAGE 12A ASSEMBLY HARDWARE

The primary element to be delivered is the P3/P4 Integrated Truss Segment. The P3/P4 truss segment provides an additional photovoltaic module (PVM) with two power channels (2A and 4A), the port Solar Alpha Rotary Joint (SARJ) and two Unpressurized Cargo Carrier Attachment System sites. The P3/P4 segment is 45.3 ft long and weighs 34,885 pounds.

Integrated Truss Segment P3/P4

The P3 structure has an elongated hexagonal cross section with two bays arrayed along the long axis. The P4 truss segment is integrated to the P3 segment before flight. A detailed description of this prime payload for the STS-115 mission can be found on page 39.





Solar Alpha Rotary Joint

The Solar Alpha Rotary Joint (SARJ) enables the new outboard solar arrays to always point to the sun by rotating like a Ferris wheel. The port SARJ on P3/P4 provides tracking for the P4 and P6 solar arrays once P6 is relocated to P5 on the STS-120 mission. The starboard SARJ for the S3/S4 arrays, to be delivered on STS-117, will provide tracking for the S4 and S6 solar arrays once S6 is installed on the STS-119 mission. The SARJ can rotate 360 degrees clockwise and counterclockwise. The SARJ also provides the structural interface between the P3 or S3 and P4 or S4 elements. It includes hardware to route power and data through the rotating SARJ interface to the outboard truss segments.

Race Rings

The SARJ includes an inboard and an outboard race ring, which provide the structural connection between the P3 and P4 elements. Along the circumference of each race ring are gear teeth that mesh with the drive lock assembly (DLA) pinion gear to rotate the SARJ. The outboard race ring is used by the DLA for rotating the SARJ.

Trundle Bearings

The 12 equally-spaced trundle bearings hold the SARJ inboard and outboard race rings together. Each trundle bearing is fixed to the inboard race ring and is clamped onto the outboard race ring with a roller interface to allow for SARJ rotation. There are three rollers on the trundle bearing that interface with the outboard race ring; the inner and outer upper rollers and the center roller. Each roller consists of two bearings: the primary and journal bearings. The primary bearing rotates. If the primary bearing seizes up, the journal bearings will begin rotating. The journal bearing is designed to operate for about 30 days. There are micro-switches in the trundle bearing that allow the ground to know if the journal bearing is rotating.

Drive Lock Assembly

Two Drive Lock Assemblies (DLAs) are responsible for rotating and locking the SARJ. Each DLA includes the engage-disengage mechanism (EDM) motor, drive motor, pinion gear, lock rack and two follower arms. The EDM motor is a stepper motor that pivots the lock rack and pinion gear about the lock/engage pivot point to the desired position. The DLA positions are locked, engaged and neutral. For the locked position, the lock rack is in contact with the race ring gear teeth to prevent the

SARJ from rotating. For the engaged position, the DLA pinion gear is meshed with the race ring gear to rotate the SARJ with the drive motor. In the neutral position, neither the lock rack nor pinion gear is engaged to the race ring gear. The follower arms, which are of the same design as the trundle bearings, are used to secure the DLA to the race ring.

Rotary Joint Motor Controller

The two rotary joint motor controllers (RJMCs) are mounted on the structural ribs of the inboard race ring and control the operation of the DLA motors via commands from the P3 multiplexers/demultiplexers (MDMs). Each RJMC has two heaters and a resistive thermal device sensor monitored by the P3 MDMs. The RJMC supplies and receives voltage signals from the resolvers on the Utility Transfer Assembly to determine the position of the SARJ (resolver A is connected to RJMC 1, resolver B is connected to RJMC 2). For SARJ outboard operations, one RJMC is moved to the outboard race ring.

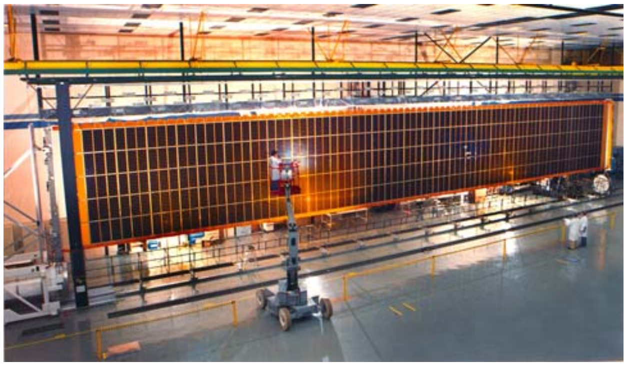
SARJ Structural Support

At launch, the SARJ is secured with 16 launch locks and 10 launch restraints. All the launch locks and the six outboard launch restraints will be removed on orbit before the SARJ is rotated, first in a short test, then in its operational configuration. On the longerons for two sides of the SARJ, there are stub rail segments that bridge over the interface that enables the SARJ to rotate. The launch restraints on the inboard and outboard side hold the stub rail segments in place. When the SARJ is operating in the inboard mode, the outboard launch restraints are removed and the inboard launch restraints are left in place so that the stubs rails are cantilevered over the rotating SARJ interface.

The SARJ inboard bulkhead is structurally attached to P3 at the P3 longerons and four SARJ braces. The braces are stowed on the diagonals and not connected to the inboard bulkhead for launch so that the SARJ loads path is supported entirely by the launch restraints.

Integrated Truss Segment P4

The major components of the P4 truss are the port inboard photovoltaic module and modified Rocketdyne truss attachment system.



Photovoltaic Module

The P4 photovoltaic module contains two power channels, 2A and 4A. The individual components of these power channels are described in more detail below.

Solar Array Wing (SAW): Each power channel begins with the solar array wing where electrical generation takes place. Each solar array wing is divided in half by its deployment mast into two PV blankets (right and left). Each blanket contains 16,400 individual silicon PV cells, eight square centimeters apiece, for the conversion of sunlight into electricity. The photovoltaic cells are grouped into 82 active panels -- each consisting of 200 cells connected in series. The active panels are wired in sets of two, providing a total of 41 independent circuits, or strings, per blanket. Two flat collector circuits run along the sides of each blanket, providing connectivity between two active panels. The circuits also route primary power from each string to the containment box wire harness, which forms the blanket power output. This setup allows each string to be treated as an independent power source. Two inactive panels are located at the top and bottom of each blanket to prevent the shadowing of the arrays and to protect the active panels while the arrays are stowed. They also provide space between them and the solar array wing, which must be directly in line with the sun whenever possible for maximum power generation. This is accomplished by maneuvering the station into certain orientations, as well as by positioning the arrays using the Beta Gimbal Assemblies (BGAs) and the SARJ.

Sequential Shunt Unit (SSU): The primary power output of each solar array wing is divided into 82 individual paths, or strings—41 per blanket—which are routed through the solar array wing mast canister to the SSU located at the base of the canister. The main purpose of the SSU is to regulate the voltage level of the primary power bus, the input from the solar array wing. It also can be used to isolate the array from the rest of the electrical power system during contingency or maintenance operations. The solar arrays are controlled via the photovoltaic controller application (PVCA) software within the photovoltaic controller unit (PVCU) routing system. To regulate the primary voltage level, a closed-loop control system is used to achieve a voltage set point. The voltage set point is sent by the PVCA to the three photovoltaic controller elements (PVCEs) within the SSU. Closed-loop control is achieved mainly through the SSU Shunt Electronics Module (SEM) and the input of the three PVCEs.

These internal electronics are powered by two sources: the channel primary power bus and a direct current control power bus (provided by a battery charge/discharge unit on the adjacent power channel). The PVCEs compare the SSU output voltage (the sum of the 82 strings) with the PVCA set point and sends a signal to the SEM, which decides how many strings need to be routed back to the array or deselected to achieve the voltage set point. Shunting is performed through field effect transistors (FETs) connected to each string within the SEM. The process always allows one transitional string for exceeding the set point. The transitional string is continuously shunted and unshunted at a specified rate in a process called dithering that results in fine voltage level control.

Beta Gimbal Assembly (BGA): The Beta Gimbal Assembly is the mechanism used to orient the face of each solar array wing toward the sun to maximize the power generation of the solar cells. The BGAs provide rotation about the axis along the mast. The BGAs also provide structural support for the SAW and accommodate power and data transfer through its rotating interface. One BGA per power channel (or SAW) is located between the base of the mast canister and the Integrated Equipment Assembly (IEA). The BGA is comprised of four main components: the Bearing Motor and Roll Ring Module (BMRRM), the Beta Gimbal Housing Subassembly (BGHS), the Beta Gimbal Deployment Transition Structure (BGDTS) and the Beta Gimbal Platform (BGP).

Bearing Motor and Roll Ring Module (BMRRM): The BMRRM is the most complex and active component of the BGA. Its main purpose is to provide sun tracking capability for the arrays while transferring power, commands, and data bi-directionally across the rotational joint. The

BMRRM consists of module housing, two sets of angular contact bearings, a brushless direct current motor drive, a roll ring assembly, and an anti-rotation latch assembly (two latches).

The BGA allows transfer of power and data through its 360-degree continual rotation joint by the use of roll rings in the BMRRM. These roll rings are metallic flexures, which ensure that a metal contact point is maintained, allowing power and data to be transferred, no matter what the angle of rotation is.

Modified Rocketdyne Truss Attachment System

The P4 element includes the active side of the P4-P5 Modified Rocketdyne Truss Attachment System (MRTAS), which will be used to attach the P5 element to P4 on the next shuttle mission, STS-116. Unlike the other type of attachment system that mated the P6 array truss to the Z1 truss and will be used to attach P6 to P5, the MRTAS does not include a capture claw since, due to the P4 BGA locations, there is no room to accommodate it. The P5 is soft-docked to P4 by positioning the four P5 coarse cones (one on each corner) into receptacles on P4. Once the P5 element is soft-docked, the crew secures the primary bolt at each corner on P5 into the nut assemblies on P4. If the primary bolt cannot be secured, two contingency bolts at each corner on P5 can be tightened into the nut assemblies on P4.

P3/P4 Preparation

During Atlantis’ rendezvous with the International Space Station, the shuttle crew performs a visual inspection of the P3/P4 truss segment using payload bay and shuttle robotic arm cameras. The crew also will observe through the aft flight deck windows to verify that the hardware survived the launch intact. The crew has no telemetry insight into the health and status of the truss hardware until after it is installed with its connectors mated. P3/P4 installation and activation is scheduled to occur the day after docking. Installation is performed using both the shuttle robotic arm and the station robotic arm, Canadarm2.

On flight day 3 after docking, the shuttle robotic arm will be used to unberth P3/P4 from the shuttle payload bay and will hand it off to the station arm. The station arm will operate from the Mobile Transporter Power and Data Grapple Fixture 3 located at work site 7 on the far port side of the truss. P3/P4 will spend the night grappled by the station arm. The next day, the P3/P4 is maneuvered to the P1 install position. After the installation, a spacewalk is performed out of station's Quest airlock. The spacewalk is critical to the activation and survival of the P3/P4 integrated hardware.

After P3/P4 is unberthed, many of its hardware components are vulnerable to the elements of space, and it is critical to expedite the installation and application of keep-alive power to those components. A number of hardware checkouts are required before proceeding with P3/P4 unberthing from the payload bay. The shuttle and station robotic arms support one another during all phases of the installation process. The shuttle robotic arm provides camera views and additional Space Vision System (SVS) targeting functions, while the station arm manipulates the P3/P4 element. Also, a number of station systems are reconfigured and powered down to support the P3/P4 zenith tray umbilical connections.

P3/P4 Installation

During P3/P4 unberthing from the payload bay, Pilot Chris Ferguson and Mission Specialist

Dan Burbank first maneuver the shuttle arm to the P3/P4 grapple fixture located on the orbiter port side and grapple the truss segment. When the cameras and viewing equipment are properly configured for unberthing, the four orbiter longeron payload retention latch assemblies and two active keel assemblies are opened, and the truss is lifted out of the payload bay.

During unberthing, another crew member monitors the clearance between the P3/P4 truss element, the orbiter aft bulkhead and the Destiny laboratory as the truss is moved using a lift and tilt maneuver. The truss is then swung out over the port side of the orbiter and maneuvered to the P3/P4 handoff position. Mission Specialist Steve MacLean and station flight engineer Jeff Williams use Canadarm2 to grapple P3/P4 at the other grapple fixture on the starboard side. When the station arm grapples P3/P4, the shuttle arm releases its grapple fixture and maneuvers out of the way. The cameras are reconfigured for the installation.

Working from the station’s robotics work station, MacLean then maneuvers the truss to the P3/P4 preinstall position on the port side of P1. P3/P4 is now in the proper orientation for installation. Just inches away from installation, all shuttle and station thrusters are inhibited as mating operations begin. From the “preinstall” position, MacLean slowly maneuvers the P3/P4 truss segment in toward the port side of P1 using computer displays and shuttle arm cameras to assist with alignment and orientation. At the same time, the P1 active attachment power/data interfaces and hardware are verified, and the attachment software state is transitioned from standby to manual.

Within 8 to 10 cm (3 to 4 in.) of mating, the three ready-to-latch (RTL) sensors on the P1 side of the truss interface contact the three RTL striker plates (passive side), which sends a signal to computers providing a positive indication to the crew that the capture latch is ready to be closed. Each RTL sensor contains dual redundant micro-switches, and only one switch indication is required to proceed with capture latch actuation.

The margin for the precise alignment of the attachment device’s capture latches is plus or minus 3 inches in either direction.

The capture of the P3/P4 and the P1 segments occurs in two stages with four huge bolts driven to form a hard mate between the two truss components.

Activation and Checkout

The P3/P4 activation operations are the most complex of the entire mission and are the most challenging for both the crew and flight controllers. The activation of the newly installed P3/P4 segments involves powering up and checking out all integrated hardware within the P3/P4 truss segment.

Following P3/P4 installation to the P1 truss, a number of activities are required to apply the keep-alive power that protects the P3/P4 hardware from freezing. The P1-to-P3 lower tray utility cable connections are required to power P3/P4 component heaters. These connections, along with similar connections for the upper tray utility cables will be accomplished during the first spacewalk by Joe Tanner and Heidemarie Stefanyshn-Piper.

Lower Tray Utility Connections (Channel 2/3)

In parallel with EVA preparation tasks and P3/P4 installation operations, the ground temporarily shuts down power to the S0, S1, and P1 truss systems on power channel 2/3. When all P1-to-P3 lower tray connections are made, the ground reactivates that power channel 2/3 for the S0, S1 and P1 truss segments in parallel with other spacewalk activities.

Upper Tray Utility Connections (Channel 4/5)

When the channel 2/3 power-up is complete and all critical S0, S1 and P1 systems are verified, all S0, S1, and P1 systems on power channel 1/4 are then shut off in preparation for the upper tray (EVA) utility cable connections between P1 and P3. Also, a truss thermal clock is started due to the loss of truss controlled heaters. The second channel is reactivated once all the cable connections are made and verified.

P4 Initial Activation and Battery Conditioning/Charging

P4 activation can begin after circuit breakers are turned on following the P1-P3 lower tray connections. P4 channel 4A activation can begin after circuit breakers 6 and 8 are removed following the P3/P4 upper tray connections. Closing or removing these breakers enables P6 channel 2B to supply P4 channel 2A with startup power. The P4 is activated on flight day 4.

P4 Solar Array Deploy

During the P6 channel 2B SAW deploy on the STS-97 mission in 2001, the solar array panels experienced a phenomenon called “stiction” during deploy. The array “stiction,” or stickiness between blankets, caused the array tension bar to slam back into the lower half blanket box intermittently. It resulted in the array flapping and waving against its tension bar. It was determined post-flight that the array “stiction” was caused by an atomic oxygen coating on the panels that fused together over time. The severity of the array “stiction” is directly proportional to the length of time the panels are stored inside the blanket boxes, as well as the temperature of the panels at deployment. To avoid this problem for the P4 solar array deployments, a new deploy procedure was developed. The blanket boxes are deployed in high-tension mode to avoid large movements of the tension bar. The arrays are also thermally conditioned to minimize panel “stiction”. Each solar array is also deployed during periods of low or no sunlight. The arrays are deployed on flight day 6.

P4 Photovoltaic Radiator Deploy

The P4 photovoltaic radiator (PVR) is deployed by commands sent by Jett and Ferguson from computers on the shuttle flight deck on flight day 7 after the radiator cinches and winches are released during the third spacewalk. The radiator is required to cool the arrays’ electronics when the P4 is providing power to station components. The P4 power channels will be provide power for P4 use only until the station’s electrical system is rewired during the STS-116 mission.

Solar Alpha Rotary Joint Activation and Checkout

The SARJ launch and pre-activation orientation is at an angle of 180 degrees to its own axis with both DLAs locked. Upon completion of its activation and checkout, the SARJ will have rotated slightly to an angle of 0 degrees relative to its axis with one DLA engaged and one DLA locked. The goals of this flight's SARJ activation and checkout are to rotate to the solar array wing deploy position and lock, verify the functionality of each SARJ power system and demonstrate its ability to accurately position itself to track the sun.

The SARJ checkout begins near the end of the second spacewalk on flight day 5 and continues through crew sleep prior to solar array deployment. The checkout is scheduled to take up to 12 hours, but could be completed in less time, if the systems operate as expected.

External Wireless Instrumentation System (EWIS)

With the launch of the P4 element, NASA will deploy a new External Wireless Instrumentation System (EWIS) for the first time. The system consists of accelerometers placed around the outboard truss elements of the integrated truss structure. The system allows engineers to gather real-time data during dynamic events that might cause higher vibrations (loads) on the truss elements. For more information on the EWIS, see page 50.

PAYLOADS OF OPPORTUNITY

Ram Burn Observation (RAMBO)

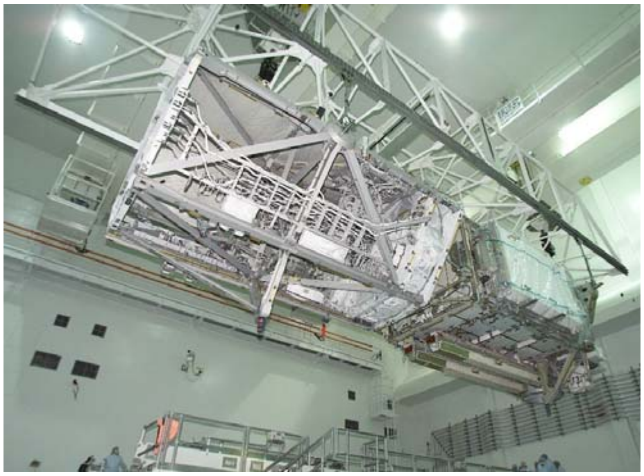
Ram Burn Observations is a Department of Defense experiment that observes shuttle Orbital Maneuvering System engine burns for the purpose of improving plume models. On manifested missions, sensors on a satellite will observe selected rendezvous and orbit adjust burns.

Maui Analysis of Upper-Atmospheric Injections (MAUI)

MAUI will observe the space shuttle exhaust plumes from the Maui Space Surveillance Site (MSSS). The observations will occur when the shuttle fires its engines at night or twilight over MSSS. Spectrally filtered images and spectra of the radiation resulting from exhaust-atmosphere interactions will be taken by the optical telescope and all-sky imagers. This will reveal the chemical and physical mechanisms associated with the interaction between the chemical species in engine exhaust and the space environment. The improved models of this interaction will result in enhanced space event characterization as well as the determination of sensor requirements for effective plume and contamination analysis of other spacecraft.

P3 AND P4 TO EXPAND STATION CAPABILITIES, PROVIDING A THIRD AND FOURTH SOLAR ARRAY

The Port Three (P3) and Port Four (P4) Truss segments are slated for launch to the International Space Station aboard Space Shuttle Atlantis no earlier than August 27, 2006, from Kennedy Space Center, Fla. The truss is the next major addition to the 11-segment integrated truss structure that will eventually span more than 300 feet to carry power, data and temperature control for the orbital outpost's electronics.



P3/P4 Specifications	
Dimensions:	**45.3 ft long by 16 feet wide by 15.6 feet high**
Weight:	**34,885 lbs**

The integrated truss segments started with Starboard zero (S0) as the center assignment and were numbered in ascending order outward to the port and starboard sides. At one time, there was an S2 and P2 planned, but these were eliminated when the station design was scaled back. From S0, the truss segments are P1, P3, P4, P5 and P6 and S1, S3, S4, S5, and S6. P6 is presently on orbit and attached to segment Z1. P6 will be eventually relocated and attached to P5.

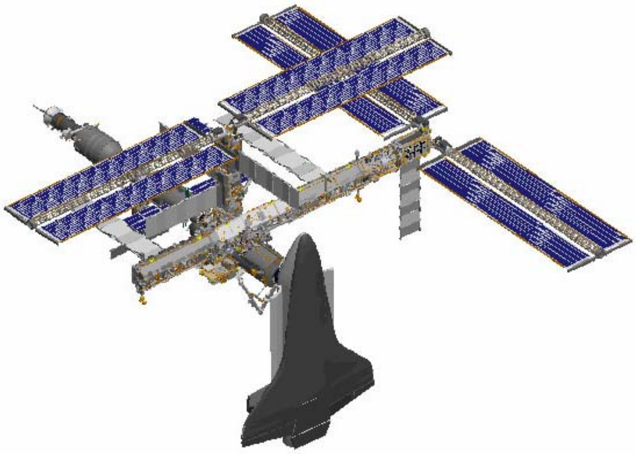
The primary cargo delivered on STS-115/Mission 12A is the Integrated Truss Segment P3/P4, which mates to P1 and provides an attachment point for P5. These new segments also provide a second set of Solar Array Wings (SAWs) and the first alpha joint. The segments also support utility routing, power distribution, and a travel path for the Mobile Remote Service Base System (MBS).

P3 and P4 will be removed from the space shuttle payload bay using the shuttle arm (SRMS – Shuttle Remote Manipulator System) and it will be handed off to the station arm (SSRMS – Space Station Remote Manipulator System), where it will be maneuvered and attached to P1.

The P3 primary structure is made of a hexagonal shaped aluminum structure and includes four bulkheads and six longerons. The secondary structure includes brackets, fittings, attach platforms, EVA equipment and miscellaneous mechanisms.

Major P3 subsystems include the Segment-to-Segment Attach System (SSAS), Solar Alpha Rotary Joint (SARJ), and Unpressurized Cargo Carrier Attach System (UCCAS). The primary functions of the P3 truss segment are to provide mechanical, power and data interfaces to payloads attached to the two UCCAS platforms; axial indexing for solar tracking, or rotating of the arrays to follow the sun, via the SARJ; movement and work site accommodations for the Mobile Transporter; accommodations for ammonia servicing of the outboard PV modules and two Multiplexer/Demuliplexers (MDMs) which are basically computers. The P3 also provides a passive attachment point to the P1 segment via the SSAS and pass through of power and data to and from the outboard segments.

The UCCAS will allow platforms to be attached to P3 for the storage of additional science payloads or spare Orbital Replacement Units. It has a capture latch to grip and secure a payload, a berthing target to align payloads to the mechanism and an Umbilical Mechanism Assembly, which has a connector that provides power and data to the payload.



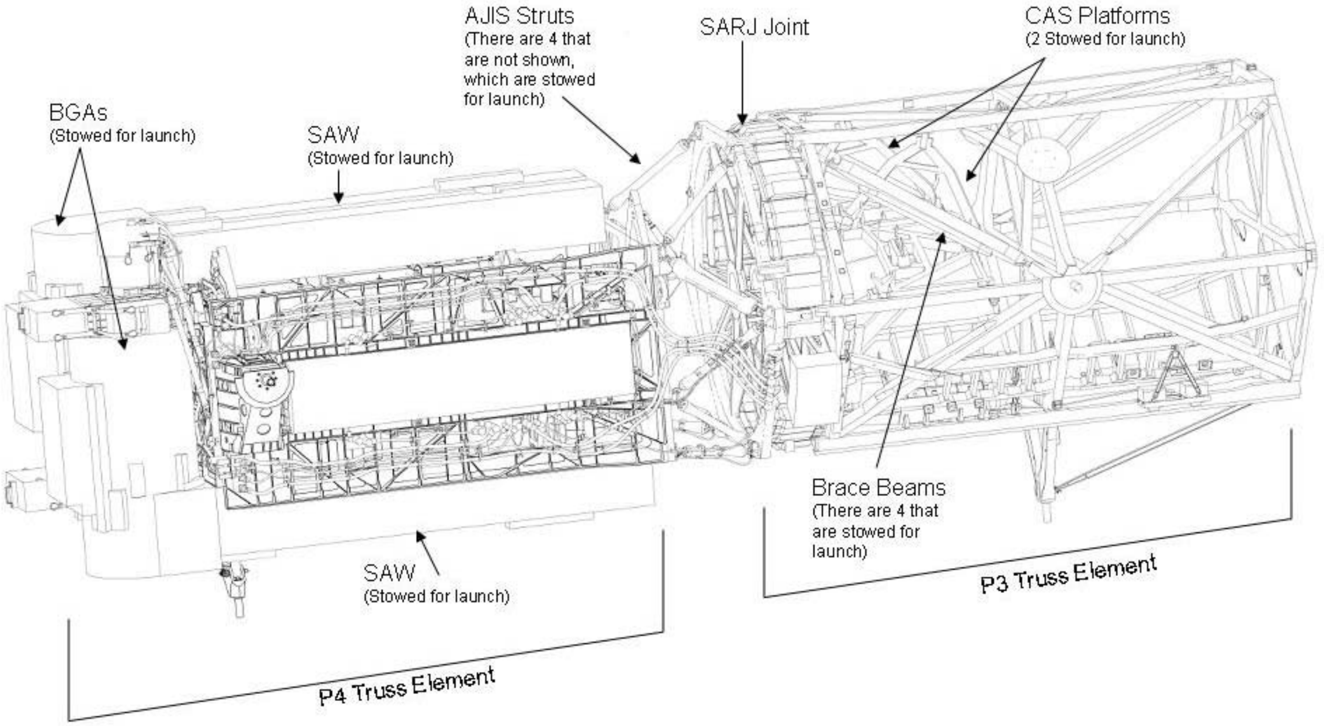
P3/P4 shown attached to the ISS at the far right of this picture

Major subsystems of the P4 Photovoltaic Module (PVM), include the Photovoltaic Radiator (PVR), the Alpha Joint Interface Structure (AJIS), and Modified Rocketdyne Truss Attachment System (MRTAS). The P4 Photovoltaic Module includes all equipment outboard of the Solar Alpha Rotary Joint (SARJ) outboard bulkhead, namely the two Photovoltaic Array Assemblies (PVAAs) and the Integrated Equipment Assembly (IEA). Each PVAA consists of a Solar Array Wing (SAW) and Beta Gimbal Assembly (BGA). The PVR provides thermal cooling for the IEA. The Alpha Joint Interface Structure (AJIS) provides the structural transition between P3 and P4 structures. P4 contains the passive side of the MRTAS, which will provide the structural attachment for P5 on P4.

P3 consists of the Solar Alpha Rotary Joint (SARJ), which continuously rotates to keep the Solar Array Wings (SAW) on P4 and P6 oriented towards the sun as the station orbits the Earth. Each SAW is also oriented by the BGA, which can change the pitch of the wing. Each wing measures 115 feet by 38 feet and extends out to each side of the Integrated Equipment Assembly. There are two wings on P4.

The P3/P4 integrated truss structure is the primary payload for the STS-115 mission and contains several discrete elements: two Solar Array Wings (SAW), Integrated Equipment Assembly (IEA), Solar Alpha Rotary Joint (SARJ), two Beta Gimbal Assemblies (BGA) and Photovoltaic Thermal Control Subsystem.

Following are specific details on each of the major elements:

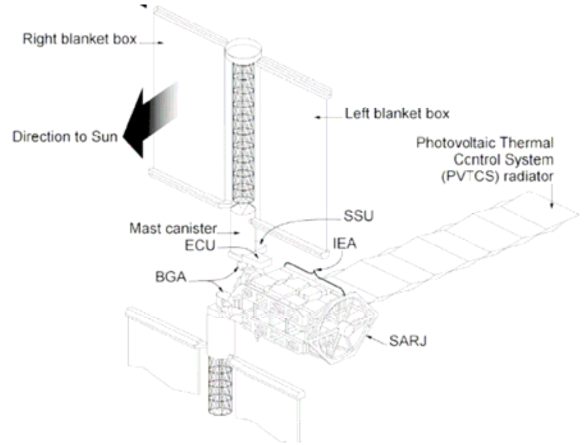


P4 Photovoltaic Module (power module)

Electrical power is the most critical resource for the ISS because it allows astronauts to live comfortably, safely operate the station, and perform complex scientific experiments. Since the only readily available source of energy for spacecraft is sunlight, technologies were developed to efficiently convert solar energy to electrical power. One way to do this is by using large numbers of solar cells assembled into arrays to produce high power levels. The cells are made from purified crystal ingots of silicon that directly convert light to electricity through a process called photovoltaics. Since a spacecraft orbiting the Earth is not always in direct sunlight, energy has to be stored. Storing power in rechargeable batteries provides a continuous source of electricity while the spacecraft is in the Earth's shadow.

NASA and Lockheed Martin developed a method of mounting the solar arrays on a "blanket" that can be folded like an accordion for delivery to space. Once in orbit, astronauts deploy the blankets to their full size. Gimbals are used to rotate the arrays so that they face the sun to provide maximum power to the Space Station. The solar arrays track the sun in two axes: beta and alpha. The complete power system, consisting of U.S. and Russian hardware, will generate 75 to 110 kW (kilowatts) total power, about as much as 55 houses would typically use.

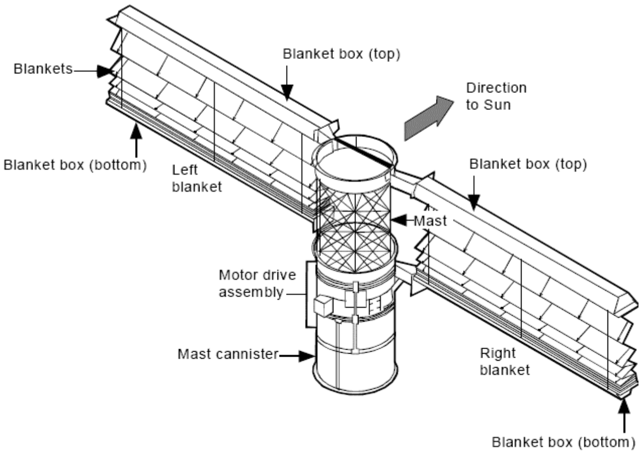
P4 is the second of four PVMs that will eventually be brought up to the International Space Station, to convert sunlight to electricity. The first one, named P6, was brought on orbit by the STS-97 crew in November 2000. The primary functions of the P4 photovoltaic module are to collect, store, convert and distribute electrical power to loads within the segment and to other ISS segments. The P4 PVM consists of two Beta Gimbal/PV Array assemblies, two Beta Gimbal Transition Structures, one integrated Equipment Assembly and associated cabling and tubing. The P4 PVM components were assembled by Boeing in Tulsa, Okla. and Lockheed Martin in Sunnyvale, Calif. prior to final assembly and testing by Boeing at Kennedy Space Center, Fla.

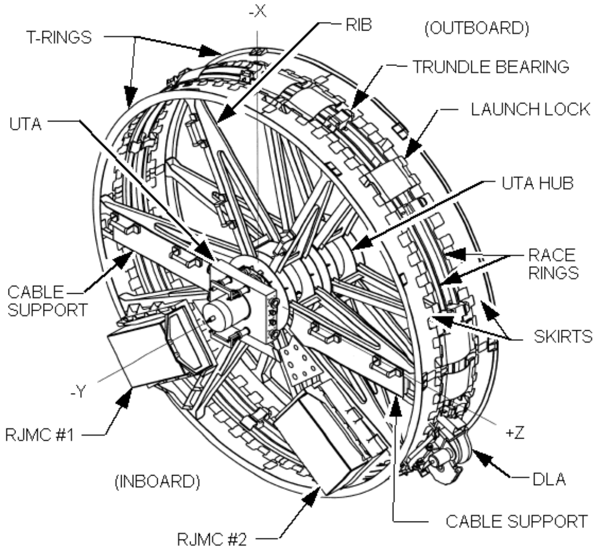


There are two solar array wings (SAW) designed, built and tested by Lockheed Martin in Sunnyvale, Calif. on the P4 module, each deployed in the opposite direction. Each SAW is made up of two solar blankets mounted to a common mast. Prior to deployment, each panel is folded accordion style into a Solar Array Blanket Box (SABB) measuring 20 inches high and 15 feet in length. Each blanket is only about twenty inches thick while in this stored position. The mast consists of interlocking battens that are stowed for launch inside a Mast Canister Assembly (MCA) designed, built and tested by ATK-Able. When deployed by the astronauts, the SAW deploys like an erector set as it unfolds. It has two arms like a human torso when mounted on P4. These arms will be rotated outwards by astronauts during planned spacewalks so they can be fully deployed. Because these blankets were stored for such a long time, NASA, Boeing and Lockheed Martin conducted extensive testing to ensure they would unfold properly once on orbit to ensure there would be no problems with the blankets sticking together. This testing was completed in July 2003.

When fully deployed, the SAW extends 115 feet and spans 38 feet across and extends out to each side of the Integrated Equipment Assembly. Since the second SAW is deployed in the opposite direction, the total wing span is over 240 feet.

Each Solar Array Wing weighs over 2,400 pounds and use nearly 33,000 (32,800 per wing) solar array cells, each measuring 8-cm square with 4,100 diodes. The individual cells were made by Spectrolab and ASEC. There are 400 solar array cells to a string and there are 82 strings per wing. Each SAW is capable of generating nearly 32.8 Kilowatts (kW) of direct current power. There are two SAWs on the P4 module yielding a total power generation capability approaching 66 kW, enough power to meet the needs of 30 average homes – without air conditioning (based on an average 2kW of power.)





P3 consists of the Solar Alpha Rotary Joint (SARJ), which continuously rotates to keep the solar array wings on P4 and P6 oriented towards the sun as the station orbits the earth. Located between P3 and P4, the SARJ is a 10 foot diameter rotary joint that tracks the sun in the alpha axis and turns the entire P4 module (and eventually the P6 module when it is relocated). The SARJ weighs approximately 2,500 pounds. The SARJ can spin 360 degrees using bearing assemblies and a servo control system to turn. All of the power will flow through the Utility Transfer Assembly (UTA) in the SARJ. Roll ring assemblies allow transmission of data and power across the rotating interface so it never has to unwind. The SARJ was designed, built and tested by Lockheed Martin in Sunnyvale, Calif., and its subcontractors.

The solar array wings are also oriented by the Beta Gimbal Assembly (BGA), which can change the pitch of the wings by spinning the solar array. The BGA measures 3 x 3 x 3 feet and provides a structural link between the Integrated Equipment Assembly (IEA). The BGA's most visual functions are to deploy and retract the SAW and rotate it around its longitudinal axis. The BGA consist of three major components all mounted on a platform: the Bearing, Motor and Roll Ring Module (BMRRM), the Electronic Control Unit (ECU) and the Beta Gimbal Transition Structure. The BGA was designed by Boeing Rocketdyne in Canoga Park, Calif., which has since been acquired by Pratt and Whitney. The Sequential Shunt Unit (SSU) that serves to manage and distribute the power generated from the arrays is also mounted on each BGA Platform. The SSU was designed by Space Systems Loral.

Both the SARJ and BGA are pointing mechanisms. They can follow an angle target, rotating in two axes to always point the surface of the arrays at the target, the sun Ground controllers continuously update the target information so the joints keep rotating, moving the arrays moving continuously as the station orbits the Earth every 90 minutes. The movement of the rotation is at a rate that maintains constant contact of the arrays with the sun as the station circles Earth. The SARJ mechanism will move much more than the BGA. The BGA will move about four or five degrees per day, whereas the SARJ will rotate 360 degrees every orbit or about 4 degrees per minute. The SARJ will be the first one to be installed on station. It is unique because it rotates the entire truss element, allowing it to rotate in the alpha axis rotation, a rotation that moves the array in the direction of the station's travel. The station has been using the P6 BGA to move as an alpha joint. Eventually, the SARJ will provide primary rotation with BGA doing minor movements and will be tested on this flight, but won’t be activated until assembly mission STS-116.

P4 Integrated Equipment Assembly (IEA)

The IEA has many components: 12 Battery Subassembly orbital replacement units (ORUs), six Battery Charge/Discharge Units (BCDU) ORUs, two Direct Current Switching Units (DCSUs), two Direct Current to Direct Current Converter Units (DDCUs), two Photovoltaic Controller Units (PVCUs). It integrates the Thermal Control Subsystem that consists of one Photovoltaic Radiator (PVR) ORU and two Pump Flow Control Subassembly (PFCS) ORU’s used to transfer and dissipate heat generated by the IEA ORU boxes. In addition, the IEA provides accommodation for ammonia servicing of the outboard PV modules as well as pass through of power, data to and from the outboard truss elements. The structural transition between the P3 and P4 segments is provided by the Alpha Joint Interface Structure.

The Integrated Equipment Assembly measures 16 x 16 x 16 feet, weighs nearly 17,000 pounds and is designed to condition and store the electrical power collected by the photovoltaic arrays for use on board the Station.

The IEA integrates the energy storage subsystem, the electrical distribution equipment, the thermal control system, and structural framework. The IEA consists of three major elements:

1. The power system electronics consisting of the Direct Current Switching Unit (DCSU) used for primary power distribution; the Direct Current to Direct Current Converter Unit (DDCU) used to produce regulated secondary power; the Battery Charge/Discharge Unit (BCDU) used to control the charging and discharging of the storage batteries; and the batteries used to store power.

2. The Photovoltaic Thermal Control System (PVTCS) consisting of: the coldplate subassembly used to transfer heat from an electronic box to the coolant; the Pump Flow Control Subassembly (PFCS) used to pump and control the flow of ammonia coolant; and the Photovoltaic Radiator (PVR) used to dissipate the heat into deep space. Ammonia has significantly greater heat transfer properties than other chemical coolants.

3. The computers used to control the P4 module ORUs consisting of two Photovoltaic Controller Unit (PVCU) Multiplexer/Demultiplexers (MDMs).

Power received from each PVAA is fed directly into the appropriate Direct Current Switching Unit (DCSU). The DCSU is a high-power, multi-path remotely controlled unit that is used for primary and secondary power distribution, protection and fault isolation within the IEA. It also distributes primary power to the ISS. During periods of isolation, or sunlight, the DCSU routes primary power directly to the ISS from its PVAA and also routes power to the power storage system for battery charging. During periods of eclipse, the DCSU routes power from the power storage system to the ISS. The DCSU measures 28" by 40" by 12" and weighs 238 pounds.

Primary power from the DCSU is also distributed to the Direct Current to Direct Current Converter Unit (DDCU). The DDCU is a power processing system that conditions the coarsely regulated power from the PVAA to 123 +/- 2 VDC. It has a maximum power output of 6.25 kW. This power is used for all P4 operations employing secondary power. By transmitting power at higher voltages and stepping it down to lower voltages where the power is to be used, much like municipal power systems, the station can use smaller wires to transmit this electrical power and thus reduce launch loads. The converters also isolate the secondary system from the primary system and maintain uniform power quality throughout the station. The DDCU measures 27.25" by 23" by 12" and weighs 129 pounds. Primary power from the DCSU is also distributed to the three power storage systems located within each channel of the IEA. The power storage system consists of a Battery Charge/Discharge Unit (BCDU) and two Battery Subassembly ORUs.

The BCDU serves a dual function of charging the batteries during solar collection periods, and providing conditioned battery power to the primary power busses (via the DCSU) during eclipse periods. The BCDU has a battery charging capability of 8.4 kW and a discharge capability of 6.6 kW. The BCDU also includes provisions for battery status monitoring and protection from power circuit faults. The PVCU commands the BCDU. The BCDU measures 28" by 40" by 12" and weighs 235 pounds.

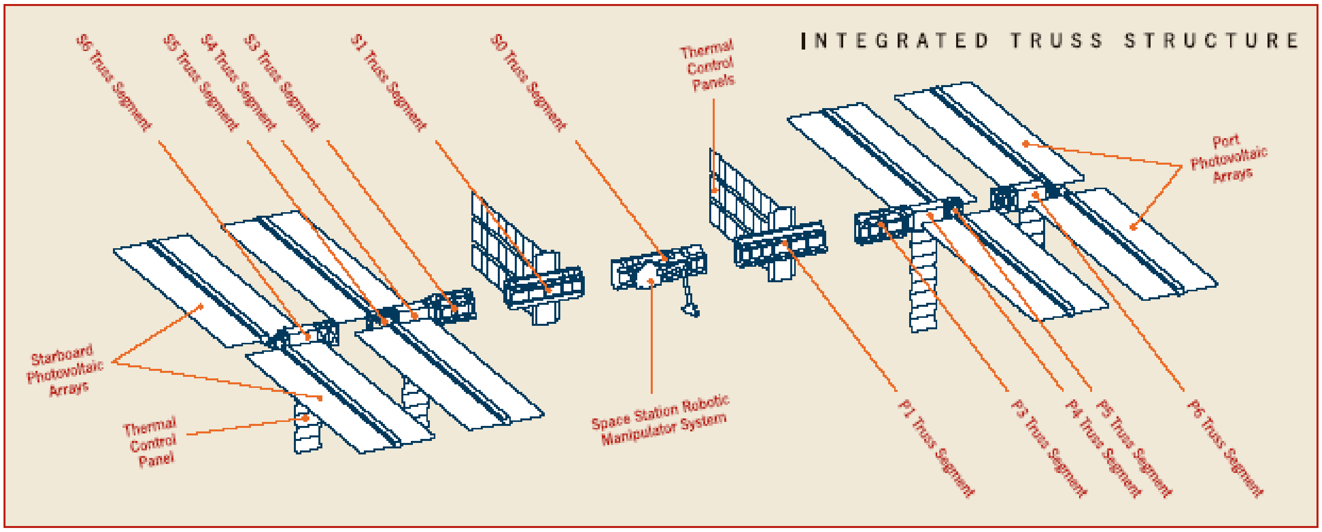
Each Battery Subassembly ORU consists of 38 lightweight Nickel Hydrogen cells and associated electrical and mechanical equipment. Two battery Subassembly ORUs connected in series are capable of storing a total of 8 kW of electrical power. This power is fed to the ISS via the BCDU and DCSU respectively. The batteries have a design life of 6.5 years and can exceed 38,000 charge/discharge cycles down to a 35% level of charge. Each battery measures 41" by 37" by 19" and weighs 372 pounds. Because of delays in launching the P3/P4 elements, the batteries were replaced in March 2005 for the lower deck and August 2005 for the upper deck.

In order to maintain the IEA electronics at safe operating temperatures in the harsh space environment, they are conditioned by the Photovoltaic Thermal Control System (PVTCS). The PVTCS consist of ammonia coolant, eleven coldplates, two Pump Flow Control Subassemblies (PFCS) and one Photovoltaic Radiator (PVR).

The coldplate subassemblies are an integral part of IEA structural framework. Heat is transferred from the IEA orbital replacement unit (ORU) electronic boxes to the coldplates via fine interweaving fins located on both the coldplate and the electronic boxes. The fins add lateral structural stiffness to the coldplates in addition to increasing the available heat transfer area.

The PFCS is the heart of the thermal system. It consists of all the pumping capacity, valves and controls required to pump the heat transfer fluid to the heat exchanges and radiator, and regulate the temperature of the thermal control system ammonia coolant. The PVTCS is designed to dissipate 6,000 Watts of heat per orbit on average and is commanded by the IEA computer. Each PFCS consumes 275 Watts during normal operations and measures approximately 40 x 29 x 19 inches, weighing 235 pounds.

The PVR – the radiator – is deployable on orbit and comprised of two separate flow paths through seven panels. Each flow path is independent and is connected to one of the two PFCSs on the IEA. In total, the PVR can reject up to 14 kW of heat into deep space. The PVR weighs 1,633 pounds and when deployed measures 44 x 12 x 7 feet.



P3/P4 Facts in brief:

Manufacturer: Boeing

Dimensions: 45.3 feet long by 16 feet wide by 15.6 feet high

Weight: 34,885 lbs

Structure: Primarily aluminum

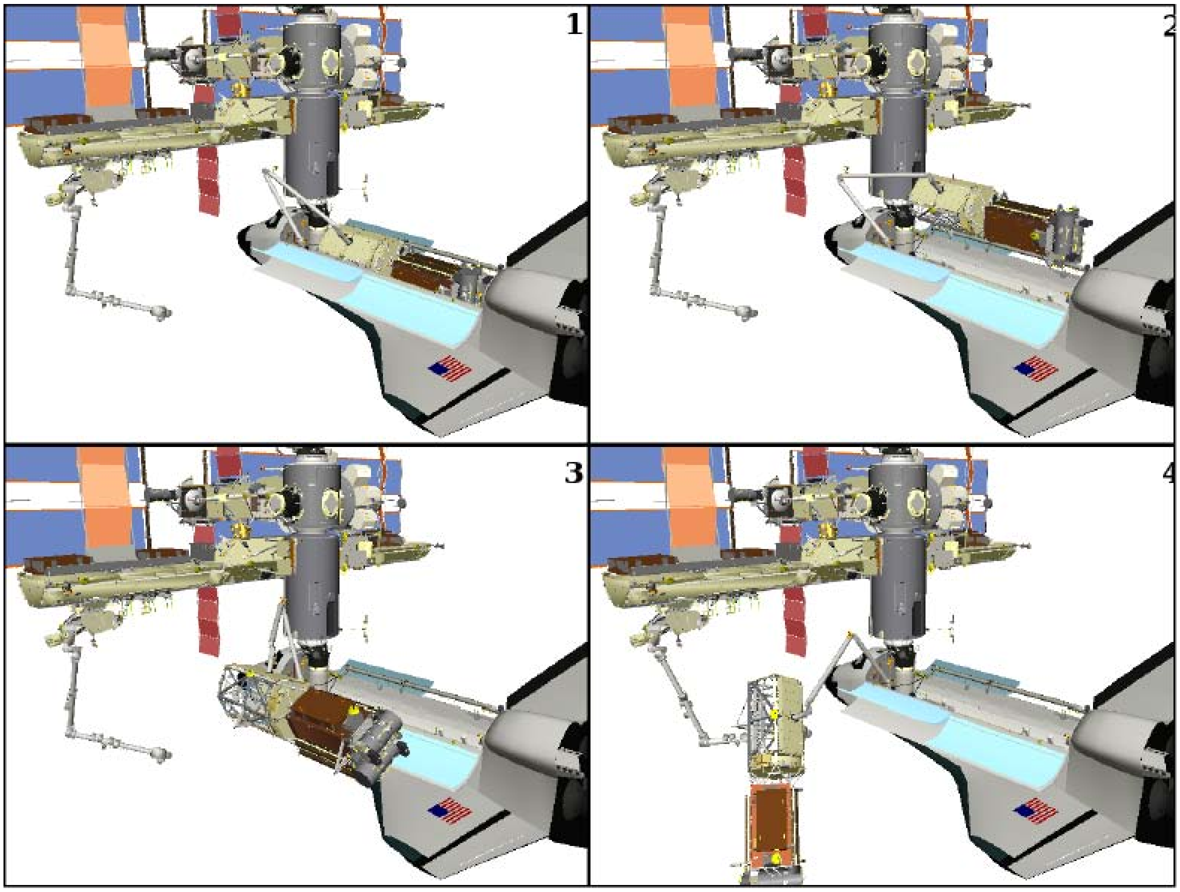
Major components: The P3 primary structure is made of a hexagonal shaped aluminum structure and includes four bulkheads and six longerons. The secondary structure includes brackets, fittings, attach platforms, EVA equipment and miscellaneous mechanisms. The P4 Photovoltaic module includes all equipment outboard of the Solar Alpha Rotary Joint (SARJ) outboard bulkhead, namely the two Photovoltaic Array assemblies and the Integrated Equipment Assembly (IEA).

Purpose: To carry power, data and environmental services along the integrated truss structure. Also, to provide active thermal protection to electrical components throughout the station and to allow the connection of platforms to store spare parts.

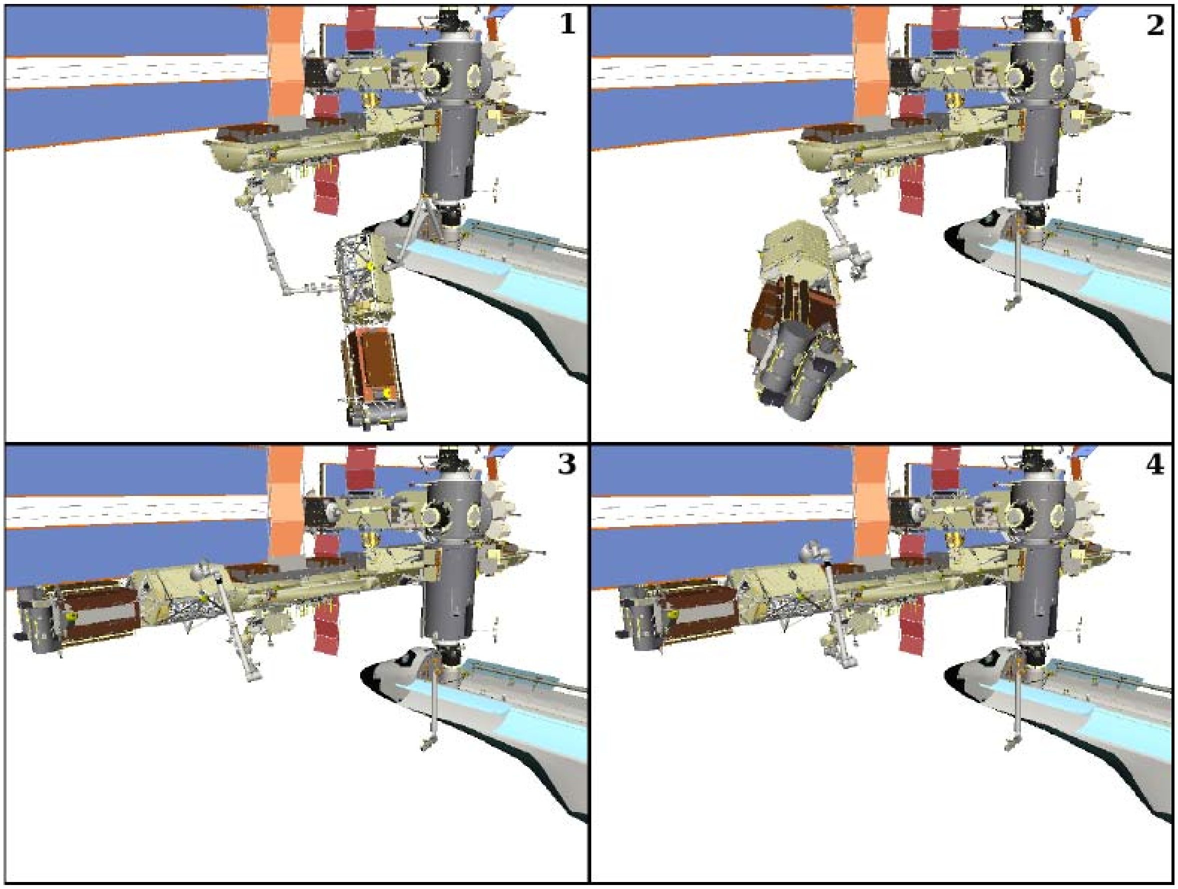
Construction: P3 was designed by the Boeing design team at Huntington Beach, Calif. Boeing (now Pratt and Whitney) Rocketdyne Power and Propulsion in Canoga Park, Calif. designed P4. Assembly of P3 and P4 in Tulsa, Okla. started in 1997. P3 was delivered to the Space Station Processing Facility at Kennedy Space Center on November 17, 1999 and P4 was delivered on July 29, 2000. P3 and P4 were handed off to NASA on September 26, 2002.

Major Subcontractors: Lockheed Martin, Honeywell, Hamilton Sundstrand, Pratt and Whitney Rocketdyne

Installation: P3/P4 is to be installed during STS-115 to the P1 truss via the Segment to Segment Attachment System (SSAS).

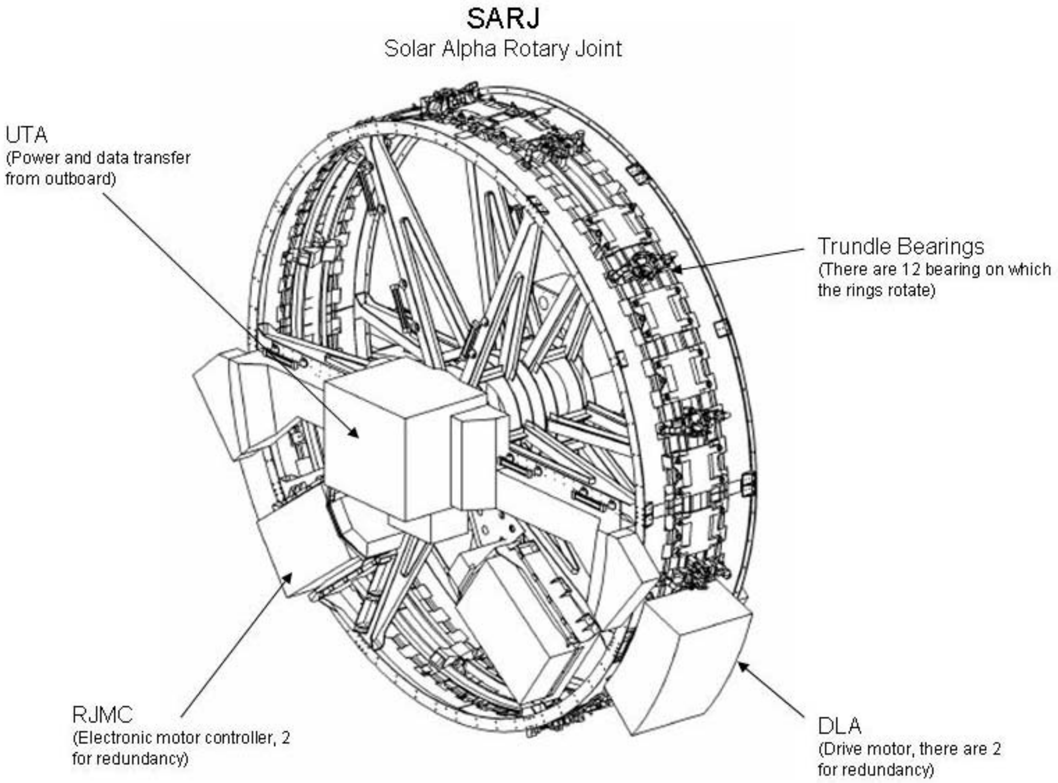


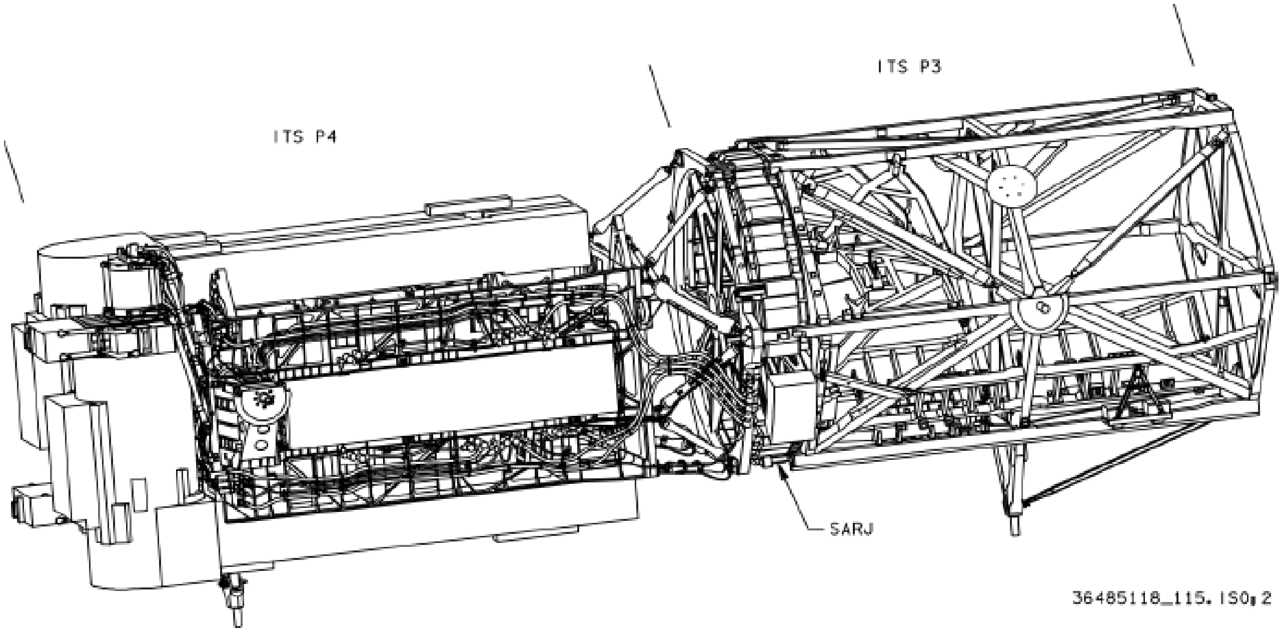
P3/P4 SRMS unberth and SSRMS handoff operations is shown above.



P3/P4 SSRMS maneuver and installation is shown above

Additional drawings to use





EXTERNAL WIRELESS INSTRUMENTATION SYSTEM (EWIS)

With the launch of the P4 element, NASA will deploy a new External Wireless Instrumentation System (EWIS) for the first time. The system consists of accelerometers placed around the outboard truss elements of the integrated truss structure. The system is currently installed on P4 and P5 and will also be installed on the S4 and S6 truss structures later this year at Kennedy Space Center, Fla. The six quarter-size accelerometers on P4 measure accelerations in all directions, the x-, y- and z- axis orientations.

The vibration data seen by the accelerometers will be compared with their loads models so they can be further refined by engineers with actual on-orbit data to better predict the durability of the station's integrated truss structure. NASA and Boeing engineers will use these measurements, using refined models, to analytically extend the 15-year design life of the truss elements. EWIS will also give engineers a better understanding of the actual response of the truss system on orbit.

The space station has 33 hardwired accelerometers currently installed on the inboard truss elements (13 on S0, four on S1, six on P1, five on S3 and five on P3). The data from these accelerometers is transferred through the station Command and Data Handling System where the data is relayed to the ground for engineers to analyze. The wireless system was created because there was no easy way to hardwire the accelerometers into the outboard truss elements, outside of the Solar Alpha Rotary Joint.

The wireless system uses a spread spectrum radio system that transmits at 900 MHz, similar to an older cordless phone. International Space Station power is supplied to the Remote Sensor Unit (RSU) on the P4 truss element, which contains the memory for the measurements, computer controls and the radio transmitter. The data will be collected as soon as P4 is powered up and will be stored in the RSU. When requested, it transmits the data to a briefcase-sized Network Control Unit (NCU), which will be located in the avionics two rack in Destiny.

In addition to the NCU, two eight-inch-long antennas will be installed on the aft end cone on the nadir side of Destiny. The spacewalk to install these antennas is considered a get-ahead task for this mission, but more than likely will be installed on assembly STS-118 in 2007. The NCU will be installed on station assembly STS-117. EWIS is expected to be fully operational upon completion of STS-119.

The new system was designed and tested by NASA and Boeing engineers, with work beginning in May 2003. It allows engineers to gather real-time data during dynamic events that might cause higher vibrations (loads) on the truss elements, such as docking operations with the space shuttle or progress vehicles, SARJ rotations or during thruster firings during re-boosts. The data is expected to be retrieved several times a month.

NASA and Boeing engineers believe these measurements will allow some of the conservatism and uncertainty to be removed from their models. Engineers also believe this data will be helpful in better understanding the kinds of loads exerted on future large structure exploration vehicles.

EXPERIMENTS

EXPERIMENTAL PAYLOADS

There are two experimental payloads that will be carried to the station on STS-115. Currently, the crew timeline does not support performing the experiments. Therefore the experiments will be left for the station crew to perform. However, should an extra day be added to the mission, the shuttle crew will perform the experiments.

Effect of Spaceflight on Microbial Gene Expression & Virulence (MICROBE)

The objective of the MICROBE payload is to characterize the effects of space on the virulence and physiology of three common microbes previously isolated from the space shuttle environment and to facilitate development of effective antimicrobials/therapeutics and effective systems for maintaining water potability.

The experiment consists of 12 Group Activation Packs (GAPs) that will be loaded on the shuttle for sortie operations. On orbit, the GAPs will be manually activated using a small hand crank, which will introduce fresh growth medium into the cultures. Following about 24 hours of passive ambient incubation, the crew will manually terminate growth using the hand crank.

Currently the timeline does not support scheduling MICROBE. If an extra day is added to the mission then eight of the 12 GAPs may be scheduled depending on the required activities on that day. The remaining four GAPs require activation as late as possible in the mission. Scheduling the four GAPs is dependent on the post undock timeline.

Yeast-GAP

This experiment will study how individual genes respond to microgravity conditions. The results could help scientists understand how mammalian cells will respond when they are grown in microgravity as well as improve culturing techniques of mammalian cells on Earth.

The experiment consists of four GAPs that will be loaded on the shuttle for sortie operations. On orbit, the GAPs will be manually activated using a small hand crank, which will introduce fresh growth medium into the cultures. Following 24 hours of passive ambient incubation, the crew will manually terminate growth using the hand crank

Currently the timeline does not support scheduling Yeast-GAP. It is to be transferred to the station to be performed by the station crew. However, if an additional day is added to the mission then the experiment may be scheduled.

DETAILED TEST OBJECTIVES

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

Such experiments assigned to STS-115 are listed below.

DTO 805 Crosswind Landing Performance (If Opportunity)

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

1. Prelaunch: Prelaunch planning must allow selection of a runway with Microwave Scanning Beam Landing System (MSBLS) support. MSBLS is a set of dual transmitters located beside the runway providing precision navigation vertically, horizontally and longitudinally with respect to the runway. This precision navigation subsystem helps provide a higher probability of a more precise landing with a crosswind of 10 to 15 knots as late in the flight as possible.

2. Entry: This test requires that the crew perform a manually controlled landing in the presence of a 90-degree crosswind component of 10 to 15 knots steady state.

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

STATION DEVELOPMENT TEST OBJECTIVE (SDTO)

SDTO 12004-U: Shuttle Booster Fan Bypass

The purpose of this SDTO is to increase shuttle on orbit cryogenic margin by bypassing and deactivating the shuttle booster fan—airlock fan—whenever possible on-orbit. The booster fan will not be activated in post insertion and will remain deactivated for most of the mission. It will however be activated for docking and undocking to provide cooling to the powered docking avionics and to prevent condensation on the Orbiter Docking System hatch window. The fan will also be activated to provide good airflow when the crew is working in the airlock, such as during checkout of the spacesuits. While docked, sufficient air circulation will be achieved through use of the lab forward intermodular ventilation fan so that carbon dioxide (CO2) levels on both the station and shuttle can be controlled during the day by the space station. A real-time call may instruct the crew to replace lithium hydroxide on the middeck to supplement the carbon dioxide removal provided by the station. Acceptable flow rate through the IMV fan and proper CO2 levels on the shuttle throughout the docked timeframe must be confirmed on-orbit to prove this cryogenic reduction method a success.

SDTO 13005-U ISS Structural Life Validation and Extension

The overall purpose of this SDTO is to guarantee safety of the station structure and crew. Specific objectives are to accurately determine structural life usage of the P3/P4 truss, to expand station operations and to increase the life of the structure. This reconstruction requires actual or educated estimates of input (forcing function) and actual output (on-orbit sensor measurements) of the station response. Measurement of the force input (i.e., thruster firing sequences, video of crew activity, etc.) and station response will aid reconstruction of station loads and structural life usage over the life of the station, and thus allowing life extension of the structure. This will be performed during P3/P4 installation operations.

SDTO 15003-U Microgravity Environment Definition

The station's microgravity instrumentation will be used to measure the microgravity environment and enable prediction of acceptable microgravity experiment times for similar station structural configurations. The measurements will be performed before experimentation times to assure station operations are consistent with the microgravity requirements. Measurements will be made for specific expected attitudes and dynamic disturbances—in the case of STS-115 to characterize the Solar Array Rotation Joint checkout.

Short Duration Bioastronautics Investigation (SDBI)

SDBI 1490B Bioavailability and Performance Effects of Promethazine (PMZ) During Spaceflight

This investigates the effects of Promethazine, an antihistamine that can be used as a medication for motion sickness. All participants will don the Actiwatch activity monitor, a wristwatch-like device that tracks body motion, as soon as possible on orbit. They will wear the Actiwatch and record sleep times throughout the mission. Before the first Promethazine (PMZ) dose, participating crew members will collect a saliva sample; thereafter, saliva samples will be collected and a Stanford Sleepiness Score completed at 1, 2, 4, 8, 24, 36 and 48 hours post-PMZ. This protocol will be repeated each time PMZ is taken. Participants who do not take PMZ will wear the Actiwatch and record sleep times throughout the mission. However, if a participant elects to take PMZ before sleep, saliva samples will be collected before the dose, just before sleep, immediately upon wake-up, one hour after wake-up, and at 24, 36, and 48 hours post-dose.

SDBI 1493 Monitoring Latent Virus Reactivation and Shedding in Astronauts

The objective of this SDBI is to determine the frequency of induced reactivation of latent viruses, latent virus shedding, and clinical disease after exposure to the physical, physiological, and psychological stressors associated with spaceflight.

Induced alterations in the immune response will become increasingly important on long-duration missions, with one focus being the potential for reactivation and dissemination or shedding of latent viruses. An example of a latent virus is herpes simplex type-1, which infects 70 to 80 percent of adults. Its manifestation is classically associated with the presence of cold sores, pharyngitis, and tonsillitis. Herpes simplex type-1 is usually acquired through contact with the saliva, skin, or mucous membranes of an infected individual. However, many recurrences are asymptomatic, resulting in shedding of the virus.

SDBI 1634 Sleep-Wake Actigraphy and Light Exposure during Spaceflight

Participating crew members will don the Actiwatch activity monitor as soon as possible upon entering orbit and will wear it continuously throughout the mission on their non-dominant wrists outside of their clothing/sleeve. The Actiwatch watch can be temporarily removed for activities such as spacewalks. Subjects will also complete a short log within 15 minutes of final awakening every morning in-flight.

SHUTTLE REFERENCE DATA

SHUTTLE ABORT MODES

RSLS Aborts

These occur when the on-board shuttle computers detect a problem and command a halt in the launch sequence after taking over from the ground launch sequencer and before solid rocket booster ignition.

Ascent Aborts

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

Intact Aborts

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

Return to Launch Site

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

The RTLS profile is designed to accommodate the loss of thrust from one space shuttle main engine between liftoff 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 external tank 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, about 3 minutes, 34 seconds into the mission; whereas an RTLS chosen due to an engine out at liftoff is selected at the earliest time, about 2 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 toward 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 maneuver 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 maneuver has been completed, the glide phase of the RTLS begins. From then on, the RTLS is handled similarly to a normal entry.

Transoceanic Abort Landing

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

In a TAL abort, the vehicle continues on a ballistic trajectory across the Atlantic Ocean to land at a predetermined runway. Landing occurs about 45 minutes after launch. The landing site is selected near the normal ascent ground track of the orbiter 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. The three landing sites that have been identified for a launch are Zaragoza, Spain; Moron, Spain; and Istres, France.

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 normal entry.

Abort to Orbit

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

Abort Once Around

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

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

Contingency Aborts

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

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

Abort Decisions

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

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

Mission Control 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 on-board 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 on-board methods, such as cue cards, dedicated displays and display information, to determine the 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 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 about 90 minutes. Which of these is selected depends on the time of the failure with three good space shuttle main engines.

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

SHUTTLE ABORT HISTORY

RSLS Abort History:
(STS-41 D) June 26, 1984

The countdown for the second launch attempt for Discovery's maiden flight ended at T-4 seconds when the orbiter's computers detected a sluggish valve in main engine No. 3.The main engine was replaced and Discovery was finally launched on Aug. 30, 1984.

(STS-51 F) July 12, 1985

The countdown for Challenger's launch was halted at T-3 seconds when on-board computers detected a problem with a coolant valve on main engine No. 2. The valve was replaced and Challenger was launched on July 29, 1985.

(STS-55) March 22, 1993

The countdown for Columbia's launch was halted by on-board computers at T-3 seconds following a problem with purge pressure readings in the oxidizer preburner on main engine No. 2 Columbia's three main engines were replaced on the launch pad, and the flight was rescheduled behind Discovery's launch on STS-56. Columbia finally launched on April 26, 1993.

(STS-51) Aug. 12, 1993

The countdown for Discovery's third launch attempt ended at the T-3 second mark when onboard computers detected the failure of one of four sensors in main engine No. 2 which monitor the flow of hydrogen fuel to the engine. All of Discovery's main engines were ordered replaced on the launch pad, delaying the shuttle's fourth launch attempt until Sept. 12, 1993.

(STS-68) Aug. 18, 1994

The countdown for Endeavour's first launch attempt ended 1.9 seconds before liftoff when on-board computers detected higher than acceptable readings in one channel of a sensor monitoring the discharge temperature of the high pressure oxidizer turbopump in main engine No. 3. A test firing of the engine at the Stennis Space Center in Mississippi on September 2nd confirmed that a slight drift in a fuel flow meter in the engine caused a slight increase in the turbopump's temperature. The test firing also confirmed a slightly slower start for main engine No. 3 during the pad abort, which could have contributed to the higher temperatures. After Endeavour was brought back to the Vehicle Assembly Building to be outfitted with three replacement engines, NASA managers set Oct. 2 as the date for Endeavour's second launch attempt.

Abort to Orbit History: (STS-51 F) July 29, 1985

After an RSLS abort on July 12, 1985, Challenger was launched on July 29, 1985. Five minutes and 45 seconds after launch, a sensor problem resulted in the shutdown of center engine No. 1, resulting in a safe "abort to orbit" and successful completion of the mission.

SPACE SHUTTLE MAIN ENGINES

Developed in the 1970s by NASA's Marshall Space Flight Center in Huntsville, Ala., the space shuttle main engine is the most advanced liquid-fueled rocket engine ever built. Every space shuttle main engine is tested and proven flight-worthy at NASA's Stennis Space Center in south Mississippi, before installation on an orbiter. Its main features include variable thrust, high performance reusability, high redundancy and a fully integrated engine controller.

The shuttle's three main engines are mounted on the orbiter aft fuselage in a triangular pattern. Spaced so that they are movable during launch, the engines are used – in conjunction with the solid rocket boosters – to steer the shuttle vehicle.

Each of these powerful main engines is 14 feet (4.2 meters) long, weighs about 7,000 pounds (3,150 kilograms) and is 7.5 feet (2.25 meters) in diameter at the end of its nozzle.

The engines operate for about 8½ minutes during liftoff and ascent—burning more than 500,000 gallons (1.9 million liters) of super-cold liquid hydrogen and liquid oxygen propellants stored in the huge external tank attached to the underside of the shuttle. The engines shut down just before the shuttle, traveling at about 17,000 mph (28,000 kilometers per hour), reaches orbit.

The main engine operates at greater temperature extremes than any mechanical system in common use today. The fuel, liquefied hydrogen at -423 degrees Fahrenheit (-253 degrees Celsius), is the second coldest liquid on Earth. When it and the liquid oxygen are combusted, the temperature in the main combustion chamber is 6,000 degrees Fahrenheit (3,316 degrees Celsius), hotter than the boiling point of iron.

The main engines use a staged combustion cycle so that all propellants entering the engines are used to produce thrust or power—more efficiently than any previous rocket engine. In a staged combustion cycle, propellants are first burned partially at high pressure and relatively low temperature—then burned completely at high temperature and pressure in the main combustion chamber. The rapid mixing of the propellants under these conditions is so complete that 99 percent of the fuel is burned.

At normal operating level, the engines generate 490,847 pounds of thrust (measured in a vacuum). Full power is 512,900 pounds of thrust; minimum power is 316,100 pounds of thrust.

The engine can be throttled by varying the output of the pre-burners, thus varying the speed of the high-pressure turbopumps and, therefore, the flow of the propellant.

At about 26 seconds into launch, the main engines are throttled down to 316,000 pounds of thrust to keep the dynamic pressure on the vehicle below a specified level—about 580 pounds per square foot or max q. Then, the engines are throttled back up to normal operating level at about 60 seconds. This reduces stress on the vehicle.

The main engines are throttled down again at about seven minutes, 40 seconds into the mission to maintain three g's – three times the Earth's gravitational pull – again reducing stress on the crew and the vehicle. This acceleration level is about one-third the acceleration experienced on previous crewed space vehicles.

About 10 seconds before main engine cutoff or MECO, the cutoff sequence begins; about three seconds later the main engines are commanded to begin throttling at 10 percent thrust per second to 65 percent thrust. This is held for about 6.7 seconds, and the engines are shut down.

The engine performance has the highest thrust for its weight of any engine yet developed. In fact, one space shuttle main engine generates sufficient thrust to maintain the flight of 2½ 747 airplanes.

The space shuttle main engine is also the first rocket engine to use a built-in electronic digital controller, or computer. The controller will accept commands from the orbiter for engine start, change in throttle, shutdown, and monitor engine operation. In the event of a failure, the controller automatically corrects the problem or safely shuts down the engine.

NASA continues to increase the reliability and safety of shuttle flights through a series of enhancements to the space shuttle main engines. The engines were modified in 1988, 1995, 1998 and 2001. Modifications include new high-pressure fuel and oxidizer turbopumps that reduce maintenance and operating costs of the engine, a two-duct powerhead that reduces pressure and turbulence in the engine, and a single-coil heat exchanger that lowers the number of post flight inspections required. Another modification incorporates a large-throat main combustion chamber that improves the engine's reliability by reducing pressure and temperature in the chamber.

After the orbiter lands, the engines are removed and returned to a processing facility at Kennedy Space Center, Fla., where they are rechecked and readied for the next flight. Some components are returned to the main engine's prime contractor, Pratt & Whitney RocketDyne, West Palm Beach, Fla., for regular maintenance. The main engines are designed to operate for 7.5 accumulated hours.

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 about 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 liftoff and during first-stage ascent. Seventy-five seconds after SRB separation, SRB apogee occurs at an altitude of about 220,000 feet, or 35 nautical miles (40 statute miles). SRB impact occurs in the ocean about 122 nautical miles (140 statute miles) downrange.

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

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

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 done 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 about 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 about a third 50 seconds after liftoff 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, a transition piece between the nose cone and solid rocket motor, 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 ATK 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 (NSDs), 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 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 on-board computers at T minus 6.6 seconds (staggered start—engine three, engine two, engine one—all about 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 liftoff 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 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 on-board 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 on-board master timing unit, event timer and mission event timers are started; the three SSMEs are at 100 percent; and the ground launch sequence is terminated.

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

Electrical Power Distribution

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

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

Hydraulic Power Units

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

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

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

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

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

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

Each HPU on an SRB is connected to both servoactuators on that SRB. One HPU serves as the primary hydraulic source for the servoactuator, and the other HPU serves as the secondary hydraulics for the servoactuator. Each servoactuator 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 liftoff 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, 1998, on mission STS-91. The SLWT is 7,500 pounds lighter than the standard external tank. The lighter weight tank allows 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 percent stronger and 5 percent less dense.

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

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

ACRONYMS AND ABBREVIATIONS

A/L	Airlock
AA	Antenna Assembly
AAA	Avionics Air Assembly
ABC	Audio Bus Coupler
AC	Assembly Complete
ACBM	Active Common Berthing Mechanism
ACO	Assembly and Checkout Officer
ACS	Atmosphere Control and Supply
ACSM	Attitude Control System Moding
ACU	Arm Computer Unit
ADO	Adaptation Data Overlay
ADSEP	Advanced Separation
ADVASC	Advanced Astroculture
ADVASC-GC	Advanced Astroculture—Growth Chamber
AEA	Antenna Electronics Assembly
AFD	Aft Flight Deck
AJIS	Alpha Joint Interface Structure
AKA	Active Keel Assembly
APAS	Androgynous Peripheral Attachment System
APCU	Assembly Power Converter Unit
APDS	Androgynous Peripheral Docking System
APFR	Articulating Portable Foot Restraint
APM	Attached Pressurized Module
APPCM	Arm Pitch Plane Change Mode
APS	Automated Payload Switch
AR	Atmosphere Revitalization
ARCU	American-to-Russian Converter Unit
ARIS	Active Rack Isolation System
ARS	Air Revitalization System
ASCR	Assured Safe Crew Return
ATA	Ammonia Tank Assembly
ATCS	Active Thermal Control System
ATU	Audio Terminal Unit
AUAI	Assemble Contingency System/UHF Audio Interface
AVU	Artificial Vision Unit
AVV	Accumulator Vent Valve
BA	Bearing Assembly
BBC	Bus Bolt Controller

BC	Bus Controller
BCDU	Battery Charge/Discharge Unit
BCU	Backup Controller Unit
BDU	Backup Drive Unit
BG	Beta Gimbal
BGA	Beta Gimbal Assembly
BGDTS	Beta Gimbal Deployment Transition Structure
BGHS	Beta Gimbal Housing Subassembly
BIT	Built-In Test
BITE	Built-In Test Equipment
BMRRM	Bearing Motor and Roll Ring Module
BONEMAC	Bone Marrow Macrophages in Space
BRS	Bottom Right Side
BSP	Baseband Signal Processor
BTS	Bolt Tight Switch
C&C	Command and Control
C&DH	Command and Data Handling
C&M	Control and Monitor
C&T	Communication and Tracking
C&W	Caution and Warning
C/A-code	Coarse/Acquisition-code
C/L	Crew Lock
CA	Control Attitude
CAS	Common Attach System
CBM	Common Berthing Mechanism
CBOSS	Cellular Biotechnology Operating Science System
CCAA	Common Cabin Air Assembly
CCASE	Commercial Cassette Experiment
CCD	Cursor Control Device
CCMS	Concentric Cable Management System
CCS	Communication and Control System
CCTV	Closed-Circuit Television
CDDT	Common Display Development Team
CDRA	Carbon Dioxide Removal Assembly
CDS	Command and Data Software
CETA	Crew and Equipment Translation Aid
CEU	Control Electronics Unit
CFA	Circular Fan Assembly
CGBA	Commercial Generic Bioprocessing Apparatus
CHeCS	Crew Health Care System
CHX	Condensing Heat Exchanger

CID	Circuit Interrupt Device
CIOB	Cargo Integration and Operations Branch
CLA	Camera and Light Assembly
CLPA	Camera Light and Pan/Tilt Assembly
CMG	Control Moment Gyroscope
CMG-TA	Control Moment Gyroscope-Thruster Assist
CO_2	Carbon Dioxide
COAS	Crew Optical Alignment Sight
COR	Communication Outage Recorder
COTS	Commercial-Off-The-Shelf
CP	Cold Plate
CPCG-H	Commercial Protein Crystal Growth-High
CR	Change Request
CRES	Corrosion Resistant Steel
CRIM	Commercial Refrigerator Incubator Module
CRIM-M	Commercial Refrigerator Incubator Module-Modified
CRPCM	Canadian Remote Power Controller Module
CSA	Computer Systems Architecture
CSA-CP	Compound Specific Analyzer-Combustion Products
CSCI	Computer Software Configuration Item
CSM	Cargo Systems Manual
CTB	Cargo Transfer Bag
CVIU	Common Video Interface Unit
CVT	Current Value Table
CVV	Carbon Dioxide Vent Valve
CWC	Contingency Water Collection

DAIU	Docked Audio Interface Unit
DAP	Digital Autopilot
DC	Docking Compartment
dc	direct current
DCP	Display and Control Panel
DCSU	Direct Current Switching Unit
DDCU	DC-to-DC Converter Unit
DDCU-CP	DC-to-DC Converter Unit-Cold Plate
DDCU-E	External DDCU
DDCU-HP	DC-to-DC Converter Unit-Heat Pipe
DDCU-I	Internal DDCU
DFL	Data Format Load
DLA	Drive Locking Assembly
DMCU	Docking Mechanism Control Unit
DMS-R	Data Management System-Russian

dp/dt	delta pressure/delta time
DPA	Digital Preassembly
DPS	Data Processing System
DTO	Development Test Objective
DTV	Digital Television
E/L	Equipment Lock
E-Stop	Emergency Stop
EACP	EMU Audio Control Panel
EAIU	EMU Audio Interface Unit
EAS	Early Ammonia Servicer
EATCS	External Active Thermal Control Subsystem
ECLSS	Environmental Control and Life Support System
ECU	Electronics Control Unit
ED	Engagement Drive
EDDA	External Maneuvering Unit Don/Doff Assembly
EEATCS	Early External Active Thermal Control System
EET	Experiment Elapsed Time
EETCS	Early External Thermal Control System
EFGF	Electrical Flight-releasable Grapple Fixture
EGIL	Electrical Generation and Integrated Lighting Systems Engineer
EIA	Electrical Interface Assembly
EMPEV	Emergency Manual Pressure Equalization Value
EMU	Extravehicular Mobility Unit
EOA	EVA Ohmmeter Assembly
EPCE	Electrical Power Consuming Equipment
EPG	Electrical Power Generator
EPS	Electrical Power System
ER	Edge Router
ESA	External Sampling Adapter
ESP	External Stowage Platform
ESSMDM	Enhanced Space Station Multiplexer/Demultiplexer
ESU	End Stop Unit
ETCS	External Thermal Control Ssytem
ETI	Elapsed Time Indicator
ETRS	EVA Temporary Rail Stop
ETSD	EVA Tool Storage Device
ETVCG	External Television Cameras Group
EUE	Experiment Unique Equipment
EV	Extravehicular
EV-CPDS	Extravehicular-Charged Particle Directional Spectrometer
EVA	Extravehicular Activity

EVR	Extravehicular Robotics
EVSU	External Video Switching Unit
EXPRESS	EXpedite the PRocessing of Experiments to the Space Station
EXT	Experimental Terminal
EWIS	External Wireless Instrumentation System
FAWG	Flight Assignment Working Group
FC	Firmware Controller
FCC	Flat Controller Circuit
FCT	Flight Control Team
FCV	Flow Control Valve
FD	Flight Day
FDA	Fault Detection Annunciation
FDIR	Failure, Detection, Isolation and Recovery
FDS	Fire Detection and Suppression
FET	Field Effect Transistor
FGB	Functional Cargo Block (Zarya Module of ISS)
FHRC	Flex Hose Rotary Coupler
FI	Fault Isolator
FPU	Fluid Pumping Unit
FQDC	Fluid Quick Disconnect Coupling
FRD	Flight Requirements Document
FRGF	Flight Releasable Grapple Fixture
FSE	Flight Support Equipment
FSS	Fluid System Servicer
FWCI	Firmware Configuration Item
GAS	Get Away Special
GC	Growth Cell
GCA	Growth Cell Assembly
GFE	Government-Furnished Equipment
GFI	Ground Fault Interrupter
GLONASS	GLObal Navigational Satellite System
GN&C	Guidance, Navigation and Control
GNC	Guidance Navigation Computer
GPC	General Purpose Computer
GPRV	Gas Pressure regulating Valve
GPS	Global Positioning System
GUI	Graphical User Interface
H_2	Hydrogen
HAB	Habitat Module
HC	Hand Controller

HCA	Hollow Cathode Assembly
HCOR	High-Rate Communication Outage Recorder
HDR	High Data Rate
HDRL	High Date Rate Link
HEPA	High Efficiency Particulate Air
HGA	High Gain Antenna
HHL	Handheld Lidar
HP	Heat Pipe
HPGT	High Pressure Gas Tank
HRF	Human Research Facility
HRF-PUF-DK	Human Research Facility Puff Data Kit
HRF-Res	Human Research Facility Resupply
HRFM	High Rate Frame Multiplexer
HRM	High Rate Modem
HRS	Hand Reaction Switch
I/F	Interface
I/O	Input/Output
IAC	Internal Audio Controller
IAS	Internal Audio Subsystem
IATCS	Internal Active Thermal Control System
ICC	Integrated Cargo Carrier
IDA	Integrated Diode Assembly
IDRD	Increment Definition Requirements Document
IEA	Integrated Equipment Assembly
IFHX	Interface Heat Exchanger
IFM	In-flight Maintenance
IMCA	Integrated Motor Control Assembly
IMCS	Integrated Mission Control System
IMU	Impedance Matching Unit
IMV	Intermodule Ventilation
INCO	Instrumentation and Communication Officer
INSTM	Instrumentation
INT	Internal
INTSYS	Internal Systems
IOC	Input/Output Controller
IOCU	Input/Output Controller Unit
IP	International Partner
IRU	In-Flight Refill Unit
ISA	Internal Sampling Adapter
ISL	Integrated Station LAN
ISO	Inventory and Stowage Officer

ISPR	International Standard Payload Rack
ISS	International Space Station
ISSSH	International Space Station Systems Handbook
IT	Integrated Truss
ITCS	Internal Thermal Control System
ITS	Integrated Truss Segment
IUA	Interface Umbilical Assembly
IV	Intravehicular
IVA	Intravehicular Activity
IVSU	Internal Video Switch Unit
IWIS	Internal Wireless Instrumentation System
JEM	Japanese Experiment Module
JEU	Joint Electronic Unit
kW	Kilowatt
LA	Launch Aft
Lab	Laboratory
LAN	Local Area Network
LB	Local Bus
LB-RWS	RWS Local Bus
LCA	Lab Cradle Assembly
LCC	Launch Commit Criteria
LCD	Liquid Crystal Display
LDI	Local Data Interface
LDR	Low Data Rate
LDU	Linear Drive Unit
LED	Light-Emitting Diode
LEE	Latching End Effector
LEU	LEE Electronic Unit
LFDP	Load Fault Detection Protection
LGA	Low Gain Antenna
LLA	Low Level Analog
LMC	Lightweight Multipurpose Carrier
LON	Launch On Need
LT	Low Temperature
LTA	Launch to Activation
LTL	Low Temperature Loop
LTU	Load Transfer Unit
LVLH	Local Vertical Local Horizontal
MA	Mechanical Assembly

MAM	Manual Augmented Role
MBE	Metal Bellows Expander
MBM	Manual Berthing Mechanism
MBS	Mobile Remote Service Base System
MBSU	Main Bus Switching Unit
MC	Midcourse Correction
MCA	Major Constituent Analyzer
MCAS	MBS Common Attach System
MCC	Mission Control Center
MCC-H	Mission Control Center-Houston
MCC-M	Mission Control Center-Moscow
MCDS	Multifunction CRT Display System
MCS	Motion Control System
MCU	MBS Computer Unit
MDA	Motor Drive Assembly
MDL	Middeck Locker
MDM	Multiplexer/Demultiplexer
MED OPS	Medical Operations
MEPS	Microencapsulation Electrostatic Processing System
MEPSI	Micro-Electromechanical System-based Pico Satellite Inspector
MER	Mission Evaluation Room
MET	Mission Elapsed Time
METOX	Metal Oxide
MFCV	Manual Flow Control Valve
MHS	MCU Host Software
MILA	Mode Indicating Light Assembly
MIP	Mission Integration Plan
MISSE	Materials International Space Station Experiment
MLI	Multi-Layer Insulation
MM/OD	Micrometeoroid/Orbital Debris
MMT	Mission Management Team
MOD	Mission Operations Directorate
MPEV	Manual Pressure Equalization Valve
MPLM	Multipurpose Logistics Module
MPM	Manipulator Positioning Mechanism
MRL	Manipulator Retention Latch
MRS	Mobile Remote Servicer
MSD	Mass Storage Device
MSFC	Marshall Space Flight Center
MSG	Microgravity Science Glovebox
MSS	Mobile Servicing System
MT	Mobile Transporter

MTCL	Mobile Transporter Capture Latch
MTL	Moderate Temperature Loop
MTS	Module-to-Truss Segment
MTSAS	Module-to-Truss Segment Attachment System
MTWsN	Move to Worksite Number

N_2	Nitrogen
n.mi.	nautical mile
NASA	National Aeronautics and Space Administration
NCC	Nominal Corrective Combination burn
NCG	Non Condensable Gas
NCS	Node Control Software
NCU	Network Control Unit
NET	No Earlier Than
NIA	Nitrogen Interface Assembly
NiH_2	Nickel Hydrogen
NIV	Nitrogen Introduction Valve
NSI	NASA Standard Initiator
NSTS	National Space Transportation System
NTA	Nitrogen Tank Assembly

O_2	Oxygen
OCA	Orbital Communications Adapter
OCAD	Operational Control Agreement Document
OCJM	Operator-Commanded Joint Position Mode
OCPM	Operator-Commanded POR Mode
OCS	Operations and Control Software
ODIN	Orbital Design Integration System
ODS	Orbiter Docking System
OI	Operational Increment
OIU	Orbiter Interface Unit
OIV	Oxygen Isolation Valve
OMI	On-Orbit Maintainable Item
OMS	Orbital Maneuvering System
OPCGA	Observable Protein Crystal Growth Apparatus
OPP	OSVS
Ops	Operations
OPS LAN	Operations Local Area Network
ORBT	Optimized RBar Targeting Technique
ORCA	Oxygen Recharge Compressor Assembly
ORU	Orbital Replacement Unit
OSE	Orbiter Support Equipment
OSO	Operations Support Officer

OSVS	Orbiter Space Vision System
OTD	ORU Transfer Device
OV	Orbiter Vehicle
P	Port
P&S	Pointing and Support
P-code	Precision Code
P/L	Payload
P/TV	Photo/Television
P3/P4	Port 3/Port 4
PAS	Payload Attach System
PBA	Portable Breathing Apparatus
PC	Personal Computer
PCA	Pressure Control Assembly
PCAM	Protein Crystallization Apparatus for Microgravity
PCBM	Passive Common Berthing Mechanism
PCC	Power Converter Controller
PCG-STES	Protein Crystal Growth-Single Thermal Enclosure System
PCMCIA	Personal Computer Memory Card International Adapter
PCP	Pressure Control Panel
PCR	Portable Computer Receptacle
PCS	Portable Computer System
PCT	Post-Contact Thrusting
PCU	Plasma Connector Unit
PCVP	Pump and Control Valve Package
PDGF	Power and Data Grapple Fixture
PDI	Payload Data Interface
PDIP	Payload Data Interface Panel
PDRS	Payload Deployment and Retrieval System
PDTA	Power Data Transfer Assembly
PDU	Power Drive Unit
PEHG	Payload Ethernet Hub Gateway
PFCS	Pump Flow Control Subassembly
PFE	Portable Fire Extinguisher
PFMC	Pump/Fan Motor Controller
PGBA-S	Plant Generic Bioprocessing Apparatus-Stowage
PGSC	Portable General Support Computer
PGT	Pistol Grip Tool
PHALCON	Power, Heating, Articulation, Lighting, and Control Officer
PJAM	Pre-stored Joint Position Autosequence Mode
PLB	Payload Bay
PM	Pump Module

PMA	Pressurized Mating Adapter
PMCU	Power Management Control Unit
PMDIS	Perceptual Motor Deficits In Space
PMP	Payload Mounting Panel
POA	Payload/ORU Accommodation
POR	Point of Reference
POST	Power ON Self-Test
PP	Planning Period
PPA	Pump Package Assembly
PPAM	Pre-stored POR Autosequence Mode
ppO_2	partial pressure of oxygen
PPRV	Positive Pressure Relief Valve
PPT	Precipitate
PRD	Payload Retention Device
PRLA	Payload Retention Latch Assembly
Prox-Ops	Proximity Operations
PSN	Power Source Node
PSP	Payload Signal Processor
PTB	Payload Training Buffer
PTCS	Passive Thermal Control System
PTR	Port Thermal Radiator
PTU	Pan/Tilt Unit
PV	Photovoltaic
PVCA	Photovoltaic Controller Application
PVCE	Photovoltaic Controller Element
PVCU	Photovoltaic Controller Unit
PVM	Photovoltaic Module
PVR	Photovoltaic Radiator
PVRGF	Photovoltaic Radiator Grapple Fixture
PVTCS	Photovoltaic Thermal Control System
PWP	Portable Work Platform
PWR	Portable Water Reservoir
PYR	Pitch Yaw Roll
QD	Quick Disconnect
R/F	Refrigerator/Freezer
RACU	Russian-to-American Converter Unit
RAIU	Russian Audio Interface Unit
RAM	Random Access Memory
RAMV	Rheostat Air Mix Valve
RBB	Right Blanket Box
RBI	Remote Bus Isolator

RBVM	Radiator Beam Valve Module
RCC	Reinforced Carbon-Carbon
RCS	Reaction Control System
RDA	Retainer Door Assembly
RF	Radio Frequency
RFCA	Rack Flow Control Assembly
RFG	Radio Frequency Group
RGA	Rate Gyro Assemblies
RHC	Rotational Hand Controller
RHX	Regenerative Heat Exchanger
RIC	Rack Interface Controller
RJMC	Rotary Joint Motor Controller
RMS	Remote Manipulator System
ROS	Russian Orbital Segment
RPC	Remote Power Controller
RPCM	Remote Power Controller Module
RPDA	Remote Power Distribution Assembly
RPM	Rbar Pitch Maneuver
RPOP	Rendezvous and Proximity Operations Program
RS	Russian Segment
RSC	RMS Sideview Camera
RSP	Resupply Stowage Platform
RSR	Resupply Stowage Rack
RSTS	Rack Standalone Temperature Sensor
RSU	Roller Suspension Unit Remote Sensing Unit
RT	Remote Terminal
RT-Box	Reaction Time Box
RTAS	Rocketdyne Truss Attachment System
RTD	Resistive Thermal Device
RTL	Ready to Latch
RWS	Robotic Workstation
S	Starboard
S&M	Structures and Mechanisms
SA	Solar Array
SABB	Solar Array Blanket Box
SAGE	Space Arabidoposis Genomics Experiment
SARJ	Solar Alpha Rotary Joint
SARJ_C	SARJ Controller
SARJ_M	SARJ Manager
SASA	S-band Antenna Support Assembly

SAW	Solar Array Wing
SCA	Switchgear Controller Assembly
SCI	Signal Conditioning Interface
SCU	Service and Cooling Umbilical
SD	Smoke Detector
SDO	Solenoid Driver Output
SDS	Sample Delivery System
SEM	Shunt Electronics Module
SEPS	Secondary Electrical Power Subsystem
SFCA	System Flow Control Assembly
SFU	Squib Firing Unit
SGANT	Space-to-Ground Antenna
SHOSS	Spacehab Oceaneering Space System
SHOT	Space Hardware Optimization Technology
SIGI	Space Integrated Global Positioning System/Inertial Navigation System
SJRM	Single Joint Rate Mode
SLDP	Spacelab Data Processing
SLP	Spacelab Logistics Pallet
SM	Service Module
SMCC	Shuttle Mission Control Center
SMDP	Service Module Debris Panel
SOC	State of Charge
SOV	Shutoff Valve
SPCE	Servicing Performance and Checkout Equipment
SPD	Spool Positioning Device
SPDA	Secondary Power Distribution Assembly
SPDM	Special Purpose Dexterous Manipulator
SPG	Single-Point Ground
SRMS	Shuttle Remote Manipulator System
SSAS	Segment-to-Segment Attach System
SSBA	Space Station Buffer Amplifier
SSC	Station Support Computer
SSMDM	Space Station Multiplexer/Demultiplexer
SSOR	Space-to-Space Orbiter Ratio
SSP	Standard Switch Panel
SSRMS	Space Station Remote Manipulator System
SSSH	Space Shuttle Systems Handbook
SSSR	Space-to-Space Station Radio
SSU	Sequential Shunt Unit
STCR	Starboard Thermal Control Radiator
STES	Single Thermal Enclosure System
STR	Starboard Thermal Radiator

SVS	Space Vision System
TA	Thruster Assist
TAA	Triaxial Accelerometer Assembly
TAH	Tray Actuation Handle
TBA	Trundle Bearing Assembly
TC	Terminal Computer
TCCS	Trace Contaminant Control Subassembly
TCCV	Temperature Control and Check Valve
TCS	Trajectory Control Sensor
TD	Translation Drive
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TEA	Torque Equilibrium Attitude
TFR	Translation Foot Restraint
THC	Temperature and Humidity Control
THOR	Thermal Operations and Resources Officer
TI	Terminal Phase Initiation
TORF	Twice Orbital Rate Flyaround
TORU	Teleoperator Control Mode
TORVA	Twice Orbital Rate +Rbar to +Vbar Approach
TPL	Transfer Priority List
TRAC	Test of Reaction and Adaption Capabilities
TRC	Transmitter Receiver Controller
TRRJ	Thermal Radiator Rotary Joint
TSP	Twisted Shielded Pair
TTCR	Trailing Thermal Control Radiator
TUS	Trailing Umbilical System
TVIS	Treadmill Vibration Isolation System
TWMV	Three-Way Mixing Valve
UCCAS	Unpressurized Cargo Carrier Attach System
UDG	User Data Generation
UF	Utilization Flight
UHF	Ultrahigh Frequency
UIA	Umbilical Interface Assembly
UIP	Utility Interface Panel
ULF	Utilization Logistics Flight
UMA	Umbilical Mechanism Assembly
UOP	Utility Outlet Panel
USL	U.S. Laboratory
USOS	United States On-Orbit Segment

UTA	Utility Transfer Assembly
VAJ	Vacuum Access Jumper
VBSP	Video Baseband Signal Processor
VCP	Video Camera Port
VDS	Video Distribution System
VDU	Video Distribution Unit
VES	Vacuum Exhaust System
VGS	Video Graphics Software
VRCV	Vent/Relief Control Valve
VRIV	Vent/Relief Isolation Valve
VRS	VES Resource System
VRV	Vent/Relief Valve
VSC	Video Signal Converter
VSSA	Video Stanchion Support Assembly
W/S	Worksite
WETA	WVS External Transceiver Assembly
WHS	Workstation Host Software
WIF	Worksite Interface
WRM	Water Recovery Management
WS	Water Separator
WVA	Water Vent Assembly
XPOP	X-axis Pointing Out of Plane
ZCG-SS	Zeolite Crystal Growth—Sample Stowage
ZSR	Zero-g Stowage Rack

MEDIA ASSISTANCE

NASA TELEVISION TRANSMISSION

NASA Television is carried on an MPEG-2 digital signal accessed via satellite AMC-6, at 72 degrees west longitude, transponder 17C, 4040 MHz, vertical polarization. For those in Alaska or Hawaii, NASA Television will be seen on AMC-7, at 137 degrees west longitude, transponder 18C, at 4060 MHz, horizontal polarization. In both instances, a Digital Video Broadcast (DVB)-compliant Integrated Receiver Decoder (IRD) (with modulation of QPSK/DBV, data rate of 36.86 and FEC ¾) will be needed for reception. The NASA Television schedule and links to streaming video are available at:

http://www.nasa.gov/ntv

NASA TV's digital conversion will require members of the broadcast media to upgrade with an 'addressable' Integrated Receiver Decoder, or IRD, to participate in live news events and interviews, press briefings and receive NASA's Video File news feeds on a dedicated Media Services channel. NASA mission coverage will air on a digital NASA Public Services ("Free to Air") channel, for which only a basic IRD will be needed. The schedule for television transmissions from the orbiter and for mission briefings will be available during the mission at Kennedy Space Center, Fla.; Marshall Space Flight Center, Huntsville, Ala.; Dryden Flight Research Center, Edwards, Calif.; Johnson Space Center, Houston; and NASA Headquarters, Washington. 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 posted at:

http://www.nasa.gov/shuttle

This site also contains information on the crew and will be updated regularly with photos and video clips throughout the flight.

Briefings

A mission press briefing schedule will be issued before launch. The updated NASA television schedule will indicate when mission briefings are planned.

Internet Information

Information on safety enhancements made since the Columbia Accident is available at:

www.nasa.gov/returntoflight/system/index.html

Information on other current NASA activities is available at:

http://www.nasa.gov/home

Resources for educators can be found at the following address:

http://education.nasa.gov

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